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932078

VOLUME I - REMEDIAL INVESTIGATION SUMMARY
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
FOR THE
93RD STREET SCHOOL SITE
(SITE NO. 9-32-078)
CITY OF NIAGARA FALLS
NIAGARA, NEW YORK

Prepared for:
NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
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Contract No. D-001319

MARCH 15, 1988

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COMM. NO. 506-01

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ACRONYMS USED

RI/FS	Remedial Investigation/Feasibility Study
NYSDEC	New York State Department of Environmental Conservation
EPA	United States Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
SARA	Superfund Amendments and Reauthorization Act
NCP	National Contingency Plan
EDA	Love Canal Emergency Declaration Area
MSL	Mean Sea Level
NYSDOH	New York State Department of Health
GA	Class A Groundwater
ATSDR	Agency for Toxic Substances and Disease Registry
ARAR	Applicable or Relevant and Appropriate Requirements
RCRA	Resource Conservation and Recovery Act
USDA	United States Department of Agriculture
USLE	Universal Soil Loss Equation
ISV	In-situ Vitrification
HTFW	High Temperature Fluid Wall
SMW-1 etc.	Monitoring Wells installed by LEA
7135 etc.	Monitoring Wells installed by E.C.
MW-1 etc.	Monitoring Wells installed by RECRA

ACRONYMS USED

NYSDEC	New York State Department of Environmental Conservation
YWC	York Wastewater Consultants, Inc.
LEA	Loureiro Engineering Associates
QA/QC	Quality Assurance/Quality Control
EPA	U. S. Environmental Protection Agency
EDA	Emergency Declaration Area
USGS	United States Geological Survey
NYSDOH	New York State Department of Health
M-1, -2, etc.	Monitoring wells installed by Recra Research, Inc.
SMW-1, -2, etc.	Monitoring wells installed under this contract
7135, 7140, etc.	Monitoring wells installed by E. C. Jordan Co.
1P-1, -2, etc.	First round soil sampling points used under this contract
2P-101, -102 etc.	Second Round soil sampling points used under this contract
SD-1, -2, etc.	Second Round sediment sampling points used under this contract
SDWA	Safe Drinking Water Act (Federal)
CWA	Clean Water Act (Federal)
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
WQ	Water Quality
GA	Class A groundwater
ND	Not Detectable
NAAQS	National Ambient Air Quality Standards

EXECUTIVE SUMMARY

This report summarizes the Remedial Investigation/Feasibility Study (RI/FS) of the 93rd Street School site in Niagara Falls, New York. This RI/FS was performed by Loureiro Engineering Associates under Contract No. D-001319 with the New York State Department of Environmental Conservation. The purpose of this RI/FS was to evaluate the nature and extent of site problems, identify and evaluate potential remedial actions which could be implemented to mitigate these problems, recommend an alternative and conceptually design the recommended alternative.

During the remedial investigation, information was obtained on site background, site features, hazardous substances present, hydrogeology, groundwater and surface water contamination, and a public health and environmental risk assessment was conducted. It was concluded that the groundwater and surface water at the site are not contaminated at levels exceeding CRDLs or health-based standards with the majority of the chemicals on the EPA Hazardous Substances List. However, it should be noted that for some parameters, the CRDLs used during this investigation exceeded NYSDEC Water Quality standards. As a result, it has been recommended that additional study of groundwater contamination be performed during the remedial design phase to determine whether or not additional consideration should be given to remediation of the groundwater at the site.

Analysis of soils indicated that they are contaminated in varying degrees with heavy metals, volatile organics, base/neutral/acid extractable organics and alpha and beta BHC. These soils include approximately 3000 c.y. of contaminated fill brought to the site in 1954 from the 99th Street School, Love Canal. This fill consists of fly ash and possibly pesticide cake, used to regrade a swale located in the school yard. In addition, although dioxin was not detected during this investigation, it was detected previously by others in three isolated surface soil samples and in one soil sample at a depth of 4 to 6 feet at concentrations ranging from 0.11 to 2.3 ppb.

A risk assessment was performed for the site and it was concluded that significant carcinogenic risks are posed by the site in its unremediated condition primarily because of the presence of arsenic, PAHs and dioxin.

As a result of this risk assessment, a hot spot area was identified at the site where arsenic, PAHs and dioxin are present at significantly higher levels than in other identified contaminated soils. If this hot spot area were excavated, approximately 7,500 cu. yds. of material would be involved.

Remedial action alternatives for addressing the potential exposure pathways were developed including a no action alternative, two containment alternatives (i.e., on-site low permeability cap and off-site RCRA landfill disposal of hot spot soils followed by placement of a low permeability cap) and three treatment alternatives (stabilization/solidification, on-site thermal treatment, and thermal treatment at Love Canal). Each of these treatment alternatives involved treatment of hot spot soils then placement of a low permeability cap. Other potential remedial actions were considered but were eliminated on the basis of technical feasibility, effectiveness in protecting human health and the environment and magnitude of cost. The final alternatives were evaluated on the basis of the following nine point criteria:

- Protection of Human Health and the Environment
- Compliance with Applicable or Relevant and Appropriate Requirements
- Reduction of Toxicity, Mobility or Volume
- Short-Term Effectiveness
- Long-Term Effectiveness and Permanence
- Implementability
- Costs
- Community Acceptance
- State Acceptance

The final conclusion made regarding which alternative would best satisfy the above criteria was as follows:

- No Action Alternative:

  The no action alternative would not adequately protect human health and the environment and is therefore not feasible.

- Containment Alternatives:

  The low permeability capping alternative would not be feasible because it does not address the 1 ppb level of concern established for dioxin. The off-site RCRA landfill disposal alternative would not be feasible unless it could be proven that hot spot soils are capable of passing the TCLP test for dioxin, and a landfill willing or able to accept the untreated hot spot soils can be identified.

- Treatment Alternatives:

  Providing that the treatment byproducts can be rendered permanently delistable or acceptable for hybrid landfill disposal during preliminary testing, and state and community acceptance are favorable, the recommended alternative is on-site solidification/stabilization. This alternative best satisfies the nine point criteria in comparison to all other alternatives considered. Thermal treatment in which treatment byproducts can be rendered delistable or acceptable for hybrid landfill disposal was the most promising thermal treatment alternative. However, due to the greater short term risks and potentially higher costs (if treatment is conducted on-site), this alternative was judged to be less desirable overall than solidification/stabilization.

1.0 INTRODUCTION

The purpose of this report is to summarize and analyze the data developed during two rounds of sampling for the remedial investigation part of the Remedial Investigation/Feasibility Study of the 93rd Street School Site in the City of Niagara Falls, Niagara, New York. This investigation was performed by Loureiro Engineering Associates under Contract No. D-001319 with the New York State Department of Environmental Conservation (NYSDEC), Division of Hazardous Waste Remediation. Included are discussions of site features; hazardous substances; hydrogeology; surface and ground water; sampling and analysis; evaluations of data; and a public health and environmental risk assessment.

In this section, pertinent introductory information related to site background; the nature and extent of site problems; sampling and laboratory analyses performed and data analyses conducted is presented. In addition, an overview of the remainder of this report including the Feasibility Study (Volume II) and the Supplemental Data (Volumes III & IV) is presented.

1.1 SITE BACKGROUND INFORMATION

1.1.1 SITE DESCRIPTION

The 93rd Street School site is located in Niagara Falls, New York less than one mile northwest of Love Canal. This site has been included in the Love Canal Emergency Declaration Area (EDA) as shown in Figure 1. It is bounded by Bergholtz Creek to the north, 93rd Street to the west, residential properties and 96th Street to the east, and Housing Authority property and Colvin Boulevard to the south. The total area studied in this investigation covers approximately 19.4 acres and includes both the 93rd Street School and Housing Authority properties.

Although the site is relatively flat, it does slope gently from the east and west to a drainage swale located in the central portion of the site (See Drawing S-1, Appendix A). This swale slopes from the southeast

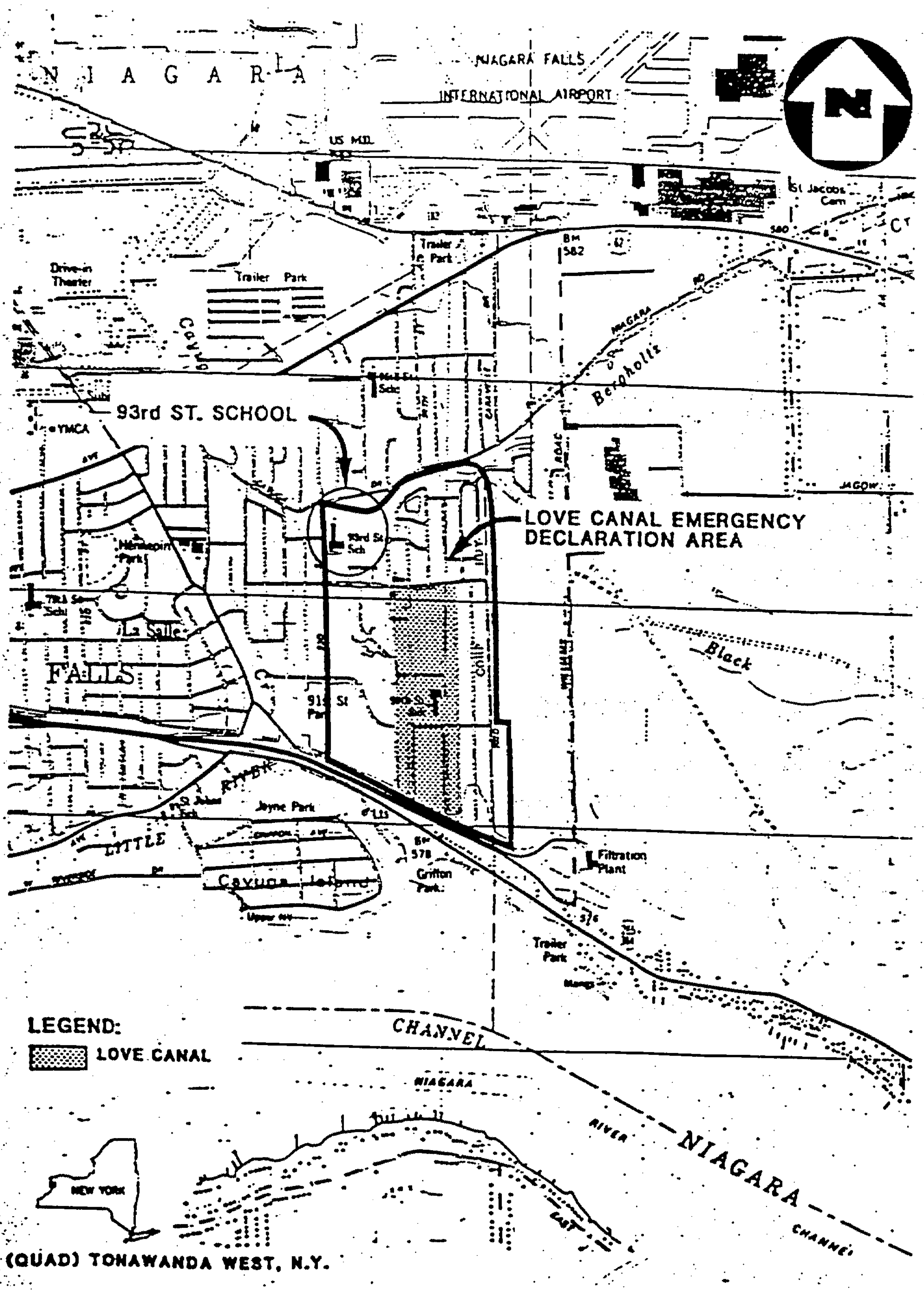

N I A G A R A
NIAGARA FALLS
INTERNATIONAL AIRPORT
US MIL
St Jacobs Cem
BM 582
Trailer Park
Drive-in Theater
Trailer Park
Cayuga
NIAGARA
Bergholtz
93rd ST. SCHOOL
YMCA
93rd St Sch
LOVE CANAL EMERGENCY DECLARATION AREA
Hennepin Park
La Salle
FALLS
91st St Park
99th St Sch
Black
JAGOW
St Johns Sch
Jayne Park
LITTLE RIVER
Cayuga Island
BM 578
Griffon Park
Filtration Plant
Trailer Park
LEGEND:
▨ LOVE CANAL
CHANNEL
NIAGARA
NIAGARA RIVER
CHANNEL
NEW YORK
(QUAD) TONAWANDA WEST, N.Y.

FIGURE 1

to the northwest and discharges into a small on-site swale which in turn discharges to Bergholtz Creek and then to the Cayuga River which is a tributary of the Niagara River. It should be noted that a number of surface drains in the area of the baseball diamond at the 93rd Street School site may be discharging into Bergholtz Creek via the drainage swale.

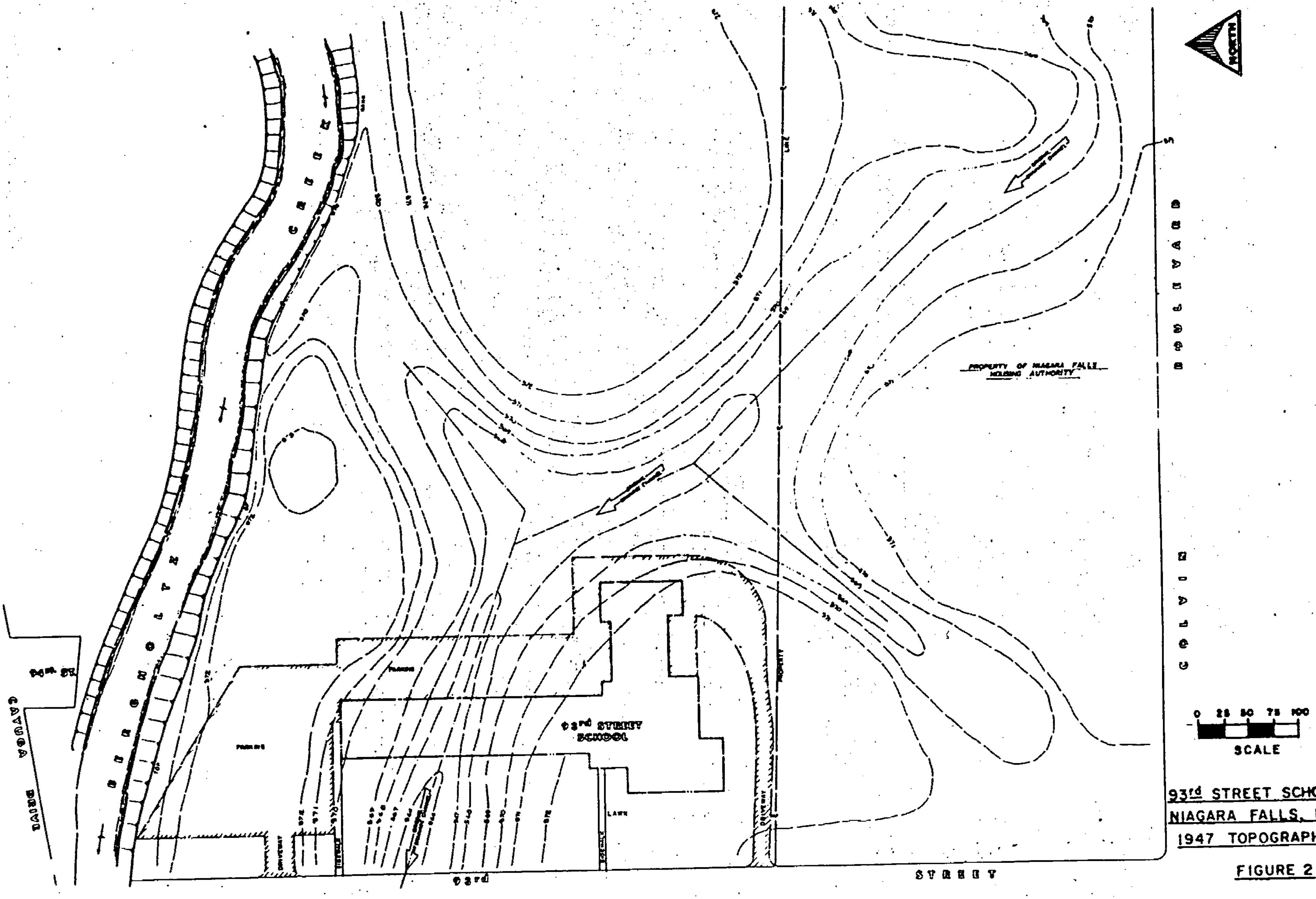
According to United States Geological Survey (U.S.G.S.) sources and a 1985 report prepared by RECRA Research, Inc., the bedrock beneath the site is predominantly a 150 feet thick layer of lockport dolostone which is composed almost entirely of dolomite, a slightly soluble calcium magnesium carbonate. In addition, a relatively thin section of limestone is also present beneath the site. The bedrock slopes gently toward the south at a rate of approximately 30 feet per mile.

A 25 to 27 feet thick layer of overburden covers the bedrock. This overburden consists of glacial till covered by layers of clay, silt, and fine sand. In addition, in some areas, layers of fill and topsoil have been deposited above the natural overburden.

Although some groundwater data for the 93rd Street School site has been obtained by RECRA Research, Inc. and others, additional study was considered necessary to accurately define site-specific groundwater flow patterns and elevations. This data is presented in Section 4.

1.1.2 SITE HISTORY

The 93rd Street School was designed in 1947 and constructed in 1950. From historical records including 1938 aerial photographs and a 1947 site development drawing, it has been determined that prior to construction of the school, a drainage swale crossed the site from the northwest to southeast. This swale intersected 93rd Street and east-lying properties and discharged into Bergholtz Creek. Figure 2 depicts preconstruction site contours based on the



93rd STREET SCHOOL
NIAGARA FALLS, N.Y.
1947 TOPOGRAPHY

FIGURE 2

COMM. No. 508-01

1947 site development drawing which is available at the City of Niagara Falls School Board Archives. Between 1938 and 1951, the swale was partially filled with soil and rock debris followed by sand and silt sized carbon waste (fly ash) materials. Finally, according to NUS Corporation (Ref. 1), the site was graded to its existing contours with approximately 3000 cubic yards of fill materials from the 99th Street School Site, Love Canal in 1954. Low areas east of the 93rd Street School including the playground (which had previously been filled with carbon waste) and the swale just south of the playground were filled with the Love Canal materials and then covered with 6 to 36 inches of topsoil. RECRA Research, Inc. (Ref. 2) reported that the fill obtained from the 99th Street School site contained fly ash and BHC (pesticide) cake. The horizontal extent of the fill materials and the thicknesses and depths of respective layers at the 93rd Street School site were not accurately recorded during filling operations. Therefore, additional studies were considered necessary to adequately define the extent and composition of the fill. In 1980, the 93rd Street School was closed due to public health concerns raised because of the presence of the fill materials brought from Love Canal.

1.1.3 PREVIOUS STUDIES

A number of studies have been performed since 1979 because of problems associated with the fill materials from Love Canal. Listed below in chronological order are the previous on-site investigations:

- Soils Report by Earth Dimensions, July 1979 and December 1979.
- Analysis of Soil for Beryllium, New York State Department of Health (NYSDOH), October to December 1979, and February to May 1980.
- Preliminary Engineering Investigations by RECRA Research, 1983, (includes summary of U.S. EPA and NYSDEC sampling conducted in 1982) and Engineering Investigations at Inactive Hazardous Waste sites - Phase II Investigation by RECRA Research, August, 1985.
- Sampling for the Screening of 2,3,7,8-tetrachlorodibenzo-p-dioxin, by NUS, Inc, August 1985 and letter to EPA Region II summarizing results of dioxin screening by NUS, Inc., March 1986.
- Additional Soil Sampling and Well Installation/Sampling by E. C. Jordan Company, March 1986.
- Love Canal Additional Creek Sampling and Sanitary Sewer Inspection by Malcolm Pirnie, Inc., June 1987.

Although these studies have shown that there are contaminants present on-site, they have not thoroughly defined the extent of these contaminants in the groundwater, surface water, soil and fill materials. Summaries of these studies are presented in the following paragraphs.

1.1.3.1 EARTH DIMENSIONS, INC. AND NYSDOH STUDIES

The initial Earth Dimensions, Inc. report describes an extensive soil sampling program conducted in May 1979 at the request of the New York State Department of Health (NYSDOH) to address concerns raised by the appearance of black material at the surface of the baseball diamond on the 93rd Street School site. A sampling grid consisting of 39 sampling points was designed to intersect the former drainage swale and the baseball field. This initial study helped to define the outer edges of the filled area where a thin layer of fill covered the native clay overburden. The report also gave preliminary contours for the fill materials placed on the site. The thickest deposit of carbon waste found by Earth Dimensions, Inc. was a 6 foot deep layer located under the baseball field and in the former swale. In most areas, this fill was found to be covered by only a thin layer (approximately 6 inches) of topsoil.

A second phase of soil sampling involving 47 soil cores was conducted by Earth Dimensions, Inc. in October 1979. The report for this phase of sampling describes the fill and undisturbed layers for each core taken. It is notable that chemical and organic odors were detected during this phase and recorded in the sampling log books.

The 511 samples collected by Earth Dimensions, Inc. were analyzed for beryllium by the NYSDOH Laboratory. One batch of 248 samples was analyzed during October to December 1979 (Phase I), while another batch of 263 samples was analyzed during February to May of 1980 (Phase II).

The analytical results obtained were compared to those of a reference soil (Soil-5) obtained from the International Atomic Energy Commission, Vienna, Austria. The subsequent NYSDOH report concluded that no significantly high levels of beryllium were found in the 511 samples. Other important findings of these Earth Dimensions, Inc. and NYSDOH studies were the detection of organic and chemical odors and a preliminary determination of the extent of the fill layer at the site.

1.1.3.2 RECRA RESEARCH INC. STUDY

A more extensive investigation covering air, soil, ground water, and surface water sampling was conducted by RECRA Research, Inc. (RECRA). Results of this investigation were reported in 1985. The RECRA report contains a site assessment including a description of the site, a hazard ranking for the site, and a preliminary assessment of remedial alternatives. In addition, it summarizes the results of RECRA sampling as well as EPA and NYSDEC sampling of air, soil, groundwater, and surface water conducted in 1982.

Air sampling conducted in 1982 by EPA indicated that benzene was detected in houses east of the school at relatively low levels. Concentrations of benzene found in air samples were 6.6 ug/m^3 outside the houses, 7.2 ug/m^3 inside a house, and 8.7 ug/m^3 in a basement. RECRA found air quality at the 93rd Street School site to be within acceptable limits for level D protective measures used to prevent skin contact.

According to the RECRA Report, soil sampling conducted by the EPA in 1982 showed a low level presence of lindane (gamma BHC) in the fly ash fill layer. The results of soil sampling by RECRA indicated the presence of dioxin at a concentration of 2.3 ppb in one sample location (MW-4) at a depth of 4 to 6 feet in the fill material. In addition, other contaminants including various metals and volatile organics were also found above detectable limits.

For groundwater, the EPA investigation used wells screened in bedrock and overburden. Traces of benzene (less than 20 ppb) and toulene (less than 25 ppb) were identified. RECRA groundwater sampling indicated the presence of halogenated organics, volatile halogenated organics, and various metals including chromium, lead, zinc, and iron in detectable concentrations.

Analysis of surface water samples from storm sewers on 93rd Street (adjacent to the School) by the EPA identified concentrations varying from 15 to 97 ug/l of lindane (gamma BHC). In addition, trace levels of benzene and lindane were found in samples from Bergholtz Creek. It should be noted, however, that upstream samples showed similar (or greater) concentrations of these contaminants. Analysis of samples collected by RECRA confirmed the presence of 2,3,7,8-TCDD (dioxin) at levels near the detection limit in the water in Bergholtz Creek at two locations. The dioxin concentration was higher at the point where the drainage from the 93rd Street School swale meets Bergholtz Creek. It was recommended by RECRA that additional sampling be performed to quantify dioxin levels at the 93rd Street School site.

1.1.3.3 NUS CORPORATION STUDY

NUS Corporation, EPA's Field Investigation Team (FIT) contractor at the 93rd Street School site, conducted a soil sampling program in two parts. The first part sampling plan established by NUS Corporation consisted of a 10-foot grid. This grid was used to determine the distribution of the fill, thickness of the topsoil layer over the fill material and the presence of dioxin in the surface soil. NUS conducted sampling from September 3-5, 1985 in this 10-foot grid. At 13 locations where the soil cover was less than 4 inches thick, soil samples were collected at a 1-foot depth for dioxin analysis. NUS Corporation sampling locations are shown on Drawing S-2 in Appendix B.

In the second part sampling plan, an 80-foot grid was superimposed over the 10-foot grid, and samples were collected from near the surface down to a depth of 2 to 3 inches below the surface. These second phase samples were used to determine the extent of dioxin contamination in surface soils. Analytical results associated with this NUS sampling program indicated that dioxin was detected in surface soils at three of the 47 locations sampled.

1.1.3.4 E. C. JORDAN COMPANY STUDY

In March, 1986, the E. C. Jordan Company installed and subsequently sampled four new groundwater monitoring wells. These wells were also sampled during this study. Well construction data for each of these four wells is presented in Section 4 of this report. Subsurface soil logs were prepared during installation of the monitoring wells to depths of 25 feet. These logs indicate that soil layers at the site include topsoil, silty fill materials, various clays, and silty clay mixed with gravel. At the two wells located nearest to the historical swale (7135 and 7150) a black silty fill material was encountered at depths to seven feet.

Analytical data from the E. C. Jordan study indicates that low levels of organic chemicals are present in the groundwater at the site including acetone, methylene chloride, benzene, toluene, and bis(2-ethylhexyl)phthalate. In addition, similar contaminants are present in the soil samples.

1.1.3.5 MALCOLM PIRNIE, INC. STUDY

Malcolm Pirnie, Inc. was contracted by NYSDEC to investigate dioxin contamination in creeks and sanitary sewers in the vicinity of Love Canal to determine the extent of remedial activities required. Samples collected for this study included soil samples from the banks of Bergholtz Creek at the 93rd Street School site as well as upstream and downstream of the site.

In addition, two stormwater runoff samples were collected from the 93rd Street School site swale. The study also included soil and sediment samples from other locations such as Black Creek, Cayuga River, Oak Island and sanitary manholes.

Soil samples were collected at a number of stations near the 93rd Street School site including stations B2 to B6 on Bergholtz Creek and BL3 on Black Creek. These sampling station were located approximately 200 feet apart as shown on Drawing S-2 in Appendix B. At each cross section, four soil samples were collected at maximum depths of 2 to 3 inches. Sample locations at each cross section included both banks at elevations of two feet above the creek water surface and both banks at elevations one foot below the top of bank. Laboratory analysis of the samples was limited to those grab samples collected two feet above the creek water surface. Composites were prepared by combining the four grab samples from two adjacent stations (e.g. a composite from stations B4 and B5 was identified as B4-C).

The samples were analyzed by the NYSDOH, and the following results were obtained:

- Composite bank samples for the Black and Bergholtz Creeks had dioxin concentrations ranging from not detectable (ND) to 0.73 ng/g (ppb). Only one of these samples did not exceed the detection limit (Black Creek upstream of the 93rd Street School site).

- Dioxin was detected in most of the Cayuga Creek locations at concentrations ranging from ND to 1.28 ng/g (ppb).

- Dioxin was detected at a concentration of 0.43 ng/g (ppb) in one sample on Oak Island at the apparent site of the former creek bed.

- Dioxin concentrations in the two stormwater runoff samples from the 93rd Street School site swale were below the sample detection limits of 1.39 ng/l and 0.49 ng/l (ppt).

- Dioxin concentrations in 4 sanitary sewer sediment samples ranged from 61 ng/g (ppb) to 622 ng/g (ppb) at locations somewhat removed from the 93rd Street School site (i.e., at Frontier Avenue west of 80th Street).

The investigation found that there appears to be a spatial relationship between the locations of sewer outfalls and natural drainages, and the occurrence of high concentrations of dioxin in creek bank soil and creek bed sediments.

1.2 NATURE AND EXTENT OF PROBLEM

The previous studies confirmed that fill materials contaminated with lindane, dioxin, volatile organics, halogenated organics, and metals were deposited at the 93rd Street School site. Analyses of surface soils, surface water, sediments (Bergholtz Creek and Cayuga River), and groundwater (monitoring well west of 93rd Street) showed that there is on-site contamination at the 93rd Street School site. It should be noted that off-site contamination was also reported, however no work has been done to determine if there is any movement of contaminants onto and/or away from the site.

The previous studies did not adequately define the extent and degree of contamination on-site, potential off-site migration paths, the extent and degree of off-site impacts, and alternative remedial measures to mitigate these problems. Therefore, this remedial investigation was conducted to determine the necessity for remedial actions at the site and to define the extent and feasibility of potential remedial actions. It was necessary to further define site topography, hydrogeology, and contamination levels and distribution of contaminants to accomplish these goals.

1.3 REMEDIAL INVESTIGATION SUMMARY

The Remedial Investigation for the 93rd Street School site included the following tasks:

- TASK 1 Background Data Review/Current Situation
- TASK 2 Project Plans and Protocols
- TASK 3 Surveying and Site Map

- TASK 4 First Round Soil Borings and Groundwater Monitoring Well Installation
- TASK 5 First Round Data Analysis and Remedial Alternatives Evaluation
- TASK 6 Second Round Soil Borings & Laboratory Analyses
- TASK 7 Second Round Data Analysis
- TASK 8 Bench Scale Treatability/Process Investigation (Task Omitted)
- TASKS 9-10 Monthly Progress/Community Relations

Each of these tasks is described in detail in the following paragraphs. It should be noted that this Remedial Investigation Summary report covers only Tasks 1 to 10 while the Feasibility Study report presented in Volume II covers Tasks 11 to 17.

1.3.1 TASK 1 - BACKGROUND DATA REVIEW/CURRENT SITUATION

During the first phase of the Remedial Investigation, background data including site plans, geological data, and previous reports was procured and reviewed, and the site was visited. Meetings were held with local officials and State and EPA personnel to review the current situation. Finally, the services of contractors were procured and contracts were negotiated and awarded for soil borings and well drilling; health and safety support; laboratory services; and other technical services.

1.3.2 TASK 2 - PROJECT PLANS AND PROTOCOLS

During this phase of the investigation, two plans were prepared including a Health and Safety Plan, and a combined Investigative Work Plan, Sampling Plan, and Quality Assurance/ Quality Control Plan. The content of each of these plans is summarized below.

- HEALTH AND SAFETY PLAN - This Plan includes an assessment of site hazards and descriptions of monitoring requirements, levels of protection required, and decontamination requirements for personnel and equipment.

- COMBINED INVESTIGATIVE WORK PLAN, SAMPLING PLAN, AND QUALITY ASSURANCE/QUALITY CONTROL PLAN - This combined plan describes site characterization including investigative objectives, sampling locations, drilling techniques, sampling techniques, logging techniques, quality assurance/quality control, record keeping, site-specific plans for sampling, sample identifications, chain-of-custody, laboratory coordination, laboratory QA/QC, and analytical procedures.

1.3.3 TASK 3 - SURVEYING AND SITE MAP

During this phase of the investigation, a site base map at a scale of 1"=50' was prepared including site features, contours at one foot intervals and all sampling locations. Contours and site features were located using photogrammetric procedures, while sampling stations were located and elevations of sampling points were determined by ground surveys.

1.3.4 TASK 4 - FIRST ROUND SOIL BORINGS & GROUNDWATER MONITORING WELL INSTALLATION

During this phase, soil borings and groundwater monitoring wells were installed, and the first round samples of soil, surface water runoff, and groundwater were collected. During the drilling of 15 soil borings and 9 groundwater monitoring wells, the services of a drilling contractor, an on-site Health and Safety Officer, a supervisor, and coordinator were required.

1.3.5 TASK 5 - FIRST ROUND DATA ANALYSIS AND REMEDIAL ALTERNATIVES EVALUATION

This task included three subtasks, (1) data analysis; (2) remedial alternatives evaluation; and (3) preliminary report preparation. For the first subtask, laboratory data was organized and classified by depth, area, or strata. Then the data was analyzed and compared to State and Federal standards, and a preliminary report was prepared to summarize the findings and analysis of the data through the end of first round sampling and analysis. This preliminary report included all pertinent maps, data and conclusions. Following submittal of the preliminary report, a preliminary review of remedial alternatives was conducted to determine the requirements for second round sampling stations. Additional reports were prepared as necessary including an addendum to the Work Plan.

1.3.6 TASK 6 - SECOND ROUND SOIL BORINGS & LABORATORY ANALYSES

During this phase of the investigation, 58 soil boring stations and 3 sediment sampling stations were established, and soil and sediment samples were collected and analyzed. In addition, two sets of readings of the static water levels in the monitoring wells (both LEA and E.C. Jordan Co. wells) were taken. As for Task 4 described previously, the services of a drilling contractor, an on-site Health and Safety Officer, a supervisor, and coordinator were required.

1.3.7 TASK 7 - SECOND ROUND DATA ANALYSIS

During this phase, second round laboratory data was organized and classified by depth, area or strata and compared to State and Federal standards. Then a toxicology review and study of the potential impacts of site contaminants on human health and the environment was performed. This data as well as technical and cost data was reviewed with respect to potential remedial alternatives. Based on this review, final alternatives were identified for consideration in the feasibility study.

1.3.8 TASK 8 - BENCH SCALE TREATABILITY/PROCESS INVESTIGATION

Bench Scale Treatability/Process Investigations were not performed as part of this Remedial Investigation/Feasibility Study. However, as a result of this RI/FS report, NYSDEC may arrange for bench scale testing during the remedial design phase.

1.3.9 TASKS 9-10 - MONTHLY PROGRESS/COMMUNITY RELATIONS

Monthly progress reports were prepared throughout the course of this investigation to track the technical and financial status of the project. Community relations input was provided to NYSDEC as required.

The remaining tasks (i.e., Tasks 11-17 as described below) are related to the feasibility study and are therefore described in greater detail in Volume II - Feasibility Study.

TASK 11 RESPONSE TO REMEDIAL INVESTIGATION
TASK 12 TECHNOLOGY MASTER LIST DEVELOPMENT
TASK 13 DEVELOPMENT OF ALTERNATIVES
TASK 14 SCREENING OF ALTERNATIVES
TASK 15 EVALUATION OF ALTERNATIVES
TASK 16 PRELIMINARY REPORT
TASK 17 FINAL REPORT

1.4 OVERVIEW OF REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT

1.4.1 VOLUME I - REMEDIAL INVESTIGATION SUMMARY

This report has six sections which present pertinent discussions and summaries covering the major aspects of the remedial investigation including introductory information, site features investigation, hazardous substances investigation, hydrogeology and groundwater investigations, surface water investigation and public health and environmental risk assessment.

