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ReSOLVE SITE
DARTMOUTH, MASSACHUSETTS

Draft Off-Site Remedial Investigation Supplement

U.S. EPA Contract No.: 68-01-6939
REM II Document Control No.: 243-RI1-RT-DZZB

Prepared For: U.S. Environmental Protection Agency
Region I
Boston, Massachusetts 02108

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February, 1987

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Work Assignment No.: 140-1L18.0
Project: EPA Contract No.: 68-01-6939
Document Control No.: 243-RI1-RT-DZZB
Subject: Draft Off-Site Remedial Investigation Supplement, ReSolve Site, Dartmouth, MA

Dear Sirs:

The enclosed document is a copy of the Supplement to the Draft Off-Site Remedial Investigation for the ReSolve Site. The study provides an assessment of on-site and off-site contamination utilizing the information and data gathered during the field operations of this phase of the remedial investigation. Included is a description of the lateral and vertical extent of contaminated groundwater, surface water and soils, and the characterization by type and movement of the contaminants. This is followed by an evaluation of the impacts to the public health and welfare and the environment. Information not essential to this description has been retained in the Appendices.

Very truly yours,

CAMP DRESSER & McKEE INC.

Richard Cote
Site Manager

APPROVED:

William R. Swanson, P.E.
REM II Regional Manager

PERFORMANCE OF REMEDIAL RESPONSE ACTIVITIES AT UNCONTROLLED HAZARDOUS WASTE SITE (REM II)

U.S. EPA CONTRACT NO. 68-01-6939

DRAFT OFF-SITE REMEDIAL INVESTIGATION SUPPLEMENT

FOR

ReSOLVE SITE
DARTMOUTH, MASSACHUSETTS

EPA WORK ASSIGNMENT NO.: 140-1L18.0
REM II DOCUMENT CONTROL NO.: 243-RI1-RT-DZZB

Prepared By: Richard C. Cote, Site Manager — Date: 2/23/87

Approved By: William R. Swanson, P.E., Region I Manager — Date: 2/23/87

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Section 1

1.0 INTRODUCTION

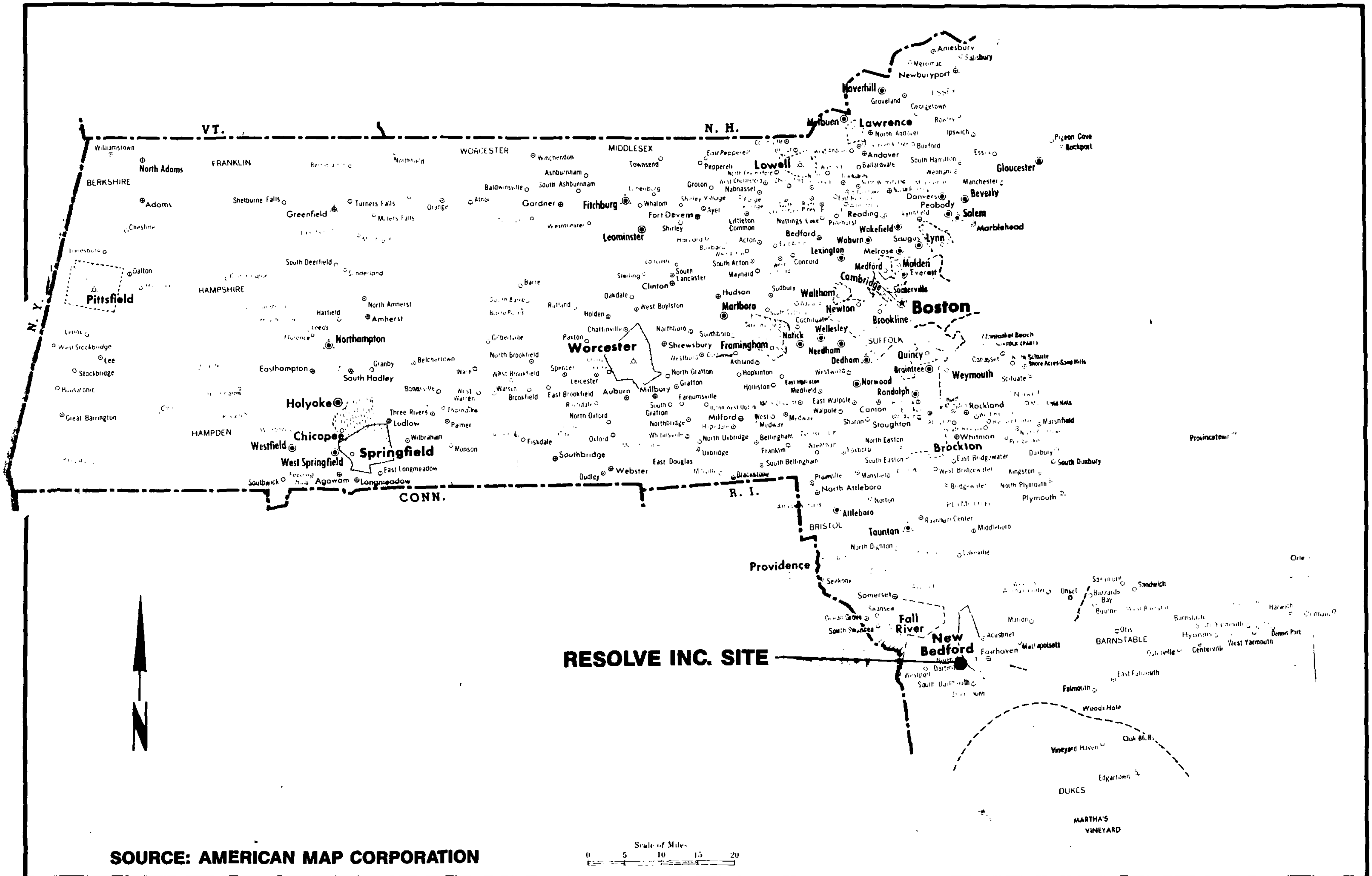
This document is a supplement to the February 1985 Off-Site Remedial Investigation report for the ReSolve, Inc. site which described the nature and extent of contamination both on the site and off the site. This supplement describes the nature and extent of on-site residual contamination and off-site groundwater and sediment contamination, including a section describing migration of groundwater contamination from the site and contaminated sediments in nearby waterbodies and wetlands. An RI supplement was deemed to be necessary because extensive soil contamination was detected on-site during the implementation of the source control alternative, selected following completion of the On-Site RI/FS in June 1983.

The information presented in this report will provide the foundation for a comprehensive Feasibility Study (FS) which will examine different alternatives for addressing the contaminated areas referred to above. The FS will evaluate the alternatives on the basis of cost and their effectiveness in protecting public health, welfare, and the environment as required by the Superfund Amendments and Reauthorization Act (SARA) of 1986.

1.1 SITE BACKGROUND

The ReSolve Inc. Site is located in a rural area of the Town of North Dartmouth, in southeastern Massachusetts, as shown in Figure 1-1. The site, which is approximately six acres in area, served as a waste chemical reclamation facility from 1956 until 1980.

The ReSolve site is located on the east side of North Hixville Road. It is surrounded by wetlands to the north and east, and a pine and mixed hardwood forested area to the south and west. The Copicut River is located about 500 feet east of the site. It drains into Cornell Pond, which is located approximately one quarter of a mile southeast of the site. Cornell



SOURCE: AMERICAN MAP CORPORATION

RESOLVE INC. SITE

NORTH DARTHMOUTH, MASSACHUSETTS
Camp Dresser & McKee
July 1986

FIGURE 1-1
SITE LOCATION

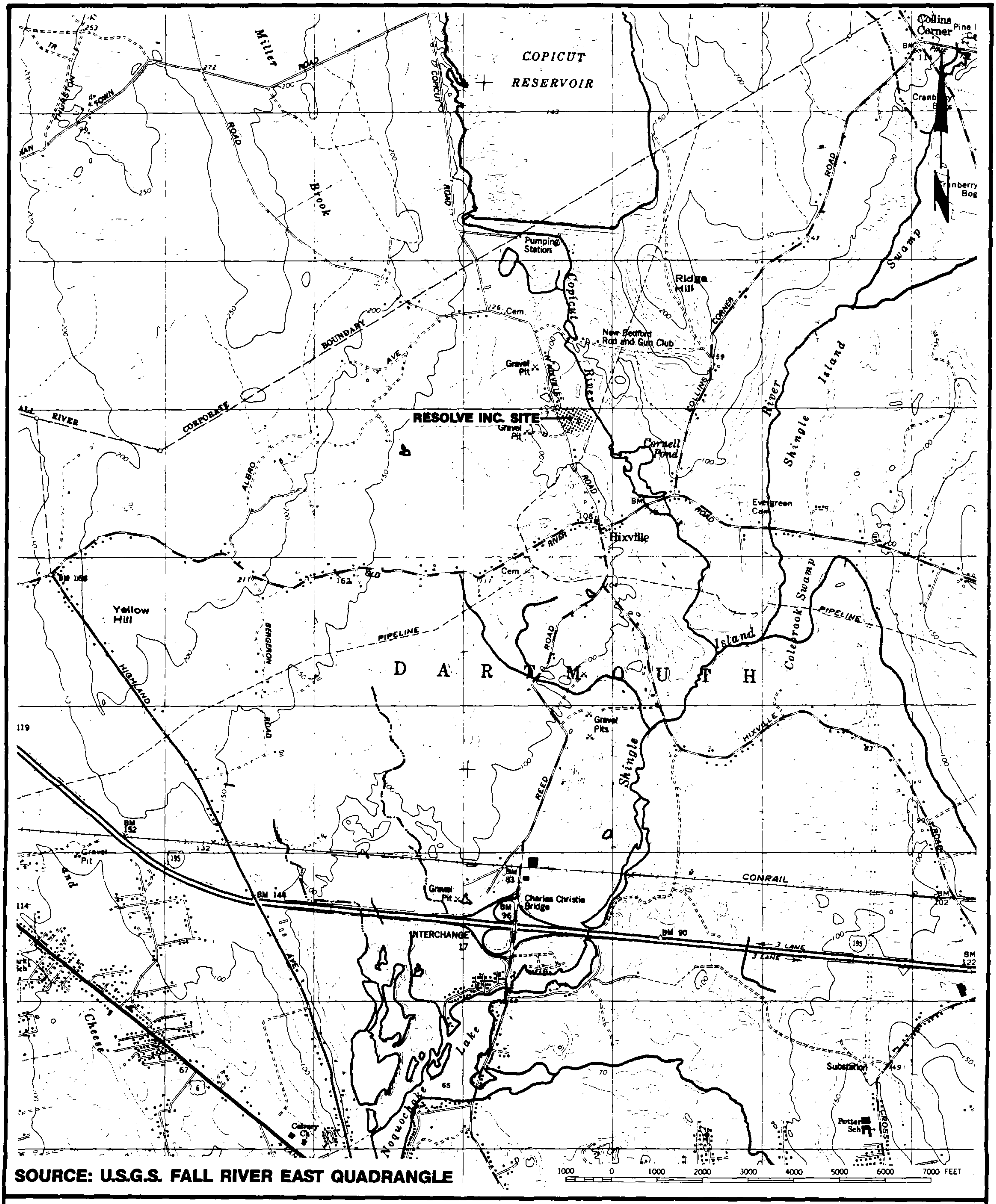
Pond drains about 2 miles into Noquochoke Lake, which is designated as a secondary water supply source for the City of Fall River. Fall River is located about eight miles east of North Dartmouth. Figure 1-2 shows the location of the site.

The subsurface soils underlying the ReSolve site and surrounding areas are stratified sand and gravels designated as glacial stratified drift. The thickness of these sediments is 20 to 35 feet. In the wetland areas, an unknown thickness of peat is overlying the glacial stratified drift. The underlying bedrock is reportedly composed of granite and metamorphic rock.

The residues from the distillation tower were disposed of in four unlined on-site lagoons in the northern portion of the site, where they were also allegedly burned to reduce levels of volatile organics. A former site owner reports that lagoons were used for the disposal of residues for over twenty years. Cooling water from the distillation tower was discharged to a shallow on-site lagoon in the eastern portion of the site. It is alleged that residues from burned tires were also disposed of in the lagoons.

On October 21, 1980, ReSolve Inc. volunteered to surrender its license to collect and dispose of hazardous waste to the Massachusetts Division of Water Pollution Control. The license had been issued in 1974. On December 23, 1980, the Massachusetts Division of Hazardous Waste agreed to accept ReSolve's offer, on the condition that all hazardous waste be removed from the site. Inspection and monitoring of the site showed that no migration of contaminants was occurring from the four lagoons and that vehicle inspection and manifest requirements were adhered to for disposal of on-site drum and tank wastes.

In the following months, there was little evidence of responsible action on the part of ReSolve, Inc. and, on March 11, 1981, the case was turned over to the Massachusetts Attorney General's Office. Later in 1981, all drums and other debris were allegedly removed from the site by ReSolve, Inc. Demolition and off-site disposal of all buildings on the site also occurred in 1981. Following this, the site, with the exception of the slab foundations and loading and unloading pads, was covered with an unknown



SOURCE: U.S.G.S. FALL RIVER EAST QUADRANGLE

RESOLVE INC. SITE

NORTH DARTHMOUTH, MASSACHUSETTS
Camp Dresser & McKee
July 1986

FIGURE 1-2
AREA OF INTEREST

amount of sand. These activities occurred under the direction of the present site owner. The contents of the four on-site lagoons were not removed.

On June 19, 1981, the Massachusetts Department of Environmental Quality Engineering (DEQE) submitted a request to EPA that the ReSolve, Inc. site be placed on the Superfund National Priorities List (NPL). In October 1981, EPA released the interim NPL list of 115 priority hazardous waste sites and the ReSolve, Inc. site was on the list. It then became eligible for federal assistance as part of the Superfund program. On December 30, 1982, the ReSolve, Inc. site was placed on the EPA's proposed NPL. At the time, it was ranked as number 156 of a total of 418 hazardous waste sites.

On July 16, 1982, EPA published a Remedial Action Master Plan (RAMP) for the site. The primary purpose of the RAMP was to assess the available site data and identify the type, scope, sequence, and schedule of remedial projects which would be appropriate at the site.

An On-Site Remedial Investigation and Feasibility Study (RI/FS) was conducted in 1982 for the assessment of on-site contamination and the evaluation of remedial measures. Additional data were also collected for the assessment of off-site contamination. The final RI/FS was published in June 1983.

During the on-site investigation, a sampling program provided chemical analyses for air, surface water, groundwater, soil, lagoon wastes, and sediment samples. Indications of contaminated areas and waste types identified in previous studies were verified during the on-site RI/FS. The lagoon materials were more extensively characterized and the limits of highly contaminated soils on-site were identified. The study identified the source of on-site contamination as approximately 3,100 cubic yards of lagoon wastes and 3,900 cubic yards of contaminated soil. Based on review of analytical data from 35 monitoring wells, it was postulated that the extent of groundwater contamination was bounded by the Copicut River and Carol's Brook.

In June 1983, EPA selected a source control remedial action that included excavation of the contaminated lagoons and soils with a PCB concentration greater than 50 ppm. This remedial action also included regrading and capping the contamination on the site, and providing final cover, drainage, and seed for site closure. However, as a result of public concern and institutional constraints, EPA modified its remedial action. The source control alternative which EPA implemented was off-site disposal of contaminated lagoon waste and soils. The design contract documents for the off-site disposal program were completed in October 1983. During the design efforts, the quantity of waste requiring disposal was increased to a total of 15,000 cubic yards.

Implementation of the remedial alternative, under the direction of the U.S. Army Corps of Engineers began in September 1984 and was completed in January 1987. During this time, approximately 15,000 cubic yards of source material were removed. During the source removal activities, extensive soil contamination was detected which was beyond the scope of this phase of the project.

The Off-Site RI/FS, which was ongoing during source removal activities, also indicated that PCB soil and sediment contamination was present in off-site wetland areas. The Final Draft Off-Site RI was completed in February 1985. This document is a supplement to that report.

1.2 NATURE AND EXTENT OF THE PROBLEM

A variety of hazardous materials were handled at the ReSolve site from 1956 until it ceased operation on October 21, 1980. These hazardous waste materials included solvents, waste oils, organic liquids and solids, acids, alkalies, and inorganic liquids and solids.

The major contaminants at the site are PCB compounds. The actual volume of the abovementioned materials handled at the reclamation facility is not known. It was reported by previous site owners that the only materials disposed of on-site were the sludge residue and cooling water from the distillation tower. Aerial photographs of the site by the EPA Environmental Monitoring Systems Laboratory reveal evidence of discharge in the oil spreading area (see Figure 1-3) in February 1974. In the 1983 RI/FS, the following four areas were identified as potential major sources of contamination. (See Figure 1-3). These sources were removed during the implementation of the remedial alternative from September 1984 to May 1985. These areas consisted of:

- Four unlined lagoons in the northern part of the site;
- Filled cooling water pond at the eastern boundary of the site;
- Areas of oil spreading in western and southwestern portions of the site; and
- Foundations and concrete pads associated with structures which had existed on-site at one time (structural remnants), and contaminated soils ("hot-spots").

During the source removal phase, additional site investigation studies were conducted. This work consisted of 48 onsite shallow borings and a series of 5 test pits. This data showed that PCB contamination exists at concentrations greater than 50 ppm in soils to a depth of 10 feet below seasonal low groundwater.

1.3 REMEDIAL INVESTIGATION SUMMARY

This report is a summary of the work completed as part of the EPA Superfund Remedial Investigation for the ReSolve site. A work plan was developed to identify the specific technical tasks necessary to determine the extent of site contamination and potential cleanup alternatives. A review of existing data regarding the site was used in developing the work plan, which was completed in 1985. Sources of data include:

- Remedial Action Master Plan (RAMP), July 16, 1982

AREA 1

SOLIDFY IN PLACE AND EXCAVATE ALL MATERIAL WITHIN LAGOON PERIMETER TO ELEV. 90.0 AS SHOWN ON DRAWING AT RIGHT. EXCAVATION BELOW 90.0 SHALL BE AS SPECIFIED. SLUDGE MATERIAL MAY BE MIXED WITH SOLID SOILS FROM AREA 2 AS NEEDED.

AREA 2

ALL MATERIAL SHALL BE EXCAVATED TO ELEVATION 90.0 AND REMOVED OFF SITE. EXCAVATION BELOW ELEV. 90.0 SHALL BE AS SPECIFIED.

AREA 3

ALL MATERIAL SHALL BE EXCAVATED TO 1'-0" BELOW EXISTING GRADE AND REMOVED AS SPECIFIED.

AREA 4

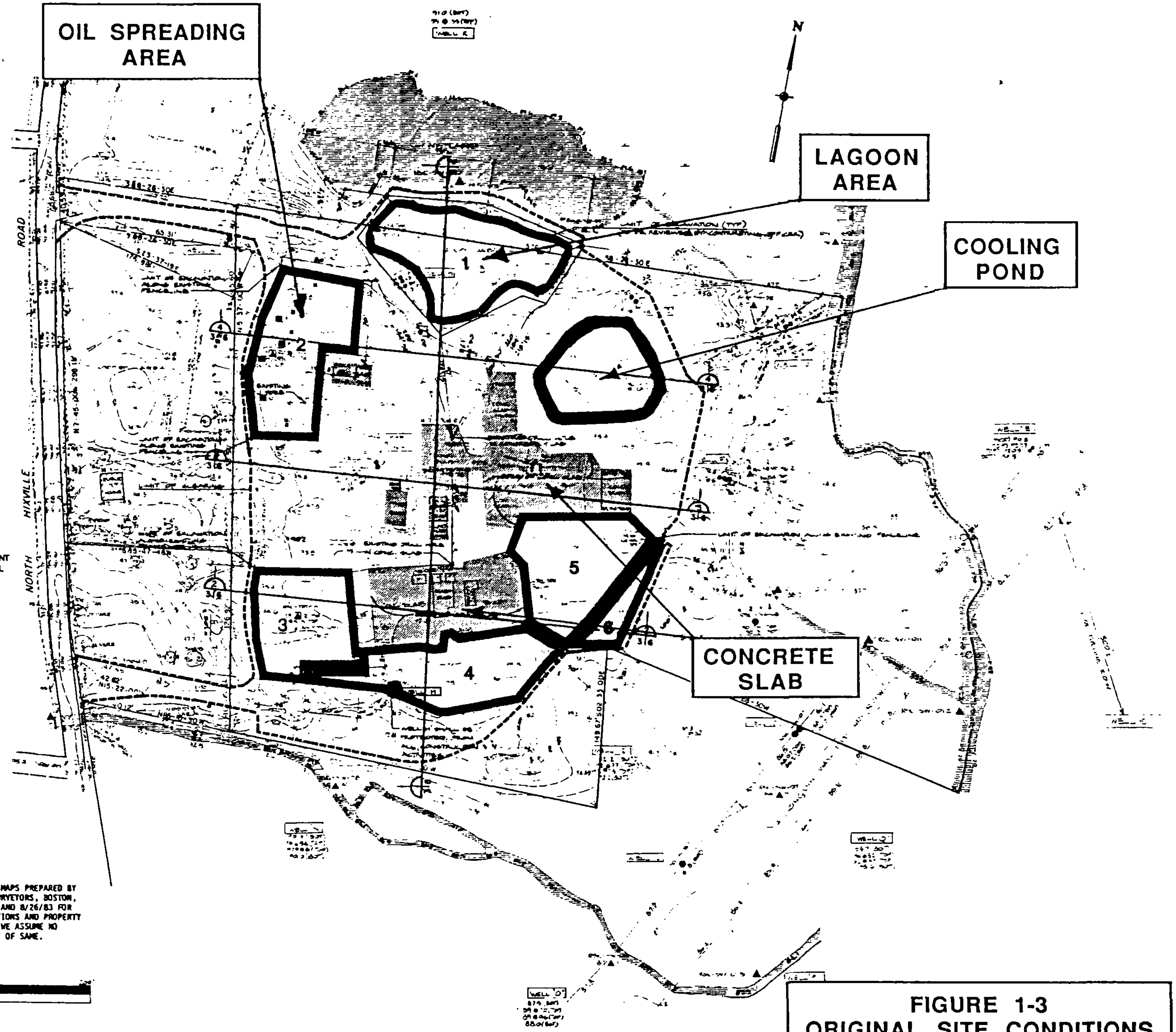
ALL MATERIAL SHALL BE SCRAPED TO 6" BELOW EXISTING GRADE AS A PART OF SITE PREPARATION AND STOCKPILED FOR SUBSEQUENT TESTING AND HANDLING. STOCKPILED MATERIAL SHALL BE SAMPLED FOR P.C.B. (SEE NOTE 5).

AREA 5

ALL MATERIAL SHALL BE EXCAVATED TO ELEVATION 94.0 AND REMOVED OFF SITE. EXCAVATION BELOW ELEV. 94.0 SHALL BE AS SPECIFIED.

AREA 6

ALL MATERIAL INCLUDING DRUMS AND DEBRIS SHALL BE EXCAVATED TO ELEV. 94.0, STOCKPILED AND SAMPLED.



WE HAVE RELIED ON AND UTILIZED MAPS PREPARED BY HARRY R. FELDMAN, INC., LAND SURVEYORS, BOSTON, MASS. DATED 10/26/82, 12/13/82 AND 8/26/83 FOR THE TOPOGRAPHY, EXISTING CONDITIONS AND PROPERTY LINES SHOWN ON THESE PLANS AND WE ASSUME NO RESPONSIBILITY FOR THE ACCURACY OF SAME.

FIGURE 1-3
ORIGINAL SITE CONDITIONS AND REMEDIAL ACTION PLAN

- Camp Dresser & McKee Inc., "Remedial Investigation and Feasibility Study for ReSolve, Inc. Hazardous Waste Site, Dartmouth, Massachusetts", June 30, 1983.
- Contract Documents: ReSolve Site Cleanup, October 1983
- Camp Dresser & McKee, Inc., "Off-Site Remedial Investigation", February 1985

Following the completion of the Work Plan, Project Operation Plans (POPs), were developed for each on-site operation. The ReSolve Quality Assurance Plan, Health and Safety Plan, Site Operations Plan, and Sampling and Analytical Plan have all been incorporated in these documents.

1.4 OVERVIEW OF REPORT

The remaining sections of this report are organized to provide a description of on-site and off-site conditions, as well as a summary of the specific data collected during this remedial investigation. Also discussed are appropriate data from previous investigations. Section 2.0 presents a description of site features, including demography, land use, natural resources, and climatology.

Section 3.0 describes the investigation of on-site hazardous substances and describes waste types and waste component characteristics as well as the work conducted to obtain this information. The hydrogeologic investigation is described in Section 4.0, while Section 5.0 presents a discussion of both historical and current surface water and sediment data. In addition, Section 5.0 presents and discusses the results of the fish sampling program conducted in the Copicut River and Cornell Pond.

Sections 6.0 and 7.0, respectively, describe the residential well and air quality investigations conducted during the RI. Section 8.0 presents an evaluation of the public health and environmental concerns that arise as a result of the contaminants found at the site.

1.5 INSTITUTIONAL REQUIREMENTS

EPA policy states that in the process of developing and selecting remedial alternatives, primary consideration should be given to remedies that attain applicable or relevant and appropriate environmental and public health requirements (ARARs) as defined by the Superfund Amendments and Reauthorization Act (SARA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

Applicable requirements are federal public health and environmental requirements which would be legally applicable to the response or remedial action if that action was not undertaken pursuant to CERCLA (Federal, State and local permits are not required for fund-financed remedial actions or remedial actions taken pursuant to federal action under Section 106 of CERCLA).

Relevant and appropriate requirements are federal public health and environmental requirements that would apply to circumstances sufficiently similar to those encountered at CERCLA sites where their application would be appropriate although not legally required.

Requirements to be considered include federal and state advisories, guidance documents, policy statements, etc. that are not enforceable but pertain to conditions encountered in the remediation of CERCLA sites. All state requirements were in this category prior to SARA. Section 121 (d)(2)(A)(ii) of SARA now requires compliance with State environmental or facility siting laws that are more stringent than federal requirements. As a result, these statutes and regulations are to be considered as potentially applicable or relevant and appropriate to the remediation of CERCLA sites.

A summary of the ARARs that are pertinent to the remedial alternatives being developed for the ReSolve Site are presented in Table 1-1.

TABLE 1-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
FOR EVALUATION OF REMEDIAL ALTERNATIVES
ReSOLVE SITE, DARTMOUTH, MA

REQUIREMENT	NOT APPLICABLE	APPLICABLE	RELEVANT & APPROPRIATE	TO BE CONSIDERED	RATIONALE
I. FEDERAL REQUIREMENTS					
1. Open Dump Criteria (RCRA Subtitle D, 40 CFR Part 257)	X				Relevant to non-hazardous wastes. Superfund wastes handled in accordance with RCRA Subtitle C (40 CFR Part 264).
2. Hazardous Waste Requirements (RCRA Subtitle C, 40 CFR Part 264)		X	X		Standards applicable to treating, storing and disposing of hazardous waste.
a. Ground Water Protection (264.90 - 264.109)			X		Remedial alternatives may include aquifer remediation. Hazardous constituents not to exceed limits in Section 264.94 (Background MCLs).
b. Ground Water Monitoring (265.90 - 265.94)	X				40 CFR 265.90 - 265.94 applies to interim status facilities.
c. Closure & Post-Closure (264.110 - 264.120)			X		Design & performance standards for remediation plans.
d. Containers (264.170 - 264.178)	X				All onsite containers to be removed prior to alternatives development.
e. Tanks (264.190 - 264.200)		X	X		Remedial alternatives include on-site water treatment involving surface tanks.
f. Surface Impoundments (264.220 - 264.249)			X		Closure by removal (clean closures) may be involved.
g. Waste Piles (264.250 - 264.269)	X				Waste piles have been removed and are not being considered as a remedial alternative.
h. Land Treatment (264.270 - 264.299)	X				Land treatment is not being considered as a remedial action.
i. Landfills (264.300 - 264.339)		X	X		A landfilling type operation is being considered as a remedial action. Site-specific circumstances may require variances from RCRA standards which must be defended in FS. Containment is also considered.

TABLE 1-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
FOR EVALUATION OF REMEDIAL ALTERNATIVES
ReSOLVE SITE, DARTMOUTH, MA

REQUIREMENT	NOT APPLICABLE	APPLICABLE	RELEVANT & APPROPRIATE	TO BE CONSIDERED	RATIONALE
j. Incinerators (264.340 - 264.999)		X	X		On-site incineration is being considered as a remedial action.
3. Safe Drinking Water Act		X	X	X	Water quality requirements.
a. Maximum Contaminant Levels (MCLs)		X	X		On-site aquifer rendered unsuitable for public drinking water source due to past disposal practices; however remedial actions may provide clean-up to the MCLs.
b. Maximum Contaminant Level Goals (MCLGs)		X	X	X	SARA Sec. 121(d)(2)(A)(ii).
c. Underground Injection Control Regulations (40 CFR Parts 144, 145, 146, and 147			X		May be applicable to on-site groundwater recirculation systems.
4. Toxic Substances Control Act (15 U.S.C. 2601)		X	X	X	Hazardous waste requirements.
a. PCB Requirements (40 CFR 761)		X	X		PCBs are a major site contaminant.
b. Disposal of Waste Material Containing TCDD (40 CFR 775.180 - 775.197)	X				TCDD not present at site.
c. TSCA health data, chemical advisories, and Compliance Program policy				X	
5. Health Advisories, EPA Office of Drinking Water				X	RI activities identified presence of chemicals for which health advisories are listed.
6. Clean Water Act (PL92-500)		X	X	X	Water quality requirements.
a. State Water Quality Standards (Sections 301, 302 and 303)		X	X		Copicut River a Class B stream. Standards only address pH, temperature and dissolved oxygen. On-site dredging alternatives will require state water quality certification (see Section II, No. 3 and 6).
b. Federal Water Quality Criteria (FWQC)		X	X	X	Remedial actions will provide groundwater remediation. SARA 121 (d)(2)(A)(ii).

TABLE 1-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
FOR EVALUATION OF REMEDIAL ALTERNATIVES
ReSOLVE SITE, DARTMOUTH, MA

REQUIREMENT	NOT APPLICABLE	APPLICABLE	RELEVANT & APPROPRIATE	TO BE CONSIDERED	RATIONALE
c. Federal Pretreatment Requirements for Discharge to Publicly Owned Treatment Works (Sections 306 and 307)		X	X		Remedial alternatives may include on-site water treatment discharged to POTW.
d. Ocean Dumping Requirements (Section 403)	X				Not a remedial alternative site.
e. NPDES Permit		X	X		Remedial alternatives may include discharge to surface waters.
7. Marine Protection Research and Santuaries Act (33 USC 1401)	X				Site not located in areas protected by Act.
a. Incineration at Sea Requirements (40 CFR Parts 220 - 225, 227, 228 and 125.120 - 125.124)	X				Not a remedial alternative at site.
8. Section 404 (b)(1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material (40 CFR Part 230)		X	X		Remedial alternatives at Site may include dredging and filling in wetlands.
9. Dredged Material Disposal Sites Denial or Restriction Procedures (404(c); 40 CFR Part 231)			X		See Above.
10. Regulation of Activities Affecting Water of the U.S. (33 CFR Parts 320 - 329)		X	X		Corps of Engineers Regulations apply to both wetlands and navigable waters (Section 10 waters). For wetland considerations see Item No. 8. Section 10 waters not affected by remedial actions.
11. The Uranium Mill Tailings Remediation Control Act (42 U.S.C. 2022)					
a. Uranium Mill Tailings Rules (40 CFR Part 192)	X				By-products or uranium mining not present at site.

TABLE 1-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
FOR EVALUATION OF REMEDIAL ALTERNATIVES
ReSOLVE SITE, DARTMOUTH, MA

REQUIREMENT	NOT APPLICABLE	APPLICABLE	RELEVANT & APPROPRIATE	TO BE CONSIDERED	RATIONALE
12. Clean Air Act (42 USC 7401)					
a. National Ambient Air Quality Standards (NAAQS) for Six Criteria Pollutants (40 CFR Part 50)		X	X		On-site remedial alternatives may include incineration.
b. Standards for Protection Against Radiation (10 CFR Part 20)	X				No radioactive waste on site.
c. National Emissions Standards for Hazardous Air Pollutants; Asbestos and Radionuclides (40 CFR Part 61)	X				Asbestos and radionuclides not presnet at site.
d. Public health basis to list pollutants as hazardous under Section 112 of the Clean Air Act				X	See No. 12a. above.
13. OSHA Requirements (29 CFR Parts 1910, 1926 and 1904)		X	X		Required for workers engaged in on-site remedial activities and for non-workplace public health.
14. Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands)			X		Both floodplain and wetland resources may be impacted by the site remedial alternative.
15. Acts Related to Protection and Preservation of National, Archaeological or Cultural Resources (32 CFR Part 229 and 229.4; and 43 CFR Parts 7 and 7.4)	X				No protected resources on site.
16. DOT Rules for Hazardous Materials Transport (49 CFR Parts 107, 171.1 - 171.500)		X	X		Remedial alternatives include off-site treatment and disposal.
17. Endangered Species Act of 1973 (16 USC 1531)	X				No listed species on site.
18. Fish & Wildlife Coordination Act (16 USC 661)			X		Remedial alternatives requiring taking of on-site wetlands may remove protected habitats, USFWS Coordination needed.

TABLE 1-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
FOR EVALUATION OF REMEDIAL ALTERNATIVES
ReSOLVE SITE, DARTMOUTH, MA

REQUIREMENT	NOT APPLICABLE	APPLICABLE	RELEVANT & APPROPRIATE	TO BE CONSIDERED	RATIONALE
19. Fish & Wildlife Improvement Act of 1978 (16 USC 742a)			X		See above.
20. Fish & Wildlife Conservation Act of 1980 (16 USC 2901)			X		See above.
21. Coastal Zone Management Act (16 USC 1451)	X				Site not located in coastal zone.
22. Pesticide Registration, Tolerances and Action Levels	X				Pesticides not present on site.
23. Waste Load Allocation Procedures				X	Site remedial actions could include discharging to POTW.
24. Health Effects Assessments				X	Public health risk assessment included in RI report
25. EPA's Groundwater Protection Strategy				X	Remedial alternatives must consider EPA classification of groundwater conditions at site.
II. STATE REQUIREMENTS					
1. Mass. Hazardous Waste Regulations (G.L. CH. 21C; 310 CMR 30.00)		X	X		Standards for treating, storing and disposing of hazardous waste.
a. Groundwater Protection (30.660 - 30.675)		X	X		See Section I, No. 2a.
b. Closure and Post Closure (30.580 - 30.586; 30.590 - 30.595)		X	X		See Section I, No. 2c.
c. Use and Management of Containers (30.680-30.689)	X				See Section I, No. 2d.
d. Storage and Treatment in Tanks (30.690 - 30.698)		X	X		See Section I, No. 2e.

TABLE 1-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
FOR EVALUATION OF REMEDIAL ALTERNATIVES
ReSOLVE SITE, DARTMOUTH, MA

REQUIREMENT	NOT APPLICABLE	APPLICABLE	RELEVANT & APPROPRIATE	TO BE CONSIDERED	RATIONALE
e. Surface Impoundments (30.610 - 30.618)		X	X		See Section I, No. 2f.
f. Waste Piles (30.640 - 30.649)	X				See Section I, No. 2g.
g. Land Treatment Units (30.650 - 30.659)	X				See Section I, No. 2h.
h. Landfills (30.620 - 30.633)		X	X		See Section I, No. 2i.
i. Additional Requirements for Prevention of Air Pollution Control		X	X		See Section I, No. 2j.
2. Hazardous Waste Facility Siting Act (G.L. CH. 21D; 990 CMR 1.00 - 16.00)		X	X		Site activities exempted by 990 CMR 1.02 (2) (e).
3. Certification for Dredging, Dredged Material Disposal and Filling in Waters (314 CMR 9.00)		X	X		Remedial alternatives at site may include dredging and filling in wetlands.
4. Mass. Groundwater Discharge Permit Program and Groundwater Quality Regulations (314 CMR 6.00)		X	X		Remedial alternatives may include groundwater recirculation and discharge after treatment.
5. Mass. Air Pollution Control Regulations, including Incineration and Dust Control Regulations		X	X		See Section I, No. 12a.
6. Mass. Surface Water Quality Standards (314 CMR 4.00)		X	X		Remedial alternatives may include discharge to surface waters.
7. Solid Waste Regulations (Ch. III, Sec. 150A, 150B)		X	X		Remedial alternatives may include landfilling
8. Mass. Underground Injection Control Regulations		X	X		See Section I, No. 3c.
9. Mass. Wetlands Protection Act		X	X		See Section I, No. 8 and Section II, No. 3.
10. Mass. Environmental Policy Act (MEPA)		X	X		Environmental Notification Form filed by Mass. DEQE.

Section 2

2.0 SITE FEATURES INVESTIGATION

This section presents the results of the investigation of the features of the ReSolve site and vicinity. The information is summarized in subsections on the following topics: demography, land use, natural resources, and climatology. Each subsection describes the key parameters investigated and analyzed for the ReSolve site. This information will be pertinent to the technical, public health, and environmental analyses to be conducted in the site feasibility study.

2.1 DEMOGRAPHY

The ReSolve hazardous waste site is located in the Town of North Darmouth, Massachusetts. According to the 1980 Massachusetts Census, North Dartmouth has a population of approximately 26,000 in an area of about 62 square miles. The 1980 population represents an increase of approximately 17 percent over the 1975 population of 21,600 persons. Based on the 1980 census, approximately 114 people live within a one half mile radius of the site, and approximately 326 people live within a one mile radius of the site. The 1980 census also indicates that within the census tracts which intersect the one mile site radius, 35 percent of the population are within the 0 to 18 year age group, 60 percent are 18 to 64 years, and the remaining 5 percent are 65 years and older.

Two residences are located within 150 yards of the site - one is located to the northwest of the site, and the other to the southwest of the site. Six other residences are found along North Hixville Road within one quarter mile of the site, and about six other residences are located along Old Fall River Road. (See Figure 1-2). All residences in the area obtain their water from private wells located on their property. The small village of Hixville is located approximately one-half mile south of the site.

2.2 LAND USE

The land surrounding the ReSolve site is predominately zoned for single family residential use, that is, lot sizes of 40,000 square feet or larger. Two auto salvage yards are located on North Hixville Road, 500 feet and 300 feet to the north and northwest of the site, respectively. The gravel pits located to the northwest of the site have been closed and revegetated. About 180 acres to the northeast of the site are owned by the Rod and Gun Club of New Bedford. This land is used by the club for hunting (rabbits and pheasants are stocked by the club), fishing, and target shooting. Part of the acreage is also used in conjunction with a forestry management program. Twenty-five acres of land immediately south of the site bordering the Algonquin Gas Pipeline right-of-way and the Copicut River are held by the Darmouth Natural Resource Trust.

The Sousa Dairy Farm is located approximately three quarters of a mile northwest of the site. The farm raises approximately 100 head of cattle as well as silage for feed.

2.3 NATURAL RESOURCES

The area surrounding the ReSolve site consists primarily of wetlands, except for a pine and mixed hardwood forested area to the south and west. The Rod and Gun Club of New Bedford also conducts a forestry management program to the northeast of the site. Vegetation typical of the wetlands areas includes:

- highbush blueberry
- sphagnum moss
- sweet pepper
- swamp azalea
- tupelo
- red maple
- bur reed
- tufted sedges
- green briar

The Copicut River, classified as Class B by the Commonwealth of Massachusetts, is located about 500 feet directly east of the site. Class B waters are designated (under 314 CMR 4.03) for the uses of protection and propagation of fish, other aquatic life, and wildlife; and for primary and secondary contact recreation. Water quality standards for Class B waters are listed in Table 2-1. In addition, the Massachusetts Division of Water Pollution Control may use EPA criteria for establishing case-by-case discharge limits for pollutants not specifically listed in these standards.

The Copicut River drains directly into Cornell Pond approximately one quarter of a mile down river from the site. Cornell Pond is popular for sport fishing. Horn pout, perch, and pickerel are the common species captured. Outflow from Cornell Pond merges with Shingle Island River which then flows into Noquochoke Lake, located about two miles downstream of Cornell Pond. (See Figure 1-2). Noquochoke Lake is highly enriched with nutrients and stratifies in the summer months, so that sufficient levels of dissolved oxygen may not be present to support a healthy aquatic community.

A town forest is located about two miles south of the site, adjacent to Interstate Highway 195. No rare or endangered species, plants or animals have been reported within a two mile radius of the site (Woolsey, 1985).

2.4 CLIMATOLOGY

Information on climatological conditions can aid in identifying how a site may impact the surrounding environment. For example, high ambient air temperatures can result in increased volatilization of organic compounds, and precipitation can result in the generation of leachate feeding into bordering streams and rivers.

Climate information is derived from the meteorological station located in New Bedford, Massachusetts. A summary of local climatological data shows that annual precipitation averages 41 inches in Dartmouth, with most annual totals within 14 percent of the normal. In some years, however, values may vary by more than 30 percent. Average monthly precipitation ranges from 2.2 inches to 4.1 inches.

TABLE 2-1

COMMONWEALTH OF MASSACHUSETTS WATER QUALITY STANDARDS FOR CLASS B WATERS*

Parameter	Criteria
1. Dissolved Oxygen	Shall be a minimum of 5.0 mg/l in warm water fisheries and a minimum of 6.0 mg/l in cold water fisheries.
2. Temperature	Shall not exceed 83°F (28.3°C) in warm water fisheries or 68°F (20°C) in cold water fisheries, nor shall the rise resulting from artificial origin exceed 4.0°F (2.2°C).
3. pH	Shall be in the range of 6.5 - 8.0 standard units and not more than 0.2 units outside of the naturally occurring range.
4. Fecal Coliform Bacteria	Shall not exceed a log mean for a set of samples of 200 per 100 ml, nor shall more than 10% of the total samples exceed 400 per 100 ml during any monthly sampling period, except as provided in 314 CMR 4.02(1).

*314 CMR 4.03

Precipitation data from the New Bedford, Massachusetts station during the remedial investigation study time period is presented in Section 5.1.

Temperatures range from an average low of about 32 degrees Fahrenheit on January 1 to about 72 degrees Fahrenheit on July 1. Evapotranspiration returns approximately 53 percent of the total volume of precipitation to the atmosphere.

Section 3

3.0 HAZARDOUS SUBSTANCE INVESTIGATION

3.1 WASTE MATERIAL CHARACTERISTICS

This section and the balance of the report present the findings of the Remedial Investigation (RI). In order for the reader to understand why particular media (air, soil, water) were sampled, and what chemical components were analyzed for, a basic understanding of how concentrations of contaminants are reported and what contaminants are typical of hazardous wastes is required. In the following subsections, a short introduction provides the reader with a basic working knowledge of the chemical nomenclature which is used throughout the report.

3.1.1 CHEMICAL CONCENTRATIONS

The concentration of a chemical compound is reported as the amount of that compound relative to the amount of whatever material it is mixed with. For ease of approach, no matter what material the chemical is mixed with, concentrations can be reported as parts per million (ppm) or parts per billion (ppb). For solids, this represents weight of chemical to weight of solid (for example, soils). For air, units are parts of vapor or gas per parts of air by volume. For liquids, units are generally weight of chemical per volume of water.

In this report, levels of contaminants in ground water and surface water are generally reported in ppb, while levels in contaminated soils or source material are presented in ppm (1 ppm = 1,000 ppb). The overall importance of these various levels of contamination are discussed in the appropriate sections, and the public health and environmental impacts of these levels are presented in Section 8.

3.1.2 CHEMICAL PARAMETERS

The hazardous compounds analyzed for in this report are based on U.S. EPA's 40 CFR Part 116.4 Designation of Hazardous Substances. These substances are broken down into two main categories, organic compounds and inorganic compounds (metals). The organic compounds are further divided into volatile, extractable and PCB/Pesticide compounds as presented below.

Organic Compounds

These carbon based chemicals are all man made and are products or wastes from industrial processes. Because they are man made there should be no background concentrations of these materials in an undisturbed rural environment.

Total Volatile Organics

A total of 35 chemical compounds make up this group of hazardous substances. As the name indicates, these compounds are most easily released or volatize into the air from water or soil. These substances are typically associated with common solvents and cleaning fluids.

Volatile Compounds

- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- Trans-1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- Trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- 2-Chloroethylvinylether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-Pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethylbenzene
- Styrene
- Total Xylenes

Extractable Compounds

These chemicals are more accurately called acid/base-neutral extractable organics or semi-volatile organics. These are commonly referred to as extractable compounds. The name is derived from the required change in pH to either acid or base in order to purge the chemical from the water or soil. The acid extractable group consists of 10 phenolic compounds, with the base-neutral extractables making up the balance of the 68 compounds in this category. These compounds have a broad source from general industrial chemistry to petrochemicals and by-products.

Extractable Compounds

N-Nitrosodimethylamine
Phenol
Aniline
bis (2-Chloroethyl) Ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis (2-chloroisopropyl) Ether
4-Methylphenol
N-Nitroso-Di-n-Propylamine
Hexachloroethane
Nitrobenzene
Isophorene
2-Nitrophenol
2,4-Dimethylphenol
bis (2-Chloroethoxy) Methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Napthalene
4-Chloroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethyl Phthalate
4-Chlorophenyl-phenylether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-Methylphenol
N-Nitrosodiphylamine (1)
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-Butyl Phthalate
Fluoranthene
Benzidine
Pyrene
Butylbenzyl Phthalate
3,3-Dichlorobenzidine

Hexachlorobutadiene
4-Chloro-3-Methylphenol
2-Methylnapthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronapthalene
2-Nitroaniline
Dimethyl Phthalate
Acenaphthylene
3-Nitroaniline
Benzo (a) Anthracene
bis (2-Ethylhexyl) Phthalate
Chrysene
Di-n-Octyl Phthalate
Benzo (b) Fluoranthene
Benzo (k) Fluoranthene
Benzo (a) Pyrene
Indeno (1,2,3-cd) Pyrene
Dibenzo (a,h) Anthracene
Benzo (g,h,i) Perylene

PCB/Pesticides

PCBs (polychlorinated biphenyls) have been used as liquid coolants in transformers, as flame retardants, lubricants, machine tool cutting oils and hydraulic fluids. Some 210 different PCB molecules that are possible blends of these different compounds were marketed under the trade name "aroclor". Pesticides refer to chemicals used for general insect/rodent control (DDT) as well as herbicides, used for control of vegetation.

PCB/Pesticides

Alpha-BHC
Beta-BHC
Delta-BHC
Gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor Epoxide
Endosulfan I
Dieldrin
4,4-DDE
Endrin
Endosulfan II
4,4-DDD
Endrin Aldehyde
Endosulfan Sulfate
4,4-DDT
Methyloxychlor
Endrin Ketone
Chlordane
Toxaphene
Aroclor 1016
Aroclor 1221
Aroclor 1232
Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260

Inorganic Compounds

Many of these elements are naturally occuring in soils at various levels depending on soil type, depth and location. Five inorganics were chosen to establish background levels (those levels which occur naturally in the area). These five (arsenic, cadmium, chromium, lead and mercury) pose a potentially serious hazard to the flora and fauna of the area and can be used to indicate "clean-up" levels.

Inorganic Compounds

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Tin
Vanadium
Zinc
Cyanide (CN)
Ammonia (NH)
Sulfide

3.2 SITE WASTE COMPONENT CHARACTERISTICS

3.2.1 INTRODUCTION

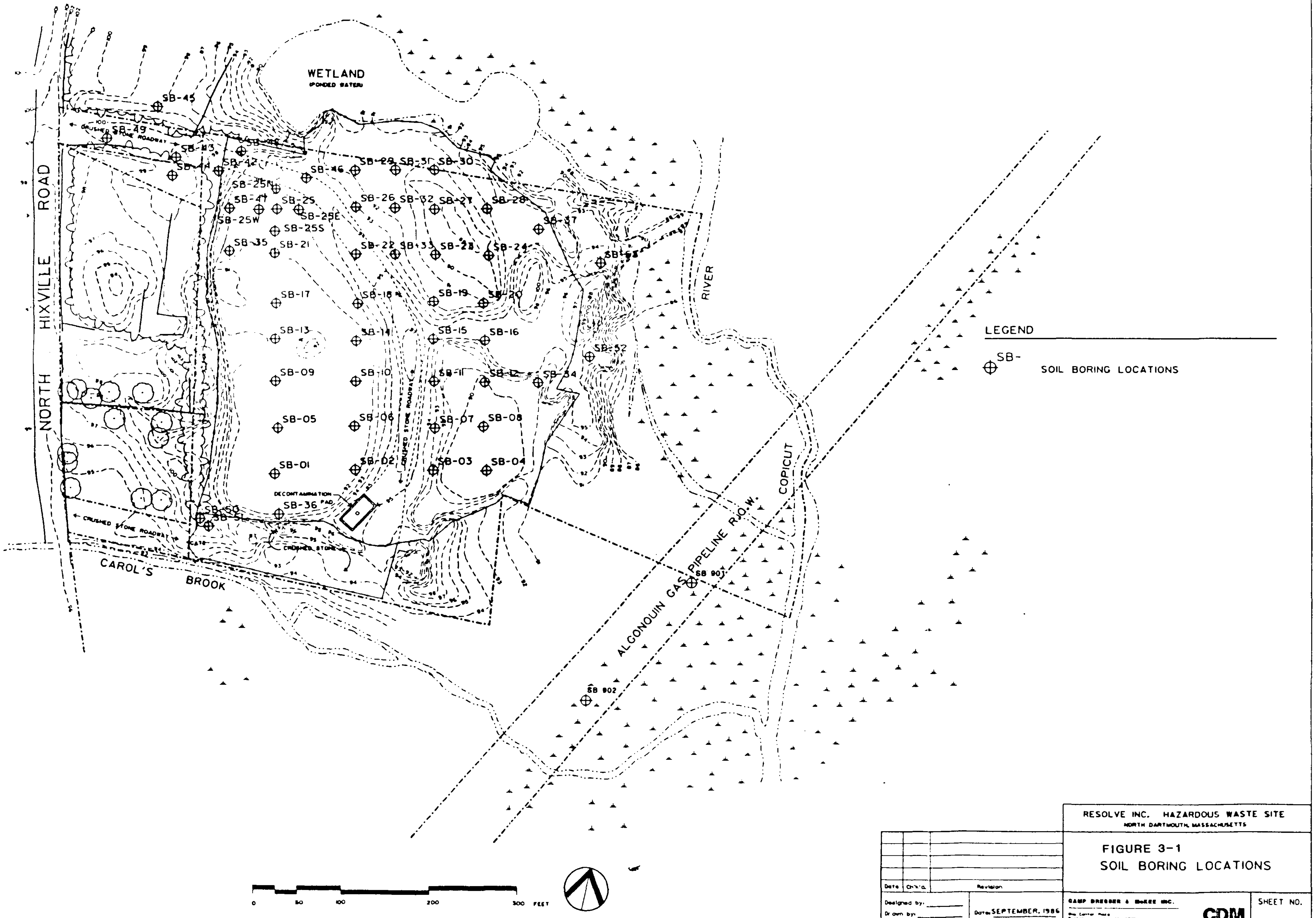
The purpose of this section is to outline the area-specific/media-specific investigation that was performed at the ReSolve Site, to define the nature of the contamination found on site, and to present the physical/chemical characteristics of this contaminated material.

Figure 1-3 in Section 1.3 locates those waste disposal and spill areas where soil was removed for offsite disposal, as a part of the source control remedial alternative initiated by the U.S. EPA. A total of approximately 15,000 cubic yards of PCB waste material and associated contaminated soil were removed. The purpose of that program was to determine the extent of residual PCB contamination including the surrounding soils and to remove these source areas.

PCB oils are generally insoluble in water and would typically be found floating on top of the groundwater, independent of the degree of PCB contamination. The results of the initial sampling program however, indicated that the PCB oils at the ReSolve Site had moved in the soil matrix to levels below even the seasonably low groundwater levels. This movement was most likely attributable to the PCB-contaminated oils solubilizing in the groundwater, caused by the high concentrations of organic solvents being land farmed onsite. The change in the physical/chemical nature of the oils resulting from the high degree of volatile organic contamination, caused the PCB migration to be much greater than would be expected in a PCB spill situation. Therefore, a more extensive onsite soil assessment program was initiated as a part of the ReSolve Site Remedial Investigation to determine the extent of the PCB and volatile organic contamination.

3.2.2 EXTENT OF CONTAMINATION

An extensive soil boring investigation was conducted including a total of 56 borings, of which 44 boreholes were on-site, and 12 were off-site, including 2 shallow boreholes on the gas pipeline ROW (SB901 and SB902). Fifty percent of the onsite boreholes extended to bedrock. Figure 3-1 presents the location of these boreholes. Each boring included continuous split-spoon sampling with samples (see Appendix A) being collected at approximately two foot intervals. These samples were then analyzed for PCB and volatile organic compounds. A summary of these data are presented in Table 3-1. Figure 3-2 indicates cross-sections of the site. These cross-sections are located in the Appendices (Figures A-1a through A-1f).



RESOLVE INC. HAZARDOUS WASTE SITE
NORTH DARTMOUTH, MASSACHUSETTS

FIGURE 3-1
SOIL BORING LOCATIONS

Date	Ch'k'd.	Revision

Designed by: ______
Drawn by: ______
Checked by: ______
Approved by: ______

Date: SEPTEMBER, 1986
Scale: AS SHOWN

CAMP DRESSER & McKEE INC.
One Center Plaza
Boston, Massachusetts [illegible]

CDM
environmental engineers, scientists, planners & management consultants

SHEET NO.