Because air samples were not collected for laboratory analysis as part of this remedial investigation, this report does not include a separate section to summarize the results of air investigations. It should be noted, however, that some air quality data was obtained by Phoenix Safety Associates, Ltd. (PSA) during air monitoring conducted during on-site investigations to ensure worker health and safety. Daily logs were kept by PSA which summarized air quality readings measured with an HNU or Century Organic Vapor Analyzer #128 (OVA 128) equipped with a photoionization detector (PID), and combustible gas readings measured with an explosimeter.

A review of PSA's daily logs indicates that no significant levels of volatile contaminants above background were detected in the breathing zone of the workers throughout drilling and well development operations. In addition, directly above the borings and monitoring wells, readings did not typically exceed background levels by more than 2 ppm. In a few cases, however, when borings were first drilled and when well caps were first removed, readings as high as 10 ppm above background levels were detected. These relatively high readings were found directly above the borings and wells, and they dropped rapidly (i.e., within one to two minutes) as vapors dissipated.

The appendicies of the Remedial Investigation Summary report present detailed supporting data such as drawings, boring and well logs and summaries of laboratory results for each parameter detected based on laboratory reports received from York Wastewater Consultants, Inc. (YWC) and ERCO Laboratory (ERCO).

1.4.2 VOLUME II - FEASIBILITY STUDY REPORT

The Feasibility Study Report for this RI/FS investigation is presented in Volume II. An overview of the contents of the Feasibility Study Report is presented in Section 1 of Volume II.

1.4.3 VOLUMES III & IV - SUPPLEMENTAL LABORATORY DATA

A supplement to this report (see Volumes III & IV) includes the laboratory data received from ERCO for dioxin analyses and YWC for all other analyses. Also included are case data packages for the YWC analyses.

2.0 SITE FEATURES INVESTIGATION

2.1 SCOPE

Pertinent site features and topographic contours at the 93rd Street School site were located with the aid of a photogrammetric map, and the sampling station locations were established by ground surveys. A comprehensive site map was developed from this information. In the following sections, the photogrammetric and ground surveys of the site as well as mapping requirements are described in greater detail.

2.2 PHOTOGRAMMETRY

VEP Associates, Inc. performed an aerial survey of the 93rd Street School site during May 1986 as part of the Black and Bergholtz Creeks Remediation Project. Photographs at a scale of 1"=400' were obtained and used to develop a photogrammetric map at a scale of 1"=50' which included major features at the 93rd Street School site (buildings, roads, trees, baseball diamond, etc.) and topographic contours at intervals of 1 foot. Drawing S-1 in Appendix A shows site features and contours taken from the VEP Associates photogrammetric map as well as the sampling stations located by ground surveys.

2.3 GROUND SURVEYS

Ground surveys were performed to locate existing groundwater monitoring wells and new groundwater, soil, and surface water sampling stations at the 93rd Street School site. Two main baselines were used at the site to establish the locations of these features. The first main baseline connected stations 101 and 103, while the second connected stations 102 and 104. These two main baselines were perpendicular to each other, and intersected at station 106. Existing wells located from these baselines include the four wells installed by RECRA Research (MW-1 to MW-4), and the four wells installed by E.C. Jordan Co. (Wells 7135, 7140, 7145, and 7150). The locations of the nine new wells installed during this study (SMW-1 to SMW-9) were also established. Elevation data for all wells including the elevations of the tops of the protective casings, tops of the well casings, and ground surface are summarized in the Monitoring Well Data table on Drawing S-1 (See Appendix A). It should be noted that these elevations were determined from Bench Mark No. 3: a 5/8 inch lag bolt at an elevation of 575.41 feet in the easterly face of power pole number NYT 24. This bench mark was established based on the USGS datum (USC&G Mon. C-93) which is a stamped brass disk at elevation 581.800' located in the vicinity of the Niagara Falls Airport at the intersection of U.S. Highway 62 and Williams Road.

Nine boring sample baseline stations (201 to 209) were established along the deepest parts of the historical drainage swale which existed prior to the addition of fill materials from Love Canal. These were based on the 1947 topography as shown on Figure 2. Fifteen first round boring sample locations for soil sampling were located along the boring station baselines. These sampling stations were identified as stations 1P-1 to 1P-6, 1P-8 to 1P-13 and 1P-15 to 1P-17. Fifty-eight second round boring sampling locations and three second round sediment sampling locations were established from the boring sample baseline stations. These sampling stations were identified as stations 2P-101 to 2P-158, and SD-1 to SD-3, respectively. It should be noted that sampling stations 2P-101 and 2P-156 were located but not sampled. This will be discussed further in Section 3.

Finally, two first round surface water sampling stations (i.e., SW-1 and SW-2) were established in the existing drainage swale where there was visible surface water. These stations are also shown on Drawing S-1 (See Appendix A).

2.4 MAPPING

Site features and contours from the VEP Associates photogrammetric maps and sampling station locations from the ground surveys are shown on Drawing

S-1 (See Appendix A). NYSDEC requested that the NUS Corporation and the Malcolm Pirnie dioxin sampling stations be located on a site map. Therefore, the dioxin sampling stations for this study, as well as for previous studies are shown on Drawing S-2 (See Appendix B). As described previously, NUS Corporation sampling was conducted in two parts. During the first phase, a 10-foot sampling grid was used to determine the thickness of the soil cover and the areal distribution of dioxin in the fill. Soil samples were collected at 1-foot depths at 13 locations. During the second phase of sampling, an 80-foot grid was superimposed over the 10-foot grid, and 47 samples were collected at depths of 2 to 3 inches below the surface within the larger grid. The NUS Corporation stations shown on Drawing S-2 were numbered based on a coordinate system in which station numbers were assigned based on the number of feet south and east from Station 0S, 0E. For example, Station 560S, 560E was 560 feet south and 560 feet east of Station 0S, 0E. Also presented on Drawing S-2 are Black and Bergholtz Creek bank soil sampling stations (BL-3 and B-1 to B-7) and the drainage swale sampling station established in the Malcolm Pirnie, Inc. report.

In summary, Drawings S-1 and S-2 show all sampling points used during this study and those used during past studies by others.

3.0 HAZARDOUS SUBSTANCES INVESTIGATION

3.1 SCOPE

The presence of hazardous substances at the site was investigated by collection and analysis of two rounds of soil samples. During the first round of sampling, soil samples were collected at the approximate locations of the deepest parts of the original drainage swale at the site. This swale was filled with materials suspected to contain hazardous substances. The location of this historic swale is shown on Figure 2. During the second round of sampling, soil samples were collected at the outer sections of the original drainage swale, and sediment samples were collected in the existing drainage swale. In the following paragraphs, descriptions of sample collection methods, field data collected, parameters studied, analytical data obtained and conclusions are presented.

3.2 SOIL AND SEDIMENT SAMPLING

3.2.1 FIRST ROUND

First round soil sampling for this remedial investigation was conducted to determine the type and degree of contamination, if any, in on-site soils located in the presumed location of the original swale on the site. Fifteen first round sampling stations (1P-1 to 6, 8 to 13 and 15 to 17) were established along the soil boring baselines shown on Drawing S-1 in Appendix A as described previously. These sampling stations were strategically located along the deepest portions of the historical swale (identified from 1947 contours in site development drawings) to concentrate efforts where the fill layers were believed to be thickest.

Soil sampling station borings were drilled with a hollow stem auger, and soil samples were collected at or near the surface (0-1'), from 1'-2' depth and then at two foot intervals down to a final depth approximately 2 feet below the base of the fill layer. Seventy soil samples were collected at the 15 sampling stations with a split spoon sampler. It should be noted that

TABLE 3-1
FIRST ROUND
SOIL SAMPLE IDENTIFICATION SUMMARY

SAMPLING STATION	DEPTH[1] INTERVAL	DATE COLLECTED	FIELD LABEL #	YWC LABORATORY CONTROL #	ERCO ID NO	SAMPLES COLLECTED BY
IP1A	0'-1'	11-20-86	3889	067		W. Thomas and J. Ingrassia
B	1'-2'	11-20-86	3888	066		
C	2'-4'	11-20-86	3890	068		
D	4'-6'	11-20-86	3891	069		
E	6'-8'	11-20-86	3892	070		
	Comp.				40965	
IP2A	0'-1'[2]	11-21-86	3895	073		J. Ingrassia and C. Wolff
B	1'-2'	11-10-86	3839	038		
C	2'-4'	11-10-86	3840	039		
D	4'-6'	11-10-86	3841	040		
E	6'-8'	11-10-86	3842	041		
	Comp.				40605	
IP3A	0'-1'[2]	11-21-86	3894	072		J. Ingrassia and C. Wolff
B	1'-2'	11-10-86	3835	034		
C	2'-4'	11-10-86	3836	035		
	4'-6'[3]	11-10-86	-	-		
E	6'-8'	11-10-86	3837	036		
F	8'-10'	11-10-86	3838	037		
	Comp.				40606	
IP4A	0.5'[4]	11-7-86	3800	001		W. Thomas and J. Ingrassia
B	0.5'-2'	11-7-86	3804	002		
C	2'-4'	11-7-86	3803	005		
D	4'-6'	11-7-86	3802	004		
E	6'-8'	11-7-86	3801	003		
F	8'-10'	11-7-86	3805	009		
	Comp.				40603	

[1] Below Grade.

[2] Surface Grab Samples collected on 11-21-86.

[3] No sample collected - no recovery in split tube (spoon) sampler for this interval. Note that sampling station depth codes were omitted intentionally for these samples.

[4] Grab sample from just below asphalt pavement.

TABLE 3-1 (Continued)
FIRST ROUND
SOIL SAMPLE IDENTIFICATION SUMMARY

SAMPLING STATION	DEPTH[1] INTERVAL	DATE COLLECTED	FIELD LABEL #	YWC LABORATORY CONTROL #	ERCO ID NO	SAMPLES COLLECTED BY
IP5A	0'-1'[2]	11-21-86	3893	071		W. Thomas and J. Ingrassia
B	1'-2'	11-07-86	3806	006		
C	2'-4'	11-07-86	3807	007		
D	4'-6'	11-07-86	3808	008		
	Comp.				40604	
IP6A	0'-1'	11-13-86	3871	048		J. Ingrassia and C. Wolff
	1'-2'[3]	11-13-86	-	-		
C	2'-4'	11-13-86	3872	049		
D	4'-6'	11-13-86	3873	050		
	Comp.				40613	
IP8A	0'-1'	11-11-86	3854	016		J. Ingrassia and C. Wolff
B	1'-2'	11-11-86	3855	017		
C	2'-4'	11-11-86	3857	019		
D	4'-6'	11-11-86	3856	018		
E	6'-8'	11-11-86	3858	020		
F	8'-10'	11-11-86	3859	021		
	Comp.				40608	
IP9A	0'-1'	11-10-86	3844	043		J. Ingrassia and C. Wolff
B	1'-2'	11-10-86	3843	042		
C	2'-4'	11-10-86	3845	044		
D	4'-6'	11-10-86	3846	045		
E	6'-8'*	11-10-86	3847	046		
F	8'-10'	11-10-86	3848	047		
	Comp.				40607	

* One of the 3 volatiles vials broke in shipment - only one vial required for analysis.

TABLE 3-1 (Continued)
FIRST ROUND
SOIL SAMPLE IDENTIFICATION SUMMARY

SAMPLING STATION	DEPTH[1] INTERVAL	DATE COLLECTED	FIELD LABEL #	YWC LABORATORY CONTROL #	ERCO ID NO	SAMPLES COLLECTED BY
IP10A	0'-1'	11-13-86	3874	051		W. Thomas
B	1'-2'	11-13-86	3875	052		and
C	2'-4'	11-13-86	3876	053		C. Wolff
D	4'-6'	11-13-86	3877	054		
E	6'-8'	11-13-86	3878	055		
F	8'-10'	11-13-86	3879	056		
	Comp.				40614	
IP11A	0'-1'	11-19-86	3884	062		J. Ingrassia
	1'-2'[3]	11-19-86	-	-		and
C	2'-4'	11-19-86	3885	063		W. Thomas
D	4'-6'	11-19-86	3886	064		
E	6'-8'	11-19-86	3887	065		
	Comp.				40964	
IP12A	0'-1'	11-12-86	3868	030		W. Thomas
B	1'-2'	11-12-86	3869	031		and
C	2'-4'	11-12-86	3870	032		C. Wolff
	Comp.				40610	
IP13A	0'-1'	11-14-86	3880	058		W. Thomas
B	1'-2'	11-14-86	3881	059		and
C	2'-4'	11-14-86	3882	060		C. Wolff
D	4'-6'	11-14-86	3883	061		
	Comp.				40615	

TABLE 3-1 (Continued)
FIRST ROUND
SOIL SAMPLE IDENTIFICATION SUMMARY

SAMPLING STATION	DEPTH[1] INTERVAL	DATE COLLECTED	FIELD LABEL #	YWC LABORATORY CONTROL #	ERCO ID NO	SAMPLES COLLECTED BY
IP15A	0'-1'	11-12-86	3860	022		J. Ingrassia
	1'-2'[3]	11-12-86	-	-		and
C	2'-4'	11-12-86	3861	023		C. Wolff
D	4'-6'	11-12-86	3862	024		
E	6'-8'	11-12-86	3863	025		
F	8'-10'	11-12-86	3864	026		
	Comp.				40611	
IP16A	0'-1'	11-11-86	3849	011		J. Ingrassia
B	1'-2'	11-11-86	3850	012		and
C	2'-4'	11-11-86	3851	013		C. Wolff
D	4'-6'	11-11-86	3852	014		
E	6'-8'	11-11-86	3853	015		
	Comp.				40609	
IP17A	0'-1'	11-12-86	3866	028		W. Thomas
B	1'-2'	11-12-86	3865	027		and
C	2'-4'	11-12-86	3867	029		J. Ingrassia
	Comp.				40612	
Field Blank		11-19-87	3834	075	41059	J. Ingrassia

collection of an additional 4 samples was attempted but no recovery was achieved. A list of all first round soil samples is presented in Table 3-1.

3.2.2 SECOND ROUND

Second round soil sampling for this investigation was conducted to determine the lateral extent and depth of contaminated soil in the vicinity of the former drainage swales and the extent and degree of contamination in sediments in the existing drainage swale. Fifty-eight soil sampling stations (i.e., 2P-101 to 2P-158) were located by ground survey at the site as shown on Drawing S-1 in Appendix B. Fifty-six of these stations (i.e. 2P-102 to 2P-155 and 2P-157 to 2P-158) were actually sampled, while the remaining two stations (i.e. 2P-101 and 2P-156) were omitted during Second Round-Phase II sampling because it was determined that site conditions at these stations were defined adequately during Second Round-Phase I sampling. The majority of these sampling stations were arranged in a pattern so that there were two rows of borings on both sides and parallel to first round stations. The outer row of these second round borings was positioned near the 1947 contour elevation of 572' as shown on Drawing S-1. In addition, a few second round soil sampling stations were located along the fence to the north of the school. Finally, three sediment sampling stations (i.e., SD-1 to SD-3) were established in the existing drainage swale as shown on Drawing S-1.

At each second round soil sampling station, a grab sample was collected from 0'-0.5'. Then a hollow stem auger was used to drill the boring. Split spoon samples were collected during drilling at 2' intervals down to a final depth at least 18 inches below the base of the fill layer. If no fill was encountered by the time a depth of 2.5' was reached, the station was abandoned.

The second round soil sampling was conducted in two phases. Samples collected during the first phase of second round sampling were analyzed while samples collected during the second phase were collected but not analyzed. Sampling was conducted in this manner so that a third set of samples (i.e., the Second Round-Phase II soil samples) would be available for analysis if it was determined that additional sample analyses would be required to define the extent and degree of soil contamination at the site.

The 32 soil sampling stations located closest to first round sampling points were sampled first during Second Round-Phase I sampling. These stations were as follows:

2P-103
2P-104
2P-108
2P-109
2P-114
2P-115
2P-116
2P-119
2P-120
2P-121
2P-122
2P-126
2P-127
2P-128
2P-129
2P-130
2P-131
2P-135
2P-136
2P-138
2P-139
2P-140
2P-141
2P-143
2P-144
2P-148
2P-152
2P-153
2P-154
2P-155
2P-157
2P-158

Following completion of Second Round - Phase I sampling, the remaining stations were sampled during Second Round - Phase II sampling. Three sediment samples were collected during Second Round - Phase II at stations SD-1 to SD-3. All sediment samples collected were grab samples collected from 0 to 6 inches. It should be noted that in spite of the fact that the sediment samples were collected during Second Round-Phase II, they were analyzed along with Second Round-Phase I samples.

Seventy-three soil samples were collected and analyzed during Second Round-Phase I sampling, while 37 soil samples were collected and archived for potential future analysis during Second Round-Phase II sampling. It should be noted that throughout second round sampling, additional samples were evaluated in the field for strata verification only. These samples were neither analyzed nor archived. Finally, 24 dioxin composite soil samples were collected during second round sampling. Fourteen of these samples were analyzed, while the remaining 10 were archived. A list of all second round samples is presented in Table 3-2.

3.3 REVIEW OF FIELD DATA

Summaries of soil boring observations for first and second round sampling are presented in Tables 3-3 and 3-4, respectively while boring logs are presented in Appendix C. Tables 3-3 and 3-4 include boring station numbers, total depths of soil borings, depths of the lower fill/native material interface, composition of the fill material, and composition of native materials. In summary, the total depths of the first round soil borings ranged from 6.0 to 10.0 feet; and depths of the lower fill/native material interface

TABLE 3-2
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-103	0-0.5	June 23, 1987	3910	011	-	Analyzed
2P-103	0.5-2.5	June 23, 1987	3911	012	-	Analyzed
2P-103	2.5-4.5	June 23, 1987	3912	(013)	-	No Fill Sample, Not Analyzed
2P-104	0-0.5	June 23, 1987	3906	007	-	Analyzed
2P-104	0.5-2.5	June 23, 1987	3907	008	-	Analyzed
2P-104	2.5-4.5	June 23, 1987	3908	009	-	Analyzed
2P-104	4.5-6.5	June 23, 1987	3909	(010)	-	Not Analyzed
2P-104	6.5-8.5	June 23, 1987	-	-	-	Strata Verification
2P-108	0-0.5	June 23, 1987	3903	004	-	Analyzed
2P-108	0.5-2.5	June 23, 1987	3904	005	-	Analyzed
2P-108	2.5-4.5	June 23, 1987	3905	(006)	-	No Fill Sample, Strata Verification
2P-109	0-0.5	June 23, 1987	3900	001	-	Analyzed
2P-109	0.5-2.5	June 23, 1987	3901	002	-	Analyzed
2P-109	2.5-4.5	June 23, 1987	3902	(003)	-	No Fill Sample, Strata Verification

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.

**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-114	0-0.5	June 23, 1987	3913	014	-	Analyzed
2P-114	0.5-2.5	June 23, 1987	3914	015	-	Analyzed
2P-114	2.5-3.5	June 23, 1987	3915	016	-	Analyzed
2P-114	3.5-4.5	June 23, 1987	-	-	-	Augered, No Sample
2P-114	Composite	June 23, 1987	3063	-	9217	Dioxin Analysis Only
2P-114A	0-4.5	June 23, 1987	-	-	-	Augered, No Sample
2P-114A	4.5-6.5	June 23, 1987	3916	017	-	Analyzed
2P-114A	6.5-8.5	June 23, 1987	3917	(018)	-	No Fill Sample, Strata Verification
2P-115	0-0.5	June 23, 1987	3918	019	-	Analyzed
2P-115	0.5-2.5	June 23, 1987	3919	020	-	Analyzed
2P-115	2.5-4.5	June 23, 1987	-	-	-	No Recovery
2P-115	4.5-6.5	June 23, 1987	3920	021	-	Analyzed
2P-115	6.5-8.5	June 23, 1987	3921	(022)	-	No Fill Sample, Strata Verification
2P-115	Composite	June 23, 1987	3064	-	9218	Dioxin Analysis Only
2P-116	0-0.5	June 23, 1987	3922	023	-	Analyzed
2P-116	0.5-2.5	June 23, 1987	3923	024	-	Analyzed
2P-116	2.5-4.5	June 23, 1987	3924	025	-	Analyzed
2P-116	4.5-6.5	June 23, 1987	-	-	-	Strata Verification
2P-116	Composite	June 23, 1987	3065	-	9232	Archived, Dioxin Analysis Only

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-119	0-0.5	June 24, 1987	3926	027	-	Analyzed
2P-119	0.5-2.5	June 24, 1987	3928	028	-	Analyzed
2P-119	2.5-4.5	June 24, 1987	3925	029	-	Analyzed
2P-119	4.5-6.5	June 24, 1987	3927	(030)	-	No Fill Sample
2P-119	Composite	June 24, 1987	3068	-	9221	Dioxin Analysis Only
2P-120	0-0.5	June 24, 1987	3934	036	-	Analyzed
2P-120	0.5-2.5	June 24, 1987	3935	037	-	Analyzed
2P-120	2.5-4.5	June 24, 1987	3936	038	-	Analyzed
2P-120	5.0-7.0	June 24, 1987	3937	039	-	Analyzed
2P-120	7.0-9.0	June 24, 1987	3938	(040)	-	No Fill Sample
2P-120	Composite	June 24, 1987	3070	-	9222	Dioxin Analysis Only
2P-121	0-0.5	June 25, 1987	3959	060	-	Analyzed
2P-121	0.5-2.5	June 25, 1987	3957	061	-	Analyzed
2P-121	2.5-4.5	June 25, 1987	3960	062	-	Analyzed
2P-121	4.5-6.5	June 25, 1987	-	-	-	No Fill Sample, Strata Verification
2P-121	Composite	June 25, 1987	3088	-	9223	Dioxin Analysis Only

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-122	0-0.5	June 25, 1987	3961	063	-	Analyzed
2P-122	0.5-2.5	June 25, 1987	3962	064	-	Analyzed
2P-122	2.5-4.5	June 25, 1987	-	-	-	No Fill Sample
2P-122	Composite	June 25, 1987	3089	-	9233	Archived, Dioxin Analysis Only
2P-126	0-0.5	June 25, 1987	3969	071	-	Analyzed
2P-126	0.5-2.5	June 25, 1987	3970	(072)	-	No Fill Sample
2P-126	2.5-4.5	June 25, 1987	-	-	-	No Fill Sample, Strata Verification
2P-127	0-0.5	June 25, 1987	3967	069	-	Analyzed
2P-127	0.5-2.5	June 25, 1987	3968	(070)	-	No Fill Sample
2P-127	2.5-4.5	June 25, 1987	-	-	-	No Fill Sample, Strata Verification
2P-128	0-0.5	June 25, 1987	3963	065	-	Analyzed
2P-128	0.5-2.5	June 25, 1987	3964	066	-	Analyzed
2P-128	2.5-4.5	June 25, 1987	3965	067	-	Analyzed
2P-128	4.5-6.5	June 25, 1987	3966	(068)	-	No Fill Sample

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TAB[illegible]3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-129	0-0.5	June 25, 1987	3971	073	-	Analyzed
2P-129	0.5-2.5	June 25, 1987	3973	(074)	-	No Fill Sample of Organic, Silt Composition (Spoon Refusal)
2P-129A	0-2.5	June 25, 1987	-	-	-	Augered, No Sample
2P-129A	2.5-3.5	June 25, 1987	-	-	-	No Recovery (Spoon Refusal)
2P-129B	0-1.5	June 25, 1987	-	-	-	Auger Refusal, No Sample
2P-130	0-0.5	June 25, 1987	3974	075	-	Analyzed
2P-130	0.5-2.5	June 25, 1987	3975	(076)	-	No Fill Sample
2P-131	0-0.5	June 25, 1987	3976	077	-	Analyzed
2P-131	0.5-2.5	June 25, 1987	3977	(078)	-	No Fill Sample
2P-135	0-0.5	June 24, 1987	3929	031	-	Analyzed
2P-135	0.5-2.5	June 24, 1987	3930	032	-	Analyzed
2P-135	2.5-4.5	June 24, 1987	3931	033	-	Analyzed
2P-135	4.5-6.5	June 24, 1987	3933	034	-	Analyzed (No VOA Sample, Poor Recovery)
2P-135	6.5-8.5	June 24, 1987	3932	(035)	-	No Fill Sample
2P-135	Composite	June 24, 1987	3069	-	9224	Dioxin Analysis Only
2P-136	0-0.5	June 25, 1987	3978	079	-	Analyzed
2P-136	0.5-2.5	June 25, 1987	3979	(080)	-	No Fill Sample
2P-136	2.5-4.5	June 25, 1987	-	-	-	No Fill Sample, Strata Verification

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.

**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-138	0-0.5	June 24, 1987	3939	041	-	Analyzed
2P-138	0.5-2.5	June 24, 1987	3940	042	-	Analyzed
2P-138	2.5-4.5	June 24, 1987	3941	043	-	Analyzed
2P-138	4.5-6.5	June 24, 1987	3942	044	-	Analyzed
2P-138	6.5-8.5	June 24, 1987	3943	(045)	-	No Fill Sample
2P-138	Composite	June 24, 1987	3071	-	9225	Dioxin Analysis Only
2P-139	0-0.5	June 24, 1987	3951	053	-	Analyzed
2P-139	0.5-2.5	June 24, 1987	3952	054	-	Analyzed
2P-139	2.5-4.5	June 24, 1987	3953	055	-	Analyzed
2P-139	4.5-6.5	June 24, 1987	-	-	-	No Fill Sample, Strata Verification
2P-139	Composite	June 24, 1987	3076	-	9226	Dioxin Analysis Only
2P-140	0-0.5	June 24, 1987	3954	056	-	Analyzed
2P-140	0.5-2.5	June 24, 1987	3955	057	-	Analyzed
2P-140	2.5-4.5	June 24, 1987	3956	058	-	Analyzed
2P-140	4.5-6.5	June 24, 1987	-	-	-	No Fill Sample, Strata Verification
2P-140	Composite	June 24, 1987	3077	-	9227	Dioxin Analysis Only

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-141	0-0.5	June 25, 1987	3980	081	-	Analyzed
2P-141	0.5-2.5	June 25, 1987	3981	(082)	-	No Fill Sample
2P-141	2.5-4.5	June 25, 1987	3982	(083)	-	No Fill Sample
2P-141	4.5-6.5	June 25, 1987	-	-	-	Strata Verification
2P-143	0-0.5	June 24, 1987	3944	046	-	Analyzed
2P-143	0.5-2.5	June 24, 1987	3945	047	-	Analyzed
2P-143	2.5-4.5	June 24, 1987	3946	048	-	Analyzed
2P-143	4.5-6.5	June 24, 1987	3947	049	-	Analyzed
2P-143	6.5-8.5	June 24, 1987	-	-	-	No Fill Sample, Strata Verification
2P-143	Composite	June 24, 1987	3074	-	9236	Archived, Dioxin Analysis Only
2P-144	0-0.5	June 24, 1987	3948	050	-	Analyzed
2P-144	0.5-2.5	June 24, 1987	3949	051	-	Analyzed
2P-144	2.5-4.5	June 24, 1987	3950	052	-	Analyzed
2P-144	4.5-6.5	June 24, 1987	-	-	-	No Fill Sample, Strata Verification
2P-144	Composite	June 24, 1987	3075	-	9228	Dioxin Analysis Only

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-148	0-0.5	June 25, 1987	3983	084	-	Analyzed
2P-148	0.5-2.5	June 25, 1987	-	-	-	No Recovery
2P-148	2.5-4.5	June 25, 1987	3984	(085)	-	No Fill Sample, Strata Verification
2P-152	0-0.5	June 25, 1987	3080	086	-	Analyzed
2P-152	0.5-2.5	June 25, 1987	3081	(087)	-	No Fill Sample
2P-152	2.5-4.5	June 25, 1987	-	-	-	Strata Verification
2P-153	0-0.5	June 26, 1987	3997	089	-	Analyzed
2P-153	0.5-2.5	June 26, 1987	3998	106	-	Poor Recovery
2P-153	2.5-4.5	June 26, 1987	3999	107	-	Poor Recovery
2P-153	4.5-6.5	June 26, 1987	-	-	-	No Recovery
2P-153	6.5-8.5	June 26, 1987	-	-	-	No Fill Sample, Strata Verification Only
2P-154	0-0.5	June 26, 1987	4000	090	-	Analyzed
2P-154	0.5-2.5	June 26, 1987	-	-	-	Poor Recovery
2P-154	2.5-4.5	June 26, 1987	-	-	-	Strata Verification Only

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE I
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108)	Enseco I.D. No. (8906-4601)	Comments
2P-155	0-0.5	June 26, 1987	3079	091	-	Analyzed
2P-155	0.5-2.5	June 26, 1987	3084	109	-	Analyzed
2P-155	2.5-4.5	June 26, 1987	3085	108	-	Analyzed
2P-155	4.5-6.5	June 26, 1987	-	-	-	No Fill Sample, Strata Verification Only
2P-157	0-0.5	June 26, 1987	3086	092	-	Analyzed
2P-157	0.5-2.5	June 26, 1987	-	-	-	No Fill Sample, Strata Verification Only
2P-158	0-0.5	June 26, 1987	3985	093	-	Analyzed
2P-158	0.5-2.5	June 26, 1987	-	-	-	No Fill Sample

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
**Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).

TABLE 3-2 (Continued)
SECOND ROUND-PHASE II
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108) (+30870-1131)	Enseco I.D. No. (8906-4601)	Comments***
2P-101	-	-	-	-	-	Deleted
2P-102	0-0.5	June 29, 1987	3109	015	-	Archived
2P-102	0.5-2.5	June 29, 1987	-	-	-	Strata Verification Only
2P-105	0-0.5	June 29, 1987	3111	017	-	Archived
2P-105	0.5-2.5	June 29, 1987	-	-	-	Strata Verification Only
2P-106	0-0.5	June 29, 1987	3110	016	-	Archived
2P-106	0.5-2.5	June 29, 1987	-	-	-	Strata Verification Only
2P-107	0-0.5	June 29, 1987	3108	014	-	Archived
2P-107	0.5-2.5	June 29, 1987	-	-	-	No Recovery
2P-107	2.5-4.5	June 29, 1987	-	-	-	Strata Verification
2P-110	0-0.5	June 29, 1987	3112	018	-	Archived
2P-110	0.5-2.5	June 29, 1987	-	-	-	No Recovery
2P-110	2.5-4.5	June 29, 1987	-	-	-	Strata Verification Only
2P-111	0-0.5	June 29, 1987	3106	012	-	Archived
2P-111	0.5-2.5	June 29, 1987	3107	013	-	Archived
2P-111	2.5-4.5	June 29, 1997	-	-	-	Strata Verification
2P-111	Composite	June 29, 1987	3357	-	9231	Archived for Dioxin Analysis

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
** Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).
***Samples archived were extracted by laboratory, but not analyzed.

TABLE 3-2 (Continued)
SECOND ROUND-PHASE II
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108) (+30870-1131)	Enseco I.D. No. (8906-4601)	Comments***
2P-112	0-0.5	June 29, 1987	3104	010	-	Archived
2P-112	0.5-2.5	June 29, 1987	3105	011	-	Archived
2P-112	2.5-4.5	June 29, 1987	-	-	-	Strata Verification
2P-112	Composite	June 29, 1987	3143	-	9215	Analyzed for Dioxin Only
2P-113	0-0.5	June 26, 1987	3102	008	-	Archived
2P-113	0.5-2.5	June 26, 1987	3103	009	-	Archived
2P-113	2.5-4.5	June 26, 1987	-	-	-	Strata Verification
2P-113	Composite	June 26, 1987	3364	-	9216	Analyzed for Dioxin Only
2P-117	0-0.5	June 29, 1987	3100	007	-	Archived
2P-117	0.5-2.5	June 29, 1987	-	-	-	Strata Verification
2P-117	Composite	June 29, 1987	3363	-	9219	Analyzed for Dioxin Only
2P-118	0-0.5	June 29, 1987	3097	004	-	Archived
2P-118	0.5-2.5	June 29, 1987	3098	005	-	Archived
2P-118	2.5-4.5	June 29, 1987	3099	006	-	Archived
2P-118	4.5-6.5	June 29, 1987	-	-	-	Strata Verification
2P-118	Composite	June 29, 1987	2368	-	9220	Analyzed for Dioxin Only

NOTES

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** Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).
***Samples archived were extracted by laboratory, but not analyzed.

TABLE 3-2 (Continued)
SECOND ROUND-PHASE II
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108) (+30870-1131)	Enseco I.D. No. (8906-4601)	Comments***
2P-123	0-0.5	June 29, 1987	3113	019	-	Archived
2P-123	0.5-2.5	June 29, 1987	3114	020	-	Archived
2P-123	2.5-4.5	June 29, 1987	-	-	-	Strata Verification Only
2P-124	0-0.5	June 29, 1987	3120	021	-	Archived
2P-124	0.5-2.5	June 29, 1987	3121	022	-	Archived
2P-125	0-0.5	June 30, 1987	3122	023	-	Archived
2P-125	0.5-2.5	June 30, 1987	3125	026	-	Archived, No Fill Sample
2P-125	2.5-4.5	June 30, 1987	-	-	-	Strata Verification Only
2P-132	0-0.5	June 30, 1987	3123	024	-	Archived
2P-132	0.5-2.5	June 30, 1987	-	-	-	Strata Verification Only
2P-133	0-0.5	June 30, 1987	3124	025	-	Archived
2P-133	0.5-2.5	June 30, 1987	-	-	-	Strata Verification Only
2P-134	0-0.5	June 29, 1987	3094	001	-	Archived
2P-134	0.5-2.5	June 29, 1987	3095	002	-	Archived
2P-134	2.5-4.5	June 29, 1987	3096	003	-	Archived
2P-134	4.5-6.5	June 29, 1987	-	-	-	Strata Verification
2P-134	Composite	June 29, 1987	2367	-	9234	Archived for Dioxin Analysis

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
** Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).
***Samples archived were extracted by laboratory, but not analyzed.

TABLE 3-2 (Continued)
SECOND ROUND-PHASE II
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108) (+30870-1131)	Enseco I.D. No. (8906-4601)	Comments***
2P-137	0-0.5	June 26, 1987	3091	102	-	Archived
2P-137	0.5-2.5	June 26, 1987	3092	103	-	Archived
2P-137	2.5-4.5	June 26, 1987	3093	104	-	Archived
2P-137	4.5-6.5	June 26, 1987	-	-	-	Strata Verification
2P-137	Composite	June 26, 1987	3119	-	9235	Archived for Dioxin Analysis
2P-142	0-0.5	June 30, 1987	3126	027	-	Archived
2P-142	0.5-2.5	June 30, 1987	-	-	-	Strata Verification Only
2P-145	0-0.5	June 26, 1987	3990	097	-	Archived
2P-145	0.5-2.5	June 26, 1987	-	-	-	Strata Verification
2P-145	Composite	June 26, 1987	3115	-	9237	Archived for Dioxin Analysis
2P-146	0-0.5	June 26, 1987	3989	096	-	Archived
2P-146	0.5-2.5	June 26, 1987	-	-	-	Strata Verification
2P-146	Composite	June 26, 1987	3116	-	9238	Archived for Dioxin Analysis Only
2P-147	0-0.5	June 26, 1987	3987	094	-	Archived
2P-147	0.5-2.5	June 26, 1987	3988	095	-	Archived
2P-147	2.5-4.5	June 26, 1987	-	-	-	Strata Verification Only

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
** Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).
***Samples archived were extracted by laboratory, but not analyzed.

TABLE 3-2 (Continued)
SECOND ROUND-PHASE II
SOIL SAMPLE IDENTIFICATION SUMMARY

Sampling Station	Depth Interval (Ft. BGL)	Date Collected*	Field Label No.	YWC** Laboratory Control No. (30870-1108) (+30870-1131)	Enseco I.D. No. (8906-4601)	Comments***
2P-149	0-0.5	June 26, 1987	3995	100	-	Archived
2P-149	0.5-2,5	June 26, 1987	3996	101	-	Archived
2P-149	2.5-4.5	June 26, 1987	-	-	-	Strata Verification
2P-149	Composite	June 26, 1987	3118	-	9239	Archived for Dioxin Analysis
2P-150	0-0.5	June 26, 1987	3994	099	-	Archived
2P-150	0.5-2.5	June 26, 1987	-	-	-	Strata Verification Only
2P-151	0-0.5	June 26, 1987	3992	098	-	Archived
2P-151	0.5-2.5	June 26, 1987	-	-	-	Strata Verification
2P-151	Composite	June 26, 1987	3117	-	9240	Archived for Dioxin Analysis Only
2P-156	-	June 26, 1987	-	-	-	Deleted
SD-1	Surface Sample	June 30, 1987	3128	028	-	Analyzed
SD-2	Surface Sample	June 30, 1987	3129	029	-	Analyzed
SD-3	Surface Sample	June 30, 1987	3130	030	-	Analyzed

NOTES

* All samples collected by Joan M. Ingrassia and Dana C. Martin.
** Samples shipped, but not analyzed, marked as "No Fill Sample", are indicated by (   ).
***Samples archived were extracted by laboratory, but not analyzed.

ranged from zero (i.e., no fill) to 7.5 feet. The depths of second round soil borings ranged from 2.5 to 9.0 feet; and depths of the lower fill/native material interface ranged from zero (i.e., no fill) to 7.0 feet. Fill materials encountered during first and second round sampling typically consisted of dark gray, dark brown or black silt with small quantities of clay, sand, gravel and wood chips. The density and consistency of the fill varied with the clay content. Native soils consisted primarily of moist, stiff clay or silty clay in a variety of colors including light gray and brown streaked with red and orange.

Soil boring logs for the first and second round soil sampling stations are presented in Appendix C. These logs provide drilling and sampling data including sample depths, blows required per 6" penetration, moisture densities (for cohesionless soils), soil consistencies (for cohesive soils), strata change depths, and soils identifications. From these logs, it is apparent that the topsoil layer at almost all stations was less than one foot thick and tended to consist of moist cohesionless soils with loose to medium dense cohesionless densities. In addition, these logs confirmed that the fill and native materials had the properties described previously.

3.4 FIRST ROUND ANALYSIS

3.4.1 PARAMETERS STUDIED - FIRST ROUND

All first round soil samples collected were analyzed for the inorganics, volatile organic compounds, base/neutral/acid extractable compounds, pesticides and PCBs listed in Appendix D. In addition, at each station a composite sample for dioxin analysis was generated which included all samples collected for the station with the exception of the surface sample. It should be noted that surface soils were not included in the composite samples collected for dioxin analysis because NUS Corporation had previously conducted a thorough investigation of dioxin levels in surface soils at the site.

3.4.2 SUMMARY OF ANALYTICAL DATA - FIRST ROUND

Summaries of laboratory results for all samples are presented in Appendix H. The data in this Appendix is organized so that the laboratory

TABLE 3-3
FIRST ROUND
SUMMARY OF SOIL BORING OBSERVATIONS

Boring Number	Total Depth of Soil Boring	Depth of[1] the Lower Fill/Native Material Interface	Composition of Fill Material	Composition of[2] Native Material
1P1	10'	5'	Dark Gray Silt, Organic, w/Trace of Gravel	Clay, Light Gray to Brown, Mottled with Orange and Dark Brown Streaks
1P2	8'	5.5'	Silt, Black, Organic, Some Cobbles; and Clay, Brn. to Red-Brown; and Gravel, Angular	Clay, Red-Brown to Brown, Mottled, with Red Streaks
1P3	10'	7'	Silt, Black, with some Gravel, Angular	Clay, Gray, Mottled with Red Streaks
1P4	10'	7.5'	Silt, Dark Gray to Black, Organic; Trace Gravel, Angular	Clay, Tan Brown to Dark Gray, Layered, Mottled, Little Silt
1P5	6'	No Fill	No Fill	Clay Orange Brown to Tan Brown w/Orange Streaks
1P6	6'	2.5'	Silt (Organic) and Clay, Dark Brown to Black with Wood Chips	Clay, Brown to Red Brown and Gray, Mottled
1P8	10'	7'	Silt, Black, Organic, and Clay, Gray with Gravel, Angular, Little Sand	Clay Brown to Red Brown, Mottled
1P9	10'	7'	Silt, Black, Some Brown (Organic)	Clay, Gray, Mottled, with Rusty Streaks
1P10	10'	6.5'	Silt, Dark Gray to Black, Organic, Little Clay, Tan-Brown, Mottled	Clay, Gray, Mottled, with Orange Streaks
1P11	10'	6'	Silt, Black, Organic and Clay, Gray, Mottled, with Orange Streaks	Silty Clay Grading to Clay, Gray, Mottled

TABLE 3-3
FIRST ROUND
SUMMARY OF SOIL BORING OBSERVATIONS(Continued)

Boring Number	Total Depth of Soil Boring	Depth of[1] the Lower Fill/Native Material Interface	Composition of Fill Material	Composition of[2] Native Material
1P12	6'	No Fill	No Fill	Clay, Red Brown to Tan Brown, Mottled, with Dark Gray Streaks; Trace Silt, Trace Sand, Medium Coarse
1P13	6'	No Fill	No Fill	Clay, Tan Brown to Gray, Mottled, with Orange Streaks
1P15	10'	6.5'	Silt, Black, Organic, Some Clay, Gray, Very Mottled, with Red Pockets, Some Root Fibers	Clay, Gray to Brown, with Red Streaks
1P16	10'	5.5'	Clay, Brown to Gray and Silt, Black, Organic, with Wood Chunks	Clay, Gray to Brown, Mottled, with Red Streaks, Grading to Red Brown, Homogenous
1P17	6'	No Fill	No Fill	Clay, Tan Brown to Gray, Mottled with Orange and Red Brown Streaks

NOTES: The organic silt fill material encountered was generally wet, sometimes over relatively dry clay, indicating mounded water conditions in fill areas

[1] The lower fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than 1 foot below the surface.

[2] Excluding topsoil composition. Note that the topsoil was typically less than 1 foot in thickness.

TABLE 3-4
SECOND ROUND-PHASE I
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower Fill/Native Material Interface[1]	Composition of Fill Material	Composition of Native Material[2]
June 23, 1987	2P-103	4.5'	2'	Silt, Black, Organic	Silty Clay, Brown-Red Grading to Gray - Brown
June 23, 1987	2P-104	8.5'	5.5'	Silt, Brown-Red; Some Clay, Little Black Silt; Wood Chip	Silty Clay, Gray-Brown
June 23, 1987	2P-108	4.5'	1'	Silt, Dark Brown, Trace Black	Silty Clay, Red-Brown to Gray
June 23, 1987	2P-109	4.5'	1'	Silt, Dark Brown, Trace Black	Silty Clay, Red-Brown, Mottled
June 23, 1987	2P-114	4.5'	Auger Refusal	Silt, Black, Organic, and Very Fine Sand; Some Gravel	Spoon Refusal at 3.5'; Auger Refusal at 4.5'
June 23, 1987	2P-114A	8.5'	6'	Very Fine Sand, Dark to Light Brown, and Silt; Trace Clay; Trace Root Fiber and Brick	Silty Clay, Brown-Gray
June 23, 1987	2P-115	8.5'	6'	Silt, Black, Organic; Little Clay; Silt, Rusty Brown	Silty Clay, Gray with Brown Mottling

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than one foot below the surface.

[2] Excludes topsoil composition. Note that the topsoil was less than one foot thick.

TABLE 3-4 (Continued)
SECOND ROUND-PHASE I
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower Fill/Native Material Interface[1]	Composition of Fill Material	Composition of Native Material[2]
June 23, 1987	2P-116	6.5'	3.5'	Silt, Brown; Some Gravel,	Silty Clay, Gray Grading to Red
June 24, 1987	2P-119	6.5'	5'	Silt, Black, Organic	Silt Clay, Brown Grading to Gray
June 24, 1987	2P-120	9.0'	6.5'	Silt, Brown-Black; Some Gravel, Trace Root Matter	Silty Clay, Gray, Some Brown Mottling
June 25, 1987	2P-121	6.5'	4.5'	Silt, Black, Organic and Clay; Black Cinder Gravel	Silty Clay, Dark Brown with Gray Streaks
June 25, 1987	2P-122	4.5'	2.5'	Silt, Black, Organic and Black Cinder Gravel	Silty Clay, Gray to Brown
June 25, 1987	2P-126	4.5'	No Fill	No Fill	Silty Clay, Reddish-Brown-Gray
June 25, 1987	2P-127	4.5'	No Fill	No Fill	Silty Clay, Light Brown

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than one foot below the surface.

[2] Excludes topsoil composition. Note that the topsoil was less than one foot thick.

TABLE 3-4 (Continued)
SECOND ROUND-PHASE I
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower Fill/Native Material Interface[1]	Composition of Fill Material	Composition of Native Material[2]
June 25, 1987	2P-128	6.5'	4'	Silt, Black, Organic	Silty Clay, Gray, Some Brown Mottling
June 25, 1987	2P-129	2.5'	Spoon Refusal	Cinder Block Fragments, (Abandoned Foundation?)	Not Determined, Spoon Refusal, Relocated Boring Location.
June 25, 1987	2P-129A	3.5'	Spoon Refusal	No Sample Recovery	No Sample Recovery, Spoon Refusal, Relocated Boring Location Again.
June 25, 1987	2P-129B	1.5'	Auger Refusal	No Sample Recovery	No Sample Recovery, Auger Refusal, Abandoned Boring Location.
June 25, 1987	2P-130	2.5'	No Fill	No Fill	Silty Clay, Brown with Reddish Streaks
June 25, 1987	2P-131	4.5'	No Fill	No Fill	Silty Clay, Brown with Gray Streaks
June 24, 1987	2P-135	8.5'	7'	Silt, Black, Organic; Trace Sand, Coarse	Silty Clay, Gray
June 25, 1987	2P-136	4.5'	No Fill	No Fill	Silty Clay, Reddish Brown
June 24, 1987	2P-138	8.5'	6'	Silt, Black, Organic	Silty Clay, Brown to Gray
June 24, 1987	2P-139	6.5'	4'	Silt, Organic, Black; Trace Silt, Tan	Clay, Brown to Gray; Trace Silt

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than one foot below the surface.

[2] Excludes topsoil composition. Note that the topsoil was less than one foot thick.

TABLE 3-4 (Continued)
SECOND ROUND-PHASE I
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower Fill/Native Material Interface[1]	Composition of Fill Material	Composition of Native Material[2]
June 24, 1987	2P-140	6.5'	3.5'	Silt, Black, Organic and Clay, Brown; Trace Gravel, Fine (Cinders)	Silty Clay, Brown to Gray
June 25, 1987	2P-141	6.5'	No Fill	No Fill	Silty Clay, Brown to Gray
June 24, 1987	2P-143	8.5'	6'	Silt, Black, Organics; Trace Silt, Tan Streaked	Silty Clay, Gray to Brown
June 24, 1987	2P-144	6.5'	4'	Silt, Black Organic, Little Brown Silt and Root Fibers	Silty Clay, Brown to Gray
June 25, 1987	2P-148	4.5'	No Fill	No Fill	Silty Clay, Brown with Gray and Red Streaks
June 25, 1987	2P-152	4.5'	No Fill	No Fill	Silty Clay, Reddish Brown with Gray Streaks
June 26, 1987	2P-153	8.5'	No Fill	No Fill	Silty Clay, Gray with Brown Streaks; (Poor Sample Recovery Due to Willow Tree Roots)

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than one foot below the surface.

[2] Excludes topsoil composition. Note that the topsoil was less than one foot thick.

TABLE 3-4 (Continued)
ROUND 2 - PHASE I
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower Fill/Native Material Interface[1]	Composition of Fill Material	Composition of Native Material[2]
June 26, 1987	2P-154	4.5'	No Fill	No Fill	Silty Clay, Reddish Brown
June 26, 1987	2P-155	6.5'	No Fill	No Fill	Silty Clay, Brown with Gray Streaks
June 26, 1987	2P-157	2.5'	No Fill	No Fill	Silty Clay, Brown, Homogeneous
June 26, 1987	2P-158	2.5'	No Fill	No Fill	Silty Clay, Brown, with Red and Gray Streaks

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than one foot below the surface.

[2] Excludes topsoil composition. Note that the topsoil was less than one foot thick.

TABLE 3-4 (Continued)
SECOND ROUND-PHASE II
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower[1] Fill/Native Material Interface	Composition of Fill Material	Composition of Native Material[2]
-	2P-101	-	-	-	Deleted
June 29, 1987	2P-102	2.5'	No Fill	No Fill	Silty Clay, Brown with Orange Streaks
June 29, 1987	2P-105	2.5'	No Fill	No Fill	Silty Clay, Weathered, Brown to Gray with Orange Streaks
June 29, 1987	2P-106	2.5'	No Fill	No Fill	Silt, Gray and Brown Streaked
June 29, 1987	2P-107	4.5'	No Fill	No Fill	Silt, Gray and Brown Streaked
June 29, 1987	2P-110	4.5'	No Fill	No Fill	Silty Clay, Gray to Brown
June 29, 1987	2P-111	4.5'	1.5'	Silt, Black to Dark Gray, Little Gravel, Medium	Silty Clay, Gray to Brown
June 29, 1987	2P-112	4.5'	2.5'	Silt, Black	Silty Clay, Brown
June 26, 1987	2P-113	4.5'	2'	Silt, Black	Silty Clay, Brown to Gray
June 29, 1987	2P-117	2.5'	No Fill	No Fill	Silty Clay, Brown with Orange Streaks

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less tham one foot below the surface.

[2] Excludes topsoil composition. Note that the topsoil was less than one foot thick.

TABLE 3-4 (Continued)
SECOND ROUND-PHASE II
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower[1] Fill/Native Material Interface	Composition of Fill Material	Composition of Native Material[2]
June 29, 1987	2P-118	6.5'	3.5'	Silt, Black Organic; Trace Silty Root Fibers; Brown Silt	Silty Clay, Gray with Brown Streaks
June 29, 1987	2P-123	4.5'	No Fill	No Fill	Silty Clay, Brown with Gray Streaks
June 29, 1987	2P-124	2.5'	1'	Silt, Black, Organic	Silty Clay, Brown with Gray and Orange Streaks
June 30, 1987	2P-125	4.5'	No Fill	No Fill	Silty Clay, Brown with Gray and Orange Streaks
June 30, 1987	2P-132	2.5'	No Fill	No Fill	Silty Clay, Brown with Gray and Orange Streaks
June 30, 1987	2P-133	2.5'	0.5'	Silt, Dark Brown to Black; Trace Cinders	Silty Clay, Brown with Gray and Orange Streaks
June 29, 1987	2P-134	6.5'	4'	Silt, Black, Organic	Silty Clay, Brown with Gray and Orange Streaks

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than one foot below the surface.

2 Excludes topsoil composition. Note that the topsoil was less than one foot thick.

TABLE 3-4 (Continued)
SECOND ROUND-PHASE II
SUMMARY OF SOIL BORING OBSERVATIONS

Date of Drilling	Boring Number	Total Depth of Boring (Ft.) BGL	Depth of the Lower Fill/Native Material Interface[1]	Composition of Fill Material	Composition of Native Material[2]
June 26, 1987	2P-137	6.5'	3.5'	Silt, Black, Organic	Silty Clay, Brown with Gray and Red Streaks
June 30, 1987	2P-142	2.5'	No Fill	No Fill	Silty Clay, Brown with Orange and Gray Mottling
June 26, 1987	2P-145	2.5'	No Fill	No Fill	Silty Clay, Brown with Gray and Orange Streaks
June 26, 1987	2P-146	2.5'	No Fill	No Fill	Silty Clay, Brown with Gray and Orange Streaks
June 26, 1987	2P-147	4.5'	1.1'	Silt, Black (¼" Thick Layer)	Silty Clay, Brown with Gray Streaks
June 26, 1987	2P-149	4.5'	2'	Silt, Black, and Clay, Brown	Silty Clay, Brown with Gray and Red Streaks
June 26, 1987	2P-150	2.5'	No Fill	No Fill	Silty Clay, Brown with Gray and Red Streaks
June 26, 1987	2P-151	2.5'	No Fill	No Fill	Clay, Brown to Gray
--	2P-156	-	-	-	Deleted

NOTES

[1] Fill/native material interface was generally identified by presence of root fibers over silty clay. Note that the upper interface was generally less than one foot below the surface.

[2] Excludes topsoil composition. Note that the topsoil was less than one foot thick.

results for each parameter are shown for all first round soil sampling stations on one sheet. Soil and aqueous sample data are shown separately. Finally, if a parameter was not detected in any soil sample, the results are not presented in Appendix H.

Table 3-5 shows all inorganic parameters found in first round soil samples; the concentration and station where the highest level was detected; the corresponding NYSDEC Water Quality Regulations Standards or Guidance concentrations for Class GA Waters; the corresponding GA effluent standard; background concentrations in soils from around New York state; and the number of samples where 100 times the GA effluent standard and background values were exceeded.

Table 3-6 shows all organic parameters found in first round soil samples; the concentration and station where the highest level was detected; and the corresponding GA WQ standard.

As shown in Appendix H, no dioxin was detected in any of the soil composite samples collected during first round sampling. Results of the composite samples for Black and Bergholtz Creek bank soils from Malcolm Pirnie, Inc. are presented in Table 3-7. In the Malcolm Pirnie, Inc. study, dioxin was present at detectable levels in all composites except the most upstream composite (BL-1) from Black Creek. Table 3-8 shows the results for the three stations where dioxin was found in on-site surface soils in the NUS Corporation studies. Finally, it should be noted that dioxin was also found at a concentration of 2.3 ppb by RECRA Research at a depth of 4 to 6 feet at well MW-4.

3.4.3 REVIEW OF ANALYTICAL DATA - FIRST ROUND

To determine the extent and degree of contamination in first round samples and to develop a second round sampling and analysis program, first round analytical data was reviewed as described in the following paragraphs.

First, the inorganic parameters shown in Table 3-5 for soils were compared with two sets of criteria to evaluate whether or not the parameters were of concern for health or environmental reasons. These criteria were as follows:

TABLE 3-5
ANALYSIS OF FIRST ROUND ANALYTICAL DATA
INORGANICS IN SOILS

			NYSDEC WQ REGS		NYSDEC GA EFFL STD		NY SOIL BKGRND††††	
Parameter	Highest Conc mg/kg† (ppm)	Highest Conc Sta	GA Std. ug/l (ppb)	GA Guid. ug/l (ppb)	(mg/l) (ppm)	No.Samples Exceeding 100 Times	Mean mg/kg (ppm)	No.Samples Exceeding Background
Aluminum	10700	1P13A	None	None	2.0	70	48,000	0
Antimony	209n	1P4B	None	3	0.6††	58	0.75(<9)	59(59)
Arsenic	350	1P4D	25	NA	0.05	36	7.0(10.6)	21(15)
Barium	565n	1P4C	1000	NA	2.0	6	300	4
Beryllium	3.4n	1P4A	None	3	0.6††	0	0.6	20
Cadmium	133n	1P4B	10	NA	0.02	56	0.4†††(4)	68(27)
Calcium	202000	1P4A	None	None	None	--	5,200	42
Chromium	516	1P1B	None	None	0.10	66	34	15
Cobalt	52	1P3E	None	None	None	--	8	21
Copper	44	1P11E	1000	NA	1.0	0	22	28
Iron	86600	1P15D	300	NA	0.3	68	28,000	17
Lead	177n	1P3B	25	NA	0.05	70	21(114)	42(5)
Magnesium	42000*	1P13B	None	35000	70*	20	5,000	28
Manganese	3000n*	1P3E	300	NA	0.6	69	1,100	5
Mercury	23	1P1B	2	NA	0.004	11	0.15(0.15)	26(26)
Nickel	47	1P8F	None	None	2.0	0	14	66
Potassium	3550*	1P5B	None	None	None	--	15,500	0
Selenium	4.1s	1P1C	20	NA	0.04	2	0.3	3
Silver	3.2	1P9D	50	NA	0.1	0	No data	-
Thallium	1.2	1P8F	None	4	None	1	9.08	0
Vanadium	59	1P15C	None	None	None	-	60	0
Zinc	18200*	1P4B	5000	NA	5.0	1	64	54
Molybdenum	229	1P4A	None	None	None	-	No data	-
Titanium	825	1P3C	None	None	None	-	No data	-

† Subscript definitions for this column are as follows:
n = indicates spike sample recovery is not within control limits
* = indicates duplicate analysis is not within control limits
s = indicates value determined by Method of Standard Addition

†† Based on twice the WQ standard.

††† Average from Cadmium in the Environment, J. O. Nriagu, ed, pg. 588.

†††† From "Summary of Inorganic Constituent Concentrations in Soil Samples from Around the State of New York" (Boerngen and Shacklette, 1981) with the exception of values in parentheses which are from Michael E. Hopkins of the Niagara County Health Dept., and which were believed to be average background concentrations for soils in the Niagara Falls area.

TABLE 3-6
ANALYSIS OF FIRST ROUND ANALYTICAL DATA
ORGANICS IN SOILS

Parameter	Highest Conc ug/kg* (ppb)	Highest Conc Sta	NYSDEC GA WQ Std ug/l (ppb)	NYSDEC GA WQ Guide. ug/l (ppb)
VOLATILE ORGANICS				
Methylene chloride	7700	1P9F	NA	50
Acetone	4500	1P5B	None	None
1,1-Dichloroethene	670	1P8A	NA	0.07
Chloroform	1100B	1P6A	100	NA
2-Butanone	5300	1P9B	None	None
1,1,2,2-Tetrachloroethane	1600	1P6A	NA	0.2
Toluene	13000B	1P10C	NA	50
Ethylbenzene	1600	1P9E	NA	50
Xylenes	2000	1P10C	NA	50
B/N/A				
1,4-Dichlorobenzene	830	1P4F	4.7**	NA
Naphthalene	1500D	1P4C	NA	10
2-Methylnaphthalene	910D	1P4C	None	None
Acenaphthene	11000D	1P4C	NA	20
Dibenzofuran	62000	1P4E	None	None
Fluorene	14000D	1P4C	NA	50
Phenanthrene	82000D	1P4C	NA	50
Anthracene	22000D	1P4C	NA	50
Fluoranthene	45000D	1P4C	NA	50
Pyrene	56000D	1P4C	NA	50
Benzo (a) anthracene	26000D	1P4C	NA	0.002
Bis (2-Ethylhexyl) Phthalate	630	1P3A	4200	NA
Chrysene	24000D	1P4C	NA	0.002
Benzo (b) fluoranthene	31000D	1P4C	NA	0.002
Benzo (k) fluoranthene	4900D	1P4C	NA	0.002
Benzo (a) pyrene	19000D	1P4C	ND	NA
Indeno (1,2,3-cd) pyrene	8200D	1P4C	NA	0.002
Benzo (g,h,i) perylene	2100	1P9B	None	None
PESTICIDES/PCBs				
Alpha BHC	13	1P8E	ND	
Beta BHC	137	1P4C	ND	
DIOXIN	None			

*Subscript definitions for this column are as follows:

B = indicates analyte was found in blank as well as sample.

D = indicates sample extract was diluted due to sample matrix and/or concentration levels.

**Applies to sum of (1,4-) and (1,2-) isomers only.

TABLE 3-7
DIOXIN IN SOILS ON BANKS OF BLACK CREEK AND BERGHOLTZ CREEK
(From Malcolm Pirnie Inc.)

COMPOSITE SAMPLE DESIGNATION	GRAB SAMPLES in the COMPOSITE*	DIOXIN CONCENTRATION (ppb)
BL1-C	**	<0.01
BL3-C		0.02
B2-C	B2 and B3	0.26
B4-C	B4 and B5	0.35
B6-C	B6 and B7	0.65
B8-C	B8 and B9	0.61
B10-C	**	0.73
B12-C	**	0.32
B14-C	**	0.42
B16-C	**	0.40

*Individual grab samples were collected 2 feet above water level on both banks at stations shown on Dwg. S-2.

**Stations not shown on Dwg S-2.

TABLE 3-8
DIOXIN IN SITE SURFACE SOILS
(From NUS Corp.)

LOCATION (GRID CORNER)	DIOXIN CONCENTRATION (ppb)	DIOXIN DETECTION LIMIT (ppb)
0S, 0E	1.20	Not applicable
160S, 80E	0.11	Not applicable
160S, 160E	0.19	Not applicable

(1) Effluent standards for discharge to Class GA waters (Schedule 1, 10NYCRR 703.6) multiplied by 100. The factor of 100 is an approximation of the relative soil:water partition coefficients to account for, low level compound solubilities in water, dilution, exchange capacity and other physical factors. This approach was based on a similar method used by SMC Martin, Inc. (Ref. 3).

(2) For parameters with no published effluent standard, the effluent standard was assumed to be twice the published GA standard or guidance value; (i.e., the 2:1 ratio is the same as that for most parameters with published effluent standards).

Table 3-5 provides a summary of the first round data and criteria which forms the basis of the following discussions of the inorganic parameters found in first round soil samples.

Aluminum - The highest concentration of aluminum found in the soil was 10700 mg/kg. This concentration is below the normal range of concentrations reported in New York soils. Therefore, aluminum was not considered to be a cause for concern in the soil.

Antimony - This metal was found in most of the soil samples (59) at concentrations higher than the normal range in New York soils. In addition, based on data provided by the Niagara County Health Department, 59 of the samples exceeded antimony concentrations found in background soils from the Niagara Falls area. Fifty-eight of the soil samples exceeded a value of 100 times the GA effluent standard (based on twice the GA WQ standard of 3 ug/l). Therefore, antimony was considered to be a parameter of concern in the soil.

Arsenic - This metal was found in some of the soil samples (21) at concentrations higher than the normal range in New York soils. In addition, based on data provided by the Niagara County Health Department, 15 samples exceeded arsenic concentrations found in background soils from the Niagara Falls area. Thirty- six of the soil samples exceeded a value of 100 times the GA effluent standard of 50 ug/l. Therefore, arsenic was considered to be a parameter of concern in the soil.

Barium - This metal was found in only four soil samples at a concentration higher than the normal range in New York soils. Only six of the soil samples exceeded a value of 100 times the GA effluent standard of 2 mg/l. Therefore, barium was not considered to be a major parameter of concern in the soil.

Beryllium - This metal was found in twenty of the soil samples at concentrations higher than the normal range in New York soils. None of the soil samples exceeded a value of 100 times the GA effluent standard (based on twice the GA WQ standard of 300 ug/l). Therefore, beryllium was not considered to be a major parameter of concern in the soil.

Cadmium - This metal was found in most of the soil samples (68) at concentrations higher than the average value found in United States soils. In addition, based on data provided by the Niagara County Health Department, 27 samples exceeded cadmium concentrations found in background soils from the Niagara Falls area. Fifty-six of the soil samples exceeded a value of 100 times the GA effluent standard of 20 ug/l. Therefore, cadmium was considered to be a parameter of concern in the soil.

Calcium - This element was found in 42 of the soil samples at concentrations higher than the normal range in New York soils. There are no effluent or WQ standards for calcium in GA waters. Therefore, calcium was not considered to be a major parameter of concern in the soil.

Chromium - This metal was found in 15 of the soil samples at concentrations higher than the normal range in New York soils. Sixty-six of the soil samples exceeded a value of 100 times the GA effluent standard of 100 ug/l. However, because the effluent standard is for hexavalent chromium which would normally be a small fraction of the total chromium (which was the basis for the reported concentrations in the soil samples analyzed in this study), chromium was not considered to be a major parameter of concern in the soil.

Cobalt - This metal was found in 21 of the soil samples at concentrations higher than the normal range in New York soils. There are no effluent or WQ standards for cobalt in GA waters. However, it should be noted that cobalt has been determined to have adverse effects on human health under conditions of long-term air exposure. Therefore, cobalt was considered to be a major parameter of concern in the soil, but was not analyzed for in second round samples for reasons described later in this section.

Copper - This metal was found in 28 of the soil samples at concentrations higher than the normal range in New York soils. However, none of the soil samples exceeded a value of 100 times the GA effluent standard. Therefore, copper was not considered to be a major parameter of concern in the soil.

Iron - This metal was found in 17 of the soil samples at concentrations higher than the normal range in New York soils. Sixty-eight of the soil samples exceeded a value of 100 times the GA effluent standard of 300 ug/l. However, iron was not considered to be a major parameter of concern in the soil because the standard is based on aesthetic considerations.

Lead - This metal was found in 42 of the soil samples at concentrations higher than the normal range in New York soils. Based on Niagara County Health Department data, 5 samples exceeded average lead concentrations found in background soils from the Niagara Falls area. However, all of the soil samples exceeded a value of 100 times the GA effluent standard of 50 ug/l. Therefore, lead was considered to be a parameter of concern in the soil.

Magnesium - This metal was found in 28 of the soil samples at concentrations higher than the normal range in New York soils. Only 20 of the soil samples exceeded a value of 100 times the GA effluent standard (based on twice the GA WQ standard of 35 mg/l). Magnesium was not considered to be a major parameter of concern in the soil because the hardness caused by the magnesium could be readily removed if the water were to be used for potable purposes.

Manganese - This metal was found in only five of the soil samples at concentrations higher than the normal range in New York soils. Most of the soil samples (69) exceeded a value of 100 times the GA effluent standard of 600 ug/l). However, manganese was not considered to be a major parameter of concern in the soil because the standard is not based on human toxicity or carcinogenic considerations.

Mercury - This metal was found in 26 of the soil samples at concentrations higher than the normal range in New York soils and than the concentration of mercury in background soils from the Niagara Falls area. Eleven of the soil samples exceeded a value of 100 times the GA effluent standard of 4 ug/l. Because of its toxicity, mercury was considered to be a parameter of concern in the soil.

Nickel - This metal was found in 66 of the soil samples at concentrations higher than the normal range in New York soils. None of the soil samples exceeded a value of 100 times the GA effluent standard of 2 mg/l. Therefore, nickel was not considered to be a major parameter of concern in the soil.

Potassium - The highest concentration of potassium found in the soil was 3550 mg/kg. This is below the normal range of concentrations reported in New York soils. Therefore, potassium was not considered to be a major parameter of concern in the soil.

Selenium - This metal was found in only three of the soil samples at concentrations higher than the normal range in New York soils. Only two of the soil samples exceeded a value of 100 times the GA effluent standard of 40 ug/l. Therefore, selenium was not considered to be a major parameter of concern in the soil.

Silver - None of the soil samples exceeded a silver concentration of 100 times the GA effluent standard of 100 ug/l. Therefore, silver was not considered to be a major parameter of concern in the soil.

Thallium - This metal was not found in any of the soil samples at concentrations higher than the normal range in New York soils. There are no effluent or WQ standards for thallium in GA waters. Therefore, thallium was not considered to be a major parameter of concern in the soil.

Vanadium - The highest concentration of vanadium found in the soil was 59 mg/kg. This is below the normal range of concentrations reported in New York soils. Therefore, vanadium was not considered to be a major parameter of concern in the soil.

Zinc - This metal was found in 54 of the soil samples at concentrations higher than the normal range in New York soils. However, only one of the soil samples exceeded a value of 100 times the GA effluent standard of 5 mg/l. Therefore, zinc was not considered to be a major parameter of concern in the soil.

Molybdenum - There are no effluent or WQ standards for molybdenum in GA waters. Therefore, molybdenum was not considered to be a major parameter of concern in the soil.

Titanium - There are no effluent or WQ standards for titanium in GA waters. Therefore, titanium was not considered to be a major parameter of concern in the soil.

The organic parameters shown on Table 3-6 for first round soil samples were evaluated by comparison with the NYSDEC effluent standards (Schedule 1, 10NYCRR 703.6) and the NYSDEC WQ standards and guidance values for Class GA waters. Because only three of these compounds are listed in the published effluent standards (chloroform, bis (2-ethylhexyl) phthalate and benzo(a)pyrene), and the values of these effluent standards are equal to the GA WQ standards, the NYSDEC effluent standards are not presented in Table 3-6.

A total of 30 organic compounds were found in at least one first round soil sample at concentrations above the CRDL. The professional judgment used in making these evaluations was based on the WQ standards as well as the human exposure risk used to establish the state and federal water quality criteria. Particular emphasis was placed on human toxicity and potential carcinogenic effects.