ARCHITECTURAL
STRUCTURAL
ELECTRICAL
INSTRUMENTATION
HVAC
PLUMBING
PROJECT ENGINEER
PROJECT MANAGER

TABLE 3-1
ON-SITE SOIL BORING ANALYTICAL RESULTS

CDM Sample No.	Sample Type	Location	Elevation Collected	Date Collected	Total PCB's	Total Volatiles
243-SB-01-001	Grab	SB-01	88	10/22/85	0.9	0.1
243-SB-01-013	Grab	SB-01	85	10/23/85	-	0.7
243-SB-01-081	Grab	SB-01	82.5-80.5	11/04/85	0.1	-
243-SB-01-082	Grab	SB-01	80.5-78.0	11/04/85	0.2	-
243-SB-01-083	Grab	SB-01	77.5-75.5	11/04/85	0.1	-
243-SB-01-084	Grab	SB-01	75-73	11/04/85	-	-
243-SB-01-085	Grab	SB-01	72.5-70.5	11/04/85	-	-
243-SB-02-002	Grab	SB-02	88	10/22/85	244.4	29,250.0
243-SB-02-014	Grab	SB-02	85	10/23/85	1.1	3.0
243-SB-02-086	Grab	SB-02	85-83	11/04/85	2.6	-
243-SB-02-087	Grab	SB-02	82.5-80.5	11/04/85	1.0	-
243-SB-02-088	Grab	SB-02	80-78	11/04/85	3.8	0.3
243-SB-02-089	Grab	SB-02	77.5-75.5	11/04/85	3.0	208.2
243-SB-02-090	Grab	SB-02	75-73	11/04/85	2.1	-
243-SB-02-091	Grab	SB-02	72.5-70.5	11/04/85	3.1	1.4
243-SB-02-092	Grab	SB-02	70-68	11/04/85	0.8	-
243-SB-03-003	Grab	SB-03	88	10/22/85	-	10.8
243-SB-03-015	Grab	SB-03	85	10/23/85	0.3	58.1
243-SB-03-102	Grab	SB-03	82.5-80.5	11/07/85	1.2	-
243-SB-03-103	Grab	SB-03	80-78	11/07/85	-	-
243-SB-03-104	Grab	SB-03	77.5-75.5	11/07/85	-	-
243-SB-04-004	Grab	SB-04	88	10/22/85	0.7	-
243-SB-04-005	Grab	SB-04	88	10/22/85	5.3	0.5
243-SB-04-016	Grab	SB-04	85	10/23/85	6.2	7.9
243-SB-04-152	Grab	SB-04	85-83	11/14/85	2.0	0.1
243-SB-04-153	Grab	SB-04	75-72.5	11/15/85	-	-
243-SB-04-154	Grab	SB-04	75-72.5	11/15/85	-	-
243-SB-05-006	Grab	SB-05	88	10/22/85	.6	1.0
243-SB-05-038	Grab	SB-05	85	10/24/85	20	0.2
243-SB-06-007	Grab	SB-06	88	10/22/85	10.8	-
243-SB-06-039	Grab	SB-06	85	10/24/85	64.6	0.2
243-SB-07-019	Grab	SB-07	85	10/24/85	0.3	0.1
243-SB-07-040	Grab	SB-07	85	10/24/85	0.7	21.2
243-SB-08-020	Grab	SB-07	85	10/24/85	1.8	0.1
243-SB-08-041	Grab	SB-07	85	10/28/85	0.3	2.8
243-SB-09-008	Grab	SB-09	88	10/22/85	63.0	-
243-SB-09-017	Grab	SB-09	85	10/23/85	2.2	0.5
243-SB-09-150	Grab	SB-09	85-83	11/14/85	17.5	-
243-SB-09-151	Grab	SB-09	70-68	11/14/85	0.8	-
243-SB-10-009	Grab	SB-10	88	10/22/85	3.2	-
243-SB-10-018	Grab	SB-10	85	10/23/85	1.1	1.1

TABLE 3-1 (Cont'd)
ON-SITE SOIL BORING ANALYTICAL RESULTS

CDM Sample No.	Sample Type	Location	Elevation Collected	Date Collected	Total PCB's	Total Volatiles
243-SB-10-148	Grab	SB-10	85-83	11/14/85	0.2	-
243-SB-10-149	Grab	SB-10	72.5-70.5	11/14/85	0.2	-
243-SB-11-010	Grab	SB-11	88	10/22/85	2.0	-
243-SB-11-042	Grab	SB-11	85	10/28/85	1.2	1.9
243-SB-11-105	Grab	SB-11	82.5-80.5	11/07/85	-	-
243-SB-11-108	Grab	SB-11	77.5-75.5	11/08/85	-	-
243-SB-11-109	Grab	SB-11	75-73	11/08/85	-	-
243-SB-11-110	Grab	SB-11	72.5-71.5	11/08/85	-	-
243-SB-12-011	Grab	SB-12	88	10/23/85	12.2	0.3
243-SB-12-012	Grab	SB-12	88	10/23/85	2.0	0.2
243-SB-12-043	Grab	SB-12	85	10/28/85	1.0	1.1
243-SB-12-112	Grab	SB-12	85-83	11/08/85	23.1	1.8
243-SB-12-113	Grab	SB-12	85-83	11/08/85	-	0.9
243-SB-12-116	Grab	SB-12	82.5-80.5	11/08/85	-	-
243-SB-12-119	Grab	SB-12	80-78	11/08/85	0.4	-
243-SB-12-120	Grab	SB-12	80-78	11/08/85	0.4	-
243-SB-12-123	Grab	SB-12	65-63.5	11/08/85	-	15.0
243-SB-13-021	Grab	SB-13	85	10/24/85	3.2	0.1
243-SB-13-044	Grab	SB-13	85	10/28/85	4.9	-
243-SB-14-022	Grab	SB-14	85	10/24/85	0.3	0.3
243-SB-14-045	Grab	SB-14	85	10/28/85	1.0	0.6
243-SB-15-046	Grab	SB-15	88	10/28/85	430.0	15.1
243-SB-15-047	Grab	SB-15	85	10/28/85	35.0	-
243-SB-16-048	Grab	SB-16	88	10/28/85	9.4	2.8
243-SB-16-049	Grab	SB-16	85	10/28/85	5.3	5.2
243-SB-17-023	Grab	SB-17	88	11/13/85	2,400.0	6.3
243-SB-17-050	Grab	SB-17	85	11/13/85	1,300.0	2.8
243-SB-17-144	Grab	SB-17	82.5-80.5	11/13/85	23.0	-
243-SB-17-145	Grab	SB-17	82.5-80.5	11/13/85	24.0	-
243-SB-17-146	Grab	SB-17	75-73	11/13/85	0.4	-
243-SB-17-147	Grab	SB-17	70-68	11/13/85	0.3	-
243-SB-18-024	Grab	SB-18	88	10/24/85	1.3	0.4
243-SB-18-051	Grab	SB-18	85	10/28/85	4.9	0.2
243-SB-18-127	Grab	SB-18	82.5-80.5	11/11/85	2.1	NA
243-SB-18-128	Grab	SB-18	80-78	11/11/85	0.5	10.0
243-SB-18-129	Grab	SB-18	75-73	11/11/85	15.9	10.2
243-SB-19-025	Grab	SB-19	88	10/24/85	0.5	312.1
243-SB-19-052	Grab	SB-19	85	10/28/85	6.3	70.8
243-SB-19-140	Grab	SB-19	85-83	11/13/85	-	-
243-SB-19-141	Grab	SB-19	75-73	11/13/85	0.1	-
243-SB-19-142	Grab	SB-19	65.5-63	11/13/85	0.3	-
243-SB-19-143	Grab	SB-19	65.5-63	11/13/85	0.2	-

TABLE 3-1 (Cont'd)
ON-SITE SOIL BORING ANALYTICAL RESULTS

CDM Sample No.	Sample Type	Location	Elevation Collected	Date Collected	Total PCB's	Total Volatiles
243-SB-20-026	Grab	SB-20	88	10/24/85	137.0	-
243-SB-20-027	Grab	SB-20	88	10/24/85	71.1	-
243-SB-20-053	Grab	SB-20	85	10/28/85	430.0	0.5
243-SB-20-124	Grab	SB-20	80-78	11/08/85	29.7	224.7
243-SB-20-137	Grab	SB-20	77-75	11/11/85	99.0	1.6
243-SB-20-125	Grab	SB-20	75-73	11/11/85	6.0	11.0
243-SB-20-126	Grab	SB-20	70-68	11/11/85	1.1	11.0
243-SB-21-028	Grab	SB-21	88	10/24/85	318.0	11.7
243-SB-21-054	Grab	SB-21	85	10/28/85	4,400.0	4.0
243-SB-21-055	Grab	SB-21	85	10/28/85	6,400.0	2.4
243-SB-22-056	Grab	SB-22	88	10/28/85	4.4	3.7
243-SB-22-057	Grab	SB-22	85	10/28/85	1.7	8.5
243-SB-23-029	Grab	SB-23	88	10/24/85	31.2	18.7
243-SB-23-058	Grab	SB-23	85	10/28/85	130.0	9.8
243-SB-24-030	Grab	SB-24	88	10/24/85	28.3	-
243-SB-24-059	Grab	SB-24	85	10/28/85	75.0	1.2
243-SB-25-031	Grab	SB-25	88	10/24/85	1,030.0	2.3
243-SB-25-060	Grab	SB-25	85	10/28/85	860.0	9.6
243-SB-25-061	Grab	SB-25	85	10/28/85	760.0	8.2
243-SB-25-093	Grab	SB-25	85-83	11/06/85	640.0	4.9
243-SB-25-094	Grab	SB-25	82.5-80.5	11/06/85	1,040.0	49.6
243-SB-25-095	Grab	SB-25	80-78	11/06/85	9,300.0	179.6
243-SB-25-096	Grab	SB-25	77.5-75.5	11/06/85	370.0	3.6
243-SB-25-097	Grab	SB-25	75-73	11/06/85	75.0	0.5
243-SB-25-098	Grab	SB-25	72.5-70.5	11/06/85	22.0	-
243-SB-25-099	Grab	SB-25	70-68	11/07/85	0.2	-
243-SB-25-100	Grab	SB-25	67.5-65.5	11/07/85	460.0	-
243-SB-25-101	Grab	SB-25	65-63	11/07/85	510.0	3.3
243-SB-25-161	Grab	SB-25N	89-87	01/09/86	520.0	0.4
243-SB-25-162	Grab	SB-25N	85-83	01/09/86	36,000.0	2,665.5
243-SB-25-163	Grab	SB-25N	83-81	01/09/86	14,700.0	2,072.1
243-SB-25-164	Grab	SB-25N	80-78	01/09/86	157.0	1.2
243-SB-25-165	Grab	SB-25N	75-73	01/09/86	810.0	182.3
243-SB-25-166	Grab	SB-25N	87-85	01/09/86	7,300.0	280.2
243-SB-25-167	Grab	SB-25W	90.5-88.5	01/09/86	3,800,0	1.6
243-SB-25-168	Grab	SB-25W	88.5-86.5	01/09/86	1,310.0	0.2
243-SB-25-169	Grab	SB-25W	86.5-84.5	01/09/86	1,620.0	0.9
243-SB-25-170	Grab	SB-25W	86.5-84.5	01/09/86	570.0	2.1
243-SB-25-171	Grab	SB-25W	84.5-82.5	01/09/86	10,000.0	1.2
243-SB-25-172	Grab	SB-25W	80.5-78.5	01/09/86	6,600.0	675.2
243-SB-25-173	Grab	SB-25W	78.5-76.5	01/09/86	10,000.0	1,012.7
243-SB-25-174	Grab	SB-25W	76.5-74.5	01/10/86	54.0	0.4
243-SB-25-175	Grab	SB-25SS	90.5-88.5	01/10/86	3,030.0	0.7
243-SB-25-176	Grab	SB-25SS	88.5-86.5	01/10/86	3,440.0	0.3
243-SB-25-177	Grab	SB-25SS	86.5-84.5	01/10/86	2,950.0	1.3
243-SB-25-178	Grab	SB-25SS	86.5-84.5	01/10/86	860.0	2.2

TABLE 3-1 (Cont'd)
ON-SITE SOIL BORING ANALYTICAL RESULTS

CDM Sample No.	Sample Type	Location	Elevation Collected	Date Collected	Total PCB's	Total Volatiles
243-SB-25-179	Grab	SB-25SS	84.5-82.5	01/10/86	1,280.0	1.7
243-SB-25-180	Grab	SB-25SS	82.5-80.5	01/10/86	385.0	1.1
243-SB-25-181	Grab	SB-25SS	80.5-78.5	01/10/86	540.0	0.6
243-SB-25-182	Grab	SB-25E	88.5-86.5	01/10/86	600.0	3.6
243-SB-25-183	Grab	SB-25E	86.5-84.5	01/10/86	1,090.0	3.8
243-SB-25-184	Grab	SB-25E	86.5-84.5	01/10/86	1,060.0	15.4
243-SB-25-185	Grab	SB-25E	84.5-82.5	01/10/86	700.0	21.8
243-SB-25-186	Grab	SB-25E	82.5-80.5	01/10/86	280.0	3.3
243-SB-25-187	Grab	SB-25E	80.5-78.5	01/10/86	310.0	8.1
243-SB-26-032	Grab	SB-26	88	10/24/85	-	0.1
243-SB-26-062	Grab	SB-26	85	10/28/85	0.3	4.9
243-SB-26-106	Grab	SB-26	85-83	11/07/85	18.7	0.3
243-SB-26-107	Grab	SB-26	80-78	11/07/85	2.1	-
243-SB-27-033	Grab	SB-27	88	10/24/85	15.5	0.2
243-SB-27-063	Grab	SB-27	85	10/28/85	7.0	0.3
243-SB-27-132	Grab	SB-27	82.5-80.5	11/11/85	-	24.7
243-SB-27-138	Grab	SB-27	72.5-70.5	11/12/85	-	-
243-SB-27-139	Grab	SB-27	70-68	11/13/85	6.1	-
243-SB-28-034	Grab	SB-28	88	10/24/85	33.6	2.0
243-SB-28-064	Grab	SB-28	85	10/28/85	2.9	0.1
243-SB-28-130	Grab	SB-28	80-78	11/11/85	8.7	12.1
243-SB-28-131	Grab	SB-28	72.5-70	11/11/85	-	NA
243-SB-29-035	Grab	SB-29	88	10/24/85	311.0	9.1
243-SB-29-036	Grab	SB-29	88	10/24/85	401.0	54.0
243-SB-29-065	Grab	SB-29	85	10/29/85	94.0	557.0
243-SB-29-111	Grab	SB-29	85-83	11/08/85	123.0	14.5
243-SB-29-114	Grab	SB-29	82.5-80.5	11/08/85	3.9	0.8
243-SB-29-115	Grab	SB-29	82.5-80.5	11/08/85	3.2	0.3
243-SB-29-117	Grab	SB-29	80-78	11/08/85	1.6	-
243-SB-29-118	Grab	SB-29	80-78	11/08/85	1.6	0.1
243-SB-29-121	Grab	SB-29	75-73	11/08/85	11.0	15.0
243-SB-29-136	Grab	SB-29	72.5-70.5	11/08/85	12.1	-
243-SB-29-122	Grab	SB-29	70-67	11/08/85	7.7	23.6
243-SB-30-037	Grab	SB-30	88	10/24/85	1,420.0	62.0
243-SB-30-066	Grab	SB-30	85	10/29/85	1,440.0	67.1
243-SB-30-067	Grab	SB-30	85	10/29/85	1,220.0	130.1
243-SB-30-133	Grab	SB-30	82.5-80.5	11/12/85	80.5	11.8
243-SB-30-134	Grab	SB-30	80-78	11/12/85	-	NA
243-SB-30-135	Grab	SB-30	75-73	11/19/85	-	10.0
243-SB-31-068	Grab	SB-31	88	10/29/85	252.0	132.6
243-SB-31-069	Grab	SB-31	85	10/29/85	1,280.0	1,125.3
243-SB-32-070	Grab	SB-32	88	10/29/85	720.0	24.9
243-SB-32-071	Grab	SB-32	85	10/29/85	24.0	23.9

TABLE 3-1 (Cont'd)
ON-SITE SOIL BORING ANALYTICAL RESULTS

CDM Sample No.	Sample Type	Location	Elevation Collected	Date Collected	Total PCB's	Total Volatiles
243-SB-33-072	Grab	SB-33	88	10/29/85	0.8	-
243-SB-33-073	Grab	SB-33	85	10/29/85	1.7	0.4
243-SB-34-074	Grab	SB-34	88	10/29/85	1.4	-
243-SB-34-075	Grab	SB-34	85	10/29/85	1.1	0.1
243-SB-34-155	Grab	SB-34	85-83	11/15/85	-	-
243-SB-34-156	Grab	SB-34	77.5-75	11/15/85	-	-
243-SB-34-157	Grab	SB-34	67.5-65	11/15/85	0.4	-
243-SB-34-158	Grab	SB-34	67.5-65	11/15/85	0.4	-
243-SB-35-076	Grab	SB-35	88	10/29/85	370.0	38.1
243-SB-35-077	Grab	SB-35	85	10/29/85	340.0	29.6
243-SB-36-078	Grab	SB-36	88	10/29/85	11.0	-
243-SB-36-079	Grab	SB-36	85	10/29/85	2.7	0.1
243-SB-36-080	Grab	SB-36	85	10/29/85	4.7	0.1
243-SB-37-188	Grab	SB-37	88.7-86.7	01/10/86	2.0	-
243-SB-37-189	Grab	SB-37	86.7-84.7	01/10/86	3.0	-
243-SB-37-190	Grab	SB-37	82.7-80.7	01/10/86	1.0	-
243-SB-37-191	Grab	SB-37	78.7-76.7	01/10/86	0.6	-
243-SB-37-192	Grab	SB-37	76.7-74.7	01/10/86	1.5	-
243-SB-37-193	Grab	SB-37	74.7-72.7	01/10/86	.5	-
243-SB-42-001	Grab	SB-42	98.5-96.5	03/03/86	5.9	-
243-SB-42-002	Grab	SB-42	94.5-92.5	03/03/86	1.6	-
243-SB-42-003	Grab	SB-42	92-90	03/03/86	1.2	-
243-SB-42-004	Grab	SB-42	89.5-87.5	03/03/86	.5	-
243-SB-42-005	Grab	SB-42	87-85	03/03/86	-	-
243-SB-42-006	Grab	SB-42	82-80	03/03/86	-	-
243-SB-42-007	Grab	SB-42	79.5-78.4	03/03/86	-	-
243-SB-43-008	Grab	SB-43	99.8-97.8	03/03/86	6.6	0.1
243-SB-43-009	Grab	SB-43	97.8-95.8	03/03/86	1.0	-
243-SB-43-010	Grab	SB-43	95.8-93.8	03/03/86	-	-
243-SB-43-011	Grab	SB-43	88.3-87.7	03/04/86	-	-
243-SB-44-013	Grab	SB-44	98.2-96.2	03/04/86	0.3	-
243-SB-44-014	Grab	SB-44	91.7-90.7	03/04/86	-	-
243-SB-45-015	Grab	SB-45	99-97.5	03/04/86	0.3	-
243-SB-46-017	Grab	SB-46	93.2-91.2	03/05/86	7.3	0.2
243-SB-46-019	Grab	SB-46	89.2-87.2	03/05/86	0.4	0.3
243-SB-46-020	Grab	SB-46	89.2-87.2	03/05/86	0.3	0.7
243-SB-46-021	Grab	SB-46	83.7-81.7	03/05/86	-	0.2
243-SB-46-022	Grab	SB-46	79.2-77.2	03/05/86	-	0.1
243-SB-46-023	Grab	SB-46	76.7-75.8	03/05/86	0.6	-

TABLE 3-1 (Cont'd)
ON-SITE SOIL BORING ANALYTICAL RESULTS

CDM Sample No.	Sample Type	Location	Elevation Collected	Date Collected	Total PCB's	Total Volatiles
243-SB-47-024	Grab	SB-47	93.5-91.5	03/05/86	86.0	-
243-SB-47-025	Grab	SB-47	91-89	03/05/86	28.0	-
243-SB-47-026	Grab	SB-47	91-89	03/05/86	12.1	-
243-SB-47-027	Grab	SB-47	88.5-86.5	03/05/86	0.6	-
243-SB-47-028	Grab	SB-47	86-84	03/05/86	0.6	-
243-SB-47-029	Grab	SB-47	78.5-76.5	03/05/86	-	-
243-SB-48-031	Grab	SB-48	95.1-93.1	03/05/86	0.7	-
243-SB-48-032	Grab	SB-48	92.1-90.1	03/05/86	0.6	-
243-SB-48-033	Grab	SB-48	92.1-90.1	03/05/86	0.7	-
243-SB-48-036	Grab	SB-48	79.6-77.6	03/06/86	0.1	-
243-SB-48-037	Grab	SB-48	74.6-72.6	03/06/86	0.6	-
243-SB-49-039	Grab	SB-49	100.6-98.6	03/06/86	157.0	-
243-SB-49-040	Grab	SB-49	98.6-96.6	03/06/86	1.4	-
243-SB-50-041	Grab	SB-50	99-97	03/06/86	1.6	-
243-SB-52-042	Grab	SB-52	94.8-92.8	03/06/86	97.0	-
243-SB-52-043	Grab	SB-52	89.8-87.8	03/06/86	3.9	-
243-SB-52-044	Grab	SB-52	87.3-85.3	03/06/86	0.6	0.4
243-SB-52-045	Grab	SB-52	82.3-80.3	03/06/86	0.4	0.1
243-SB-52-046	Grab	SB-52	72.3-70.3	03/06/86	-	-
243-SB-53-047	Grab	SB-53	92-90	03/06/86	2.8	-
243-SB-53-048	Grab	SB-53	92-90	03/06/86	2.6	-
243-SB-53-049	Grab	SB-53	87.5-85.5	03/06/86	-	-
243-SB-53-050	Grab	SB-53	85-83	03/06/86	-	-
243-SB-53-051	Grab	SB-53	82.5-80.5	03/06/86	-	0.4
243-SB-53-053	Grab	SB-53	70-69.2	03/07/86	-	1.2
243-SB-54-055	Grab	SB-54	95-93	03/07/86	-	-
243-SB-54-056	Grab	SB-54	93-91	03/07/86	-	0.2
243-SB-54-057	Grab	SB-54	91-89	03/07/86	-	-
243-SB-54-058	Grab	SB-54	87-85	03/07/86	-	-
243-SB-54-059	Grab	SB-54	87-85	03/07/86	-	-
243-SB-54-060	Grab	SB-54	85-83	03/07/86	-	-
243-SB-901-159	Grab	SB-901	0.5′ Depth	11/15/85	670	-
243-SB-902-160	Grab	SB-902	0.5′ Depth	11/15/85	-	49

\- - No Contaminants Found
NA - Not Analyzed

Total PCB's and Total Volatiles are expressed in parts per million (ppm).

NOTE: The first two depths at each location were obtained with a hand auger and represent soil from an interval .25′ above the listed elevation to .25′ below. Deeper borings were obtained using a drill rig and the elevation is indicated.

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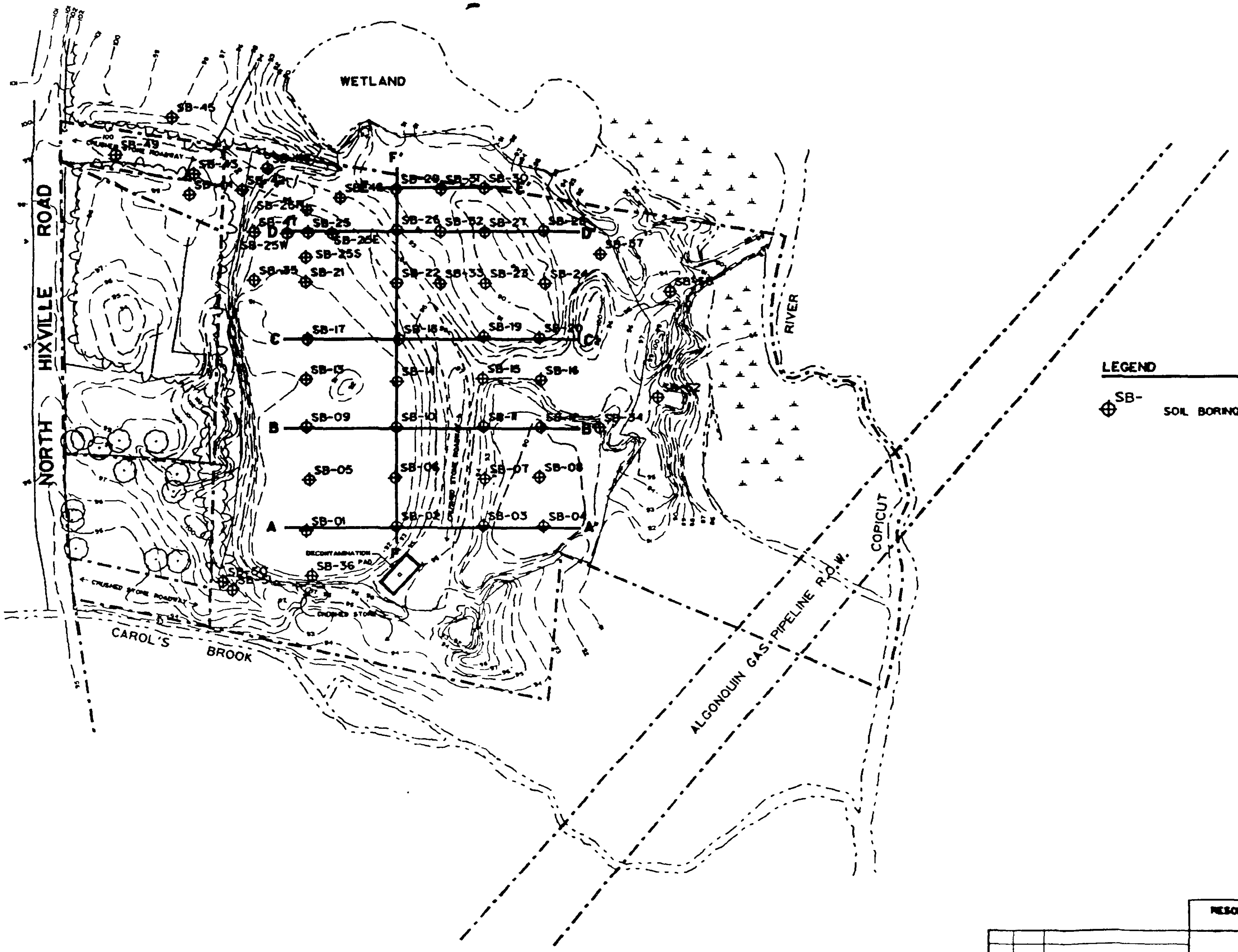

LEGEND

⊕ SB- SOIL BORING LOCATIONS

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FIGURE 3-2

CROSS SECTION LINES

Date	Chk'd.	Revision

Designed by: ______
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Total Volatile Organics

As presented in Table 3-1, soil samples collected during the boring program were analyzed for total volatile organics (TVO). The analyses show that, depending on depth and the location of the sample, the contamination ranged from lows of 1-100 ppb to highs of 10-1,000 ppm. For presentation purposes, levels greater than 50 ppm and greater than 10 ppm of TVO in soil were selected as concentrations that would represent areas of contamination. Figure 3-3 and 3-4 illustrate these data by delineating areas of significant contamination at various depths. These areas are not intended to represent the limits of contamination, but the location of possible source areas. There is a total of approximately 31,000 cubic yards of soils contaminated with TVO greater than 10 ppm, 20,000 of that being saturated and 11,000 being unsaturated, assuming a groundwater elevation of 88 feet. The areal extent of contamination would have been influenced by previous onsite excavation activities and rainfall infiltration, therefore the source areas would contribute to groundwater contamination as presented in Section 4.0.

PCB

Data representing the extent of PCB contamination greater than 50 ppm and greater than 10 ppm are presented on Figures 3-5 and 3-6. The data represent a similar pattern to that shown on Figures 3-3 and 3-4 for the total volatile organic compounds, indicating several distinct source areas. The figures show that, in relative terms, the PCB contamination is located in the same source areas as the TVO contamination and is generally more wide spread than the TVO contamination. Approximately 53,000 cubic yards (cy) of soil is contaminated with PCBs greater than 10 ppm, 31,000 cy being saturated and 22,000 being unsaturated.

As presented earlier, the TVO contamination was limited in its areal extent of contamination. PCBs are relatively insoluble in water and adsorb readily to soil particles. However, due to the high TVO contamination found in on-site soils and observation wells, the PCB solubility and therefore the mobility may be enhanced (U.S. EPA, 1980) explaining the PCB contamination found in observation well OW-SB-25S and the F cluster which is discussed further in Section 4.4.4.

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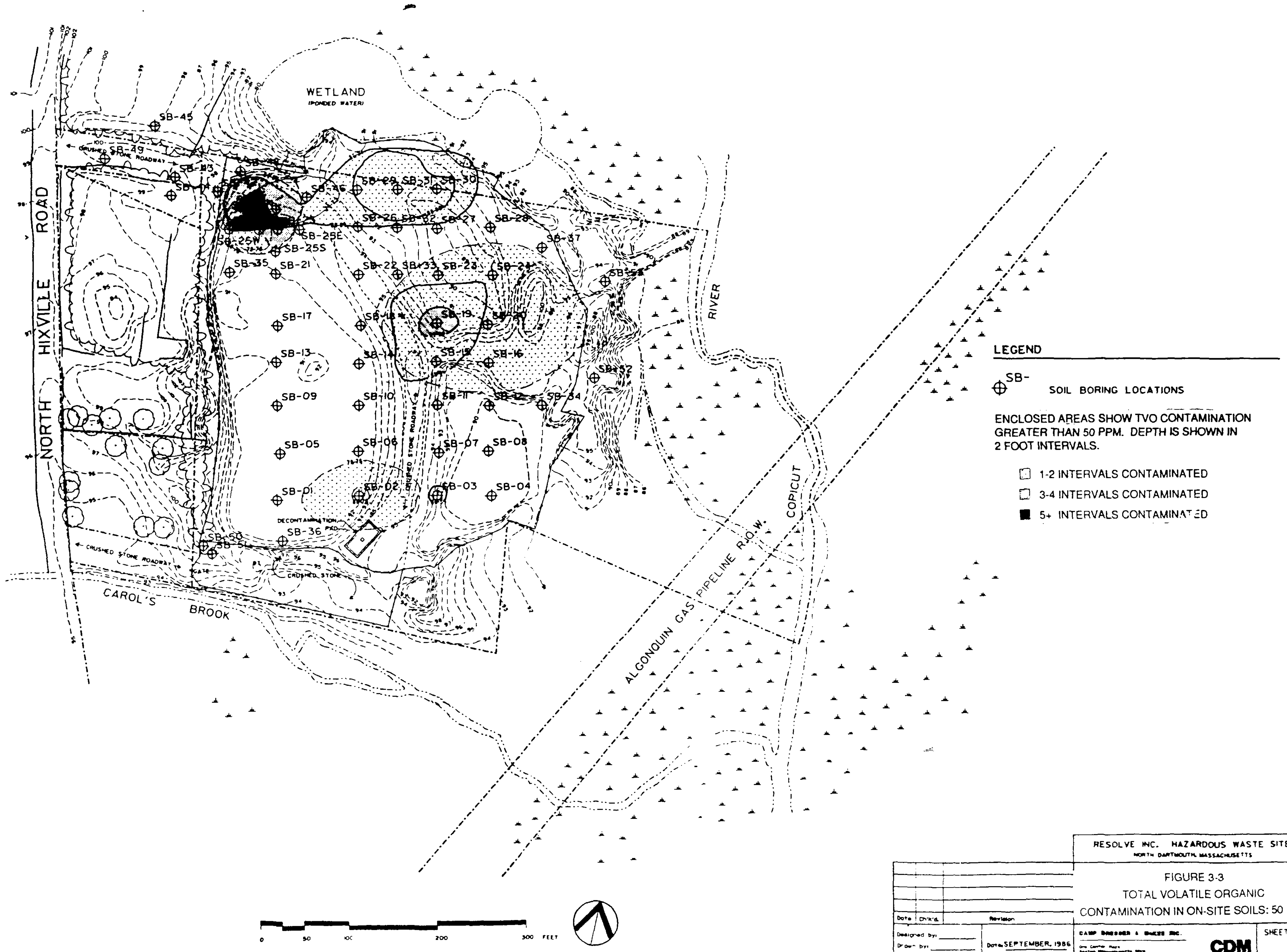

LEGEND

⊕SB- SOIL BORING LOCATIONS

ENCLOSED AREAS SHOW TVO CONTAMINATION GREATER THAN 50 PPM. DEPTH IS SHOWN IN 2 FOOT INTERVALS.

- ☐ 1-2 INTERVALS CONTAMINATED
- ▨ 3-4 INTERVALS CONTAMINATED
- ■ 5+ INTERVALS CONTAMINATED

RESOLVE INC. HAZARDOUS WASTE SITE
NORTH DARTMOUTH, MASSACHUSETTS

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FIGURE 3-3
TOTAL VOLATILE ORGANIC
CONTAMINATION IN ON-SITE SOILS: 50 PPM

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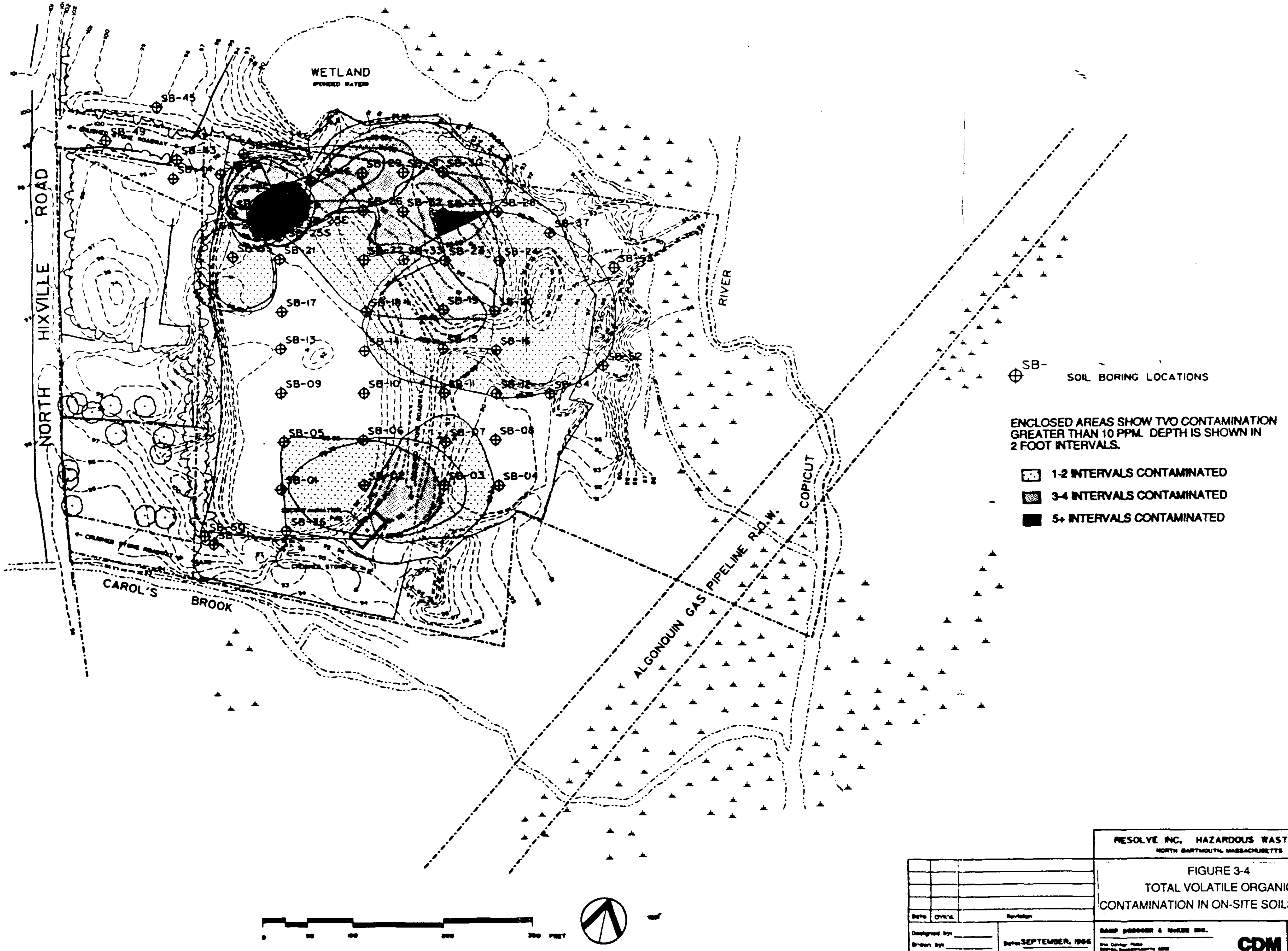

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FIGURE 3-4
TOTAL VOLATILE ORGANIC
CONTAMINATION IN ON-SITE SOILS: 10 PPM

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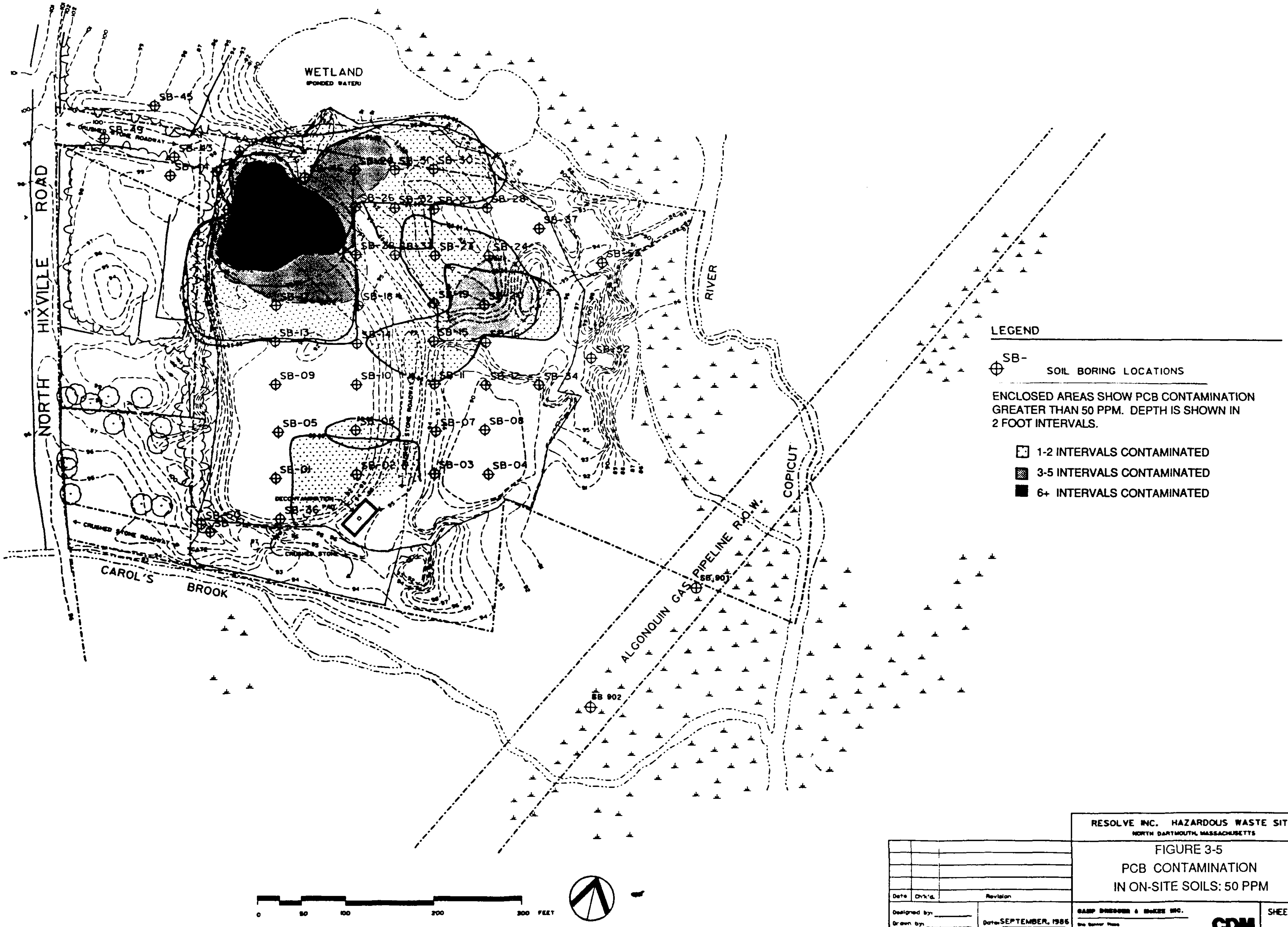

LEGEND

⊕ SB- SOIL BORING LOCATIONS

ENCLOSED AREAS SHOW PCB CONTAMINATION GREATER THAN 50 PPM. DEPTH IS SHOWN IN 2 FOOT INTERVALS.

- ⬚ 1-2 INTERVALS CONTAMINATED
- ▨ 3-5 INTERVALS CONTAMINATED
- ■ 6+ INTERVALS CONTAMINATED

RESOLVE INC. HAZARDOUS WASTE SITE
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FIGURE 3-5
PCB CONTAMINATION
IN ON-SITE SOILS: 50 PPM

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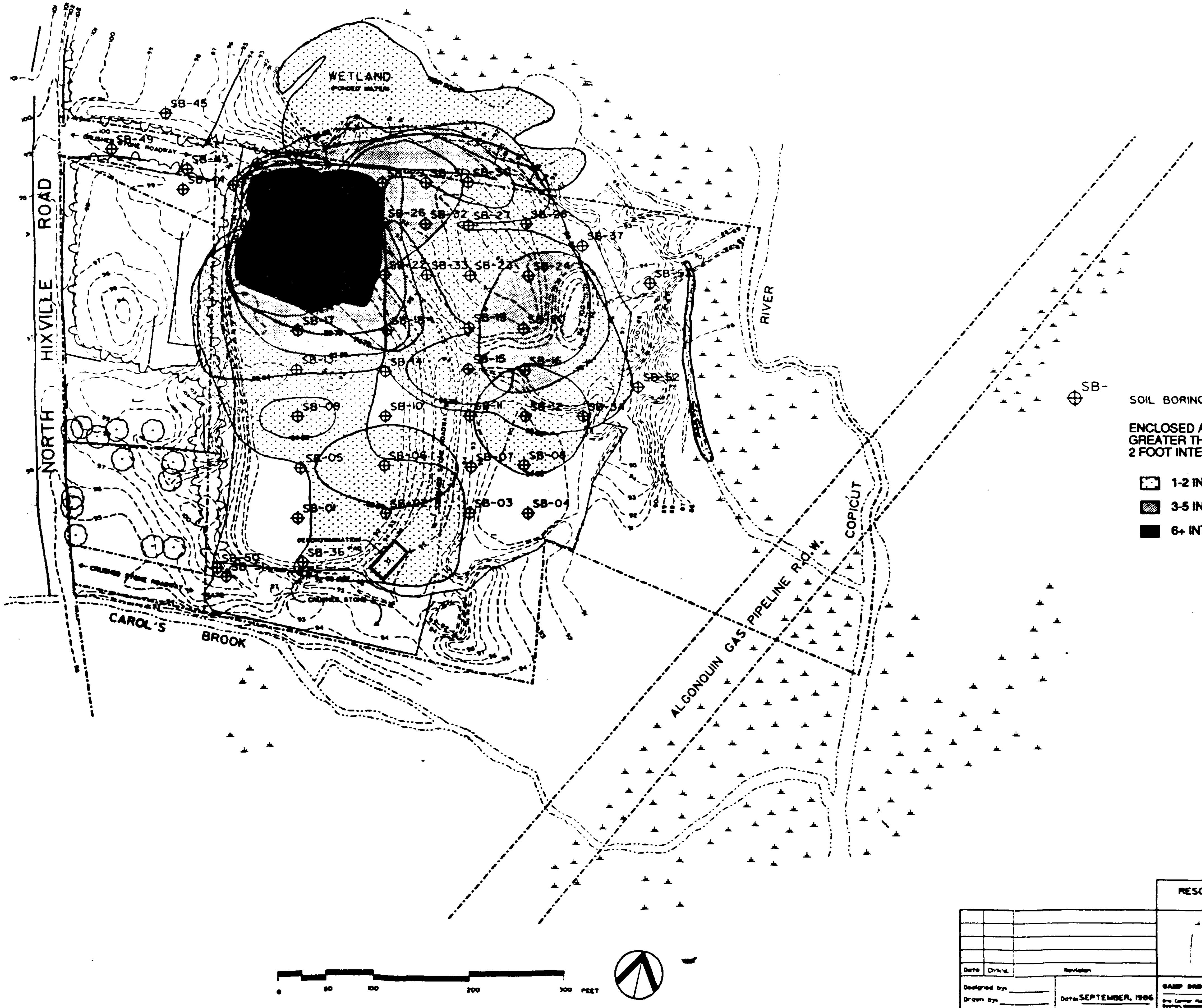

⊕ SB- SOIL BORING LOCATIONS

ENCLOSED AREAS SHOW PCB CONTAMINATION GREATER THAN 10 PPM. DEPTH IS SHOWN IN 2 FOOT INTERVALS.

⬚	1-2 INTERVALS CONTAMINATED
▨	3-5 INTERVALS CONTAMINATED
■	6+ INTERVALS CONTAMINATED

RESOLVE INC. HAZARDOUS WASTE SITE
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FIGURE 3-6
PCB CONTAMINATION
IN ON-SITE SOILS: 10 PPM

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Data Summary

Analysis of the soil boring program on the ReSolve Site indicated the existance of four distinctive source areas or hot spots where significant levels of soil contamination were found. These areas were similar for both the total volatile organics and PCBs as illustrated on Figures 3-3 through 3-6. These areas are identified as follows:

- Former Lagoon Area
- Oil Spreading Area
- Cooling Pond Area
- Smaller Localized Areas

A primary area of concern is located in the northwest quadrant surrounding observation well SB-25. A review of the past site history at this location reveal this area was the site of the waste oil spreading operation.

The soil boring results (listed in Appendix A and Table 3-1) indicate high levels of total volatile organic contamination (2,666 ppm in SB-25N). In addition, PCB levels in the 500 ppm range penetrating through the overburden down twenty feet to bedrock were found in SB-25N. It is unusual for PCB compounds to be highly mobile due to low solubility of the PCB constituent in water.

The migration of PCB compounds in groundwater at the ReSolve Site is dramatically increased due to the presence of various organic solvents such as hexane, carbon tetrachloride, benzene, methylene chloride and acetone. PCB compounds form complexes and dissolve in these compounds which increases the mobility of PCB in groundwater. Carbon tetrachloride and methylene chloride have greater specific gravities than water. PCBs dissolved in these compounds could migrate downward in the aquifer. In addition, long term surface loading of waste oils at a high rate caused extensive mounding of these contaminants and subsequent downward migration to lower sections of the overburden aquifer.

The second locality of high soil contamination is the former site of the waste lagoons situated in the northern section of the site. An analysis of the soil borings at the SB-30S location shows high levels of the following volatile organics:

- Methylene Chloride
- 2-Butanone (MEK)
- Trans-1,2-Dichloroethene
- Trichloroethene
- 4-Methyl 2-Pentanone
- Tetrachloroethene
- Toluene

The concentration and depths of penetration of these contaminants demonstrates that this area is also a substantial source of groundwater contamination.

The third area of concern is the location northwest of the F well cluster and south of observation well SB-27D, which is the location of the former cooling pond. The numerous soil borings at this locale show significant concentrations of various organics, particularly acetone and 2-butanone (MEK).

The fourth region of high soil contamination is situated west of observation well SB-04 at soil boring SB-02. The soil boring data exhibit high levels of acetone, methylene chloride, 2-butanone (MEK), trichloroethene, 4-methyl-2-pentanone, and tetrachloroethene.

The four contaminated soil areas mentioned are significantly impacting the quality of downgradient groundwater. The contaminants found in the groundwater in downgradient wells, such as the "F" cluster (shown on Figure 4-1 in Section 4.0), are of similar chemical composition and relative concentrations as contaminants adhered to soils in upgradient soil borings.

When analyzing the relationship between soil and groundwater contamination many factors must be taken into account. For example, microbiological activity can transform the chemical composition of the leachate derived from the soil. According to Parson _et al_. (1984) tetrachloroethene and trichloroethene can be biodegraded to trans-1,2-dichloroethene in the subsoil environment. The chemical and physical reactions between contaminants must also be considered. The water solubility of PCB being augmented by high volatile organic levels at depth at OW-SB-25S illustrates this.

In the low drainage areas on the pipeline right-of-way, the samples SB-901 and SB-902 were collected from the top 0.5 foot depth of surface soil. This confirms the presence of contamination in this seasonally inundated off-site area.

Section 4

4.0 HYDROGEOLOGIC INVESTIGATION

4.1 INTRODUCTION

Two previous studies have been performed by Camp Dresser & McKee at this site as described in Section 1.0. The first investigation was a on-site RI/FS which was completed on June 30, 1983, and the second was the off-site investigation completed in February of 1985.

4.1.1 REGIONAL GEOLOGY

The dominant topographic feature of the study area is the Copicut River Valley. This valley was formed by glacial action which scoured and eroded the underlying bedrock. With retreat of the glacier, ablation till was deposited on the bedrock surface in an irregular manner causing variable till thickness. Meltwaters from the somewhat stagnant and down-wasting glacier flowed down the valley depositing outwash sands and gravels on the till. The outwash is in the form of a valley train which, simply stated, is an outwash deposit in the Copicut River Valley. Associated with the valley train are small, local ice contact kames such as in the vicinity of alluvium and organic materials where wetlands and swamps have formed. During installation of monitoring wells sand, silt and gravel was encountered overlying the glacial till and/or bedrock. At some locations the stratified drift deposit is coarse grained, indicating the high carrying power of the meltwater streams. Cobbles and boulders were found in the outwash deposits generally in the lower strata and at the easterly part of the site.

The sand and gravel including the sand and silt stratum, are interpreted as being ice contact materials. Hydraulic conductivity in the outwash is relatively high. With sufficient hydraulic gradients, this sand and gravel formation is capable of relatively high rates of groundwater and contaminant transport.

Bedrock over the study area consists of granite to granite gneiss. These intrusive rocks are part of the Fall River Pluton and are locally known as the Bulgarmarsh granite. Across the study area bedrock exhibits a wide range of the extent of fracturing, and the corresponding water yield from bedrock observation wells range from low to relatively high at different locations in the formation.

4.1.2 HISTORICAL CONTAMINANT LEVELS AND MOVEMENT

Historically groundwater movement in the general area of the site has been towards the Copicut River as indicated by 1983 and 1985 reports by Camp, Dresser & McKee as referenced previously. East of the site, the unnamed tributary and the Copicut River intercept a major portion of the groundwater flow that passes through or originates on the site. The sampling results in 1984 showed increased levels of volatile organics in seven of the eleven monitoring wells over the 1983 levels. One well showed little change and lowered levels were reported for three wells. Observing the same eleven observation wells in 1985, eight indicated decreases in concentration, one increased, and two showed little change from 1984 levels. Historical groundwater contaminant plume migration is discussed in Section 4.4.4 and presented in Table 4-6. These high contaminant levels in observation wells indicate the persistence of high contaminant concentrations in the groundwater, and to a limited extent the dispersion and dilution processes occurring in the highly contaminated aquifer in the near vicinity of the site.

4.2 FIELD INVESTIGATION

4.2.1 OBJECTIVES AND SCOPE

A hydrogeologic investigation was conducted to determine the present and potential future extent of groundwater contamination and to evaluate site conditions relative to the implementation of specific remedial alternatives. The program was developed based on the results of previous hydrogeologic studies conducted at the site and other existing data. Data collected during the survey included groundwater and surface water

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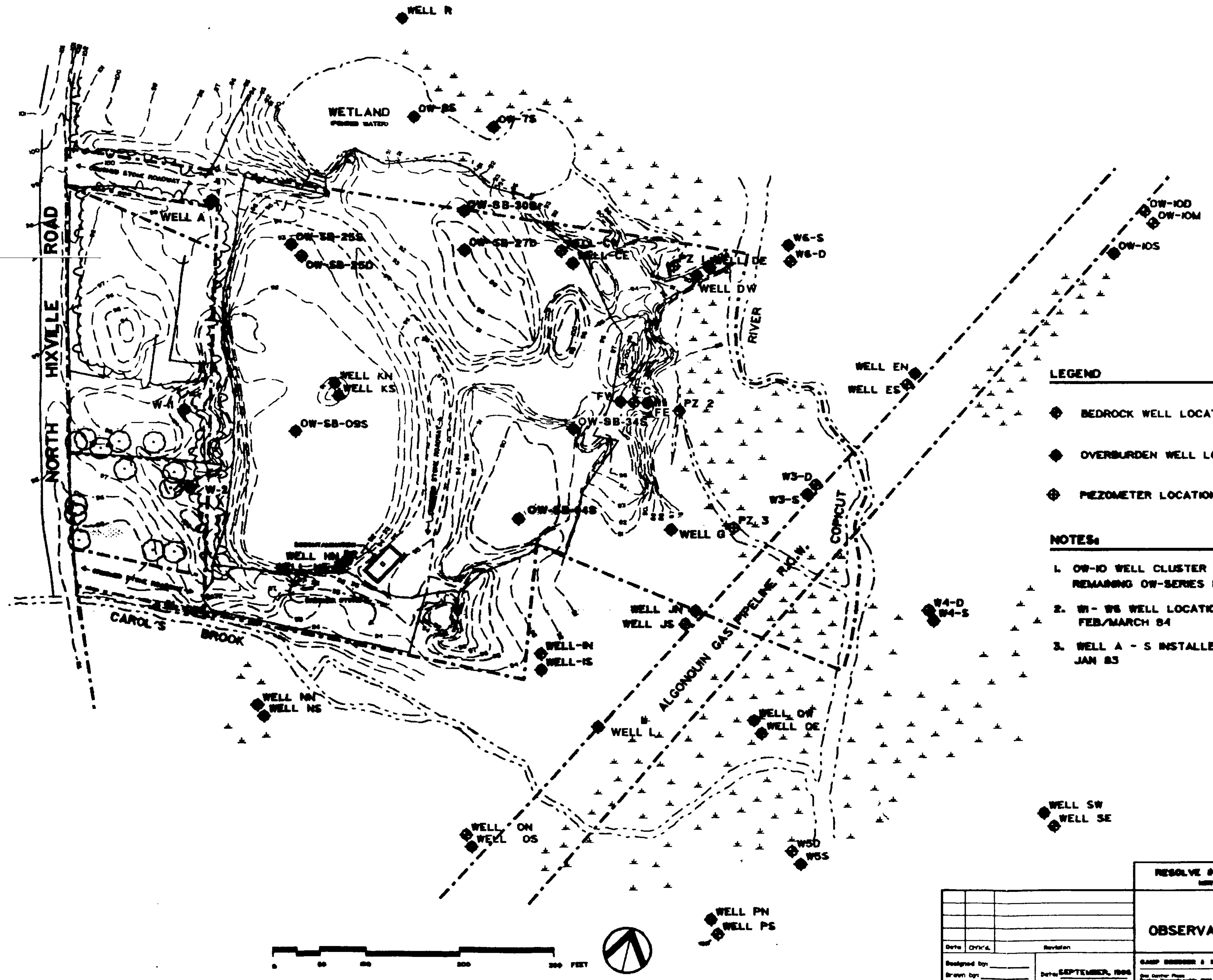
INSTRUMENTATION Approved by Date
HVAC Approved by Date
PLUMBING Approved by Date
PROJECT ENGINEER Approved by Date
PROJECT MANAGER Approved by Date



LEGEND

◈ BEDROCK WELL LOCATION

◆ OVERBURDEN WELL LOCATION

⊕ PIEZOMETER LOCATION (INSTALLED AUG. 86)

NOTES:

1. OW-10 WELL CLUSTER INSTALLED MARCH 86
   REMAINING OW-SERIES INSTALLED NOV/DEC 85
2. W1 - W6 WELL LOCATIONS INSTALLED
   FEB/MARCH 84
3. WELL A - S INSTALLED NOV/DEC 82 AND
   JAN 83

Date	Chk'd.	Revision

Designed by: ______
Drawn by: ______
Checked by: ______
Approved by: ______

Date: SEPTEMBER, 1986
Scale: AS SHOWN

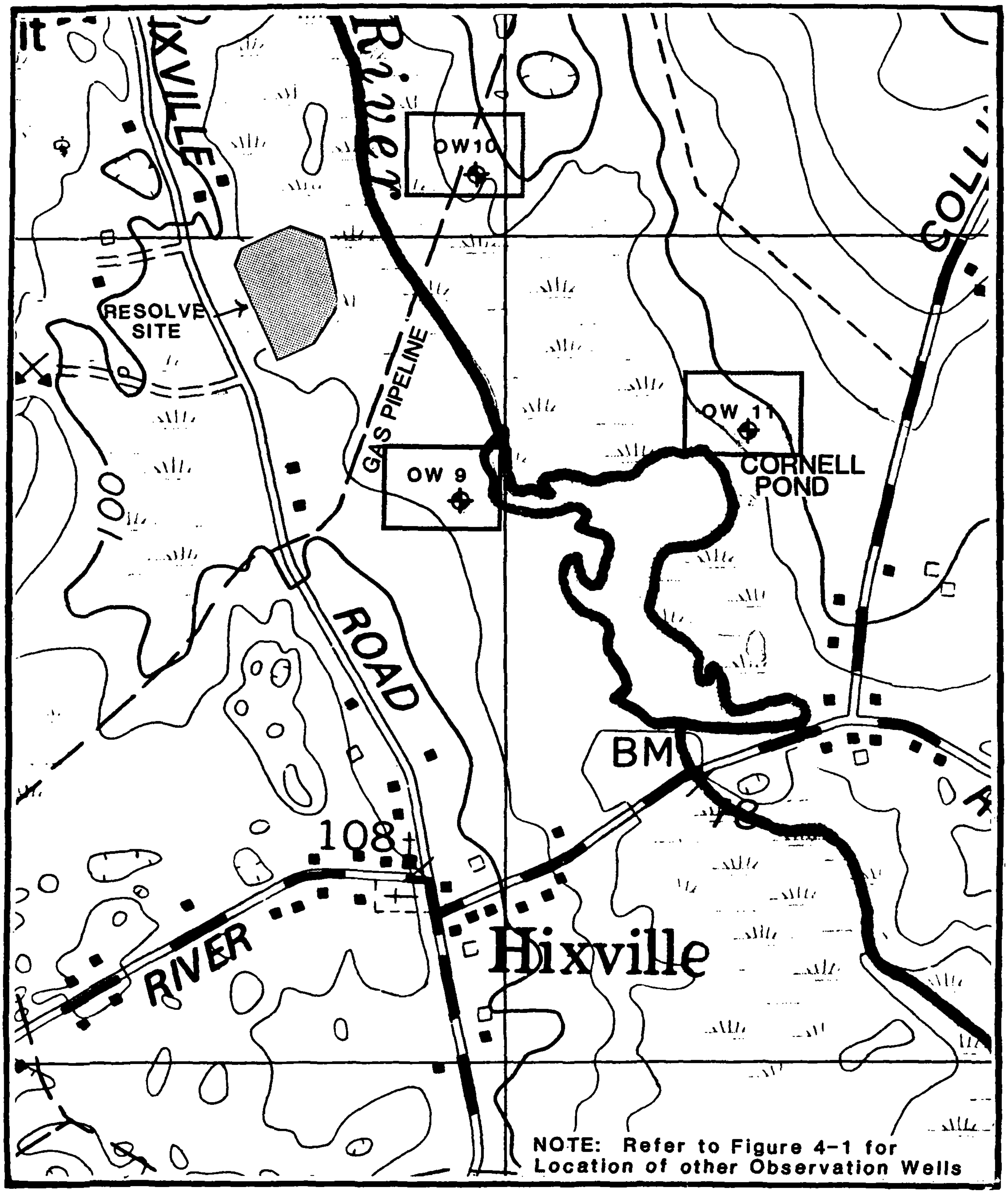
RESOLVE INC. HAZARDOUS WASTE SITE
NORTH DARTMOUTH, MASSACHUSETTS

FIGURE 4-1
OBSERVATION WELL LOCATIONS

CAMP DRESSER & McKEE INC.
One Center Plaza
Boston, Massachusetts [illegible]

CDM
environmental engineers, scientists, planners & management consultants

SHEET NO.



NOTE: Refer to Figure 4-1 for Location of other Observation Wells

FIGURE 4-2

LOCATION OF OBSERVATION WELLS OW-9,10,11 ⌖

TABLE 4-1

OBSERVATION WELL INSTALLATION INFORMATION

Overburden Monitoring Well	Ground Elevation (ft)	Depth of Well (ft)	Depth of Well Screen	Top of Screen Elevation (ft)	Bedrock Monitoring Well	Ground Elevation (ft)	Depth of Well (ft)	Depth of Well Screen	Top of Screen Elevation (ft)	Bedrock Surface (ft)	Remark
A	98.6	21	16–21	82.6							1.5" PVC
B Center	—	—	—	—							REMOVED 1984
					B West	—	—	—	—	—	REMOVED 1984
B East	—	—	—	—							REMOVED 1984
C West	92.1	12	7–12	85.1							1.5" PVC
					C East	92.1	27	22–27	70.1	24	1.5" PVC
D East	89.8	15	10–15	79.8							1.5" PVC
D West	89.4	4.5	2.5–4.5	86.9							1.5" PVC
E North	90.5	10	5–10	85.5							1.5" PVC
					E South	90.5	26	24–26	66.5	21	1.5" PVC
F East	94.6	18	13–18	81.6							1.5" PVC
					F Center	94.6	39	37–39	57.5	34.5	1.5" PVC
F West	94.5	12	7–12	87.5							1.5" PVC
G	90.3	11	6–11	84.3							1.5" PVC
H North	95.2	23.5	18.5–23.5	76.7							1.5" PVC
H South	95.2	10	5–10	90.2							1.5" PVC
I South	95.2	17	12–17	80.2							1.5" PVC
					I North	92.2	31.5	29.5–31.5	52.7	27.5	1.5" PVC
J North	86.2	7	5–7	81.2							1.5" PVC
					J South	86.2	18	13–18	73.2	12	1.5" PVC
K North	92.6	18	13.8	79.6							1.5" PVC
K South	93	8.5	3.5–8.5	89.5							1.5" PVC
L	87.8	15	10–15	77.8							1.5" PVC
M	—	—	—	—	—						REMOVED 1984
N South	90	10	5–10	85							1.5" PVC
					N North	90.43	31	29–31	61.4		1.5" PVC
O North	88	7	2–7	86							1.5" PVC
					O South	88.8	15	13–15	75	11	1.5" PVC
P North	87.2	15	10–15	77.2							1.5" PVC
					P South	89.2	25	23–25	66.2	21.5	1.5" PVC
Q West	85.6	15	10–15	75.6							1.5" PVC
					Q East	85.6	28.5	23.5–28.5	61.2	24	1.5" PVC
R	91	17	12–17	79							1.5" PVC
S West	89.5	14	9–14	80.5							1.5" PVC
					S East	89.5	23.5	21.5–23.5	68.0	19.5	1.5" PVC
W1	100.5	21.3	11.3–21.3	98.2							2" PVC

TABLE 4-1 (Cont'd)

OBSERVATION WELL INSTALLATION INFORMATION

Overburden Monitoring Well	Ground Elevation (ft)	Depth of Well (ft)	Depth of Well Screen	Top of Screen Elevation (ft)	Bedrock Monitoring Well	Ground Elevation (ft)	Depth of Well (ft)	Depth of Well Screen	Top of Screen Elevation (ft)	Bedrock Surface (ft)	Remark
W2	101.4	17.6	7.6–17.6	93.8							2" PVC
W3S	86	18	8–18	78							2" PVC
					W3-D	86	43	33–43	53	23	2" PVC
W4-S	86.8	20	10–20	76.6							2" PVC
					W4-D	86.8	49	39–49	47.8		2" PVC
W5-S	85.5	17.2	7.2–17.2	78.3							
					W5-D	85.5	47	37–47	48.5	22	2" PVC
W6-S	87.5	13	8–13	79.5							2" PVC
					W6-D	87.5	35	25–35	62.5	15	2" PVC
OW-7S	89.2	12	7–12	92.2							1.5" PVC
OW-8S	89	11.5	6.5–11.5	82.5							1.5" PVC
OW-9S	91.3	16.5	6.5–16.5	84.5							1.5" PVC
					OW-9M	91.2	556	24–55	67.2	17	6" OPEN BOREHOLE
					OW-9D	91.2	122	68–122	33.2	18.5	6" OPEN BOREHOLE
OWO-10S	89.1	21	11–21	78.1							2" PVC
					OW-10M	94.6	63.5	28–63.5	66.6	23	6" OPEN BOREHOLE
					OW-10D	95.5	143	60–143	35.5	23	6" OPEN BOREHOLE
OW-11S	89.6	9	4–9	85.6							2" PVC
					OW-11M	90.2	53	20=53	70.2	13	6" OPEN BOREHOLE
					OW-11D	90.2	302	58.3–202	31.9	13	6" OPEN BOREHOLE
OW-SB-4S	89.1	15	5–15	84.1							1.5" PVC
OW-SB-9S	91.1	22	12–22	79.1							1.5" PVC
OW-SB-34S	91.1	25	15–25	76.1							1.5" PVC
OW-SB-25S	93	27.5	17.5–27.5	75.5							1.5" PVC
					OW-SB-25D	93	38	31–36	62	28	1.5" PVC
OW-SB-30S	91.1	19.6	9.6–19.6	81.5							1.5" PVC
					OW-SB-27D	89.1	28	23–28	66.1	21	1.5" PVC
PZ-1	88.3	6.5	3.5–6.5	84.8							1.25" STEEL
PZ-2	87.3	6.5	3.5–6.5	83.8							1.25" STEEL
PZ-3	86.8	6.5	3.5–6.5	83.3							1.25" STEEL

TABLE 4-2A

OBSERVATION WELL GROUNDWATER ELEVATIONS
OVERBURDEN WELLS

Well Location	Reference Point TOC	Reference Point PVC	11/18/85 to 11/26/85	11/26/85	12/13/85	12/23/85	4/15/86	4/16/86	7/16/86	8/1/84	8/4/86
A	100.16		91.40	91.35	—	90.43	90.38	—	90.31		
CW	93.04		87.36	—	87.26	86.17	87.44	87.55	87.74		87.39
DE	90.55	90.26	87.05	87.10	87.10	87.01	86.26	—	87.93		
DW	90.17	—	86.02	85.99	85.98	85.87	86.70	86.67	86.62		86.57
EN	90.93	—	—	86.19	86.17	86.03	—	86.08	85.93		
FE	95.43	95.41	89.04	85.95	85.91	85.70	86.48	—	86.41		85.23
FW	96.03	95.97	87.33	87.24	87.23	87.03	86.38		86.18		85.03
G	90.64	—	86.32	86.31	86.29	86.13	86.17	—	86.08		85.89
HN	96.69	—	90.18	89.79	89.54	88.66	88.69	—	89.19		
HS	96.81	—	88.99	89.48	88.90	88.34	88.36	—	88.41		
IS	92.64	—	86.94	86.93	86.98	86.59	86.59	—	86.57		
JN	88.06	—	—	85.66	85.65	85.55	85.56	85.56	85.68		
KN	94.18	—	89.89	—	89.55	89.00	88.98	—	89.18		
KS	94.11	—	89.87	—	89.58	88.45	88.91	—	89.13		
L	89.94	89.98	86.37	86.51	86.46	86.27	86.19	—	86.20		
NN	90.43	90.40	89.14	89.09	88.99	88.6	88.58	—	88.56		
NS	90.55	—	89.41	89.30	89.85	89.06	89.00	—	88.91		
ON	89.59	—	87.22	87.29	87.25	86.95	—	86.79	86.72		
PN	87.68	—	84.85	84.83	84.81	84.78	—	84.83	84.96		
QW	86.41	—	85.44	85.40	85.39	85.36	—	85.41	84.96		
R	95.24	—	—	93.54	93.61	93.46	93.40	—	93.41		
SW	89.63	—	85.37	85.36	85.32	85.16	—	85.23	84.93		
W-1	—	102.68	89.84	90.55	90.33	89.65	89.53	—	—	89.75	
W-2	—	103.41	91.36	90.54	90.32	89.65	89.61	—	—	89.76	
W-3S	—	88.18	—	85.20	85.23	85.19	—	85.28	—	85.00	84.88
W-4S	—	88.71	—	85.09	85.10	85.07	—	85.11	—	84.75	
W-4D	—	88.71	—	85.61	85.61	85.53	—	85.60	—	85.36	
W-5S	—	87.65	—	84.99	84.99	84.96	—	84.95	—	84.60	
W-6S	—	89.70	—	86.29	86.29	86.21	—	86.32	—	85.70	

TABLE 4-2A (CONT'D)

OBSERVATION WELL GROUNDWATER ELEVATIONS
OVERBURDEN WELLS

Well	Reference Point		11/18/85 to									
Location	TOC	PVC	11/26/85	11/26/85	12/13/85	12/23/85	4/15/86	4/16/86		7/16/86	8/1/84	8/4/86
OW-SB-4S	—	91.57	—	87.47	87.42	87.02	87.82	—	—	87.02		86.77
OW-SB-9S	—	93.45	—	89.40	89.71	89.06	89.05	—	—	89.18		
OW-SB-25S	—	94.10	—	—	89.85	89.34	89.30	89.30	—	89.55	89.07	
OW-SB-30S	—	93.84	—	88.80	88.70	88.28	—	—	—	88.54	88.09	
OW-SB-34S	—	93.47	—	87.20	87.11	86.80	87.63	—	—	86.78		86.55
OW-7	92.71	92.66	—	—	88.65	88.32	—	—	—	88.49		
OW-8	90.55	90.55	—	—	89.31	89.07	—	—	—	89.10		
OW-9S	94.19	—	—	—	—	85.55	85.99	—	—	84.69		
OW-10S	90.99	89.99	—	—	—	88.97	—	88.29	—	88.75		
OW-11S	92.50	—	—	—	—	—	—	—	86.08	86.70		
PZ-1	88.31											86.76
PZ-2	87.30											85.80
PZ-3	86.77											85.52

TABLE 4-2B

OBSERVATION WELL GROUNDWATER ELEVATIONS
BEDROCK WELLS

Well	Reference Point		11/18/85 to								
Location	TOC	PVC	11/26/85	11/26/85	12/13/85	12/23/85	4/15/86	4/16/86	7/16/86	8/1/84	8/4/86
CE	93.40		88.37	—	88.27	87.90	87.35	87.34	87.40		87.10
ES	90.73	—	—	85.84	85.84	85.76	—	85.80	85.68		
FC	96.08	96.08	86.94	86.88	86.83	86.57	86.68	—	86.61		86.34
IN	92.66	—	87.06	87.08	86.87	86.73	86.74	—	86.73		
JS	87.96	88.00	—	85.86	85.86	85.73	85.75	85.75	85.60		
NN	90.43	90.40	89.14	89.09	88.99	88.6	88.58	—	88.56		
OS	89.85	—	87.31	87.39	87.33	97.03	—	86.85	87.00		
PS	87.81	—	85.22	85.16	85.16	85.13	—	85.18	85.22		
QE	86.28	86.31	85.20	85.12	85.13	85.09	—	85.16	85.00		
SE	89.65	89.63	85.39	85.40	85.35	85.20	—	85.25	84.95		
W-3D	—	88.43	—	85.78	85.80	85.72	—	85.78	—	85.56	85.43
W-4D	—	88.71	—	85.61	85.61	85.53	—	85.60	—	85.36	
W-5D	—	87.42	—	85.43	85.89	85.37	—	85.42	—	85.15	
W-6D	—	89.63	—	87.21	87.19	87.07	—	87.13	—	86.93	
OW-SB-25D	—	95.55	—	—	89.85	89.33	89.30	89.29	—	89.97	
OW-SB-27D	—	91.65	—	—	88.63	—	88.30	—	—	88.25	88.05
OW-9M	93.42	—	—	—	—	—	85.59	—	—	84.77	
OW-9D	93.37	—	—	—	—	—	85.54	—	—	84.67	
OW-10M	96.48	—	—	—	—	—	—	86.70		86.48	
OW-10D	97.62	—	—	—	—	—	—	93.14	—	93.13	
OW-11M	92.15	—	—	—	—	—	—			86.35	
OW-11D	92.16	—	—	—	—	—	—	—	86.51	86.36	

elevations, local hydraulic gradients, the mobility of pollutants considered, the soils attenuation capacity, identification of discharge/ recharge areas, regional groundwater flow characteristics, and water quantity and quality.