Volatile Organic Compounds (VOC's) - In general, VOC's are a cause for concern in soil because many of them are toxic or carcinogenic. The major VOC's of concern identified in the first round soil samples are as follows:

- Methylene chloride	Found in 54 samples at 70-150 x WQ STD
- 1,1 Dichloroethene	Found in only one sample but carcinogenic
- Chloroform	Found in 34 samples at 7-11 x WQ STD
- 1,1,2,2-Tetrachloroethane	Found in only one sample but carcinogenic
- Toluene	Found in 15 samples at 4-260 x WQ STD
- Ethylbenzene	Found in 29 samples at 16-32 x WQ STD
- Total Xylenes	Found in 22 samples at 20-40 x WQ STD

Further discussion of the potential human health effects of VOC's will be presented in Section 6.

The other VOC's found are of lesser concern for the reasons presented below:

- Acetone	No WQ STD; not reported to be toxic or carcinogenic
- Butanone	No WQ STD; not reported to be toxic or carcinogenic

Base/Neutral/Acid Extractable Organics (BNA's) - The major BNA's of concern identified in the first round soil samples are the polynuclear aromatic hydrocarbons (PNA's) as follows:

PNA'S

Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo (a) anthracence
Chrysene
Benzo (b) fluoranthene
Benzo (K) fluoranthene
Indeno (1,2,3-cd) pyrene

- These BNA compounds were found in 4 to 15 of the soil samples. The first five of the PNA's listed here have a GA WQ guidance value of 50 ug/l, while the remainder have GA WQ guidance values of 0.002 ug/l with the exception of benzo(a) pyrene which is ND. Benzo(a) pyrene is the only proven carcinogen of the PNA compounds listed. However, the low levels of the WQ standards indicate that PNA's should be considered to be parameters of concern in the soil.

Further discussion of the potential human health effects of PNA's will be presented in Section 6.

BNA's of lesser concern are as follows:

1,4-Dichlorobenzene	Found in only 2 samples; not reported to be toxic.
Naphthalene	Found in only 2 samples; WQ STD based on aesthetics.
2-Methylnaphthalene	Found in only 1 sample; No WQ STD
Acenaphthene	Found in only 3 samples; WQ STD based on aesthetics.
Dibenzofuran	Found in only 4 samples; No WQ STD

Bis (2-Ethylhexyl)	Found in only 2 samples at less than WQ STD
Benzo (g,h,i) perylene	Found in only 4 samples; No WQ STD

Pesticides/PCB's - No PCB's were found in first round soil samples. Alpha and beta BHC, however, were found in seven of the first round soil samples. Therefore, due to the potential carcinogenic effects of these compounds, alpha and beta BHC were considered to be parameters of concern in the soil. Further discussion of the potential effects of alpha BHC and beta BHC on human health will be presented in Section 6.

Dioxin - Although dioxin was not found in any first round soil samples, it was considered to be a parameter of concern in the soil because it was found by others in surface soil samples at three locations on the site (NUS Corporation study), one sample at a depth of 4-6 feet (RECRA Research study) and at several locations along the banks of Bergholtz Creek and Black Creek near the school site.

Summary - In summary, the major parameters of concern found in first round soil samples were as follows:

Inorganic

Antimony
Arsenic
Cadmium
Cobalt
Lead
Mercury

Volatile Organics

Methylene chloride
1,1 Dichloroethene
Chloroform
1,1,2,2-Tetrachloroethane
Toluene
Ethylbenzene
Xylenes

B/N/A Organics

Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Benzo (a) anthracene
Chrysene
Benzo (b) fluoranthene
Benzo (k) fluoranthene
Benzo (a) pyrene
Indeno (1,2,3-cd) pyrene

Pesticides/PCBs/Dioxin

Alpha BHC
Beta BHC
Dioxin

Additional parameters of concern include the following Love Canal Indicator Parameters: 1,2-Dichlorobenzene and 1,2,3,4-Tetrachlorobenzene.

3.5 SECOND ROUND ANALYSIS

3.5.1 PARAMETERS STUDIED - SECOND ROUND

Following completion of review of first round analytical data as described in the previous section, it was determined that almost all of the major parameters of concern listed at the end of section 3.4.3 should be studied during the second round of this investigation. It should be noted that a few parameters of concern were not studied during the second round including cobalt, alpha BHC and beta BHC. These parameters were, however, considered during an evaluation of the potential impacts of site contaminants on public health and the environment and during the Feasibility Study. Additional Love Canal Indicator Parameters (1,2-Dichlorobenzene and 1,2,3,4-Tetrachlorobenzene) were included in the analysis of the second round samples because these compounds are frequently found in the Love Canal area and are used as tracers. In conclusion, a complete list of parameters studied during the second round of this investigation is presented below:

Inorganics

- Antimony
- Arsenic
- Cadmium
- Lead
- Mercury

Volatile Organics

- Methylene chloride
- 1,1 Dichloroethene
- Chloroform
- 1,1,2,2-Tetrachloroethane
- Toluene
- Ethylbenzene
- Xylenes

B/N/A Organics

- Fluorene
- Phenanthrene
- Anthracene
- Fluoranthene
- Pyrene
- Benzo (a) anthracene
- Chrysene
- Benzo (b) fluoranthene
- Benzo (k) fluoranthene
- Benzo (a) pyrene
- Indeno (1,2,3-cd) pyrene
- 1,2 Dichlorobenzene
- 1,2,3,4-Tetrachlorobenzene

Dioxin

Second Round - Phase I soil samples which showed visual evidence that fill was present and Second Round - Phase II sediment samples were analyzed for all of the parameters listed above with the exception of dioxin.

Second Round - Phase II soil samples which showed visual evidence that fill was present were saved for possible future analysis. A review of the Phase I analytical data indicated that it was not necessary to analyze Phase II soil samples. Therefore, the Phase II samples were discarded.

Dioxin composites for the Second Round were collected at each of the 24 stations listed below: (* = Samples actually analyzed for dioxin).

2P-111
2P-112*
2P-113*
2P-114*
2P-115*
2P-116
2P-117*
2P-118*
2P-119*
2P-120*
2P-121*
2P-122
2P-134
2P-135*
2P-137
2P-138*
2P-139*
2P-140*
2P-143
2P-144*
2P-145
2P-146
2P-149
2P-151

These dioxin composites typically included all samples collected for a particular station with the exception of the surface grab sample and the bottom split spoon sample (which was collected only to confirm that the base of the fill layer had been reached). It should be noted that the surface soils were not typically included in the composite samples because NUS Corporation had previously conducted a thorough investigation of dioxin levels in surface soils at the site. Exceptions occurred at stations 2P-117, 2P-145, 2P-146, and 2P-151 where surface samples were included in the dioxin composites because the depth of these borings was only 2.5'.

The dioxin composites which were collected but not analyzed have been archived for possible future analysis.

3.5.2 SUMMARY OF ANALYTICAL DATA - SECOND ROUND

Summaries of laboratory results for all samples are presented in Appendix H. The data in this Appendix is organized so that the laboratory results for each paramater for each round of analysis are summarized on individual sheets.

Table 3-9 summarizes the highest concentrations of inorganic parameters found in second round soil and sediment samples; the concentration and station where the highest level was detected; the corresponding GA effluent standard; background concentrations in soils from New York State; and the number of stations where 100 times the GA effluent standard and background values were exceeded. It should be noted that the only inorganic parameter which had a highest second round concentration exceeding the highest first round concentration was lead.

Table 3-10 summarizes the highest concentrations of all organic parameters found in second round soil and sediment samples; the concentration and station where the highest level was detected; and the corresponding NYSDEC GA WQ standards and guidance values. It should be noted that the only organic parameters for which highest concentrations were found during the second round were 1,1-dichloroethene, chloroform, and 1,1,2,2-tetrachloroethane.

Finally, as for first round samples, no dioxin was detected in any of the 14 second round soil sample composites which were analyzed for dioxin. It should be noted that 10 of the 24 soil sample composites collected for dioxin analysis were not analyzed but instead were archived for possible future analysis.

3.5.3 REVIEW OF ANALYTICAL DATA - SECOND ROUND

First, the inorganic parameter results summarized in Table 3-9 for second round soils and sediment samples, were compared with the same criteria as first round soils to determine the degree of inorganic contamination present in the outer edges of the historic swale.

Table 3-9 provides a summary of the second round data and criteria which forms the basis of the following discussions of the inorganic parameters found in second round soil and sediment samples.

TABLE 3-9
ANALYSIS OF SECOND ROUND ANALYTICAL DATA
INORGANICS IN SOILS

	Highest Conc		NYSDEC WQ REGS		NYSDEC GA EFFL STD		NY SOIL BKGRND††††	
Parameter	mg/kg (ppm)	Sta	GA Std. ug/l (ppb)	GA Guid. ug/l (ppb)	(mg/l) (ppm)	No. Samples Exceeding 100 Times	Mean mg/kg (ppm)	No. Samples Exceeding Background
Antimony	123n†	2P-121	None	3	0.6††	1	0.75(<9)	1(1)
Arsenic	60	2P-140	25	NA	0.05	48	7.0(10.6)	36(29)
Cadmium	5.2	2P-139	10	NA	0.02	10	0.4†††(4)	19(1)
Lead	843	2P-114A	25	NA	0.05	76	21(114)	35(6)
Mercury	4.6	2P-121	2	NA	0.004	15	0.15(0.15)	36(36)

†The subscript n indicates spike sample recovery is not within control limits

††Based on twice the WQ standard.

†††Average from Cadmium in the Environment, J.O. Nriagu, ed., pg. 558.

††††From "Summary of Inorganic Constituent Concentrations in Soil Samples from Around the State of New York" (Boerngen and Shacklette, 1981). Values in parentheses are from Michael E. Hopkins of the Niagara County Health Department and which are believed to be average background concentrations for soils in the Niagara Falls area.

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TABLE 3-10
ANALYSIS OF SECOND ROUND ANALYTICAL DATA
ORGANICS IN SOILS

Parameter	Highest Conc ug/kg (ppb)	Highest Conc Sta	NYSDEC GA WQ Std ug/l (ppb)	NYSDEC GA WQ Guide. ug/l (ppb)
VOC				
Methylene chloride	1700B*	2P-135	NA	50
1,1-Dichloroethene	1400B*	2P-135	NA	0.07
Chloroform	1500	2P-135	100	NA
1,1,2,2-Tetrachloroethane	2400	2P-135	NA	0.2
Toluene	720	2P-140	NA	50
Xylenes	720	2P-135	NA	50
B/N/A				
1,2-Dichlorobenzene	1900	2P-114A	4.7***	NA
Fluorene	3800	2P-128	NA	50
Phenanthrene	19000	2P-128	NA	50
Anthracene	4900	2P-128	NA	50
Fluoranthene	16000	2P-128	NA	50
Pyrene	8600	2P-128	NA	50
Benzo(a)anthracene ✓	8400 ✓	2P-128	NA	~~50~~ 0.002
Chrysene ✓	7300 ✓	2P-128	NA	0.002
Benzo(b)fluoranthene ✓	4500 ✓	2P-128	NA	0.002
Benzo(k)fluoranthene	1100	2P-128	NA	0.002
Benzo(a)pyrene ✓	6200	2P-128	ND	NA
Indeno(1,2,3,-cd)pyrene ✓	2700	2P-128	NA	0.002
1,2,3,4-Tetrachlorobenzene	1000	2P-114A/ 2P-121	NA	10**

depth 2.5'–4.5'

*The subscript B indicates that the analyte was found in the blank as well as in the samples.

**This is a guidance standard based on human health and aesthetic considerations.

***Applies to sum of (1,4-) and 1,2-) isomers only.

Antimony - Only one second round sample was found to contain antimony at a concentration above the Contract Required Detection Limit (CRDL). This sample exceeded the NYSDEC GA effluent standard multiplied by 100, the normal range in New York soils, and the average background concentration in soils from the Niagara Falls area.

Arsenic - The highest concentration of arsenic in second round samples was 60 mg/kg. This metal was found in some (48) of the samples at levels exceeding 100 times the NYSDEC GA effluent standard of 0.05 mg/l. In 36 of the samples, arsenic was found at concentrations exceeding the normal range in New York soils, and in 29 samples, arsenic was found at concentrations exceeding the average background concentration in soils from the Niagara Falls area.

Cadmium - The highest concentration of cadmium in second round samples was 5.2 mg/kg. This metal was found in a few (10) samples at levels exceeding 100 times the NYSDEC GA effluent standard of 0.02 mg/l. In 19 of the samples, cadmium was found at concentrations exceeding the normal range in New York soils, while in one of the samples, cadmium was found at a concentration exceeding the average background concentration in soils from the Niagara Falls area.

Lead - The highest concentration of lead in second round samples was 843 mg/kg. This metal was found in all 76 (i.e., 73 soil and 3 sediment) samples at levels exceeding 100 times the NYSDEC GA effluent standard of 0.05 mg/l. In some (35) of the samples, lead was found at concentrations exceeding the normal range in New York soils. In addition, six of the second round samples exceeded average lead concentrations found in background soils from the Niagara Falls area.

Mercury - The highest concentration of mercury in second round samples was 4.6 mg/kg. This metal was found in a few (15) of the samples at levels exceeding 100 times the NYSDEC GA effluent standard of 0.004 mg/l. In some (36) of the samples, mercury was found at concentrations exceeding the normal range in New York soils and the average background concentration in soils from the Niagara Falls area.

The organic parameters presented in Table 3-10 for second round soils and sediment samples were evaluated by comparison with the same criteria as described for first round data analysis. Only one of the second round analytes is listed in the published effluent standards (i.e., chloroform), and this standard is equal to the GA WQ standard. Therefore the NYSDEC effluent standards are not presented in Table 3-10.

Six volatile organic compounds were found in at least one second round soil or sediment sample at concentrations above the CRDL. As for first round data analysis, the professional judgement used in making these evaluations was based on the WQ standards as well as the human exposure risk used to establish the state and federal water quality criteria. Particular emphasis was placed on human toxicity and potential for carcinogenic effects.

Volatile Organic Compounds (VOC's) - The extent of VOCs found in the second round soil and sediment samples was as follows:

- Methylene Chloride	Found in 16 samples at 1.1-34 x WQ std.
- 1,1 Dichloroethene	Found in 9 samples at 7571-20,000 x WQ std.
- Chloroform	Found in 7 samples at 5.1-15 x WQ std.
- 1,1,2,2-Tetrachloroethane	Found in 5 samples at 2500-12000 x WQ std.
- Toluene	Found in 9 samples at 1.1-14.4 x WQ std.
- Ethylbenzene	Not Detected
- Xylenes	Found in 10 samples at 10.2-14.4 x WQ std.

Base/Neutral/Acid Extractables (BNA's) - Results for the BNA analyses performed on second round soils and sediment samples are summarized below:.

- 1,2-Dichlorobenzene	Found in 3 samples at 98-404 x WQ std.
- Fluorene	Found in 1 sample at 76 x WQ std.
- Phenanthrene	Found in 7 samples at 7.6-380 x WQ std.
- Anthracene	Found in 1 sample at 98 x WQ std.
- Fluoranthene	Found in 8 samples at 9.2-320 x WQ std.
- Pyrene	Found in 6 samples at 7.8-172 x WQ std.

- Benzo(a)Anthracene	Found in 4 samples at 205,000-4,200,000 x WQ std.
- Chrysene	Found in 4 samples at 245,000-3,650,000 x WQ std.
- Benzo(b)Fluoranthene	Found in 3 samples at 255,000-2,250,000 x WQ std.
- Benzo(k)Fluoranthene	Found in 1 sample at 550,000 x WQ std.
- Benzo(a)Pyrene	Found in 4 samples at 1-infinity x WQ std.
- Indeno(1,2,3-cd)Pyrene	Found in 2 samples at 230,000-1,350,000 x WQ std.
- 1,2,3,4-Tetrachlorobenzene	Found in 2 samples at 100 x WQ std.

Dioxin - Results of dioxin analyses indicated that dioxin was not present at detectable levels in any of the second round composite soil samples analyzed.

3.6 CONCLUSIONS

The locations at which the highest concentrations of the contaminants of concern were found are summarized on Figures 3 through 5 on the following pages. Figure 3 shows all site and adjacent creek bank locations where dioxin was detected by others.

Figure 4 shows the locations where the highest concentrations of inorganics were found. The highest concentrations of antimony, arsenic and cadmium were found at station 1P-4; the highest concentration of mercury was found at station 1P-1; and the highest concentration of lead was found at station 2P-114A.

Figure 5 shows the locations where the highest concentrations of organics (i.e., VOCs, BNAs, and pesticides) were found. The highest concentration of methylene chloride was found at 1P-9; the highest concentrations of 1,1-dichloroethene, chloroform and 1,1,2,2 - tetrachloroethane were found at 2P-135; and the highest concentrations of toluene and xylenes were found at 1P-10. The location where all BNAs of concern were found to have the highest concentration was station 1P-4. Finally, alpha BHC was found at 1P-8 at its highest concentration and the concentration of beta BHC was highest at 1P-4. It should be noted that second round samples were not analyzed for these pesticides for the reasons discussed previously.

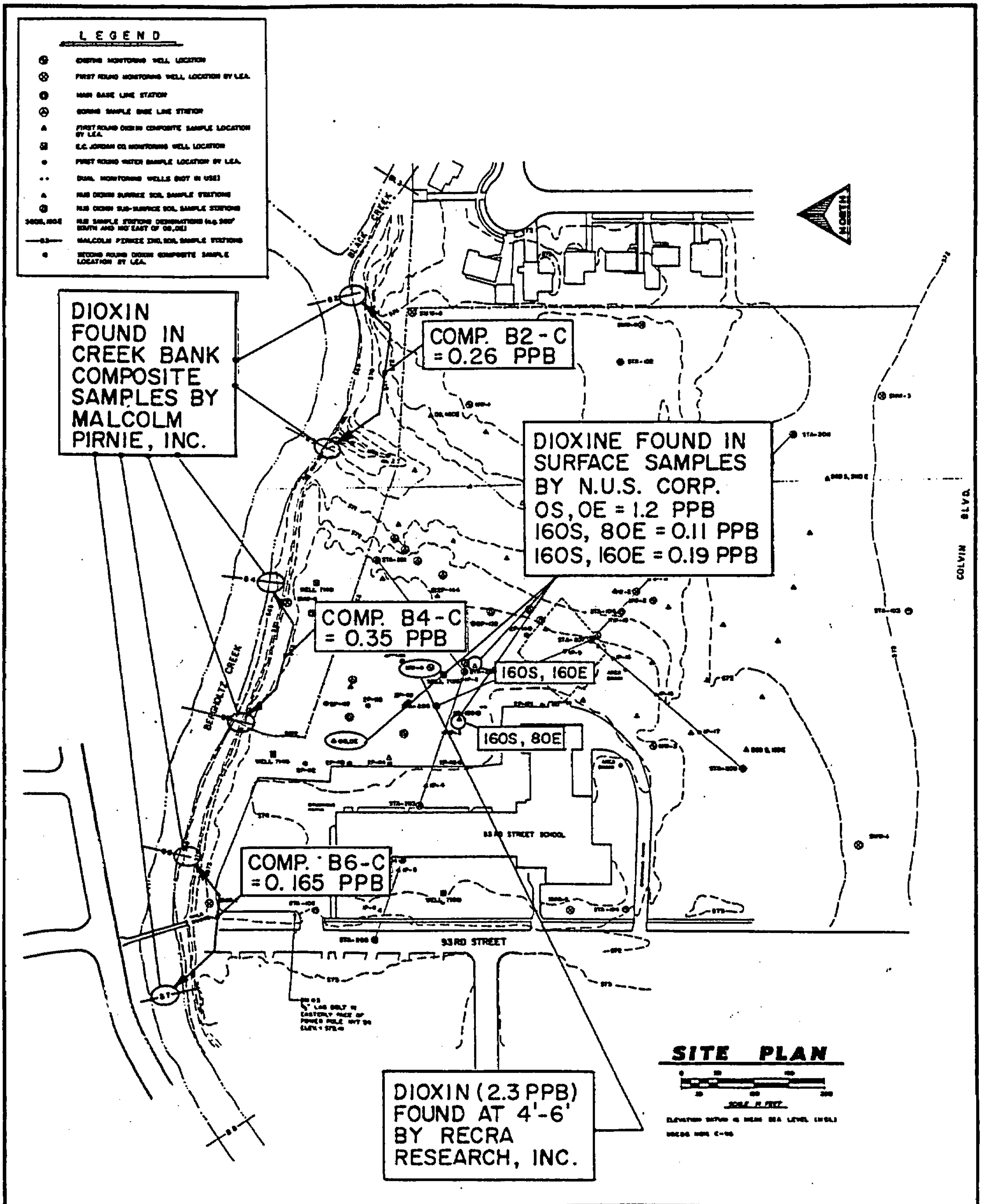

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FIGURE 3
LOCATIONS OF HIGHEST CONCENTRATIONS OF DIOXIN IN SOILS

by	app.	scale	date
L.K., S.C	C.J., J.L.	NOTED	3-9-88

COMM. No. 506-01

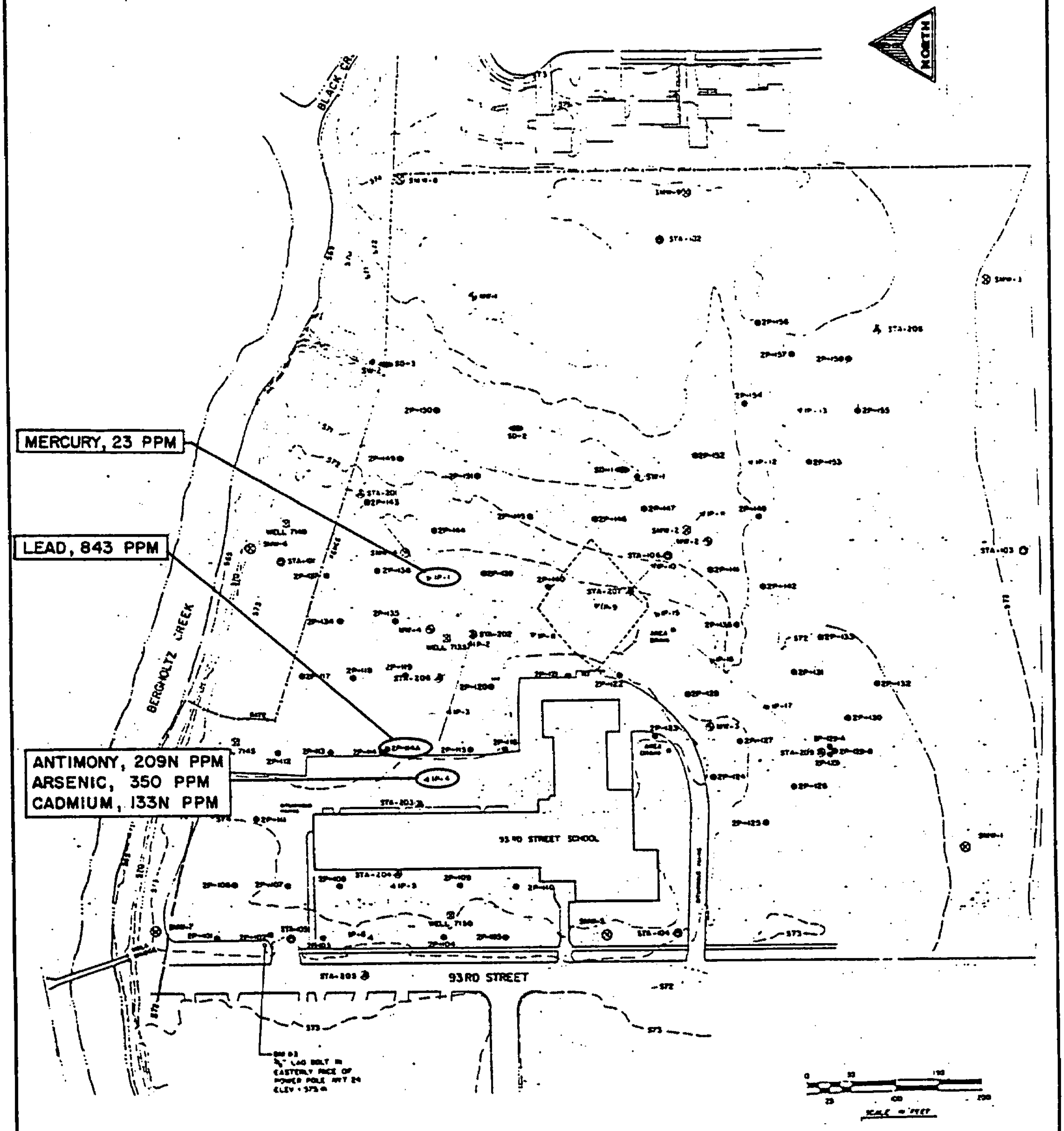

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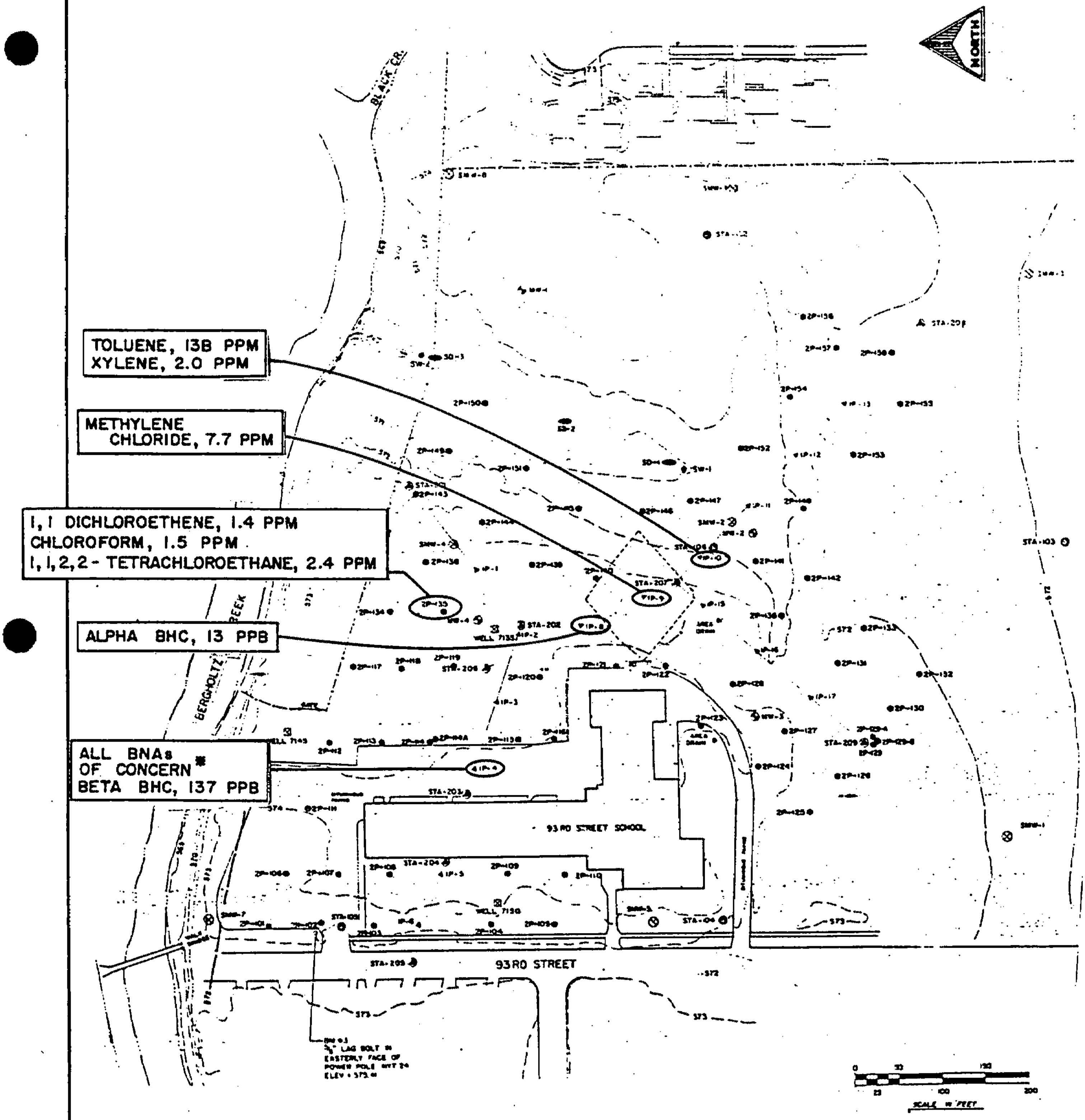
FIGURE 4
LOCATIONS OF HIGHEST CONCENTRATIONS OF INORGANICS IN SOILS

by L.K., E.F.	app. C.J.,J.L.	scale NOTED	date 3-9-88

COMM. No. 506-01



TOLUENE, 138 PPM
XYLENE, 2.0 PPM

METHYLENE
CHLORIDE, 7.7 PPM

1,1 DICHLOROETHENE, 1.4 PPM
CHLOROFORM, 1.5 PPM
1,1,2,2- TETRACHLOROETHANE, 2.4 PPM

ALPHA BHC, 13 PPB

ALL BNAs
OF CONCERN *
BETA BHC, 137 PPB

* REFER TO TABLES 3-6 AND 3-10
FOR THE HIGHEST CONCENTRATIONS
OF BNAs IN SOILS.

LEA LOUREIRO ENGINEERING ASSOCIATES
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FIGURE 5
LOCATIONS OF HIGHEST
CONCENTRATIONS OF ORGANICS
IN SOILS

by L.K., E.F.	app. C.J., J.L.	scale NOTED	date 3-9-88

COMM. No. 506-01

All first and second round sampling stations were found to exhibit at least one parameter of concern. Tables 3-11 and 3-12 summarize where the contaminants of concern were detected without regard to depth during first and second round sampling, respectively. During first round sampling, station 1P-4 showed the highest concentrations and widest distributions of types of contaminants while other stations including 1P-3, 9 and 10 showed similar levels of contamination. Metals were found in most of the first round borings with the exception of mercury which was found in only six borings. The most widely distributed organics in first round borings were methylene chloride, acetone, 2-butanone and ethylbenzene; and to a lesser extent chloroform, toluene and xylenes. 1,1 Dicholorethene and 1,1,2,2 - tetrachloroethane were each found in only one first round location (at 1P-3 and 1P-6, respectively). The BNAs were found primarily in borings 1P-2, 1P-3, 1P-4 and 1P-9; and the pesticides were found primarily in 1P-4, 1P-8 and 1P-10 during first round sampling.

During second round sampling, stations showing the highest concentrations and widest distribution of contaminants were as follows:

- Inorganics were relatively evenly distributed, however station 2P-114A had a notably high lead concentration.
- VOCs: 2P-135
- BNAs: 2P-128

All metals except antimony and cadmium were found in most of the second round borings. The most widely distributed VOC identified in second round samples was methylene chloride which was found at 15 second round stations. Finally, the most widely distributed BNAs in second round samples were fluoranthene and phenanthrene which were found at 8 and 7 stations, respectively.