The sampling program was developed to determine the horizontal and vertical distribution of contaminants and predict the long-term disposition of contaminants.

4.2.2 MONITORING WELL INSTALLATION AND SAMPLING

Based on existing data from previous hydrogeologic studies, an on-site soil borehole investigation program was developed and carried out. Piezometer/ monitoring wells installed under this program were primarily constructed through the drive and wash method. This method utilizes a 3 inch casing to advance the borehole which is then completed with 1.5 inch 0.010 slot well screens. Monitoring wells of this type were installed at five locations: OW-SB-04S, 09S, 34S, 25S and 30S as seen on Figure 4-1. A full size 2′ x 3′ plan sheet of Figure 4-1 is enclosed in the attached map pocket. Groundwater monitoring data at these locations in the overburden aquifer, together with the previously installed monitoring wells, provide information on groundwater elevations, aquifer hydraulic conductivity and water quality in the on-site source areas. The aquifer is composed primarily of sand and gravel with some silt to a depth of 20-25 feet. Observation well installation information and groundwater elevations are listed in Tables 4-1 and 4-2. Location of off-site monitoring well locations OW-9, 10, and 11 are shown in Figure 4-2. Observation well borehole logs are included in Appendix B.

Two bedrock monitoring wells (OW-SB-25D and 27D) were installed at locations which corresponded to on-site source areas. Their depths of penetration into the bedrock at these locations were 10 and 8 feet, respectively. The purpose of these wells was to determine the composition, consistency and hydraulic conductivity of the shallow bedrock zone at these locations and provide information on groundwater elevations and water quality. In addition, the alignment of bedrock wells OW-SB-25D, OW-SB-27D, *CE, W-6D and FC provide an opportunity to obtain bedrock observation well* monitoring information relative to source areas, contaminant plume migration and surface water receptors.

Two overburden monitoring wells, OW-7S and OW-8S, were installed in the wetland to the north of the site to depths of 11 and 9 feet, respectively. These wells were placed to provide information on the subsurface geology, groundwater interaction with the surface water in the wetland, and water quality characteristics in the wetland.

Off-site cluster monitoring wells (OW-9, 10, 11) were installed to determine the extent of contaminants in the overburden and bedrock aquifers east of the Copicut River and in the vicinity of Cornell Pond. In previous sampling events, monitoring wells W-6D, ES, W-4S and W-4D east of the Copicut showed that contamination was present in both the overburden and bedrock aquifers at those locations. Contamination east of the Copicut was located primarily in the bedrock. Shallow and deep bedrock monitoring wells OW-10S, M, D were located approximately 450 east of well W-6D to confirm that contaminants had not migrated and to provide information in both the overburden and bedrock aquifers. These wells also provided information on vertical gradients and bedrock composition and consistency.

At two locations (Figure 4-2), monitoring wells (OW-9 and OW-11) were installed in the overburden, shallow and deep bedrock zones. The shallow overburden wells were installed directly above bedrock. The shallow bedrock wells were installed at an approximate 50 foot depth into the upper bedrock zone. At each of the two cluster well locations, deep bedrock monitoring wells were installed to a depth of 122 ft at OW-9 and 302 ft at OW-11 to determine possible contaminant presence in the water-bearing fractures in the deep zones. The deep monitoring wells provide information on the composition and consistency of the bedrock. The OW-9 and OW-11 locations were selected to confirm that contaminants had not migrated to these areas. An added reason for the installation of these cluster wells was to provide water level data which allows for an insight into horizontal and vertical gradients of the groundwater in the overburden and bedrock aquifers. This information is useful, together with previously collected data, in making judgements about potential contaminant movement in areas where contaminants are present.

4.3 SITE HYDROGEOLOGY

4.3.1 INTRODUCTION

The results and conclusions of past hydrogeologic investigations were used as baseline data to which additional information was added as a result of the work described in this report. Section 3 of the February 1985 RI report presented a discussion of hydrogeologic investigations performed to that date. This information is briefly summarized in this section. For greater detail and specific data, refer to the February 1985 RI report.

Bedrock in the area of the site is predominately a pink granite or a granite gneiss. Cores taken from 15 ft to 25 ft into the bedrock appeared sound at some locations but were highly fractured at others. Wells completed in rock were pumpable but generally at low rates. The rates obtained, although somewhat inconsistant due to the loss of drilling water during drilling, were verified by slug tests. Transmissivities in the bedrock generally ranged from 9 to 14 ft^2/day. The transmissivity of one bedrock well (W6-D) did prove to be much greater with a recorded value of 100 ft^2/day.

The overburden at the site consists of rather permeable sands and gravels ranging in thickness from less than 10 ft to about 28 ft at one location. Generally, but with some exceptions, a till layer is found in contact with the bedrock and below the surficial sands and gravels. The thickness of the till layer over the study area is variable ranging from 0 to over 25 ft.

Numerous large boulders, up to 5 ft in diameter are present in the overburden at the site. These are primarily found in the till layer, but they are also present in the overlying permeable sands and gravels. Of eight cross-sections presented in the February 1985 report, one or more boulders are shown in five sections. Monitoring wells installed in the upper sands and gravels were capable of being pumped at some locations at rates of up to 10 to 14 gallons per minute (gpm). Slug test data shows transmissivities ranging from 100 to 176 ft^2/day. Recent pump test data indicate that transmissivities in the overburden may range be greater than 400 ft^2/day.

4.3.2 GROUNDWATER MOVEMENT

Groundwater flow is from the site area (east of North Hixville Road) to the east and southeast towards the Copicut River and the unnamed tributary. Groundwater contours are presented in Figures 4-3 and 4-4 for November 1985 and July 1986, respectively. Groundwater elevation data and surface topography indicate that the unnamed tributary and the Copicut River are the discharge points for the overburden aquifer.

Table 4-3 indicates that the vertical gradients between the bedrock and overburden material are upward from the bedrock to the overburden aquifer in almost all of the well clusters installed at or adjacent to the site. Table 4-3 includes a winter monitoring (December, 1985), a spring monitoring (April, 1986) and a summer monitoring (July, 1986). During these monitoring periods the only well cluster to show a downward gradient for all three seasons was the one at location E, east of the Copicut River. Of the sixteen locations only three recorded a downward gradient in April. In July four wells were also recorded with downward gradients, but with the exception of the E location, these were not the same wells identified with downward gradients in April. In addition, two of these wells were new monitoring well clusters either upgradient or over 1600 ft from the site.

The most distant off-site bedrock monitoring well clusters (OW-9S, M, D and OW-11S, M, D) did not exhibit significant vertical gradients. A significant vertical gradient was found, however, from the shallow OW-10S overburden well to the shallow bedrock OW-10M observation well. This condition indicates that a hydraulic conductive zone exists to transport groundwater within the shallow bedrock zone to downgradient receptors.

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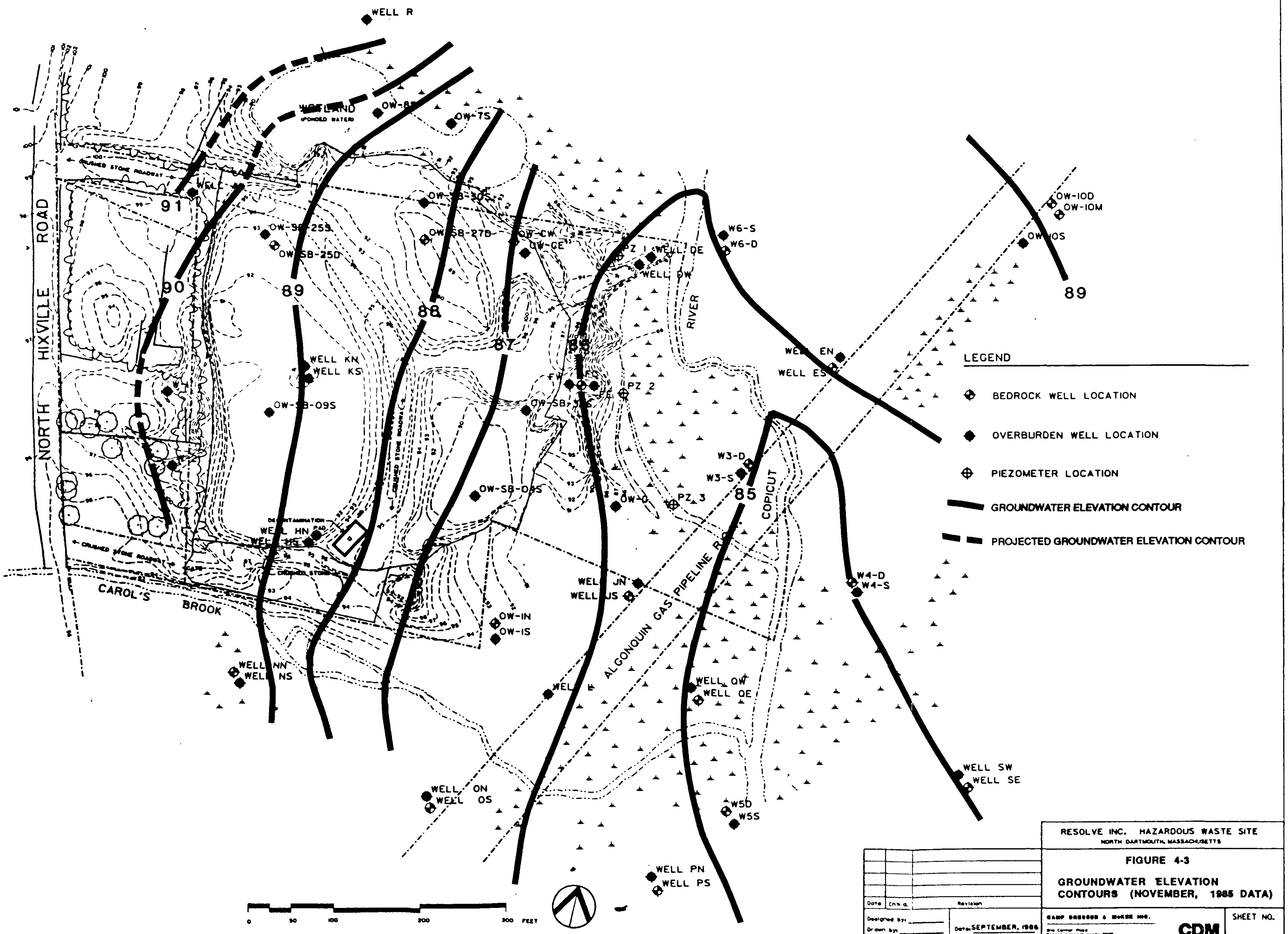

RESOLVE INC. HAZARDOUS WASTE SITE
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FIGURE 4-3

GROUNDWATER ELEVATION CONTOURS (NOVEMBER, 1985 DATA)

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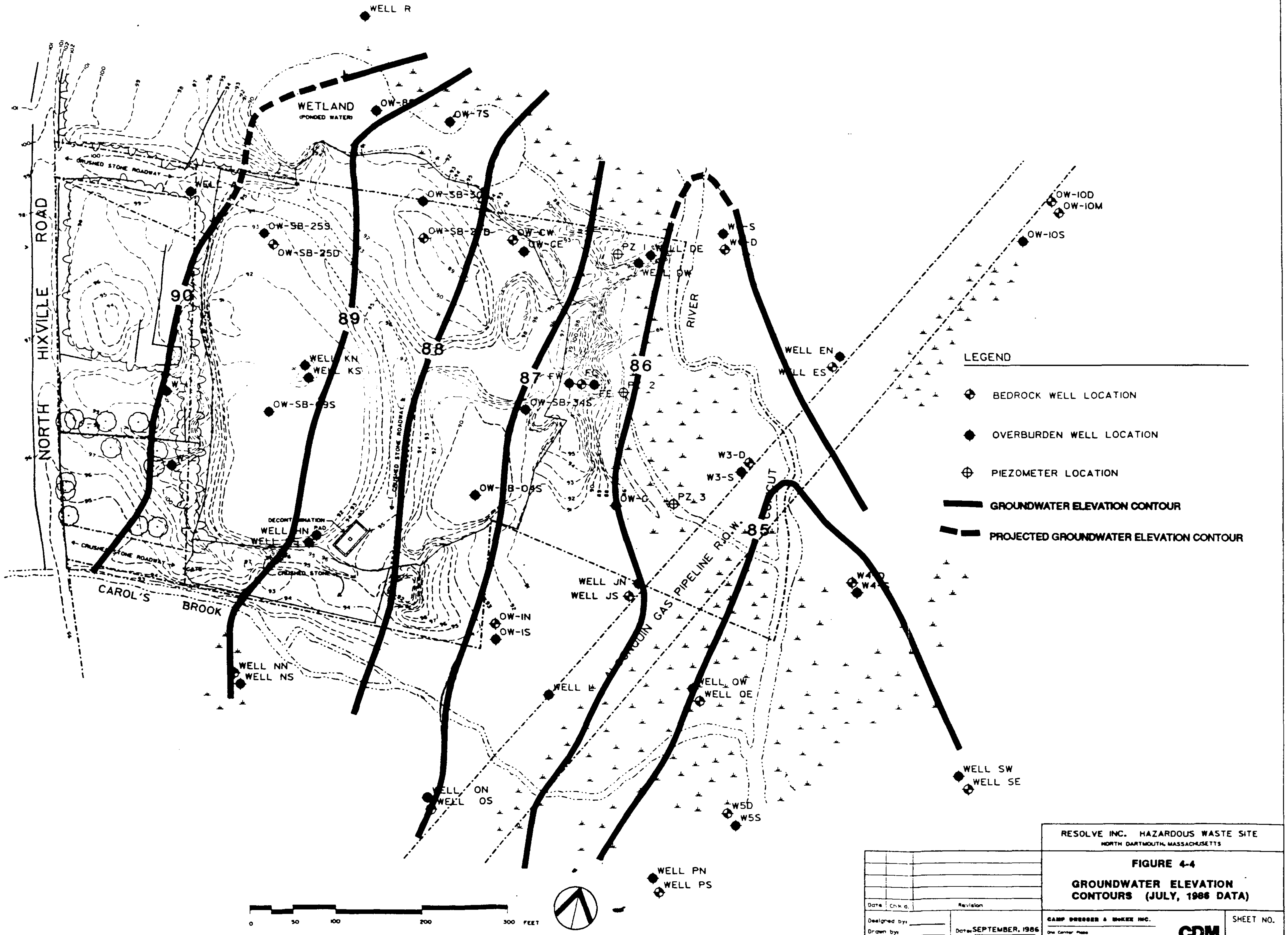

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FIGURE 4-4

GROUNDWATER ELEVATION CONTOURS (JULY, 1986 DATA)

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TABLE 4-3
VERTICAL GRADIENT INFORMATION

	12/13/85	Vertical Gradient	4/15-16/86	Vertical Gradient	7/16/86	Vertical Gradient	Change from 4/86
C west	87.26		87.35		87.74		
C east	88.27		87.44		87.40		
	0.01	up	0.09	up	0.34	down*	-0.43
E north	87.17		86.08		85.93		
E south	85.84		85.80		85.68		
	0.33	down	0.28	down	0.25	down	+0.03
F east	85.91		86.48		86.41		
F west	87.23		86.38		86.18		
	1.32	down	0.10	up*	0.21	up*	+.11
I south	86.87		86.59		86.57		
I north	86.98		86.74		86.73		
	0.11	up	0.15	up	0.16	up	+0.01
J north	85.65		85.56		85.68		
J south	85.86		85.75		85.60		
	0.21	up	0.19	up	0.08	down*	-0.27
O north	87.25		86.79		86.72		
O south	87.33		86.85		87.00		
	0.08	up	0.06	up	0.28	up	+0.22
P north	84.81		84.83		84.96		
P south	85.16		85.18		85.22		
	0.35	up	0.35	up	0.26	up	-0.09
Q west	85.39		85.41		84.96		
Q east	85.13		85.16		85.00		
	0.26	down	0.25	down	0.04	up*	+0.29
S west	85.32		85.23		84.93		
S east	85.35		85.25		84.95		
	0.03	up	0.02	up	0.02	up	0.00
W3S	85.23		85.28		85.00		
W3D	85.80		85.78		85.56		
	0.57	up	0.50	up	0.56	up	+0.06
W5S	84.99		84.95		84.60		
W5D	85.89		85.42		85.15		
	0.90	up	0.47	up	0.55	up	+0.08
W6S	86.29		86.32		85.70		
W6D	87.19		89.13		86.93		
	0.90	up	0.81	up	1.23	up	+0.42
OW9S			85.99		84.69		
OW9D	—		85.54		84.67		
			0.45	down	0.02	down	+0.43
OW10S			88.29		88.75		
OW10D	—		93.14		93.13		
			4.85	up	4.38	up	-0.47
OW11S			86.08		86.70		
OW11D	—		86.51		86.36		
			0.43	up	0.34	down*	-0.77
OWSB25S	89.85		89.30		89.55		
OWSB25D	89.85		89.30		89.97		
		none		none	0.42	up	+0.42

*change from previous recorded gradient direction

The groundwater flow through a cross sectional area can be expressed by Darcy's equation:

$$Q = KIA.$$

where Q = flow quantity; cubic feet per day (ft^3/d)
K = hydraulic conductivity; ft/day
I = hydraulic gradient; ft/ft
A = cross sectional area through which flow is being calculated

A geologic profile section (Figure 4-5, shown as profile section C-W5 in the February 1985 report) from monitoring well C through well F, G, J and W-5 was used to represent the groundwater outflow cross sectional area. The length is approximately 720 feet and the average saturated depth is approximately 20 feet, with an approximate groundwater outflow area of 14,400 ft^2. The hydraulic conductivity was calculated by permeability tests on the on-site wells, resulting in an average value of approximately 10 feet/day (3.5×10^{-3} cm/sec.). The hydraulic gradient is calculated from the 4 foot drop of groundwater elevation over a distance of 435 feet. This results in an I value of .009 ft/ft. Thus the flow quantity (Q) can be calculated by the following:

$$Q = 10 \text{ ft/day} \times .009 \text{ ft/ft} \times 14{,}400 \text{ ft}^2$$

Q = 1,296 cubic feet per day, 9,694 gallons per day, or 6.7 gallons per minute of groundwater

Such simplified calculations for flow from the site shows only the general order of magnitude which can be anticipated. The variations in thickness of the more permeable sands and gravels from 7 to over 25 ft and the variable nature of the hydraulic conductivity of the subsurface materials preclude a precise value. As illustrated in Table 4-4, hydraulic conductivities calculated from recovery tests and limited pump tests conducted during this investigation indicate a range of hydraulic conductivities in the on-site observation wells. A drawdown pump test performed on OW-SB-34S indicated that the hydraulic conductivity at that location in the lower section of the aquifer could range as high as 24

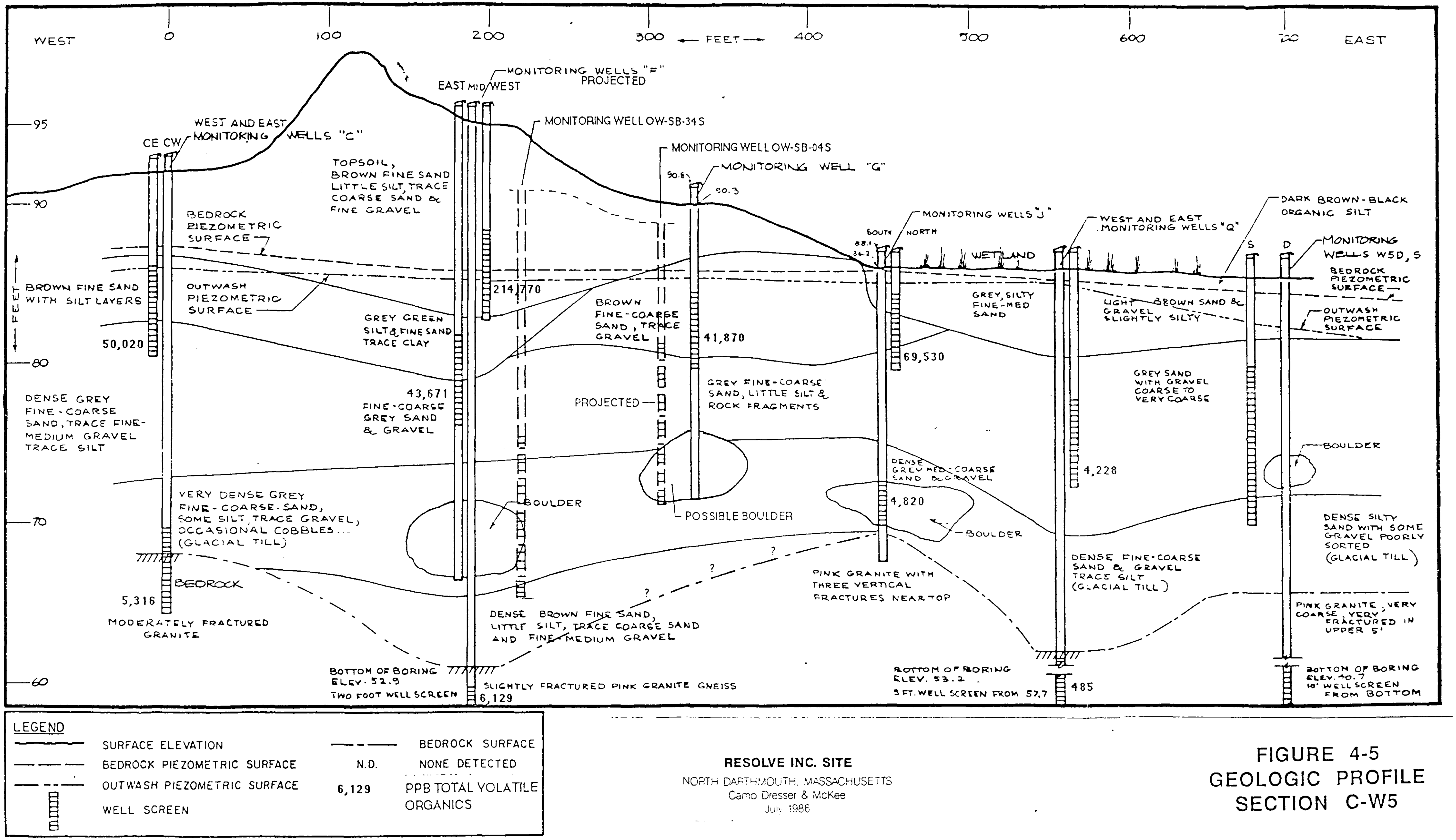

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FIGURE 4-5
GEOLOGIC PROFILE
SECTION C-W5

TABLE 4-4

HYDRAULIC CONDUCTIVITY VALUES FOR SELECTED OBSERVATION WELLS

Well	Surface Elevation (ft)	Elevation of Well Screen (ft)	Bedrock Elevation (ft)	K_h (cm/sec.)	K_h (ft/day)
			ONSITE		
FW	94.5	87.5-82.5	-	1.4×10^{-3}	4.0
OW-SB-4S	89.1	84.1-74.1	-	3.4×10^{-3}	9.7
FE	94.6	81.6-76.6	-	9.5×10^{-4}	2.7
OW-SB-30S	91.1	82-72	-	4.8×10^{-3}	13.6
KN	92.6	79.6-74.6	-	5.7×10^{-3}	16.1
OW-SB-25S	93	75.5-65.5	-	5×10^{-4}	1.4
OW-SB-34S	91.1	74.1-64.1	-	8.7×10^{-3}	24
CE	92.1	70.1-65.1	68.1	2.1×10^{-4}	0.6
OW-SB-25D	93	62-57	65	2.1×10^{-4}	0.6
			OFFSITE		
ON	88	86-81	-	7.3×10^{-5}	0.2
OW-08	89	82.5-77.5	-	2.3×10^{-5}	0.7
PN	87.2	77.2-72.5	-	1.3×10^{-3}	3.7
OS	88	75-65	77	5.5×10^{-4}	1.6
JS	86.2	73.2-68.2	74.2	5.1×10^{-3}	14.5
OW-10M	94.6	66.6-31.1	71.6	3.0×10^{-4}	0.8
ES	90.5	66.5-64.5	69.5	1.7×10^{-3}	4.9
PS	89.2	66.2-64.2	67.7	6.9×10^{-3}	19.5
W3D	86	53-43	63	1.64×10^{-4}	0.5
W5D	85.5	48.5-38.5	63.5	1.6×10^{-3}	4.5
OW-9D	91.2	33.2-(-30.8)	72.7	5.0×10^{-4}	1.4

ft/day, or 2.4 times the value used in the above calculations. Variability in the stratified drift deposits throughout the site area, both horizontally and vertically, would account for the range of hydraulic conductivities from 10 ft/day to greater than 24 ft/day and a resulting groundwater outflow several times the 6.7 gpm (9,694 gpd) calculated above.

An overview of groundwater contours (Figures 4-3 and 4-4) indicates that approximately 90-95 percent of the groundwater from the site, which discharges to the surface water system, enters either the unnamed tributary that bounds the site to the northeast or the Copicut River. A review of the surface water flow data in Section 5.0 describing the current surface water investigation shows that most of the groundwater from the site that discharges to the surface water system during high water table conditions is intercepted by this unnamed tributory. A small portion of the groundwater outflow to the surface water may discharge to Carol's Brook, but this is minimal. Review of water quality data indicates that no contamination was detected downstream of the site in Carol's Brook, reinforcing the concept that groundwater flow is easterly toward the unnamed tributary and the Copicut River. An inspection of flow data for the unnamed tributary (presented in Section 5.0) during 1985 shows some 18 to 22.5 gpm that can be attributed to groundwater discharge to this tributary, a not unreasonable figure according to the prior discussion of groundwater flow. The 100 gpm increase during the April 15, 1986 measurement between the wetlands north of the site and the tributary's confluence with the Copicut River can only be accounted for by some overland flow from the Copicut River crossing the intervening swamp. This is supported by the increased surface water elevation of the Copicut River during that monitoring period. With a lower seasonal groundwater table, groundwater does not discharge to the unnamed tributary but enters the Copicut River directly. A consistent increase in total volatile organic (TVO) compounds between the river sampling point north of the site and the one just upstream of the confluence with the unnamed tributary indicates that the Copicut River is a receptor of contaminated groundwater from the site.

The velocity (V) of the groundwater through the interconnected pore spaces can be calculated by the equation $V = K \times I/\emptyset$, where K and I are as defined above. The effective porosity, Ø, is approximately .20 in this type of geologic deposit. Thus the velocity can be calculated by the following:

$$V = 10 \text{ ft/day} \times \frac{.009 \text{ ft/ft}}{.20}$$

$$V = 0.45 \text{ feet/day or } 164 \text{ feet/year}$$

Therefore a time period of approximately three to six years would be necessary for contaminants in the groundwater to be transported across the expanse of the site to the Copicut River along the established flow lines. However, it is entirely possible that a hydraulic conductivity of 24 ft/day is present at some locations, and flow from parts of the site to the Copicut River occurs in 1 to 2 years.

On-site differences in hydraulic conductivity relative to stratification within the aquifer is not immediately evident. Subsurface soils lithology appears to vary across the site, with some boreholes having fine-medium sands with a higher silt content. Generally, the fine-medium sands are located in the upper sections of the aquifer, with occasional silt lenses. The deeper sections of the aquifer, especially over the eastern area of the site, appear to be comprised of relatively coarse material, as indicated by borehole logs OW-SB-34, 12 and 20. A higher hydraulic conductivity at OW-SB-34S reflects the coarser, more permeable material found at the lower elevations at that borehole location. Therefore, groundwater outflows within the lower sections of the aquifer may be higher than in finer overlying sections. This may not be universally the case, as wells at location F, less than 100 ft. away from OW-SB-34S, encountered till at a depth corresponding to its screened interval.

The relative contribution of groundwater outflow to the unnamed tributary and Copicut River can be estimated by observing relative hydraulic gradients between the aquifer and the surface water and estimating the relative hydraulic conductivity of the stream bed. Groundwater elevations in observation wells DW, DE and W-6S can be compared to the surface water elevations at the Copicut upstream surface water monitoring location SWM-4 listed in Section 5.0. Downstream in the Copicut, at the SWM-5 location, the surface water elevation can be compared to the groundwater elevation in W-3S. Vertical gradients at the overburden D wells, and the overburden/bedrock cluster wells W-6 and W-3 exhibited consistent upward vertical gradients indicating potential upward groundwater flow and potential discharge to the Copicut River.

Groundwater elevations in the shallow D, W-6, and W-3 wells directly adjacent to the Copicut River indicate an approximate 1 ft upward gradient with a potential head to cause inflow to the Copicut. Surface water sampling in the Copicut from November 1985 shows an increase from 2 ppb total volatile organic concentration just upstream of the site to 105 ppb just upstream of the confluence with the unnamed tributary. A repeat sampling in January of 1986 showed similar results with an increase of 17 to 198 ppb for the same two sampling locations, respectively. This information confirms that a significant portion of the groundwater flow and contaminant plume discharges into the Copicut.

4.4 CONTAMINANT MOVEMENT

4.4.1 CHARACTERISTICS OF GROUNDWATER CONTAMINATION

There is widespread contamination in the on-site groundwaters from volatile organics and extractable organics. High concentrations of volatiles and extractable organics were found onsite. There are four discernable soil contamination source areas, discussed previously in Section 3.0, from which contaminants originate and migrate from the site. The contaminants are found downgradient in both the overburden and bedrock aquifers as well as in the surface waters. The groundwater contaminant plume in the overburden and bedrock aquifers is indicated in Figures 4-6 and 4-7, respectively.

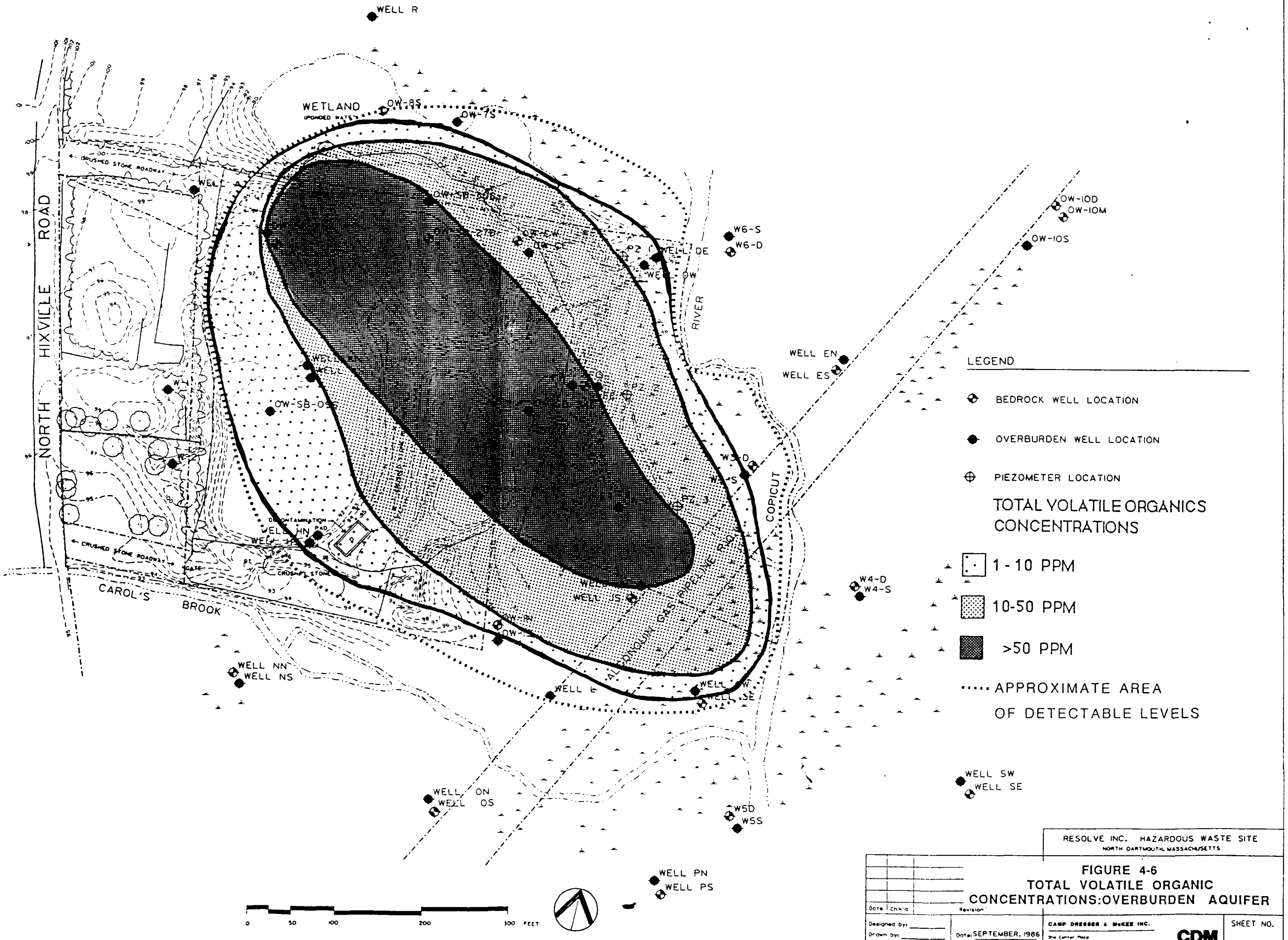

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FIGURE 4-6
TOTAL VOLATILE ORGANIC CONCENTRATIONS:OVERBURDEN AQUIFER

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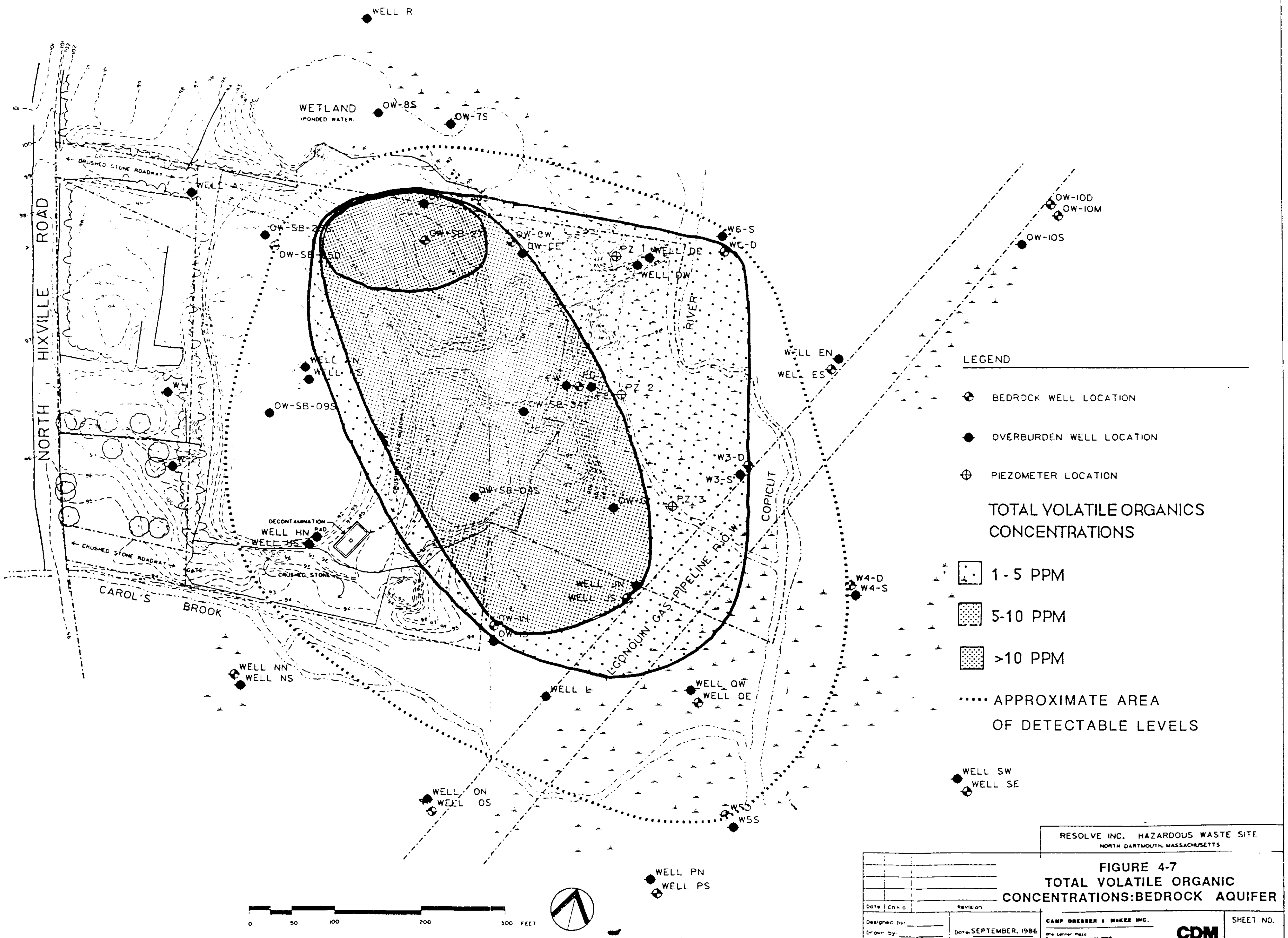

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FIGURE 4-7
TOTAL VOLATILE ORGANIC CONCENTRATIONS:BEDROCK AQUIFER

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4.4.2 CONTAMINANT MIGRATION FACTORS

The physical and chemical characteristics of the contaminants affect their rate of movement in the groundwater network. Volatile organics, for example, exhibit moderate solubility, low octanol/water partition coefficients, low soil adsorption coefficients, high biodegradation,, high volatilization and low viscosity which explains why these compounds can migrate faster in the groundwater system than extractable organics which have chemical and physical properties that retard their flow. For the purposes of groundwater analyses in this report, the movement of contaminants, especially the volatile organics, is assumed to occur at the same rate of migration as the groundwater flow. The physical, chemical, and biological factors which promote or retard movement of contaminants in the groundwater include the following:

- Solubility;
- Octanol/Water Partition Coefficients;
- Soil Adsorption Coefficients;
- Soil Permeability;
- Biodegradation (biological half-life);
- Vapor Pressure; and
- Viscosity

Migration of metals is highly dependent on the soil adsorption coefficents, and on metal ion solubilities and ph of the groundwater which are inversely proportional. Filtered groundwater samples from on-site wells with high VOC concentrations indicate that metals concentrations above expected background levels are not exhibited at the ReSolve site.

Solubility

This is one of the most important factors in determining the ultimate disposition of organic chemicals in the groundwater. Constituents which are miscible in water tend to travel more freely in the groundwater because these compounds have low bioconcentration factors, low adsorption coefficients for soils and sediments, and are readily biodegraded. Other compounds which are immiscible in water have different factors, such as specific gravity and viscosity, which play an important role in their movement in groundwater. These factors, however, do not promote contaminant movement to the same degree as the factors associated with water soluble compounds.

Octanol/Water Partition Coefficient

The octanol/water partition coefficient (K_{ow}) is defined as the ratio of a chemical's concentration in the octanol phase to its concentration in the aqueous phase of a two phase octanol/water system.

$$K_{ow} = \frac{\text{Concentration in octanol phase}}{\text{Concentration in aqueous phase}}$$

K_{ow} is an indicator parameter which describes the attraction of a particular compound for organics (soil/sediment) as compared to water. A high K_{ow} value describes a compound which adsorbs to soils and sediment, retarding its migration to groundwater. Low K_{ow} values indicates a hydrophilic compound which migrates through the soil to groundwater more easily.

Soil Adsorption Coefficient

This coefficient (K_{oc}) describes the ratio of the amount of chemical adsorbed per unit weight of organic carbon in the soil to the concentration of the organic chemical in solution at equilibrium.

$$K_{oc} = \frac{\text{ug adsorbed/g organic carbon}}{\text{ug/ml in solution}}$$

Values of K_{oc} may range from 1 to 107. High K_{oc} values for compounds indicate high absorption rates onto soil or sediments which attenuate migration rates. The adsorption coefficient is also related to volatilization, hydrolysis and biodegradation.

Soil Permeability

Soil permeability describes the ability of a fluid to penetrate through a porous medium (soil). The size of the pores depend largely on the type of soil, with clays and silts having small pores and low permeability and sands and gravel having large pores and high permeability. The soil permeability which affects leachate mobility is also related to ionic forces and capillary action.

Biodegradation

Biodegradation is defined as any biologically induced structural transformation of an organic compound that alters its structural integrity. The variables that influence this process include those that influence the size and activity of the microbial population and those that control the rate of degradation.

Viscosity

Viscosity is a measure of how a liquid behaves when subjected to a hydraulic gradient, which is essentially a measure of the liquid's resistance to shear or angular deformation.

4.4.3 CONTAMINANT MOBILITY

High values for the physical and chemical properties that affect contaminant mobility which were previously discussed, indicate the following:

- Solubility (high) indicates an increase in mobility
- Octanol/Water Coefficent (Kow) (high) indicates a decrease in mobility
- Soil Adsorption Coefficient (Koc) (high) indicates a decrease in mobility
- Soil Permeability (high) indicates an increase in mobility
- Biodegradation (high) indicates an increase in mobility
- Viscosity (high) indicates a decrease in mobility

Table 4-5 provides specific chemical properties for selected volatile organic compounds detected in the groundwater onsite.

These six volatile organic compounds were selected based on their relatively high mobility as compared to the remaining contaminants detected. Other factors contributing to their selection are low viscosities and soil adsorption factors and relatively high solubilities.

The migration of contaminants in the groundwater flow regime can be related to the on-site source areas as discussed in Section 3.0. Disposal of contaminants onsite resulted in direct contamination of the groundwater and soil matrix. Transport of contaminants within the groundwater and desorption of contaminants from the soil matrix results in a long term contaminant source. Extensive excavation at locations across the site removed substantial portions of the contaminated soil matrix. However, a significant quantity of source material still remains.

Adsorption of contaminants within the soil matrix is significant yet the retentive and physical capacity of the largely non-organic silt, sand and gravel soil matrix is greatly exceeded by the type and concentration of chemical contamination. The moderate to high solubilities of the organic compounds present in the groundwater indicate that their probable rate of transport is at the approximate velocity of the groundwater flow. Migration of the contaminant plume off-site indicates that the adsorptive capacity of the soil is minimal in relation to contaminant concentrations. This is further illustrated at off-site well locations where high contaminant levels were found.

TABLE 4-5

SPECIFIC CHEMICAL PROPERTIES FOR SELECTED VOLATILE ORGANIC COMPOUNDS

Volatile Organic Compound	Solubility (ppb)	Viscosity (m_L)	K_{ow}	K_{oc}
Methylene Chloride	1.7×10^7	0.449	1.82×10^1	1×10^1
Tetrachloroethylene	1.65×10^5	0.896	7.4×10^2	3.6×10^2
Trans-1-2-Dichloroethene	6×10^5	0.29	1.74×10^1	9.6
Trichloroethylene	1.1×10^6	0.58	6.92×10^1	3.8×10^1
Toluene	5.35×10^5	0.59	6.17×10^2	3.39×10^2
Vinyl Chloride	1.1×10^3	0.3	1.7×10^1	9.3

4.4.4 MOVEMENT OF GROUNDWATER CONTAMINATION

Discharge to Surface Waters

As previously discussed, the contamination from the ReSolve Site is being transported by the groundwater flow towards and into the unnamed tributary and the Copicut River. Some volatile organic compounds would be expected to travel at the approximate velocity of the groundwater because they are semi-mobile.

The volatiles exhibit the following physical properties which result in higher migration rates when compared to the extractables and metals: moderate solubility, low octanol/water partition coefficient, low soil adsorption coefficients, high biodegradation, high volatilization and low viscosity. The extractables and metals have properties that retard their flow; thus they are not as widespread as the volatiles. Groundwater in the observation wells appears to be slightly acidic, generally in the 5.5 to 6.5 pH range. Evaluation of the groundwater chemical data for selected volatile organics, as presented in Table 4-5, supports the description of groundwater movement presented in Section 4.3.2. Contaminants in the overburden aquifer situated in the northern, central, and southeastern reaches of the site are currently migrating toward wells F, G, I and J as indicated in Figure 4-5. The overburden contaminant migration plume is almost entirely discharging into the unnamed tributary and the Copicut River as indicated by the lack or low levels of contamination in overburden observation wells east of the Copicut River.

In addition, the pattern of surface water contamination found in the Copicut River and unnamed tributary supports the statement that the overburden aquifer is largely discharging into the unnamed tributary and Copicut River. The unnamed tributary appears to be a receptor of contaminant groundwater outflows and exhibits consistent contaminant concentrations in the 2-3 ppm total volatile organic range at its downstream portion. The Copicut River is also a primary receptor of contaminant outflow, exhibiting consistent contaminant levels of approximately 100 ppb downstream of the site before the confluence with the unnamed tributary.

On-Site Source Areas

Concentrations of total volatile organics in samples from newly installed observation wells at OW-SB-27D and OW-SB-30S indicate high contaminant concentrations in the bedrock and overburden aquifers at the site of the former lagoon area.

The total volatile organics data for observation wells CW and CE from 1983 through 1985 (Table 4-6) exhibit increasing concentrations indicating leachate infiltration from the former waste lagoons and plume movement downgradient. Decreasing concentrations of volatile organic data for observation well DW, however, indicate the contaminants are being diluted by surface water interaction with shallow groundwater. Observation well DE, as shown by groundwater elevations in Table 4-2, indicates a groundwater elevation which exhibits upward vertical gradients, driving the contaminants present in the lower portion of the overburden aquifer at a level greater than 10 ppm volatile organics toward the Copicut River.

Surface water in the UT is ponded north of a causeway that was constructed to place the D wells near the Copicut River. Analyzing the surface water and groundwater elevations of the PZ1 location during the 8/4/86 monitoring, the localized effect of the ponding north of the causeway is evident. The surface water elevation measured of the PZ1 location is 87 ft. (Table 5-2B), the groundwater elevation in PZ1 is 86.76 ft. (Table 4-2) and the groundwater elevation in monitoring well DW is 86.62. The elevation of the adjacent Copicut River is 85.54 ft. This indicates that ponded surface water in the UT at the PZ1 location, which is less than 50 ppb volatile organics, is causing a downward vertical gradient in this ponded water area north of the causeway. The UT surface water infiltrating the subsurface at this location is causing a dilution effect in the groundwater at this location as evidenced by the decrease in contamination in well DW from a concentration greater than 1 ppm concentration to less than 50 ppb volatile organics in less than a 2 year period.

TABLE 4-6A

SELECTED OBSERVATION WELL CHEMICAL ANALYSIS DATA (ppb)
OVERBURDEN WELLS

Observation Wells	Total Volatile Organics			Tetrachloroethylene			Trans-1-2-dichloroethene			Trichloroethylene			Vinyl Chloride			Methylene Chloride			Toluene		
	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85
A																					
BE	1,622,500	+	+		+	+		+	+	6,500	+	+		+	+	68,000	+	+	91,000	+	+
BC	85,540	+	+				1,400			860	+	+		+	+	16,000			62,000		
CW	19,342		50,020	350		240	2,200		7,400	3,000		300			5,400				8,500		16,000
DE	43,070	37,010	19,940					6,000	2,500					2,600	2,800	8			200	26,000	6,600
DW	1,003	2,995	13				93	74	2		21		17		1,100	550			15,000		
EN	106						10	13		65											
FW	82,283		43,671		11,000	14,000	14,000	36,000		35,000	2,200	25,000	300			330			150		
FE	111,902	222,000	214,770	14,000		1,600	380		83,000	35,000		50,000	14		8,000	19,000		16,000	6,800		9,000
G	1,953	109,000	41,870			790	12,000	94,000	19,000			9,200			2,500					15,000	3,000
HN	1,953		1,382	1,300		830			2			130									
HS	1,701		3,724			170			1,500			900	1,700		1,000						
IS	637		5,174			36	1,600		280			23	1,700		2,700				610		1,300
JN	71,220	99,000	64,550				47,000	4,900	4,900					5,000	7,100			1,400	64,000	39,000	33,000
KN	137		351	53		31	8		120	34		180			20				40		
KS	445		1,776	220		410	17		310	95		960			1	27					
L	228	729	51				10		1			6	23	470	20	32			13	150	
NS	11																				
NN	57															35					
ON	19															19					
QW	7,200	8,050	4,228												420				6,200	6,800	2,400
R																					
SW	31															23			8		
W1	*			*			*			*			*								
W2	*			*			*			*			*								
W3S	*	64,944	221	*	61		*	43,500	59	*	224		*	4,570	140		83			4,340	
W4S	*			*				*		*	3		*								
W4D	*	14	83	*	2	8	*	3	3	*	14	73	*								
W5S	*		99	*	5		*	5	6	*	5	14	*	202	21		5				
W6S	*	330		*																	

TABLE 4-6A (CONT'D)

SELECTED OBSERVATION WELL CHEMICAL ANALYSIS DATA (ppb)

OVERBURDEN WELLS

Observation Wells	Total Volatile Organics			Tetrachloroethylene			Trans-1-2-dichloroethene			Trichloroethylene			Vinyl Chloride			Methylene Chloride			Toluene		
	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85
OW-07	*	*	510	*	*		*	*	510	*	*		*	*							
OW-08	*	*	330	*	*		*	*	330	*	*		*	*							
OW-09S	*	*		*	*		*	*		*	*		*	*							
OW-10S	*	*		*	*		*	*		*	*		*	*							
OW-11S	*	*		*	*		*	*		*	*		*	*				10			
SB-04S	*	*	205,000	*	*	8,000	*	*	32,000	*	*	23,000	*	*				7,000			13,000
SB-09S	*	*	95	*	*	15	*	*	27	*	*	53	*	*							
SB-34S	*	*	17,005	*	*	5,400	*	*		*	*	7,900	*	*							705
SB-25S	*	*	105,000	*	*		*	*	7,800	*	*	27,000	*	*							
SB-30S	*	*	57,060	*	*	2,100	*	*	16,000	*	*	4,100	*	*				1,400			16,000

* Well did not exist at time of sampling.

\+ Wells removed after 1983 sampling.

TABLE 4-6B

SELECTED OBSERVATION WELL CHEMICAL ANALYSIS DATA (ppb)
BEDROCK WELLS

Observation Wells	Total Volatile Organics			Tetrachloroethylene			Trans-1-2-dichloroethene			Trichloroethylene			Vinyl Chloride			Methylene Chloride			Toluene		
	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85
BW	1,400	+	+		+	+	600	+	+		+	+	800	+	+						
CE	2,133		5,316			87	2,900		2,200	850		360			540						890
ES		13																			
FC	6,390	6,449	6,129		3,200	2,200		26	600	2,000	69,000	2,400		10	35				190	9	71
IN	3,910	581	481			23	41	93	41		42	6		190	330	26			130	48	
JS	4,801	40,000	4,820				1,900	9,000	280					1,100	3,300		4,400		2,300	27,000	
NN	57															35					
OS	79															45					
PS	19											6				19					
QE	915	303	487				8	5	9				16	40	310	39			100	72	
SE	50															41					
W3D	*	49		*	49		*	5		*	5		*				5				
W4D	*	14	87	*	2	8	*	3	3	*	14	73	*								
W5D	*	64	46	*			*	18	18	*	5	11	*	10	15		5				
W6D	*		2,840	*	340	340	*	23		*	2,000	2,100	*							1	
OW-09M	*	*		*	*		*	*		*	*		*	*							
OW-09D	*	*		*	*		*	*		*	*		*	*							
OW-10M	*	*		*	*		*	*		*	*		*	*							
OW-10D	*	*		*	*		*	*		*	*		*	*							
OW-11M	*	*		*	*		*	*		*	*		*	*							
OW-11D	*	*		*	*		*	*		*	*		*	*							
SB-25D	*	*	506	*	*	3.4	*	*	290	*	*	210	*	*							2.2
SB-27D	*	*	44,920	*	*	8,900	*	*	6,800	*	*	26,000	*	*				600			

* Well did not exist at time of sampling.

\+ Wells removed after 1983 sampling.

Downgradient of the former lagoon area, the cooling pond areas, and the contaminated on-site soil areas, a highly contaminated portion of the overburden aquifer is seen at observation wells OW-SB-4S, OW-SB-34S, FW, FE, G, JN in the southeast section of the site and nearby off-site locations. TVO levels in observation wells at location F show persistence with continuous high levels. At the FW location, TVO contamination levels were in excess of 67 ppm in the upper 3-4 ft. of the saturated zone of the aquifer. Directly downgradient at the FE location, beneath a silt lense, contamination was in excess of 200 ppm TVO indicating high contaminant concentrations at a shallow to middle depth of the overburden aquifer at this off-site location.

The location of observation well F downgradient of highly contaminated soils at the oil spreading lagoon and cooling pond sites provides an explanation for these high contaminant levels located off-site. The aquifer at the F cluster well location is being infiltrated with groundwater contaminants originating from upgradient source areas and contaminated soils. Analyses of groundwater at wells JS and HS exhibit a similar situation of off-site contaminant migration of a highly contaminated plume from an on-site source. OW-SB-4S which is screened within the upper 5 to 15 feet of the aquifer exhibited high contaminant levels, in excess of 200 ppm TVO. OW-SB-34S, which is within the contaminant plume area north of OW-SB-4S and west of the F location, exhibited comparatively lower contaminant levels (17 ppm TVO) at a depth of 15-25 ft. in the aquifer. This indicates lower contaminant levels in the deeper zones of the aquifer at this location. In the northern section of the site at the OW-SB-25S and OW-SB-30S locations, which are primary source areas, groundwater contamination extends to lower sections of the aquifer causing contaminant migration in the full saturated thickness of the overburden aquifer and infiltration into the bedrock aquifer.

North of the site in the wetland area, observation wells OW-8S and 7S contained 1,2-trans-dichloroethane at levels below 1 ppm. Volatile organic contamination in sediments and surface water of the wetland, as reported in the 1985 CDM Off-Site RI, can be seen to influence contaminant levels in

OW-8S and 7S observation wells. Limited outflow and dispersion from the highly contaminated source areas directly adjacent to the wetland probably account for a limited portion of the contamination in the groundwater beneath the wetland. The primary mechanism of contamination in the wetlands was probably direct disposal and/or surface runoff from the site during its operation.

Groundwater sampling at 16 observation well locations, primarily at on-site and immediate off-site locations, indicated PCB contamination ranging from 4 ppb to 1200 ppb in unfiltered groundwater during the November and December 1985 sampling events. However, PCBs are relatively insoluble in water with a range of 2.5 ppb - 15 ppb solubility (U.S. EPA 1980). The existence of high levels of PCBs in groundwater samples at the locations tested is, to a great extent, attributable to PCBs adhered to silt and suspended solids sampled with the unfiltered groundwater samples. Subsequent review of these data necessitated a second sampling event in July, 1986. Groundwater samples were filtered through a 0.45 micron standard filter for organic analyses to determine if PCB contaminants detected were adsorbed onto silt and soil particles.

Sampling and analyses in July, 1986 of filtered groundwater at ten of the observation well locations, as indicated in Appendix B, exhibited a presence of PCBs at three of the observation wells as indicated below. The remaining seven wells did not indicate the presence of PCBs in groundwater.

Observation Well	Total PCB Concentration (ppb)	
	Nov./Dec. 1985 (unfiltered)	July 1986 (filtered)
SW	5.5	1.4
OW-SB-25S	1160	52
OW-SB-34S	6	9.7

However, this information indicates that PCB oils at OW-SB-25S are present in groundwater at levels higher than the 15 ppb maximum solubility.

The presence of other volatile organic compounds in which PCBs are soluble increases the presence of PCBs in the groundwater (U.S.EPA 1980). Soil borings and groundwater samples at the SB-25S location indicate high concentrations of volatile organics and PCB contaminants at depths throughout the thickness of the overburden aquifer.

Bedrock Contamination

Contaminants in the bedrock aquifer have migrated to the eastern side of the Copicut River and south of Carol's Brook as illustrated in Figure 4-7. High contaminant levels in the bedrock are exhibited on-site at OW-SB-27D and CE which are directly influenced by the contaminant disposal practices at the former lagoon area. At locations FC, IN and JS, a contaminant plume with concentrations greater than 5 ppm TVO in the shallow bedrock has migrated off-site. As evidenced by drilling operations at some locations across the study area from the 1985 CDM off-site RI and boring logs in Appendix B from the current study, bedrock at some locations is extensively fractured. Fracturing has occurred to the extent that the groundwater in the bedrock aquifer flows in a similar direction to that of the overburden aquifer. Some bedrock wells exhibit relatively high hydraulic conductivities, as seen in Table 4-3. Contaminants in the bedrock groundwater do not entirely discharge to the Copicut River and are transmitted beneath the Copicut as illustrated by contaminant detection in observation wells W-6D and W-4D and south of Carol's Brook as illustrated by contaminant levels in observation well W-5D. Potential for contaminant migration east of the Copicut, especially to the W-6D location, occurs during the transient conditions of an elevated overburden water table and high surface water levels, causing downward vertical gradients as exhibited during the April 1984 monitoring from the 1985 off-site RI. The newly installed off-site cluster of monitoring wells at locations OW-9, 10, 11 did not exhibit any contamination in the overburden or bedrock aquifers, indicating that the contaminant plume has not migrated to that downgradient area.

As indicated in these groundwater analyses, contaminant flow in the overburden aquifer is primarily towards the Copicut River. Some of the contaminants have higher specific gravities than water. This fact, in combination with precipitation recharge, contaminant recharge rates, and possible seasonal downward gradients in the contaminated sandy soils can cause a downward migration of contaminants in the overburden aquifer. At some locations, especially the highly contaminated areas on-site, contaminated groundwater in the overburden aquifer may be infiltrating the upper bedrock aquifer. Contaminants in the bedrock aquifer can be very persistent, and future contaminant migration in the bedrock will be dependent on the physical/chemical properties of the chemicals as discussed in Section 4.4.2, hydraulic gradients present, and bedrock fracture patterns.

4.5 GEOPHYSICAL INVESTIGATION

4.5.1 INTRODUCTION

Geophysical studies were conducted at the ReSolve Site during February of 1986 to investigate the presence of buried objects. This investigation was focused primarily over the western section and areas of the site which were not investigated and excavated during the removal operation conducted by CECOS and the U.S. Army Corp of Engineers in 1984. Previous excavations onsite, supervised by the US Army Corp of Engineers, had removed approximately 50 drums from areas of the site that had been excavated during the removal operation. Depth of excavation of the on-site soils at several sections of the site extended to four feet. Sections of the site which were not excavated and served as access roadways during the excavation and removal process were the primary focus of this geophysical investigation.

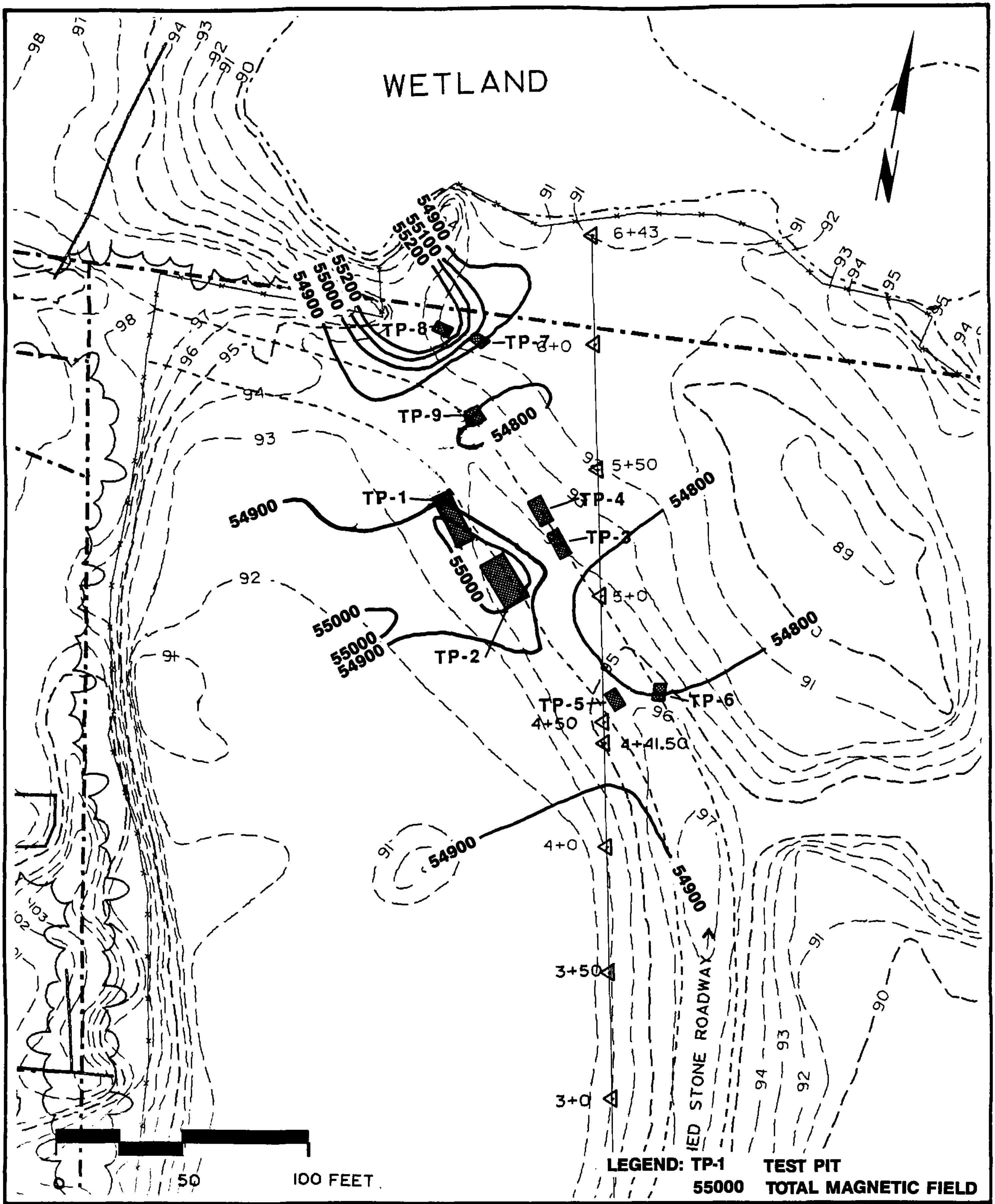
Figure 4-4 indicates the results of the geophysical survey and testpit locations. Initially an electromagnetic Geonics EM 31 Unit was used in a buried object detection mode to screen for the existence of buried objects over the entire site. The locations indicated as suspect by the EM 31 unit were also evaluated using an EDA OMNI MAG magnetometer, a Geophysical Survey System's subsurface interface radar (SIR) unit, and a Metrotech Model 880 metal detector.

4.5.2 APPROACH

In conjunction with the EM 31 survey, the magnetometer unit was used to demarcate the existance of buried ferromagnetic objects. To verify the absence of ferromagnetic material, localized measurements using the magnetometer were taken at sections of the site which did not indicate anomalous electromagnetic field measurements using the EM 31 Unit. Total magnetic field readings were initialliy obtained in suspect areas of the site which are listed in Appendix I. Total magnetic field contours are listed on Figure 4-4. A subsequent magnetometer survey using the magnetometer in a vertical gradient mode (VGM) was conducted in the areas designated as suspect by the first total field magnetometer survey. The grid size was reduced to 10 foot intervals for better definition. The VGM anomalous measurements correlated with the anomalous magnetometer total field measurements. In conjunction with the EM 31 and magnetometer surveys, a subsurface interface radar survey was used to distinguish the presence of buried objects. During the excavation process a Metrotech Model 880 metal detector was also used to indicate location and extent of buried ferromagnetic material.

4.5.3 GEOPHYSICAL RESULTS

As a result of the geophysical investigations, nine testpits (Figure 4-8) were excavated resulting in the removal of seven 40 gallon barrels which contained waste contaminants. Five high hazard material samples were obtained from three of the testpits. The analytical results are listed in Appendix A. Three drums were placed in overpacks and the remaining four intact drums were stored onsite for removal.



LEGEND: TP-1 TEST PIT
55000 TOTAL MAGNETIC FIELD

RESOLVE INC. SITE

NORTH DARTHMOUTH, MASSACHUSETTS
Camp Dresser & McKee
July 1986

FIGURE 4-8
GEOPHYSICAL SURVEY
TEST PIT LOCATIONS

Section 5

5.0 SURFACE WATER AND WETLANDS INVESTIGATION

5.1 INTRODUCTION

The purpose of the surface water and wetlands investigation conducted at the ReSolve site was to assess the quantity of flow, characterize and determine the extent of contamination and evaluate the mechanisms by which contaminants are being transported from the site via any one of the three surface streams draining the site vicinity. The specific elements of this investigation were as follows:

- Analyze the surface waters to characterize current contaminant levels in the streams draining the site.
- Estimate the base flows of Carols Brook, the Copicut River and the Unnamed Tributary.
- Estimate the seasonal and short-term flow response of the Unnamed Tributary from induced infiltration of groundwater and/or rainfall.
- Assess the current extent and condition of wetland areas onsite and offsite to provide a characterization and baseline for the impact analysis that will be conducted during the feasibility study.

As shown in Figure 1-3, the ReSolve site is bordered on the north by a wetland. This wetland, which is largely ponded water to a depth of 1 to 2 ft, forms the headwaters of the unnamed tributary which trends northwest to southeast following the contour of the site's northeastern border. This tributary obtains substantial flow pickup from small perennially wet areas and is a receptor of the site's groundwater outflow. This tributary joins the Copicut River just past its crossing of the Algonquin gas pipeline right-of-way. Carols Brook flows in a general west to east direction and forms part of the site's southern boundary. Carols Brook joins the Copicut River 220 ft below its confluence with the unnamed tributary.

Sample collection locations and task objectives were selected to augment earlier efforts at site characterization and to provide sufficient information to begin screening final remedial alternatives.

5.2 SURFACE WATER HYDROLOGY

The purpose of the hydrologic analysis was to determine the interconnectedness of surface water near the site with groundwater and determine surface water flow patterns. Flow measurement stations were established on each of the surface streams and water elevation gages were strategically placed in order to achieve the objectives described above.

5.2.1 WATERSHED AND DRAINAGE PATTERNS

The Copicut River is a small tributary of the East Branch Westport River. It is considered to originate at the Copicut Reservoir where leakage at the base of the dam supplies a relatively constant baseflow. The Copicut River flows from the Copicut Reservoir approximately 0.75 miles north of the site, through a small private pond, to a point adjacent to the ReSolve site. From the site, it flows approximately 1/4 mile to Cornell Pond. Discharge from Cornell Pond flows south where it joins Shingle Island River. Shingle Island River flows into Noquochoke Lake, the outlet of which becomes the head of the East Branch Westport River and eventually discharges to Rhode Island Sound. Water from the Naquochoke is used as a nonpotable industrial water supply for fire protection purposes for the town of Westport.

The drainage area of the Copicut River at the site is 8.11 sq mi. The main tributary in the vicinity of the site is Carols Brook. During a previous investigation of the aquatic community (CDM, 1985), it was noted that the Copicut River is being fed by leaks at the base of the Copicut Reservoir dam, located at the southern end of the reservoir approximately 0.7 mi north of the site. At this location, the stream contained orange-colored flocculant masses. These masses are probably filamentous, ensheathed chemoheterotrophic iron bacteria of the Sphaerotilus group which accumulate iron oxide on the sheaths, but do not physiologically use iron.

The iron is a result of naturally occuring dissolved iron being discharged to the stream. Water from the Copicut Reservoir is periodically pumped to the Fall River reservoir for treatment and distribution. Iron content is typically high, in the 1 ppm range, and pH low, generally less than 5. In addition, two auto salvage yards are located upgradient within one-half mile of the site.

The Copicut Reservoir was completed between 1971 and 1972 and was constructed to augment the water supply of Fall River. During the fall period until January 1, 1986 no water was pumped from the reservoir. From January 1986 until May 1986, approximately 10 to 12 mgd was removed from the reservoir. From May until August 1986, approximately 5 to 6 mgd was pumped off. According to conversations with the operator of the Fall River Filtration Plant, seepage through the dam occurs year round at an estimated flow rate of 50,000 gpd. The only controlled release of water from the dam occurs annually during the months of March, April, May and possibly June when the depth of the reservoir exceeds 30 ft. Estimated flow through the spillway is approximately 250,000 gpd during these spring months. During the November 1985 to July 1986 time period, the monitoring conducted on July 16, 1986 of the Copicut may have been affected by a lower streamflow in the Copicut.

5.2.2 PRECIPITATION - NEW BEDFORD STATION

Meteorological data were obtained from the New Bedford Station of the National Weather Service. Summaries of daily temperature and precipitation are available within three months of collection, while hourly readings of temperature and precipitation can be obtained within six months.

The climatic data indicate that the winter of 1985-86 was not unusual in regard to temperature. Therefore, normal averages for frost depth and duration applies to the study period. Rainfall was below normal however, for many of the monthly averaging periods. Daily precipitation data from September 1985 to April 1986 are presented in Table 5-1.

TABLE 5-1
DAILY PRECIPITATION DATA*
Re-Solve Site Sept. 1985 - April 1986

Day of Month	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.
1				.05	.14	.05				.06		
2	.03		.09	.25		.58			T	.06	1.73	
3		.24	.01		1.63						.38	.64
4	T	.07	.01			.40		.04				
5		.07	1.57		.67	.06			.05		.01	
6	.25		.18		T		.09	.17	.08	.41		
7	.05					.25		.40	.04	.83		.10
8						.03		.28	.09	1.23		1.15
9	.67							.05			.02	T
10	.06		T				.33	.03				
11	.18		.08	.30		.53	1.0			.10		.52
12			.73	.08					.01	.64	.74	
13		.28	.03	.37			.72			.21	.98	
14			.21	.01		.14	1.01				.71	
15		.25				T	.59					
16		.08	1.05									.01
17			.40			.15			.02			.01
18				.10		.75						1.16
19		.19	.01		2.55	.11	1.2					.10
20					.13					.11	T	
21				.05		.58		.24	.39		.01	.42
22			.79			.01			2.39			.41
23				.16				.74	.05	.01		T
24	.21	.01						.13	.49	.20		.16
25		.21			T	T		.05	.02			
26			.46		2.88				.02		.02	
27	.05		.07	T	.31		.23	.15		.01	.09	.01
28			.57		T		.13	.02	.01	.03		.29
29			.03								.96	
30					T						.41	
31				.09					.02		.01	
Total	1.50	1.40	6.29	1.46	8.31	3.65	3.02	2.80	3.68	3.90	6.07	4.98
Departure from Normal	-1.85	-1.80	2.13	-3.20	4.25	-.19	-1.18	-.96	0.33	1.17	3.70	.72
Greatest Day	.67	.28	1.57	.37	2.88	.75	1.01	.74	2.39	1.23	1.73	1.16
Date	9th	13th	5th	13th	26th	18th	14th	23rd	22nd	8th	2nd	18th
Normal Monthly Average	3.35	3.20	4.16	4.66	4.06	3.84	4.20	3.76	3.35	2.73	2.37	4.26
% Difference from Normal	-55	-56	+51	-69	+105	-5	-28	-25	+10	+43	+156	+17

*Source: National Oceanic and Atmospheric Administration 1986. Data for New England 98(7), July, 1986.

Figure 5-1 illustrates that precipitation was 32% below normal for September through December and was still 8% below normal for September through March, despite January precipitation being 105% above normal. It should also be noted that 85% of the precipitation in January fell on just 3 days. Despite that large amount of rain that fell, the deficit created over the fall period was not reversed. In addition, the presence of ground frost could prevent significant infiltration from occuring.

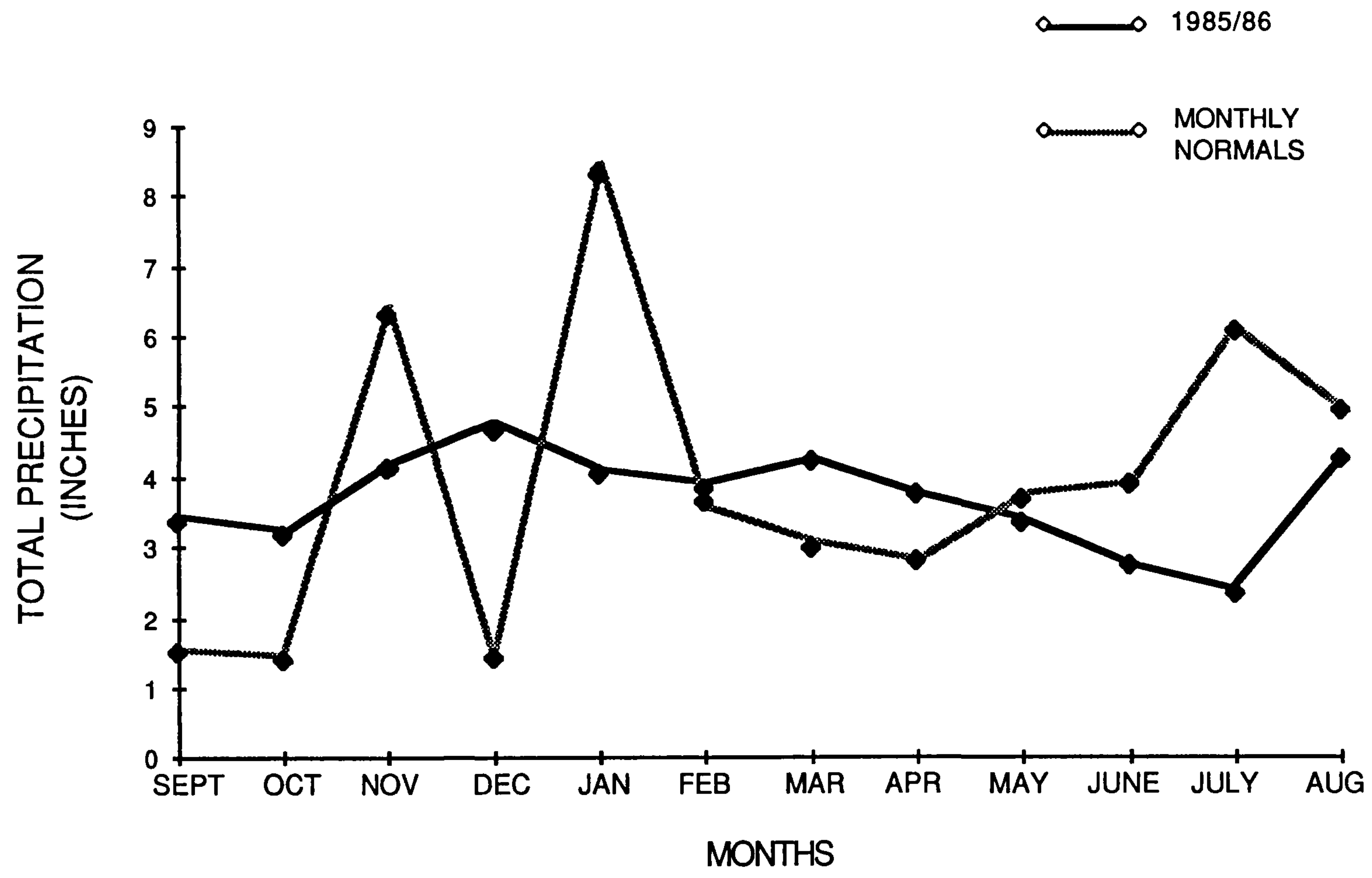
5.2.3 STRUCTURE OF SURFACE WATER MONITORING PROGRAM

As previously discussed in this section, surface water flow stations were established and surface water samples were collected to meet the objectives of the surface water investigation.

As shown in Figure 5-2, stations were established on Carols Brook (SWM-6) and the Copicut River (SWM-5) where each surface stream crosses the Algonquin gas pipeline right-of-way (ROW). Flows were calculated periodically using a stream cross section method at each of these locations with velocity measurements made using a Marsh-McBirney instream velocity meter. Each location was chosen based upon the following factors.

- straightness of the stream channel
- uniform bottom type and depth
- relatively steep stream bank to contain a large range of flows within the same channel width.

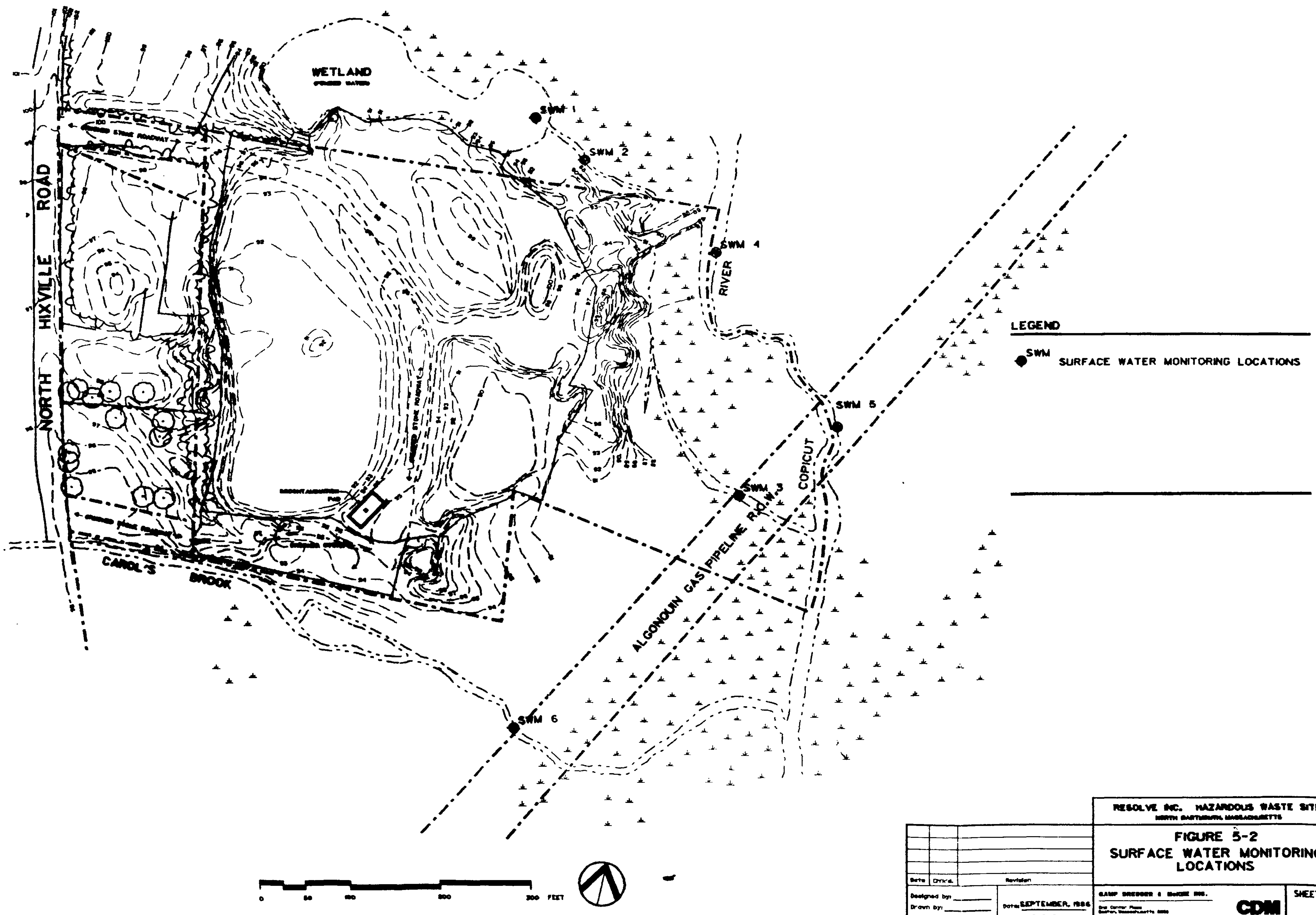
The Carols Brook location had an approximate width of four feet which was divided into eight one-half foot wide segments. The depth of each segment was measured at the midpoint. Depths in the Copicut Stream and Carols Brook were less than two feet, therefore the velocity of each section was



RESOLVE INC. SITE
NORTH DARTHMOUTH, MASSACHUSETTS

Camp Dresser & McKee Inc.
November 1986

FIGURE 5-1
ACTUAL PRECIPITATION
BY MONTH - NEW BEDFORD, MASSACHUSETTS



RESOLVE INC. HAZARDOUS WASTE SITE
NORTH DARTMOUTH, MASSACHUSETTS

FIGURE 5-2
SURFACE WATER MONITORING LOCATIONS

Date	Chk'd.	Revision

Designed by: ______
Drawn by: ______
Checked by: ______
Approved by: ______

Date: SEPTEMBER, 1986
Scale: AS SHOWN

CAMP DRESSER & McKEE INC.
One Center Plaza
Boston, Massachusetts 02108
CDM
environmental engineers, scientists, planners & management consultants

SHEET NO.

ARCHITECTURAL Approved by Date
STRUCTURAL Approved by Date
ELECTRICAL Approved by Date
INSTRUMENTATION Approved by Date
HVAC Approved by Date
PLUMBING Approved by Date
PROJECT ENGINEER Approved by Date
PROJECT MANAGER Approved by Date

measured at the midpoint of the segment, at approximately 0.6 of the total depth. The flow at each segment was then calculated using the following formula:

$$Q = VA$$

where: Q is the flow in ft^3/sec
V is the velocity in ft/sec
A is the area of segment in ft^2

Each of the eight segment flows were calculated and summed to obtain the total flow of stream at that point.

The Copicut River section was approximated fourteen feet wide and was split into seven two foot wide segments. The depth and velocity was measured and flows calculated as with the Carols Brook station.

The flow pickup of Carols Brook and Copicut River as each flowed past the site was not determined because the inherent error of the cross sectional method, typically ±10%, would not allow accurate measurement of small flow increases over such a short distance.

Special attention was given to the unnamed tributary because it flows from the wetland; it has typically contained the most contaminated surface water near the site; it is in the direct path of overburden groundwater flow; and it appears to pick up substantial groundwater baseflow between the wetland to the Algonquin ROW. Therefore, locations were selected just below the wetland outlet and near the Algonquin ROW that would be amenable to construction of a temporary pool in which a small calibrated pipe weir or overflow device could be installed. In an area just below the wetland a small overflow device was installed which could be measured with a calibrated bucket and a stop watch (SWM-2).

At the gas line a small temporary pool was constructed around a one foot diameter smooth galvanized pipe into which a 12 inch pipe weir calibrated in gallons per day (gpd) was inserted (SWM-3). Following stabilization, a reading was taken.

In order to further establish the interaction of the surface water and groundwater, reference stakes were placed at the following locations (Figure 5-2):

SW-1	Above wetland outlet
SW-4	Copicut River downstream (at Algonquin ROW)
SW-5	Copicut River upstream (adjacent to D wells)
SW-6	Carols Brook at gas line

5.2.4 FLOW DISCHARGE AND WATER LEVEL ELEVATIONS

As previously discussed it was suspected that flow of the unnamed tributary (UT) increases dramatically as it flows from the wetland to the Algonquin right-of way (ROW). As discussed in Section 4.3.2, this increased flow is thought to be a result of groundwater outflow to the UT.

Stream flow data collected during this investigation is presented in Table 5-2A. If flow data from the unnamed tributary (UT) below the wetland on December 11, 1985 are compared to the UT flows at the Algonquin right-of-way (ROW), it can be observed that flow increased by 17.75 gpm (24 gpm to 41.75 gpm) or 74 percent. Similarly, data from December 23, 1985 shows an increase of 21.3 gpm (15.5 gpm to 36.8 gpm), or 137 percent. Considering that precipitation was below average during the preceding fall, it appears that flow approximately doubles in the 520 feet from the wetland to the Algonquin ROW.

An examination of the UT flows for other dates (Table 5-2A) reveals a wide range of flow regimes which maintain a similar trend. On January 16, 1986, flow at the Algonquin ROW was 22.5 gpm while there was no apparent flow out of the outfall wetland due to severely cold weather. This value is considered the groundwater baseflow to the UT during this monitoring period. On January 21, 1986, flow was measured following a brief January thaw and torrential warm rain (2.55" on January 19). The UT still showed a 93 percent increased inflow (50 gpm to 96.7 gpm), even though the ground was substantially frozen.

TABLE 5-2A

SUMMARY OF SURFACE WATER FLOWS (gpm)

ReSolve Inc. - Dartmouth, MA

Station Location	1985 11/26	12/5	12/10	12/11	12/23	1986 1/16	1/21	4/15	4/16	7/16	8/4
SWM2 Unnamed Tributary at Wetland outlet	—	39	—	24	15.5	frozen	80	8.8	6	1	
SWM3 Unnamed Tributary at pipeline	—	—	—	41.75	36.8	22.5	96.7	107.7	96.7	1	
SWM6 Carols Brook at pipeline	—	—	835	—	555	frozen	3,942	1,889	—	322	
SWM5 Copicut River at pipeline (downstream)	—	2,199	1,839	—	1,773	—	2,101	6,724	—	1,728	

TABLE 5-2B

SUMMARY OF SURFACE WATER ELEVATIONS (ft)

ReSolve Inc. - Dartmouth, MA

Station Location	Reference Elevations (ft)	1985 11/26	12/5	12/10	12/11	12/23	1986 1/16	1/21	4/15	4/16	7/16	8/4
Wetland at OW-8	90.55	—	—	—	—	89.44	frozen	—	—	—	89.05	
SWM1 Above Wetland Outlet	91.95	89.06	89.06	—	88.98	frozen	frozen	89.15	88.92	88.88	88.95	
SWM6 Carols Brook at pipeline	85.87	—	—	82.72	—	82.69	frozen	—	—	—	82.55	
SWM4 Copicut River (upstream)	88.77	85.98	86.02	—	86.00	85.97	85.86	85.89	86.06	86.07	85.54	85.54
SWM5 Copicut River at pipeline (downstream)	85.96	84.02	84.04	84.04	84.04	83.98	83.98	84.06	—	84.08	83.65	83.67
Surface Water Near Location PZ1											87.0	87.0
Surface Water Near Location PZ2											85.79	85.00
Unnamed Tributary at pipeline weir											85.21	85.21
Unnamed Tributary at pipeline											84.62	84.62

This UT surface water flow increase is influenced by the high surface runoff conditions during this monitoring period.

The last flow measurements were taken on successive days in April to determine if the rate of flow increase was maintained under spring flows. Measurements on April 15 and 16 indicated that flow originating from the wetland made up only 4-5% of the UT flow as it crossed the Algonquin ROW.

The presence of fine to coarse sand on-site and a lack of vegetation maximizes the percent of precipitation which results in direct infiltration. In addition, the site is a topographic low point, serving as its own small catchment area where any potential runoff or snowmelt within the on-site perimeter infiltrates and recharges groundwater. This may explain both the large flow and large contaminant pickup observed in the UT between the wetland and the Algonquin ROW. It also indicates that, at least under post Corps-of-Engineers (COE) removal conditions, site groundwater does not substantially communicate with the wetland, while it does to a large degree with the UT south of the D-wells.

Groundwater elevations in observation wells OW-7S and OW-8S in the wetland were not significantly different for the surface water elevations indicating that the wetland does not act as a perched water table or a major receptor of groundwater outflow from the site. Groundwater flow patterns indicated in Figures 4-3 and 4-4 indicate that the wetland receives groundwater inflow from direct upgradient sources. Limited outflow and dispersion of contaminants from on-site contamination sources may influence the groundwater contamination in the wetland. In order to determine aquifer hydraulic heads at locations along the UT, three piezometers (PZ_1, PZ_2, PZ_3) were driven into the UT on August 1, 1986, as indicated in Figure 4-1. Bentonite clay was used to seal the drive pipe.

A significant groundwater hydraulic downward gradient was observed in PZ_1, indicating that the UT surface water is ponding upgradient from the causeway constructed for the installation of the D wells. Piezometer 2 was driven due east of the D wells which exhibited a slight 0.1 ft vertical upgradient relative to the surface water level. Piezometer 3 was driven near the Algonquin ROW stream gauging station through material which appeared to be resistive. No differences between the aquifer hydraulic head and surface water elevations were indicated at this location. During the limited August 4, 1986 monitoring, no perceptible surface water flow increases were estimated.

For the measurements that were made for the Copicut River, flows appeared to be stable during December 1985 and January 1986 ranging from 1773 gpm to 2199 gpm. Flows tripled during the April 15 monitoring, which was attributed to higher precipitation recharge and water table conditions.

Flows in Carol's Brook also remained stable in December and approximately tripled during the mid-April flow measurement. However, while the Copicut River appeared to increase only moderately (1773 gpm on December 23, 1985 to 2,101 gpm on January 21, 1986) due to the January 19 rainstorm and thaw, flow in Carols Brook increased from 555 gpm on December 23, 1986 to 3,942 on January 21, 1986. This may be due to peak discharge being attenuated by regulation at the Copicut Reservoir, located within one mile upstream.

In addition to flow measurement stations, several reference stakes were placed at various locations to determine if surface water in the vicinity of the site is perched or is an expression of the water table. It was also desirable to document whether surface water might seasonally be recharging groundwater. Measurements were made concurrently with groundwater measurements of wells, but are listed separately in Table 5-2B.

5.2.5 CONTAMINANT TRANSPORT

As stated in section 5.2.4, surface water quality data were collected to document current water quality conditions at areas contiguous with source areas and in areas where human receptors might be affected by contaminated conditions. Listed in Table 5-3 are surface water descriptions and frequency of sampling. Sample locations of surface waters and sediments are illustrated in Figures 5-3, 5-4 and 5-5. Water quality data is attached as Appendix C. A summary of PCB and total volatile organic analytic results by location and data collected are included in Table 5-4.

TABLE 5-3

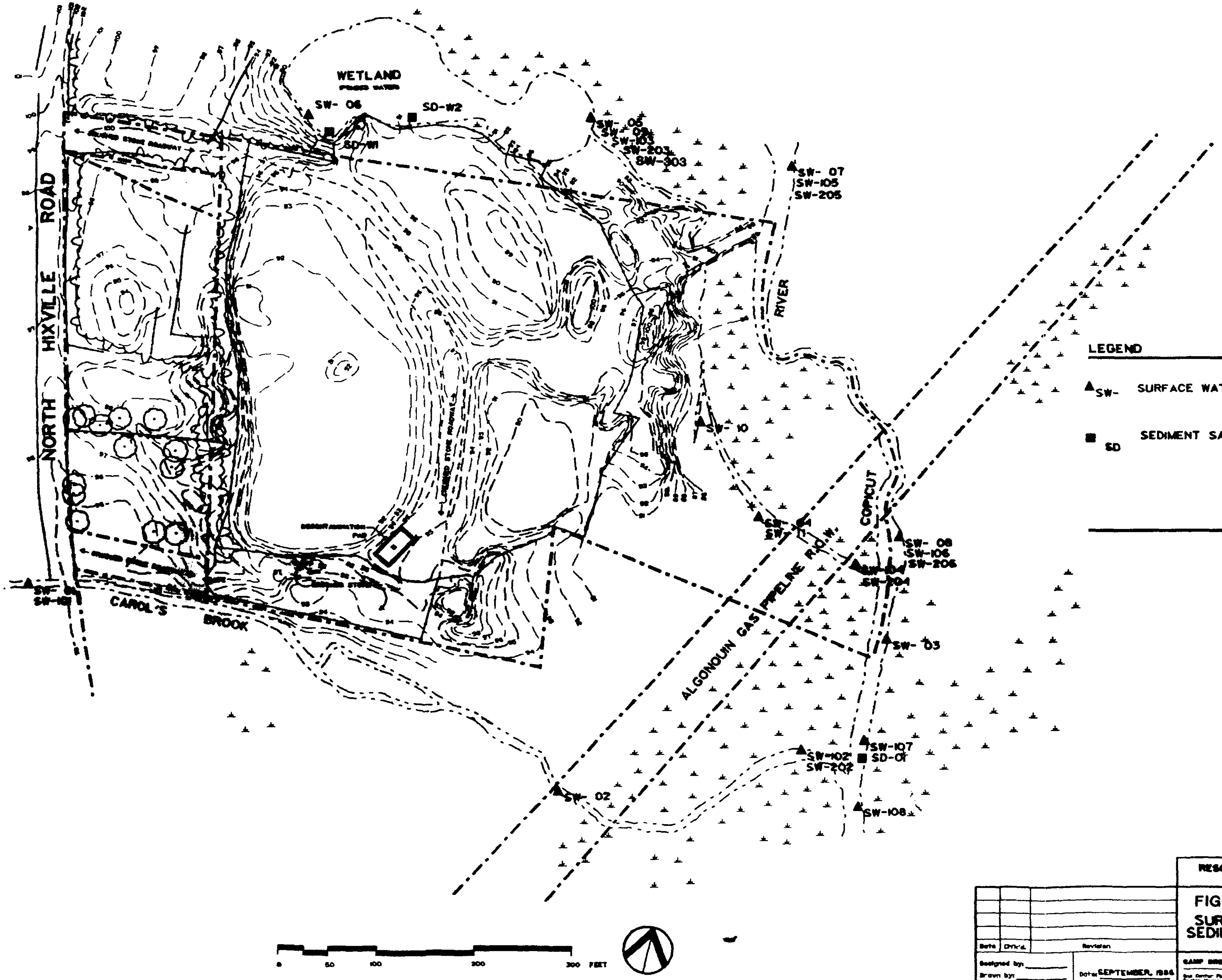
SURFACE WATER STATIONS DESCRIPTION AND FREQUENCY OF SAMPLING

Re-Solve Inc. Site November 1985 - July 1986

	Station No.	11/22/85[1]	11/26/85[1]	12/10-11/85[2]	1/16/86[2]	7/29/86[2]
Carols Brook						
Carols Brook at N. Hixville Rd.	01, 101	X		X		
Carols Brook at Algonquin Gasline	02	X				
Carols Brook just above outlet to Copicut River	102, 202			X	X	
Unnamed Tributary and Wetland						
Wetland at West End	06	X				
Wetland outlet	05, 09, 103, 203, 303	X	X	X	X	X
Unnamed Tributary 50′ below F-wells	10		X			
Unnamed Tributary at Algonquin Gasline	04, 11	X	X			
Unnamed Tributary just above Copicut River	104, 204			X	X	
Copicut River and Cornell Pond						
Copicut River adjacent to D-wells	07, 105, 205	X		X	X	
Copicut River 20′ above Unnamed Trib. inlet	08, 106, 206	X		X	X	
Copicut River between inlets of Unnamed Trib. and Carols Brook	03	X				
Copicut River just above Carols Brook Inlet	107			X		
Copicut River just below Carols Brook Inlet	108			X		
Copicut River at head of Cornell Pond	109, 209			X	X	
Cornell Pond west shore	110			X		
Cornell Pond at outlet	111			X		
Copicut River below Cornell Pond	112			X		
Copicut River just above Shingle Island River	113			X		
Shingle Island River and Noguochoke Lake						
Shingle Island River above Copicut River inlet	114			X		
Shingle Island River below Copicut River inlet	115			X		
Upper Noguochoke Lake	116			X		
Noguochoke Lake at I-195	117			X	X	

[1] -CLP Volatile Organics Only

[2] -Full CLP Hazardous Substance List (HSL) Organics and Inorganics



LEGEND

▲ SW- SURFACE WATER SAMPLING LOCATIONS

■ SD SEDIMENT SAMPLING LOCATIONS

ARCHITECTURAL	STRUCTURAL	ELECTRICAL	INSTRUMENTATION	HVAC	PLUMBING	PROJECT ENGINEER	PROJECT MANAGER
Approved by Date	Approved by Date	Approved by Date	Approved by Date	Approved by Date	Approved by Date	Approved by Date	Approved by Date

RESOLVE INC. HAZARDOUS WASTE SITE
NORTH DARTMOUTH, MASSACHUSETTS

FIGURE 5-3 NEAR SITE
SURFACE WATER SAMPLING &
SEDIMENT SAMPLING LOCATIONS

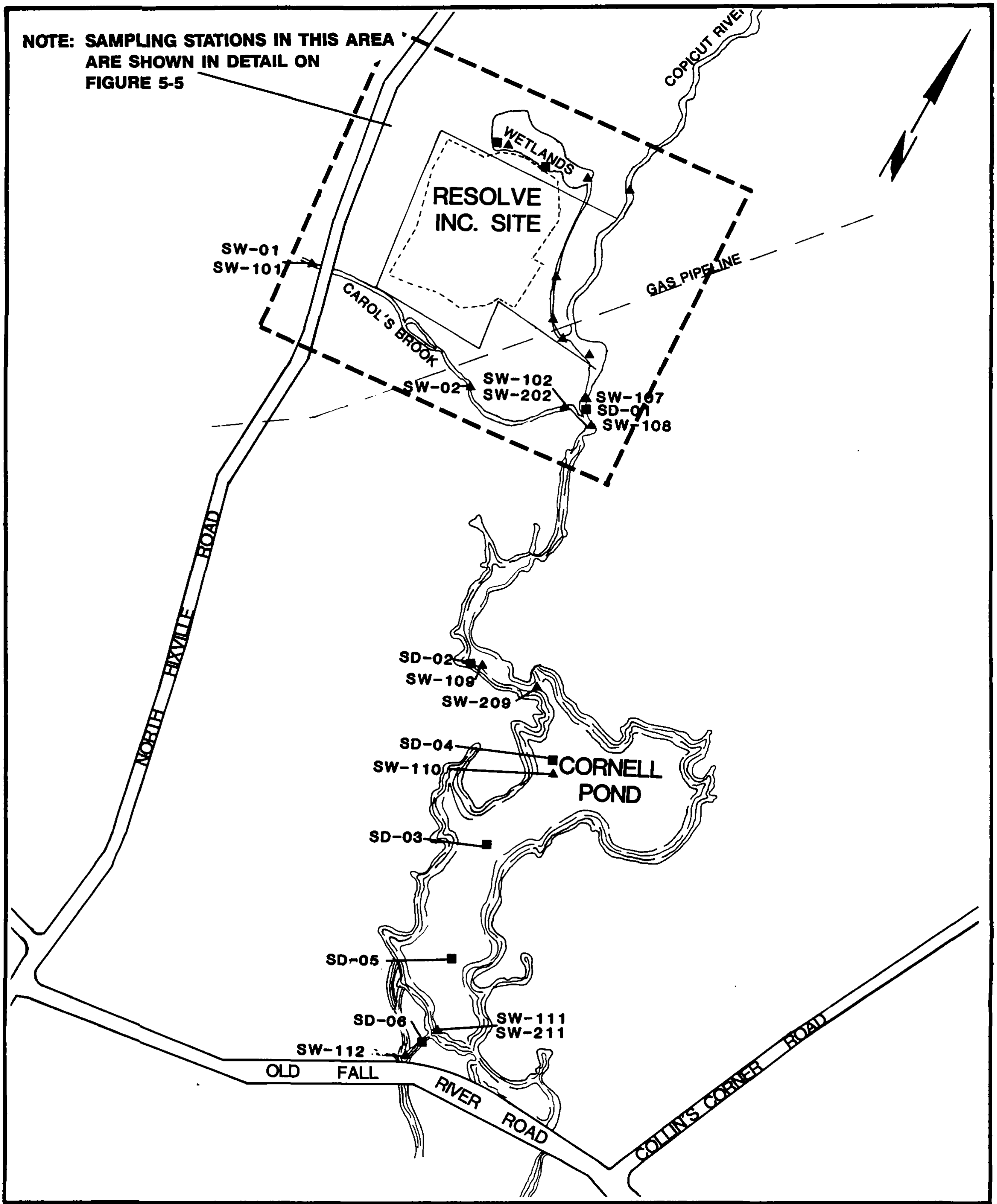
Date	Chk'd.	Revision

Designed by:______
Drawn by:______
Checked by:______
Approved by:______

Date: SEPTEMBER, 1986
Scale: AS SHOWN

CAMP DRESSER & McKEE INC.
One Center Plaza
Boston, Massachusetts 02108
CDM
environmental engineers, scientists,
planners & management consultants

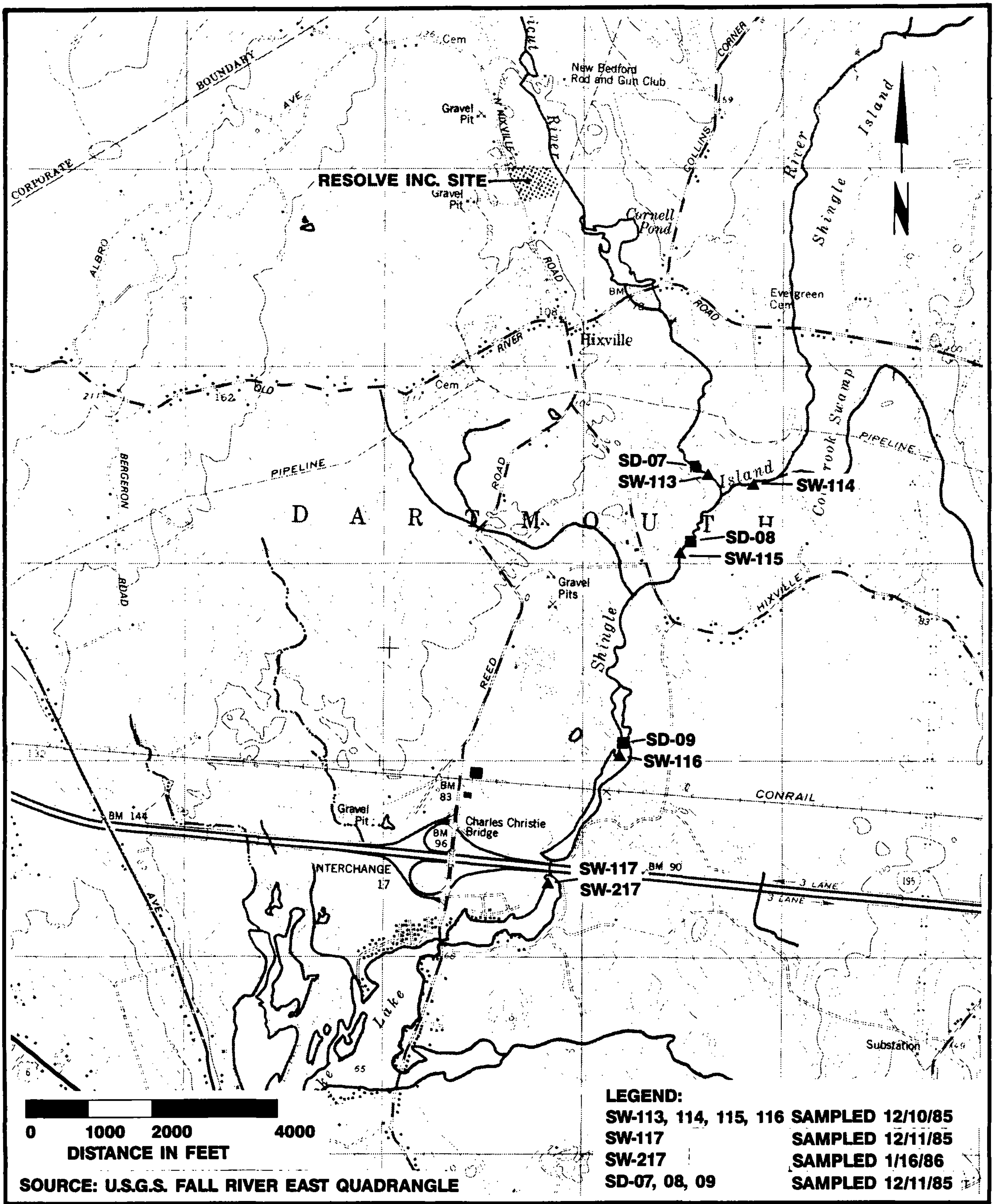
SHEET NO.



RESOLVE INC. SITE

NORTH DARTHMOUTH, MASSACHUSETTS
Camp Dresser & McKee
July 1986

FIGURE 5-4
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS - OFF SITE



LEGEND:

SW-113, 114, 115, 116 SAMPLED 12/10/85
SW-117 SAMPLED 12/11/85
SW-217 SAMPLED 1/16/86
SD-07, 08, 09 SAMPLED 12/11/85

SOURCE: U.S.G.S. FALL RIVER EAST QUADRANGLE

RESOLVE INC. SITE

NORTH DARTHMOUTH, MASSACHUSETTS
Camp Dresser & McKee
July 1986

FIGURE 5-5
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS – DOWNSTREAM

TABLE 5-4
SURFACE WATER ANALYTICAL RESULTS

CDM Sample No.	Sample Type	Location	Date Collected	Total PCB's	Total Volatiles
243-SW-01-047	Grab	SW-01	11/22/85	-	-
243-SW-02-048	Grab	SW-02	11/22/85	-	-
243-SW-03-049	Grab	SW-03	11/22/85	-	301.1
243-SW-03-050	Grab	SW-03	11/22/85	-	286
243-SW-04-051	Grab	SW-04	11/22/85	-	3,969
243-SW-05-052	Grab	SW-05	11/22/85	-	32
243-SW-06-053	Grab	SW-06	11/22/85	-	3,770
243-SW-07-054	Grab	SW-07	11/22/85	-	2
243-SW-08-055	Grab	SW-08	11/22/85	-	105
243-SW-09-056	Grab	SW-09	11/26/85	-	15
243-SW-10-057	Grab	SW-10	11/26/85	-	620
243-SW-11-058	Grab	SW-11	11/26/85	-	2,621
243-SW-101-001	Grab	SW-101	12/10/85	-	-
243-SW-102-002	Grab	SW-102	12/10/85	-	270
243-SW-103-003	Grab	SW-103	12/10/85	0.52	38
243-SW-104-004	Grab	SW-104	12/10/85	-	2,698
243-SW-105-005	Grab	SW-105	12/10/85	-	-
243-SW-106-006	Grab	SW-106	12/10/85	-	101
243-SW-107-007	Grab	SW-107	12/10/85	-	264
243-SW-108-008	Grab	SW-108	12/10/85	-	2,528
243-SW-109-009	Grab	SW-109	12/10/85	-	123
243-SW-110-010	Grab	SW-110	12/10/85	-	70
243-SW-111-011	Grab	SW-111	12/10/85	-	2,300
243-SW-111-012	Grab	SW-111	12/10/85	-	605
243-SW-112-013	Grab	SW-112	12/10/85	-	62
243-SW-113-014	Grab	SW-113	12/10/85	-	20
243-SW-114-015	Grab	SW-114	12/10/85	-	-
243-SW-115-016	Grab	SW-115	12/10/85	-	7
243-SW-116-017	Grab	SW-116	12/10/85	-	950
243-SW-116-018	Grab	SW-116	12/10/85	-	1,600
243-SW-117-020	Grab	SW-117	12/10/85	-	-
243-SW-202-021	Grab	SW-202	01/16/86	-	-
243-SW-203-022	Grab	SW-203	01/16/86	1.2	28
243-SW-204-023	Grab	SW-204	01/16/86	-	3,422
243-SW-205-024	Grab	SW-205	01/16/86	-	17
243-SW-206-025	Grab	SW-206	01/16/86	-	198
243-SW-209-026	Grab	SW-209	01/16/86	-	270
243-SW-211-028	Grab	SW-211	01/16/86	-	160
243-SW-211-029	Grab	SW-211	01/16/86	-	177
243-SW-217-027	Grab	SW-217	01/16/86	-	6
243-SW-303-003	Grab	SW-303	07/29/86	0.24	-
243-SW-303-004*	Grab	SW-303	07/29/86	-	-

Total PCB's and Total Volatiles are expressed in parts per billion (ppb).

*Filtered Sample.

While helpful in making quick general assessments, this table does not reflect the presence of high concentrations of anomalous compounds of which the total may be primarily composed. For example, 2300 ppb of methylene chloride was found at SW-111, collected on December 10, 1985. Methylene chloride was below standard detection limits when water from this location was resampled on January 16, 1986. Surface water was only analyzed for the full HSL organics and metals during the December 19, 1985 and January 16, 1986 sampling rounds. Screening samples collected on November 22 and 26 1985 were only analyzed for HSL volatile organics. Surface water quality measurements indicate that pH in the surface waters is generally less than 5.5 and specific conductance less than 65 umho/cm. Surface water pH measurements at the Copicut Reservoir by the Fall River filtration plant personnel indicate a pH generally less than 5.

The data reveals that the unnamed tributary plays a major role in the transport of contaminants off-site via surface water. At the wetland outlet, total volatiles ranged from 8-38 ppb over the four sample collections at that location with trans-1,2-dichloroethene predominating. Total volatiles jumped up to 753 ppb at SW-10 which is about 50 feet downstream of the F-wells. Total volatiles at SW-4 (11-22-85) and SW-11 (11-26-86) both at the Algonquin ROW were 3,969 and 2,238 ppb, respectively with trans-1,2-dichloroethene still dominant. Using the December flow increase data (15.5 to 36.8 gpm) presented in Table 5-2A, together with the increase of TVO (8 to 3969 ppb) presented in Table 5-4, it can be seen that the doubling of flow that occurs in the UT between the wetland and the Algonquin ROW results in over a thousand-fold increase in the mass transport rate of TVO. This represents groundwater outflow of contaminants from the contaminant plume upgradient and directly adjacent to the UT. In the Copicut, TVO contaminants have been consistently detected downgradient from the site and upstream from its confluence with the UT. This indicates that the Copicut is also a receptor of groundwater contaminant outflow from the off-site contaminant plume.

Table 5-5 presents a historical perspective of contaminant outflow to the surface waters and indicates the downstream migration of these contaminants.

TABLE 5-5

SELECTED SURFACE WATER CHEMICAL ANALYSIS DATA(1) (ppb)

	Total Volatile Organics			Tetrachloroethylene			Trans-1,2-dichloroethene			Trichloroethylene			Vinyl Chloride			Methylene Chloride			Toluene		
	83	84	85-86	83	84	85-86	83	84	85-86	83	84	85-86	83	84	85-86	83	84	85-86	83	84	85-86
Surface Water Location																					
Western Section of Wetland																					
SW-00	570						460												110		
C-19							140				47									20	
C-20		8,400			11			750			220			5			7400			6	
SW-06			3,770						1,900			460			110						
Eastern Section of Wetland																					
C-22		132						89			26									12	
SW-05			32						24			8									
SW-09			15						15												
SW-103			38						36												
SW-203			31						24			3									
Unnamed Tributary East of D Wells																					
SW-10	1,115						770						150			54			72		
C-11		8,219						780			78			6			7,100			59	
C-23		10,810						5,500			2,400			1,100						1,400	
Unnamed Tributary at Algonquin ROW																					
C-12		3,051			10			1,600			220			300							
SW-04			3,969						1,700			330			210						
Unnamed Tributary before confluence with Copicut River																					
SW-12	65						65		1,800												
C-13		3,963									180			470			56			720	40
SW-104			2,698						1,400				210								20
SW-204			2,500						2,000				170		350						

TABLE 5-5 (Cont'd)

SELECTED SURFACE WATER CHEMICAL ANALYSIS DATA (ppb)

	Total Volatile Organics			Tetrachloroethyelene			Trans-1,2-dichloroethene			Trichloroethylene			Vinyl Chloride			Methylene Chloride			Toluene		
	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85	83	84	85
Copicut River before confluence with Tributary																					
C-4		1,337						140			6			34			1,100			21	
SW-08			105						49												26
SW-106			101						59												
SW-206			98												55						
Surface Water Location																					
C-5		2,070						220			13			61			1,600			110	
SW-03			301						150			2			31						72
SW-107			148						110			11			27						
Copicut River downstream of confluence with Carol's Brook																					
		C-6	202						98						27			14		25	
SW-108					2,528													2.300			38

[1] 1983 surface water sampling occurred in January 1983
1984 surface water sampling occurred in January 1984
1985-86 SW-03 series sampled in November 1985
SW-103 series sampled in December 1985
SW-203 series sampled in January 1986

A further examination of Table 5-4 reveals that PCBs were detected on two separate occasions in surface water at the outlet of the wetland. Since PCBs are relatively insoluble in water at a range of 2.7 ppb - 15 ppb (U.S. EPA 1980) and total volatiles averaged 36 ppb in these samples, it was suspected that the PCBs were not in solution but were adsorbed onto silt, clay or anthropogenic materials which were collected incidental to the sampling of the surface water and were subsequently extracted by the analytical laboratory. Surface water samples were obtained at the outlet of the wetland at the SW303 location in July, 1985 and filtered (0.45 micron) and unfiltered samples sent for full HSL analysis. The unfiltered sample exhibited a 0.24 ppb PCB concentration and there was no detection of PCB contaminants in the filtered sample indicating that the PCBs exported out of the near-field study area by surface streams are adsorbed onto sediment particles.

A careful review of the data in Appendix C illustrates an additional point of interest. This involves the sporadic appearance of high quantities of methylene chloride in samples from a number of different locations. This may be attributed to laboratory or CLP sample bottle contamination. While methylene chloride is acknowledged as one of the principal contaminants (1,450 ppb in the old cooling pond), it's high vapor pressure (7 psi at 20°C) makes it unlikely that it could be present in concentrations of the same order-of-magnitude below Carols Brook, at the outlet of Cornell Pond and at Noguochoke Lake. In addition, it was not detected in samples taken immediately upstream and downstream, nor was it detected in a sample taken later at the downstream location.

Downstream detection of contamination in the surface water was generally most extensive during the January 16, 1986 monitoring period which was conducted during a groundwater baseflow period with minimal surface water dilution and minimal volatilization. At this time, approximately four inches of ice was found on portions of Cornell Pond with ice cover over lower sections of the Copicut River.

5.3 SEDIMENT SAMPLING PROGRAM

5.3.1 INTRODUCTION - OBJECTIVES

The objectives of the sediment sampling portion of the current investigation were to further delineate the degree and extent of contaminantion principally in Cornell Pond and downstream towards the Noquochoke Lake (primarily PCB contamination) and to assess transport mechanisms affecting sediment.

5.3.2 SEDIMENT CONTAMINANT DISTRIBUTION

Since PCBs were discovered throughout the ReSolve site with high concentrations in certain areas, a strong emphasis was placed on delineating all source areas and off-site areas with potentially unacceptable concentrations.

Since the first major study at ReSolve in 1982, there have been four major sediment sampling rounds, as indicated below:

Study	# Of Locations	Approximate Dates(s) Collected
On-site study (CDM 1983)	17	Fall 1982
Off-site study part 1	22	January 1984
part 2	51 (multiple depths)	November 6-20, 1984
(CDM February, 1985)		
Current Study	2	March 27, 1985
	9	December 11, 1985

In the initial on-site study, total volatile organics, phthalates and PCBs ranged from below detectable limits to hundreds of ppm. As might be expected, concentrations were highest in the area of the wetlands and the unnamed tributary and decreased with distance from the site. The Copicut River, while containing substantial volatile organic contamination, did not demonstrate PCB contamination. Carols Brook did show PCB contamination as well as volatile organic contamination throughout most of its length.

Sediment data from the off-site February 1985 study generally confirmed the results of the earlier study. As part of the February 1985 report a sampling effort performed in November, 1984 illustrated that PCBs were widespread in sediments at levels above 1 ppm. One sample from the Algonquin right-of-way had a concentration of 11.3 ppm. No PCBs were detected in sediments of Cornell Pond. Sediments from the UT had PCBs at concentrations up to 107 ppm.

The current sampling round of nine samples obtained in December 1985 and two samples obtained in March 1985 was designed to supplement earlier sampling efforts. Sediment sample locations are listed in Figures 5-3, 5-4 and 5-5, two samples obtained in the wetland. A summary of the PCB and volatile organic analytical results are included in Table 5-6 and Appendix C.

These samples provided HSL detection limit data for PCBs as well as the other full scan organics. From these data from samples obtained in the top 0.5 ft of the sediments, it can be seen that sediment contamination with volatile organics persists, but at lower levels. At locations SD-01 and SD-02 in the lower sections of the Copicut PCB and other organic contamination persists in the upper 0.5 ft of the sediment. Three of the four Cornell Pond sediment stations demonstrated PCBs with a high value of 1,102 ppb at SD-03 which is located at about the center of the pond. At sampling locations SD-06 and SD-07 downstream of Cornell Pond and before the confluence of the Shingle Island stream, PCBs and other organic contaminants in the upper sediment layer are evident. Downstream in the Shingle Island stream at sediment sampling locations SD-08 and SD-09, PCBs were not detected but other organic contaminants were.

It is apparent that organic contamination has been and may presently to a limited extent be transported from off-site vicinity of the ReSolve site via surface water and sediment pathways and/or is pervasive within the sediments with no appreciable siltation over the contaminated layers. It

TABLE 5-6
SEDIMENT ANALYTICAL DATA
RE-SOLVE SITE

CDM Sample No.	Sample Type[a]	Location[b]	Date Collected	Total PCB's (ppb)	Total Volatile Organics (ppb)
243-SD-01-001	Grab	SD-01	12/11/85	476	ND
243-SD-02-002	Grab	SD-02	12/11/85	240	170
243-SD-03-003	Grab	SD-03	12/11/85	1102	1239
243-SD-04-004	Grab	SD-04	12/11/85	32	112
243-SD-04-005	Grab	SD-04	12/11/85	ND	64
243-SD-05-006	Grab	SD-05	12/12/85	ND	418
243-SD-06-007	Grab	SD-06	12/12/85	15	78
243-SD-07-008	Grab	SD-07	12/12/85	34.2	181.6
243-SD-08-009	Grab	SD-08	12/11/85	ND	107
243-SD-09-010	Grab	SD-09	12/11/85	ND	230

NOTES:

a. Sample taken in top 0.5 ft of sediment.
b. As shown in Figures 5-3, 5-4 and 5-5.

appears likely tht the transport of organic contaminants to downstream areas will continue, especially during high flows. The possibility that contaminants could reach Noquochoke Lake cannot be ruled out.