TABLE 3-11
DISTRIBUTION OF CONTAMINANTS IN SOIL BASED ON FIRST ROUND ANALYSIS

	SOIL BORING NOS. (See Dwg. No. S-1)														
PARAMETER	1	2	3	4	5	6	8	9	10	11	12	13	15	16	17
Antimony		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Arsenic	x	x	x	x	x	x	x	x	x	x		x	x	x	
Cadmium	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Cobalt	x	x	x	x	x	x	x	x	x		x	x	x	x	x
Lead	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mercury	x	x	x				x		x	x					
Methylene chloride	x	x	x	x	x	x	x	x	x	x		x	x	x	x
Acetone	x	x	x	x	x	x	x		x	x		x			
1,1 dichloroethene							x								
chloroform	x		x			x	x	x	x	x		x			
2-Butanone	x	x	x	x		x		x	x	x		x	x	x	x
1,1,2,2-Tetrachloroethane						x									
Toluene	x	x	x	x	x	x			x			x			
Ethylbenzene	x	x	x		x	x	x	x	x	x		x			x
Xylenes	x		x		x	x	x		x	x		x			
1,4 Dichlorobenzene				x											
Naphthalene				x				x							
2-Methylnaphthalene				x											
Acenaphthene				x				x							
Dibenzofuran				x				x							
Fluorene				x				x							
Phenanthrene	x	x	x	x	x			x							
Anthracene				x				x							
Fluoranthene	x	x	x	x	x			x							
Pyrene		x	x	x	x			x	x						
Benzo(a)Anthracene		x	x	x				x							
Bis(2-ethylhexyl)phthalate	x		x												
Chrysene		x	x	x				x							
Benzo(b)fluoranthene		x	x	x				x							
Benzo(k)fluoranthene		x	x	x				x							
Benzo(a)pyrene		x	x	x				x							
Indeno(1,2,3-cd)pyrene		x	x	x				x							
Benzo(g,h,i)pyrene			x	x				x							
Alpha BHC				x			x		x						
Beta BHC				x			x		x						

TABLE 3-12
DISTRIBUTION OF CONTAMINANTS IN SOILS AND SEDIMENTS BASED ON SECOND ROUND ANALYSIS

	Soil Boring Nos. (see Dwg. No. S-1)									
Parameter	103	104	108	109	114	114A	115	116	119	120
Antimony										
Arsenic	X	X	X	X	X	X	X	X	X	X
Cadmium	X				X		X	X		
Lead	X	X	X	X	X	X	X	X	X	X
Mercury	X		X	X	X	X	X	X	X	X
Methylene Chloride	X	X	X	X	X	X	X	X	X	
1,1-Dichloroethene										X
Chloroform					X			X		X
1,1,2,2-Tetrachloroethane										X
Toluene						X				
Ethylbenzene										
Xylenes						X				
1,2-Dichlorobenzene						X				
Fluorene										
Phenanthrene						X	X	X		
Anthracene										
Fluoranthene					X	X	X	X		
Pyrene							X	X		
Benzo(a)Anthracene							X			
Chrysene							X			
Benzo(b)Fluoranthene							X			
Benzo(k)Fluoranthene										
Benzo(a)Pyrene							X			
Indeno(1,2,3,-cd)Pyrene										
1,2,3,4-Tetrachlorobenzene						X				

TABLE 3-12 (Continued)
DISTRIBUTION OF CONTAMINANTS IN SOILS AND SEDIMENTS
BASED ON SECOND ROUND ANALYSIS

	Soil Boring Nos. (see Dwg. No. S-1)									
Parameter	121	122	126	127	128	129	130	131	135	136
Antimony	X									
Arsenic	X	X	X	X	X	X	X	X	X	X
Cadmium	X						X		X	
Lead	X	X	X	X	X	X	X	X	X	X
Mercury	X	X			X	X			X	X
Methylene Chloride			X		X	X			X	
1,1-Dichloroethene									X	
Chloroform									X	
1,1,2,2-Tetrachloroethane									X	
Toluene										
Ethylbenzene										
Xylenes			X		X	X	X	X	X	X
1,2-Dichlorobenzene	X	X								
Fluorene					X					
Phenanthrene	X	X			X					
Anthracene					X					
Fluoranthene	X	X			X					
Pyrene	X	X			X					
Benzo(a)Anthracene	X	X			X					
Chrysene	X	X			X					
Benzo(b)Fluoranthene		X			X					
Benzo(k)Fluoranthene					X					
Benzo(a)Pyrene	X	X			X					
Indeno(1,2,3,-cd)Pyrene		X			X					
1,2,3,4-Tetrachlorobenzene	X									

TABLE 3-12 (Continued)
DISTRIBUTION OF CONTAMINANTS IN SOILS AND SEDIMENTS
BASED ON SECOND ROUND ANALYSIS

	Soil Boring Nos. (see Dwg. No. S-1)									
Parameter	138	139	140	141	143	144	148	152	153	154
Antimony										
Arsenic	X	X	X	X	X	X	X	X	X	X
Cadmium	X	X	X		X	X				
Lead	X	X	X	X	X	X	X	X	X	X
Mercury	X	X			X	X			X	
Methylene Chloride					X	X				
1,1-Dichloroethene	X		X		X					
Chloroform	X				X	X				
1,1,2,2-Tetrachloroethane	X		X							
Toluene	X	X			X					
Ethylbenzene										
Xylenes				X	X	X		X		
1,2-Dichlorobenzene										
Fluorene										
Phenanthrene					X					
Anthracene										
Fluoranthene					X					
Pyrene										
Benzo(a)Anthracene										
Chrysene										
Benzo(b)Fluoranthene										
Benzo(k)Fluoranthene										
Benzo(a)Pyrene										
Indeno(1,2,3,-cd)Pyrene										
1,2,3,4-Tetrachlorobenzene										

TABLE 3-12 (Continued)
DISTRIBUTION OF CONTAMINANTS IN SOILS AND SEDIMENTS BASED ON SECOND ROUND ANALYSIS

	Soil Boring Nos. (see Dwg. No. S-1)					
Parameter	155	157	158	SD-1	SD-2	SD-3
Antimony						
Arsenic	X	X	X	X	X	X
Cadmium			X			
Lead	X	X	X	X	X	X
Mercury	X			X		
Methylene Chloride						
1,1-Dichloroethene						
Chloroform				X	X	X
1,1,2,2-Tetrachloroethane						
Toluene					X	
Ethylbenzene						
Xylenes						
1,2-Dichlorobenzene						
Fluorene						
Phenanthrene						
Anthracene						
Fluoranthene						
Pyrene						
Benzo(a)Anthracene						
Chrysene						
Benzo(b)Fluoranthene						
Benzo(k)Fluoranthene						
Benzo(a)Pyrene						
Indeno(1,2,3,-cd)Pyrene						
1,2,3,4-Tetrachlorobenzene						

4.0 HYDROGEOLOGY AND GROUNDWATER INVESTIGATIONS

4.1 SCOPE

The hydrogeology of the site was investigated by the installation of nine new monitoring wells and study of soils data obtained during drilling of the wells and collection of the soil samples as described in Section 3. Water levels from these wells and data from previous studies were used in the investigation of hydrogeology. Groundwater contamination was evaluated by sampling nine new wells and the four wells installed during previous study of the site by E.C. Jordan Co., Inc.

4.2 EXISTING MONITORING WELLS

As described previously, eight groundwater monitoring wells existed at the 93rd Street School site prior to the initiation of this remedial investigation. Four of these wells (MW-1 to MW-4) were installed by RECRA Research. All borings for these wells were advanced to the bedrock surface. The other four existing wells (Wells 7135, 7140, 7145 and 7150) were installed by E. C. Jordan Company in March 1986. All four E. C. Jordan Company wells were sampled during the first round of sampling for this remedial investigation. The locations and depths of all wells are shown on Drawing S-1 in Appendix A. In addition, monitoring well data including elevations of the tops of protective casings and the ground surface are presented on Drawing S-1.

4.3 NEW MONITORING WELLS

The four existing E. C. Jordan wells and nine new shallow groundwater monitoring wells (SMW-1 to SMW-9) were sampled during the first round of sampling and analysis. The new wells were installed under this contract to help define the site-specific hydraulic flow regime of the water table aquifer and to identify contaminants which may have resulted from migration of leachate from the contaminated fill material. It should be noted that the RECRA wells were not sampled during this study because these wells were advanced to the bedrock surface and were therefore not considered to accurately represent the groundwater table at the site.

The locations of wells SMW-1 to SMW-9 are shown on Drawing S-1 in Appendix A. These locations were established such that wells SMW-2 and SMW-4 were located along the historical swale where the contaminated fill layer was expected to be thickest; and wells SMW-1, 3, and 5 to 9 were relatively evenly spaced near the perimeter of the study area. This configuration was selected to ensure adequate coverage of the study area and to allow for measurement of hydraulic gradients.

Groundwater monitoring well borings were drilled with a four inch interior diameter hollow stem auger equipped with a retractable auger plug. These borings were drilled to extend to a depth approximately 8 to 10 feet below the observed water table depth. Split tube soil samples were collected at 2 foot intervals during auger advancement to identify the soil layers penetrated at each well station.

Appendix E presents Well Log Data including soil drilling and sampling methods, observations, and well construction information. From these logs it is apparent that the topsoil, fill materials, and native soils encountered during well drilling were similar to those described previously for soil sampling except that the fill layers encountered were much thinner for the wells not located in the historical swale. Pertinent well construction and other data for the E. C. Jordan wells and the new wells is summarized in Table 4-1. Included are elevations, well dimensions, construction materials, static water level data, and miscellaneous physical/chemical data including pH, water temperature (°C), and water conductivity (umhos) for each well at the time of sampling.

Materials used for the construction of new groundwater monitoring wells are summarized below:

- Monitoring Well Screen - 10 feet of 2-inch diameter stainless steel with 0.010" slot size.
- Screen Filter Fabric - new non-woven monitoring well quality fabric
- Monitoring Well Riser Pipe (Casing) and Fittings - 2-inch diameter stainless steel

TABLE 4-1

GROUNDWATER MONITORING WELL DATA

Well No.	Elevation of TOR in Feet (Above MSL)	Elevation of Grade in Feet (Above MSL)	Well Riser Pipe Stick-Up Above Grade in Feet	Steel Protective Casing Stick-Up Above Grade in Feet	Measured Well Depth Below TOR in Feet	Well Depth BGL in Feet	Screen Setting Depth Interval BGL (Ft.)	Screen Setting Elev. Interval (Ft. Above MSL)
SMW-1	574.13	572.47	1.66	1.92	21.25	19.59	19.59-9.59	562.88-552.88
SMW-2	574.13	572.71	1.42	1.66	16.42	15.00	15.00-5.00	567.71-557.71
SMW-3	573.69	572.23	1.46	1.75	20.58	19.12	19.12-9.12	563.11-553.11
SMW-4	574.87	573.50	1.37	1.58	14.95	13.58	13.58-3.58	569.92-559.92
SMW-5	575.49	573.95	1.54	1.83	17.00	15.46	15.46-5.46	568.49-558.49
SMW-6	574.43	573.04	1.39	1.70	21.06	19.67	19.67-9.67	563.37-553.37
SMW-7	575.33	574.08	1.25	1.50	21.08	19.83	19.83-9.83	564.25-554.25
SMW-8	575.81	574.15	1.66	1.92	20.87	19.21	19.21-9.21	564.94-554.94
SMW-9	575.87	574.50	1.37	1.50	17.46	16.09	16.09-6.09	568.41-558.41
#7135	576.71	573.34	3.37	3.43	28.93	25.50	25.50-15.5	557.90-547.90*
#7140	576.78	573.50	3.28	3.53	28.37	25.60	25.60-15.6	558.60-548.60*
#7145	577.43	573.90	3.53	3.66	28.50	24.00	24.00-14.0	559.20-549.20*
#7150	577.22	574.20	3.02	3.35	28.66	25.30	25.30-15.3	558.90-548.90*

*As reported by E. C. Jordan

TABLE 4-1

GROUNDWATER MONITORING WELL DATA (Continued)

Well No.	Well Screen Length	Well Riser Pipe Length	Thickness of Sand Filter Pack From Bottom of Well Screen (Ft.)	Water pH	Water Temperature °C	Water Conductivity (umhos)	Thickness of Bentonite Seal From Top of Sand Pack	Thickness of Cement Bentonite Grout From Top of Bentonite Seal	Length of 5" Dia. Protective Steel Casing (Feet)	Filter Fabric
SMW-1	10'	11.25	12	7.30	9	1,320	5	2.59	5	Yes
SMW-2	10'	6.42	11	6.60	8	1,000	3	1	5	Yes
SMW-3	10'	10.58	12	7.17	7.8	1,190	5	2.12	5	Yes
SMW-4	10'	4.95	11	6.70	9.1	700	2	0.58	5	Yes
SMW-5	10'	7.00	11	6.78	7.9	450	3	1.46	5	Yes
SMW-6	10'	11.06	12	6.87	9	610	5	2.67	5	Yes
SMW-7	10'	11.08	12	7.35	9	590	5	2.83	5	Yes
SMW-8	10'	10.87	12	7.50	9.8	455	5	2.21	5	Yes
SMW-9	10'	7.46	11	7.27	10	925	4	1.09	5	Yes
#7135	10'	18.93	NA	6.57	5.8	550	NA	NA	5	Yes
#7140	10'	18.37	NA	6.84	10	590	NA	NA	5	Yes
#7145	10'	18.50	NA	7.30	10	420	NA	NA	5	Yes
#7150	10'	18.66	NA	7.30	9.5	500	NA	NA	5	Yes

NOTE:

Temperature, conductivity, and pH measurements taken December 11-12, 1986 during groundwater sampling activities.

TABLE 4-1
GROUNDWATER MONITORING WELL DATA(Continued)

	Static Water Level on 12-10-86			Static Water Level on 6-23-87			Static Water Level on 6-29-87		
Well No.	Below TOR Pipe (Ft.)	Elevation (Ft. MSL)	Height of Standing Water Column in Well (Ft.)	Below TOR Pipe (Ft.)	Elevation (Ft. MSL)	Height of Standing Water Column in Well (Ft.)	Below TOR Pipe (Ft.)	Elevation (Ft. MSL)	Height of Standing Water Column in Well (Ft.)
SMW-1	13.46	560.67	7.79	10.38	563.75	10.87	10.46	563.67	10.79
SMW-2	2.08	572.05	14.33	5.54	568.59	10.88	5.79	568.34	10.63
SMW-3	3.42	570.27	17.16	7.96	565.73	12.62	8.44	565.25	12.14
SMW-4	2.20	572.67	12.76	7.44	567.43	7.51	7.19	567.68	7.76
SMW-5	2.75	572.74	14.25	7.69	567.80	9.31	7.92	567.57	9.08
SMW-6	14.12	560.31	6.94	10.38	564.05	10.68	10.42	564.01	10.64
SMW-7	5.50	569.83	15.58	8.01	567.32	13.07	7.56	567.77	13.52
SMW-8	7.12	568.69	13.75	9.77	566.04	11.10	10.17	565.64	10.70
SMW-9	2.83	572.04	14.63	7.13	568.74	10.33	7.42	568.45	10.04
#7135	10.08	566.63	18.85	11.44	565.33	14.06	11.46	565.31	14.04
#7140	8.92	567.86	19.45	11.48	565.55	14.12	11.65	565.38	13.95
#7145	4.46	572.97	24.04	8.85	568.71	15.15	8.65	568.91	15.35
#7150	6.16	571.06	22.50	9.67	567.88	15.63	9.50	568.05	15.80

- Surface Steel Protective Casing - 5 feet minimum length of 5-inch diameter steel pipe with lockable hinged cover equipped with a padlock and 0.25 inch diameter drain port.
- Well Screen Sand Pack - No. 30 Ottawa Flint Shot Silica Sand
- Bentonite Seal - bentonite pellets and powder
- Bentonite/Cement Grout Mixture - 10 parts cement mixed with 0.5 parts bentonite powder and a maximum of 10 gallons of water per 94 pound bag of cement
- Gravel Fill - a gravel fill layer approximately 6" thick was placed around the monitoring wells at the ground surface

It should be noted that wells were constructed so that approximately 2 feet of the screen extended above the existing water table to allow for seasonal water level variations.

4.4 GROUNDWATER SAMPLING AND PARAMETERS STUDIED

Groundwater samples were collected during first round sampling from a total of 13 wells including the nine new wells (SMW-1 to SMW-9) and the four existing E. C. Jordan Company wells (7135, 7140, 7145 and 7150). Groundwater Monitoring Field Data Sheets (see Appendix F) were completed at the time of collection of samples from each well. These data sheets included pertinent information such as the date of sample collection, name of person sampling, well number, appearance of well surface components, weather conditions, height of standing water in the well, volume of water purged with a peristaltic pump, sampling equipment construction, sample descriptions (including sample appearance, container types and sizes, filtered/non-filtered, preservatives used, and analytical parameters), field measurements (pH, temperature, and conductivity), and comments. Samples were analyzed for the inorganics, volatile organic compounds, base/neutral/acid extractable organic compounds, pesticides and PCBs listed in Appendix D and for dioxin. Table 4-2 shows a list of the groundwater samples collected. Since no significant groundwater contamination at levels exceeding CRDLs and health based standards was identified during analysis of first round samples, no samples were collected for analysis during the second round. This will be discussed further later in this section.

TABLE 4-2

GROUNDWATER SAMPLE IDENTIFICATION SUMMARY

MONITORING WELL NO.	DATE COLLECTED	FIELD LABEL NO.	YWC LABORATORY CONTROL NO.	ERCO ID NO.	SAMPLES COLLECTED BY
SMW-1	12-12-86	2371	003	41956	W. Thomas/C. Wolff
SMW-2	12-11-86	2388	004	41951	C. Wolff/W. Thomas
SMW-3	12-12-86	2389	005	41957	C. Wolff/W. Thomas
SMW-4	12-11-86	2390	006	41952	C. Wolff/W. Thomas
SMW-5	12-12-86	2391	007	49158	C. Wolff/W. Thomas
SMW-6	12-11-86	2392	008	41953	C. Wolff/W. Thomas
SMW-7	12-11-86	2393	009	41959	C. Wolff/W. Thomas
SMW-8	12-12-86	2394	010	41960	C. Wolff/W. Thomas
SMW-9	12-12-86	2395	011	41961	C. Wolff/W. Thomas
7135	12-11-86	2396	012	41954	C. Wolff/W. Thomas
7140	12-11-86	2397	013	41962	C. Wolff/W. Thomas
7145	12-11-86	2398	014	41955	C. Wolff/W. Thomas
7150	12-11-86	2399	015	41963	C. Wolff/W. Thomas
Field Blank	12-12-86	2400	016	41964	W. Thomas

4.5 SITE HYDROGEOLOGY

Static water level elevation data was collected from the shallow groundwater monitoring wells installed under this contract (SMW-1 to SMW-9) as well as from the four E.C. Jordan Co. Wells (7135 to 7150) in December 1986 (first round) and in June 1987 (second round). This data indicates that a groundwater divide exists in the water table aquifer on-site, roughly intersecting the middle of the study area in a northwest to southeast direction.

This groundwater divide occurs due to a mounding effect of the groundwater table in the area of the former (natural) drainage swale which existed prior to site grading activities in the late 1940's. Permeability and transmissivity values for the black organic silt fill material deposited in the former drainage swale area are much greater than those of the native glaciolacustrine clay overburden material. While the moderate permeability of the organic silt fill material allows percolation of precipitation to the point of saturation, the native clay forms an aquitard which effectively prevents percolation of appreciable amounts of rain water from the surface to a depth of more than a few feet. Fill materials in the swale area are underlain by this clay aquitard, causing ponding conditions.

Boring logs prepared during soil sampling activities at the northwestern end of the school building indicate that native clay material was used for fill in the area of Boring No. 1P-5, effectively creating a relatively impermeable "dam" at the western (down gradient) end of the former drainage swale. This "dam" prevents water from draining out of the former swale area in the direction of the original swale gradient, thereby creating a closed "basin" and enhancing the ponding conditions observed. Drawing G-1 in Appendix G shows the resulting configuration of the water table aquifer flow regime. It should be noted that the groundwater contours presented on Drawing G-1 were based on the static water levels measured in the new monitoring wells in December 1986. The June 1987 data was relatively consistant with the pattern of contours shown on Drawing G-1, however there is a rather large seasonal variation in water levels. Water levels measured in June 1987 were typically 0 to 5 feet lower than those measured in December 1986.

Since the screen setting intervals in monitoring well Nos. 7135, 7140, 7145 and 7150 are at a depth which intersects the more permeable glacial till material underlying the clay aquitard, water levels measured in these monitoring wells display pronounced artesian effects and are not characteristic of water table elevations. Thus water level data from these wells was not used in the preparation of Drawing G-1.

It should be noted that glacial till may have been penetrated by the new wells SMW-3, SMW-7 and/or SMW-8 with the possible till/screen interval ranging from 1.12 feet at SMW-3 to 3.21 feet at SMW-8. As a result, it is possible that these wells may display slight artesian effects. In spite of this, it was determined that water level data from these wells could be used in the preparation of Drawing G-1 for the following reasons:

- For wells SMW-3 and SMW-7, the boring logs indicate that the till material encountered should have a permeability similar to that of the overlying glaciolacustrine clay. In addition, since the depth of penetration into the till material was so short, artesian effects are estimated to be minimal and therefore do not significantly affect the contours presented on Drawing G-1.
- For well SMW-8, artesian effects are probably greater since the till material was more permeable and the depth of penetration was somewhat greater. If it were assumed, however, that the actual water table at SMW-8 were significantly lower, the flow regime depicted for the northeast corner of the study area would bend in a much more pronounced fashion to the northeast. Since Bergholtz Creek flows to the west-northwest, however, this assumed scenario is much less likely than the estimated flow regime currently presented on Drawing G-1.

Hydraulic gradients between monitoring well points at the 93rd Street School site were determined using the following formula:

$$I = \frac{h_1-h_2}{L}$$

Where:
I = Hydraulic Gradient (Ft./Ft.)
h_1-h_2 = Difference in Total Head at Points of Measurement (Ft.)
L = Distance Between Points of Total Head Measurement (Ft.)

The average hydraulic gradients for the northern and southern components of the (water table aquifer) groundwater flow regime on-site were calculated to be 0.061 ft./ft. and 0.032 ft./ft., respectively.

Hydraulic conductivities for the glaciolacustrine clay material observed at the site ranged from approximately 10^{-7} to 10^{-3} ft./day (Ref. 4). Porosity values for this type of material average approximately 50 percent.

Assuming an average hydraulic gradient of 0.061 ft./ft., an average hydraulic conductivity of 10^{-5} ft./day, and an approximate porosity of 50 percent, the average linear flow velocity of groundwater from the fill material "recharge basin" through the native clay material toward Bergholtz Creek was calculated to be 1.2×10^{-6} ft./day (4.453×10^{-4} ft./yr.) using Darcy's Law as follows:

$$V = K/n \times I$$

Where:
V = Average Linear Groundwater Flow Velocity
K = Hydraulic Conductivity
I = Average Hydraulic Gradient
n = Porosity

Assuming an average hydraulic gradient of 0.032 ft./ft. for the southerly component of the site flow regime, the approximate linear velocity of groundwater flow from the swale area through the clay material toward the south was calculated to be 6×10^{-7} ft./day (2.336×10^{-4} ft./yr.).

Calculated average flow velocities listed are approximate and are presented only to illustrate the extremely sluggish nature of groundwater flow from saturated fill material on-site through the surrounding natural clay (aquitard) material. The principal zone of groundwater flow beneath the 93rd Street School site is thought to be in glacial till material separating the clay overburden layer and bedrock (Lockport Dolostone). Groundwater flow in bedrock may also be substantial, depending upon the degree of fracturing and solution channeling present. In any event, run-off and evaporation of precipitation far exceeds percolation on-site. Transport of any contaminants present in the organic silt fill material to off-site areas would occur almost exclusively through erosion caused by surficial run-off resulting from precipitation.

4.6 SUMMARY OF ANALYTICAL DATA

Summaries of laboratory results for all samples are presented in Appendix H. It should be noted that groundwater samples were only collected during the first round sampling and analysis. The data in Appendix H is organized so that the laboratory results for each parameter are shown for all surface water and groundwater sampling stations on one sheet. Soil data are shown separately. If a parameter was not detected above the CRDL for that parameter in any groundwater sample, no results for that parameter are presented in Appendix H.

Table 4-3 shows all parameters found at levels exceeding the CRDLs in groundwater; the concentration and station where the highest level was detected; and selected water criteria and standards.

Table 4-4 shows the total organic chemical concentration found in each sample. Parameters not detected at levels equal to or exceeding CRDLs are not included in these tables or in any of the following discussions.

No dioxin or pesticides were found in the groundwater samples collected during this study.

TABLE 4-3
ANALYSIS OF ANALYTICAL DATA
INORGANICS AND ORGANICS IN GROUNDWATER
(all values in ug/l = ppb) except where noted otherwise

	Highest Conc		NYSDEC WQ REGS		NYSDOH	DW Standards/
Parameter	ug/l†	Sta	GA Std	GA Guidance	Source Std	Health Advisories
INORGANICS						
Aluminum	1020	SMW1	None	None	None	None
Antimony	219	SMW1	None	3	None	None
Cadmium	8.5	SMW1	10	NA	10	10
Calcium	3001000	SMW9	None	None	None	None
Copper	52	SMW7	1000	NA	200	1000
Iron	19400E	SMW2	300	NA	None	300
Magnesium	401000	SMW1	None	35000	None	None
Manganese	3930E	SMW2	300	NA	None	50
Mercury	0.92	SMW9	2	NA	5	2
Nickel	553	SMW6	None	None	None	None
Potassium	6600	SMW1	None	None	None	None
Sodium	228000	SMW1	None	None	None	20,000
Zinc	64	7140	5000	NA	300	5000
Molybdenum	1590	SMW1	None	None	None	None
VOLATILE ORGANICS						
Methylene Chloride	24B*D	7140	None	50	None	None
Acetone	1100D	7140	None	None	None	None
B/N/A						
Bis(2-ethylhexyl) phthalate	100	7150	4200	NA	None	21000
Di-n-octyl phthalate	35	7150	None	50	None	None
PESTICIDES/PCBs/DIOXIN						
	None					

†Subscript definitions for this column are as follows:

E = indicates a value estimated due to the presence of interference
B = indicates analyte was found in blanks as well as the sample
* = indicates duplicate analysis is not within control limits
D = indicates sample extract diluted due to sample matrix and/or concentration levels.

TABLE 4-4
ANALYSIS OF ANALYTICAL DATA
TOTAL ORGANICS IN GROUNDWATER

STATION NO.	SUM OF CONCENTRATIONS OF TOTAL ORGANIC CHEMICALS* (ug/l) VOC	B/N/A	PEST/PCB	DIOXIN	TOTAL
SMW-1	ND	18	ND	ND	18
SMW-2	ND	ND	ND	ND	ND
SMW-3	ND	ND	ND	ND	ND
SMW-4	ND	ND	ND	ND	ND
SMW-5	ND	ND	ND	ND	ND
SMW-6	ND	ND	ND	ND	ND
SMW-7	ND	ND	ND	ND	ND
SMW-8	ND	13	ND	ND	13
SMW-9	ND	29	ND	ND	29
Well 7135	ND	ND	ND	ND	ND
Well 7140	24	ND	ND	ND	24
Well 7145	ND	23	ND	ND	23
Well 7150	16	35	ND	ND	51
Field Blank	16	140	ND	ND	156
Trip Blank	6	ND	ND	ND	6

*Includes compounds specified in NYSDEC ambient water quality standards.

Groundwater sampling data reported by E. C. Jordan was as follows for parameters found at concentrations higher than the contract required detection limits:

	Concentration (ug/l)*			
Parameter	Well 7135	Well 7140	Well 7145	Well 7150
Methylene Chloride	8.5B		5.4B	
Acetone	40B	120B	70B	88B
Benzene			11B	
Toluene			47	
bis(2-ethylhexyl)phthalate			47B	

* The B subscript indicates that the analyte was found in the blank as well as in the sample.

4.7 REVIEW OF ANALYTICAL DATA

As shown on Table 4-3, the analytical data for first round samples was compared with currently available standards for groundwater quality. These include published groundwater standards and guidance values in the NYSDEC document 85-W-38 of the Technical and Operational Guidance Series, dated April 1, 1987. Values taken from this publication are shown on Table 4-3 for comparison with concentrations found in the groundwater samples. Also shown for comparison are values from the NYSDOH source standards (10 NYCRR, Part 170); and Drinking Water Standards/Health Advisories provided by NYSDEC.

The following discussion covers the various parameters shown in Tables 4-3 and 4-4:

Aluminum - This metal is found extensively in nature and is used in treatment of drinking water. There are no federal or state standards for aluminum in groundwater. Most of the well samples had aluminum concentrations of 300-600 ug/l. The highest concentration found was 1020 ug/l in SMW-1. The allowable aluminum concentration in a discharge of an effluent to groundwater is 2000 ug/l (NYSDEC GA Effluent Standard). Since there are no state or federal standards for aluminum based on health considerations, the concentrations of aluminum found in the groundwater were not considered to be a cause for concern.

Antimony - This metal was found in 10 of the 13 wells sampled at levels much higher than the NYSDEC ambient groundwater guidance value of 3 ug/l, which is toxicity based but is not a standard. The EPA guidelines under the CWA show a significantly higher value of 146 ug/l for antimony based on health considerations. All wells showed levels below 146 ug/l for antimony except for 219 ug/l in SMW-1. Therefore, antimony was not considered to be of major concern in the groundwater.

Cadmium - This metal was detected in only three wells at a maximum concentration of 8.5 ug/l. This value is less than the value of 10 ug/l cited in all of the sources cited for groundwater or drinking water. The allowable cadmium in a discharge for an effluent to groundwater is 20 ug/l (NYSDEC GA Effluent Standard). Therefore cadmium was not a parameter of concern in the groundwater.

Calcium - This element was found in all wells, most of which showed calcium below 500 mg/l (SMW-9 showed 3000 mg/l calcium). There are no state or federal aquatic or health-based standards for calcium. Therefore, calcium was not considered to be of major concern in the groundwater.

Copper - This metal was found in only one well at a concentration higher than the CRDL (52 ug/l in SMW-7). The lowest standard or guidance value for this parameter is the NYSDOH source standard of 200 ug/l. Therefore, copper was not considered to be of concern in the groundwater.

Iron - This metal was found in 10 of the 13 wells in concentrations ranging from 0.19 to 19.4 mg/l. Although the NYSDEC WQ standard is 0.3 mg/l in groundwater, this limit is not based on toxicity. Furthermore, NYSDOH does not list a limit for iron in the source standards. Therefore, iron was not considered to be a major parameter of concern in the groundwater.

Magnesium - This element was found in all wells, the maximum concentration being

400 mg/l. The NYSDEC WQ guidance value is 35 mg/l based on toxicity, and this concentration was exceeded in all wells. However, this is not a standard, and NYSDOH does not list a limit for magnesium in the source standards. Therefore, magnesium was not considered to be a major parameter of concern in the groundwater.

Manganese - This metal was found in 6 of the 13 wells in concentrations higher than the NYSDEC WQ standard of 0.3 mg/l in groundwater (the maximum concentration was 3.93 mg/l in SMW-2). This WQ standard is not based on toxicity, and NYSDOH does not list a limit for manganese in the source standards. Therefore, manganese was not considered to be a major parameter of concern in the groundwater.

Nickel - This metal was found in 8 of the 13 wells in concentrations of 51 to 553 ug/l. There is no NYSDEC WQ standard or guidance value for nickel in groundwater, but the allowable limits for nickel in an effluent discharge to groundwater is 2000 ug/l. Therefore, nickel was not considered to be a major parameter of concern in the groundwater.

Potassium - This element was found in only one well at a concentration above the CRDL (6.6 mg/l in SMW-1). There are no state or federal aquatic or health-based standards for potassium. Therefore, potassium was not considered to be of concern in the groundwater.

Sodium - This element was found in all wells, most of which showed sodium below 75 mg/l (SMW-1 showed 228 mg/l sodium). There are no state or federal health-based groundwater standards for sodium. Therefore, sodium was not considered to be of major concern in the groundwater.

Zinc - This metal was found in 10 of the 13 wells in concentrations up to 64 ug/l. The NYSDEC WQ standard and drinking water standard/health advisory are 5000 ug/l in groundwater. Therefore, zinc was not considered to be a parameter of concern in the groundwater.

Molybdenum - This metal was found in all of the wells at concentrations up to 1.6 mg/l. There are no state or federal WQ standards or guidance values for molybdenum in groundwater. Therefore, molybdenum was not considered to be a parameter of concern in the groundwater.

Methylene chloride - This compound was found in two of the 13 wells (the highest level was 24 ug/l in well 7140). The NYSDEC WQ guidance value for methylene chloride in groundwater is 50 ug/l. Therefore, methylene chloride was not considered to be a parameter of concern in the groundwater.

Acetone - This compound was found in 9 of the 13 wells at concentrations up to 1100 ug/l. There are no state or federal WQ standards or guidance values for acetone in groundwater. Therefore, acetone was not considered to be a parameter of concern in the groundwater.

Bis(2-ethylhexyl)phthalate - This compound was found in two of the 13 wells (the highest level was 100 ug/l in well 7150). The NYSDEC WQ standard for bis(2-ethylhexyl)phthalate in groundwater is 4200 ug/l. Therefore, bis(2-ethylhexyl)phthalate was not considered to be a parameter of concern in the groundwater.

Di-n-octyl phthalate - This compound was found in 5 of the 13 wells (the highest level was 35 ug/l in well 7150). The NYSDEC WQ guidance value for di-n-octyl phthalate in groundwater is 50 ug/l. Therefore, di-n-octyl phthalate was not considered to be of concern in the groundwater.

Total Organic Chemicals (TOC) - There is a limit of 100 ug/l for the sum of designated organic chemicals in the NYSDEC ambient water quality standards. As shown in Table 4-4 this standard was not a cause for concern at any of the wells because the highest TOC value encountered in any wells was 51 ug/l.

It should be noted that E.C. Jordan Co. detected benzene and toluene in well 7145 at concentrations of 118 and 47 ug/l, respectively. In addition, RECRA Research Inc. detected benzene and toluene at levels of less than 20ppb and 25ppb, respectively. Since the NYSDEC GA WQ standard for toluene is 50 ug/l, this parameter was not considered to be a parameter of concern. In addition, although the NYSDEC GA WQ standard for benzene is ND, benzene was not detected in any wells including Well 7145 during this study at levels above the CRDL.

(516) 349-0058

F

4th

8:40
9:43

⑦ 7:05
8:12

/USAIR

It should be noted that following completion of this remedial investigation of the groundwater at the 93rd Street School site, it was determined that for a number of parameters, the CRDLs approved for use during this investigation exceeded NYSDEC GA Water Quality Standards or guidance values. As a result, NYSDEC has made the decision to reassess the groundwater at the site during the remedial design phase. At that time, samples will be collected from the 13 wells which were sampled during this investigation. These samples will be analyzed for the following parameters as well as any additional parameters for which NYSDEC may want additional data:

- Vinyl Choride
- 1,1,2,2-Tetrachloroethane
- Benzene
- 1,2-Dichloroethane
- 1,1-Dichloroethene
- Tetrachloroethene
- Phenols, Total
- Bis(2-chloroethyl) Ether
- Dichlorobenzenes (1,4- and 1,2- isomers)
- 2,4-Dichlorophenol
- Hexachloro~~cyclo~~butadiene cyclo
- 2,6-Dinitrotoluene
- Hexachlorobenzene
- Pentachlorophenol
- Benzo(a) Anthracene
- Chrysene
- Benzo(b) Fluoranthene
- Benzo(k) Fluoranthene
- Indeno (1,2,3-cd) Pyrene
- Chlordane

Detection limits will be selected such that contamination at levels exceeding NYSDEC GA standards or guidance values can be quantified. It is recommended that if contamination is found which exceeds health based standards, NYSDEC will assess potential remedial actions so that groundwater ARARs can be met.

4.8 CONCLUSIONS

Hydrogeology and groundwater investigations at the 93rd Street School site have resulted in the ~~following~~ conclusions/ listed on the following page.

- Hydraulic conductivity estimates indicate that the velocity of groundwater flow is very low.
- The direction of groundwater flow from the fill material appears to be to the south-southwest and to the north (i.e., toward SMW-1 and SMW-6).
- Due to the low permeability of site soils, runoff and evaporation of precipitation far exceed percolation on-site. Therefore, transportation of any contaminants present in the fill material off-site would probably occur almost exclusively due to erosion caused by surficial runoff of precipitation rather than by percolation and movement with the groundwater.
- Based on currently available data, the majority of contaminants are not leaching readily into groundwater at the site. Groundwater samples collected from 13 wells at the site were essentially free of contaminants at levels exceeding CRDLs and human health based standards. However, as described previously, additional sampling and analysis is recommended during the remedial design phase to determine whether or not any ARARs are being exceeded for the parameter(s) for which CRDLs exceeded NYSDEC GA standards and guidance values during this investigation.

5.0 SURFACE WATER INVESTIGATION

5.1 SCOPE

Surface water contamination at the site was investigated through analysis of two samples from the existing swale which carries runoff flow from the site to Bergholtz Creek. Contamination in Bergholtz Creek is being addressed under a separate contract.

5.2 SURFACE WATER SAMPLING AND PARAMETERS STUDIED

Two surface water sampling stations (SW-1 and SW-2) were established in the existing drainage swale at the 93rd Street School site as shown on Drawing S-1 in Appendix A during the first round of sampling. Station SW-1 was located upgradient of Station SW-2 in the drainage swale. Sampling at these stations was conducted when there was visible surface water in the swale, and samples were analyzed for dioxin as well as all parameters listed in Appendix D. A list of surface water samples collected is shown in Table 5-1.

5.3 SUMMARY OF ANALYTICAL DATA

Summaries of laboratory results for all samples are presented in Appendix H. The data in this Appendix is organized so that the laboratory results for each parameter are shown for all surface water sampling stations on one sheet. Soil data are shown separately. If a parameter was not detected in any surface water sample at a level exceeding the CRDL, no results for the parameter are presented in Appendix H.

Table 5-2 shows all parameters found above the CRDLs in surface water; the concentration and station where the highest level was detected; and selected water criteria and standards. Table 5-3 shows the total organic chemical concentration found in each sample. Parameters not detected or those found below the CRDL are not included in the tables or in any of the following discussions.

TABLE 5-1

SURFACE WATER SAMPLE IDENTIFICATION SUMMARY

SAMPLE LOCATION	DATE COLLECTED	FIELD LABEL NO.	YWC LABORATORY CONTROL NO.	ERCO ID NO.	SAMPLES COLLECTED BY
Surface Water No. 1	12-10-86	2369	001	41949	W. Thomas
Surface Water No. 2	12-10-86	2370	002	41950	W. Thomas

TABLE 5-2
ANALYSIS OF ANALYTICAL DATA
INORGANICS AND ORGANICS IN SURFACE WATER
(all values in ug/l = ppb)

Parameter	Highest Conc ug/l†	Highest Conc Sta	NYSDEC WQ REGS A Std	NYSDEC WQ REGS A Guidance	NYSDOH Source Std
INORGANICS					
Aluminum	259	SW1	None	None	None
Antimony	90	SW2	None	3	None
Calcium	52300	SW2	None	None	None
Chromium	46	SW1	50	NA	50
Iron	378E	SW1	300	NA	None
Lead	12	SW1	50	NA	50
Magnesium	25200	SW2	35000	NA	None
Manganese	209E	SW2	300	NA	None
Nickel	55	SW1	None	None	None
Silver	44N	SW1	50	NA	50
Sodium	7400	SW2	None	None	20,000
Zinc	72	SW1	300	NA	300
VOLATILE ORGANICS					
	None				
B/N/A					
Di-n-octyl phthalate	21	SW1	NA	50	None
PESTICIDES/PCBs/DIOXIN					
	None				

†Subscript definitions for this column are as follows:
E = indicates a value estimated due to the presence of interference
N = indicates spike sample recovery is not within control limits

TABLE 5-3
ANALYSIS OF ANALYTICAL DATA
TOTAL ORGANICS IN SURFACE WATER

STATION NO.	SUM OF CONCENTRATIONS OF TOTAL ORGANIC CHEMICALS* (ug/l)				
	VOC	B/N/A	PEST/PCB	DIOXIN	TOTAL**
SW-1	ND	21	ND	ND	21
SW-2	ND	13	ND	ND	13

*Includes compounds specified in NYSDEC ambient water quality standards.

No dioxin was detected above detection limits in the two surface water samples collected during this study (See Appendix H). During a concurrent study by Malcolm Pirnie, Inc. of dioxin concentrations in Bergholtz Creek, two surface water runoff samples resulting from two separate storms were collected in the 93rd Street School drainage swale and analyzed for dioxin. According to the Malcolm Pirnie, Inc. report, "Reported dioxin concentrations (for these samples) were less than the sample detection limits of 1.39 ng/L (ppb) and 0.49 ng/L (ppb), respectively." (Ref.5)

5.4 REVIEW OF ANALYTICAL DATA

As shown on Table 5-2, the analytical data was compared with currently available NYSDEC standards and guidance values for surface water quality. These standards were selected based on human health considerations as opposed to aquatic life protection considerations. These include surface water class A published standards and guidance values in the NYSDEC document 85-W-38 of the Technical and Operational Guidance Series, dated April 1, 1987. Values taken from this publication are shown on Table 5-2 for comparison with concentrations found in the surface water samples. Also shown for comparison are values from the NYSDOH source standards (10 NYCRR, Part 170).

The following discussion covers the various parameters shown in Tables 5-2 and 5-3:

Aluminum - This metal is found extensively in nature and is used in the treatment of drinking water. There are no federal or state water standards for aluminum based on health considerations. The two surface water samples showed aluminum at concentrations of approximately 250 ug/l. Since there are no state or federal standards for aluminum based on health considerations, aluminum was not considered to be a parameter of concern in the surface water.

Antimony - This metal was found in one of the surface water samples at a concentration much higher than the NYSDEC ambient surface water guidance value of 3 ug/l, which is toxicity based but is not a standard. The EPA guidelines under the Federal Clean Water Act (CWA) show a significantly higher value of 146 ug/l for antimony based on health considerations. The surface water concentration found was below 146 ug/l for antimony, therefore, this parameter was not considered to be of major concern in the surface water.

Calcium - This element was found in both surface water samples at concentrations of 40-50 mg/l. There are no state or federal aquatic or health-based standards for calcium. Therefore, calcium was not considered to be of concern in the surface water.

Chromium - This metal was found in one of the surface water samples at a concentration of 46 ug/l. The NYSDEC WQ standard for surface water is 50 ug/l. Therefore, chromium was not considered to be of concern in the surface water.

Iron - This metal was found in the two surface water samples at concentrations of 133 and 378 ug/l. Although the NYSDEC WQ standard is 300 ug/l in surface water, the limit is not based on toxicity. Furthermore, the NYSDOH does not list a limit for iron in the source standards. Therefore, iron was not considered to be a major parameter of concern in the surface water.

Lead - This metal was found in one surface water sample at 12 ug/l. The NYSDEC WQ standard for lead is 50 ug/l. Therefore, lead was not considered to be a parameter of concern in the surface water.

Magnesium - This element was found in both surface water samples. The maximum concentration found was 25 mg/l, while the NYSDEC WQ standard is 35 mg/l. Therefore, magnesium was not considered to be a parameter of concern in the surface water.

Manganese - This metal was found in the two surface water samples at concentrations of 65 and 209 ug/l. The NYSDEC WQ standard is 300 ug/l. Therefore, manganese was not considered to be a parameter of concern in the surface water.

Nickel - This metal was detected in one surface water sample at a concentration of 55 ug/l. However, there is no NYSDEC WQ standard or guidance value for nickel in surface water, nor does NYSDOH have a source standard for nickel. Therefore, nickel was not considered to be a parameter of concern in the surface water.

Silver - This metal was found in one surface water sample at 44 ug/l. The NYSDEC WQ standard is 50 ug/l. Therefore, silver was not considered to be a parameter of concern in the surface water.

Sodium - This metal was found in one surface water sample at 7400 ug/l. The NYSDOH source standard is 20000 ug/l. Therefore, sodium was not considered to be a parameter of concern in the surface water.

Zinc - This metal was found in the two surface water samples at 72 and 46 ug/l. The NYSDEC WQ standard is 300 ug/l. Therefore, zinc was not considered to be a parameter of concern in the surface water.

Di-n-octyl phthalate - This compound was found in the two surface water samples at 13 and 21 ug/l. The NYSDEC WQ guidance value for di-n-octyl phthalate in surface water is 50 ug/l. Therefore, di-n-octyl phthalate was not considered to be of concern in the surface water.

Total Organic Chemicals (TOC) - There is a limit of 100 ug/l for the sum of designated organic chemicals in the NYSDEC ambient water quality standards. As shown in Table 5-3 this standard was not a cause for concern in the surface water because the highest TOC value found in any surface water sample was 21 ug/l.

5.5 CONCLUSIONS

In conclusion, all contaminants detected in surface water samples collected at the 93rd Street School site at levels exceeding ⓔ the CRDLs were inorganics with the exception of di-n-octyl phthalate which is a base/neutral/acid extractable organic. All but two of the contaminants detected were present in concentrations which did not exceed ARARs (Class A published surface waters and standards obtained from NYSDEC document 85-W-38 or NYSDOH source standards obtained from 10 NYCRR, Part 170). Antimony and iron were the two exceptions. Antimony was found in one of the samples at a concentration much higher than the NYSDEC ambient surface water guidance value of 3 mg/l. Since the concentration was less than that of the EPA guidelines under the CWA, however, antimony was ruled out as a major concern in surface water at the site. Iron was found in one of the samples at a concentration somewhat higher than the NYSDEC ambient surface water standard. Since this standard was not toxicity based, and NYSDOH does not have a source standard for iron, iron was ruled out as a major concern in the surface water at the site. Thus it was concluded that surface water contamination at the 93rd Street School site does not pose a significant threat to human health based on the results of this investigation.

6.0 PUBLIC HEALTH AND ENVIRONMENTAL RISK ASSESSMENT

6.1 SCOPE

In this section a baseline health risk assessment for the 93rd Street School site is presented as Exhibit 1. This assessment was written based on the guidelines presented in the EPA Superfund Public Health Evaluation Manual. Its purpose is to evaluate the potential risks imposed by the contaminants at the site.

6.2 CONCLUSIONS

The important conclusions of the baseline health risk assessment were as follows:

- The contribution of volatiles to the overall risk of the site is expected to be negligible.

- If the site remains in its current state (i.e., if the 'no action' alternative is selected), then a theoretical cancer risk of 2 x 10^{-4} may exist. Since EPA guidance implies that an acceptable risk lies in the range of one cancer chance per 10,000 to ~~a~~ one chance per 10,000,000, implementation of the no action alternative may lead to unacceptable cancer risks. The primary contaminants contributing to this unacceptable risk are dioxin and arsenic, and the primary route of exposure is ingestion. [illegible]

- If the site were dist~~ru~~urbed without careful implementation of direct contact and dust controls, then it was determined that an even greater cancer risk of 1.3 x 10^{-3} could be imposed.

- Regardless of whether or not the site is disturbed, it is unlikely that the non-carcinogenic contaminants will pose a significant toxic effect.

EXHIBIT 1

RISK ASSESSMENT FOR
93rd STREET SCHOOL SITE RI/FS

Risk Assessment to Accompany the Remedial Investigation/ Feasibility Study of the 93rd Street School Superfund Site

Niagara Falls, New York

Date:

March 14, 1988

Prepared for:

Loureiro Engineering Associates
10 Tower Lane
Avon, CT 06001

I. INTRODUCTION

The following report is a baseline health risk assessment of the 93rd Street School Superfund Site, which is located in the Love Canal Emergency Declaration Area (EDA) in Niagara Falls, New York. The report follows the guidelines outlined in the Superfund Public Health Evaluation Manual (EPA, 1986) and is intended to accompany the Remedial Investigation/Feasibility Study (RI/FS) Report developed by Loureiro Engineering Associates. A summary of the history of the site and all of the subsequent site evaluations are presented in the aforementioned document.

EPA Hotline

1-800-424-
9346

II. SELECTION OF INDICATOR CHEMICALS

It is stated in the Superfund Public Health Evaluation Manual that it is typical to narrow the number of indicator chemicals to 10-12 compounds in order to perform a manageable health risk assessment. Thus, while all parameters analyzed and detected in the remedial investigation were candidates for detailed risk assessment, compounds not expected to contribute significantly to the overall health risk of the site were eliminated.

A. Groundwater

A detailed health risk assessment of constituents present in groundwater was not undertaken as it appeared improbable that exposure to compounds via this route would occur. This area of Niagara Falls is served by a public water supply, and no wells are present in the area. NYDEC is treating groundwater at the site as a separate operable unit. This media may be revisited in terms of estimating potential risk at a later time.

B. Soils

The chemical parameters presented in Chapter 3 were candidate indicator parameters, but some compounds were eliminated based on low concentrations present in soil, limited toxicity data available for health risk assessment, or low potential for exposure.

Of the metals that were detected, cadmium was eliminated because it was found only rarely above the average detected "background" concentration for the Niagra Falls area (4 ppm, Hopkins, 1988). No cadmium sample exceeded the 9 ppm level considered "elevated" by the NYDOH (Hopkins, 1988). Cobalt was not considered further, as insufficient quantitative toxicity data was available for health risk assessment.

1,2-dichlorobenzene, 1,2,3,4-tetrachlorobenzene and alpha and beta HCCH were eliminated because of extremely rare positive analytical findings.

Several of the lower molecular weight PAH (fluorene, phenanthrene, anthracene, fluoranthene, and pyrene) were not considered further, as insufficient quantitative toxicity data was available for health risk assessment. Several higher molecular weight PAH, which are rated as C or B-2 carcinogens, have no carcinogenic potency slopes (benzo[a]anthracene, benzo[b]fluoranthene, chrysene, indeno[1,2,3,cd]pyrene). However, a decision was made to assess the possible health risk of these compounds by using the conservative approach of assuming their carcinogenic potency is comparable to benzo[a]pyrene.

The volatiles detected at the site were eliminated because of low concentrations and/or low toxicity. As will be discussed in subsequent chapters, the presumed exposure routes for materials at the 93rd Street Site are inhalation and direct contact. At the concentrations present in soils at the site, volatiles present a negligible source of air emissions. This is particularly true in ~~in~~ the case of the site in its current condition, where most or all of the volatiles have probably gassed off of surface soils. If this assumption is true, no materials are likely to be available in surface soils for direct contact either. This assumption is consistent with the finding during Remedial Investigations that field instruments indicated no detected air contaminants in breathing zones even close to sampling sites. At fairly shallow depths, volatile materials do remain, the overlying soils acting as a barrier to volatilization. As the overlying material is removed (by hand, or during an excavation) it would be expected that an extremely transient air emission would occur and be effective at removing most volatile material from the soil. This is also consistent with findings during the remedial investigation that field instruments often registered detection of volatile compounds as a boring was removed or a well uncapped. The positive readings lasted no more than a few minutes. This should be true even for the volatile compounds with the lowest vapor pressures - the aromatic compounds ethylbenzene, toluene, and xylenes. Even if volatilization is not equally efficient for these compounds, their toxicity is substantially less (based on comparison of potency factors or AICs) than the compounds selected as indicator chemicals for detailed health risk assessment. Thus, while these chemicals may not be said to pose no risk, the contribution of these compounds to the overall risk of the site is expected to be negligible.

A list of the remaining indicator chemicals for soil, which are subjected to detailed health risk assessment in the following portions of this report, are presented in Table 1. The selection of indicator parameters using the logic detailed above is consistent with comments of the NYDOH (March 2, 1988) who suggested that health risk assessment of metals at background concentrations or volatiles at low levels do not appear necessary or appropriate.

Table 1.

93rd Street School Site
Niagara Falls, N.Y.

Indicator Chemicals

Antimony
Arsenic
Lead
Mercury
Benzo[a]anthracene(*)
Benzo[b]fluoranthene (*)
Benzo[a]pyrene (*)
Chrysene (*)
Indeno[1,2,3,cd]pyrene (*)
Dioxin

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* The high molecular weight PAH were treated as a class of "carcinogenic PAH" with carcinogenic potency equivalent to benzo[a]pyrene.

III. EXPOSURE ASSESSMENT

A. Selection of Exposure Scenarios

At any site, individuals may be exposed to contaminants in soils, water, or air. The routes of exposure are ingestion, inhalation, or absorption through the skin. The significant exposure media and route of exposure varies and is determined by specific conditions at each site.

The extent and nature of contamination of the 93rd Street Site was evaluated by reviewing the geological and hydrological survey sampling and analysis in the Remedial Investigation, as well as data from previous studies. After consideration of the site parameters, it was determined that plausible routes of exposure for potential receptors for the 93rd Street School site would be inhalation of contaminated soils if they were entrained as a dust and inadvertent ingestion of contaminated soil, e.g., children playing on the site. Exposure via drinking water was not evaluated because the site is served with a public water supply, and the probability of drilling for a potable water supply in this area is extremely low.

In order to quantitatively estimate human exposure and potential health risk, two hypothetical scenarios were applied to the unremediated site:

- o Potential exposures at the undisturbed site.
- o Potential exposures if soils were disturbed by persons unaware or unconcerned that the site contained potentially hazardous materials.

For each of these scenarios, magnitude of exposure was calculated for inhalation and ingestion based on assumptions detailed below.

It should be noted that at this point the health risk assessment becomes specific for the particular exposure scenarios utilized. The exposure parameters chosen are conservative and are more likely to overestimate than underestimate exposure at the site, even if exposures occur in ways different from the scenarios presented here. They should therefore be useful for determining the potential impact of the site, and possible remedial measures. However, the applicability of the exposure scenarios and their level of conservatism should be revisited as risk management decisions are made.

B. Quantitative Assumptions for the Exposure Scenarios

The logic and justification for exposure parameters of each scenario is discussed below. Table 2 presents the exposure parameters in equation form. Exposure point concentrations and estimated intake for each exposure route are given in Table 3.

1. Potential exposures at the undisturbed site.

a. Inhalation

i) Particulate loading of the air in the immediate region is a result of air-entrainment of surface soil at the site. The concentration of each contaminant in the suspended particulate matter is the mean of the concentrations found present at a depth of 0 - 1 ft.(the depth range for the shallowest samples taken in the Remedial Investigation, this exposure scenario was not applied to dioxin, as this indicator parameter was not detected in samples taken by LEA) .

ii) The total suspended particulate levels are constantly at the level of 0.0525 mg/m^3. This value is the average of the annual geometric mean for 1976-1986 in the Niagara Falls area (NYDEC, 1987).

iii) The receptor is an individual weighing 70 kg who breathes 20 m^3 per day for 70 years in the zone of impact.

b. Ingestion

i) The concentration of each contaminant in the ingested soil is the highest concentration in the surface soil at a depth of 0 - 1 ft. (no dioxin was detected during sampling by LEA, but the highest dioxin concentration found in earlier sampling, 1.2 ug/kg was used for this exposure assessment).

ii) The receptor is a child weighing 17 kg who makes contact with and ingests 100 mg soil (EPA, 1986).

iii) The exposure duration is daily, 6 months per year for 5 years.

2. Potential exposures at the disturbed site:

a. Inhalation

i) Particulate loading of the air in the immediate region is a result of air-entrainment of soil during excavation. at the site. The concentration of contaminants in the particulates are equal to the mean of all samples in Round 1 (i.e. the construction is in the fill area; this exposure scenario was not applied to dioxin, as this indicator parameter was not detected in samples taken by LEA)).

ii) Construction activities create a dusty atmosphere with the concentration of total suspended particulates at a constant 10 mg/m^3. This value is the TLV set by the ACGIH for "nuisance dusts" and is a conservative approach for assessing a health impact in a construction area.

iii) The receptor is an individual weighing 70 kg who breathes 10 m^3 of air during the work shift, for a period of one year.

b. Ingestion

i) The concentration of each contaminant in the ingested soil is the maximum concentrations of indicator parameters in samples taken during Round 1 or 2 of the Remedial Investigation (no dioxin was detected during sampling by LEA, but the highest dioxin concentration found in earlier sampling, 1.2 ug/kg was used for this exposure assessment) . The assumption essentially represents potential exposure if an excavation occurred and the excavation materials were left at the surface.

ii) The receptor is a child weighing 17 kg who makes contact with and ingests 100 mg soil (EPA, 1986).

iii) The exposure duration is daily, 6 months per year for 5 years.

Table 2.

93rd Street School Site
Niagra Falls, N.Y.

Exposure Equations

UNDISTURBED SITE

Ingestion

$E_{ing} = C_s * I_s * D * 1/BW$

where

E_{ing} = exposure due to ingestion (mg contaminant/kg body weight day)
C_s = maximum contaminant concentration in surface soil (mg contaminant/mg soil)
I_s = soil ingestion rate (100 mg soil/day)
D = duration of exposure (5yr/70yr * 6mo/12mo)
BW = Body weight (17kg for child ingesting soil)

Inhalation

$E_{inh} = C_a * Inh * D * 1/BW$

where

E_{inh} = exposure due to inhalation
C_a = contaminant concentration in air (mg/m^3, calculated as the mean surface concentration of contaminant, in mg/mg soil, times suspended particulate concentration, 0.0525 mg/m^3)
Inh = Volume of contaminated air breathed (20 m^3/day)
D = duration of exposure (lifetime, 70yr/70yr)
BW = Body weight (70 kg for an adult)

Table 2 (continued).

93rd Street School Site
Niagra Falls, N.Y.

Exposure Equations

DISTURBED SITE

Ingestion

$E_{ing} = C_s * I_s * D * 1/BW$

where

E_{ing} = exposure due to ingestion (mg contaminant/kg body weight day)
C_s = maximum contaminant concentration in Round 1 or 2 samples of soil (mg contaminant/mg soil)
I_s = soil ingestion rate (100 mg soil/day)
D = duration of exposure (5yr/70yr * 6mo/12mo)
BW = Body weight (17kg for child ingesting soil)

.14

For 5 years daily @ 7 6 months/year

Inhalation

$E_{inh} = C_a * Inh * D * 1/BW$

where

E_{inh} = exposure due to inhalation (mg contaminant/kg body weight day)
C_a = contaminant concentration in air (mg/m^3, calculated as the mean concentration of contaminant from Round 1 sampling, in mg/mg soil, times suspended particulate concentration, 10 mg/m^3)
Inh = Volume of contaminated air breathed (10 m^3/workshift)
D = duration of exposure (1yr/70yr)
BW = Body weight (70 kg for an adult)

Was it done

- Total suspended particulate level is 0.052.5 mg/m^3

Data used is
not consistent, some where data
for 1 to 2ft used and in some
0–6" or 0–1' used.

1ft to 2ft depth

TABLE 3

93rd Street School Site
Niagra Falls, NY

Exposure Point Concentrations and Intake Estimates (‡)

92 PPM .52 PPM 840 PPM 7.6 PPM 1.2 PPM 5.7 PPM 1.1 PPM 1 PPM .65 ppm

6.5×10^{-7}

UNDISTURBED SITE

	Antimony	Arsenic	Lead	Mercury	Benzanth	Chrysene	Bzflanth	Benzpyr	Indpyr	dioxin
Cs	9.2E-05	5.2E-05	8.4E-04	7.6E-06	1.2E-06	5.7E-06	1.1E-06	1.0E-06	6.5E-07	1.2E-09
Ca	4.9E-07	4.3E-07	3.5E-06	1.8E-08	6.3E-09	1.3E-08	5.6E-09	5.1E-09	2.7E-09	
Eing	1.9E-05	1.1E-05	1.8E-04	1.6E-06	2.5E-07	1.2E-06	2.3E-07	2.1E-07	1.4E-07	2.5E-10
Einh	1.4E-07	1.2E-07	1.0E-06	5.2E-09	1.8E-09	3.7E-09	1.6E-09	1.5E-09	7.8E-10	

DISTURBED SITE

	Antimony	Arsenic	Lead	Mercury	Benzanth	Chrysene	Bzflanth	Benzpyr	Indpyr	dioxin
Cs	2.1E-04	3.5E-04	1.8E-04	2.3E-05	2.6E-05	2.4E-05	3.1E-05	1.9E-05	8.2E-06	1.2E-09
Ca	5.8E-06	2.7E-06	7.0E-06	1.4E-07	8.3E-08	8.0E-08	8.6E-08	6.0E-08	2.7E-08	
Eing	4.4E-05	7.4E-05	3.7E-05	4.8E-06	5.5E-06	5.0E-06	6.5E-06	4.0E-06	1.7E-06	2.5E-10
Einh	1.2E-08	5.5E-09	1.4E-08	2.8E-10	1.7E-10	1.6E-10	1.7E-10	1.2E-10	5.6E-11	

Table 3 gives exposure point concentrations and estimated intakes by each route for the two exposure scenarios described in the text, and calculated according to equations listed in Table 2. The symbols used in this table are defined in Table 2.

‡ Cs (soil concentration) in units of mg contaminant/mg soil.
Ca (air concentration) in units of mg contaminant/m3 air.
Eing (intake by ingestion) in units of mg contaminant/kg body weight day.
Einh (intake by inhaltion) in units of mg contaminant/kg body weight day.

Lead → $8.4 \times 10^{-4} \times 100 \times \frac{5}{70} \times \frac{6}{12} \times \frac{1}{17}$

C. Comparison of Exposure Point Concentrations to Relevant and Appropriate Requirements (ARAR's) of Federal Laws and More Stringent Promulgated State Environmental and Public Health Laws

Comparisons of estimated exposure point concentrations to ARARs are presented in Table 4. Estimated air concentrations (C_a) were compared to NY State Air Guidelines and Federal Ambient Air Quality Standards (AAQS) under the Clean Air Act. No ARARs for soil concentrations were available.

Table 4

93rd Street School Site
Niagra Falls, N.Y.

Comparison of Estimated Exposure Point Concentrations to ARARs (*)

Compound	NY Air Guideline	Federal AAAQS	Ca (**) Undisturbed	Ca (**) Disturbed
Antimony	6.7E-04		4.9E-07	5.8E-06
Arsenic	6.7E-04		4.3E-07	2.7E-06
Lead	1.5E-03	1.5E-03	3.5E-06	7.0E-06
Mercury	3.3E-04		1.8E-08	1.4E-07

* All values in units of mg/m^3
** C_a is estimated exposure point concentration for air.

IV. TOXICITY ASSESSMENT

A. General Profile for the Metals

The main route of exposure for toxic metals is primarily by ingestion of contaminated food, water, and soil and inhalation of dusts or fumes containing the metal. Dermal absorption is generally inefficient unless very high concentrations of a soluble salt are liberally applied. Many factors affect the toxicity of the metals, including chemical speciation (rarely in the elemental form, usually present as the ion), solubility, presence of competing anions (e.g. phosphate) or chelating compounds (NTA), and affinity or degree of binding to organics that may be present in both the aqueous and gaseous phases.

Antimony

Antimony, like other metals, is a common pollutant in urban areas. It is used in many alloys (e.g. lead batteries, pewter), ceramics, rubber, enamels, paints, and textiles. It was used as a medicinal for many years, but its use was discontinued due to its toxicity. The toxicity of the compound is similar to arsenic, in that the degree of absorption, distribution, and excretion is dependent on the speciation, i.e. whether the element exists in the +3 or +5 valence state. Occupationally, the symptoms caused by antimony are similar to arsenic. The signs include upper respiratory tract irritation, pneumonitis, dizziness, diarrhea, vomiting, and dermatitis. Antimony miners have developed disabling but benign forms of silicosis. There is no conclusive evidence as to whether antimony contributes to any form of malignancy in humans (Hammond and Beliles, 1980). In experimental animals, the data is contradictory. It is assumed that there is a toxic threshold for the effects caused by antimony. That is, there is some exposure level below which there is no risk of a health effect. The U.S. EPA has derived levels of intake, called acceptable intakes for chronic exposure (AIC) that are anticipated to be below threshold. If the estimated exposure levels from section II of this risk assessment fall below the AIC (i.e. the ratio of estimated exposure/AIC is less than 1), it is unlikely that a health risk exists due to the exposure scenario used for the health risk assessment. The AIC for oral exposure to antimony is risk 0.0004 mg/kg/day. No AIC for inhalation of antimony has been developed.

Arsenic

Inorganic arsenic exists in various chemical and physical states, and the effect that this toxic metal has on biological systems is highly dependent on the chemical species present or available. In general, the trivalent form, arsenite (+3), is ten times more toxic than the pentavalent form, arsenate (+5). In addition, the metal can be reductively methylated and/or transformed from the +5 to the +3 state by biotransformation *in vivo* (EPA, 1984). Arsenic if found naturally in certain foods (e.g. shellfish, potatoes) and some evidence suggests that it may be an essential nutrient. It is, however, a health risk to humans where increased levels are found in drinking water, from pesticide use, or improper disposal of arsenic chemicals. Smelting operations emit fairly high concentrations of arsenic and people working in these facilities or living in the adjacent areas are at high risk to the metal (ATSDR, 1987a). Symptoms of arsenic intoxication include malaise and fatigue, GI disturbances, hyperpigmentation, anemia, and peripheral neuropathy. The normal body burden for arsenic is 100 mg/70 kg.

There is evidence that chronic oral exposure to elevated levels of arsenic increase the risk of skin cancer. This is based on an epidemiological study of a Taiwanese population by Tseng *et. al*. (1968). There was a strong correlation between the incidence of skin cancer and other signs of arsenic poisoning. The incidence was also highly dose-dependent (*op. cit.*). Studies on chemical carcinogenesis suggest that, for some compounds, no threshold for the effect exists. That is, certain carcinogens, even in extremely small doses will pose some risk of cancer. This assumption is incorporated into the cancer dose-response assessment for arsenic. The EPA Carcinogen Assessment Group has applied a "one-hit" model of carcinogenesis to the epidemiologic data of Tseng *et. al.* to derive a dose-response slope function, or "potency factor" for arsenic. Multiplying the predicted intake of arsenic by the potency slope gives an estimate of the excess risk of contracting cancer due to exposure at the site. The "potency factor" used for arsenic in evaluating the carcinogenic risk was 15 mg/kg/day^{-1}.

Although there does appear to be a causal link between arsenic and skin cancer, the study does have several uncertainties associated with it. All of the evidence and data available with regard to the carcinogenicity of arsenic is currently under review by the EPA (EPA, 1987).

Lead

Lead is a major environmental contaminant that, with regard to the metals, has historically produced the most problems in the human population. In the general population, the major hazard is for young children who chew and/or swallow lead-based paint chips. Again, human populations working in or living near lead smelting operations are also at a risk of exposure to the metal. Because lead is a cumulative toxicant, many regulatory actions have been recently introduced to decrease the concentration in the general environment, including the production of unleaded gasoline. The four major systems affected by lead are the central nervous system, the peripheral nerves, the kidney, and the blood-forming organs. Symptoms of chronic lead poisoning include malaise, loss of appetite, anemia, irritability, palsy, analgesia, and reproductive and kidney dysfunction (Hammond and Beliles, 1980). The AIC values for ingestion or inhalation of lead are 0.0014 and 0.00043 mg/kg/day, respectively.

Mercury

Mercury is unique in that the elemental form of the metal exists as a liquid at room temperature. This form has a very high vapor pressure, and represents a considerable hazard in a normal setting. In the general environment, the metal is easily methylated by indigenous microbial flora, and thus readily available for bioaccumulation in the food chain. Thus, one major source of mercury exposure for the general population is fish, especially species at the top of the food chain, such as tuna and swordfish. Another source of mercury contamination is from widespread dissemination of organomercurials from fungicides, chloralkali plants and wood preservatives. In general, elemental mercury and the organomercury compounds affect primarily the central nervous system, whereas inorganic mercury salts target the kidney. With organomercury compounds, the symptoms of intoxication include tremor, insomnia, emotional instability, depression, and irritability. For inorganic mercury, symptoms of nephrotoxicity are apparent, such as proteinuria and edema of the lower extremities. For this risk assessment, it is assumed that the mercury found in the sampling rounds is inorganic. The AIC cited in the SPHEM is 0.002 mg/kg/day for ingestion and 0.0004 mg/kg/day for inhalation.

B. Carcinogenic PAH

PAH are formed as a result of combustion or natural petroleum synthetic mechanisms. PAH are not generally intentionally synthesized, but are obtained by refining natural material for use as fuels, lubricants, preservatives, and starting materials for petrochemical manufacture.

Only a subset of the general chemical category of PAH have the potential to cause cancer. No PAH has been unequivocally demonstrated to cause cancer in humans. However, by extrapolation from individuals who smoke, and from animal data on certain PAH compounds, there is reason to believe that some PAH are carcinogenic in humans. The U.S. EPA has developed a "weight-of-evidence" system for ranking from A to D (in decreasing order) the level of certainty that a compound is a human carcinogen. There are no A or B-1 level carcinogens among the PAH detected at the 93rd Street School site. Five PAH compounds found at the site have EPA ratings of "probable" (B-2) to "possible" (C) human carcinogens (EPA, 1986) and have been chosen for detailed risk analysis in the present assessment. Of these compounds, only one, benzo[a]pyrene, has experimental data sufficient for quantitatively estimating carcinogenic potency. In determining the Water Quality Criteria for PAH, EPA (1980) used animal dose-response data to establish a criterion for all carcinogenic PAH (summed quantities). This approach is very conservative, because the carcinogenic potency of benzo[a]pyrene is likely to be greater than other PAH. The approach is also an oversimplification because the potency of an individual PAH may change according to the presence of other compounds in the exposure mixture (ATSDR, 1987a). Applying dose-response data from benzo[a]pyrene to other PAH is, nonetheless, the only method currently available. It is noteworthy that the Carcinogen Assessment Group of the U.S. EPA is currently studying the possibility of using a "comparative potency" method for addressing mixtures of carcinogenic PAH.

Studies on chemical carcinogenesis suggest that, for some compounds, no threshold for the effect exists. That is, certain carcinogens, even in extremely small doses will pose some risk of cancer. This assumption is incorporated into the cancer dose-response assessment for PAH. The EPA Carcinogen Assessment Group has applied a curve-fitting program to data on carcinogenesis in experimental animals (mice in the case of ingestion potency, Neal and Rigdon, 1967; and hamsters for inhalation potency, Thyssen, et al, 1981), which calculates the upper 95% confidence interval on a dose-response line, assuming a no threshold, multistage mechanism of chemical carcinogenesis. This value, called a "potency slope" is 11.5 (milligram/kg body weight day)$^{-1}$ for ingestion exposures to benzo[a]pyrene. Multiplying the predicted intake of carcinogenic PAH by the potency slope gives an estimate of the excess risk of contracting cancer due to PAH exposure at the site. Because the potency slope is an upper bound estimate of carcinogenic potency, the product is more likely to overestimate than underestimate carcinogenic risk due to PAH. The potency slope for inhalation exposures to benzo[a]pyrene, which will be applied to all carcinogenic PAH, is 6.1 (milligram/kg body weight day)$^{-1}$.

C. Chlorinated dibenzo-p-dioxins

Chlorinated dibenzo-p-dioxins are not intentionally synthesized. Rather, they exist as trace contaminants of synthetic chlorinated aromatic compounds such as pentachlorophenol and 2,4,5-trichlorophenoxyacetic acid or, as a combustion product of chlorinated compounds.

Limited data is available on human exposure to dioxin. It has been documented that exposure to dioxin (and related compounds) in the workplace will produce chloracne, a persistent, severe skin lesion that usually occurs on the head and upper body. This appears to be the effect seen in humans that is most clearly correlated with dioxin exposure. Other signs of toxicity that have been observed in small groups of exposed people are aching muscles, loss of appetite, weight loss, headache, insomnia, and irritability (ATSDR, 1987b). Dioxin has been shown to be extremely toxic to certain laboratory animals. There is a great deal of interspecies variability with regard to the magnitude of response. For example, the lethal dose of 2,3,7,8-TCDD differs 5000-fold between the guinea pig and hamster (Safe, 1986). It has been demonstrated that 2,3,7,8-TCDD causes tumors in rats (Kociba, et al, 1978), and this finding has been used for dose-response assessment. The current EPA potency factor dioxin is 15,600.