5.4 WETLANDS CHARACTERIZATION

5.4.1 INTRODUCTION

This section provides an assessment of impacts from site contamination on the adjacent wetlands and a preliminary analysis of impacts from past and proposed remedial activities at the site. The content of this report is intended to comply with the EPA guidelines for conducting wetland/floodplain characterizations and impact assessments for CERCLA activities.

The following elements are considered in this discussion:

- Wetlands characterization
- Biological characteristics

Much of the information on drainage characteristics and contamination in sediments, surface water and groundwater was obtained from previous field studies summarized in the following reports:

- Camp Dresser & McKee Inc. "Remedial Investigation and Feasibility Study for ReSolve, Inc. Hazardous Waste Site, Dartmouth, Massachusetts." June 30, 1983.
- Camp Dresser & McKee Inc. "Off-Site Remedial Investigation" February 1985.

5.4.2 IDENTIFICATION AND BOUNDARY DELINEATION

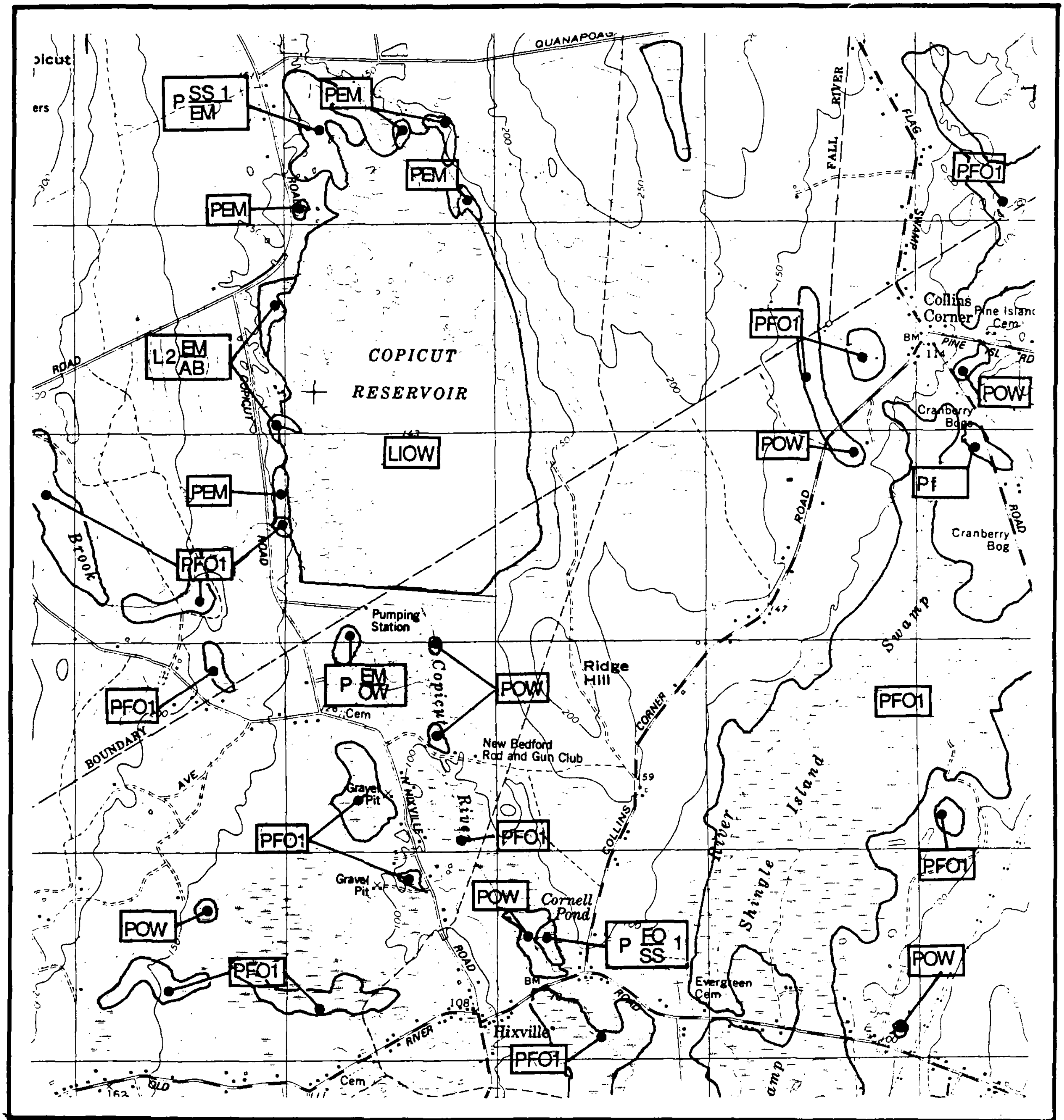
Wetlands are land areas which, because of their frequent inundation by surface or groundwater, can support vegetative or aquatic life requiring saturated soil conditions. Examples, include ocean coastlines, salt marshes and tidal streams, swamps, marshes, bogs, river overflows, mud flats, and natural ponds.

The wetland areas in the vicinity of the ReSolve site were identified using the USGS 7.5-minute topographic map of the Fall River East quadrangle, the U.S. Fish and Wildlife Service National Wetlands Inventory map (see Figure 5-6), and aerial photos taken in conjunction with ground level primary field investigation.

The wetlands discussed in this report cover a broader area than those addressed in previous studies. Past reports focused on the wetlands immediately north and east of the site, although sediment and water sampling was conducted in and near wetlands to the south of the site in the vicinity of Cornell Pond. This current study also addresses the wetlands south of the site that are in hydrologic connection to those adjacent to the site. The purpose of expanding on previous information is to better assess the extent of contamination and compare the characteristics of various wetland areas.

Site-specific mapping of wetland areas was completed with a compass and the pace method for ground verification of site conditions using high resolution color aerial photos. Classification of wetlands was accomplished in the field using the methods described in the USFWS manual Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al., 1978), which provides for a hierarchal system of wetland classification based upon physical and biological parameters.

The classification of the wetland areas according to the USFWS method is shown in Figure 5-6. A total of approximately 350 acres of various wetland types (exclusive of the Copicut Reservoir) adjacent to and downstream from the site were identified as part of this effort. Field observations were



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LEGEND

POW	Palustrine Open Water
PFO1	Palustrine Broad Leaved Deciduous
PFO/SS 1	Mixed Palustrine Broad-Leaved Deciduous and Deciduous Scrub Shrub
LIOW	Lacustrine Impounded Open Water
PEM	Palustrine Emergent

RESOLVE INC. SITE

NORTH DARTHMOUTH, MA
Camp Dresser & McKee Inc.

FIGURE 5-6

NATIONAL WETLANDS INVENTORY MAP VICINITY OF RESOLVE SITE

conducted in specific locations to characterize vegetation and general conditions in the immediate vicinity of the site. The major wetland systems are: POW, PFO1, PFO/SS 1, and LIOW. A discussion of the biological characteristics and functional value of these wetland systems is presented in the following two sections of this report.

5.4.3 WETLANDS EVALUATION

General Wetlands Characteristics

The area to the north and east of the site consists primarily of wetlands that drain the site via both surface water and groundwater. These wetlands may be classified as a shrub swamp, comprising such species as:

- highbush blueberry
- sphagnum moss
- sweet pepper
- swamp azalea
- tupelo
- red maple
- bur reed
- tufted sedges
- green briar

The wetlands are not attractive to recreational users because they are heavily overgrown with scrub and briars. However, they are still accessible and of environmental significance. Therefore, from both a public health and environmental standpoint, the quality of these areas is of concern.

The wetlands to the north of the site are separated from the contaminated lagoons onsite by a disturbed area containing some upland vegetation. The lagoon area drains to these wetlands which then discharge to an unnamed tributary that flows north and east to the Copicut River. The Copicut River is also the discharge point for groundwater which flows in a general easterly direction.

The following sections address existing wetland quality with respect to surface water and sediments.

Surface Water in Wetlands

In the CDM February 1985 study, a surface water sampling program was implemented to evaluate existing and potential future contamination to area surface water bodies, including wetlands. Four sampling locations (C-19, C-20, C-21, C-22) were established in the wetland north of the site.

Grab samples were collected from all locations and analyzed for:

- Volatile Organic Compounds
- Refractory Organic Compounds
- Heavy Metals
- Oil and Grease
- Total Halogenated Organic Compounds

Field measurements were made for temperature, pH, and specific conductance. As observed following the first round of sampling conducted in March 1982 (onsite study), contamination exists in the wetland and the unnamed tributary, as well as the Copicut River, downstream of the confluence with the unnamed tributary. Also, as observed previously, the contaminants consist largely of volatile organics, dominated by chlorinated hydrocarbons.

From the information indicated in the February 1985 investigation the wetland north of the site was found to be contaminated with volatile organics (Table 5-5), dominated by methylene chloride, observed at station C-20 at 7,400 ppb and 1,2-trans-dichloroethylene observed at station C-21 at 1,700 ppb. The unnamed tributary and the Copicut River were also both highly contaminated with volatile organics, dominated by methylene chloride (7,100 ppb at Station C-11).

The current study obtained surface water samples in the western part of the wetland at the SW06 location (Figure 5-3) and at the outlet to the wetland at SW05, 09, 102, 203, and 303 indicating high levels of TVO (3770 ppb at SW06 and >25 ppb at the outlet). Surface water contamination extends from the wetland north of the site, the unnamed tributary, and the Copicut River to the Copicut downstream of Cornell Pond. Surface water flow from the wetland, groundwater discharge to the unnamed tributary and Copicut River and subsequent downstream transport causes extensive contaminant migration in the surface water pathway from the site.

Sediments in Wetlands

As discussed in Section 5.3, sediment investigations were conducted in January 1984 (CDM, 1985) to assess the extent of offsite sediment contamination. The results of this investigation were evaluated in conjunction with data collected during the 1982 onsite RI to evaluate sediment contamination. An additional round of sampling was conducted in January 1984 to focus specifically on PCB contamination.

The sampling locations in the wetland north of the site during the January 1984 sampling round correspond to the surface water sampling locations identified in the CDM February 1985 study.

As part of the 1985 off-site RI, sampling was conducted at 15 locations in the wetland to the north of the site in January 1984. The results indicate that the highest concentrations of PCBs occur in this wetland, which formerly drained the onsite lagoons, and in the unnamed tributary, which drains the wetland.

All sediment samples were analyzed for the following parameters:

- Volatile Organic Compounds
- Refractory Organic Compounds
- Oil and Grease
- Total Organic Halogenated Compounds
- Inorganic Compounds

The sediments in the wetland north of the lagoons were found to be heavily contaminated with nonvolatile organic compounds, dominated by PCB compounds (with two observations measuring 60 and 32 ppm of PCB at stations C-19 and C-21, respectively) and phthalates (with two observations measuring 720 and

21 ppm at stations C-19 and C-20, respectively). In addition, significant levels of other extractable and volatile organics were found.

Specifically, the following was found:

- The entire wetland area north of the site is PCB-contaminated above 1 ppm to a depth of 1-1.5 feet with only four of 27 samples analyzed showing concentrations below 1 ppm. Two locations (SD 53 and 54) were sampled over the full 18 inch depth intended. These showed 4.9 to 10.8 ppm differences in concentrations over the 18 inch depth interval. Surface samples showed a maximum of 102 ppm.

- The unnamed tributary is highly contaminated with PCB compounds to a depth of one foot approximately 300 feet downstream from the outlet from the wetland but is less contaminated 150 feet further downstream to the Copicut River.

In March of 1985 two sediment samples were collected in the top 0.5 ft of the wetland at locations SDW1 and SDW2 as listed on Figure 5-3. These locations correspond to locations 52 and 48 presented in the February 1985 RI which indicated high PCB contaminant levels in the top 0.5 and 1 ft. of the wetland. The contaminant levels indicated in the SDW1 and SDW2 and presented in Appendix C duplicated PCB levels detected in the previous sampling event at levels of 110 and 55 ppm total PCB concentrations.

In addition, ethylbenzene was detected in the ppm range of the SDW1 location. Comparison of these two sampling events indicate that high contaminant levels exist and are pervasive in the upper layer of sediment in the wetland.

5.4.4 PHYSICAL AND HYDROLOGICAL CHARACTERISTICS

Results of soil sampling conducted in site work indicate that the sediments underlying the site and surrounding areas are stratified sand and gravels designated as glacial stratified drift. The glacial stratified drift varies between 20 and 30 feet in thickness in the site area. In the wetlands to the north and east of the site an approximate two foot thickness of peat overlies the glacial stratified drift. The underlying bedrock is comprised of granite and metamorphic rock.

As discussed in previous reports, the wetland bordering the northern site boundary forms the headwaters of an unnamed tributary which flows to the southeast, following the contours of the site's northeastern boundary. The tributary picks up substantial flow from small, perennially wet areas adjacent to the northeastern corner of the site which is downgradient of the site's overburden groundwater flow path. Tracing contaminants and surface water flow have lead to the conclusion that the unnamed tributary receives most of its flow from groundwater rather than from the wetland during a low precipitation, groundwater baseflow time period. A limited amount of groundwater from the site outflows to the wetland to the north of the site.

The unnamed tributary joins the Copicut River just past its crossing of the Algonquin gas pipeline right-of-way. Carol's Brook also joins the Copicut 220 feet below its confluence with the unnamed tributary. The Copicut River originates north of the site at the Copicut Reservoir and flows south through Cornell Pond (located about 1/4 mile south of the site) to the Shingle Island River. The Shingle Island River flows into Noquochoke Lake which forms the head of the East Branch Westport River at the lake outlet.

Groundwater flow in the site vicinity is to the east and southeast towards the unnamed tributary andd Copicut River. These two water bodies act as discharge zones for the overburden aquifer, as evidenced by the lack of contamination found in the overburden aquifer to the east of the Copicut River. However, contaminants in the bedrock aquifer have migrated to the eastern side of the Copicut, indicating that a portion of the contaminants in the bedrock aquifer is transmitted beneath the Copicut.

According to flow measurements taken by CDM in April of 1986, flow originating from the wetland accounted for only 4 to 5 percent of the tributary flow as it crossed the gas line. As mentioned previously, groundwater appears to be a major source of flow in the unnamed tributary. The large flow (and large contaminant pickup) observed in this tributary is attributable to groundwater recharge from the site. Because the site is a topographic low point, is comprised of medium to coarse sand, and is not vegetated, infiltration is maximized and groundwater recharge is significant.

The largest seasonal variation in flow was measured in Carols Brook. Measurements were stable during December 1985 and most of January 1986 but tripled in mid-April 1986. A similar increase was measured in the Copicut River during this time period. Further data was collected before and following a rainstorm and thaw on January 19, 1986. Flows in the Copicut River increased only slightly from December 23 to January 21 while flows in Carols Brook increased 7-fold. The difference may be attributable to flow regulation at the Copicut Reservoir.

5.4.5 BIOLOGICAL CHARACTERISTICS

Field studies were conducted in July 1986 in order to classify dominant vegetative types. A list of species identified in wetland areas adjacent to the site is presented in Table 5-7. In addition, a limited sampling of fish found in the Copicut River and Cornell Pond was conducted in December, 1985. Fish captured were analyzed for organic compounds and metals.

Rare/endangered species

No rare or endangered species have been reported within a 2-mile radius of the site, according to the Massachusetts National Heritage Program (Woolsey, 1985).

Fish Sampling Methods

Fish sampling was conducted at two stations downstream of the ReSolve site (Figure 5-7). Station One was located in the Copicut River, approximately 100 yards due east of the site where the river intersects the Algonquin ROW. Station Two was in Cornell Pond.

TABLE 5-7

FLORAL SPECIES IN THE RE-SOLVE WETLAND AREAS

COMMON NAME	LATIN NAME
white ash	*Flaxinus americana*
quaking aspen	*Populus tremuloides*
american elm	*Ulmus americana*
juniper	*Juniperis virginiana*
red maple	*Acer rubrum*
swamp white oak	*Quercus bicolor*
white pine	*Pinus strobus*
red oak	*Quercus rubra*
eastern hemlock	*Tsuga canadensis*
speckled alder	*Alnus rugosa*
arrow-wood	*Viburnum recognitum*
swamp azalea	*Rhododendron viscosum*
greenbrier	*Smilax rotundifolia*
silky dogwood	*Cornus amomum*
grapevines	*Vitis* spp.

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*Compilation of species for wetland areas based upon field observations June-July 1986.

TABLE 5-7 (Cont'd)

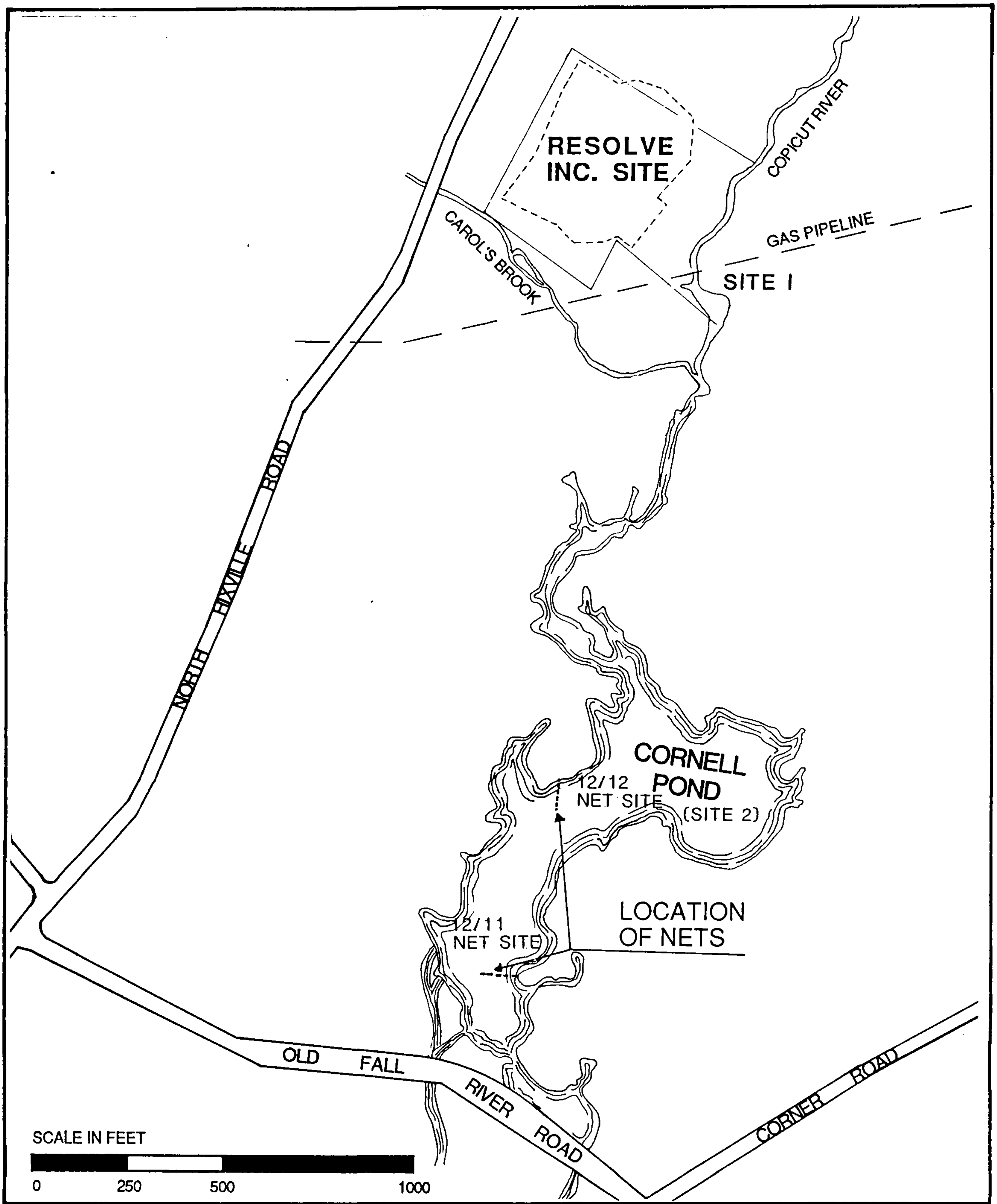
FLORAL SPECIES IN THE RE-SOLVE WETLAND AREAS

COMMON NAME	LATIN NAME
sweet pepperbush	Clethra alnifolia
winterberry	Ilex verticillata
spicebush	Lindera benzoin
witch-hazel	Hamamelis virginiana
brambles	Rubus spp.
skunk cabbage	Symplocarpus foetida
checkerberry	Gaultheria procumbens
sweet fern	Comptonia peregrina
poison ivy	Rhus radicans
jewel weed	Impatiens capensis
canada mayflower	Maianthemum canadense
tussock sedge	Carex stricta
sphagnum moss	Sphagnum sp.
interrupted fern	Osmunda claytoniana
royal fern	Osmunda regalis
sensitive fern	Onoclea sensibilis
marsh fern	Dryopteris thelypteris
spinulose woodfern	Dyopteris spinulosa
indian poke	Veratrum viride

TABLE 5-7 (Cont'd)

FLORAL SPECIES IN THE RE-SOLVE WETLAND AREAS

COMMON NAME	LATIN NAME
cat-tail	*Typha latifolia*
rush	*Juncus canadensis*
soft rush	*Juncus effusus*
wool glass	*Scirpus cyperinus*
blue flag	*Iris versicolor*
duckweed	*Lemna minor*
pickerel weed	*Pontederia cordata*
umbrella sedge	*Cyperus diandrus*
vervain	*Verbena hastata*
aster	*Eupatorium* spp.
gold thread	*Coptis Groenlandica*



RESOLVE INC. SITE

NORTH DARTHMOUTH, MASSACHUSETTS
Camp Dresser & McKee
July 1986

FIGURE 5-7
FISH SAMPLING LOCATIONS

Sampling at Station One was conducted on December 12, 1985 using a gasoline powered, back pack electroshocking unit. A river length of about 160 feet was shocked twice using a voltage of 350v which produced an amperage of 200 watts. This portion of the river has a width of about 16 feet and an average depth of about 2 feet. The fish at this station included; one brown bullhead (Ictalurus nebulosus) two eastern brook trout (Salvelinus fontinalis), four redfin pickerel (Esox americanus), and four american eels (Anguilla rostrata).

At Station Two (Cornell Pond), a variable mesh gill net 125′ long and 6′ deep was used to sample. The mesh sizes ranged from 1/2" to 1-1/4". The net was set in the morning and left overnight, then retrieved the next morning. This was done twice, once on December 11, 1985 and once on December 12, 1985. The fish caught on the first setting included; two chain pickerel (Esox niger), seven yellow perch (Perca flavescens), and 22 golden shiners (Notemigonus crysoluecas). On the second setting three chain pickerel, three brown bullhead, four yellow perch, and 25 golden shiners were caught.

In Appendix C, a list of fish sampling total length frequencies are presented which indicate species length and total weight of the unprocessed fish of that species in that days catch. Each fish collected was filleted with the skin on and composited relative to total weight of sample per species. Each of the two separate fillets per fish was wrapped individually with aluminum foil and then immediately stored on dry ice. Combined fish fillets per fish were then weighed before shipment with the individual fillets wrapped in aluminum foil. The fillets were then separated for separate organic and inorganic analyses and the combined total weight of the sample measured. Table 5-8 presents of list of the resulting samples and their weight.

The fish samples listed in Table 5-8 and in Appendix C (FS01001 through FS07008) were composited according to species, location, and feeding patterns.

TABLE 5-8

FISH TISSUE SAMPLES AND RESULTS OF ORGANIC ANALYSES

SAMPLE NO.	SPECIES	LOCATION	TOTAL WEIGHT OF SAMPLE (GRAMS)	ORGANIC COMPOUNDS DETECTED (ppb)				
				BIS (2-ETHYL HEXYL)PHTHALTATE	ISOPHORONE	1,2,4 TRICHLORO-BENZENE	AROCLOR 1248	AROCLOR 1254
FS01001	Golden Shiner	Cornell Pond	240		130			304
FS02002	Golden Shiner	Cornell Pond	260	470JB				330
FS03003	Brown Bullhead	Cornell Pond and Copicut River	101					1100
FS04004	Redfin Pickerel American Eel	Copicut River	74		1200	780J	10,000	10,000
FS05005	Yellow Perch	Cornell Pond	94					401
FS06006	Chain Pickerel	Cornell Pond	244				460	590
FS07007	Chain Pickerel	Cornell Pond	200		170J		260	
FS07008	Chain Pickerel (Duplicate)	Cornell Pond	217				390	

Notes:

The three Eastern Brook trout caught in the Copicut River were not included due to limited sample size.

All sample weights include foil wrap.

Fish Habitat Assessment

The habitat requirements of the species caught were consistent with the habitat observed at the two sampling stations, with the exception of the brook trout. Brook trout are primarily insectivorous. They prefer cool, fast moving streams. Those caught at Station One may not be year-round residents but rather transients from an uncontaminated tributary which joins the Copicut River or may also have moved down from an uncontaminated segment of the river.

Brown bullheads are bottom feeding omnivors (utilizing a wide range of food substances) which prefer ponds and sluggish streams with muddy bottoms. Redfin pickerel and chain pickerel are piscevores and insectivores. They are found in small streams, ponds, and marshes. American eels are benthic omnivores in streams and ponds, where they mature for between 5 and 20 years then return to sea to spawn. Yellow perch are omnivorous. They are found primarily in ponds and lakes, in which they exhibit schooling behavior. Golden shiners are schooling planktonic feeders. They are found in weedy ponds, in which they used the weeds for spawning and for cover. They are common forage for the larger predatory fish.

Fish Tissue Assessment

Results from the laboratory analysis showed that there was <10 ppm total volatile organic compounds detected in samples of the surface water. No volatile organic compounds were detected in fish tissue. Volatile organic compounds are not generally bioaccumulated in tissues and organs, although they may have been present at levels below detection limits or lost during sample preparation.

Two semi-volatiles compounds (isophorone and trichlorobenzene), were present in the fish samples from the Copicut River and in one golden shiner and one chain pickerel sample from Cornell Pond. Isophorone was not detected in any surface water, but was found in one sediment sample (SD-04). It was also detected in a number of observation wells (FW, JN, KS, 04S, 34S, 27D, 30S). Trichlorobenzene was only detected in the sediment at Station One in the Copicut River.

Limited information is available about isophorone except that it has a high water solubility and will remain in solution until removed biologically or photochemically. It is not significantly bioaccumulated (U.S.EPA, 1979).

Trichlorobenzene was found in the fish sample (FS04004) collected from the Copicut River at a concentration of 0.78 ppm. This chemical has a high potential for bioaccumulation in the lipids and tissues of organisms. The level found in the fish captured in the Copicut River suggests some form of bioaccumulation is occuring. Both the redfin pickerel and american eel feed on other fish species and are therefore higher in the food chain. The higher up the food chain a predator is, the more food is required to maintain body functions. Therefore, the more an organism eats the larger a dose of chemicals it receives.

One phthalate ester was found in the fish sample from Cornell Pond. This compound was not found in the water samples, but was present in the sediment samples from the Copicut River and Cornell Pond. Phthalate esters do not bioaccumulate in aquatic organisms and are readily broken down by aquatic organisms and bacteria. There is also some evidence that phthalate esters are produced by some organisms (Autian, 1973).

PCBs were found in one water sample from Cornell Pond and in sediment samples throughout the study area. They are readily adsorbed onto organic sediments and suspended particles. These compounds are strongly bioaccumulated and very resistant to biodegradation or breakdown in aquatic organisms. The highest levels of total PCBs in the fish samples collected were found in the american eel sample from the Copicut River (FS 06004) at a concentration of 20 ppm, and in the brown bullhead sample (FS 03003) from Cornell Pond, at a concentration of 1.1 ppm.

The US Food and Drug Administration has set a limit of 2 ppm as the safe level for eating PCB contaminated fish. However this level may be changing to 1 ppm in the very near future (Kimbal, 1986). Both the american eels and brown bullheads favor muddy bottom habitats which are highly contaminated at the ReSolve site. Concentrations of PCBs in the sediment samples ranged from 1.5 ppm to 9.9 ppm. Feeding on macroinvertebrates, such as worms and insects, which feed on bottom detritus, the eels and bullheads are high on the food chain and have concentration levels of PCB's in the tissues, comparable to those levels present in the sediments. The levels in these bottom feeders are relatively high, but the levels in the pelagic (open water) species were well below the USFDA limit. The pickerel samples had total levels between 0.26 ppm and 1.05 ppm, the yellow perch sample had a level of 0.40 ppm, and the golden shiners samples had levels of 0.30 ppm. These results also exhibit biomagnification. The pickerel, being the predator highest on the food chain feeds on shiners and perch. The perch feed on shiners and zooplankton, and the shiners feed on insects and zooplankton only. Levels detected in the gamefish were below USFDA permissible levels, but with further bioaccumulation they could increase beyond the USFDA safety levels.

Fish tissue samples were analyzed for concentrations of 24 metals. Only mercury was present in concentration levels above the USFDA limit for safe consumption of 1.0 ppm. The mercury concentrations ranged from 0.4 to 4.2 ppm, although the latter value was found in a duplicate of a sample having a concentration of 0.4 ppm, and therefore may be inaccurate. The second highest concentration was 2.9 ppm. Bioaccumulation of mercury occurs in aquatic organisms through direct absorption from the water and through ingestion of animals lower in the food chain. (USDC, 1979)

5.4.6 WETLANDS FUNCTIONAL VALUE

Water Quality

Surface water contamination attributed to the site is limited for the most part to the wetland north of the site, the unnamed tributary, and the Copicut River downstream from the unnamed tributary.

The unnamed tributary contributes significantly to the offsite transport of contaminants via surface water. From the data presented, doubling of flow in this tributary results in approximately a thousand-fold increase in the contaminant transport rate. At the wetland outlet, total volatiles ranged from 8 ppb to 38 ppb during four sampling rounds with trans-1,2-dichloroethane predominating. At the Algonquin ROW, total volatiles ranged from 2,238 ppb in November 1985 to 3,969 in November 1986.

PCBs were also detected in the surface water at the wetland outlet. Data suggest they were not dissolved, but were adsorbed onto silt, clay or anthropogenic materials collected incidental to surface water sampling. However, these data still indicate that PCBs are being transported out of the near-field study area by surface water streams.

Sediment Quality

Concentrations of volatiles, phthalates and PCBs are highest in the area of the wetlands on the northern site boundary and the unnamed tributary and decrease with distance from the site, according to the initial 1982 onsite sampling program. The Copicut River did contain substantial volatile organic contamination but did not demonstrate PCB contamination. Carols Brook was contaminated with both PCBs and volatiles through most of its length according to 1982 data. These 1982 data were confirmed in the 1984 NUS offsite study (CDM, 1985). PCBs are also found in sediments of Cornell Pond.

The major conclusion that may be drawn from most recent data is that organic contamination continues to be transported from the vicinity of the ReSolve site associated with organic particulate matter in stream sediment. Volatiles contamination is still associated with the sediment but at less signficant levels than previously measured. Transport of contaminated soil via surface runoff does not appear to pose a problem due to the on-site excavation patterns and high infiltration rates in the sandy soil.

Wetlands Flood Storage Capacity, Recharge, Discharge, Low Flow Modulation

Wetlands to the north and east drain the site vicinity via surface water and groundwater. As previously described, these wetlands discharge into the unnamed tributary of the Copicut River. Flow studies suggest that this wetland area supplies only 4 to 5 percent of the flow in this tributary.

Aesthetic, Recreational, Education Value

The wetlands to the immediate north and east of the site are relatively inaccessible due to the preserve of catbriar and areas of standing water. It is possible to walk across some wet areas of the wetland where sphagnum moss is thick but, because of the surrounding catbriar, public access would be difficult. Therefore, use of this area as a recreational resource is probably very limited. Because of its proximity to the site, some members of the New Bedford Rod and Gun Club may venture into the northern section of the wetland. The aesthetic value of the north and east wetlands is also limited because of the dark orange-colored water.

5.5 FLOODPLAIN ASSESSMENT

Floodplains are relatively flat areas or lowland adjoining the channel of a river, stream or water course that have been or may be covered by floodwater.

Based upon flood-plain maps provided by the Federal Emergency Management Agency (FEMA), the site itself is not subject to flooding. Site elevations are up to 10 feet higher than surrounding areas and consist of sandy, well-drained soils.

The area to the north and east of the site is a wetland and is prone to flooding. Local flooding was observed on numerous occasions while site investigations were being conducted especially during the April 14, 1984 monitoring period listed in the February 1985 CDM report. The water level in the wetland north of the site fluctuates with precipitation periods. Water also ponds regularly along the power line right-of-way between the unnamed tributary and Carol's Brook during wet periods at SB 901 and 902 locations. A surface soil sample taken at SB 902 indicated low levels of contamination.

Flooding can result in the transport of contaminated soils and sediments to areas outside of the stream channels where they become available for direct contact after flood waters recede. There is also the potential for exposure to contaminated water at the surface that has ponded as a result of flooding.

Section 6

6.0 RESIDENTIAL WELLS

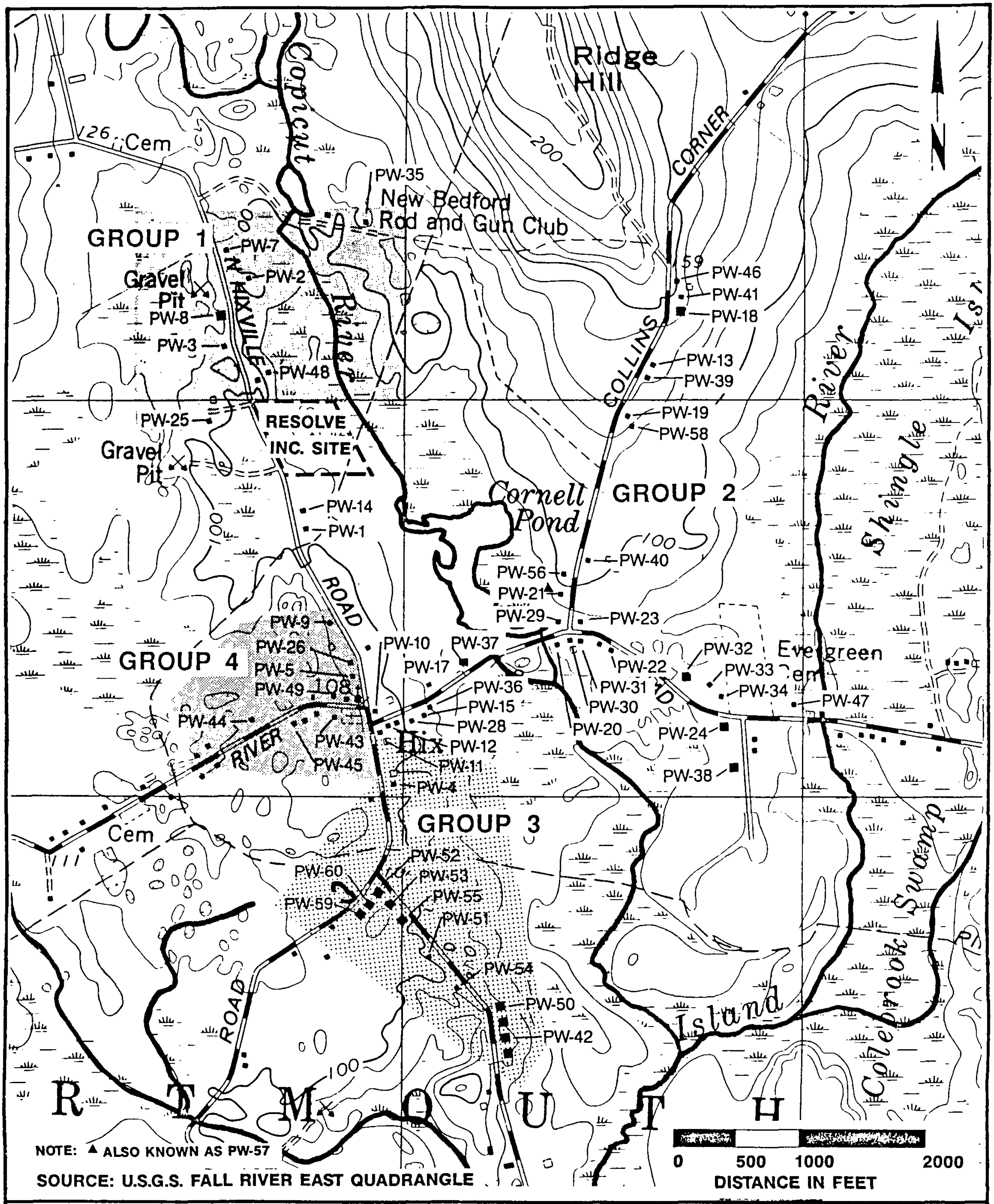
6.1 INTRODUCTION

Between 1985 and 1986, a total of 56 residential wells have been sampled by the U.S. EPA as part of this Remedial Investigation (RI) for the ReSolve site. These wells, which are located within approximately a one mile radius of the site, derive their water from the overburden and bedrock aquifers. Of the 56 residential wells sampled, 14 have shown low level organic contamination. In addition, four wells were found to contain inorganic lead in excess of the EPA's maximum contaminant levels (MCLs) allowed in drinking water supplies.

It is EPA policy to sample wells repeatedly before conclusions are drawn as to the origins of contamination and the contaminant levels to be used for determining risks associated with the consumption of the water. This is done to observe seasonal flucuations of the concentration of contaminants and to confirm the results which approach analyzing instrumentations detection limits. Although there were three sampling rounds, (1) November 1985 - January, 1986, (2) March, 1986 - May, 1986, (3) November 1986, there was little repetition of contaminants from one well to the next, even when residences are located in close proximity to one another and wells are of similar depths.

Three sources of residential well water quality information were available for use in this study: 1) the results of sampling and analysis conducted by EPA as part of the 1985-1986 Supplemental RI program, as mentioned above 2) the results of analysis conducted in conjunction with the Phase II, off-site investigation completed in February of 1985, and 3) the Phase I, on-site investigation completed in 1983.

Contaminant concentrations associated with individual wells are discussed in Subsections 6.4 and 6.5. Figure 6-1 shows the locations of residences sampled as part of this RI. A public health evaluation of the compounds detected in the wells is presented in Section 8.0. Appendix D contains all



NOTE: ▲ ALSO KNOWN AS PW-57

SOURCE: U.S.G.S. FALL RIVER EAST QUADRANGLE

RESOLVE INC. SITE

NORTH DARTHMOUTH, MASSACHUSETTS
Camp Dresser & McKee
July 1986

FIGURE 6-1
LOCATIONS OF RESIDENTIAL WELLS SAMPLED

of the analytical results of the samples collected from the residential wells.

6.2 DEPTH OF WELLS

The depths of the wells sampled range from hand dug wells of 9 feet to 15 feet to drilled wells with maximum depths of 525 feet. Thus, groundwater is derived from the surficial and bedrock aquifers. Information on well depths was obtained from interviews with residents.

In the vicinity of the ReSolve Site, the geology is such that as compounds infiltrate the groundwater aquifers they may reach a bedrock fracture, which may result in their being transported long distances from the site. On the other hand, contaminants in the overburden are more susceptible to dilution and adsorption within the soil matrix and are generally not transported as far. Also overburden wells (shallow wells) are inherently more susceptible to surface spills. If this was a source of contamination, it would be more likely to effect an overburden well than a bedrock well. If a shallow well is located far from a site and has been found to contain contaminants, then contamination from a localized source may be a possibility. Consequently, the effect of a pollutant source on a well is dependent upon its distance from a source, its depth and the geology of the area.

While the presence and concentration of contaminants is affected by the generalities expressed above, the actual transport of the chemicals within the overburden or bedrock aquifers is largely subject to horizontal or vertical hydraulic gradients within the aquifers. Also the contaminant's transport, dispersion and diffusion characteristics within the aquifer are largely dependent on its chemical properties, characteristics of the soil matrix and extent of the fracture of the bedrock, in addition to the hydraulic pressures or gradients driving the contaminants downgradient within the overburden and bedrock aquifers.

It should be noted that, unlike monitoring wells, there are many unknown residential well construction details, i.e. depth of seals and screens and in bedrock wells, and the location and form of fractures from which the water is withdrawn. Therefore, the depth from which water is actually obtained may not be the depth to which the well was drilled.

6.3 POTENTIAL OFFSITE CONTAMINANT SOURCES

Any assessment to attribute contamination to sources other than the ReSolve site needs to be based on knowledge of the direction of groundwater flow, type of contaminant, depth of well, location of potential off-site contaminant sources; such as auto salvage yards, underground abandoned gasoline tanks, and backyard spills; distance from the site, information gathered in the field through observation and interview with residents and sampling procedures. This type of background information was utilized in the evaluation of the analytical data. However, without further investigation into the potential localized sources and geohydrology in the near vicinity of each well, a definitive determination as to the origin of contamination associated with the individual private wells cannot be made.

6.4 HISTORICAL DATA

Six private wells along North Hixville Road and Old Fall River Road were sampled by DEQE December 10, 1981. It was reported that there were no violations of the National Primary Drinking Water Standards maximum contaminant levels (MCLs). In January 1983, EPA sampled five private wells tested by the DEQE plus the well PW-48. The analytical results showed that well PW-48 contained 6.1 ppb trichloroethylene and 2-hexanone was identified below the analytical detection limit. No organic contaminants were detected in the other wells.

According to the Off-Site Investigation Report completed in 1985, six private wells (PW-01, PW-14, PW-15, PW-36, PW-42 and PW-48) were sampled. Methylene chloride and trichloroethylene were identified below analytical detection limits at PW-14 and PW-48 respectively. No lead was detected in any well during this sampling.

6.5 CURRENT DATA

In evaluating the data and for record-keeping purposes, individual wells were organized based on their proximity to one another and to the site. This resulted in four groups which are shown in Table 6-1. Group 1 includes wells which are located north of the site on North Hixville Road. Group 2 includes wells which are located east and southeast of the site along Collins Corner Road and Old Fall River Road. Group 3 wells are located to the south of the site along Reed Road and Hixville Road. Group 4 wells are located to the southwest of the site along North Hixville Road and Old Fall River Road (west of its intersection with North Hixville Road). In the following sections, the concentrations of contaminants detected are presented along with a discussion of the possible causes of contamination. The discussion includes information such as the depth of well, distance from the site,other known potential contaminant sources and specific chemical properties of the contaminants which indicate their mobility.

6.5.1 GROUP NO. 1

The seven wells in this group are located north of the site. All seven wells are upgradient of the site, in other words groundwater is generally moving away from these wells towards the site. As shown in Figures 4-3 and 4-4, the groundwater from the site is generally moving to the east and southeast. Refer to Section 4.0 for a detailed discussion of the site hydrogeology. Of the seven wells, three (PW-03, PW-25 and PW-48) showed organic contamination. One well (PW-03) also contained the inorganic, lead, at higher than U.S. EPA National Primary Drinking Water Standards maximum contaminant level (MCL). The contamination in these wells is not likely to have originated from the site, because they are upgradient wells. However, since PW-48 has had a history of contamination, is approximately 200 feet from the site and is very deep, the potential for contamination via the site exists.

Well PW-03, which is 12 feet deep, was sampled three times, November 14, 1985, March 28, 1986 and November 18, 1986. In the first round it contained 28 ppb of 2-Butanone (methyl ethyl ketone) and a trace (detected below the

TABLE 6-1

RESIDENTIAL WELLS SAMPLED

Group 1	Well Depth (feet)
PW-2	--
PW-3	12
PW-7	40+
PW-8	88
PW-25	--
PW-35	--
PW-48	268
Group 2	
PW-46	203
PW-41	525
PW-18	--
PW-13	--
PW-39	--
PW-19	--
PW-58	50
PW-40	120
PW-23	25
PW-32	9
PW-33	--
PW-34	--
PW-47	±180
PW-24	180*
PW-38	--
PW-22	50-100*
PW-31	--
PW-30	--
PW-20	--
PW-29	175
PW-21/PW-57	160*
PW-56	10-12
PW-36	220
PW-15	110
PW-28	110
PW-12	--
PW-37	--
PW-17	--
PW-10	--
PW-01	--
PW-14	10

Notes:

See Figure 6-1 for sampling locations.
Well Depths obtained from resident interview by EPA's contractor.
- :unknown depth
* :artesian well

TABLE 6-1 (Cont'd)

RESIDENTIAL WELLS SAMPLED

Group 3	Well Depth (feet)
PW-11	50-60
PW-04	15
PW-52	--
PW-53	300
PW-50	110
PW-42	155
PW-54	85
PW-51	284*
PW-55	28
PW-60	20-25
PW-59	*
Group 4	
PW-09	--
PW-26	24
PW-05	25
PW-49	±47
PW-43	--
PW-44	90
PW-45	90

Notes:

See Figure 6-1 for sampling locations.
Well Depths obtained from resident interview by EPA's contractor.
- :unknown depth
* :artesian well

EPA contract required detection limit (CRDL's)) of tetrachloroethylene (perchloroethylene). In the second round, neither compound was detected. In the third round, tetrachloroethylene was detected below the analytical detection limit. This last value is highly suspect due to the very low level laboratory reading below 1 ppb and could not be confirmed. The chemical compound 2-butanone is used as a solvent in introcellulose coatings and vinyl films, in paint removers and in cleaning fluids. The compound tetrachloroethylene is commonly used as a dry-cleaning solvent, a vapor-degreasing solvent and a drying agent for metals. Lead was also detected in the well at a value of 61 ppb which is greater than the MCL of 50 ppb. It also exceeds the proposed maximum contaminant level goal (MCLG) of 20 ppb. (Refer to Section 6.7 for an explanation of MCLs and MCLGs). There is an auto salvage yard located upgradient of the well which is a potential source of contamination.

Well PW-25, which is of unknown depth, was sampled three times, on December 15, 1985, March 28, 1986 and November 18, 1986. No contaminants were detected during the first sampling round. It contained an estimated 27 ppb of n-nitrosodiphenylamine in the second sampling round but nothing was detected in the third round. N-nitrosodiphenylamine is used to accelerate the hardening of rubber during its production. It is suspected that this sample was cross-contaminated during the second round, when on-site soil samples were collected which were found to contain n-nitrosodiphenylamine (120 ppb). N-nitrosodiphenylamine was not detected in any on-site or off-site observation well.

Well OW-48, which is 268 feet deep, was sampled once, January 16, 1986. It contained a trace of di-n-butylphthalate. Di-n-butylphthalate is widely used as a plasticizer. It was found on site at a maximum concentration of 260 ppm at SB-02, 560 ppm at TP-01, and detected in on-site well OW-30S at 34 ppb. This well also showed 6 ppb trichloroethane and a trace of 2-hexanone in the on-site RI and a trace of trichloroethane in the off-site RI.

Well PW-07 contained an estimated 31 ppb of lead which exceeds the 20 ppb MCLG for lead.

6.5.2 GROUP NO. 2

Thirty-one wells located downgradient, to the southeast and east of the site, were sampled. The Copicut River has characteristics of a hydraulic boundary in regards to groundwater flow. Consequently, the overburden contaminant migration plume discharges, almost entirely, into the Copicut River and the Unnamed Tributary which is also in the path of the plume. Therefore, flow is mostly east into the Copicut River and then south. Contaminants in the bedrock aquifer do not entirely discharge to the Copicut as illustrated by contaminant detection in observation wells W6D and W4D and south of Carol's Brook in W-5D. Due to the flow direction patterns, the wells to the southeast of the site are considered to be directly downgradient of the site and the wells to the east of the site are not considered directly downgradient. Of the 31 wells, five (PW-13, PW-15, PW-29, PW-30, PW-47) showed organic contamination. Two wells (PW-01 and PW-28) contained lead at higher than the MCL for lead. Since these wells are located downgradient of the site, they can potentially be effected from site contamination.

Well PW-13, which is of unknown depth and located 2,500 feet east of the site, was sampled once on November 22, 1985. It contained a trace of phenol. Phenol was detected in on-site soil at maximum concentrations of 9.3 ppm (SB-29) and 63 ppm (TP-01). The well OW-DE was reported to have a concentration of 120 ppb and the off-site observation well OW-W5D contained 5 ppb.

Well PW-15, which is 110 feet deep and located southeast of the site, was sampled twice on November 22, 1985. It contained a trace of phenol in one sample, and in the duplicate sample nothing was detected.

Well PW-29, which is 175 feet deep and approximately 2,000 feet southeast of the site, was sampled three times, December 5, 1985, May 8, 1986 and November 18, 1986. It contained 6 ppb 1,2-dichloroethane in the first round and nothing was detected in the two subsequent rounds. The contaminant 1,2-dichloroethane was found in on-site soil at maximum concentrations of .84 ppm (SB-22) and 300 ppm (TP-02), but not detected in any on-site or off-site observation wells.

Well PW-30, which has an unknown depth and is located approximately 2,000 feet to the southeast of the site, was sampled four times, December 5, 1985, May 8, 1986 and November 18, 1986. In the first round it contained 5 ppb benzene in one sample and a trace of benzene in the duplicate sample. In the second round, nothing was detected and in the third round a trace of 1,1,1-trichloroethylene was reported below the requested 1 to 2 ppb detection limit. This last value is highly suspect due to the very low level laboratory reading below 1 ppb and could not be confirmed. Benzene was found in on-site soil at maximum concentration of .1 ppm (SB-22) and 1,700 ppm (TP-03), detected in on-site well SB-30 at 1,000 ppb and not detected in any off-site observation well. The contaminant 1,1,1-trichloroethylene was found in on-site soil at a maximum of 56 ppm (SB-31) and not detected in any on-site observation well but was detected off-site in observation wells OW-W6D at 400 ppb and OW-W4D at 3 ppb.

Well PW-47, which is 180 feet deep and is located approximately 3,900 feet southeast of the site, was sampled once on December 20, 1985. It contained 7 ppb di-n-Octyl phthalate. Di-n-Octyl phthalate was found in on-site soil at a maximum of 2.2 ppm (SB-25) and was not detected in any on-site observation well.

The wells PW-01 and PW-28 showed 108 ppb and 241 ppb of lead respectively. These concentrations exceed the MCL for lead which is 50 ppb. Also the wells PW-10 and PW-29 contained an estimated 26 ppb and 22 ppb of lead respectively which exceeds the proposed MCLG of 20 ppb.

6.5.3 GROUP NO. 3

There are 11 wells located to the south of the site and group 2 wells along Reed Road and Hixville Road which is over 0.5 miles downgradient of the site. Of these, three wells (PW-04, PW50, PW-51) showed organic contamination. One well (PW-11) contained lead at higher than the MCL. Although they are over a half mile away, because they are downgradient bedrock wells, a potential exists for contamination via the site. Since contamination in the wells are relatively immobile extractables and over 0.5 miles from the site, this possibility is very remote.

Well PW-04, which is a hand dug, 15 foot well and located approximately 2,600 feet south of the site, was sampled twice, November 14, 1985 and March 27, 1986. It contained a trace of 1,1,1-trichloroethane in the first round and nothing was detected in the second. The compound 1,1,1-trichloroethane is a common solvent for cleaning precision instruments, metal degreasing and textile processing.

Well PW-50, which is 110 feet deep and located approximately 4,300 feet south of the site, was sampled twice, March 26, 1986 and November 18, 1986. It contained an estimated 31 ppb n-nitrosodiphenylamine, a trace of di-n-butylphthalate and a trace butylbenzylphthalate in the first sampling round but nothing was detected in the second sampling round. The n-nitrosodiphenylamine is suspected to be due to cross-contamination during the second round, when on-site soil boring was conducted the same week as the private well sampling on soil containing n-nitrosodiphenylamine up to 120 ppb. Butylbenzylphthalate was found in on-site soil at a maximum of 2.0 ppm (SB30) but was not detected in any observation wells. Well-51, which is 284 feet deep and located approximately 3,900 feet from the site, was sampled once, March 26, 1986. It contained a trace of butylbenzylphthalate.

These are the farthest residential wells from the site that were sampled. They contained butylbenzylphthalate which is the least soluble and has the largest soil sorption coefficient of the compounds detected in the residential wells. A localized spill area was identified in the vicinity of these wells but none of the compounds found in the wells were detected in the spill area. The phthalates found in the wells are widely used as plasticizers and may be a field contaminant from rubber gloves routinely worn during sampling.

Well PW-11 contained 106 ppb of lead which exceeds the MCL for lead of 50 ppb. Also, PW-04 contained an estimated 31 ppb lead which exceeds the proposed MCLG.

6.5.4 GROUP NO. 4

The seven wells in this group are located to the southwest of the site are not downgradient of the site. Three of these, (PW-26, PW-44 and PW-49) were contaminated. PW-26 is a 24 foot deep well which was drilled 4 feet into the bedrock, PW-44 is a 90 foot deep well which is cased to rock, and PW-49 is approximately 50 feet deep. The contamination in these wells is not likely to have originated from the site, because they are not downgradient of the site.

PW-26 was sampled three times, December 5, 1985, March 8, 1986, and November 18, 1986. It contained 9 ppb of benzene in the first round and no contaminants were detected in the subsequent rounds. Well PW-44 was sampled three times, December 12, 1985, March 8, 1986 and November 18, 1986. It contained a trace of toluene in the first round. In the second round it contained 180 ppb (estimated value) methylene chloride. This value is most likely overestimated due to laboratory blank contamination. In the third round, 1.6 ppb carbon disulfide was detected. However, this value is highly suspect due to the very low level detected. PW-49 was sampled once, November 16, 1986. It contained a trace of chloromethane. Toluene is a common solvent for paints, gums, oils and rubbers and is a gasoline additive.

PW-49 and PW-44 are upgradient 700 and 200 feet respectively, from an underground gasoline tank on the property where well PW-43 is located. While this tank could be a source of contamination, well PW-43 did not contain any contaminants.

6.6 DIFFERENCES IN ANALYTICAL RESULTS

When low levels of contamination are detected in residential wells the factors described below could lead to inconsistencies in the results. Residential wells may have been in use before samples were obtained, i.e. washing machines or showers, which could in turn effect the sampling results. Heavy use by a resident will purge the well and may result in different concentrations than if the well had remained inactive other than running the tap immediately prior to sampling.

An examination of the groundwater elevations collected from monitoring wells from November 26, 1985 until April 16, 1986 indicate there were no significant general changes, i.e. all of the wells did not indicate a dramatic seasonal change in the groundwater table. However, on an individual basis, fluctuations were recorded as much as 0.8 feet. Therefore even though the groundwater table stays at a fairly constant level, fluctuations on an individual basis were noted and such fluctuations in turn may effect sampling results.

6.7 DRINKING WATER STANDARDS/CRITERIA

Enforceable drinking water standards, referred to as Maximum Contaminant Levels (MCLs), have been developed by EPA under the Safe Drinking Water Act. They apply to all public water supply systems and, as a matter of policy, CERCLA also uses them for other drinking water exposures, i.e. individual water supply systems. MCLs are based upon health effects data, existing treatment technology, risk analysis and economic factors. The calculation of health effects are generally based upon lifetime exposure to the contamination for a 70 kg (154 pound) adult who consumes 2 liters (0.53 gallons) of water per day. A margin of safety is included in each of the health standards. The total environmental exposure to contaminants was generally considered in calculating specific MCLs. EPA estimated the amount of the substance to which the average person is likely to be exposed from all sources (air, food, water, etc.), and then determined the fraction of the total intake from drinking water. EPA is also developing Maximum Contaminent Level Goals (MCLGs), formerly RMCLs, for drinking water based entirely on health considerations. Also, additional criteria is available such as the Clean Water Act, Water Quality Criteria and Health Advisories. Contaminant levels detected in each well have been compared to the above described applicable and relevant criteria, advisories and guidance.

In an evaluation of inorganic compounds, four wells (PW-01, PW-03, PW-11, PW-28) were found to contain lead in excess of the EPA's maximum contaminant levels (MCLs) allowable in drinking water supplies. However, elevated lead levels are commonly due to naturally occurring lead in the soil, corrosion of lead piping and connections, residues from lead paints or a combination of these and other sources. Most commonly, elevated lead levels are associated with older houses containing lead plumbing, particularly in areas having soft acidic water, (Federal Register, Wednesday, November 13, 1985). Other inorganic compounds were below MCL values.

The organic compounds; tetrachloroethylene, benzene, 1,2-dichloroethane, and n-nitrosodiphenylamine; were present in residential wells in concentrations which exceeded EPA Water Quality Criteria (refer to Table 6-2). This table only presents compounds which have exceeded EPA standards and criteria. Tetrachloroethylene, 1,2-dichloroethane, and n-nitrosodiphenylamine were each detected in one well, where as benzene was detected in two wells. The remainder of compounds present in wells were either detected in concentrations below criteria levels or there are no criteria levels for that particular compound. The health risks presented by these contaminants are evaluated in Section 8.0 of this report.

6.8 CONSTITUENT PROPERTIES

Table 6-3 presents the specific chemical properties of the constituents detected in the residential wells. Phenol, with a solubility of 93,000 mg/l, is the most soluble organic contaminant found in the wells and is considered soluble in water (Hawley, 1981). Because of its solubility, it is very mobile. A review of the solubilities and soil adsorption coefficients indicate that the extractable compounds tend to adhere to soils and are less mobile than the volatiles.

6.9 SUMMARY AND CONCLUSIONS

Between 1985 and 1986, a total of 56 residential wells were sampled by the U.S. EPA as part of the Remedial Investigation (RI) for the Re-Solve site. Fourteen wells have at some point shown low level organic contamination.

TABLE 6-2

RESIDENTIAL WELL CONTAMINANT CONCENTRATIONS WHICH EXCEED CRITERIA/STANDARDS

COMPOUND	WELL	CRITERIA/STANDARDS	MAXIMUM LEVEL DETECTED IN WELL (PPB)
Organics			
Tetrachloroethylene	PW-03	MCLG[a]=0	TR
Benzene	PW-26	Proposed MCL[d]=5 ppb	9
	PW-30		5
1,2-dichloroethane	PW-29	Proposed MCL[d]=5 ppb	6
N-nitrosodiphenylamine	PW-25	Clean Water Act, Water Quality Criteria for human health -- adjusted for drinking water only (7.0 PPB)[c]	27[b]
	PW-50		31[b]
Inorganics			
Lead	PW-01	MCL[d]=50 PPB	108
	PW-03		61
	PW-11		106
	PW-28		241

NOTES:

TR = trace (detected below EPA CRDL's)

a = Maximum Contaminant Level Goal
b = estimated value

c = 10^{-6} carcinogenic risk level

d = Maximum Contaminant Level

All wells were sampled after removing any filters which are normally used by the resident.

TABLE 6-3*

SPECIFIC CHEMICAL PROPERTIES OF CONTAMINANTS FOUND IN RESIDENTIAL WELLS

Group Number	Well Number	Well Depth (ft)	Distance From Site (ft)	Contaminant Detected	Solubility (mg/l @ 20°-25°C)	Density (g/ml)	Liquid Viscosity (centiposes)	Soil Sorption Coefficient (Koc)
1	PW-03	12	500	2-Butanone	—	—	—	—
				Tetrachloroethylene	165	1.62	.90	360
	PW-25	Unknown	400	N-Nitrosodiphenylamine	—	—	—	2,690
	PW-48	268	200	Di-n-Butylphthalate	13	1.38	21.50	1,000
2	PW-13	Unknown	2,500	Phenol	93,000	1.06	3.49	16.2
	PW-15	110	2,000	Phenol	93,000	1.06	3.49	16.2
	PW-29	175	2,000	1,2-Dichloroethane	8,690	1.24	0.84	16.6
	PW-30	Unknown	2,200	Benzene	1,780	0.88	0.65	74.2
	PW-47	180	3,900	Di-n-Octylphthalate	3	—	—	2,400
3	PW-04	15	2,600	1,1,1-Trichloroethane	720	1.34	0.90	174
	PW-50	110	4,300	Butylbenzyl Phthalate	2.9	1.14	45.13	200,000
				N-Nitrosodiphenylamine	—	—	—	2,690
				Di-n-Butylphthalate	13	1.38	21.50	1,000
4	PW-26	24	1,600	Benzene	1,780	0.88	0.65	74.2
	PW-51	284	3,900	Butylbenzyl Phthalate	2.9	1.14	45.13	200,000
	PW-44	90	2,000	Toluene	535	0.87	0.59	339
	PW-49	47	1,800	Methylene Chloride	17,000	1.33	0.45	10
				Chloromethane	6,850	0.92	0.36	4.9

NOTES:

— Indicates no available data.

* Arthur D. Little, Inc., 1981.

The contaminated wells are both shallow and deep and scattered in the vicinity of the site. Of the 56 wells sampled reported depths were obtained for 35. Of these 35, 25 are deep wells and 10 are shallow, based on classifing any well over 40 feet as deep. Identifying trends or patterns in the contamination of the residential wells is difficult. About 32% of the wells reported to be deep and 30% of the wells reported to be shallow were contaminated at some time during the sampling conducted as part of this Remedial Investigation.