1.56×10^5
↓
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Manual.

A summary of AIC and potency factor values is given in Table 5. An AIC is a dose, in mg/kg/day, which has been calculated from toxicity data (human and/or animal), below which no observed effects would be expected if an individual were exposed to it over a long period of time. A potency factor is a measure of the carcinogenicity of a chemical. It is a statistical estimate based on the upper 95% confidence interval of the slope of the dose-response curve for that chemical. The higher the potency factor, the more potent the carcinogen.

Table 5

93rd Street School Site
Niagra Falls, N.Y.

Toxicity Assessment

Compound	AIC (*)		Potency Factor (**)	
	Oral	Inhalation	Oral	Inhalation
Antimony	0.0005			
Arsenic			15	50
Lead	0.00043	0.0014		
Mercury	0.002	0.0004		
PAH			11.5	6.1
Dioxin			15600	

* AIC in units of mg/kg bw day
** Potency Factor in units of (mg/kg bw day)$^{-1}$

V. RISK CHARACTERIZATION

A. Comparison to Standards and Criteria

Table 4 provides information on predicted exposure point concentrations for contaminants as compared to relevant standards or criteria. It can be seen that conservative predictions of contaminant concentrations in air are below the available air quality criteria and standards (the NY Air Guidelines and the Federal AAQS for lead). Using the method of comparison to standards and criteria, the 93rd Street School site does not appear to have high impact.

However, it should be noted that comparison to standards and criteria is limited because several potential air contaminants have no value with which to be compared, and no soil criteria are available.

B. Results of the Health Risk Assessment

The potential health impact of the 93rd Street School site for the assumed exposure scenarios was determined by calculating cancer risks and hazard indices for indicator parameters.

For evaluating cancer risk, the estimated exposure point concentrations were multiplied by the appropriate cancer potency factor. The product obtained is a "risk" factor for that theoretical exposure, i.e. how many people would be expected to contract cancer per unit population. For example, if the product were 3×10^{-5}, then one may expect 3 cases of cancer for every 100,000 people.

One does not calculate non-carcinogenic risk <u>per se</u>. Assuming that most non-carcinogenic toxic materials have a threshold (as discussed in Section 3), it is more appropriate to assess the impact of non-carcinogenic substances in a quantal fashion: the assumed exposure either will or will not produce an effect. The determination is made by dividing the estimated exposure point concentrations by the AIC and summing the values for all indicator parameters in the non-carcinogenic category. If this value, called a hazard index, is below unity, then it is assumed that no risk is associated with that scenario. If the hazard index is greater than unity, a impact may be possible. The toxicants that contribute greatly to the hazard index are evaluated individually. Provided no compounds that truly have additive toxic effect produce a sum of ratios greater than one, it is unlikely that a toxic effect will be seen. If the summed ratios of compounds with additive toxic effects is greater than one, a toxic impact is possible for the assumed exposure scenarios.

The cancer risk and hazard indicies for the 93rd Street School Sites are given in Tables 6 and 7, respectively.

Inspection of the Tables indicates an overall summed cancer risk for the "Undisturbed Site" exposure scenario of approximately 2 chances in 10,000 (Table 6). The cancer risk is contributed overwhelmingly by the ingestion component of the scenario. Excess cancer risk is produced primarily by arsenic, with the remainder of the risk distributed approximately 1:2 between carcinogenic PAH and dioxin. There does not appear to be an appreciable risk of non-cancer effect due to materials in the unremediated site, as the hazard index is below unity (see above for definition of hazard index).

Cancer risk for the "Disturbed Site" scenario is approximately 5 times higher than the previous scenario; about 1 chance in 1,000 (see above for definition). Again, the risk is contributed mostly by ingestion. The increased risk derives from "exposing" higher concentration of arsenic and carcinogenic PAH during the hypothetical excavation. Arsenic is again, the most important compound at the site, in terms of contributed risk. The hazard index for the non-carcinogenic category is below unity, and no effects would be anticipated at the site due to these indicator chemicals.

The notion of of acceptable risk is, of course, a value judgement. However, EPA guidance implies that acceptable risk lies in the range of 1 cancer chance per 10,000 to 1 chance per 10,000,000; depending on the cost and engineering feasibility of correcting the health impact. As such, the unremediated condition of the site lies outside the guidelines. Assuming the exposure scenarios used in the health risk assessment are valid, the equations may be used to screen potential remedial alternatives by inserting estimated residual concentrations of contaminants to determine what level of risk would remain. Alternate exposure scenarios may need to be developed if remediation alters predicted site use.

It is notable that all three compounds determined to be significant health impacts at the 93rd Street School site are under review by EPA relevant to their toxic potency. It is unlikely that reviews will reveal greater toxic potency for these compounds than has been assumed here. Thus, the risk estimates are conservative.

TABLE 6

93rd Street School Site
Niagra Falls, N.Y.

Cancer Risk(*)

UNDISTURBED SITE

3.9×10^{-8}

	Arsenic	Benzanth	Chrysene	Bzflanth	Benzpyr	Indpyr	Dioxin	Total
ingestion	1.6E-04	2.9E-06	1.4E-05	2.7E-06	2.4E-06	1.6E-06	3.9E-05	2.3E-04
inhalation	6.1E-06	1.1E-08	2.2E-08	9.8E-09	9.0E-09	4.8E-09		6.2E-06
							Total:	2.4E-04

1.9×10^{-4}

DISTURBED SITE

	Arsenic	Benzanth	Chrysene	Bzflanth	Benzpyr	Indpyr	Dioxin	Total
ingestion	1.1E-03	6.3E-05	5.8E-05	1.4E-06	4.6E-05	2.0E-05	3.9E-05	1.3E-03
inhalation	1.8E-05	6.9E-08	9.9E-10	6.6E-08	5.0E-08	2.3E-08		1.8E-05
							Total:	1.3E-03

* Risk estimates are unitless values between 0 and unity. Thus, 1.0e-06 may be read as 1 excess chance in 1,000,000 of contracting cancer as a result of exposure to materials at the site.

According to the health risk assessment calculation, 52 PPM of Arsenic is a risk of 1.6 in 10000 which is not acceptable.

TABLE 7

93rd Street School Site
Niagra Falls, N.Y.

Hazard Index for Non-Carcinogenic Indicator Chemicals*

UNDISTURBED SITE

	Antimony	Lead	Mercury	Total
ingestion	4.8E-02	1.3E-01	8.0E-04	1.8E-01
inhalation		2.3E-03	5.2E-05	2.3E-03
			Hazard Index	1.8E-01

DISTURBED SITE

	Antimony	Lead	Mercury	Total
ingestion	1.1E-01	1.3E-01	2.4E-03	2.4E-01
inhalation		2.2E-03	1.9E-04	2.5E-03
			Hazard Index	2.4E-01

* Hazard indices are the summed ratios of the estimated intakes of each compound to the AIC. Thus, values lower than 1 indicate unlikely risk of toxic effect as a result of exposure, while values above one indicate an exposure that may produce a toxic effect.

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APPENDIX A

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VOLUME II - FEASIBILITY STUDY
REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT
FOR THE
93RD STREET SCHOOL SITE
(SITE NO. 9-32-078)
CITY OF NIAGARA FALLS
NIAGARA, NEW YORK

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CRDL	Contract Required Detection Limit
ARAR	Applicable or Relevant and Appropriate Requirements
PSA	Phoenix Safety Associates, Ltd.
ERCO	ERCO Laboratory

1.0 INTRODUCTION

The purpose of this report is to evaluate potential remedial action alternatives for the mitigation of the contamination found at the 93rd Street School site in the City of Niagara Falls, New York. This report has been written to satisfy the requirements of the feasibility study phase of the Remedial Investigation/Feasibility Study (RI/FS) of the 93rd Street School site performed under Contract No. D-001319 with the New York State Department of Environmental Conservation (NYSDEC), Division of Hazardous Waste Remediation.

This report conforms with the guidance provided by the U.S.Environmental Protection Agency (EPA) in the document entitled "Guidance on Feasibility Studies Under CERCLA" (EPA/540/G-85/003; June 1985), in Section 300.68 of the November 20, 1985 National Contingency Plan (NCP), and in a number of EPA memoranda concerning interim guidance following passage of the Superfund Amendments and Reauthorization Act (SARA) of 1986.

Included in this report are presentations of introductory background information, development and screening of potential remedial action technologies, development and screening of preliminary remedial action alternatives, development and analysis of the most promising remedial action alternatives, the recommended alternative and a conceptual design of the recommended alternative. In this section, pertinent introductory information related to the site, results of previous studies, the nature and extent of contaminated soils, the objectives of remedial action, and an overview of the feasibility study process are presented.

1.1 SITE BACKGROUND INFORMATION

1.1.1 SITE DESCRIPTION

A detailed description of site background information was presented previously in Section 1.1 of Volume I - Remedial Investigation

Summary. Therefore, this section will briefly highlight factors which are pertinent to the selection of a remedial action alternative for the site.

The 93rd Street School site and adjacent housing authority properties are located on 19.4 acres of land in the City of Niagara Falls, New York. This site is located less than one mile northwest of Love Canal and is included in the Love Canal Emergency Declaration Area (EDA). Boundaries of the site include Bergholtz Creek to the north, 93rd Street to the west, residential properties and 96th Street to the east, and Housing Authority Property and Colvin Boulevard to the south.

The site is relatively flat with typical elevations ranging from 572' to 574' above mean sea level (MSL). There is, however, an existing drainage swale in the central portion of the site which slopes from the southwest to the northeast and discharges into Bergholtz Creek. The only other significant slope at the site is present along the bank of Bergholtz Creek where the elevation drops to 565' above MSL.

Drainage at the site occurs primarily via the existing swale. However, there are a few surface drains in the vicinity of the baseball diamond. Although the exact location to which these surface drains discharge has not been determined, it appears that they may be discharging to Bergholtz Creek.

The bedrock underlying the site consists of an approximately 150 feet thick layer of dolomite and a thin layer of limestone. The bedrock slopes toward the south at a rate of 30 feet per mile.

Overburden overlying the bedrock varies in thickness from 25 to 27 feet, and consists of glacial till covered by layers of clay, silt, and fine sand. In the immediate vicinity of the school, layers of fill (ranging from 0 to 7.5 ft. in thickness) and a thin layer of topsoil (typically less than 1 ft. thick) have been deposited on top of the native overburden.

Groundwater flow at the site has a very low velocity. Groundwater contours for the site indicate the presence of a groundwater "mound" across the middle of the site in an east-west direction. The direction of groundwater flow out of this "mound" appears to be to the south-southwest from the southern end of the property and to the north-northeast from the northern end of the property.

Runoff and evaporation of precipitation far exceed percolation at the site due to the relatively low permeability of site soils. As a result, any potential aqueous phase transport of contaminants present in the organic fill material to off-site areas would occur primarily through erosion caused by superficial runoff rather than through percolation and movement with the groundwater.

1.1.2 SITE HISTORY

As described previously in the Remedial Investigation Summary, the 93rd Street School was designed in 1947 and constructed in 1950. Prior to construction of the school, a drainage swale crossed the site from the northwest to the southeast, intersected 93rd Street and east-lying properties and discharged into Bergholtz Creek. Between 1938 and 1951, this swale was filled with soil and rock debris followed by sand and silt sized carbon waste and finally by approximately 3000 cubic yards of materials from the 99th Street School which was located in Love Canal. Then a final layer of topsoil was placed over the entire site. Further discussion of the extent of the fill material and the degree of contamination will be presented later in this report.

1.1.3 PREVIOUS STUDIES

Studies of the 93rd Street School site have been performed since 1979 because of the problems associated with the Love Canal fill. These studies were described in detail in Section 1.1.3 of Volume I - Remedial Investigation Summary. The most pertinent findings of these studies are summarized on the following pages.

- The Earth Dimensions Inc. and NYSDOH studies defined the extent and thickness of the fill layer at the site and found no significantly high levels of beryllium.
- RECRA Research Inc. studies found low levels of lindane (gamma BHC), metals, and volatile organics in the fly ash fill layer. In addition, one sample (collected at MW-4 at a depth of 4 to 6 ft.) was found to be contaminated with 2.3 ppb of dioxin. Study of groundwater identified benzene and toluene at concentrations less than 20 ppb and 25 ppb, respectively, and other contaminants including halogenated organics, volatile halogenated organics, chromium, lead, zinc and iron at detectable concentrations. Finally, study of surface water samples from storm sewers identified lindane (gamma BHC) at concentrations of 15 to 97 ug/L while study of surface water samples from Bergholtz Creek identified trace levels of benzene, lindane (gamma BHC) and dioxin.
- NUS Corporation detected dioxin at three locations in the surface soils at the site. Dioxin concentrations at two of these locations were below 1 ppb (0.11 ppb and 0.19 ppb) while the dioxin concentration at station OS,OE was 1.2 ppb.
- E.C. Jordan Co., Inc. studied contamination in site soils and groundwater. Acetone, methylene chloride, benzene, toluene, and bis (2-ethylhexyl) phthalate were identified in the groundwater. All of these compounds were detected at levels lower than the NYSDEC GA effluent standards or guidelines with the exception of benzene which was detected in one sample at a concentration of 11B mg/L (Note that the B flag indicates that benzene was also detected in the method blanks). Similar contaminants at similar concentrations were detected in soil samples.

- Malcolm Pirnie, Inc. detected dioxin at concentrations ranging from ND to 0.73 ng/g in composite creek bank samples collected from the banks of Black Creek and Bergholtz Creek. Only one composite creek bank sample did not exceed the detection limit. This sample was collected from Black Creek upstream of the 93rd Street School. Dioxin was not found in two stormwater runoff samples collected from the 93rd Street School swale at levels exceeding the detection limits. The report concluded that there appeared to be a spatial relationship between the locations of sewer outfalls and the occurrence of high concentrations of dioxin in creek bank soils and creek bed sediments.

1.2 NATURE AND EXTENT OF SITE PROBLEMS

During the remedial investigation phase of this study, contaminants were not found in the groundwater or surface water at levels exceeding the Contract Required Detection Limits (CRDL's) and standards based on human health criteria. It should be noted, however, that for a number of compounds NYSDEC drinking water standards are lower than the CRDL's that were used during the remedial investigation. Therefore, it is recommended that additional samples be collected and analyzed during the remedial design phase to ensure that the levels of aqueous contamination at the site do not exceed ARAR's.

Soils and sediments at the site were found to be contaminated with the parameters listed on the following page at levels exceeding background data and/or criteria developed from human health based aqueous standards.

Inorganic

*Antimony
*Arsenic
Cadmium
Cobalt
*Lead
*Mercury

Volatile Organics

Methylene Chloride
1,1 Dichloroethene
Chloroform
1,1,2,2-Tetrachloroethane
Toluene
Ethylbenzene
Xylenes

B/N/A Organics

Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
*Benzo(a)anthracene
*Chrysene
*Benzo(b)fluoranthene
Benzo(k)fluoranthene
*Benzo(a)pyrene
*Indeno (1,2,3-cd)pyrene

Pesticides/Dioxin

Alpha BHC
Beta BHC
*Dioxin (only found by others)

Summaries of the concentrations of these parameters in site soils and sediments were presented in Section 3 of Volume I - Remedial Investigation Summary.

It should be noted that during the risk assessment, it was determined that not all of these parameters would contribute significantly to risks at the site. Thus the parameters denoted with an asterisk (*) above were considered, while others were eliminated. Further discussion of this process was presented in Section 6 of Volume I - Remedial Investigation Summary.

Dioxin contamination was not detected in any of the 29 composite soil samples collected and analyzed during the remedial investigation phase of this study. However, since the composite samples analyzed for this study did not typically include surface soils, the dioxin contamination data for site surface soils from the NUS Corporation Study is considered in this feasibility study. As described previously, NUS Corporation detected dioxin in three surface soil samples at the following locations and concentrations:

NUS Corporation Sampling Location (Grid Corner) See Drawing S-2	Dioxin Concentration (ppb)
0S, 0E	1.20
160S, 80E	0.11
160S, 160E	0.19

The locations of these NUS sampling locations are shown both on Drawing S-2 and on Figure 3 in Volume I - Remedial Investigation Summary. In addition to the NUS Corporation findings, RECRA Research, Inc. also detected dioxin on-site at one location (i.e. MW-4 at a depth of 4 to 6 ft.). The concentration of dioxin at this location was determined to be 2.3 ppb.

The Center for Disease Control (CDC) has recommended 1 ppb as the level of concern for dioxin in residential areas in the case of the Times Beach, Missouri site. Based on conversations with representatives of NYSDEC, it has been agreed that 1 ppb should also be used as the level of concern for dioxin at the 93rd Street School site. Additional justification for the use of 1 ppb as the level of concern in this study is the proposed land disposal ban that will go into effect this Fall. In summary, under RCRA, certain dioxin bearing wastes will be banned on November 8, 1988 from land disposal per the requirements of 40CFR268.31. The only exceptions to this ban will be wastes which have been treated sufficiently to pass the Toxicity Characteristic Leaching Procedure (TCLP) as described in Appendix I of 40CFR268, and wastes which have been granted an exemption or extension. In order to pass the TCLP test, the leachate from a dioxin bearing waste cannot contain dioxin at a concentration greater than 1 ppb.

As described previously, dioxin has only been identified at the 93rd Street School site at concentrations exceeding 1 ppb at two 'hot spot' locations. Soils from these hot spots should be treated such that the treated residuals are capable of passing the TCLP test prior to disposal. In addition, if other site soils are excavated and treated during remediation of the site, the treatment residuals from these soils should also be demonstrated capable of passing the TCLP test prior to disposal.

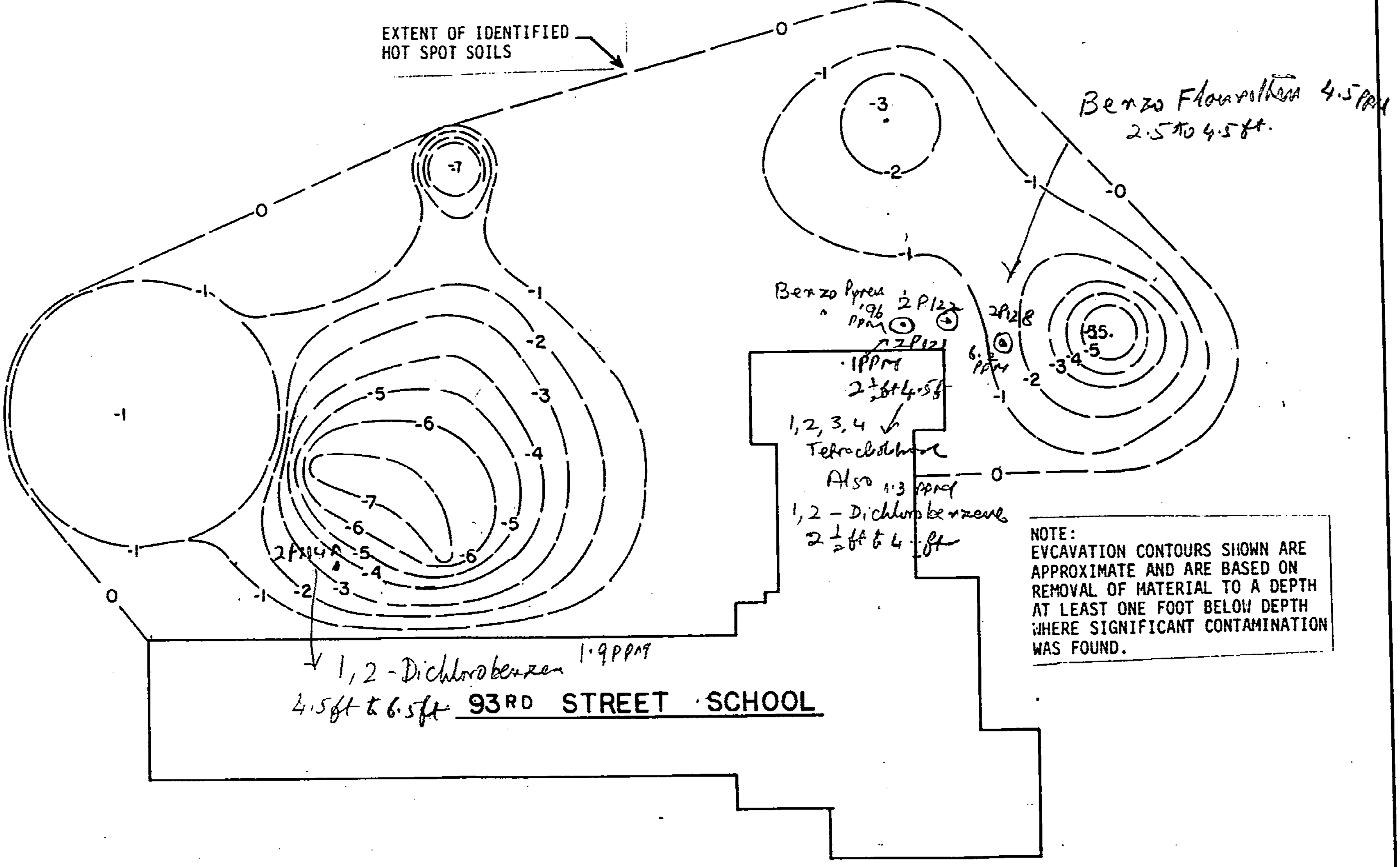
The quantities of soils present at each of the two known dioxin 'hot spots' have been computed based on the following assumptions for the purpose of this feasibility study:

- At NUS Corporation sampling station OS,OE, surface soil contamination may extend to a depth of 1 foot within a 60 foot radius of station OS,OE. A radius of 60 feet was selected because it is known that dioxin was not detected at the adjacent stations (i.e. 80S,OE and OS,80E). Therefore, a circular area with a radius of 60 feet centered at station OS,OE was used to obtain an estimate of the extent of soils contaminated with greater than 1 ppb of dioxin in the vicinity of OS,OE. Using this circular area and a depth of 1 foot, a volume of 420 cubic yards of soil was computed.
- At MW-4, it was estimated that soils may be contaminated with dioxin to a depth at least 1 foot below the depth at which RECRA found dioxin and within a 5' radius of this depth. The volume of contaminated soil was computed within a truncated cone with a lower diameter of 10' and an upper (surface) diameter of 38 feet, a total depth (height) of seven feet, and side slopes at an angle of approximately 26.5° (1 footrise per 2 foot run) to ensure soil stability during excavation. The

volume of soil in this truncated cone is approximately 130 cubic yards.

Thus the total volume of dioxin 'hot spot' soils equals the sum of 420 cu. yd. plus 130 cu. yd. or 550 cu. yd.

The extent of non-dioxin soil contamination which could impose a significant risk to nearby populations was determined during the remedial investigation. While contamination was typically greatest in the thickest fill layers located in the deepest portions of the historic swale, there was some contamination present in the thinner fill layers also. Therefore, a preliminary estimate of the volume of soil/fill potentially requiring remediation was developed based on the assumption that the entire volume of fill should be addressed. Additional study during the preparation of the risk assessment, however, indicated that some of the contaminated fill/soils could remain at the site without posing a significant risk, while others would require remediation to reduce risks to acceptable levels. Figure 1 on the following page shows the extent of hotspot soils ~~requiring remediation~~ (including the dioxin hot spots). These soils contributed higher risk than other site soils primarily because they exhibited higher levels of PNA's and arsenic. The total volume of soils requiring remediation was computed by the average end area method by comparing present day surficial contours with depths at least 1 foot below depths at which contaminants posing an unacceptable risk were identified in the risk assessment. The final volume of soil obtained by this method was approximately 6,000 cu. yds. (including dioxin hot spots).



EXTENT OF IDENTIFIED HOT SPOT SOILS

Benzo Flouranthen 4.5 PPM
2.5 to 4.5 ft.

Benzo Pyren .96 PPM
2P122
2P128
2P121
.1PPM
$2\frac{1}{2}$ ft 4.5 ft
6.2 PPM

1,2,3,4 Tetrachlorbenzene
Also 1.3 PPM
1,2 - Dichlorobenzene
$2\frac{1}{2}$ ft to 4 ft

2P114A
1,2 - Dichlorobenzen 1.9 PPM
4.5 ft to 6.5 ft

NOTE:
EVCAVATION CONTOURS SHOWN ARE APPROXIMATE AND ARE BASED ON REMOVAL OF MATERIAL TO A DEPTH AT LEAST ONE FOOT BELOW DEPTH WHERE SIGNIFICANT CONTAMINATION WAS FOUND.

LEA LOUREIRO ENGINEERING ASSOCIATES
a professional corporation
CONSULTING ENGINEERS AVON, CONN.

FIGURE 1
HOT SPOT EXCAVATION

by KR, KD	app. LK,JL	[illegible]=50'	date 3-15-88

1.3 OBJECTIVES OF REMEDIAL ACTION

Based on the public health and environmental risk assessment presented in Section 6 of Volume I - Remedial Investigation Summary, it has been determined that the primary source of concern at the 93rd Street School site is the presence of dioxin, PNA's and arsenic in the soils in the vicinity of the eastern side of the school as shown on Figure 1. In addition, there are some contaminants (particularly arsenic) present at other areas of the site which could pose a significant risk if not contained or treated. Uncontrolled site access, surface water and wind related erosion at the site or implementation of certain remedial actions could result in the development of one or more of the following primary exposure pathways:

(1) Emission of fugitive particles into the air
(2) Direct exposure of humans and other life forms to contaminated soils

or possibly one or more of the following secondary exposure pathways:

(3) Transport of contaminated particles in surface water runoff
(4) Emission of volatiles into the air

Therefore, to protect human health and the environment, the primary objectives of remedial action at the 93rd Street School site will be to develop a method by which all of these exposure pathways can be addressed. It should be noted that significant groundwater contamination was not identified during this remedial investigation, but because of a problem related to the Contract Required Detection Limits, potential groundwater contamination will be reassessed during the remedial design phase as described in Section 4 of Volume I.

The remedial action alternative selected will be that alternative which best satisfies the following criteria:

1. Compliance with Applicable or Relevant and Appropriate Requirements (ARAR's)
2. Reduction of waste toxicity, mobility or volume
3. Short-term effectiveness
4. Long-term effectiveness and permanence
5. Implementability
6. Cost
7. Community acceptance
8. State acceptance
9. Overall protection of human health and the environment

1.4 SUMMARY OF FEASIBILITY STUDY

As described previously in Section 1 of Volume I - Remedial Investigation Summary, the RI/FS process typically involves completion of 17 tasks. Tasks 1-10 are related to the Remedial Investigation, and therefore were described in Volume I. Tasks 11-17, however, are related to the Feasibility Study. These tasks are summarized in the following paragraphs.

1.4.1 TASK 11 - RESPONSE TO REMEDIAL INVESTIGATION

Site problems were identified based on the conclusions of the remedial investigation, and general response actions were developed.

1.4.2 TASK 12 - TECHNOLOGY MASTER LIST DEVELOPMENT

Remedial action technologies for each of the general response actions identified during Task 11 were researched and summarized.

1.4.3 TASK 13 - DEVELOPMENT OF ALTERNATIVES

Remedial action technologies were screened for technical feasibility and some technologies were eliminated from further consideration. Following screening, the remaining technologies were combined to form preliminary remedial action alternatives.

1.4.4 TASK 14 - SCREENING OF ALTERNATIVES

Preliminary remedial action alternatives were screened on the basis of their effectiveness in minimizing threats to human health and the environment, their technical feasibility, and their estimated magnitude of cost.

1.4.5 TASK 15 - EVALUATION OF ALTERNATIVES

The final set of remedial action alternatives which passed preliminary screening were analyzed on the basis of a number of criteria including compliance with ARAR's; effectiveness in reducing waste toxicity, mobility or volume; short-term effectiveness; long-term effectiveness and permanence; implementability; cost effectiveness; community and state acceptance; and overall effectiveness in protecting human health and the environment. Following this analysis, the recommended alternative was selected.

1.4.6 TASK 16 - PRELIMINARY REPORT

A preliminary report was prepared and submitted to NYSDEC for review.

1.4.7 TASK 17 - FINAL REPORT

Following receipt of comments from NYSDEC concerning the preliminary Remedial Investigation/Feasibility Study Report, the preliminary report was revised as necessary, and a final report was submitted.

2.0 DEVELOPMENT AND SCREENING OF REMEDIAL ACTION TECHNOLOGIES

The purpose of this section is to present brief summaries of the containment and treatment remedial action technologies which were considered as potential aids for mitigation of the problems associated with the contaminated soils at the 93rd Street School site. Following presentation of these technology summaries, the technologies are screened on the basis of their compatibility with site and waste characteristics and implementation feasibility. A table is presented at the end of this section which summarizes all technologies considered, their status regarding further evaluation, and reasons for eliminating non-feasibile technologies.

2.1 DEVELOPMENT OF TECHNOLOGIES

The following sections present brief descriptions of containment and treatment remedial action technologies including explanations of how these technologies could be used to remediate the 93rd Street School site and potential advantages and disadvantages of each technology with respect to site and waste characteristics and implementation feasibility.

2.1.1 CONTAINMENT TECHNOLOGIES

2.1.1.1 INTRODUCTION

Based on the conclusions of the public health and environmental risk assessment, containment technologies would be most useful at the 93rd Street School Site to minimize risks associated with the contaminated soils located outside of the 'hot spot' area defined on Figure 1 or to contain the soils within the 'hot spot' area following proper treatment and testing of residuals. Containment of the 'hot spot' area soils without prior treatment and residuals testing would not be prudent since permanent treatment of these soils would ultimately provide greater long-term protection of human health and the environment and would correspond more closely with the goals of the NCP.

Although it has not been determined whether or not the contaminated soils (including the fly ash fill) meet the criteria to be defined as hazardous under the Resource Conservation and Recovery Act (RCRA) it is likely that some aspects of RCRA containment and closure regulations are applicable or relevant and appropriate (i.e., ARAR's). Therefore, a brief summary of RCRA closure regulations is presented in this section followed by descriptions of containment technologies which could be used to address each of the primary and secondary exposure pathways described previously.

RCRA regulations include several closure options for land disposal facilities which could be used as remedial action technologies at Superfund sites. At the present time, there are two land disposal closure options under RCRA. These options are closure by removal or decontamination (clean closure) and closure as a landfill. Soon it is anticipated that a hybrid land disposal approach combining the two existing RCRA closure options will be allowed as a third option under the RCRA program.

Clean closure under RCRA requires that at the time of closure, levels of contamination in wastes must be below levels established by EPA as acceptable for inhalation, ingestion and dermal contact, while levels of contamination in leachate (i.e. groundwater) must meet drinking water standards or EPA recommended health based levels.

Landfill closure under RCRA requires full containment of hazardous materials and long-term management of these materials. Caps and liner systems must be designed in accordance with RCRA and more stringent state standards.

The proposed hybrid closure procedure would involve removing (or treating) the majority of contaminated materials and then allowing covers (caps) and post-closure monitoring programs to be designed based on the exposure pathway(s) of concern. This procedure was proposed on March 19, 1987 and it is anticipated that the USEPA will promulgate a final regulation in May of 1988.

Based on this proposal, it appears that the most feasible containment option for the 93rd Street School soils and treatment residuals would involve the use of a hybrid closure cap and post closure monitoring program. The Superfund program has focussed on two options for hybrid closure and post closure monitoring. The first option is 'alternate clean closure' in which most hazardous contaminants can be demonstrated to be of minimal threat to groundwater or by direct contact, thus making containment unnecessary and minimizing post closure care requirements. Fate and transport modeling must be performed prior to approval of this option to ensure that the groundwater aquifer is usable. This option might be used to address the treatment residuals from the area defined on Figure 1.

The second option is alternate landfill closure in which hazardous materials are removed or treated such that residuals pose a direct contact threat but are not a threat to groundwater (i.e., leachate contamination does not exceed health based levels). In this option, a permeable soil cover can be used to address the direct contact threats and some long-term management is required including maintenance and some groundwater monitoring. This option might be used to address the non hot spot soils, providing groundwater contamination was not identified during the remedial design phase.

EPA currently has the authority to implement the alternate closure options at Superfund sites in certain cases even though RCRA regulations have not yet been promulgated. The only exceptions include cases in which the current RCRA regulations are definitely applicable because the wastes have been demonstrated to be RCRA hazardous wastes and disposal of these wastes occurs.

For wastes which are contaminated with a RCRA land ban contaminant, (such as dioxin at concentrations exceeding 1 ppb) land disposal may be somewhat more complicated. Therefore, to minimize complications, it will be preferable to select a treatment alternative for the dioxin hot spot soils which will reduce dioxin contamination in the residuals to the point where they can pass the TCLP procedure and meet ARAR's associated with clean or alternate clean closure requirements. This will make it possible to dispose of the residuals in a manner that is both cost effective and protective of human health and the environment.

In the following paragraphs, descriptions of a variety of potential containment technologies including capping, disposal in new or existing landfills, or disposal in new or existing storage units are presented. It should be noted that many of these technologies would not be necessary if groundwater problems are not identified at the site. They are described in detail, however, since they might be utilized in the unlikely event that treatment residuals cannot be disposed via the hybrid approach, or groundwater contamination is discovered during the remedial design phase which can be attributed to non hot spot contaminated site soils.

2.1.1.2 CAPPING

Capping technologies involve the placement of soil, clay, concrete, asphalt and/or synthetic membranes over a contaminated area to prevent humans and other life forms from coming into direct contact with wastes, to prevent wind and surface water erosion of soils which could potentially lead to migration of contaminants off-site, and to minimize groundwater flow through contaminated materials.