Table 6-4 shows all wells which contain organic constituents. As can be seen, there is little repetition of contaminants from one well to the next. The compounds benzene and phenol were found most often. Each compound was detected in two wells. Phenol was detected in two Group 2 wells where as benzene was found in a Group 2 well and a Group 4 well. The well showing the highest level of organic contamination was PW-03, located to the northwest or upgradient of the site.

As part of the Public Health Evaluation (refer to Section 8.0), the exposure to contaminated residential well water was examined based on the health indicator compounds. The following is the summary of the evaluation.

The absence of detectable levels of all but one of the human health indicator chemicals suggests that, based on current data, site-related contamination has not significantly affected downgradient residential wells. The downgradient private wells were considered to be PW01, PW14, PW20-PW23, PW37, PW40, and PW56.) The observed lead levels in the downgradient wells also do not indicate the presence of extensive or dangerous contamination originating from the ReSolve site, due to the distribution and levels of lead found in these wells.

The current quality of drinking water in private wells downgradient from the ReSolve site is not considered to have been noticeably affected by contaminants originating from the site. As a result, potential risks to residents using well water downgradient of the site will not be evaluated in this PHE. If, however, additional information indicates the presence of site-related contamination in these wells or a clearly migrating plume of contamination, the potential for human health effects due to contaminated well water should be re-evaluated.

TABLE 6-4
RESIDENTIAL WELLS SHOWING CONTAMINANTS[a]
RE-SOLVE SITE

Contaminant	Frequency of Detection[b]	PW-03			PW-04		PW-29			PW-26			PW-30			PW-44			PW-49	PW-13	PW-15	PW-47	PW-48	PW-50		PW-51	PW-25		
		11/14/85	3/28/86	11/18/86	11/14/85	3/27/85	12/5/85	5/8/86	11/18/86	12/5/85	5/8/86	1/18/86	12/5/85	5/8/86	11/18/86	12/12/85	5/8/86	11/18/86	11/16/85	11/22/85	11/22/85	12/20/85	1/16/86	3/26/86	11/18/86	3/26/86	12/5/85	3/28/86	11/18/86
Volatiles																													
2-Butanone	1 of 56	28	ND	ND																									
Tetrachloroethylene	1 of 56	*	ND	**																									
1,1,1-Trichloroethane	2 of 56				*	ND									**														
1,2-Dichloroethane	1 of 56						6.0	ND	ND																				
Benzene	2 of 56									9.0	ND	ND	5(*)[c]	ND	ND														
Toluene	1 of 56															*	ND	ND											
Chloromethane	1 of 56																		*										
Methylene Chloride	1 of 56																180[e]	ND											
Carbon Disulfide	1 of 56																	1.6[d]											
Extractables	1 of 56																												
Phenol	2 of 56																			*	*(ND)[c]								
Di-n-octylphthalate	1 of 56																					*							
Di-n-butylphthalate	2 of 56																						*	*	ND				
N-Nitrosodiphenylamine	2 of 56																							31[e]	ND		ND	27[e]	ND
Butylbenzylphthalate	2 of 56																							*	ND	*			

NOTES:

a) See Figure 6-1 for well locations. Results tabularized include validated and EPA approved organic analytical data.

b) Number of samples in which contaminant was detected divided by the total number of residential wells sampled.

c) Duplicate Sample.

d) Due to the very low level, close to 1 ppb, this reading is highly questionable and suspect and could not be confirmed. It was found in the blank but at a very low level. Carbon disulfide is used in labs for air analysis.

e) Estimated Value.

Blanks indicate no detection.

ND Indicates Nothing Detected.

* Indicates trace detection below the EPA Contract Required Detection Limits (CRDL's).

** Indicates trace detection below the 1 CRDL requested for this round of analyses. Due to the very low levels, these readings are highly questionable and suspect and could not be confirmed.

Units: ppb

Section 7

7.0 AIR INVESTIGATION

7.1 INTRODUCTION

As part of the on-site Remedial Investigation (RI) for the Re-Solve Inc. Site, documentation of air quality to ensure the health and safety of off-site receptors, in addition to standard health and safety protocol to protect on-site workers, was considered to be an integral part of the overall site investigation. An analysis of air quality is critical because on-site RI activities may result in the incidental release of levels of volatile organic chemicals or respirable particulates which could pose a health and safety threat to off-site residences.

Previous air quality investigations at the Re-Solve Inc. Site were performed by CECOS and the Army Corps of Engineers as well as the (NUS/FIT) team during on-site remedial excavation/removal activities between September 1984 and May 1985.

Previous on-site waste characterization revealed volatile organics and PCB's (as Arochlor 1254) to be the predominant on-site soil contaminants.

This section summarizes the results of a site perimeter air monitoring and sampling program conducted at Re-Solve Inc. Site on Thursday, November 8, 1985. The air monitoring program was conducted to assess the levels of off-site migration of airborne particulates and volatile organics associated with on-site drilling and soil sampling activities.

7.2 VOLATILE ORGANICS SAMPLING

7.2.1 OBJECTIVE AND SCOPE

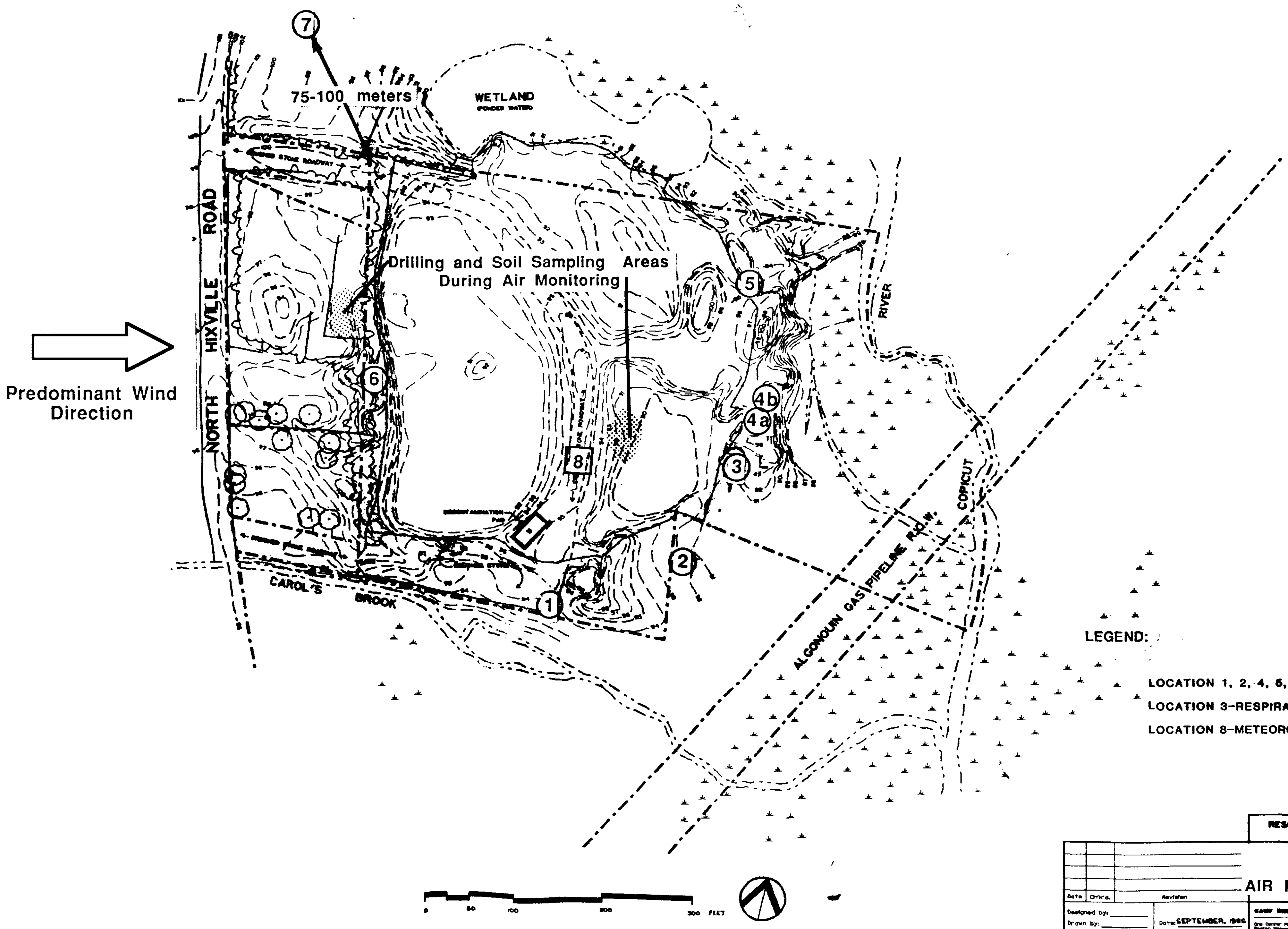
Sampling for volatile organics was conducted in order to determine the impact of on-site remedial activities (borehole drilling and soil sampling) on ambient air at the site boundary. Outside of implementation of remedial actions such as excavation of contaminated soils and sludges, borehole drilling and soil sampling is considered to pose the greatest potential for releases of volatile organics in the soil to on-site and off-site ambient air. Data generated would be used to document that on-site, borehole drilling and soil sampling activities would not violate appropriate health and safety standards developed to be protective of the general public (off-site).

7.2.2 VOLATILE ORGANICS SAMPLING METHODOLOGY

Volatile organics sampling was conducted using 3 x ½-in. glass tubes containing approximately 1-2 grams of 60/80 mesh tenax support and approximately 1-2 grams of fine mesh coconut-base charcoal separated by glass wool. Both ends of the tube contained a stainless swagelock fitting with teflon ferrule and end cap. Each tube was N2-purged at 300°C for 2 hours and QC checked for volatile organic contamination by the CLP contractor laboratory to insure contamination free tubes before shipment.

Volatile organic sampling was performed at the perimeter fenceline at the locations designated in Figure 7-1, Air Monitoring Locations. Sampling tubes were connected by Tygon tubing to SKC Aircheck I sample pumps and calibrated to desired flow rates using a Gillian Buck Flow Calibrator. The tubes were sampled using the tenax portion as the primary sorbent and charcoal as a backup. Upon completion of sampling, all flow rates were verified to be within ±5% of the initial flow rates (60-70 cc/min.). For sampling times and volumes refer to Table 7-1, Volatile Organics Sampling Summary.

The tenax/charcoal tubes were analyzed by a CLP contractor laboratory using thermal desorbtion-GC/MS. The samples were screened for the approximately 30 volatile organic compounds as defined by EPA method 624 (see Table 7-5) plus an additional ten (10) tentatively identified compounds. Instrument detection limits were on the average of 50 nanograms (ng) which equates to air concentration compound detection limits in the range of 1-5 parts per billion (ppb) based on the air volumes collected. The results were presented by the laboratory as ng compound/sample. Table 7-2 Volatile Organics Results Summary, contains a listing of compounds detected at each



LEGEND:

LOCATION 1, 2, 4, 5, 6, 7-TENAX/CHARCOAL

LOCATION 3-RESPIRABLE DUST MONITOR

LOCATION 8-METEOROLOGICAL STATION

RESOLVE INC. HAZARDOUS WASTE SITE
NORTH DARTMOUTH, MASSACHUSETTS

FIGURE 7-1

AIR MONITORING LOCATIONS

Date	Chk'd.	Revision

Designed by: ______
Drawn by: ______
Checked by: ______
Approved by: ______

Date: SEPTEMBER, 1986
Scale: AS SHOWN

CAMP DRESSER & McKEE INC.
One Center Plaza
Boston, Massachusetts [illegible]
environmental engineers, scientists, planners & management consultants

SHEET NO.

ARCHITECTURAL Approved by Date
STRUCTURAL Approved by Date
ELECTRICAL Approved by Date
INSTRUMENTATION Approved by Date
HVAC Approved by Date
PLUMBING Approved by Date
PROJECT ENGINEER Approved by Date
PROJECT MANAGER Approved by Date

TABLE 7-1

VOLATILE ORGANIC SAMPLING SUMMARY
11/8/85

Sample Code	Sample Location*	Sampling Time (min)	Average Flowrate (1/min)	Sample Volume at (STP)[1] (liters)
243-A0-001	1	403	.062	24.7
243-A0-002	2	383	.059	22.3
243-A0-004	4	392	.057	22.1
243-A0-004-DUP (Duplicate)	4	364	.062	22.3
243-A0-005	5	365	.061	21.9
243-A0-006	6	420	.063	26.1
243-A0-007 (Background)	7	374	.061	22.5
243-A0-000-FB (Field Blank)	-	-	-	-

---

*Figure 7-1

1. Standard Temperature and Pressure (25 C and 29.92 in Hg).

TABLE 7-2

VOLATILE ORGANICS RESULTS SUMMARY
11/8/85

Sampling Location	Target Compounds Detected[1]	Concentration	TLV-TWA[4]	AAQS[5]
1	Trichlorofluoromethane[2]	3 ppb	1,000 ppm	
	1,1,1-Trichloroethane	0.6 ppb		47.6 ppb
	Tetrachloroethylene	0.33 ppb		2.7 ppb
	Toluene	1 ppb		13.6 ppb
	Total xylenes	0.5 ppb	100 ppm	
2	Toluene[3]	1 ppb		13.6 ppb
4 (DUP)	Trichlorofluoromethane	11 ppb	1,000 ppm	
	1,1,1-Trichloroethane	3 ppb		47.6 ppb
	Trichloroethylene	0.9 ppb		7 ppb
	Tetrachloroethylene	5 ppb		2.7 ppb
	Toluene	2 ppb		13.6 ppb
	Total xylenes	1 ppb	100 ppm	
4	1,1,1-Trichloroethane	0.44 ppb		47.6 ppb
	Trichloroethylene	0.3 ppb		3.4 ppb
	Tetrachloroethylene	0.5 ppb		2.7 ppb
	Toluene	0.9 ppb		13.6 ppb
5	Trichlorofluoromethane	5 ppb	1,000 ppm	
	1,1,1-Trichloroethane	0.6 ppb		47.6 ppb
	Trichloroethylene	1 ppb		3.4 ppb
	Tetrachloroethylene	1 ppb		2.7 ppb
	Toluene	1 ppb		13.6 ppb
	Total xylenes	0.7 ppb	100 ppm	
6	Toluene	1 ppb		13.6 ppb
7	Toluene	2 ppb		13.6 ppb

---

1. Greater than detection limit.
2. All trichlorofluoromethane levels should be treated as highly suspect due to prolonged storage times and blank contamination.
3. All Toluene levels estimated due to blank contamination.
4. Threshold Limit Value-Time Weighted Average established by the American Conference of Governmental Industrial Hygienists for an average 8-hour workday.
5. Proposed DEQE 24-hour ambient air quality standard.

sampling location. For QA/QC purposes, the laboratory supplied surrogate recoveries, spike recoveries and lab blank water analyses.

7.3 PARTICULATE MONITORING

7.3.1 OBJECTIVE AND SCOPE

Due to the extent and levels of PCB contamination in the soils at the Re-Solve Inc. Site as well as its low vapor pressure (VP) and strong affinity for soil particles, particulate monitoring was conducted at the site perimeter as a surrogate measure of off-site migration of PCB contaminated particulates. Because of its physical and chemical properties this would represent the greatest threat of chronic or acute exposure to PCB's for off-site receptors during on-site remedial activities. Off-site migration could occur from wind-blown deposition of surface soils or newly exposed sub-surface soils contaminated with PCB's.

An extensive air monitoring program for ambient PCB levels was conducted at the Re-Solve Inc. Site by the Army Corps of Engineers during on-site remedial excavation/removal of contaminated soils between September 1984 and May 1985.

Of the total suspended particulate (TSP) in ambient air only a small fraction is considered respirable (0.1 to 10 microns). This fraction of the TSP would represent the ambient air suspended particulate fraction which would possess the greatest potential for acute or chronic exposure to PCB contaminated dusts for off-site receptors.

7.3.2 PARTICULATE MONITORING METHODOLOGY

Particulate monitoring was performed using a GCA Miniram Model PDM-3 airborne particulate monitor and a GCA PDL-1 Data Logger. The Miniram utilizes a pulsed GaAlAs light emitting source which continuously senses the combined scattering from the population of particles present in its 1 cm^3 sensing chamber. The Miniram has been designed for preferential response to particle sizes in the range of 0.1 to 10 micrometers which represents the normal distribution of man-made and naturally occurring particles as well as the respirable fraction of TSP in ambient air. The Miniram was zeroed before entering the field and equipped with an optional sunshield (GCA Model PDM-SNS) to protect the sensing elements from excessive ambient light fluctuations.

The GCA PDL-1 Personal Data Logger is a single-channel analog data unit compatible with the Miniram. A two-point calibration of the input signal was performed prior to entering the field. The PDL-1 was programmed to record start time, test duration, elapsed time, overall minimum concentration (mg/m^3), time minimum occurred, overall maximum concentration (mg/m^3) time maximum occurred, overall average, short term exposure limit (STEL) and time STEL occurred. Particulate monitoring was performed at the perimeter fenceline with the PDM-3 supported on a portable tripod in the breathing zone (5 ft.) at the location designated in Figure 7-1. Refer to Table 7-3 for specific results.

7.4 METEOROLOGICAL MONITORING

7.4.1 OBJECTIVE AND SCOPE

On-site meteorological determinations were performed at the Re-Solve Inc. Site in order to determine upwind and downwind orientation of the site perimeter air monitoring locations. Meteorological monitoring was performed two (2) days prior to the air sampling for the initial determination of the perimeter air sampling network design. Meteorological monitoring was performed during the air sampling to evaluate the placement of the air sampling locations.

7.4.2 METEOROLOGICAL DETERMINATION METHODOLOGY

A Climatronics Model EWS weather station was used to record on-site meteorological conditions prior to and during sampling. A Rustrak strip-chart recorder was connected to the EWS to record temperature, wind speed and wind direction on a continuous basis. The EWS was placed on-site (see Figure 7-1) to monitor at ten feet above open grade. The strip chart

TABLE 7-3

PARTICULATE MONITORING SUMMARY
11/8/85

Start Time:	10:35:00
Test Duration:	5:59:59
Elapsed Time:	5:44:16
Overall Minimum:	0:0 mg/m^3
Minimum Occurred:	12:22:57
Overall Maximum:	0.42 mg/m^3
Maximum Occurred:	12:17:09
Overall Average:	0.04 mg/m^3
NAAQS[2]:	150 ug/m^3

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1. (mg/m^3) - Milligrams per cubic meter.

2. National Ambient Air Quality Standard for "PM_{10}" (<10 microns dia.)

data was sent to Evirodata Inc. for digitized averages of each measurement parameter. Refer to Table 7-4 for specific results.

7.5 AIR MONITORING RESULTS

Based on average wind direction during sampling, Westerly (270), volatile organics (VO) sampling Station No. 4 and 5 were designated as the primary downwind locations and VO sampling Station No. 6 as the primary upwind location. VO analytical results (Table 2) showed Stations 4 and 5 to have the highest levels of detectable compounds and Station 6 to have the lowest (i.e. not detected) along with Location 7. Location 7 was situated 75-100 meters off-site close to the nearest residence, and served as the off-site background station. Good correlations in compounds detected were exhibited at Stations 4 and 5 indicating proper monitoring placement to measure maximum downwind concentrations. These results along with small fluctuations in wind direction (203-336) would indicate the contaminant plume to be tightly dispersed with a downwind impact in the general direction of west to east over the site during sampling.

Only those contaminants that were above the detection limits are reported in Table 7-2. All concentrations of the VO contaminants detected were found to be below the Proposed DEQE 24-hour Ambient Air Quality Standards (AAQ's) with the exception of tetrachloroethylene at Station 4. These proposed standards are being developed to be more stringent measures to protect the health and welfare of the general public. Where Proposed AAQ's have not been established for specific compounds detected, ACGIH TLV-TWA standards have been used as a guideline for allowable levels. In general, VO levels were at or close to the detection limits for the individual contaminants. Comparison of the contaminant levels at the perimeter sampling stations with the background station (Station 7), indicates that some volatile contaminants were one order of magnitude above background at the site perimeter. This indicates the site as the source of the pollutants. For example: at downwind Station 4, tetrachloroethylene measured 5 ppb and at background Station 7 was not detected (DL = 0.33 ppb). Comparisons of volatile organic contaminants found in this study to a similar study conducted by NUS/FIT (TDD No. F1-8410-20) and the EPA,

TABLE 7-4

METEOROLOGICAL SUMMARY
11/6/85-11/7-85

Meteorological Station Parameter	Low	High	Average	Total Hours
Wind Direction (degrees)	203	336	272	26
Wind Speed (mph)	1.6	9.0	4.7	26
Temperature (°F)	47.3	59	53	26

Additional Observations: Clear, sunny, 55% Relative Humidity, large portions of site underwater due to heavy rainfall earlier in the week, soil conditions - soggy, no observable dust levels.

showed similarities in ambient air volatile compounds detected. Most prevalent were toluene, xylene, tetrachloroethylene, and 1,1,1-trichloroethylene.

QA/QC results for the volatile organic analysis showed acceptable spike recoveries (80-100%) for the majority of the 30 Priority Pollutant Volatile Organics as well as acceptable surrogate recoveries for all samples (>90%). No contaminants were detected in the lab blank water analysis. The field blank contained suspicious levels of toluene and especially trichlorofluoromethane. Because of this, all toluene results are estimated and trichlorofluoromethane results are treated as highly suspicious due to the fact that this could be contamination from storage under refrigeration.

The front section (tenax) and back section (charcoal) of the volatile organic sampling tubes were not analyzed separately. The relative concentrations detected along with the breakthrough volumes of tenax and charcoal for the majority of the volatile organics indicate that no breakthrough occurred on any samples.

The downwind particulate monitor measured a maximum level of 0.42 milligrams/cubic meter (mg/m^3) and an average of 0.04 mg/m^3. Using the maximum PCB concentration detected in on-site soils (36,000 ppm) at location SB-25N, the maximum possible PCB concentration in air would be: 0.42 mg/m^3 x 0.036 = 0.015 mg/m^3. This value is well below the ACGIH TLV-TWA occupational standard of 0.5 mg/m^3 (aroclor 1254). Although no air standard for PCB's exists, the State of Pennsylvania recommends a "chronic" annual air guideline for PCB's as 0.18 ug/m^3 (0.00018 mg/m^3). Although the calculated surrogate level (0.015 mg/m^3) is in excess of this guideline at the fenceline boundary, simple dilution in air as off-site migration occurs would in all likelihood reduce this value below the 0.00018 mg/m^3 guideline. In addition, this standard is an annual value which because of changing wind direction and other climatological variations are lower than a 24-hour or 8 hour standard. The average value of 0.04 mg/m^3 was well below the 24-hour PM$_{10}$ average of 150 ug/m^3. Although the sampling times for volatiles and particulates were approximately 7 hours, the 24-hour averaged values would in all likelihood not be significantly greater.

These measured values represent the peak values for the day (measured during on-site activities) and are therefore comparable to established and proposed 24-hour AAQS to protect the general public.

Due to on-site conditions during this survey, e.g. soggy topsoil, large formations of water, and moderate temperatures (50 F), particulate and volatile organic emissions would be suppressed. Since particulate and volatile organics levels would most likely be higher when on-site soil conditions are dry and the temperatures elevated (80-90 F), additional particulate monitoring and volatile organic sampling is recommended during implementation of remedial actions to determine ambient contamination levels during these "worst-case" scenarios. This would include on-site monitoring to identify point source material as well as perimeter monitoring.

Although the ambient dust levels measured would not indicate a PCB hazard for off-site receptors, particulate collection and subsequent analysis for presence of PCB's is highly recommended during on-site remedial actions involving soil-disturbing activities, especially during drier conditions.

TABLE 7-5

VOLATILE PRIORITY POLLUTANT COMPOUNDS
EPA METHOD 624

- CHLOROMETHANE
- BROMOMETHANE
- VINYL CHLORIDE
- CHLOROETHANE
- METHYLENE CHLORIDE
- TRICHLOROFLUOROMETHANE
- 1,1-DICHLOROETHYLENE
- 1,1-DICHLOROETHANE
- TRANS-1,2-DICHLOROETHYLENE
- CHLOROFORM
- 1,2-DICHLOROETHANE
- 1,1,1-TRICHLOROETHANE
- CARBON TETRACHLORIDE
- BROMODICHLOROMETHANE
- 1,2-DICHLOROPROPANE
- TRANS-1,3-DICHLOROPROPYLENE
- TRICHLOROETHYLENE
- DIBROMOCHLOROMETHANE
- 1,1,2-TRICHLOROETHANE
- BENZENE
- CIS-1,3-DICHLOROPROPYLENE
- 2-CHLOROETHYL VINYL ETHER
- BROMOFORM
- TETRACHLOROETHYLENE
- 1,1,2,2-TETRACHLOROETHANE
- TOLUENE
- CHLOROBENZENE
- ETHYLBENZENE
- DICHLOROBENZENE

Section 8

8.0 PUBLIC HEALTH EVALUATION

8.1 INTRODUCTION

This section is a baseline public health evaluation (PHE) that forms part of the EPA remedial investigation/feasibility study (RI/FS) for the Re-Solve site in North Dartmouth, Massachusetts. The PHE assesses the potential risks to public health and the environment associated with exposure to contaminants from the Re-Solve site in the absence of remediation. This assessment is based on the sampling data summarized in earlier sections of this report and on information provided in the Draft Off-Site Remedial Investigation Report (CDM 1985).

The initial step in this assessment is to identify a subset of chemicals found at the site that poses the greatest potential health or environmental risks. Then the potential pathways of exposure to these contaminants are described, and the potential effects of exposure to these compounds on human health, welfare, and the environment are examined under current land use conditions and under future-use scenarios. This allows for an evaluation of the potential risks associated with the site and surrounding areas in the absence of remediation, both with and without institutional controls on future use and development of the site.

8.2 SELECTION OF CHEMICALS FOR ASSESSMENT

The data presented in preceeding sections of this report and in the Draft Off-Site Remedial Investigation Report (CDM 1985) indicate the continuing presence of a large number of contaminants in groundwater monitoring wells, surface water, sediments, and soils at or near the Re-Solve site. Since more than 50 chemical compounds have been measured, a subset of chemicals that are considered likely to contribute most to risk at the site has been selected for evaluation in this PHE. These chemicals are referred to as indicator chemicals. The compounds of greatest concern because of their effects on humans are referred to as human health indicator chemicals, while those of most concern because of their effects on freshwater aquatic life are called aquatic life indicator chemicals. The procedure used to select the human health indicator chemicals has been recommended by EPA's Office of Emergency and Remedial Response and delineated in EPA's Draft Superfund Public Health Evaluation Manual (EPA 1986a). The aquatic life indicator chemicals were selected based on a qualitative evaluation of their reported concentrations, relative toxicities, and other factors, including their prevalence and persistence.

In the initial selection process for human health indicator chemicals, a toxicity score was calculated for each chemical in each medium by multiplying the representative concentration by a medium-specific toxicity constant provided in the PHE manual.[1] When a chemical was found in more than one water medium (e.g., surface water and groundwater), the PHE manual recommends using only the highest water concentration in calculating the toxicity score for that chemical. The soil-specific toxicity factor was applied to both soil and sediment data collected in the site area. Similarly, the highest concentration from these two sample data sets for each chemical was used to calculate the soil toxicity score.

The chemicals are ranked according to these indicator scores. Carcinogenic and noncarcinogenic effects are scored separately. Therefore, some contaminants have two ranks, one based on their potential carcinogenic effects and the other on their noncarcinogenic effects. The indicator scores for potential carcinogens and noncarcinogens are not directly comparable, and the PHE manual recommends selecting some contaminants from each class for further evaluation.

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[1] The derivation of the toxicity constants is described in the PHE manual (EPA 1986a). These toxicity constants, T, are medium specific (i.e., for drinking water, air, and soils). The toxicity constants for noncarcinogens are derived from the minimum effective dose (MED) for chronic effects, a severity of effect factor, and standard factors for body weight and oral inhalation intake (e.g., 70-kg body weight, 2 liters/day of drinking water, 20 cubic meters/day of air). Toxicity constants for potential carcinogens are based on the dose at which a 10% incremental carcinogenic response is observed (ED_{10}) and the same standard intake and body weight factors. The intake factor for soil toxicity constants is based on an assumption of 100 milligrams of soil consumed per day for 2- to 6-year-olds.

For the selection of indicator chemicals, sample data collected by Camp Dresser & McKee, Inc. (CDM) in 1985 and 1986 were used to represent present levels of contamination at and near Re-Solve site.

The levels of contamination used in the indicator chemical selection process were based on samples collected from within the general area bounded by North Hixville Road to the west, the wetland to the north, Copicut River to the east, and Carol's Brook to the south. This sample area was considered to provide an accurate indication of the extent and magnitude of site-related contamination.

The geometric means of concentrations in each medium were used in the selection process. Geometric means were calculated from samples in which contaminants were measured, as well as samples in which contaminants were not present at levels above the detection limits. One-half of the detection limit was used for all of the "nondetect" samples.[1]

Geometric statistics were used based on the observation that trace environmental contaminants usually follow a log normal distribution (Dean 1981). If duplicate samples were collected and analyzed, the mean concentration for both samples was used in calculating the overall geometric mean for that chemical.

8.2.1 HUMAN HEALTH INDICATOR CHEMICALS

Contaminants in Groundwater and Surface Water

Table 8-1 summarizes the frequency of detection, the range of detected concentrations, and the geometric mean concentration for all of the chemicals

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[1] If for the samples in which a contaminant was not detected the stated detection limits were used in calculating a geometric mean, the geometric mean could be biased upward and as a result be over-conservative. If, however, the samples in which a contaminant was not detected were treated as zeros, the estimated geometric mean could underestimate the potential level of contamination. Use of one-half the detection limit was thus considered to provide a reasonable approach for calculating geometric mean concentrations.

TABLE 8-1
RE-SOLVE SITE
SUMMARY OF SURFACE WATER AND GROUNDWATER DATA
NOVEMBER/DECEMBER 1985 SAMPLING PERIODS

CHEMICAL (CAS NO.)	GROUNDWATER DATA (a)			SURFACE WATER DATA (a)		
	Frequency (b)	Concentration Range of Detected Samples (ppb)	Geometric Mean Concentration (ppb) (c)	Frequency (b)	Concentration Range of Detected Samples (ppb)	Geometric Mean Concentration (ppb) (c)
Acetone(67-64-1)	8/27	11 - 37,000	25	3/22	93 - 1,300	9
Aluminium(7429-90-5)	23/27	824 - 152,000	7,840	11/12	15 - 272	108
Arsenic(7440-38-2)	16/27	5 - 148	8			
Barium(7440-39-3)	17/27	101 - 798	168	12/22	6.4 - 23	10
Benzyl alcohol(100-51-6)	2/27	2 - 78	2			
Beryllium(7440-41-7)	16/27	3 - 43	5			
Bis(2-ethylhexyl)phthalate(117-81-7)	3/27	3 - 7	2			
Cadmium(7740-39-3)	13/27	5 - 724	8	2/12	3.8 - 5.1	3
Calcium(7440-70-2)	27/27	1,120 - 67,200	9,856	12/12	1,430 - 6,444	3,110
Chloroethane(75-00-3)	3/27	790 - 2,600	10	6/22	8 - 90	8
Chloroform(67-66-3)	2/27	110 - 190	4			
Chromium(67-66-3)	22/27	13 - 221	31	8/12	4 - 8	5
Cobalt(7440-48-4)	12/27	21 - 402	34			
Copper(7440-50-8)	16/27	23 - 458	34			
Di-n-Butyl-Phthalate(84-74-2)	3/27	2 - 34	4			
1,2-Dichlorobenzene(95-50-1)	4/27	2 - 19	3			
1,4-Dichlorobenzene(106-46-7)	3/27	1 - 12	3			
1,1-Dichloroethane(75-34-3)	9/27	7 - 3,700	10	7/22	3 - 475	5
1,1-Dichloroethylene(75-35-4)	5/27	29 - 1,000	6			
trans-1,2-Dichloroethylene(156-60-5)	23/27	1 - 83,000	274	14/22	15 - 2,000	43
Dichloromethane(75-09-2)	5/27	600 - 16,000	9			
Diethyl phthalate(83-6-2)	6/27	2 - 9	3			
2,4-Dimethylphenol(105-67-9)	2/27	2 - 4	3			
Ethylbenzene(100-41-4)	12/27	1 - 1,300	19	3/22	3 - 58	3
Iron(7439-89-6)	26/27	1,740 - 293,000	36,800	12/12	132 - 7,436	1,370
Isophorone(78-59-1)	7/27	7 - 440	5			
Lead(7439-92-1)	18/27	13 - 1,120	31	2/12	6.2 - 6.5	3
Magnesium(7439-95-4)	27/27	706 - 27,200	4,250	12/12	869 - 2,040	1,300
Manganese(7439-96-5)	26/27	236 - 20,700	2,940	12/12	30 - 2,353	466
Mercury(7439-97-6)	3/27	0.16 - 0.8	0			
Methyl ethyl ketone(78-93-3)	8/27	10 - 62,000	21			
Methyl isobutyl ketone(108-10-1)	7/27	40 - 6,800	12			
2-Methylphenol(95-48-7)	3/27	8 - 93	5			
4-Methylphenol(106-44-5)	3/27	2 - 14	2			
Naphthalene(91-20-3)	6/27	4 - 22	6			
Nickel(7440-02-2)	14/27	29 - 202	38			

TABLE 8-1 (Cont'd)

CHEMICAL (CAS NO.)	GROUNDWATER DATA (a) Frequency (b)	GROUNDWATER DATA (a) Concentration Range of Detected Samples (ppb)	GROUNDWATER DATA (a) Geometric Mean Concentration (ppb) (c)	SURFACE WATER DATA (a) Frequency (b)	SURFACE WATER DATA (a) Concentration Range of Detected Samples (ppb)	SURFACE WATER DATA (a) Geometric Mean Concentration (ppb) (c)
Polychlorinated biphenyls (PCBs)	8/27	4 - 1,200	3	2/15	0.52 - 1.2	0.3
Phenol(108-95-2)	3/27	22 - 120	3	2/15	4 - 18	5
Potassium(7440-09-7)	7/27	660 - 12,200	2,640	10/12	816 - 1,990	1,460
Selenium(7782-49-2)	5/27	3 - 3	2			
Silver(7440-22-4)	4/27	6 - 6	5			
Sodium(7440-23-5)	3/27	13,800 - 60,300	3,200	12/12	4,120 - 7,404	5,100
Tetrachloroethylene(127-18-4)	18/27	3 - 14,000	81			
Tin(7440-31-5)	10/27	17 - 336	23			
Toluene(108-88-3)	13/27	2.2 - 33,000	81	11/22	2 - 280	12
Total xylenes	13/27	21 - 6,700	43	5/22	5 - 330	5
1,2,4-Trichlorobenzene(120-82-1)	16/27	1 - 230	8			
1,1,1-Trichloroethane(71-55-6)	13/27	6 - 35,000	44	7/22	16 - 440	8
Trichloroethylene(79-01-6)	20/27	6 - 50,000	236	10/22	2 - 460	8
Vanadium(7440-62-2)	16/27	21 - 404	45			
Vinyl chloride(75-01-4)	15/27	1 - 8000	61	9/22	1 - 350	13
Zinc(7440-66-6)	11/27	229 - 1,320	49	8/12	4 - 45	12

(a) Based on samples collected from within the general area bounded by Copicut River, Carol's Brook, the wetlands to the north of the site, and North Hixville Road. Data analysis was performed by an EPA-approved contract laboratory. Sample results have met EPA validation requirements.

(b) Number of samples in which contaminant was detected divided by the total number of samples.

(c) Based on samples in which contaminant was detected and in which contaminant was not detected (i.e., below the detection limit). In calculating the geometric mean, one-half of the detection limit was used for samples in which the contaminant was not detected.

that were detected more than once in groundwater wells and surface water within the site-related sample area. Data from upgradient and background sample locations have not been included in the table in order to keep the analysis representative of site conditions. Residential well data have not been included since there are not believed to be any site related contaminants in these wells (see Section 8.3.2). It should be kept in mind throughout this report that the groundwater and surface water samples used to evaluate exposures and risks were not filtered prior to analysis. As a result, the listed concentrations may represent contaminants adsorbed to sediments in the sample as well as contaminants actually dissolved. An analysis of the limited number of filtered surface water and groundwater samples collected at the site indicates that the unfiltered sample data may overestimate filtered water concentrations by less than a factor of two to a factor of ten depending upon the specific chemical and specific sample examined. Table 8-2 presents the greater of the geometric mean concentration from groundwater or surface water for each chemical and, where available, the water ingestion toxicity constants from the PHE manual. The chemicals in this table are ranked according to their toxicity scores for both potential carcinogenic effects and noncarcinogenic effects. The chemicals for which no toxicity constants were available are listed at the bottom of Table 8-2.

Five human health indicator chemicals were selected on the basis of their potential carcinogenic effects. Four of the selected chemicals (arsenic, tetrachloroethylene, trichloroethylene, and vinyl chloride) were measured in 15 or more of the total 27 groundwater samples collected in the general site area. PCBs were detected in 8 of 27 groundwater samples. Although the measured PCB concentrations are suspect, for reasons that are described below, PCBs were selected as a human health indicator chemical because they are known to have been disposed of at the site. The two remaining compounds ranked as potential carcinogens (1,1-dichloroethylene and chloroform) were not selected because they were detected in five or fewer samples.

In this PHE, "PCBs" refers to the mixture of PCB congeners (Aroclors 1242, 1248, and 1254) found at the site. The detected PCB concentrations in the unfiltered groundwater samples shown in Table 8-1 ranged from 4 to 1,200 ppb. However, the water solubilities of Aroclors 1242, 1248, and 1254 are estimated

TABLE 8-2

SELECTION OF HUMAN HEALTH INDICATOR CHEMICALS FROM CHEMICALS DETECTED IN GROUNDWATER AND SURFACE WATER NOVEMBER/DECEMBER 1985 SAMPLING PERIODS

CHEMICAL (CAS NO.)	Maximum Geometric Mean Concentration (ppb) (b)	Maximum Value From Surface Water(S) or Groundwater(G)	Water Ingestion Toxicity Factor (ppm)-1 (a) Potential Carcinogenic Effects	Water Ingestion Toxicity Factor (ppm)-1 (a) Non-Carcinogenic Effects	Toxicity Score For Potential Carcinogenic Effects (c)	Toxicity Score For Potential Non-Carcinogenic Effects (c)	Rank
Rank Based on Potential Carcinogenic Effects							
Arsenic(7440-38-2)	8	G	3.71E+00		2.97E-02		1
Polychlorinated biphenyls (PCBs)	3	G	1.06E+00		3.29E-03		2
Trichloroethylene(79-01-6)	236	G	5.14E-03		1.21E-03		3
1,1-Dichloroethylene(75-35-4)	6	G	1.31E-01		7.86E-04		4
Tetrachloroethylene(127-18-4)	81	G	5.14E-03		4.16E-04		5
Vinyl chloride(75-01-4)	61	G	4.57E-03		2.79E-04		6
Chloroform(67-66-3)	4	G	5.71E-02		2.28E-04		7
Rank Based on Noncarcinogenic Effects							
Barium(7440-39-3)	168	G		4.08E+00		6.85E-01	1
Trichloroethylene(79-01-6)	236	G		1.05E+00		2.48E-01	2
Selenium(7782-49-2)	2	G		1.05E+02		2.10E-01	3
Nickel(7440-02-2)	38	G		4.26E+00		1.62E-01	4
Arsenic(7440-38-2)	8	G		1.80E+01		1.44E-01	5
Silver(7440-22-4)	5	G		2.00E+01		1.00E-01	6
Cadmium(7740-39-3)	8	G		4.45E+00		3.56E-02	7
2-Methylphenol(95-48-7)	5	G		5.97E+00		2.99E-02	8
Lead(7439-92-1)	31	G		8.93E-01		2.77E-02	9
Copper(7440-50-8)	34	G		7.14E-01		2.43E-02	10
trans-1,2-Dichloroethylene(156-60-5)	274	G		5.29E-02		1.45E-02	11
4-Methylphenol(106-44-5)	2	G		5.97E+00		1.19E-02	12
Vanadium(7440-62-2)	45	G		1.43E-01		6.44E-03	13
Vinyl chloride(75-01-4)	61	G		8.77E-02		5.35E-03	14
Zinc(7440-66-6)	49	G		1.07E-01		5.24E-03	15
1,1-Dichloroethylene(75-35-4)	6	G		3.71E-01		2.23E-03	16
Mercury(7439-97-6)	0	G		1.84E+01		2.21E-03	17
1,2,4-Trichlorobenzene(120-82-1)	8	G		2.14E-01		1.71E-03	18
Tetrachloroethylene(127-18-4)	81	G		9.62E-03		7.79E-04	19
Phenol(108-95-2)	5	S		1.00E-01		5.00E-04	20
Toluene(108-88-3)	81	G		5.20E-03		4.21E-04	21
Polychlorinated biphenyls (PCBs)	3	G		1.00E-01		3.10E-04	22
1,1-Dichloroethane(75-34-3)	10	G		2.58E-02		2.58E-04	23
Ethylbenzene(100-41-4)	19	G		1.10E-02		2.09E-04	24
Methyl ethyl ketone(78-93-3)	21	G		7.75E-03		1.63E-04	25
1,4-Dichlorobenzene(106-46-7)	3	G		5.19E-02		1.56E-04	26
1,2-Dichlorobenzene(95-50-1)	3	G		5.19E-02		1.56E-04	27
Di-n-Butyl-Phthalate(84-74-2)	4	G		3.81E-02		1.52E-04	28
1,1,1-Trichloroethane(71-55-6)	44	G		7.33E-04		3.23E-05	29
Dichloromethane(75-09-2)	9	G		9.20E-04		8.28E-06	30
Diethyl phthalate(88-6-2)	3	G		2.67E-04		8.01E-07	31

TABLE 8-2 (Continued)

CHEMICAL (CAS NO.)	Maximum Geometric Mean Concentration (ppb) (b)	Maximum Value From Surface Water(S) or Groundwater(G)	Water Ingestion Toxicity Factor (ppm)-1 (a) Potential Carcinogenic Effects	Water Ingestion Toxicity Factor (ppm)-1 (a) Non-Carcinogenic Effects	Toxicity Score For Potential Carcinogenic Effects (c)	Toxicity Score For Potential Non-Carcinogenic Effects (c)	Rank
Chemicals Not Listed in the PHE Manual							
Tin(7440-31-5)	23	G					
Calcium(7440-70-2)	9,856	G					
Bis(2-ethylhexyl)phthalate(117-81-7)	2	G					
Chloroethane(75-00-3)	10	G					
Total xylenes	43	G					
Naphthalene(91-20-3)	6	G					
Beryllium(7440-41-7)	5	G					
Chromium(67-66-3)	31	G					
2,4-Dimethylphenol(105-67-9)	2	G					
Iron(7439-89-6)	36,800	G					
Potassium(7440-09-7)	2,640	G					
Magnesium(7439-95-4)	4,250	G					
Isophorone(78-59-1)	5	G					
Cobalt(7440-48-4)	34	G					
Benzyl alcohol(100-51-6)	2	G					
Manganese(7439-96-5)	2,940	G					
Methyl isobutyl ketone(108-10-1)	12	G					
Aluminium(7429-90-5)	7,840	G					
Sodium(7440-23-5)	5,100	S					
Acetone(67-64-1)	25	G					

(a) Water ingestion toxicity factors were obtained from the PHE Manual (ICF 1985).
(b) Maximum geometric mean concentration for groundwater or surface water.
(c) Geometric mean concentration * toxicity factor / 1000.

by Mackay et al. (1983) to be 400 ppb, 200 ppb, and 60 ppb, respectively. The fact that the measured groundwater levels greatly exceeded the estimated PCB congener solubilities indicates that some suspended sediments, to which PCBs strongly adsorb, were present in the unfiltered samples.

Three additional chemicals (cadmium, trans-1,2-dichloroethylene, and lead) ranked on the basis of their noncarcinogenic effects were selected. Of the remaining chemicals that were ranked based on their noncarcinogenic effects, 10 were not selected as indicator chemicals because they were detected in fewer than 6 groundwater samples.

Of the other inorganic compounds that are naturally occurring, two, barium and nickel, were ranked high among the chemicals for noncarcinogenic effects. Barium was detected in over 11 samples collected from groundwater and from surface water. Nickel was detected in 14 of 27 groundwater samples. In addition, the maximum detected concentrations of barium (798 ppb) and nickel (202 ppb) in groundwater were greater than the maximum concentrations observed in the three background groundwater wells (275 ppb and 114 ppb, respectively). Despite these factors, neither barium nor nickel were selected as human health indicator chemicals for several reasons. Neither inorganic compound is associated with the PCBs, oils or solvents known to have been processed at the site. The geometric mean groundwater concentrations from within the general site area (168 ppb and 38 ppb, respectively) were below the observed background levels. (Because of the small background sample size, a statistical test of significance for the difference between site groundwater contamination levels and background groundwater contamination levels could not be conducted.) Finally, the toxicity factor for nickel is known to be incorrect and, when revised, it will lower nickel's overall ranking.

The rest of the chemicals listed in Table 8-2 were not selected for further analysis because of their relatively low concentrations, low frequency of detection (e.g., less than five samples in which the contaminant was detected), lower toxicities (based in part on structure-activity considerations), or a combination of these factors.

Contaminants in Soils and Sediments

Table 8-3 lists the frequency of detection, the range of detected concentrations and the geometric mean concentration for all of the chemicals measured in soils and sediments within the general site-related sample area. The soil samples that were considered for this data summary consisted of those collected at the surface and at the most shallow sampling level for each soil boring location. The data are summarized in Table 8-3.

Table 8-4 lists the highest geometric mean concentration from soils or sediments for each chemical and, where available, the soil toxicity constants from the PHE manual. As with the chemicals detected in groundwater and surface water, these chemicals are ranked according to their toxicity scores for both potential carcinogenic effects and noncarcinogenic effects. The nonranked chemicals are also listed at the bottom of the table.

No additional chemicals were selected as indicator chemicals based on the ranking for contaminated soils and sediments. Four of the nine chemicals ranked on the basis of their potential carcinogenic effects were already selected as human health indicator chemicals based on their presence in groundwater and surface water. Four of the other chemicals (4,4'DDD, chloroform, 1,1,2-trichloroethane and benzene) were not selected because they were measured infrequently (i.e., in fewer than eight of the samples collected) and were present at lower levels in soils on site. The remaining chemical, bis(2-ethylhexyl)phthalate was detected in 29 of the 51 soil samples but was not detected in the sediments or the surface water. It was not selected as an indicator chemical since it is not believed to be site related and is not widely distributed in all of the environmental media at the site. Six of the chemicals ranked on the basis of their noncarcinogenic effects were also selected in the previous section. Of the remaining chemicals that were not selected but ranked high on this list, barium is not known to be a major site-related contaminant and it is not considered to be toxic to humans at the levels measured. Selenium, although detected in sediments, was not detected in any of the on-site soil samples considered. Mercury was detected in all of

TABLE 8-3
RE-SOLVE SITE
SUMMARY OF SOIL AND SEDIMENT DATA
OCTOBER/NOVEMBER 1985 SAMPLING PERIODS

CHEMICAL (CAS NO.)	SOIL DATA (a)			SEDIMENT DATA (a)		
	Frequency (b)	Concentration Range of Detected Samples (ppb)	Geometric Mean Concentration (ppb) (c)	Frequency (b)	Concentration Range of Detected Samples (ppb)	Geometric Mea Concentration (ppb) (c)
Acetone(67-64-1)	16/51	1 - 100,000	16			
Aluminium(7429-90-5)	51/51	1,724,000 - 19,247,000	3,000,000	7/7	1,230,000 - 4,350,000	2,300,000
Arsenic(7440-38-2)	5/51	1400 - 5,100	1.1			
Barium(7440-39-3)	38/51	300 - 126,000	210	7/7	6,300 - 86,000	32,000
Benzene(71-43-2)	3/51	50 - 100	3			
Benzoic acid(65-85-0)	4/51	71 - 18,200	910	4/7	200 - 1,000	280
Beryllium(7440-41-7)	23/51	200 - 1,600	6.8			
Bis(2-ethylhexyl)phthalate(117-81-7)	29/51	64 - 260,000	730			
2-Butanone	10/51	4 - 180,000	12			
Cadmium(7740-39-3)	17/51	2400 - 488,600	6.9			
Calcium(7440-70-2)	47/51	3800 - 1,990,000	240,000	7/7	410,000 - 4,070,000	870,000
Chloroform	3/51	1 - 260	2.7			
Chromium(67-66-3)	46/51	2000 - 36,000	2,000			
Chrysene				2/7	110 - 180	72
Cobalt(7440-48-4)	32/51	2000 - 15,000	210			
Copper(7440-50-8)	44/51	2000 - 181,000	2,200	4/7	2,700 - 15,000	160
Cyanide (-CN)				7/7	710 - 3,570	1,400
4,4-DDD				2/7	86 - 92	16
1,1-Dichloroethane(75-34-3)	5/51	1.2 - 50	3	2/7	32 - 33	5
trans-1,2-Dichloroethylene(156-60-5)	16/51	1 - 9,200	6	2/7	2 - 44	4
Diethyl phthalate	4/51	37 - 161	21			
Di-n-octyl phthalate(117-84-0)	4/51	57 - 740	32			
Di-n-butyl phthalate(84-74-2)	12/51	41 - 260,000	280			
Ethylbenzene(100-41-4)	17/51	1 - 1,600,000	12			
Fluoranthene	2/51	36 - 56	19	5/7	14 - 310	37
2-Hexanone(591-78-6)	3/51	18 - 100	6			
Iron(7439-89-6)	48/51	1,760,000 - 22,437,000	2,100,000	7/7	3,270,000 - 15,600,000	6,700,000
Isophorone(73-59-1)	5/51	8 - 8,550	190			
Lead(7439-92-1)	20/51	3,800 - 3,585,000	22	7/7	5,100 - 49,000	16,000
Magnesium(7439-95-4)	51/51	54,000 - 3,840,000	670,000	7/7	126,000 - 780,000	310,000
Manganese(7439-96-5)	48/51	100 - 235,000	37,000	7/7	104,000 - 4,170,000	640,000
Mercury(7439-97-6)	5/51	100 - 74,000	0.04	7/7	140 - 710	280

TABLE 8-3 (Cont'd)

CHEMICAL (CAS NO.)	SOIL DATA (a) Frequency (b)	SOIL DATA (a) Concentration Range of Detected Samples (ppb)	SOIL DATA (a) Geometric Mean Concentration (ppb) (c)	SEDIMENT DATA (a) Frequency (b)	SEDIMENT DATA (a) Concentration Range of Detected Samples (ppb)	SEDIMENT DATA (a) Geometric Mean Concentration (ppb) (c)
Methylene chloride(75-09-2)	8/41	25 - 1,200,000	6			
4-Methyl-2-pentanone	11/51	6 - 49000	13			
4-Methylphenol	2/51	4 - 350	2.2			
Naphthalene(91-20-3)	3/51	4 - 2,000	56	6/7	5 - 31	10
Nickel(7440-02-2)	6/51	5,600 - 1,950,000	6			
Phenanthrene(85-01-8)	4/51	6 - 1,100	4	6/7	5 - 300	30
Phenol(108-95-2)	4/51	330 - 2,040	190			
Polychlorinated biphenyls (PCBs)	30/51	67 - 2,800,000	310	5/7	240 - 1,102	110
Potassium(7440-09-7)	5/51	301,000 - 953,000	520			
Selenium(7782-49-2)	4/51	2600 - 6,200	0.53			
Silver(7440-22-4)	12/51	1200 - 613,000	4.4			
Sodium(7440-23-5)	34/51	4400 - 5,435,000	31,000			
Tetrachloroethylene(127-18-4)	27/51	2 - 110,000	31			
Thallium				7/7	7,100 - 36,000	9,900
Tin(7440-31-5)	3/51	4300 - 18,000	3			
Toluene(108-88-3)	29/51	0.5 - 8,100,000	16	6/7	2 - 9	3
Total xylenes	21/51	2.5 - 6,700,000	26			
1,2,4-Trichlorobenzene(120-82-1)	12/51	35 - 13,000	270			
1,1,1-Trichloroethane(71-55-6)	18/51	1 - 3500	7			
1,1,2-Trichloroethane(79-00-5)	10/51	1 - 520	4			
Trichloroethylene(79-01-6)	28/51	2 - 740,000	22			
Vanadium(7440-62-2)	36/51	2000 - 18,000	510	6/7	2,500 - 16,000	5,700
Zinc(7440-66-6)	21/51	11000 - 596,000	78	7/7	13,000 - 69,000	39,000

(a) Based on samples collected from within the general area bounded by Copicut River, Carol's Brook, the wetlands to the north of the site, and North Hixville Road. Soil samples consisted of those collected closest to the surface at each soil boring location (e.g., from approximately three feet below the surface at an elevation of 88 feet). Soil data analysis was performed by an EPA-approved contract laboratory. Sample results have met EPA validation requirements.

(b) Number of samples in which contaminant was detected divided by the total number

(c) Based on samples in which contaminant was detected; for samples in which contaminant was not detected, 1/2 of the CLP detection limit was used

(d) A detection limit of 40 ppb was assumed for the PCB mixture.

TABLE 8-4
SELECTION OF HUMAN HEALTH INDICATOR CHEMICALS FROM CHEMICALS DETECTED IN SOILS AND SEDIMENTS OCTOBER/NOVEMBER 1985 SAMPLING PERIODS

CHEMICAL (CAS NO.)	Maximum Geometric Mean Concentration (ppb) (b)	Maximum Value From Soil(Sl) or Sediment(Sd)	Soil Toxicity Factor (ppm)-1 (a) Potential Carcinogenic Effects	Soil Toxicity Factor (ppm)-1 (a) Non-Carcinogenic Effects	Toxicity Score For Potential Carcinogenic Effects (c)	Toxicity Score For Potential Non-Carcinogenic Effects (c)	Rank
Rank Based on Potential Carcinogenic Effects							
Arsenic(7440-38-2)	1	Sl	2.03E-04		2.23E-07		1
Polychlorinated biphenyls (PCBs)	310	Sl	2.86E-07		8.87E-08		2
4,4'-DDD	16	Sd	1.86E-06		2.98E-08		3
Bis(2-ethyhexyl)phthalate(117-81-7)	730	Sl	2.86E-08		2.09E-08		4
Tetrachloroethylene(127-18-4)	31	Sl	4.43E-07		1.37E-08		5
Chloroform	3	Sl	2.81E-06		7.59E-09		6
Trichloroethylene(79-01-6)	22	Sl	2.14E-07		4.71E-09		7
1,1,2-Trichloroethane(79-00-5)	4	Sl	5.14E-07		2.06E-09		8
Benzene(71-43-2)	3	Sl	3.86E-07		1.16E-09		9
Rank Based on Noncarcinogenic Effects							
Barium(7440-39-3)	32,000	Sd		2.04E-04		6.53E-03	1
Lead(7439-92-1)	16,000	Sd		4.46E-05		7.14E-04	2
Mercury(7439-97-6)	280	Sd		9.21E-04		2.58E-04	3
Zinc(7440-66-6)	39,000	Sd		5.33E-06		2.08E-04	4
Copper(7440-50-8)	2,200	Sl		3.57E-05		7.85E-05	5
Vanadium(7440-62-2)	5,700	Sd		7.14E-06		4.07E-05	6
Silver(7440-22-4)	4	Sl		1.00E-03		4.40E-06	7
1,2,4-Trichlorobenzene(120-82-1)	270	Sl		1.07E-05		2.89E-06	9
Selenium(7782-49-2)	0.53	Sl		5.26E-03		2.79E-06	10
Cadmium(7740-39-3)	7	Sl		2.23E-04		1.54E-06	11
Nickel(7440-02-2)	6	Sl		2.13E-04		1.28E-06	12
Trichloroethylene(79-01-6)	22	Sl		5.26E-05		1.16E-06	13
Arsenic(7440-38-2)	1	Sl		9.00E-04		9.90E-07	14
Phenol(108-95-2)	190	Sl		5.02E-06		9.54E-07	15
Di-n-butyl phthalate(84-74-2)	280	Sl		1.90E-06		5.32E-07	16
Benzene(71-43-2)	3	Sl		5.85E-06		1.76E-08	17
trans-1,2-Dichloroethylene(156-60-5)	6	Sl		2.65E-06		1.59E-08	18
Tetrachloroethylene(127-18-4)	31	Sl		4.81E-07		1.49E-08	19
Ethylbenzene(100-41-4)	12	Sl		5.52E-07		6.62E-09	20
1,1-Dichloroethane(75-34-3)	5	Sd		1.29E-06		6.45E-09	21
Toluene(108-88-3)	16	Sl		2.60E-07		4.16E-09	23
Diethyl phthalate	21	Sl		1.34E-08		2.81E-10	24
Methylene chloride(75-09-2)	6	Sl		4.60E-08		2.76E-10	25
1,1,1-Trichloroethane(71-55-6)	7	Sl		3.67E-08		2.57E-10	26

TABLE 8-4 (Cont'd)

CHEMICAL (CAS NO.)	Maximum Geometric Mean Concentration (ppb) (b)	Maximum Value From Soil(Sl) or Sediment(Sd)	Soil Toxicity Factor (ppm)-1 (a)		Toxicity Score For Potential Carcinogenic Effects (c)	Toxicity Score For Potential Non-Carcinogenic Effects (c)	Rank
			Potential Carcinogenic Effects	Non-Carcinogenic Effects			
Chemicals Not Listed in the PHE Manual							
2-Butanone	12	Sl					
2-Hexanone(591-78-6)	6	Sl					
4-Methyl-2-pentanone	13	Sl					
4-Methylphenol	2	Sl					
Acetone(67-64-1)	16	Sl					
Aluminum(7429-90-5)	3,000,000	Sl					
Benzoic acid(65-85-0)	910	Sl					
Beryllium(7440-41-7)	7	Sl					
Calcium(7440-70-2)	870,000	Sd					
Chromium(67-66-3)	2,000	Sl					
Chrysene	72	Sl					
Cobalt(7440-48-4)	210	Sl					
Cyanide (-CN)	1400	Sd					
Di-n-octyl-phthalate(117-84-0)	32	Sl					
Fluoranthene	37	Sd					
Iron(7439-89-6)	6,700,000	Sd					
Isophorone(78-59-1)	190	Sl					
Magnesium(7439-95-4)	670,000	Sl					
Manganese(7439-96-5)	640,000	Sd					
Naphthalene(91-20-3)	56	Sl					
Phenanthrene(85-01-8)	30	Sd					
Potassium(7440-09-7)	520	Sl					
Sodium(7440-23-5)	31,000	Sl					
Thallium	9900	Sd					
Tin(7440-31-5)	3	Sl					
Total xylenes	26	Sl					

(a) Soil toxicity factors were obtained from the PHE Manual (ICF 1985).
(b) Maximum geometric mean concentration for soils or sediments.
(c) Geometric mean concentration * toxicity factor / 1000.

the sediment samples at estimated values[1] but was detected in five or fewer soil and groundwater samples and was not selected based on its limited distribution at the site. The toxicity factor for nickel in soil, as in water, is known to be too high. The remaining compounds, both those ranked based on their noncarcinogenic effects and those without toxicity factors, were not selected because they were detected infrequently (e.g., detected in less than 6 of over 40 samples), were present at levels considered to be at or near normally occuring background levels, or are not believed to be related to the oils or solvents disposed of at the site.

Contaminants in Air

A limited one-day air sampling effort was conducted in November 1985 during the Re-Solve Site RI (see Section 7). Several volatile contaminants that were frequently observed in soils, groundwater, and surface water were also detected in the air samples (e.g., tetrachloroethylene, trichloroethylene, and 1,1,1-trichloroethane). Although the air data were not used in the indicator chemical selection process (see Section 8.4.3), the detected chemicals were well represented in the soil, groundwater, and surface water data that were used in the indicator chemical selection process.

8.2.2 AQUATIC LIFE INDICATOR CHEMICALS

There are no official guidelines on selecting indicator chemicals for aquatic life. In this PHE, aquatic life indicator chemicals were selected based on a qualitative evaluation of surface water contaminant levels (see Table 8-1). Factors that were considered in selecting aquatic life indicator compounds included concentration, toxicity to freshwater aquatic life, and existence of a potentially exposed population.

A close examination of the surface water data showed that the levels at which most of the site-related contaminants were measured would not be of concern to

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[1] According to EPA definitions (EPA 1984a), estimated values represent tentative identification only.

freshwater aquatic life. This is shown in Table 8-5 which compares surface water concentrations to EPA Ambient Water Quality Criteria for the protection of freshwater aquatic life. The criteria are exceeded only for cadmium and lead (which were detected infrequently) and PCBs.

Several chlorinated hydrocarbons and other chemicals (e.g., 1,1-dichloroethane, trans-1,2-dichloroethylene, 1,1,1-trichloroethane, trichloroethylene, and toluene) were measured only at elevated levels in the southeastern segment of the unnamed tributary. The unnamed tributary is an intermittently flowing, small stream that may only be a suitable habitat for invertebrates (Zupkas 1986). Although the elevated contaminant levels in the unnamed tributary do not exceed the Ambient Water Quality Criteria, they may still adversely affect the limited array of aquatic life that is capable of inhabiting the tributary. Because of its small size and intermittent flow characteristics, however, the unnamed tributary is not considered to be the primary freshwater aquatic life habitat of concern in the Re-Solve site area. Rather the nearby Copicut River and Carol's Brook are of greater potential concern. Therefore, the chemicals measured at elevated levels only in the unnamed tributary were not selected as indicator chemicals. Surface water samples collected in the Copicut River and Carol's Brook did not indicate the presence of organic contaminants at levels of concern. Several inorganic compounds were also detected in surface water. With the exception of manganese and zinc, the surface water concentrations in the site area were essentially the same as background levels measured in an upstream surface water location (SW01). Neither zinc nor manganese are expected to pose risks to freshwater aquatic life at the levels observed.

Although none of the contaminants measured in surface water were selected as aquatic life indicator chemicals, the continuing presence of PCBs in sediments in the site area may be of concern. As a result, PCBs were selected as the only aquatic life indicator chemical.

8.2.3 FINAL LIST OF INDICATOR CHEMICALS

The final list of eight human health indicator chemicals is presented in Table 8-6. Appendix A contains detailed human health profiles for these

TABLE 8-5

COMPARISON OF SURFACE WATER CONCENTRATIONS TO AMBIENT WATER QUALITY CRITERIA FOR THE PROTECTION OF FRESHWATER AQUATIC LIFE

Chemical (CAS. No.)	Frequency[a]	Concentration Range of Detected Samples (ppb)	Geometric Mean Concentration (ppb)	Ambient Water Quality Criteria (ppb)	
				Average	Maximum
Acetone (67-64-1)	3/22	93-1,300	9	-	-
Aluminum (7429-90-5)	11/12	15-272	108	150[c]	950[d]
Barium (7440-39-3)	12/22	6.4-23	10	-	-
Cadmium (7740-39-3)	2/12	3.8-5.1	3	0.66[bc]	1.8[bd]
Calcium (7440-70-2)	12/12	1,430-6,444	3,110	-	-
Chloroethane (75-00-3)	6/22	8-90	8	-	-
Chromium (67-66-3)	8/12	4-8	5	11[c]	16[d]
1,1-Dichloroethane (75-34-3)	7/22	3-475	5	-	-
<u>trans</u>-1,2-Dichloroethylene (156-60-5)	14/22	15-2,000	43	-	11,600
Ethylbenzene (100-41-4)	3/22	3-58	3	-	-
Iron (7439-89-6)	12/12	132-7,436	1,370	-	-
Lead (7439-92-1)	2/12	6.2-6.5	3	1.3[bc]	34[bd]
Magnesium (7439-95-4)	12/12	869-2,040	1,300	-	-
Manganese (7439-96-5)	12/12	30-2,353	466	-	-
Polychlorinated biphenyls	2/15	0.52-1.2	0.3	0.014	2.0
Phenol (108-95-2)	2/15	4-18	5	2,560[e]	10,200[e]
Potassium (7440-09-7)	10/12	816-1990	1,460	-	-
Sodium (7440-23-5)	12/12	4,120-7,404	5,100	-	-
Toluene (108-88-3)	11/22	2-280	12	-	17,500[e]
Total xylenes	5/22	5-330	5	-	-
1,1,1-Trichloroethane (71-55-6)	7/22	16-440	8	9,400[e]	18,000[e]
Trichloroethylene (74-01-6)	10/22	2-460	8	21,900[e]	45,000[e]
Vinyl chloride (75-01-4)	9/22	1-350	13	-	-
Zinc (7440-66-6)	8/12	4-45	12	49[bc]	54[bd]

[a] Number of samples in which contaminant was detected divided by total number of samples.

[b] A water hardness of 50 mg/l CaCO$_3$ was assumed based on Sawyer and McCarty (1978).

[c] Four-day average not to be exceeded more than once every three years on the average.

[d] One-hour average not to be exceeded more than once every three years on the average.

[e] These are not ambient water quality criteria; however, available evidence indicates that adverse effects may occur at concentrations exceeding these levels.

EPA Sources: Fed. Reg. 45:79318-79379 (1980), Fed. Reg. 50:30784-30796 (1985), Fed Reg. 51:8361-8363 (1986), and Fed. Reg. 51:19269-19270 (1986).

TABLE 8-6

FINAL LIST OF HUMAN HEALTH INDICATOR CHEMICALS FOR THE RE-SOLVE SITE

	Rank Based on Carcinogenic Effects		Rank Based on Non-Carcinogenic Effects	
Chemical (CAS No.)	Water	Soil	Water	Soil
Arsenic (7440-38-2)	1	1	5	15
PCBs (11097-69-1)	2	2		
Trichloroethylene (79-01-6)	3	7	2	14
Vinyl chloride (75-01-4)	6		14	
Tetrachloroethylene (127-18-4)	5	5	19	20
Lead (7439-92-1)			9	2
Cadmium (7740-39-3)			7	12
trans-1,2-Dichloroethylene			11	19

eight selected chemicals. The only aquatic life indicator chemical that was selected was PCBs. Appendix B contains a profile summarizing the effects of PCBs on aquatic life and other target organisms.

8.3 IDENTIFICATION OF EXPOSURE PATHWAYS

The following elements are important in identifying potential exposure pathways from the Re-Solve site: (1) a source and mechanism of chemical release to the environment, (2) an environmental receiving and transport medium for the released chemical, (3) a point of potential exposure by humans or biota with the contaminated medium, and (4) a route of exposure to the contaminants. A pathway is considered "complete" if all of these elements are present.

The following section outlines the principal exposure pathways, given current use of the site, that will be evaluated in this PHE, other potential exposure pathways that may currently exist but are expected to be incomplete or to have negligible effects and that therefore will not be evaluated further, and hypothetical exposure pathways associated with potential development of the site under the no-action alternative.

8.3.1 PRINCIPAL EXPOSURE PATHWAYS: PRESENT SITE USE

The results of groundwater, surface water, sediment, and soil sampling at the Re-Solve site, which were presented in earlier sections of this report, indicate the presence of elevated levels of PCBs, volatile organic chemicals (VOCs), and inorganic compounds. As discussed in Section 1 of this report, the major sources of contamination at the site were the four unlined lagoons in the northern part of the site, the filled cooling water pond at the eastern boundary of the site, the oil spreading areas in the western and southwestern portions of the site, the old foundation and concrete pads, and a few contaminated soil "hot spots". These areas were remediated during the removal action conducted in 1984 and 1985. Residual contamination remains in the areas where the unlined lagoons, the cooling water pond, and the oil spreading area were once located. The contaminants in these areas are released into surface water and groundwater in which they are transported off site. The surface water may transport both dissolved contaminants and contaminants adsorbed to soils and sediments such as PCBs. The groundwater will primarily transport dissolved contaminants.

The available information on the Re-Solve site indicates that contaminants are transported off-site via surface runoff and groundwater flow to nearby soils, surface water (e.g., the Copicut River) and sediments. The resulting exposure pathways thus include dermal contact with soil and surface water. Contaminants in soil may also be released into the air, either by volatilization or by suspension of soil particles by wind, and then subsequently inhaled. Volatile organic chemicals may also be released from nearby surface waters and be transported to nearby downwind receptors. An additional exposure pathway may consist of ingestion of fish which have bioaccumulated PCBs in their tissues. Although the site is presently surrounded by a secure chain link fence, exposures to contaminants by on-site receptors may occur under present site use conditions should the fence be knocked down or trespassers climb the fence.

Human Exposure to Contaminated Soils, Sediments, and Surface Water

Potential exposures to contaminated soils and sediments in the Re-Solve site area have been a major focus of concern. Although approximately 15,000 cubic yards of contaminated waste materials and soils were removed from the site through past remedial activities, contamination has persisted in surface and subsurface on-site soils. The transport of contaminants in surface water and groundwater, both in the dissolved form and adsorbed to suspended soil and sediment particles, has also resulted in the contamination of off-site soils and sediments.

As already mentioned, under present site conditions individuals may gain entry onto the site although this activity does not have a high probability. Thus, exposure to contaminated on-site soils is considered at present to be a complete pathway although it is not very probable. Contaminated soils, sediments, and surface water extend beyond the fenced-in site area. Sediments in the wetlands to the north of the site have been found to contain PCBs, inorganic compounds, and some VOCs. Contamination has also been measured in the sediments of the unnamed tributary. A few soil samples have been collected outside of the site's fence (SB49, SB50, SB52, SB53, SB901, and SB902). Data from these samples indicate that there are some contaminants in nearby off-site areas.

There is unlimited access to the areas outside of the fence. Hunters from the nearby Rod and Gun Club which is located on about 180 acres northeast of the site may regularly pass through contaminated areas. In addition, children living in the vicinity of the site may play in the areas adjacent to the site's fence, such as along the Algonquin Gas Pipeline right-of-way or in the unnamed tributary. These individuals may be exposed to contaminants in the soils via dermal contact; the contaminants may then be ingested or absorbed through the skin.

Individuals who occassionally trespass onto the site or pass by the site may also be exposed via inhalation to contaminants that have been released from soils into the air. These contaminants may either volatilize from the soils or may be suspended by the wind on soil particles.

From the site, the Copicut River flows approximately 1/4 mile to Cornell Pond. Overflow from Cornell Pond flows south where it joins Shingle Island River. Shingle Island River flows into Noquochoke Lake, which is located about two miles downstream of Cornell Pond. Analysis of surface water samples collected from this watershed indicate that VOCs are being transported off site. High levels of VOCs have been measured in the unnamed tributary and a few VOCs have been detected as far away as Shingle Island River and the entrance to Noquochoke Lake. For example, trans-1,2-dichloroethylene has been measured in the unnamed tributary at high levels (2,000 ppb) and at successively more dilute levels further downstream (approximately 100 ppb in Cornell Pond and 6 ppb upstream of Noquochoke Lake).

Individuals living in the Re-Solve site area have easy access to Carol's Brook, the Copicut River, Cornell Pond, Shingle Island River, and Noquochoke Lake. Contamination in the surface water bodies adjacent to the Re-Solve site, especially the Copicut River, may pose risks to individuals primarily by dermal contact during wading with chemicals that can be absorbed through the skin and inhalation of volatile organics released from the surface water.

Human Exposure to PCBs Via Ingestion of Fish

Tissue samples of fish obtained from the Copicut River and Cornell Pond were analyzed as part of the RI/FS for the Re-Solve site. Results of the fish sampling program indicated the presence of a few contaminants in some of the fish tissues (PCBs, isophorone, trichlorobenzene, and two phthalate esters). Except for PCBs, the origin of the observed tissue contaminants and their relationship with site-related contamination is questionable. This is because the other contaminants were not detected in surface water or sediment samples. The presence of PCBs in fish tissues, however, is more likely to be site related given the frequent occurrence of PCBs at the site and in off-site sediments, and the strong tendency for PCBs to bioaccumulate in aquatic organisms. Since Cornell Pond is a popular local area for fishing (it is unknown if the Copicut River is used for fishing), individuals may be exposed to PCBs via ingestion of fish caught in the pond.

Exposure of Aquatic Organisms to Contaminated Sediments

The wetland to the north of the site forms the headwaters of the unnamed tributary (see Figure 5-4). The unnamed tributary is a small, intermittently flowing stream which extends from the wetland southeast to the Copicut River. Carol's Brook, which forms the site's southern boundary, flows eastward to join the Copicut River. The wetland, the unnamed tributary, the Copicut River and Carol's Brook all receive contaminants from the Re-Solve site via surface water runoff and, with the exception of the wetland, groundwater discharge.

Due to the intermittent nature of its flow, the unnamed tributary is considered likely to be an unsuitable habitat for aquatic life other than invertebrates. The wetland, the Copicut River and Carol's Brook, however, do act as aquatic life habitats in the Re-Solve site area. Although the surface water in these three water bodies do not contain contaminants at levels high enough to pose adverse effects to aquatic life (see Section 8.2.2), the underlying sediments have been found to contain PCBs. The persistent PCB contamination of these sediments may pose risks to aquatic organisms.

8.3.2 OTHER EXPOSURE PATHWAYS: PRESENT SITE USE

Human Exposure to Contaminated Residential Well Water

Individuals may be exposed to Re-Solve site contaminants which have been transported from on-site groundwater into their private wells. Of the 58 private wells sampled as part of the RI/FS for the Re-Solve site, 12 were located downgradient of the site along Collins Corner Road, Old Fall River Road, and North Hixville Road.[1]

Eight of these wells are shallow, hand-dug wells supplied primarily by groundwater from the overburden aquifer. The remaining four wells are screened in the bedrock aquifer. The downgradient private well closest to the site is approximately 300 feet south of the southern edge of the site.

Analysis of the samples collected from the downgradient private wells indicated that several volatile organics were detected in wells PW01, PW29, PW30, and PW31. Some of the compounds (such as acetone and 2-butanone) are common laboratory contaminants and therefore may not be site related. Two other compounds, 1,2-dichloroethane and benzene, were detected in only one well each. Due to this low frequency of detection, these compounds are not considered further for analysis. Inorganic compounds were also detected in each well, however, a comparison of upgradient and downgradient wells does not show any major differences in the concentrations detected. Lead was measured in eight of the wells at concentrations ranging from 2 ppb to 108 ppb. The lead observed in these private wells may not, however, originate from the Re-Solve site, but rather may reflect a combination of typical background lead levels for the North Dartmouth area as well as specific characteristics of the residential wells that were sampled.

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[1] The downgradient private wells were considered to be PW01, PW14, PW20-PW23, PW29-PW31, PW37, PW40, and PW56.

Given the existing normal groundwater flow patterns (i.e., not under heavy flood conditions) and residential well pumping rates, the downgradient overburden private wells are not expected to receive contaminants from the Re-Solve site according to CDM. If private well pumping rates were altered to induce infiltration from Cornell Pond or reversal of normal groundwater flow patterns, site-related contaminants could possibly migrate into overburden wells. The downgradient bedrock private wells could theoretically induce flow from the site's bedrock plume if bedrock fractures were continuous from the site to the off-site bedrock wells. Because of the unknown bedrock fracture patterns, the potential for future migration of site-related contaminants in the bedrock aquifer to downgradient residential wells cannot be determined.

The absence of detectable levels of all but one of the human health indicator chemicals suggests that, based on current data, site-related contamination has not significantly affected downgradient residential wells. The observed lead levels in the downgradient wells also do not indicate the presence of extensive or dangerous contaminantion originating from the Re-Solve site, due to the distribution and levels of lead found in these wells.

In conclusion, the current quality of drinking water in private wells downgradient from the Re-Solve site is not considered to have been noticeably affected by contaminants originating from the site. As a result, potential risks to residents using well water downgradient of the site will not be evaluated in this PHE. If, however, additional information indicates the presence of site-related contamination in these wells or a clearly migrating plume of contamination, the potential for human health effects due to contaminated well water should be re-evaluated.

8.3.3 POTENTIAL EXPOSURE PATHWAYS RESULTING FROM FUTURE USE OF THE SITE

In addition to the principal exposure pathways that are of most concern under present site conditions, new pathways may be created by development of the Re-Solve site. The site area is currently zoned for residential/agricultural use. In the absence of any remedial activity at the Re-Solve site, exposure to on-site contamination in the future via pathways that currently do not exist (e.g., ingestion of on-site groundwater), but could hypothetically become complete, may be of concern.

One possible future use of the site is the construction of a drinking water well on site to accomodate possible future development. This is a hypothetical exposure scenario designed to determine whether the site could pose risks if there were no restrictions placed on its future use.

Another exposure pathway that may be of particular concern if the site were developed involves on-site exposures to contaminated soils. For example, if no remedial actions were taken and a house was built on the site contaminated sols that were previously buried could be moved to the surface, and then infants and children could theoretically come into frequent contact with on-site contaminants, particularly in soils, while playing. As a result, the potential risks associated with ingestion and dermal absorption of contaminated soils by both children and adults is evaluated as a possible future exposure pathway. Table 8-7 summarizes the current and future exposure pathways to be considered in the following sections.

8.4 HUMAN HEALTH RISK ASSESSMENT: PRESENT SITE USE

8.4.1 INTRODUCTION

In this section, data collected in 1985 and 1986 during the remedial investigation are used to estimate the risks to potentially exposed populations. This baseline evaluation assesses the risks associated with the no-action remedial alternative; i.e., it is assumed that no remedial actions will be performed at the Re-Solve site.

The principal exposure pathways discussed in the previous section are evaluated in this PHE. The principal exposure pathways under present site use conditions are (1) dermal contact and subsequent ingestion of on- and off-site soils and, for PCBs, dermal contact and subsequent ingestion plus direct absorption of contaminants from surface soils, (2) inhalation of volatile chemicals released from soils, (3) inhalation of particulate matter released

TABLE 8-7

POTENTIAL PATHWAYS OF EXPOSURE TO CONTAMINANTS ORIGINATING AT THE RE-SOLVE SITE UNDER PRESENT AND FUTURE SITE USE SCENARIOS

Exposure Medium	Potential Routes of Exposure	Potential Receptors	Pathway Complete
<u>Present Site Use</u>			
Soil (on and off site)	Direct contact with subsequent incidental soil ingestion and dermal absorption	Local population (e.g., children and Rod and Gun Club members) trespassing onto site or using nearby off-site areas	Yes
Air	Inhalation of volatile organic compounds and particulate matter released from surface soils	Local population using nearby off-site areas	Yes
	Inhalation of volatile organic compounds released from surface water	Nearby residents	Yes
Surface Water	Dermal absorption while wading	Local population (i.e., children)	Yes
Fish	Ingestion of fish	Members of general population who may fish from nearby surface water	Yes
Sediments	Direct contact with sediments	Aquatic life	Yes
<u>Future Site Use</u>			
Groundwater	Ingestion from a well assumed to be installed on site	Local population	Yes
Soil (on site)	Direct contact and subsequent incidental soil ingestion and dermal absorption	Local population	Yes
Air	Inhalation of volatile organic compounds and particulate matter released from soils	Local population	Yes

from on-site soils, (4) dermal contact with surface water, (5) inhalation of volatile chemicals released from surface water, (6) ingestion of fish, and (7) exposure to sediments by freshwater aquatic life. In this section, the first six human exposure pathways are evaluated.

This introduction briefly outlines the approach used to estimate the quantities of chemicals individuals may be exposed to (exposure point concentrations) and the potential human health risks associated with these exposures. Each exposure pathway is evaluated individually and then where appropriate the human health risks are summed across the relevant pathways.

Exposure Point Concentrations

Concentrations at potential exposure points are calculated for each of the selected indicator chemicals detected in the media of interest (i.e., soil, sediments, surface water, fish tissues, or groundwater). The geometric mean concentrations were used to represent the average exposure point concentrations. The maximum concentrations detected were used to represent the maximum exposure point concentrations.

In calculating the geometric mean concentrations, one-half of the detection limit was used for all of the "nondetect" samples [i.e., samples in which less than the detection limit was reported (see Section 8.1)]. The EPA Contract Laboratory Program (CLP) detection limits were used for the groundwater samples in which contaminants were not detected and for the soil and sediment samples in which organic contaminants were not detected. For inorganic compounds in soils and sediments, the detection limits were based on CLP aqueous detection limits adjusted by a factor of 0.1.[1] Results of samples from background and upgradient locations were not included in the analysis.

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[1] The aqueous detection limit can be converted to a soil/sediment detection limit by the equation: ADL (0.1 liter/g) = SDL, where ADL = aqueous detection limit (ug/liter or ppb), 0.1 liter = final water volume of digested soil or sediment sample, 1 g = amount of soil or sediment analyzed per sample, and SDL = soil/sediment detection limit (ug/g, mg/kg or ppm) (EPA 1984a).

Geometric mean values were not calculated for PCBs found in fish tissues due to the small sample size of analyzed tissues.

Comparison to Standards and Criteria

According to the procedures for public health evaluations developed by EPA, the potential adverse effects on human health and the environment should be assessed where possible by comparing the concentrations found at or near the site with "applicable or relevant and appropriate requirements" (ARARs). At the present time, EPA considers the Maximum Contaminant Levels (MCLs) and the maximum contaminant level goals (MCLGs) developed under the Safe Drinking Water Act, federal ambient water quality criteria, National Ambient Air Quality Standards (NAAQS) and state environmental standards to be potentially applicable or relevant and appropriate requirements for ambient concentrations (see below for definitions of the specific ARARs used in this assessment). If ARARs are not available for all of the selected indicator chemicals and for the exposures considered, a quantitative risk assessment must be performed for all of the contaminants, according to EPA guidelines as discussed in the PHE manual (EPA 1986a).

Risk Assessment

To quantitatively assess the risks associated with exposure to the potentially carcinogenic indicator chemicals, unit risk factors calculated by EPA's Carcinogen Assessment Group (CAG) are used. Unit risks (in $(mg/kg/day)^{-1}$) represent the individual excess cancer risk associated with lifetime chronic exposure per mg/kg/day of exposure. A 10^{-6} risk indicates that theoretically if an individual were exposed to the stated level every day throughout life, his or her lifetime excess individual probability (i.e., the probability above a background rate) of developing cancer resulting from that exposure is highly unlikely to exceed 10^{-6} (1 in 1 million), but may be smaller than 10^{-6} by an undetermined factor.[1] For the noncarcinogens, reference doses (RfDs) are

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[1] Federal regulations for environmental contaminants have generally fallen in the 10^{-4} to 10^{-6} lifetime risk range, as calculated from a linear (footnote continued on the next page)

compared with chronic intakes estimated for each exposure pathway. RfDs are estimates of the daily chemical exposure which appears to present low risk of adverse effects during a lifetime of exposure to a person. The RfDs and the potency factors are derived by EPA and are presented in their Health Effects Assessments for chemicals commonly found at Superfund sites.

Chemical Mixtures

In this assessment, the effects of exposure to each of the contaminants present at Re-Solve site have initially been considered separately. However, the pollutants occur together at the site, and individuals may be exposed to complex mixtures of contaminants, including many of the indicator chemicals and some of the other contaminants detected at the site. Consequently, it is important to recognize the potential adverse effects that these mixtures can have on humans.

EPA (1985a) has proposed guidelines for evaluating the potential toxicity of complex mixtures. In the absence of specific information on the toxicity of the mixture to be assessed or on similar mixtures, the guidelines generally recommend use of the assumption that the effects of different components of the mixture are additive. Synergistic or antagonistic interactions may be taken into account if there is specific information on particular combinations of chemicals. In this risk assessment, carcinogens and noncarcinogens are treated separately. In keeping with EPA policy, the risks for each individual carcinogen are added together to develop a total cancer risk. Noncarcinogens are also assessed individually by comparing the estimated chemical intake to the appropriate RfD (dose:RfD ratio), and summing the dose:RfD ratios across chemicals.

(footnote continued from the previous page)
multistage model. Most of those decisions incorporated consideration of cost and feasibility . . . . An incremental lifetime risk level of 10^{-6} would probably be more represenative than 10^{-5} as the 'no effect' level for these chemicals . . . as envisioned by Congress" (EPA 1984b).

Uncertainties in the Risk Assessment

The procedures and inputs used to assess potential human health (and environmental) risks in this evaluation as in all such risk assessments, are subject to a wide variety of uncertainties. In general, there are six main sources of uncertainty in any risk assessment:

- Environmental sampling and chemical analysis
- Environmental parameter measurement
- Fate and transport modeling
- Exposure parameter estimation
- Toxicological data
- Errors through combinations of the above

Environmental chemistry sampling and analysis error can stem from the error inherent in the procedures, from a failure to take an adequate number of samples to arrive at sufficient areal resolution, from mistakes on the part of the sampler, or from the heterogeneity of the matrix being sampled. One of the most effective ways of minimizing procedural or systematic error is to subject the data to a strict quality control review. Even with all the quality of the data rigorously assured, however, there is still error inherent in all analytical procedures.

Environmental parameter measurements primarily contribute to uncertainty due to their absence. Lack of site-specific measurements dictates that estimates must be made based on literature values, regression equations, extrapolations, and best professional judgment.

Modeling error arises primarily from the use of an inapproporiate model or the use of an appropriate model but with inappropriate boundary conditions. A further limitation in modeling is that a model can only approximate reality. Other model errors can stem from a lack of validation or verification of the models. Typically, an order of magnitude result is considered to be satisfactory for most complex modeling scenarios.

There are inherent uncertainties in determining the exposure parameters that are combined with toxicological information to assess risk. For example, the dermal contact exposure estimates used in this PHE are based on information provided in several studies (Hawley 1985, Kimbrough et al. 1984, Gallacher et al. 1984, Schaum 1984). Although the values presented in these studies vary, average and maximum soil contact exposure estimates were selected for use in the risk assessment. (See Appendix C for a further discussion of the derivation of the soil ingestion rates.)

As is the case for most risk assessments, toxicological data error is probably the largest source of uncertainty in this risk assessment. As EPA noted in its Proposed Guidelines for Carcinogenic Risk Assessment (EPA 1986b):

> There are major uncertainties in extrapolating both from animals to humans and from high to low doses. There are important species differences in uptake, metabolism, and organ distribution of carcinogens, as well as species and strain differences in target site susceptibility. Human populations are variable with respect to geometric constitution, diet, occupational and home environment, activity patterns, and other cultural factors.

EPA has developed a classification system for the overall weight of evidence for carcinogenicity of chemicals based on human and animal studies as well as other supporting data. The classification system divides chemicals into five categories: Group A - Carcinogenic in Humans; Group B - Probably Carcinogenic to Humans (B1 and B2 for higher and lower degrees of evidence, respectively); Group C - Possibly Carcinogenic to Humans; Group D - Not Classifiable as to Human Carcinogenicity; and Group E - No Evidence of Carcinogenicity for Humans. For the indicator chemicals selected for detailed evaluation in this PHE, for example, EPA has classified arsenic and vinyl chloride as Group A chemicals, trichloroethylene and PCBs as Group B2 chemicals, and lead as a Group C chemical.

8.4.2 DIRECT CONTACT WITH SOILS

Under present site use conditions, individuals may trespass onto the Re-Solve site or may pass through or play in the areas to the east, south, and north of the Re-Solve site fence. These areas include the wetland to the north, the Copicut River, Carol's Brook, the unnamed tributary and all accessible areas in between these water bodies. Soils in the Re-Solve site area have been found to be contaminated. In this section, the potential risks to individuals who may occasionally pass through or play in areas with contaminated soils or sediments are assessed. Exposure to contaminated sediments could occur while an individual walks through wetlands and stream beds in the area but this scenario is not considered here since exposure to surface soils is more probable and generally concentrations in soils exceed those in sediments.

Exposure Point Concentrations

Both on- and off-site soil contaminant data were used to develop exposure point concentrations to evaluate the potential risks associated with dermal contact with soils. Surface soil samples were collected at seven locations during the RI (SB47, SB49, SB50, SB52, SB53, SB901, and SB902). The shallowest samples from five of the borings (SB47, SB49, SB50, SB52, and SB53) were collected at the surface (0-6 inches). Soil borings 901 and 902 consisted of one sample each collected at the surface. The data obtained from four of these locations, SB47, SB50, SB52, and SB53, were used to represent on-site surface soil concentrations (i.e., within the fenced-in area). Although SB50, SB52, and SB53 are actually situated just outside of the fence, they are close enough to the fenced-in area to be considered representative of potential on-site contaminant levels. The data obtained from six of the seven locations, SB49, SB50, SB52, SB53, SB901, and SB902, were used to represent off-site soil concentrations. Borings 901 and 902 were situated to the southeast of the site above the Algonquin Gas Pipeline Right-of-Way. Boring sample SB49 was collected along the northern roadway leading into the site. Tables 8-8 and 8-9 summarize the sampling results for the on-site and off-site surface soils, respectively, for the human health indicator chemicals detected.

It should be noted that arsenic was not detected in any of the on-site surface soil samples. The two surface soil samples in which arsenic was detected, SB901 and SB902, are both situated off site above the Algonquin Gas Pipeline Right-of-Way. Although arsenic was detected in several of the below surface soil boring samples collected on site, the measured concentrations in these samples (1.2-7.4 ppm) are well within the range of background arsenic levels estimated for Eastern United States soils (Shacklette and Boerngen 1984). The mean background soil concentration for Eastern United States soils is estimated to be 4.8 ppm. The concentrations measured in SB901 and SB902 were

TABLE 8-8

CONCENTRATIONS OF HUMAN HEALTH INDICATOR CHEMICALS IN ON-SITE SURFACE SOILS

Compound[a]	Frequency[b]	Concentration Range (ppb)	Geometric Mean Concentration[c] (ppb)
trans-1,2-Dichloroethylene	1/4	ND[d] - 1	<1[e]
Lead	4/4	5,000J-16,000J[f]	8,000
PCBs	4/4	1,590- 97,000	13,500
Tetrachloroethylene	2/4	ND - 66	9

[a] Arsenic, cadmium, trichloroethylene, and vinyl chloride were not detected in on-site surface soils.

[b] Number of samples in which contaminant was detected divided by total number of samples. Four soil samples collected at the surface: SB47, SB50, SB52, and SB53, were considered.

[c] Calculated using detected concentrations and one-half of the CLP detection limit for organics.

[d] Not detected.

[e] Less than the detection limit of 1 ppb as marked.

[f] J indicates an estimated value.

TABLE 8-9

CONCENTRATIONS OF HUMAN HEALTH INDICATOR CHEMICALS IN OFF-SITE SURFACE SOILS

Compound[a]	Frequency[b]	Concentration Range (ppb)	Geometric Mean Concentration[c] (ppb)
Arsenic	2/6	ND[d]–21,000	1,600
Cadmium	1/6	ND - 7,000	<500[e]
Lead	6/6	6,200J-81,000J[f]	20,400
PCBs	5/6	ND -157,000	3,400
Tetrachloroethylene	2/6	ND - 17	<5[e]
Trichloroethylene	2/6	ND - 17J	<5[e]

[a] trans-1,2-Dichloroethylene and vinyl chloride were not detected in off-site soil samples.

[b] Number of samples in which contaminant was detected divided by total number of samples. Six off-site soil samples were collected at the surface: SB49, SB50, SB52, SB53, SB901, and SB902.

[c] Calculated using detected concentrations and one-half of the CLP detection limit for organics. For the inorganic compounds the detection limit for sediments was based on the aqueous CLP detection limit (see text).

[d] Not detected.

[e] Less than the detection limit as marked.

[f] J indicates an estimated value.

15(J)[1] ppm and 21 ppm. This information suggests that the arsenic levels measured off site in SB901 and SB902 may not be related to past waste activities at the Re-Solve site, but rather to an off-site source of contamination. One potential source of arsenic at these two sample locations may result from the application of arsenicals as defoliants along the Algonquin Gas Pipeline Right-of-Way.

Risk Estimation

In this section, the potential risks to children who may occasionally play in the contaminated on- and off-site soils are evaluated. Exposures to children are expected to be greater than for adults, since children are more likely to come into contact with soil during playing and have not developed personal hygiene practices. Although individuals from the Rod and Gun Club may also come into direct contact with soils in the Re-Solve site area, the potential exposures to children are expected to be greater.

Two exposure scenarios are considered in this assessment: (1) an average exposure case and (2) a plausible maximum case. The assumptions used for each scenario are summarized in Table 8-10 and are discussed below. It was assumed that younger children (6-11 years old) would be most likely to play on the Resolve Site assuming the fence was knocked down and in the off-site soils. For the average exposure case, it was assumed that children would visit the site area ten times a year, while more frequent visits (50 visits a year) were assumed for the plausible maximum case[2]. It was assumed that older children (12-16 years old) would be less likely to want to play in the soils at or near the site. For the purposes of this risk assessment, the average weight over the period of exposure was assumed to be 30 kg.

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[1] J indicates an estimated value. According to EPA (1984a) definitions, estimated values represent tentative identification only.

[2] A frequency of 50 visits/year could be achieved, for example, by (1) six visits per month between April and October (seven months total) and eight additional visits during the remaining five winter months of the year, or (2) seven visits per month between April and October.

TABLE 8-10

ASSUMPTIONS USED IN ESTIMATING EXPOSURE TO INDICATOR CHEMICALS VIA DIRECT CONTACT WITH SOILS NEAR THE RESOLVE SITE[a]

(Present Site Use)

Parameter	Average Exposure	Plausible Maximum Exposure
1. Frequency of contact	10 times/year	50 times/year
2. Ages of children exposed	6-11 years	6-11 years
3. Average weight over period of exposure	30 kg	30 kg
4. Years of exposure	5	5
5. Quantity of soil coming into contact with skin	1 g/visit	5 g/visit
6. Percentage of PCBs in soil absorbed through the skin	1	5
7. Percentage of arsenic, cadmium and lead in soils absorbed through the skin	Negligible	Negligible
8. Percentage of tetrachloroethylene, trichloroethylene, and _trans_-1,2-dichloroethylene in soils absorbed through the skin	Negligible	Negligible
9. Incidental ingestion of contaminated soil	20 mg/visit	100 mg/visit
10. Percentage of PCBs absorbed from ingested soils	35	50

[a] See text and Appendix C for derivation of exposure parameters.

Several studies have estimated the levels of soil that come into contact with exposed skin (Hawley 1985, Kimbrough et al. 1984, Gallacher et al. 1984, Schaum 1984). Schaum (1984) presented estimates of quantities of soil adsorbed to skin ranging from 0.5 to 1.5 milligrams of soil per square centimeter of exposed skin. He based the lower value of 0.5 mg/cm^2 on the work of Lepow (1975) in which the quantity of soil adsorbed was determined by pressing a tape on the hands of children. The upper limit (1.5 mg/cm^2) was derived using soil quantities from a study in which children's hands were rinsed with nitric acid to remove adsorbed soil (Roels et al. 1980) and measurements of the surface areas of the palm and fingers reported by Snyder (1975 as cited in Schaum 1984).

Schaum (1984) used a value of 2,940 cm^2 to represent the exposed skin area for an adult wearing a short-sleeved open-necked shirt, pants, and shoes, and a value of 910 cm^2 for an adult wearing a long-sleeved shirt, pants, and shoes. Schaum (1984) also gave an estimated range of 490-1600 cm^2 for a 9-10 year old child. Hawley (1985) estimated exposed surface areas of 2100 cm^2 for young children, 1600 cm^2 for older children, and 1700 cm^2 for adults. EPA (1985b) presented higher estimates for the upper extremities with 4,320 cm^2 reported for male adults and for children aged 9-15 estimates ranging from 2,680-3,370 cm^2.

Upon consideration of these studies, a range of 1-5 g may be used to represent the average and maximum quantities of soil that may adsorb to the skin of children, respectively. These values were derived using the EPA (1985b) surface areas for upper extremities of children 9-15 years of age and the Schaum (1984) exposure rate range of 0.5-1.5 mg/cm^2.

Absorption is another parameter that must be considered in estimating exposures. PCBs tend to strongly adsorb to particles and thus they are not as bioavailable from a soil matrix as they are from a solvent vehicle. Specific absorption data for PCBs are not available, but they have similar chemical and physical properties similar to tetrachlorodibenzodioxin (TCDD), for which absorption rates are available. The absorption rates of PCBs in soil were therefore estimated by analogy to TCDD.

TCDD is well-absorbed (greater than 80%) from the gastrointestinal tract when administered as the pure compound in oil (EPA 1985c). The fraction of TCDD in soil that is absorbed after ingestion was estimated as approximately 35 to 50% (Poiger and Schlatter 1980). For the purposes of this PHE, the oral absorption of PCBs in soil was assumed to be 35 and 50% for the average and plausible maximum exposure cases, respectively. The proportion of a dermally applied dose of TCDD that was absorbed through the skin of rats was approximately 0.3 to 3% in a soil:water paste (Poiger and Schlatter 1980). By analogy to TCDD, the dermal absorption of PCBs in soil was roughly assumed to be 1 and 5% for the average and plausible maximum exposure cases, respectively.

In studies relevant to the problem of lead bioavailability in soils and dusts, researchers have demonstrated that lead in soils is almost completely solubilized by the acid conditions of the stomach (Dacre and Ter Haar 1977, Day et al. 1975). Gastric solubilization must occur for metals in soil to be absorbed. Since virtually complete solubilization does occur, the experimentally determined absorption of lead in a solvent vehicle does not significantly differ from the absorption in a soil matrix. As a result, it is not necessary to adjust the absorption factor in estimating potential exposures to lead in ingested soils or sediments. For the purposes of this risk assessment, it was assumed that arsenic and cadmium behave similarly to lead. Inorganic compounds are generally not significantly absorbed through intact skin and are less likely to be absorbed when bound to soil. Consequently, the absorption of arsenic, cadmium, and lead in soils and sediments through the skin is considered to be negligible and was not considered in this assessment.

For the indicator VOCs measured in the soils, it was assumed that approximately 30% would volatilize from soils adsorbed to the skin prior to either their ingestion or dermal absorption. VOCs are readily soluble and do not strongly adsorb to soils. As a result, the bioavailability of VOCs ingested in soils is not expected to differ from their bioavailability in a solvent vehicle. As with the inorganic indicator compounds, it was thus not necessary to adjust the absorption factor in estimating potential ingestion exposures to VOCs in soils. At the concentrations measured in soils and considering the high volatility of the indicator VOCs, the amount of the VOC in soils absorbed across the skin is expected to be negligible. Thus, dermal absorption of VOCs was not considered further in this assessment.

Using the exposure assumptions presented in Table 8-10 and the chemical concentrations listed in Tables 8-8 and 8-9 the amount of each indicator chemical absorbed per visit to the Re-Solve site area was calculated using the relevant portions of the following general equation:

$$ABS = C(V)((SC)(X)(AS) + (IN)(Y)(AI))$$

where

ABS = chemical absorbed per visit (mg),

C = chemical concentration (mg/kg),

V = fraction of VOC not volatilized (0.7, VOC indicators only; 1 for other compounds),

SC = soil contact rate (1-5 g/visit),

X = conversion factor (1 kg/1,000 g),

AS = skin absorption factor (0.01 - 0.05, PCBs only),

IN = soil ingestion rate (20 - 100 mg/visit),

Y = conversion factor (1 kg/10^6 mg), and

AI = differential ingestion absorption factor (0.35 - 0.50, PCBs only).

The total amount of absorbed chemical over the 5-year exposure period was calculated using the following equation:

$$TA = (ABS)\ (V)\ (YR)$$

where

TA = total amount of chemical absorbed (mg),

ABS = chemical absorbed per visit (mg),

V = number of visits per year (10-50), and

YR = years site is visited (5).

The cumulative amount of each indicator chemical absorbed over the 5 years of assumed potential exposure was converted to an average daily exposure. The average daily exposure for the chemicals with potential carcinogenic effects (PCBs, trichloroethylene, tetrachloroethylene, arsenic, and vinyl chloride) were prorated over a 70-year lifetime, since the carcinogenic potency factors used for risk assessment are calculated for lifetime exposures. The average daily exposure is calculated as follows:

$$ADE = (TA)/(BW)(EP)(365)$$

where

ADE = average daily exposure (mg/kg/day),

TA = total amount of chemical absorbed (mg),

BW = body weight (30 kg),

EP = exposure period (70 years for carcinogens, 5 years for noncarcinogens), and

365 = conversion (days/yr).

The average daily exposures (lifetime for the potential carcinogens; 5 years for the noncarcinogens), were used as the basis for estimating the upper lifetime cancer risks associated with exposure to the potential carcinogens in sediments or for comparison to the noncarcinogenic chronic allowable intake dose for the other indicator chemicals.

The doses and risks associated with exposure to the indicator chemicals in the onsite and off-site surface soils are shown in Table 8-11 and 8-12. The doses are expressed in units of mg/kg/day and the risks are calculated for a 30 kg individual, the assumed average weight of a 6- to 11-year-old child.

The results for exposure to on-site surface soils indicate a total incremental lifetime cancer risk (upper bound) of 6×10^{-8} under average exposure conditions and 4×10^{-5} under plausible maximum conditions. PCBs were the major chemicals of concern for this exposure. Exposure to off-site surface soils would result in a possible total incremental lifetime cancer risk (upper bound) of 5×10^{-8} for the average case and 8×10^{-5} for the plausible maximum case. The major compounds contributing to the risk are arsenic and PCBs. As already

TABLE 8-11

DOSES AND RISKS ASSOCIATED WITH DIRECT CONTACT (INGESTION AND DERMAL ABSORPTION) WITH ON-SITE SOILS AT THE RE-SOLVE SITE

(Present Site Use)

A. POTENTIAL CARCINOGENS

Potential Carcinogen	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime: Average Case	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime: Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Incremental Lifetime Cancer Risk: Average Case	Incremental Lifetime Cancer Risk: Plausible Maximum Case
PCBs	1.5×10^{-8}	9.5×10^{-6}	4.34 [B2]	6×10^{-8}	4×10^{-5}
Tetrachloroethylene	8.4×10^{-12}	1.4×10^{-9}	5.1×10^{-2} [B2]	4×10^{-13}	7×10^{-11}
Total	--	--	--	6×10^{-8}	4×10^{-5}

B. NONCARCINOGENS

Noncarcinogen	Total Dose (mg/kg/day) Averaged Over a 5-Year Period: Average Case	Total Dose (mg/kg/day) Averaged Over a 5-Year Period: Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Total Dose:RfD Ratio: Average Case	Total Dose:RfD Ratio: Plausible Maximum Case
trans-1,2-Dichloroethylene	NC[b]	3.2×10^{-10}	0.01	NC	3×10^{-8}
Lead	1.5×10^{-7}	7.3×10^{-6}	6.7×10^{-4}[c]	2×10^{-4}	1×10^{-2}
Total	--	--	--	2×10^{-4}	1×10^{-2}

[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] Total dose and risk were not calculated for trans-1,2-dichloroethylene for the average case because the geometric mean soil concentration for this chemical was determined to be less than its detection limit.

[c] Use of a reference dose (RfD) is not recommended for lead. A draft health advisory (HA) value of 2×10^{-2} mg/day (6.7×10^{-4} mg/kg/day) based on a sensitive subpopulation of fetuses and infants is provided for guidance.

TABLE 8-12

DOSES AND RISKS ASSOCIATED WITH DIRECT CONTACT (INGESTION AND DERMAL ABSORPTION) WITH OFF-SITE SOILS IN THE RE-SOLVE SITE AREA

(Present Site Use)

A. POTENTIAL CARCINOGENS

	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime			Incremental Lifetime Cancer Risk	
Potential Carcinogen	Average Case	Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
Arsenic	2.1×10^{-9}	6.9×10^{-7}	15(A)	3×10^{-8}	1×10^{-5}
PCBs	3.8×10^{-9}	1.5×10^{-5}	4.34 (B2)	2×10^{-8}	7×10^{-5}
Tetrachloroethylene	NC[b]	3.9×10^{-10}	5.1×10^{-2} (B2)	NC	2×10^{-11}
Trichloroethylene	NC	3.9×10^{-10}	1.1×10^{-2} (B2)	NC	4×10^{-12}
	--	--	--	5×10^{-8}	8×10^{-5}

B. NONCARCINOGENS

	Total Dose (mg/kg/day) Averaged Over a 5-Year Period			Total Dose:RfD Ratio	
Noncarcinogen	Average Case	Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Average Case	Plausible Maximum Case
Cadmium	NC	3.2×10^{-6}	1.4×10^{-4}	NC	2×10^{-2}
Lead	3.7×10^{-7}	3.7×10^{-5}	6.7×10^{-4}[c]	6×10^{-4}	6×10^{-2}
Total	--	--	--	6×10^{-4}	8×10^{-2}

[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] Total doses and risks were not calculated for tetrachloroethylene, trichloroethylene, and cadmium for the average case because the geometric mean soil concentrations for these chemicals were determined to be less than their detection limits.

[c] Use of a reference dose (RfD) for a general population exposure is not recommended for lead. A draft health advisory (HA) value of 2×10^{-2} mg/day (6.7×10^{-4} mg/kg/day) based on a sensitive subpopulation of fetuses and infants is provided for guidance.

discussed, the estimated risks due to expsoure to arsenic in off-site soils may not be associated with contaminants originating from the Re-Solve site but rather may be associated with another source of contamination such as the application of arsenical defoliants along the Algonquin Gas Pipeline Right-of-Way. For the chemicals with noncarcinogenic effects under both exposure scenarios, the estimated exposures for both the average and the plausible maximum cases are below the chronic intake levels of concern.

8.4.3 INHALATION OF VOLATILE COMPOUNDS RELEASED FROM ON-SITE SOILS

Air sampling for volatile organic compounds (VOCs) was conducted at the Resolve Site on November 8, 1985. The results of this sampling, presented in Section 7, indicate that several VOCs detected frequently in on-site soils were also present in the air. This 1985 air sampling data will be used to evaluate inhalation exposures to VOCs under present site use conditions.

EXPOSURE POINT CONCENTRATIONS

The measured air data for the human health indicator chemicals is summarized in Table 8-13. As can be seen, only two indicator VOCs, tetrachloroethylene and trichloroethylene, were detected during the sampling period. The measured data are considered to be the most reliable indicators of potential on-site VOC levels available, given the large uncertainties inherent in using soil volatilization and air models to estimate on-site air levels and given the spatial variability of current soil VOC levels at the site. The measured air data were thus used as a basis for developing exposure point concentrations. It should be noted, however, that the risks presented for this exposure pathway only take into account exposures to the two measured VOCs and thus the calculated risks may be underestimated.

The meteorological conditions during the six-hour air sampling period for VOCs were clear, sunny, and cool (approximately 50°F) with light westerly winds (approximately 4.5 mph). Large portions of the site were under water due to heavy rainfall earlier in the week and soils on site were soggy.

TABLE 8-13

MEASURED AND SELECTED EXPOSURE POINT CONCENTRATIONS OF VOLATILE ORGANIC HUMAN HEALTH INDICATOR CHEMICALS AT THE RESOLVE SITE

Chemical[a]	Measured Concentration Frequency[b]	Measured Concentration Range (mg/m^3)	Geometric Mean Concentration[c] (mg/m^3)	Selected Maximum Exposure Point Concentration[d] (mg/m^3)
Tetrachloroethylene	3/3	3.4×10^{-3} - 3.4×10^{-2}	9.2×10^{-3}	9.2×10^{-2}
Trichloroethylene	3/3	1.6×10^{-3} - 5.4×10^{-3}	3.5×10^{-3}	3.5×10^{-2}

[a] The other volatile organic human health indicator chemicals, vinyl chloride and trans-1,2-dichloroethylene, were not detected in the air samples. The air samples were not tested for PCBs.

[b] Number of samples in which contaminant was detected divided by total number of samples. Three downwind samples collected at the site, 4, 4 Dup, and 5, were used for this table.

[c] The geometric mean concentration was based on the measured data and was used as the mean exposure point concentration.

[d] Because the soil conditions during air sampling were wet and the temperature relatively cool, the measured VOC levels were not considered representative of levels that could be associated with worst-case conditions. Thus, the maximum exposure point concentrations were assumed to be one order of magnitude greater than the geometric mean concentrations.

Volatilization from soils is likely to be highest, however, during hot periods when the soil is dry. As a result, the air sampling measurements taken at the Re-Solve site are unlikely to have been collected under worst-case volatilization conditions.

The specific meteorological conditions during sampling were considered in selecting exposure point concentrations for this exposure pathway. The geometric mean concentrations shown in Table 8-13 were used as exposure point concentrations for the average exposure case. For the plausible maximum exposure case, however, it was assumed that VOC levels at the site would be an order of magnitude greater on the average than the mean concentrations. In evaluating potential exposures, the exposure point concentrations were assumed to represent average VOC levels during periods when volatilization is expected to occur (e.g., no snow cover) at and immediately adjacent to the site (e.g., between the east site fence and the Copicut River). In addition, it was assumed that the measured VOC data would reflect potential future VOC air levels at the site. However, many factors (e.g., VOC degradation and transport from soils and construction-related soil disturbances and runoff) would likely influence the extent of VOC volatilization from on-site soils. Given the limited meteorological conditions under which the air sampling was conducted and the potential for VOC removal processes to affect volatilization, the selected exposure point concentrations could potentially either underestimate or, more likely, overestimate actual average VOC air levels.

Risk Estimation

Inhalation exposures to VOCs under present site use conditions were evaluated for individuals assumed to intermittently pass through the Re-Solve site area such as children, members of the Rod and Gun Club, or nearby residents. Although methods are theoretically available to estimate concentrations at off-site receptor locations (the nearest receptor is about 142 m away), their application would yield air concentrations which would be highly uncertain and could not be validated for this site.[1]

The assumptions for the average and plausible maximum exposure scenarios are summarized in Table 8-14. It was assumed that individuals six years and older would trespass onto the site or pass nearby the site fence 10 times/year for the average exposure case and 50 times/year for the plausible maximum exposure case. It was also assumed that the same individual would visit the site for a total period of 30 years for the average case and 64 years (i.e., 6-70 years) for the plausible maximum case. Each visit to the site area was assumed to last 30 minutes. During the exposure period, a light activity inhalation rate of 0.014 m^3/min (14 l/min or 20 m^3/day) was assumed based on data presented in EPA (1985b). It was also assumed that the inhaled VOCs were completely absorbed in the lung.

The total amount of chemical absorbed over the exposure period was calculated using the equation:

$$TA = (C_{air})(IR)(Dur)(V)(YR)$$

where

C_{air} = VOC air concentration (mg/m^3),

TA = total amount of chemical absorbed (mg),

IR = inhalation rate (0.014 m^3/min),

Dur = duration of exposure per visit (30 min/visit),

V = number of visits per year (10-50), and

YR = years area is visited (30-64).

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[1] Two methods could theoretically be used to estimate off-site VOC concentrations. First, measured on-site air data could be used in conjunction with assumptions regarding the extent of dispersion and dilution as the airborne VOCs move off-site. Second, a soil volatilization model could be used to estimate emission rates from soils for use in an area source dispersion model. Standard approaches for these two methods have not been developed for use in risk assessments and neither method has been extensively validated in the field.

TABLE 8-14

ASSUMPTIONS USED IN ESTIMATING EXPOSURE TO VOLATILE ORGANIC INDICATOR CHEMICALS VIA INHALATION NEAR THE RE-SOLVE SITE

(Present Site Use)

Parameter	Average Exposure	Plausible Maximum Exposure
1. Frequency of contact	10 times/year	50 times/year
2. Age of individual exposed	6 years-adult	6 years-adult
3. Average weight over period of exposure	70 kg	70 kg
4. Years of exposure	30	64
5. Duration of exposure	30 minutes	30 minutes
6. Inhalation rate	0.014 m3/min	0.014 m3/min
7. Percentage of tetrachloroethylene and trichloroethylene absorbed through the lung	100	100

The cumulative amount of each indicator VOC absorbed over the exposure period was converted to an average daily exposure. The average daily exposure for trichloroethylene and tetrachloroethylene, chemicals with potential carcinogenic effects, were prorated over a 70-year lifetime assuming a body weight of 70 kg.

Estimates of the potential carcinogenic risks were obtained by multiplying the average daily exposures by the carcinogenic potency factors for inhalation exposure. The potential incremental lifetime cancer risks associated with inhalation of VOCs released from contaminated soils at the Re-Solve site are shown in Table 8-15. These values represent the upper limit on the excess lifetime cancer risk that might occur as result of exposure under these present site use scenarios. The excess lifetime cancer risks associated with the average exposure case and the plausible maximum exposure case may be as high as $9x10^{-9}$ and $1x10^{-6}$, respectively, but they are unlikely to be higher than these values.

8.4.4 INHALATION OF PARTICULATE MATTER RELEASED FROM ON-SITE SOILS

Contaminants present in soils at the Re-Solve site may be suspended into the air by turbulence in the environment (i.e., wind). Because the site surface is generally not vegetated, soils are exposed to the air. As a result, Re-Solve site soils are particularly susceptible to suspension especially during dry, windy conditions. In this section, potential exposures due to inhalation of particulate matter containing chemicals from on-site soils are evaluated.

Exposure Point Concentrations

Sampling of airborne particulate matter was conducted at the Re-Solve site on November 8, 1985, at the same time as the VOC air sampling effort. As already mentioned in Section 8.4.3, the soils on site were soggy during the one-day

TABLE 8-15

DOSES AND RISKS ASSOCIATED WITH INHALATION OF VOLATILE ORGANIC CHEMICALS RELEASED FROM RE-SOLVE SITE SOILS

(Present Site Use)

	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime			Incremental Lifetime Cancer Risk	
Potential Carcinogen	Average Case	Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
Tetrachloroethylene	6.5×10^{-7}	6.9×10^{-5}	4.6×10^{-3} [B2]	3×10^{-9}	3×10^{-7}
Trichloroethylene	2.6×10^{-7}	2.6×10^{-5}	2.5×10^{-2} [A]	6×10^{-9}	7×10^{-7}
Total	--	--	--	9×10^{-9}	1×10^{-6}

[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

TABLE 8-17

DOSES AND RISKS ASSOCIATED WITH INHALATION OF CHEMICALS IN PARTICULATE MATTER RELEASED FROM RE-SOLVE SITE SOILS

(Present Site Use)

A. POTENTIAL CARCINOGENS

	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime			Incremental Lifetime Cancer Risk	
	Average Case	Plausible Maximum Case	Carcinogenic Potency Factor[a] (mg/kg/day)$^{-1}$	Average Case	Plausible Maximum Case
PCBs	1.9×10^{-11}	1.5×10^{-8}	4.34 (B2)	8×10^{-11}	7×10^{-8}

B. NONCARCINOGENS

	Total Dose (mg/kg/day) Averaged Over the Exposure Period			Total Dose:RfD Ratio	
	Average Case	Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Average Case	Plausible Maximum Case
Lead	5.3×10^{-11}	5.3×10^{-9}	6.7×10^{-4}[b]	8×10^{-8}	8×10^{-6}

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[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] Use of a reference dose (RfD) is not recommended for lead. A draft health advisory (HA) value of 2×10^{-2} mg/day (6.7×10^{-4} mg/kg/day) based on a sensitive subpopulation of fetuses and infants is provided for guidance.

Exposure Point Concentrations

The general pattern of contaminant distribution observed in the surface water is that higher concentrations of contaminants are present close to the site, with successively more dilute concentrations downstream. In assessing the potential risks from wading in the surface water, the maximum concentrations in surface water are used as the maximum exposure point concentrations, and the geometric mean concentrations are used as the average exposure point concentrations. The maximum concentrations were measured predominantly in the unnamed tributary. Although wading is unlikely to occur in this tributary due to its small, intermittent nature, these maximum concentrations were used to characterize potential worst-case concentrations in more accessible waters (i.e., the Copicut River) under low flow conditions. The exposure point concentrations are presented in Table 8-18.

Risk Estimation

In this section, the potential risks to individuals who may occasionally wade in the larger bodies of surface water are evaluated.

Both an average exposure case and a plausible maximum exposure case are considered in this assessment. The assumptions used for each of these exposure scenarios are summarized in Table 8-19 and discussed below. It was assumed that teenagers (13-17 years old) would be most likely to wade in the surface water near the Re-Solve site. The duration and frequency of water contact used for the average case analysis are the national average figures of 7 days/year and 2.6 hours/day (Versar 1986). The maximum plausible exposure scenario will consider water contact over five years of one day/week for June-August (12 days/year) and 2.6 hours/day. For the purposes of this risk assessment, the average weight over the period of exposure was assumed to be 45 kg. The exposed surface area for a teenager was assumed to be 6,500 cm^2 for the average case and 9,500 cm^2 for the plausible maximum case. These surface areas are based on surface area data provided in EPA (1985b) by body part for teenagers. The average value assumed exposure of the feet and legs whereas the maximum value assumed exposure of the feet, legs, arms, and hands.

TABLE 8-18

CONCENTRATIONS OF HUMAN HEALTH INDICATOR CHEMICALS IN SURFACE WATER IN THE RE-SOLVE SITE AREA

Compound[a]	Frequency[b]	Concentration Range (ppb)	Geometric Mean Concentration[c] (ppb)
Cadmium	2/12	3.8-5.1	<5[d]
Lead	2/12	6.2-6.5	<5[d]
PCBs	2/15	0.52-1.2	0.53
<u>trans</u>-1,2-Dichloroethylene	14/22	15-2,000	43
Trichloroethylene	10/22	2-460	8
Vinyl chloride	9/22	1-350	13

[a] Neither arsenic nor tetrachloroethylene were detected in surface water samples at detection limits of 10 ppb and 5 ppb, respectively.

[b] Number of samples in which contaminant was detected divided by the total number of samples.

[c] Calculated using detected concentrations and one-half of the CLP detection limit.

[d] Less than the EPA CLP detection limit given.

TABLE 8-19

ASSUMPTIONS USED IN ESTIMATING EXPOSURE TO INDICATOR CHEMICALS PRESENT IN SURFACE WATER NEAR THE RE-SOLVE SITE

(Present Site Use)

Parameter	Average Exposure	Plausible Maximum Exposure
1. Frequency of contact	7 times/yr	12 times/yr
2. Average weight over period of exposure	45 kg	45 kg
3. Years of exposure	5 yr	5 yr
4. Duration of exposure event	2.6 hr	2.6 hr
5. Skin surface available for contact	6,500 cm^2	9,500 cm^2
6. Flux rate of water across skin	0.5 $mg/cm^2/hr$	1.0 $mg/cm^2/hr$

A simplified approach presented in the Draft Superfund Exposure Assessment Manual (Versar 1986) is used to estimate exposures due to dermal absorption. This approach assumes that contaminants are carried through the skin as a solute in water that is absorbed (rather than being preferentially absorbed independently of the water). Dermal exposure per event is calculated as follows:

$$DEX = (D)(A)(C)(Flux)$$

where

DEX = estimated dermal exposure per event (mass of contaminant per event),

D = duration of exposure event (hours),

A = skin surface available for contact (cm^2),

C = contaminant concentration in water (weight fraction), and

Flux = flux rate of water across skin ($mass/cm^2/hr$).

The flux rate of water across the skin boundary is assumed to be the factor controlling the contaminant absorption rate. Although the Exposure Assessment Manual suggests using a flux rate of 0.5 $mg/cm^2/hr$, more recent data suggest this value may be closer to 1 $mg/cm^2/hr$ (Brown et al. 1984). In this assessment, 0.5 $mg/cm^2/hr$ will be used to evaluate the average exposure scenario, and 1 $mg/cm^2/hr$ will be used to evaluate the maximum plausible exposure scenario.

Table 8-20 presents the doses and risks associated with the exposure scenarios discussed above. The dose per exposure event is presented for all of the indicator chemicals. For the potential carcinogens the total dose averaged over a 70-year lifetime is presented. This total dose is multiplied by the carcinogenic potency factor to determine the incremental lifetime cancer risk. These risks represent upper bound lifetime cancer risks and are estimated to be $9x10^{-9}$ for the average exposure case and $1x10^{-6}$ for the plausible maximum exposure case. The chemical associated with the greatest incremental risk is vinyl chloride.

For the noncarcinogenic indicator chemicals, the total dose averaged over the period of exposure (5 years) is determined. For each chemical, the total dose

TABLE 8-20

DOSES AND RISKS ASSOCIATED WITH DERMAL ABSORPTION OF CHEMICALS WHILE WADING IN THE RE-SOLVE SITE AREA

(Present Site Use)

A. POTENTIAL CARCINOGENS

	Dose/Event (mg/kg/event)		Total Dose Averaged over 70-Year Lifetime (mg/kg/day)			Incremental Lifetime Cancer Risk	
Potential Carcinogen	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
PCBs	$9.9x10^{-8}$	$6.5x10^{-7}$	$1.3x10^{-10}$	$1.5x10^{-9}$	4.34 [B2]	$6x10^{-10}$	$7x10^{-9}$
Trichloroethylene	$1.5x10^{-6}$	$2.5x10^{-4}$	$2.1x10^{-9}$	$5.9x10^{-7}$	$1.1x10^{-2}$ [B2]	$2x10^{-11}$	$7x10^{-9}$
Vinyl chloride	$2.4x10^{-6}$	$1.9x10^{-4}$	$3.3x10^{-9}$	$4.5x10^{-7}$	2.3 [A]	$8x10^{-9}$	$1x10^{-6}$
Total	--	--	--	--	--	$9x10^{-9}$	$1x10^{-6}$

B. NONCARCINOGENS

	Dose/Event (mg/kg/event)		Total Dose Averaged over 5-Year Lifetime (mg/kg/day)			Total Dose: Total Dose:RfD Ratio	
Noncarcinogen	Average Case	Plausible Maximum Case	Average Case	Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Average Case	Plausible Maximum Case
Cadmium	NC[b]	$2.8x10^{-6}$	NC	$9.2x10^{-8}$	$1.4x10^{-4}$	NC	$7x10^{-4}$
Lead	NC	$3.6x10^{-6}$	NC	$1.2x10^{-7}$	$6.7x10^{-4}$[c]	NC	$2x10^{-4}$
trans-1,2-Dichloroethylene	$8.1x10^{-6}$	$1.1x10^{-3}$	$1.5x10^{-7}$	$3.6x10^{-5}$	$1.0x10^{-2}$	$2x10^{-5}$	$4x10^{-3}$
Total	--	--	--	--	--	$2x10^{-5}$	$5x10^{-3}$

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[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] Total doses and risks were not calculated for cadmium and lead for the average case because the geometric mean surface water concentrations for these chemicals were determined to be less than their detection limits.

[c] Use of an acceptable daily intake (AIC) is not recommended for lead. A draft health advisory (HA) value of $2x10^{-2}$ mg/day ($6.7x10^{-4}$ mg/kg/day) based on a sensitive subpopulation of fetuses and infants is provided for guidance.

is much less than the recommended reference dose for each, resulting in hazard indices for each exposure scenario of much less than one, indicating that these exposures would not be a cause for concern.

8.4.6 INHALATION OF VOLATILE COMPOUNDS RELEASED FROM SURFACE WATER

The compounds detected at the Re-Solve site are transported to the Copicut River in surface water and groundwater. Many of these compounds are volatile organics which may be released from surface water into the air and transported downwind. Individuals residing near the site may then be exposed via inhalation to these volatile organic compounds (VOCs). In this section, potential exposure to VOCs released from surface water and associated risks for off-site receptors (i.e., nearby residents) are estimated. The available VOC air data (see Section 8.4.3) measured on site was not used to estimate exposures to nearby residents because air modeling approaches are not yet sophisticated enough to allow prediction of off-site, downwind air levels using on-site measured air levels for an area source of contamination.

Exposure Point Concentrations

It was assumed in this exposure scenario that the Copicut River would act as the source of VOCs released into the air. The surface water sample data used to estimate VOC emissions from the river conservatively included samples collected from both the Copicut River and the unnamed tributary. Contaminants were observed to be more concentrated in the small tributary and were used in this scenario to reflect potential worst-case VOC concentrations in the Copicut River under low flow conditions. Table 8-21 presents the concentrations of volatile indicator chemicals detected in the unnamed tributary and the Copicut River and their frequency of detection.

The magnitude of chemical volatilization from the Copicut River was estimated by first calculating the flux rate of each chemical as follows:

$$F = K_L\ C_W/1000$$

where

F = chemical flux (ug/cm^2-hr),

TABLE 8-21

CONCENTRATIONS OF VOLATILE HUMAN HEALTH INDICATOR CHEMICALS IN THE UNNAMED TRIBUTARY AND THE COPICUT RIVER AT THE RE-SOLVE SITE

Chemical[a]	Frequency[b]	Concentration Range (ppb)	Geometric Mean Concentration (ppb)[c]
PCBs	2/11	ND - 1.2	<0.5[d]
Trichloroethylene	8/16	ND - 330	10
trans-1,2-Dichloroethylene	13/16	ND - 2,000	70
Vinyl chloride	8/16	1 - 350	15

[a] Concentrations in the unnamed tributary and Copicut River were based on surface water samples: SW01, 03-05, 08-11, 103-104, 106-108, 203-204, and 206. The volatile indicator chemical tetrachloroethylene was not detected in any of these samples.

[b] Number of samples in which contaminant was detected divided by the total number of samples.

[c] Calculated using detected concentrations and one-half of the CLP detection limit.

[d] The calculated geometric mean concentration was less than the CLP detection limit of 0.5 ppb.

K_L = overall mass transfer coefficient (cm/hr),

C_w = water concentration (ppb = ug/l), and

1000 = 1,000 cm^3/l.

The overall mass transfer coefficient was calculated according to the two-layer film model proposed by Liss and Slater (1974):

$$K_L = \left[\frac{1}{k_l} + \frac{RT}{Hk_g}\right]^{-1}$$

where

k_l = liquid-phase mass transfer coefficient (cm/hr),

k_g = gas-phase mass transfer coefficient (cm/hr),

R = gas constant (8.21×10^{-5} atm-m^3/mol-K),

T = temperature (286 K)[1], and

H = Henry's Law Constant (atm-m^3/mol).

The theory behind the two-layer film approach is that there is resistance to mass transfer in both the air and water interfacial layers. It is assumed that the bulk of the water body is well mixed with a thin surface layer across which a concentration gradient exists. It is also assumed that the air above the water is well mixed and that a thin layer above the water surface contains a second concentration gradient. The concentrations across the thin layers are assumed to be unequal (i.e., the volatilization rate to the air does not equal the rate of the reverse process), and the condensation from the air to the water is limited by the Henry's Law Constant. The dominant process considered in this model is molecular diffusion, which is dependent on the phase exchange coefficients rather than vaporization from the solution (Lyman et al. 1982).

The liquid- and gas-phase mass transfer coefficients were calculated as follows (Lyman et al. 1982):

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[1] The average annual river water temperature was based on USGS data collected from the nearest river of similar drainage, the Chipuxet River in West Kingston, Rhode Island (USGS 1974).

$$k_g = 3{,}000 \left(\frac{18}{MW}\right)^{1/2} \text{ (cm/hr)}$$

$$k_l = 20 \left(\frac{44}{MW}\right)^{1/2} \text{ (cm/hr)}$$

where

MW = compound molecular weight.

The estimated mass transfer coefficients (k_g, k_l, and K_L) are tabulated in Table 8-22. Using the overall mass transfer coefficient estimates, the flux of each chemical from the river can then be calculated for an average and a plausible maximum case. The geometric mean surface water concentrations presented in Table 8-21 are used to estimate average flux rates while the maximum concentrations were used to estimate the plausible maximum flux rates. These flux values are presented in Table 8-23.

In order to estimate downwind air concentrations, the chemical flux values must be converted into emission rates that can be used in an air dispersion model. The type of air model considered most appropriate for estimating downwind concentrations from the Copicut River was a line source model (Turner 1970). Thus the chemical flux values were converted into line source emission rates (e.g., in units of mg/m-sec) by the equation:

$$Q = FW\ (100)/[(3600)(1000)]$$

where

Q = emission rate (mg/m-sec),

W = river width (cm),

100 = 100 cm/m,

3600 = 3600 sec/hr, and

1000 = 1000 ug/mg.

The estimated emission rates are also shown in Table 8-23 assuming an average river width of 427 cm (14 feet). Use of these flux rates to estimate long-term emission rates conservatively assumes that the source of volatiles in the air will remain constant over several decades. It is, however, likely that the source will become less strong over time as VOCs are depleted by

TABLE 8-22

ESTIMATES OF MASS TRANSFER COEFFICIENTS FOR VOLATILE INDICATOR CHEMICALS DETECTED IN THE UNNAMED TRIBUTARY AND THE COPICUT RIVER

Chemical	MW (g/mol)[a]	Henry's Law Constant (atm-m^3/mol)[a]	k_g (cm/hr)	k_l (cm/hr)	K_L (cm/hr)
PCBs	328	1.07×10^{-3}	703	7.3	5.96
<u>trans</u>-1,2-Dichloroethylene	97	6.56×10^{-3}	1,292	13.5	13.0
Trichloroethylene	131	9.10×10^{-3}	1,112	11.5	11.2
Vinyl Chloride	63	8.19×10^{-2}	1,603	16.7	16.7

[a] Source: EPA (1986a).

TABLE 8-23

ESTIMATED FLUX AND EMISSION RATES FOR VOLATILE INDICATOR CHEMICALS

	Flux Rate (ug/cm^2 - hr)		Emission Rate (mg/m-sec)	
	Average	Plausible Maximum	Average	Maximum Plausible
PCBs	NC[a]	7.2×10^{-3}	NC	8.5×10^{-5}
trans-1,2-Dichloroethylene	9.1×10^{-1}	26.0	1.1×10^{-2}	3.1×10^{-1}
Trichloroethylene	1.1×10^{-1}	3.7	1.3×10^{-3}	4.4×10^{-2}
Vinyl chloride	2.5×10^{-1}	5.8	3.0×10^{-3}	6.9×10^{-2}

[a] Not calculated because mean PCB surface water concentration was less than the CLP detection limit.

degradation, volatilization, advection, and other removal processes. It should be noted that the assumption that the VOC source strength will remain constant over time may overestimate exposures and associated risks.

The annual average air concentrations downwind from the Copicut River were estimated based on Turner's (1970) infinite line source model according to the equation:

$$C_{air}\ (x,H) = \frac{2Q\ (Fr)}{(2\pi)^{0.5}\sigma_z u}\ \exp\left[\frac{-1}{2}\ \frac{H}{\sigma_z}\right]^2$$

where

C_{air} = air concentration (mg/m^3),

x = distance to nearest residence (m),

H = height of receptor (m),

Fr = fraction of year wind blows towards receptor,

σ_z = vertical dispersion coefficient (m), and

u = annual average wind speed (m/sec).

The nearest residences to the site are located 150 yards (142 m) to the northwest and southwest of the site and west of the Copicut River. Assuming neutral atmospheric stability (Stability Class D), the vertical dispersion coefficient, σ_z, is estimated at 6.4 m. Although the wind direction is predominantly from the southwest throughout the year as measured at Providence, Rhode Island, it was conservatively assumed that the wind would blow from the east (i.e., towards the receptors) 30% of the year (i.e., Fr = 0.3). The annual average wind speed, u, was assumed to be 4.8 m/sec based on measurements from Providence, Rhode Island (NOAA 1980). Receptor height, H, was assumed to be 2 m. Table 8-24 presents the estimated air concentrations for the receptors nearest to the Re-Solve site.

Risk Estimation

In this section, the potential risks to nearby receptors through the inhalation of volatile organic chemicals released from surface water are

TABLE 8-24

ESTIMATES OF AMBIENT AIR CONCENTRATIONS DOWNWIND FROM THE COPICUT RIVER

	Air Concentration (mg/m^3)	
Chemical	Average	Plausible Maximum
PCBs	NC[a]	6.6x10^{-7}
trans-1,2-Dichloroethylene	8.6x10^{-5}	2.4x10^{-3}
Trichloroethylene	1.0x10^{-5}	3.4x10^{-4}
Vinyl Chloride	2.3x10^{-5}	5.4x10^{-4}

[a] NC = Not calculated because mean PCB surface water concentration was less than the CLP detection limit.

estimated. Two cases will be considered, an average case and a plausible maximum case.

The calculated air concentrations can be converted to chronic average daily doses using the following equation and assuming that 100% of the inhaled chemical is absorbed by the body:

$$ADD = \frac{(C_{air})(IR)}{BW}$$

where

ADD = chronic average daily dose (mg/kg/day),

C_{air} = concentration in air (mg/m^3),

IR = inhalation rate (20 m^3/day), and

BW = body weight (70 kg).

This equation conservatively assumes that an individual would be exposed every day for a 70-year lifetime. The estimated average daily doses are presented in Table 8-25. The potential cancer risk associated with these exposures is obtained by multiplying the dose by the carcinogenic potency factor for inhalation exposure. These risks, also presented in Table 8-25, represent the upper limit on the lifetime cancer risks associated with this exposure scenario.

The excess lifetime cancer risks associated with the average exposure case and the maximum exposure case may be as high as 2×10^{-7} and 5×10^{-6}, respectively, but they are unlikely to be higher than these values. As can be seen in Table 8-25, the dose:RfD ratio for trans-1,2-dichloroethylene is much lower than one for both exposure scenarios, indicating that this exposure pathway poses no health threat to the surrounding population.

8.4.7 INGESTION OF CONTAMINATED FISH

In this section, the risks from consumption of fish from two areas downstream from the site, the Copicut River and Cornell Pond, are addressed. PCB levels measured in fish fillets from fish collected downstream of the site fall into three groups:

TABLE 8-25

DOSES AND RISKS ASSOCIATED WITH INHALATION OF VOLATILE CHEMICALS RELEASED FROM THE COPICUT RIVER

(Present Site Use)

A. POTENTIAL CARCINOGENS

	Total Dose (mg/kg/day) Averaged Over a 70-year Lifetime			Incremental Lifetime Cancer Risk	
	Average Case	Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
PCBs	NC[b]	1.9×10^{-7}	4.34 (B2)	NC	8×10^{-7}
Trichloroethylene	2.8×10^{-6}	9.7×10^{-5}	4.6×10^{-3} (B2)	1×10^{-8}	4×10^{-7}
Vinyl Chloride	6.6×10^{-6}	1.5×10^{-4}	2.5×10^{-2} (A)	2×10^{-7}	4×10^{-6}
Total	--	--	--	2×10^{-7}	5×10^{-6}

B. NONCARCINOGENS

	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime			Total Dose:RfD Ratio	
	Average Case	Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Average Case	Plausible Maximum Case
trans-1,2-Dichloroethylene	2.4×10^{-5}	6.9×10^{-4}	0.01	2×10^{-3}	2×10^{-2}

[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] NC = Not calculated because the geometric mean PCB surface water concentration was less than the CLP detection limit.

1. Six samples of fish (golden shiner, yellow perch, chain pickerel) from Cornell Pond: range, 0.26-1.05 ppm, mean 0.46 ppm.
2. One sample of fish (redfin pickerel, American eel) from Copicut River: 20 ppm.
3. One pooled sample of fish (brown bullhead) from both locations: 1.10 ppm.

It is not clear from the sediment sampling results [Table 4-2 in the Draft Off-Site Remedial Investigation Report (CDM 1985)] whether the difference in PCB levels between groups 1 and 2 above results from the differences in fish species or from higher levels of contamination in the Copicut River. However, studies in Canada have indicated that American eel typically have much higher PCB levels than other fish caught in the same waters (Graham 1976). Hence, it is likely that the high PCB levels in sample 2 will prove to be characteristic of American eels and that sampling of eels from Cornell Pond (or downstream in the same drainage system) will show similarly elevated levels.

The U.S. Food and Drug Administration has set a criterion of 2 ppm for PCB concentrations in fish. This level, however, may be changed to 1 ppm in the near future (Section 5 of this report). These levels were exceeded in some of the fish tissue samples.

Table 8-26 presents an exposure and risk assessment for consumption of American eels from the Copicut River. Under various assumptions about consumption of fish, upper bound estimates of lifetime excess cancer risk would be in the range of $7x10^{-4}$ to $8x10^{-3}$. Under the same exposure scenarios, there would also be potential risks of adverse effects other than carcinogenesis. For example, adverse effects of PCBs (Aroclor 1248) on reproduction in rhesus monkeys have been reported at a dietary concentration of 0.22 ppm (0.5 ppm administered 3 days per week) administered for 7 months (Allen et al. 1979, Bowman et al. 1981). Based on conversion factors reported by EPA (1983) and Barsotti and Van Miller (1984), this dietary concentration would correspond to dose rates of 9 ug/kg/day or 6.3 ug/kg/day, respectively. The dose rates of 1.2-1.9 ug/kg/day calculated for human consumers of eels (Table 8-21) would be within a factor of 5 of these known effect levels.

TABLE 8-26

EXPOSURE AND RISK ASSESSMENT FOR CONSUMPTION OF AMERICAN EELS FROM THE COPICUT RIVER

PCB concentration in edible tissue: 20 ppm (assuming single sample caught in December 1985 to be representative).

Unit cancer risk for PCBs (based on Aroclor 1260): 4.34 $(\mathrm{mg/kg/day})^{-1}$ (USEPA 1980).

Exposure Scenario 1

Long-term consumption of American eels at U.S. average rate of 6.5 g/day for freshwater fish (USEPA 1980).

Average body weight of consumer = 70 kg

Mean daily intake of PCBs = (6.5)(20)/70

Upper bound of lifetime excess cancer risk = $(4.34)(1.88)(10^{-3}) = 8.06 \times 10^{-3}$

Exposure Scenario 2

Consumption of American eels (150 g/serving) from the Copicut River 10 times per year for 10 years.

Average body weight of consumer = 70 kg

Mean daily intake of PCBs = (150)(20)(10)/(70)(365)
= 1.17 ug/kg/day (during period of exposure)
= 0.17 ug/kg/day (lifetime average)

Upper bound on lifetime excess cancer risk = $(4.34)(0.17)(10^{-3}) = 7.4 \times 10^{-4}$

The exposure scenarios presented in Table 8-26 assume regular consumption of eels, and this would be applicable only to a specialized subgroup of people living near the site. For fish species other than eels, reported PCB concentrations in edible tissues are in the range of 0.01-0.05 times those in eels. Hence, under the same assumptions exposures to PCBs via consumption of these fish would be in the range of 0.01-0.05 times those calculated for consumption of eels. Upper bound estimates of lifetime excess cancer risk would then fall in the range of $7x10^{-6}$ for the average case and $4x10^{-4}$ for the plausible maximum case.

Data from the National Pesticide Monitoring Program (NPMP) show the nationwide average level of PCBs from whole body freshwater fish samples as 0.88 ppm for 1976-1977, falling to 0.53 ppm for 1980-1981 (Schmitt et al. 1985). The average PCB level for 1980-1981 was 2.0 ppm for NPMP stations in the coastal northeastern United States, 1.5 ppm for stations in the Great Lakes Basin, and 1.7 ppm for all these stations combined (Appendix A in Schmitt et al. 1985). In fish sampling on the Connecticut River, the U.S. Fish and Wildlife Service has found PCB fillet/whole body ratios ranging from 0.2 to 0.5 (Beckett 1986). Based on these results, whole body PCB concentrations in fish from the Re-Solve site area may be two to five times higher than the concentrations found in the fillets (0.26 - 1.1 ppm). If this is the case, then the results from the fish sampling at the Re-Solve site would not compare with the national averages.

8.5 POTENTIAL DEVELOPMENT OF THE RE-SOLVE SITE

Four potential exposure pathways may be of concern if the site is developed in the future: ingestion of drinking water from a well drilled on site, ingestion of contaminated soil, and inhalation of volatile organic compounds and particulate matter released from surface soils. These pathways characterize hypothetical exposure scenarios that cannot be ruled out if no remedial activities are conducted at the Re-Solve site and no restrictions are placed on its use.

8.5.1 INGESTION OF ON-SITE GROUNDWATER

Exposure Point Concentrations

The concentrations of the human health indicator chemicals in on-site unfiltered groundwater samples were used to evaluate the potential risks associated with ingestion of groundwater under possible site development conditions. The average and maximum unfiltered sample concentrations for the human health indicator chemicals are provided in Table 8-27. The groundwater samples considered in this exposure pathway are located on site where a well could theoretically be installed. These samples are: W-A, OW-G, CW, CE, DW, DE, FW, FE, FC, HN, HS, IN, IS, KN, KS, OW-SB04S, OW-SB09S, OW-SB30S, OW-SB34S, OW-SB25S, OW-SB25D, and OW-SB27D. The groundwater wells situated along the Algonquin Gas Pipeline Right-of-Way were not included because it is improbable that a well would be installed on or directly adjacent to a right-of-way.

It should be recognized that these concentrations were measured from unfiltered groundwater samples. Although PCBs were measured in on-site unfiltered groundwater samples, they were present at levels exceeding their solubilities [approximately 60 to 400 ppb (Mackay et al. 1983)]. As a result, they are not considered representative of potential concentrations that may occur in drinking water and are not included in this portion of the risk assessment.

Although the other chemical concentrations are used in estimating risks, it should be kept in mind that the use of these unfiltered groundwater sample data may overestimate potential risks. An additional set of nine groundwater samples were filtered prior to analysis to allow a comparison of contaminant levels in the filtered samples with levels measured in unfiltered samples obtained from the same locations. These results are also shown in Table 8-27. The volatile organic indicator compounds were detected as frequently in the filtered samples as in the unfiltered samples collected from the same nine locations. Concentrations of the volatile compounds in most of the unfiltered

TABLE 8-27

COMPARISON OF CONCENTRATIONS OF INDICATOR CHEMICALS IN ON-SITE GROUNDWATER TO DRINKING WATER STANDARDS OR PROPOSED VALUES

	Exposure Point Concentrations-Unfiltered Data[a]			Filtered Data[d]		
Chemical	Frequency[b]	Geometric Mean Concentration (ppb)[c]	Maximum Concentration (ppb)	Frequency[b]	Maximum Concentration (ppb)	MCL or Proposed Value (ppb)
Arsenic	15/22	<10[e]	24	0/9	ND[f]	50(50[g])
Cadmium	11/22	9	724	1/9	6.4	10(5[g])
Lead	16/22	38	1,120	2/9	14J	50(20[g])
Tetrachloroethylene	17/22	157	14,000J[i]	5/9	18,000	
Trichloroethylene	19/22	527	50,000J	6/9	22,000	5[h]
Vinyl Chloride	10/22	47	8,000J	1/9	3,300	1[h]
trans-1,2-Dichloroethylene	17/22	411	83,000J	7/9	79,000	70[g]

[a] The groundwater samples used to assess risks were unfiltered when analyzed. Use of these concentrations may overestimate risks associated with ingestion of drinking water from an on-site well. PCB data were not included in this data summary because many of the reported groundwater concentrations exceeded the aqueous solubilities for PCBs. Groundwater sample locations considered were: W-A, OW-G, CW, CE, DW, DE, FW, FE, FC, HN, HS, IN, IS, KN, KS, OW-SB34S, OW-SB04S, OW-SB25S, OW-SB25D, OW-SB09S, OW-SB30S, and OW-SB27D.

[b] Number of samples in which contaminant was detected divided by the total number of valid samples.

[c] Samples in which contaminants were not detected were included in calculating average (geometric mean) concentrations by using a value of one-half the EPA contract laboratory detection limits.

[d] Nine additional groundwater samples were filtered prior to analysis. The sample locations were: SW, KS, KN, FW, FE, OW-SB04S, OW-SB30S, OW-SB25S, and OW-SB34S.

[e] Less than the EPA CLP detection limit given.

[f] ND = not detected at a detection limit of approximately 10 ppb.

[g] Proposed MCLG.

[h] Proposed MCL.

[i] J = estimated value.

samples were one to 30 times higher than the filtered sample levels. In one case, the unfiltered sample level exceeded the filtered sample level by three orders of magnitude.

The inorganic compounds, in contrast, were detected far less frequently in the filtered samples than in the unfiltered samples. For the most part, inorganic concentrations in the unfiltered samples were one to 20 times higher than the concentrations in the filtered samples. In a few cases, the unfiltered sample concentrations exceeded the filtered sample concentrations by as much as one order of magnitude.

A closer examination of the filtered and unfiltered sample data for the inorganic compounds also suggests that the inorganics are predominantly associated with suspended sediments in groundwater, not the groundwater itself. For example, arsenic was not detected in any of the nine filtered samples but was detected in six of the nine unfiltered samples from the same locations. The unfiltered sample arsenic concentrations were one to seven times higher than the filtered samples' detection limit of 10 ppb. Cadmium was detected in only one of the nine filtered samples (at 6.4 ppb) and in five of the nine matched unfiltered samples (at 7.6-724 ppb). Lead was detected in two of the nine filtered samples at estimated levels (8J and 14J ppb) and in seven of the nine matched unfiltered samples (at 29-1,120 ppb).

For the purposes of this hypothetical exposure pathway, it was conservatively assumed that the drinking water obtained from an on-site well would not be filtered. Thus the unfiltered sample data were used to assess the potential risks for this pathway. Because the levels of suspended solids in the unfiltered groundwater samples were not measured, however, it is not known if the unfiltered samples contained more suspended solids than would normally be present in drinking water obtained from an on-site well. As a result, the risks estimated based on the unfiltered data may be overestimated.

Comparison to Standards

Drinking water standards (MCLs), proposed MCLs, and MCLGs are available for six of the seven human health indicator chemicals detected in groundwater at the Re-Solve site (Table 8-27). The MCLGs are nonenforceable health goals to be set at a level which prevents the occurrence of any known or anticipated adverse effect and which allows an adequate margin of safety. The MCLGs serve as goals for EPA in the course of setting MCLs. The MCLs are enforceable standards which must be set as close to the health-based MCLGs as is feasible (e.g., with the use of the best technology, treatment techniques, and other means).

The geometric mean unfiltered groundwater concentrations at the site exceed the proposed MCLs for lead, trichloroethylene, and vinyl chloride and exceed the proposed MCLG's for cadmium. For each chemical except arsenic, the maximum unfiltered concentrations exceed the standards and proposed values presented in Table 8-27. The maximum concentrations of volatile organic compounds measured in the filtered data exceed the proposed MCLs for trichloroethylene, vinyl chloride, and trans-1,2-dichloroethylene. The maximum concentrations of arsenic, cadmium, and lead measured in the filtered samples do not exceed the proposed MCLs although the one measured cadmium level slightly exceeds the proposed MCLG. Based on this comparison, contaminants at the Re-Solve site would pose a potential risk if groundwater from an on-site well was used for drinking water. If the groundwater was filtered prior to use, potential risks would be associated with the presence of volatile organics in the water.

Risk Estimation

Because ARARs are not available for all the indicator contaminants at the Re-Solve site for the groundwater ingestion scenario considered, the risks posed by ingestion of contaminated groundwater were assessed quantitatively using currently available health-based criteria. Carcinogenic and noncarcinogenic risks were assessed separately as shown in Table 8-28. In each case, the risks posed by each contaminant were summed according to EPA guidelines for complex mixtures (EPA 1985a) to estimate the total risk posed by the mixture of chemicals at the site. (This conservatively assumes that an individual would be exposed to the entire mixture.) The risk estimates presented in Table 8-28 indicate that the group of carcinogenic indicator

TABLE 8-28

DOSES AND RISKS POSED BY INGESTION OF HUMAN HEALTH INDICATOR CHEMICALS IN DRINKING WATER ON SITE

(Future Site Use)

A. POTENTIAL CARCINOGENS

Potential Carcinogen	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime: Average Case	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime: Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Incremental Lifetime Cancer Risk: Average Case	Incremental Lifetime Cancer Risk: Plausible Maximum Case
Arsenic	NC[b]	6.6×10^{-4}	15(A)	NC	1×10^{-2}
Tetrachloroethylene	4.5×10^{-3}	4.0×10^{-1}	5.1×10^{-2} (B2)	2×10^{-4}	2×10^{-2}
Trichloroethylene	1.5×10^{-2}	1.43	1.1×10^{-2} (B2)	2×10^{-4}	2×10^{-2}
Vinyl Chloride	1.7×10^{-3}	2.3×10^{-1}	2.3(A)	4×10^{-3}	5×10^{-1}
Total	--	--	--	4×10^{-3}	5×10^{-1}

B. NONCARCINOGENS

Noncarcinogen	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime: Average Case	Total Dose (mg/kg/day) Averaged Over a 70-Year Lifetime: Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Total Dose:RfD Ratio: Average Case	Total Dose:RfD Ratio: Plausible Maximum Case
Cadmium	2.6×10^{-4}	2.1×10^{-2}	1.4×10^{-4}	2	150
Lead	1.1×10^{-3}	3.2×10^{-2}	6.7×10^{-4}[c]	2	48
trans-1,2-Dichloroethylene	1.2×10^{-2}	2.4	0.01	1	240
Total	--	--	--	5	438

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[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] Total dose and risk were not calculated for arsenic for the average case because the geometric mean soil concentration for this chemical was determined to be less than its detection limit.

[c] Use of a reference dose (RfD) is not recommended for lead. A draft health advisory (HA) value of 2×10^{-2} mg/day (6.7×10^{-4} mg/kg/day) based on a sensitive subpopulation of fetuses and infants is provided for guidance.

compounds may pose risks of $4x10^{-3}$ at the average concentrations and $5x10^{-1}$ at the maximum concentrations. The risks estimates for ingestion of unfiltered well water are primarily attributable to ingestion of vinyl chloride.

For the noncarcinogens, the estimated hazard indices for cadmium, trans-1,2-dichloroethylene and lead each exceed one, indicating that chronic ingestion of these compounds could pose a hazard to residents drinking unfiltered well water. The kidney appears to be the most sensitive target organ in humans chronically exposed to cadmium by ingestion. Early clinical signs of renal damage include proteinuria, glucosuria, and aminoaciduria. Following acute exposure, trans-1,2-dichloroethylene primarily affects the liver and kidney, and may cause central nervous system effects at very high concentrations. Although longer-term exposure data are not available for trans-1,2-dichloroethylene, it appears likely that the liver is the most sensitive target organ for this compound based on analogy with structurally similar compounds for which suitable toxicological data are available. Chronic exposure to lead may adversely affect the nervous system, hematopoietic system, and other physiological processes. As suggested by the hazard indices in Table 8-28, at the currently observed on-site unfiltered groundwater concentrations, each of these chemicals individually may cause adverse health effects in potentially exposed individuals. Furthermore, because there is some overlap in the organ systems and physiological processes affected, these chemicals may to some extent act additively or synergistically.

8.5.2 DIRECT CONTACT WITH SOILS

Exposure to chemicals in on-site soils may be of concern under potential site development conditions because it is assumed that an individual could be exposed throughout an entire lifetime if for example a house were built on the site. In this section, the direct contact route of exposure is evaluated.

Exposure Point Concentrations

The exposure point concentrations are assumed to be represented by all of the soil samples collected at the site. If the site were developed, the soils could be disturbed thereby redistributing the deeper contaminated layers to the surface. Table 8-29 summarizes the on-site soil data for the human health indicator chemicals. The shallowest soil boring sample was used in compiling this data. As mentioned earlier in Section 8.4.2, the levels of arsenic measured in the below surface soil boring samples collected on site are well within the range of background arsenic levels estimated for Eastern United States soils (Shacklette and Boerngen 1984).

Risk Estimation

In this exposure scenario, not only adults, but also infants and children could theoretically come into contact with contaminated soils and subsequently ingest or dermally absorb them. As in the present use scenario for soil exposure, an average and a plausible maximum exposure case was considered in assessing the potential risks associated with direct contact with on-site and off-site soils. Table 8-30 outlines the assumptions used for each scenario. The exposure assumptions are the same as those used for assessing exposures previously with a few exceptions. It was assumed that an individual would contact contaminated soils 100 times per year on the average and 200 times per year as a maximum. The hypothetical exposure period was assumed to be 70 years (an average lifetime) with an average weight over the exposure period of 70 kg. As stated earlier, young children are most likely to be potential receptors for soil ingestion. The assumption of a 70-year exposure period and 70-kg average body weight accounts for adults who may engage in regular gardening or other outdoor activities.

The exposure equation presented in Section 8.4.2 was used to estimate the potential exposures to the indicator chemicals in soils at the Re-Solve site. The cumulative exposure to each chemical was averaged over the entire exposure period (70 years) for chemicals with both carcinogenic and noncarcinogenic effects.

Table 8-31 presents the estimated average daily doses in mg/kg/day and the potential risks associated with these exposures. The results show estimated excess lifetime cancer risks of 1×10^{-7} and 3×10^{-2} under the hypothetical average and plausible maximum exposure conditions, respectively, for the chemicals with potential carcinogenic effects. Again, exposure to PCBs in

TABLE 8-29

HUMAN HEALTH INDICATOR CHEMICALS IN SOIL BORING SAMPLES AT THE RE-SOLVE SITE[a]

Compound[b]	Frequency[c]	Concentration Range (ppb)	Geometric Mean Concentration[d] (ppb)
Arsenic[g]	5/51	ND[e]-5,100	1.1
Cadmium	17/51	ND -488,600	6.9
Lead	20/51	ND -3,585,000	22
Trichloroethylene	28/51	ND -740,000	22
Tetrachloroethylene	27/51	ND -110,000	31
PCBs	30/51	ND -2,800,000	310[f]
trans-1,2-Dichloroethylene	16/51	ND -9,200	6

[a] The shallowest soil boring sample collected from each boring location was used in compiling this data.

[b] Vinyl chloride was not detected in soil boring samples.

[c] Number of samples in which contaminant was detected divided by the total number of samples.

[d] Calculated using detected concentrations and one-half of EPA's contract laboratory program (CLP) detection limits for the organics. For the inorganic compounds, the detection limit for soils were based on the aqueous CLP detection limit (see footnote in Section 8.4.1).

[e] ND = Not detected.

[f] The soil detection limit for the PCB mixture was assumed to be 80 ppb.

[g] The range of arsenic levels measured in on-site soil borings are within the range of background arsenic levels estimated for Eastern United States soils (Shacklette and Boerngen 1984).

TABLE 8-30

ASSUMPTIONS USED IN ESTIMATING EXPOSURE TO INDICATOR CHEMICALS VIA DIRECT CONTACT WITH SOILS AT NEAR THE RE-SOLVE SITE

(Future Site Use)

Parameter	Average Exposure	Plausible Maximum Exposure
1. Frequency of contact	100 times/year	200 times/year
2. Age of individual exposed	lifetime	lifetime
3. Average weight over period of exposure	70 kg	70 kg
4. Years of exposure	70	70
5. Quantity of soil coming into contact with skin	1 g/visit	5 g/visit
6. Percentage of PCBs in soil absorbed through the skin	1	5
7. Percentage of arsenic, cadmium and lead in soils absorbed through the skin	Negligible	Negligible
8. Percentage of tetrachloroethylene, trichloroethylene, and <u>trans</u>-1,2-dichloroethylene in soils absorbed through the skin	Negligible	Negligible
9. Incidental ingestion of contaminated soil	20 mg/visit	100 mg/visit
10. Percentage of PCBs absorbed from ingested soils	35	50

TABLE 8-31

DOSES AND RISKS ASSOCIATED WITH DIRECT CONTACT WITH ON-SITE SOILS AT THE RE-SOLVE SITE

(Future Site Use)

A. POTENTIAL CARCINOGENS

	Total Dose (mg/kg/day) Averaged Over a 70-year Lifetime			Incremental Lifetime Cancer Risk	
	Average Case	Plausible Maximum Case	Carcinogenic[a] Potency Factor $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
Arsenic	8.4×10^{-11}	4.0×10^{-6}	15 (A)	1×10^{-9}	6×10^{-5}
Trichloroethylene	1.2×10^{-9}	4.1×10^{-4}	1.1×10^{-2} (B2)	1×10^{-11}	4×10^{-6}
Tetrachloroethylene	1.7×10^{-9}	6.1×10^{-5}	5.1×10^{-2} (B2)	9×10^{-11}	3×10^{-6}
PCBs	2.1×10^{-8}	6.6×10^{-3}	4.34 (B2)	1×10^{-7}	3×10^{-2}
Total	--	--	--	1×10^{-7}	3×10^{-2}

B. NONCARCINOGENS

	Total Dose (mg/kg/day) Averaged Over a 70-year Lifetime			Total Dose:RfD Ratio	
	Average Case	Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Average Case	Plausible Maximum Case
Cadmium	5.5×10^{-10}	3.8×10^{-4}	1.4×10^{-4}	4×10^{-6}	2.7
Lead	1.7×10^{-9}	2.8×10^{-3}	2.9×10^{-4}	6×10^{-6}	9.6
<u>trans</u>-1,2-Dichloroethylene	3.3×10^{-10}	5.0×10^{-6}	0.01	3×10^{-8}	5×10^{-4}
Total	--	--	--	1×10^{-5}	12

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[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] Use of a reference dose (RfD) is not recommended for lead. A draft health advisory (HA) value of 2×10^{-2} mg/day (2.9×10^{-4} mg/kg/day) based on a sensitive subpopulation of fetuses and infants is provided for guidance.

soils accounts for the major portion of these estimated risks. For the noncarcinogens, the hazard indices for cadmium and lead under the plausible maximum exposure conditions exceed one. Potential exposures to trans-1,2-dichloroethylene are well below the chronic intake levels of concern.

8.5.3 INHALATION OF VOLATILE COMPOUNDS RELEASED FROM ON-SITE SOILS

If the site was developed in the future, an individual could theoretically be exposed to volatile organic compounds (VOCs) released from contaminated soils. As with the dermal contact exposure scenario presented in Section 8.5.2, it was assumed that an individual could be exposed to VOCs throughout an entire lifetime as a child and subsequently as an adult.

Exposure Point Concentrations

The exposure point concentrations are assumed to be the same as those used in the present site use VOC inhalation scenario (Table 8-13). Several assumptions and data gaps regarding use of the available VOC data have been discussed in Section 8.4.3. Because this exposure pathway is hypothetical, it cannot be determined whether use of currently available VOC data will underestimate or (more likely) overestimate inhalation exposures if the site were developed in the future.

Risk Estimation

It was assumed for this exposure scenario that an individual would be exposed every day throughout a lifetime (70 years) to airborne VOCs. The equation used to calculate the total amount of chemical absorbed over the exposure period was:

$$TA = (C_{air})(IR)(DY)(YR)$$

where

TA = total amount of chemical absorbed (mg),

C_{air} = VOC air concentration (mg/m^3),

IR = inhalation rate (20 m^3/day),

DY = days exposed per year (365 days/yr), and

YR = years exposed (70).

The inhalation rate was assumed to be 20 m^3/day. The duration of exposure was assumed to be 24 hours per day, 365 days per year for 70 years. The cumulative amount of each indicator VOC absorbed over the exposure period was converted to an average daily exposure by prorating over a 70-year lifetime assuming a body weight of 70 kg. The risk estimates shown in Table 8-32 were obtained by multiplying the average daily exposures by the carcinogenic potency factors for the two VOCs. These risks represent the upper limit on the lifetime cancer risks associated with this hypothetical exposure scenario. The risks for the average and maximum exposure cases may be as high as $3x10^{-5}$ and $3x10^{-4}$, respectively, but they are unlikely to be higher than these values.

8.5.4 INHALATION OF PARTICULATE MATTER RELEASED FROM ON-SITE SOILS

If the site was developed in the future, an individual could also theoretically be exposed to chemicals adsorbed to suspended particulate matter throughout a lifetime. In this section, potential inhalation exposures to chemicals in particulate matter from Re-Solve site soils are evaluated.

Exposure Point Concentrations

The exposure point concentrations are assumed to be equivalent to those used in the present site use particle inhalation scenario (Table 8-16). It was assumed that the air contaminant levels calculated in Section 8.4.4 based on a one-day site sampling period would reflect potential future particle levels at the site (in the absence of actual site construction activities). As this is a hypothetical exposure pathway, it is not known whether use of this data will underestimate or overestimate inhalation exposures if the site were developed.

TABLE 8-32

DOSES AND RISKS ASSOCIATED WITH INHALATION OF VOLATILE ORGANIC CHEMICALS RELEASED FROM RE-SOLVE SITE SOILS

(Future Site Use)

	Total Dose (mg/kg/day)			Incremental Lifetime Cancer Risk	
Potential Carcinogen	Average Case	Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
Tetrachloroethylene	$2.6x10^{-3}$	$2.6x10^{-2}$	$4.6x10^{-3}$ [B2]	$1x10^{-5}$	$1x10^{-4}$
Trichloroethylene	$1.0x10^{-3}$	$1.0x10^{-2}$	$2.5x10^{-2}$ [A]	$2x10^{-5}$	$2x10^{-4}$
Total	--	--	--	$3x10^{-5}$	$3x10^{-4}$

[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

Risk Estimation

Exposures and risks were estimated using the approach presented in the previous section (8.5.3). Table 8-33 presents the estimated exposures and risks for this pathway. The excess lifetime cancer risks for inhalation of PCBs for the average and maximum exposure cases may be as high as $3x10^{-7}$ and $2x10^{-5}$, respectively. These risks represent the upper limit on the lifetime cancer risks associated with this hypothetical exposure scenario. The dose:RFD ratio for lead was well below the chronic intake level of concern.

8.6 ENVIRONMENTAL ASSESSMENT

The environmental hazard posed by site-related contamination was evaluated for five areas in the vicinity of the site. These areas are the wetland immediately north of the site, the unnamed tributary, the Copicut River, Carol's Brook and Cornell Pond. The wetland has one to two feet of standing water; the associated flora has been previously described (see Section 2.3). Although the wetland is small, it would be expected to provide habitat for birds, amphibians, and small mammals as well as aquatic invertebrates. The unnamed tributary, due to its small size and intermittent nature, is not considered likely to be a suitable habitat for organisms other than invertebrates (see Section 8.2.1). A variety of fish have been noted in the Copicut River and Cornell Pond (see Section 5); birds such as herons and ducks have also been reported at these locations (Zupkas and Brickell 1986). Carol's Brook may provide habitat for small fish and juveniles. No endangered or threatened species have been reported to occur in the area.

The following analysis will focus on the PCB contamination found in sediments in the Re-Solve site area. Section 5 of this report and the Draft Off-Site Remedial Investigation Report (CDM 1985) present sampling data for sediments in the Re-Solve site area. Sediment concentrations of PCBs in five areas are shown in Table 8-34. As already mentioned, the wetland sediments have particularly high PCB concentrations. Although PCBs were detected in the sediments in the Copicut River in only 3 out of 14 samples, the maximum measured value of 283 ppm is of particular concern. The concentrations of 20

TABLE 8-33

POTENTIAL RISKS POSED BY INHALATION OF CHEMICALS IN PARTICULATE MATTER RELEASED FROM RE-SOLVE SITE SOILS

(Future Site Use)

A. POTENTIAL CARCINOGENS

	Total Dose (mg/kg/day) (Averaged Over a 70-Year Lifetime)			Incremental Lifetime Cancer Risk	
	Average Case	Plausible Maximum Case	Carcinogenic Potency Factor[a] $(mg/kg/day)^{-1}$	Average Case	Plausible Maximum Case
PCBs	$7.5x10^{-8}$	$5.6x10^{-6}$	4.34 (B2)	$3x10^{-7}$	$2x10^{-5}$

B. NONCARCINOGENS

	Total Dose (mg/kg/day) Averaged Over the Exposure Period			Total Dose:RfD Ratio	
	Average Case	Plausible Maximum Case	Reference Dose (RfD) (mg/kg/day)	Average Case	Plausible Maximum Case
Lead	$9.1x10^{-8}$	$1.8x10^{-6}$	$6.7x10^{-4}$[b]	$1x10^{-4}$	$3x10^{-3}$

[a] The carcinogenic potency factor is the same as the unit risk. All potency factors used in this report are followed by EPA's qualitative weight of evidence classification. The significance and appropriate use of these designations are discussed in EPA's Guidelines for Carcinogenic Risk Assessment (EPA 1986b) and in other EPA documents.

[b] Use of a reference dose (RfD) is not recommended for lead. A draft health advisory (HA) value of $2x10^{-2}$ mg/day ($6.7x10^{-4}$ mg/kg/day) based on a sensitive subpopulation of fetuses and infants is provided for guidance.

TABLE 8-34

CONCENTRATIONS OF PCBS IN SEDIMENTS COLLECTED IN THE RE-SOLVE SITE AREA

Location	Frequency[a]	Concentration Range (ppb)	Geometric Mean Concentration (ppb)
January 1984 Sampling Period			
Wetland	4/4	950-60,000	8,100
Unnamed Tributary	3/6	ND[c]-22,000	270
Carol's Brook	2/2	270-420	340
Copicut River	2/6	440-283,000	260
Cornell Pond	0/1	ND	ND
July 1985 Supplemental Sampling Period			
Wetland	15/15	1,900-102,700	14,700
Unnamed Tributary	4/5	ND-107,000	9,400
Carol's Brook	3/5	ND-2,700	760
Copicut River	1/8	ND-1,700	(d)
Cornell Pond	0/6	ND	ND

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[a] Number of samples in which contaminant was detected divided by the total number of samples.

[b] Geometric means were calculated using detected concentrations and one-half the detection limit for nondetected samples. If no detection limit was indicated, a detection limit of 80 ppb was used in the calculations.

[c] Not detected.

[d] PCBs were detected in only one sample in the Copicut River supplemental sampling effort. In addition, detection limits for some of the samples were high due to interference. For these reasons, no geometric mean was calculated for this location.

ppm in fish caught in the Copicut River provide additional evidence that high concentrations of PCBs may be present. PCBs have been detected in the sediments in Carol's Brook in 5 of 7 samples, with a maximum of 2.7 ppm. No PCBs were detected in the sediments of Cornell Pond during the January 1984 and July 1985 sampling periods. PCBs were detected in the unfiltered surface water samples twice at concentrations of 0.52 and 1.2 ppb; both samples were taken from a location immediately downstream of the wetland discharge into the unnamed tributary.

There is little information regarding the toxicity of PCB-contaminated sediments to freshwater aquatic organisms. Increased mortality of freshwater prawns (Macrobranchium rosenbergii) was reported in sediments containing 42% organic carbon and about 30 mg/kg of a mixture of PCBS (Tatem 1986). It is generally thought that toxicity associated with contaminated sediments (C_S) is due to exposure to contaminants in the interstitial water (C_W) (i.e., between sediment particles). Under assumptions of equilibrium, a simple linear partitioning model for the sediment:water interface is:

$$\frac{C_s}{C_w} = (K_{oc})(f_{oc})$$

where

C_S = concentration in sediment,

C_W = concentration in water,

f_{OC} = fraction organic carbon, and

K_{OC} = organic carbon partition coefficient.

The amount of organic carbon in sediments has a great influence on the desorption of PCBs into the water column. Organic carbon would be expected to vary greatly in the different areas around the Re-Solve site. Whereas the wetland would contain high amounts of organic carbon, a moderately or fast moving stream such as Carol's Brook or the Copicut River would contain much less. To roughly estimate concentrations of PCBs in the interstitial water, the partitioning model was applied for the wetland and the Copicut River. A K_{OC} value of 1.3×10^5 which is representative of Aroclors 1248 and 1254

(Kadeg et al. 1986) was used, the f_{oc} was assumed to be 0.50 for the wetland and 0.02 for the river, and the geometric mean of PCBs in the sediments of each location was used to represent C_s. Using these values, water concentrations of 0.012 ppb and 0.1 ppb were estimated for the wetland and the Copicut River, respectively.

It should be recognized that the results produced by the partition model should be considered only rough approximations. The use of adsorption partition coefficients to describe desorption may be inappropriate for PCBs. The interaction of organic compounds at the sediment:water interface is complex. For example, some fraction of the PCBs adsorbed on the sediments may not be available for desorption. DiToro and Horzempa (1983) noted that for many pesticide-adsorbent systems, the desorption reaction is not completely or even moderately reversible. They concluded that the assumption of complete reversibility is not necessarily realistic and, as a result, the predicted equilibrium concentrations based on the adsorption coefficients may be overestimated. In addition, application of the equilibrium partition model to sediments which are covered by a layer of litter (such as in the wetland), may also overestimate water column concentrations.

Further, the use of an equilibrium model may not be appropriate for some hydrophobic chemicals. It has been estimated that it may take as long as 280 days for 90% of adsorbed PCBs to desorb from sediment particles (Wu and Gshwend 1986). For a moderately moving river such as the Copicut River, the assumption of equilibrium would result in an overestimation of water concentrations. A kinetic model of desorption may be a more suitable model of PCB behavior in sediments underlying moving waters. However, for the wetlands, which are fairly stagnant, the equilibrium model may be a more appropriate model for prediction of water concentrations.

A detailed discussion of the environmental effects of PCBs is provided in Appendix B. Weber and Mrozek (1979) investigated the phytotoxic effects of PCBs (Aroclor 1254) and found that water usage significantly decreased at soil PCB concentrations as low as 1 ppm. This effect, however, was mitigated through the application of organic carbon (Strek et al. 1981). The effects of

PCBs on aquatic organisms have been extensively documented. Daphnids are particularly sensitive; the LC_{50}[1] for Daphnia magna is 1.3 ppb (EPA 1976). The midge Tanytarsus dissimilis was also very sensitive with a 50% reduction in survival and growth reported at concentrations of 0.45 ppb (EPA 1976).

Although neither of these organisms were specifically reported as occurring in the site area, other midges were found at all sampling points in the benthic survey and cladocerans are nearly ubiquitous in freshwater systems. Of fish species tested, the rainbow trout (Salmo gairdneri) was the most sensitive with an LC_{50} after 25 days of 3.4 ppb for Aroclor 1254 (Mayer et al. 1977). Reproductive effects occur at very low concentrations (Birge et al. 1981). Concentrations of 4.6 ppb totally blocked spawning of fathead minnows; concentrations of 0.52 ppb reduced egg hatchability (Nebeker et al. 1974 as cited in Birge et al. 1981). Adverse second generation effects occurred in estuarine fish at concentrations as low as 0.1 ppb (Nebeker et al. 1974 as cited in EPA 1976). EPA has established an Ambient Water Quality criterion of 0.014 ppb for protection of freshwater aquatic life under continuous exposure to PCBs (EPA 1980).

In addition to direct exposure via sediments and water, biota can be exposed to PCBs indirectly via the food web. Of particular concern would be birds and mammals feeding on invertebrates or amphibians in the wetland or fish in the river. The bioaccumulation of PCBs has been extensively documented. Bioaccumulation factors for aquatic invertebrates have been reported to range from 2,800 to 47,000. In fathead minnows, the bioaccumulation factor for Aroclor 1248 was as high as 270,000 (EPA 1976). Eels and turtles, organisms found or expected to be found in the site area, are particularly efficient bioaccumulators of PCBs (Graham 1976, Alberg et al. 1986). Although little conclusive evidence is available for natural systems, elevated concentrations of PCBs have been linked to decreased reproductive success in both birds and

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[1] An LC_{50} is the concentration at which 50% mortality would be expected in the tested animal species.

mammals (EPA 1976). Mustelids appear to be particularly sensitive; in laboratory studies using mink, dietary concentrations of 2 ppm Aroclor 1254 resulted in a reduced number of offspring per female (Ringer 1983).

In conclusion, PCB contamination in the wetland, the Copicut River, and Carol's Brook, areas near the Re-Solve site which provide wildlife habitats, is of concern regarding environmental effects. PCBs are toxic at very low concentrations to a wide variety of aquatic invertebrates, fish and terrestrial vertebrates. Although the potential risks cannot be quantified, the elevated concentrations of PCBs in sediments are likely to adversely affect sediment-dwelling organisms and may also impact on animals at higher trophic levels that depend on this area for habitat. In addition, although the unnamed tributary is not of concern as an exposure point, it may be a source of pollutants to downgradient areas.

8.7 CONCLUSIONS

This report assesses the potential risks to human health and freshwater aquatic life associated with exposure to contaminants from the Re-Solve site in the absence of remediation. It should be recognized, however, that in all risk assessments the procedures and inputs that are used to assess the potential human health and environmental risks are subject to uncertainty, as outlined in Section 8.4.1. For example, the cancer risk values presented in this report represent the upper limits on the incremental lifetime cancer risks that might occur as a result of the specific exposures evaluated. The actual risks are unlikely to be higher than these values because of the conservatism that is built into the cancer potency factors. At the end of this section, many of the other major uncertainties in this risk assessment are summarized.

Several principal exposure pathways considered to pose the greatest potential human health and environmental risks under present site use conditions were evaluated. These pathways were direct contact with on-site and off-site soils and subsequent ingestion and dermal absorption of contaminants in these soils, inhalation of volatile compounds released from on-site soils and surface water, inhalation of particulate matter released from on-site soils, dermal contact with surface water and subsequent contaminant absorption, human ingestion of PCB-contaminated fish, and contact with PCB-contaminated sediments by freshwater aquatic life. Under potential site development conditions (i.e., development for residential use), four hypothetical exposure pathways were evaluated: ingestion of on-site groundwater, ingestion of and dermal contact with contaminated on-site soils, and inhalation of volatile compounds and particulate matter released from on-site soils.

The human health risks estimated under present site use conditions are summarized in Table 8-35. Potential risks were estimated for children who may occassionally play in the soils at or near the Re-Solve site. Exposures and risks were evaluated for all the human health indicator chemicals detected in the soils. Exposures to the potentially carcinogenic human health indicator chemicals found in the on-site surface soils may result in potential upper bound incremental lifetime cancer risks as high as $6x10^{-8}$ for the average case and $4x10^{-5}$ for the plausible maximum case. Incremental lifetime cancer risks posed by exposures to off-site surface soils could be as high as $5x10^{-8}$ under average exposure conditions and $8x10^{-5}$ under plausible maximum exposure conditions. The primary potentially carcinogenic compounds contributing to the risks were PCBs. The estimated exposures to the noncarcinogenic indicator chemicals in on-site and off-site surface soils were below chronic intake levels of concern.

The potential risks associated with inhalation of volatile organic compounds and particulate matter released from soils at the Re-Solve site were evaluated. The incremental lifetime cancer risks associated with the inhalation of volatiles released from soils may be as high as $9x10^{-9}$ for the average exposure conditions and $1x10^{-6}$ for the plausible maximum exposure conditions. Exposures to chemicals present in suspended particulate matter were associated with upper bound lifetime cancer risks of $8x10^{-11}$ for the average exposure scenario and $7x10^{-8}$ for the plausible maximum exposure scenario. These risks were associated with the inhalation of PCBs. Exposures to volatile organic compounds released from the Copicut River were also evaluated. These exposures were estimated to result in excess lifetime cancer risks as high as $2x10^{-7}$ for the average exposure scenario and $5x10^{-6}$ for the

TABLE 8-35

SUMMARY OF RISK ASSESSMENT RESULTS FOR HUMAN EXPOSURE TO RE-SOLVE SITE CONTAMINANTS

(Present Site Use)

Present Site Use Exposure Pathway	Total Excess Upper Bound Lifetime Cancer Risk	Hazard Index for Noncarcinogenic Effects
Direct contact with on-site soils		
Average case	$6x10^{-8}$	<1
Plausible maximum case	$4x10^{-5}$ [b]	<1
Direct contact with off-site soils		
Average case	$5x10^{-8}$	<1
Plausible maximum case	$8x10^{-5}$ [b]	<1
Inhalation of VOCs[a] released from on-site soils		
Average case	$9x10^{-9}$	NE
Plausible maximum case	$1x10^{-6}$ [b]	NE
Inhalation of particulate matter released from on-site soils		
Average case	$8x10^{-11}$	<1
Plausible maximum case	$7x10^{-8}$	<1
Dermal contact with surface water		
Average case	$9x10^{-9}$	<1
Plausible maximum case	$1x10^{-6}$ [b]	<1
Inhalation of VOCs released from surface water		
Average case	$2x10^{-7}$	<1
Plausible maximum case	$5x10^{-6}$ [b]	<1
Ingestion of fish		
Average case	$7x10^{-4}$ [b] (eel consumption)[c]	NE
Plausible maximum case	$8x10^{-3}$ [b] (eel consumption)[c]	NE

NE = not estimated.

[a] VOC = volatile organic compound.

[b] Note that excess cancer risks greater than $1x10^{-6}$ may be unacceptable.

[c] For ingestion of fish species other than eels, total excess lifetime cancer risks would range from $7x10^{-6}$ for the average case to $4x10^{-4}$ for the plausible maximum case.

plausible maximum exposure scenario. The estimated exposures to the noncarcinogenic indicator chemicals released from both soils and surface water were below the chronic intake levels of concern.

Individuals may also wade in the Copicut River adjacent to the Re-Solve site area. The potential risks to these individuals who may occasionally have dermal contact with contaminants in the river were assessed. The incremental lifetime cancer risks may be as high as $9x10^{-9}$ under average exposure conditions and $1x10^{-6}$ under plausible maximum exposure conditions. Dermal contact with the noncarcinogenic indicator chemicals detected in the Copicut River and the unnamed tributary was estimated to result in exposures well below the human health reference doses.

The potential risks associated with ingestion of PCB-contaminated fish living near the site were also evaluated. For an individual assumed to regularly ingest American eels caught near the site, incremental lifetime cancer risks were estimated to range from $7x10^{-4}$ to $8x10^{-3}$ under average and plausible maximum exposure scenarios. The excess lifetime cancer risks associated with ingestion of other less contaminated fish species were estimated to range from $4x10^{-4}$ to $7x10^{-6}$.

If the site were developed in the future (i.e., for a residence), excess risks would be associated with each of the hypothetical pathways considered in this report: ingestion of on-site groundwater, ingestion of and dermal contact with contaminated soils, and inhalation of volatile compounds and particulate matter released from contaminated on-site soils. The potential human health risks associated with exposures under future site use conditions are summarized in Table 8-36. Based on a comparison to standards and a risk assessment, the contaminants in groundwater at the site would pose significant risks if unfiltered drinking water was obtained from an on-site well. The incremental lifetime cancer risks for ingestion of the human health indicator chemicals ranged from $4x10^{-3}$ to $5x10^{-1}$ under average and plausible maximum exposure conditions, respectively. These risks are primarily attributable to ingestion of vinyl chloride. Chronic ingestion of the noncarcinogens, cadmium, trans-1,2-dichloroethylene, and lead at the levels measured in unfiltered on-site groundwater would also pose a hazard to potential well water users.

TABLE 8-36

SUMMARY OF RISK ASSESSMENT RESULTS FOR HUMAN EXPOSURE TO RE-SOLVE SITE CONTAMINANTS

(Future Site Use)

Future Site Use Exposure Pathway	Total Excess Upper Bound Lifetime Cancer Risk	Hazard Index for Noncarcinogenic Effects
Ingestion of on-site groundwater		
Average case	4×10^{-3} [b]	4 [c]
Plausible maximum case	5×10^{-1} [b]	410 [c]
Direct contact with soils		
Average case	1×10^{-7}	<1
Plausible maximum case	3×10^{-2} [b]	12 [c]
Inhalation of VOCs[a] released from on-site soils		
Average case	3×10^{-5} [b]	NE
Plausible maximum case	3×10^{-4} [b]	NE
Inhalation of particulate matter released from on-site soils		
Average case	3×10^{-7}	<1
Plausible maximum case	2×10^{-5} [b]	<1

NE = not estimated.

[a] VOC = volatile organic compound.

[b] Note that excess cancer risks greater than 1×10^{-6} may be unacceptable.

[c] These scenarios may pose unacceptable health risks.

For an individual assumed to incidentally ingest and have dermal contact with on-site soils under the future site development scenario, the estimated average and plausible maximum exposure conditions were associated with incremental lifetime cancer risks of 1×10^{-7} and 3×10^{-2}, respectively. Exposure to PCBs in soils accounted for the major portion of the estimated risks. For the noncarcinogenic indicator chemicals, chronic incidental ingestion of cadmium and lead under the plausible maximum exposure conditions could also pose risks to human health.

Inhalation of volatile compounds released from Re-Solve site soils under future site use conditions was estimated to result in incremental upper bound lifetime cancer risks as high as 3×10^{-5} and 3×10^{-4} for the average and plausible maximum exposure scenarios, respectively. Inhalation of chemicals adsorbed to suspended particulate matter was estimated to result in excess upper bound lifetime cancer risks of 3×10^{-7} for the average exposure case and 2×10^{-5} for the maximum exposure case. Inhalation exposures to noncarcinogenic indicator chemicals were estimated to be below chronic intake levels of concern.

Finally, PCB-contaminated sediments near the Re-Solve site are likely to adversely affect sediment dwelling organisms and may also impact animals at higher trophic levels that depend on the Re-Solve site area as a habitat.

As in all risk assessments, these conclusions must be viewed relative to the uncertainties inherent in the risk assessment process. These uncertainties have been noted throughout the text. Some of the important uncertainties specific to this assessment are listed below.

- In all exposure calculations, a range of values was used for frequency and duration of exposure, dermal contact rates, soil ingestion rates, extent of exposed surface area, inhalation rates, and other parameters. The plausible maximum estimates for these parameters may cause risks to be overestimated.

- Dermal absorption of volatile organic and inorganic compounds from soils were assumed to be negligible. This may result in underestimates of risk.

- Only seven surface soil samples were collected during the Re-Solve site RI. These samples were used to estimate exposure point concentrations for dermal contact with soils under present site use conditions. Use of these data may underestimate or overestimate risks for the direct soil contact exposure pathway.

- It was assumed that measured VOC and particulate matter levels would remain constant over time. This is likely to overestimate risks due to ongoing VOC removal processes (e.g., degradation, transport) and the probability that currently exposed site soils will become increasingly vegetated over time.

- Air sampling was conducted on only one day during the RI. VOC samples were collected at a few locations and particulate matter was collected at only one location. Because meteorological conditions during sampling did not favor worst-case volatilization or dust generation rates, the maximum exposure point concentrations were assumed to be one order of magnitude greater than the average measured levels. This use of measured air data to estimate exposure point concentrations may overestimate or underestimate risks.

- It was assumed that suspended particles at the site were composed entirely of contaminated site soils and were all respirable. These assumptions are likely to overestimate risks.

- Contaminants in surface water were assumed to be absorbed across the skin as a solute in water, i.e., using the flux rate of water to estimate dermal absorption. This may overestimate risks from this pathway.

- The maximum surface water concentrations measured in the unnamed tributary were used to characterize potential worst-case concentrations in the Copicut River under low flow conditions. This may overestimate risks for two pathways, dermal absorption of chemicals from surface water and inhalation of VOCs released from surface water.

- The absorption of inhaled VOCs and inorganic compounds on particulate matter was assumed to be 100%. This assumption may overestimate risks. The absorption of inhaled PCBs that are adsorbed to suspended soil particles was assumed to be 50%. This may overestimate or underestimate risks.

- Ingestion of on-site groundwater (future site use) was assessed using data from unfiltered samples. This may result in overestimates of risk, particularly for the inorganic compounds which were predominantly associated with suspended sediments in the groundwater.

- The organic carbon content for sediments was assumed to be 0.5 for the wetland and 0.02 for the river. These numbers may overestimate or underestimate risk depending on the actual concentrations.

Section 9

9.0 REFERENCES

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