2.1.1.2.1 RCRA CAPS

Caps for RCRA hazardous waste facilities are typically designed in accordance with the RCRA regulations presented in Title

40 of the Code of Federal Regulations, Section 264.310 (i.e., 40CFR264.310), in related EPA guidance as presented in the document entitled "RCRA Guidance Document for Landfill Design", and in more stringent state regulations. These regulations and guidance materials require that RCRA caps consist of three layers including a vegetative top layer, a middle drainage layer, and a bottom low permeability layer. Specific requirements for each of the RCRA cap layers are as follows:

- The vegetative top layer should be at least two feet thick and designed to support drainage and minimize erosion. Soils, vegetation and slopes of this layer are selected such that the United States Department of Agriculture (USDA) Universal Soil Loss Equation (USLE) can be used to demonstrate that soil erosion will not be excessive.
- The middle drainage layer should be at least one foot thick and designed to support drainage in a lateral direction. This layer is typically overlain with filter fabric to prevent potential plugging by fine earth particles carried down from the vegetative top layer.
- The bottom low permeability layer should consist of a synthetic membrane overlying a two foot thick layer of soil compacted to a saturated hydraulic conductivity of not more than 1×10^{-7} cm/sec.

When properly designed, the layers of a RCRA cap work together to provide long-term minimization of migration of liquids through the underlying soils, function with minimum maintenance, promote drainage, minimize erosion or abrasion of the cover, accomodate settling and subsidence such that the integrity of the cover is maintained, and have a permeability less than or equal to that of the natural subsoils.

The primary technical disadvantages of RCRA caps are the need for long-term maintenance and the uncertain design life. Although caps designed in accordance with RCRA standards are constructed to require minimum maintenance, they must be inspected periodically for signs of settling, ponding of liquids, erosion, and invasion of deep rooted vegetation. Damage to RCRA caps should be corrected as necessary to prevent minor problems from becoming more serious.

In addition to inspecting and maintaining the cap, the groundwater monitoring wells must be inspected, sampled, and maintained. If monitoring indicates that contaminants are migrating due to damage to the cap, partial or even complete cap replacement may be necessary. According to EPA (Ref. 1), caps designed with both a low permeability layer and a synthetic membrane may have a design life greater than 100 years if the wastes remain unsaturated, and if proper maintenance procedures are observed. Because some of the wastes at the 93rd Street School site are located beneath the groundwater table during most of the year, however, the design life of a cap at the site might be somewhat shorter.

In conclusion, because hybrid closure would be most desirable at the 93rd Street School site, the only cases for which a RCRA cap might be feasible would be if there were no acceptable treatment alternatives capable of reducing contamination in site soils to levels acceptable for hybrid closure, or if additional groundwater sampling during the design phase indicates the need for minimizing groundwater flow at the site.

2.1.1.2.2 Non-RCRA Caps

There are a variety of cap designs and capping materials which do not meet the RCRA standards. These would be appropriate for hybrid land disposal of treated 'hot spot' soils at the site or to minimize direct contact and inhalation risks associated with non-hot spot soils at the site.

Virtually impermeable, non-RCRA caps could be constructed by placing a single low permeability layer consisting of asphalt, concrete, or chemical stabilizers/sealants over the site. Low permeability soils or admixes would not be preferable because they are particularly subject to damage due to freeze/thaw cycles and drying related shrinking/cracking (Ref. 1). Asphalt and concrete caps, however, could be designed to accommodate some frost heaving and settling. Commercially available sealants could be used to prolong the design lives of these caps. Since at the present time significant groundwater contamination has not been identified at the site, it is not anticipated that these caps would be applicable for this site.

? Is it necessary

If groundwater contamination is not found during the sampling to be conducted during the remedial design phase, a low permeability soil cap could be used. Such a cap might consist of a layer of soil compacted and vegetated such that it is resistant to erosion, and graded to promote proper drainage.

2.1.1.3 ON-SITE DISPOSAL

There are many containment technology options for disposal of the contaminated soils from the 93rd Street School site immediately on-site or within the Love Canal Emergency Declaration Area including the following:

- Cut through the new Love Canal cap liner, deposit soils, and repair liner (i.e., disposal in an existing RCRA landfill).
- Construct a new RCRA landfill on top of the Love Canal cap or on the 93rd Street School grounds.
- Convert the 93rd Street School building into an interim storage facility (i.e., disposal in an existing structure).
- Construct a RCRA grade concrete vault* (Times Beach Design) on the 93rd Street School grounds or elsewhere within the EDA.

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* RCRA-grade storage facility (landfill or Times Beach Vault) will be double lined with a leachate collection system, a leak detection system, a cap, and a contingency plan in case of failure. The facility would meet RCRA criteria in all respects.

In summary, each of these alternatives would involve implementation of one of the following technologies: disposal of contaminated soils in an existing capped landfill, disposal in a newly constructed RCRA landfill, disposal in an existing structure or disposal in a newly constructed RCRA concrete storage vault. Brief descriptions of each of these technologies are presented in the following paragraphs.

Placement of the contaminated soils in the existing Love Canal containment area would probably only be desirable if treatment residuals for soils from the hot spot area defined in Figure 1 could not be disposed on-site or at an established hazardous waste landfill. Steps involved would include excavation and treatment of site soils, testing of treatment residuals, transportation to the capped Love Canal facility, removal of a portion of the Love Canal cap liner, placement of the 93rd Street School soils, and repair of the cap. This alternative would definitely not be preferable since opening of the Love Canal Cap would increase the potential for exposure of the environment to more hazardous materials than the tested residuals from the 93rd Street School site, and there may not physically be enough room for placement of the residuals beneath the existing cap.

Construction of a new earthen bermed RCRA landfill facility would involve excavation of soils followed by the steps listed below:

- Construct earthen berms
- Fine grade base
- Install bottom liner
- Place and compact clay layer
- Install leak detection system
- Install second synthetic liner
- Place granular material and piping for leachate collection system
- Deposit soils and decontaminate
- Construct a RCRA cap (as described previously)

This alternative would also be used only if treatment residuals from the hot spot area defined on Figure 1 could not be disposed on-site or at an established hazardous waste landfill.

If the earthen bermed facility were to be constructed on top of the Love Canal cap, a hole would have to be cut in the HDPE liner followed by welding of a new bottom liner to the HDPE liner. It should be noted that CH_2M Hill eliminated construction of an earthen berm on top of the Love Canal cap for the same reasons as described previously (Ref. 2). Construction of earthen berms at the 93rd Street School or inside the Love Canal fenceline, however, were considered to be technically feasible options by CH_2M Hill. These options might not be feasible for the 93rd Street School soils, however, since unless groundwater contamination is found during the remedial design phase, a simple cap would probably achieve the same degree of protection with lower costs and short-term risks.

Current EPA/RCRA guidance requires new landfills to have a double liner system and two leachate detection, collection and removal systems. An earthern berm could be constructed in accordance with this guidance to ensure that the liners are compatible with site and waste characteristics, that the foundation is stable, that direct contact between wastes and leachate and surrounding soils is prevented, and that the structure is inspected periodically to ensure adequate performance.

Leachate collection systems for new RCRA landfills consist of a drainage layer at least one foot thick composed of a soil with a hydraulic conductivity greater than or equal to 1×10^{-3} cm/sec and a minimum slope of two percent. This layer is placed directly above a secondary clay liner with a hydraulic conductivity of no more than 1×10^{-7} cm/sec. In addition, a filter is placed over the drainage layer to prevent infiltration of fines and subsequent clogging. Leachate collection pipe networks are designed in accordance with EPA guidance and more stringent state standards.

The primary RCRA landfill liner system can consist of a soil or a synthetic membrane. However, according to EPA, synthetic membranes are usually preferable for long term containment. There are many different synthetic membrane materials to choose from. For the 93rd Street School site, a synthetic membrane would have to be resistant to cold temperatures and soil organics and easy to seam and repair.

Soil should be placed and compacted in a landfill in a series of cells to prevent excessive quantities of rainfall from entering a single large cell. In addition, efforts to prevent run-on of rainwater would be required.

Following completion of placement of contaminated soils in an on-site landfill, the landfill would have to be closed in accordance with ARARs. This might necessitate placement of a RCRA cap as described previously.

During both the operating life of the landfill and the post-closure period, inspections would be required to ensure the proper operation of the water controls and cap integrity. In addition, a groundwater monitoring system consisting of a minimum of one upgradient and three downgradient wells would be necessary to ensure that the groundwater was not being contaminated. Typically EPA requires that these systems be sampled semi-annually and that samples be analyzed for site specific indicator parameters for a period of approximately 30 years.

It should be noted that potential technical disadvantages associated with construction of a landfill at the 93rd Street School site include the facts that the site has a relatively high groundwater table, and freeze/thaw effects may adversely affect the design life of an on-site landfill. Finally, it should also be noted that according to EPA (Ref. 1), on-site landfilling is not typically considered to be feasible unless one or more of the following conditions apply:

(1) There is so much waste to be disposed that costs of on-site disposal will be comparable to acceptable off-site disposal.

(2) Simple capping of the site will not provide adequate protection of human health and the environment; and

(3) On-site conditions will allow for the construction of a landfill that will protect human health and the environment.

Placement of the contaminated sediments from nearby creeks in the 93rd Street School was considered by CH_2M Hill (Ref. 2) in another study but was eliminated as an alternative due to the fact that the building was not designed to contain contaminated soils and use of it for this purpose would not be technically feasible. In addition, this option would not allow for reopening of the school.

Construction of a new Times Beach concrete vault facility would involve the following steps:

- Excavate soils and install synthetic membrane
- Place drainage gravel and geotextile layers
- Pour 8" reinforced concrete and coat with polymeric asphalt
- Place drainage gravel and geotextiles to act as a leachate collection system
- Similarly construct concrete sidewalls
- Deposit soils and decontaminate all contacted equipment
- Construct RCRA cap as described previously

CH_2M Hill considered this technology to be technically feasible if implemented at the 93rd Street School site or within the Love Canal fenceline. It was not considered feasible, however, for implementation at the LaSalle housing development due to time considerations related to procuring the property and conducting engineering studies (Ref. 2). As for the RCRA earthen bermed facility, construction of a concrete vault would probably not be necessary for disposal of the 93rd Street School soils since a cap would probably achieve virtually the same degree of protection at a lower cost and short-term risks.

2.1.1.4 OFF-SITE DISPOSAL

The principle technology available for off-site disposal of soils from the 93rd Street School site is land disposal at an EPA approved off-site landfill. Landfilling of soils off-site would make it necessary for the wastes to be handled in accordance with ARARs including the RCRA and more stringent state regulations. These regulations describe how to identify wastes as hazardous, how to manifest hazardous wastes, and how disposal facilities should be operated in accordance with RCRA regulations.

There are at least two hazardous waste landfills located near the Love Canal. These landfills are owned and operated by CECOS and SCA. Preliminary discussions with representatives of each of these facilities suggested that while they would not be willing or able to accept untreated soils from the site (primarily because of the dioxin hot spots), they might be willing to accept treated residuals.

2.1.2 TREATMENT TECHNOLOGIES

There are a variety of treatment technologies which could be used to treat the contaminated soils within the 'hot spot' area defined on Figure 1 in-situ, on-site, or off-site. Discussions of these treatment technologies are presented in the following sections.

2.1.2.1 IN-SITU TREATMENT TECHNOLOGIES

In-situ treatment technologies involve the use of biological or chemical agents or physical manipulation to degrade, remove, or immobilize contaminants. In the following sections, descriptions of biological, chemical and physical in-situ treatment technologies are presented.

2.1.2.1.1 BIORECLAMATION

In-situ bioreclamation technologies involve the use of biological agents to break down organic contaminants in soils. Typically, successful biological treatment requires that soil conditions be optimized to stimulate the growth of the particular microorganism(s) which are capable of breaking down the contaminants of concern. Either native micro-organisms or genetically engineered organisms may be introduced into the soil. If it is desired to degrade more than one contaminant compound, it may be necessary to treat the soil first under aerobic conditions then under anaerobic conditions or vice versa.

Factors which could affect the technical feasibility of biological in-situ treatment at the 93rd Street School site include the following:

- There are a broad range of organic and inorganic contaminants at the site even in the hot spot soils. Therefore it would be difficult to develop/isolate a group of micro-organisms capable of degrading and/or detoxifying all contaminants (particularly the inorganic metallic contaminants).
- Biological degradation of dioxin in natural soil systems has not been demonstrated effective and will probably not be possible for at least three years (Ref. 2) due to factors including isolation of an effective microbe, propagation of a large enough population of the microbe, provision of adequate nutrients, control of environmental factors, and achievement of adequate treatment in the low ppb range. Thus even if the majority of the contaminated soils could be treated by this technology, dioxin hot spots would have to be remediated by another method.
- The site is located in an area which has relatively cold winters. Thus during winter months, microbial activity would be inhibited. According to EPA, for every 10°C decrease in temperature below the optimum range of 20°-37°C, enzyme activity is halved (Ref. 1).
- The relatively low hydraulic conductivity of the native site soils might inhibit uniform distribution of microorganisms throughout the contaminated fill and therefore result in non-uniform levels of treatment across the site.

2.1.2.1.2 CHEMICAL TREATMENT

In-situ chemical treatment technologies are typically used to immobilize, mobilize for extraction, or detoxify organic or inorganic contaminants. Immobilization of contaminants can be achieved by introducing chemicals which are capable of precipitating, chelating, or polymerizing undesirable contaminants. These techniques can help prevent contaminants from leaching out of the soil matrix by rendering them insoluble.

Precipitation technologies are typically employed to render heavy metal contaminants insoluble. Chemicals commonly added to induce precipitation include sulfides, carbonates, phosphates and hydroxides. It should be noted that at the 93rd Street School, addition of phosphates would be undesirable due to the presence of arsenic which might be converted to arsenate and released from the soil matrix (Ref. 3). The pH and rate of addition of precipitating agents would have to be carefully controlled to ensure that complexes which were more mobile than the free metallic ions were not formed. The primary disadvantage of precipitation agent addition would be that the complexed metallic ions present in hot spot soils would achieve maximum precipitation over a wide range of pHs. Therefore, it would be difficult to precipitate/effectively immobilize all of the metals of concern at once.

Chelating technologies involve introduction of chelating agents which attach themselves with coordinate links to central metal ions to form heterocyclic rings. Some of these rings are relatively immobile because they are strongly sorbed to clay in soils.

Polymerization technologies are used to immobilize contaminants by trapping them in a gel-like mass. This technology involves injection of a catalyst into the groundwater to polymerize an organic monomer. Since organic monomers are not believed to be present in the 93rd Street School fill, this technology does not appear feasible.

In-situ chemical detoxification techniques include neutralization, hydrolysis, oxidation/reduction, enzymatic degradation, and permeable bed treatment. Neutralizing agents are added to soils to adjust the pH. Since the soil pH at the 93rd Street School is not perceived to be a problem, neutralizing agents are not required.

Hydrolysis typically involves the addition of a waterbase mixture to degrade compounds such as esters, amides, carbonates, organophosphorous compounds and some pesticides. Since the majority of these contaminants are not parameters of concern for the 93rd Street School soils, hydrolysis does not appear feasible.

Oxidation techniques involve introduction of oxidizing agents to reduce concentrations of lead and arsenic in soils or to detoxify organics such as benzene, phenols, nitro aromatics, PAHs, heterocyclic nitrogen and oxygen compounds, aldehydes, ketones, sulfides and disulfides. Use of oxidation to address the contamination in the soils at the 93rd Street School might prove difficult since no single oxidizing agent will address all of the contaminants present, and there is a potential for more toxic or mobile degradation products to form as a result of oxidation.

Reduction techniques involve the introduction of reducing agents such as ferrous sulfate to reduce hexavalent chrome to trivalent chrome or hexavalent selenium to tetravalent selenium. Since these metals are not parameters of concern in the soils at the site, reduction technologies are not considered feasible.

Enzymatic degradation involves use of enzyme extracts from microbial cells to detoxify wastes such as organophosphates and pestices (diazinon). Since this technology could only potentially be used to address a few of the contaminants at the site, it does not appear feasible.

Permeable treatment beds are excavated trenches filled with treatment materials through which groundwater will flow and be treated. Materials placed in these trenches typically include lime (for metals removal), activated carbon (for non-polar organics removal), and glauconitic greensand (for metals removal). The primary problem associated with use of permeable treatment beds at the 93rd Street School site is the fact that based on currently available data, the contaminants of concern are not leaching in significant quantities into the groundwater.

Four chemical treatment technologies which have been evaluated by others for remediation of dioxin contaminated soils include chemical degradation by chlorination, catalytic oxidation, chloroiodide degradation and dechlorination.

Chlorination involves the reaction of gaseous fuel materials with chlorine at high pressures (i.e. 200-700 atm) and temperatures (up to 800°C). This procedure has been used to treat liquid Agent Orange successfully, but information concerning treatment of dioxin in a soil matrix is not yet available.

Catalytic oxidation involves dissolving dioxin in a non-nucleophilic solvent and reacting it with ruthenium tetroxide. This procedure has been used in laboratory studies, but the high cost and high toxicity of ruthenium tetoxide make catalytic oxidation infeasible for full-scale operations (Ref. 2).

Chloroiodide degradation involves contacting contaminated media with chloroiodides in micellar solutions at ambient temperatures. Thus far, available literature indicates that this technology has only been used on a small scale in laboratory experiments.

Finally, dechlorination involves removal of chlorine atoms from dioxin molecules by introducing chemical reagents. Once the chlorine atoms are removed, the toxicity is reduced and the final product can be further treated or disposed. This process has been proven successful on liquid samples in laboratory experiments, however, testing with large scale contaminated soils has not been conducted.

2.1.2.1.3 PHYSICAL TREATMENT

Physical in-situ treatment technologies including in-situ heating, vitrification, and artificial ground freezing can be used to immobilize or detoxify waste constituents. Each of these technologies is described briefly in the following paragraphs.

In-situ heating technologies such as steam injection and radio frequency heating can be used to reduce the levels of some of the organic compounds in soils. These methods are not capable, however, of reducing the concentrations of metals and some complex organics. Thus in-situ heating does not appear to be a feasible technology for treatment of the site soils.

Artificial ground freezing involves use of freezing plates to immobilize soil contaminants. According to EPA, (Ref. 1) the high cost of operating the soil freezing apparatus renders this technology effective only as a temporary remedy.

In-situ vitrification (ISV) is a thermal treatment process in which contaminated soils are converted into a chemically inert glass and crystalline product resembling natural obsidian. This product is capable of retaining its physical and chemical integrity over geologic time periods. The ISV process involves placement of four electrodes in a soil mass through which an electric current can be passed. When the current is applied, the adjacent soils are heated to temperatures of up to 3600°F. As a result, soils and rocks melt while other inorganic materials such as metals are encapsulated in the vitrified mass. Organic materials in the soil pyrolze, diffuse to the soil surface, and combust as a result of the temperature increase. Therefore, to prevent air pollution, a hood is placed over the processing area to collect off gases. These off gases are then treated (i.e., cooled, scrubbed, sorbed, and heated) in a system which includes a glycol gas cooler, a wet scrubber, a heater, a charcoal filter assembly and a blower system.

Bench and engineering scale testing of the ISV process on soils contaminated with cyanides, heavy metals (including cadmium, lead and cobalt), and various organics (including dioxin) have been performed. Results of these tests are as follows:

- TCLP and EP toxicity testing of treatment residuals from soils contaminated with inorganics have indicated that the final product can be delisted.
- Dioxin treatment efficiencies of 99.999 percent have been achieved in bench scale testing.

It should be noted, however, that Battelle Pacific Northwest Laboratories claims that information on the use of ISV to treat soils contaminated with dioxin and low boiling point organics is very limited. Therefore, feasibility studies involving the soils from the 93rd Street School site would be required if this technology were selected.

Finally, it should also be noted that there are some significant disadvantages associated with the ISV process including the fact that according to EPA (Ref. 4), the Battelle ISV system "...is best suited where processing at depths of greater than approximately ten feet is required. If contamination is near the surface (as is the case at the 93rd Street School), it would be more economical to remove the soil and stage it in a deeper trench for ISV processing." In addition, this process becomes very costly when the soil moisture content is high. Because of the high groundwater table at the 93rd Street School site, it is anticipated that the soil moisture content would be very high if in-situ vitrification were attempted. In conclusion, ISV would not be technically feasible for in-situ treatment of soils at the 93rd Street

School site primarily due to the fact that the contaminated soils are situated at shallow depths of less than 10 feet below the ground surface and the groundwater table is relatively high. Vitrification might be feasible, if the soils were removed, dried, and placed in deeper trenches elsewhere within the EDA. However, procurement of a site for vitrification of the materials might prolong the remediation process.

2.1.2.2 ON-SITE STABILIZATION/SOLIDIFICATION TECHNOLOGIES

Stabilization and solidification technologies are used to improve waste handling characteristics, to decrease the surface area from which contaminants may leach, and to limit the solubility or toxicity of certain contaminants. Stabilization/solidification technologies including cement based solidification, silicate based solidification, sorbent addition, thermoplastic solidification, and surface microencapsulation are described in the following sections.

2.1.2.2.1 CEMENT BASED SOLIDIFICATION

Cement based solidification is a technology in which wastes are mixed with Portland cement to form a solid or crumbly soil-like mass. The consistency of the final product is dependent upon the original waste characteristics and the quantity of cement added. Metals are typically immobilized because of the high pH of the cement mixture which leads to the formation of insoluble metal hydroxides or carbonates.

Potential problems associated with implementating conventional cement based solidification at the 93rd Street School site are that the organic contaminants would not be immobilized; the volume and weight of the wastes could increase by as much as 100 percent (although this is not always the case); and the presence of silt, clay and organic matter could potentially interfere with the curing of the cement waste mixture.

2.1.2.2.2 SILICATE BASED SOLIDIFICATION/STABILIZATION

Silicate based solidification/stabilization is performed by adding a silicate material (such as fly ash, blast furnace slag, soluble silicates or other pozzolanic materials) and lime, cement, gypsum or other setting agents to the waste. Addition of these materials along with a variety of proprietary additives, such as surfactants and emulisifiers can result in the stabilization of a broad range of contaminants including divalent metals, oils, and organic solvents. Stabilization occurs when the silicate reacts with polyvalent metal ions in the waste or in an additive thereby forming a solid mass which can vary in consistency from a moist cohesive clay-like material to a material resembling concrete. A number of processes have been developed which are capable of stabilizing wastes contaminated with both metals and organics. These processes include a process developed by Hazcon, Inc., a process developed by Soliditech, Inc. and the Chemfix process developed by Chemfix Technologies, Inc.

Hazcon, Inc. has developed a process in which a proprietary polymer based formula is mixed with a waste and a pozzolanic material. The resulting product is a hardened, leach resistant mass that can typically be landfilled. If organics are present in the waste, a reagent called Chloranan can be added during mixing to coat the organic molecules thereby preventing them from inhibiting the normal crystalization of the pozzolanic material. Once mixed, the resulting slurry can then be pumped or poured into the ground prior to setting. Volume changes as a result of this process are typically in the range of a 30 to 70 percent increase. Currently available data indicates that this process is effective for immobilizing heavy metals and organics, and testing of treatment residuals has indicated that it is possible to meet delisting requirements for many wastes. No large scale testing data is currently available, however, for the treatment of wastes contaminated with VOCs, PAHs or dioxin. Therefore, a feasibility study involving wastes from the site should be conducted prior to implementation of this technology.

Soliditech, Inc. has developed a similar process in which contaminated wastes can be chemically stabilized/solidified as a result of mixing with pozzolanic agents, water and liquid reagents including URRICHEM. Advantages of this technology are the facts that the mixer can be equipped to control volatile emissions, the manufacturer believes that it is capable of addressing all of the contaminants in the 93rd Street School soils and that it is likely that the final product following treatment would be delistable.

Chemfix Technologies, Inc. has developed a process in which soluble silicates, setting agents, and additives are mixed with wastes in proportions which vary depending upon the contamination. Each waste to be treated is first subjected to bench scale testing in Chemfix's labs to determine the types and quantities of additives required. Once this testing is completed and appprovals are obtained, remediation in the field can be initiated. In the field, this treatment process involves excavation of contaminated soils followed by pulverization and slurrying and then feeding into the treatment system which consists of a dry reagent silo, a liquid reagent tank, a pubmill, load cells, skids and associated motor controls and instrumentation. Reactions which occur as the waste is mixed with the necessary additivies include the precipitation of amorphous colloidal silicates, precipitation of metals within the physical structure of the silicate colloids, water hydrolysis and water hydration. As a result of these reactions, most heavy metals become part of the complex silicates while water, organics (including PNA's and dioxin according to Chemfix) and small quantities of heavy metals are immobilized between the complex silicates. Treatment residuals are tested on a daily basis, and materials not meeting treatment criteria are reprocessed. The final product from this process resembles a stabilized clay-like soil. Current data indicates that it is likely that this process could be used to treat the 93rd Street School site soils resulting in a delistable product capable of passing the TCLP test for dioxin.

Technological drawbacks of the silicate based solidification technologies include the facts that a number of waste constituents may inhibit the stabilization and/or solidification efficiencies of the additives, and large amounts of water often leach from the solidified mass following treatment. This water sometimes contains contaminants thus secondary containment may be required following treatment. Preliminary discussions with Chemfix representatives indicate that secondary containment of residuals treated by the process would probably not be necessary in the case of the 93rd Street School soils.

2.1.2.2.3 SORBENT ADDITION

Natural or synthetic sorbent materials are sometimes added to wastes to eliminate free liquids and to improve handling characteristics. Absorbent materials typically used include fly ash, kiln dust, vermiculite, bentonite, activated carbon, and synthetic sorbents designed to sorb specific types of contaminants such as volatile organics.

Disadvantages of sorbent addition include the fact that waste volume may increase, not all contaminants can be addressed, and secondary containment would almost definitely be required following treatment.

2.1.2.2.4 THERMOPLASTIC SOLIDIFICATION

Thermoplastic solidification technologies involve drying, heating, and dispensing a waste through a heated matrix such as asphalt bitumen, paraffin, or polyethylene. Asphalt is typically used for wastes containing heavy metals to form a solid.

Waste Chem Corporation has developed a mobile volume reduction and solidification system in which wastes are fed simultaneously with asphalt or plastic into a heated extruder/evaporator. As a result, free water and VOC's evaporate while other contaminants are immobilized in the asphalt or plastic waste mixture. The mixture is discharged from the unit in liquid form and then hardens to form a free-standing solidified mass at ambient temperatures. To prevent air pollution, the evaporated VOC's and water vapor are condensed and treated via carbon adsorption and HEPA filters. This process has been proven effective for the immobilization of heavy metals and PNAs in refining sludges. However, there has been little or no experience in treating soils contaminated with VOC's, pesticides, or dioxin according to the manufacturer.

Advantages of thermoplastic solidification over cement based processes include the facts that the volume increase and rate of leaching are typically reduced. Solidifying soils which contain organics in addition to metals can be complicated, however, since the organics tend to soften the asphalt and diffuse through it. In addition, because of the plasticity of and potential for leaching from the final waste mixture following treatment, secondary containment of the final product is typically required.

2.1.2.2.5 SURFACE MICROENCAPSULATION

There have been a number of technologies developed to microencapsulate waste by sealing them in a binder. These technologies can be used to completely isolate wastes from leaching solutions as well as from direct air and surface water contact which could lead to off-site migration of contaminants. Typically these technologies are employed when wastes are going to be stored, then transported and disposed at an off-site location. This results in efficient space utilization, elimination of the potential for spills, and waste in a form which is better able to withstand the physical and chemical stresses that may be posed during disposal.

2.1.2.3 ON-SITE THERMAL TREATMENT TECHNOLOGIES

A variety of transportable thermal destruction units have been developed in recent years to destroy hazardous wastes. Typically, these units are designed such that they are very similar to fixed thermal treatment units which use high temperatures to degrade organic compounds in hazardous wastes into a variety of gaseous and solid by-products. Most of the mobile thermal treatment units are equipped with various combinations of the following components:

- Waste storage container(s)
- Waste sorting devices
- Waste drying devices
- Waste feed system
- Fuel or thermal energy introduction systems
- Primary thermal treatment tank(s)
- Secondary thermal treatment after burner(s)
- Ash collection system(s)
- Air pollution control system(s)

Following treatment, the resulting ash byproduct must typically be delisted as a hazardous waste if non-RCRA disposal methods are desired because of the potential presence of residual organics and heavy metals.

It should be noted that if the dioxin hot spot soils were to be incinerated/thermally treated, the selected technology would have to be capable of achieving 99.9999 percent removal efficiency per EPA regulations. Typically, to achieve this removal efficiency, the dioxin must first be vaporized at a temperature in the range of 1300°F to 1800°F and then destroyed at a temperature greater than 2200°F (Ref. 2).

Brief descriptions of mobile thermal destruction units which could be used at the 93rd Street School site are presented in the following sections.

2.1.2.3.1 MOBILE ROTARY KILN INCINERATION

Rotary kiln incinerators have been proven effective for thermal destruction of liquid and solid hazardous wastes. Typically, a rotary kiln incinerator consists of the following components: Waste storage hopper, primary rotary kiln chamber, secondary afterburner chamber, flue gas scrubbing system and ash removal system. Wastes are fed from the storage hopper into the rotary kiln which has been heated by combustion of fuel. The rotary kiln rotates constantly to ensure effective heat transfer efficiency. During heating, organics from the waste volatilize, and are heated further in the secondary afterburner chamber while the solid residual ash is removed. Following destruction in the afterburner, the residual gases are passed through a flue gas scrubber system which removes air pollutants.

There are a number of mobile rotary kiln incinerators either currently available or being developed. According to EPA (Ref. 4), these include units manufactured by the following companies:

- ENSCO/PYROTECH
- DETOXCO (not yet built)
- EPA MOBILE UNIT (fabricated by DETOXCO)
- PEDCO(has built cascading rotary incinerators which are a variation of rotary kiln incinerators).
- FULLER POWER CORP. (not yet built)

Because the soils from the 93rd Street School which are being addressed by this feasibility study would contain low levels of dioxin, low levels of alpha and beta BHC, and no PCB's, it is presumed that ~~any~~ most of the above units would be capable of addressing the organic contaminants in soils from the site. They might not, however, address the heavy metals contamination. Depending on the operation temperatures, it is anticipated that some metals would be volatilized and present in the residual gases while others would be present in the ash. This might make delisting the ash difficult. In addition, removal of volatilized metals from the residual gases might prove difficult because of the extremely small sizes of the metals present as a vapor. Another potential disadvantage of these technologies is that since the contaminated fill materials have relatively high moisture contents because of the groundwater table, thermal efficiencies and feed rates might be relatively low without prior soil drying. Based on estimates provided by CH_2M Hill (Ref. 2), incineration of a minimum of 7,500 cubic yds. of soils from the 93rd Street School site might take up to years (using the EPA Mobile incinerator to treat a soil with a moisture content of 50%, and including time allowances for design, regulatory approval, mobilization and demobilization).

2.1.2.3.2 CIRCULATING BED COMBUSTION INCINERATION

A Circulating Bed Combustion (CBC) incinerator is a variation of a fluidized bed incinerator in which the fluidized bed operates at higher velocities and is recirculated. Conventional fluidized bed incinerators consist of a single chamber which contains a bed of inert granular material on top of a perforated metal plate. Hot air is introduced from beneath the plate, and it rises up through the plate and into the inert granular material. As a result of this hot air flow, the bed becomes fluidized (i.e., it mixes turbulently). Waste material is introduced into the bed and is combusted at temperatures typically ranging from 1400-1600°F. Air pollution controls are used to treat the resulting flue gases.

According to EPA (Ref. 4), Mobile CBC incinerators have been developed by Ogden Environmental Services. These units have been demonstrated effective in treating wastes containing high levels of PCBs and trichlorobenzene and have been approved for use by EPA in treating PCB contaminated soils. The feed rates of existing units are similar to those for the mobile rotary kiln incinerators described previously. Therefore it is presumed that total times required for treatment would be similar. In addition it is anticipated that similar problems related to waste moisture content, metal vapors in the residual off-gases and residual ash delisting would be demonstrated by the mobile CBC.

2.1.2.3.3 ADVANCED ELECTRICAL REACTORS

Advanced electric reactors (AERs) destroy organics in solid wastes by pyrolysis. These reactors typically consist of the following components: solids preparation systems (to reduce moisture content to below 3 percent), feed systems, a reactor chamber, two post reactor zones and air pollution controls. Feed rates for AERs can vary significantly. Relatively efficient units include an existing unit manufactured by J.M. Huber capable of processing 1.5 tons per hour of soil at 20 percent moisture content, and a unit owned by Westinghouse capable of processing up to 35 tons per/day (i.e., 1.5 tons per hour). Utilizing either of these units would result in a total treatment time similar to that for a mobile rotary kiln or CBC unit as described previously. It is anticipated that residual ash delisting might be difficult since metals would not be destroyed but instead would be present in a glass matrix. In addition, J.M. Huber is not currently accepting toxic or hazardous wastes at its facilities.

2.1.2.3.4 INFRARED FURNACES

According to EPA, Shirco Infrared Systems has developed small mobile infrared furnaces capable of handling 100 lbs/hr or larger units capable of handling 5 to 8 tons/hr of contaminated soils. The smaller units (100 lbs/hr) would probably not be feasible for use on the 93rd Street School soils due to the time it would take to process a minimum of 7,500 cu. yd. of soil. The larger unit, however would be feasible in terms of implementation time. It should be noted that the smaller units have been demonstrated effective for treating soils contaminated with creosote, penta-chlorophenol and dioxin. It is anticipated that some metals would volatilize and others would remain in the ash thus making it necessary to prevent air pollution and possibly difficult to delist the ash residue.

2.1.2.3.5 PLASMA ARC PYROLYSIS

Plasma arc pyrolysis involves use of a gas which has been energized to its plasma state by an electrical discharge to pyrolyze liquid and organic solid wastes. Existing mobile units manufactured by Westinghouse Plasma Systems have been proven successful in treating a variety of organic liquids and sludges. They are not, however, applicable for thermal destruction of organics in a soil matrix. Westinghouse Plasma Systems recently developed an electric pyrolyzer capable of handling 5 tons/day of soil at 20% moisture content (Ref. 4). However, test burn data for contaminated soils is not yet available.

2.1.2.3.6 HIGH TEMPERATURE FLUID WALL REACTORS

High temperature fluid wall (HTFW) reactors consist of a porous cylindrical core of refractor material in which the waste is placed. Infrared radiation is supplied to the core by electrodes on the reactor vessel jacket. An inert gas is drawn through the core during thermal treatment to prevent damage to the core due to contact with the waste which may be heated to 4000°F. Wastes are heated rapidly and completely in the core to ensure high thermal destruction efficiency.

According to EPA (Ref. 4), Thagard Research Corporation has developed a mobile HTFW reactor capable of handling 1.5 to 2.0 tons/day of soil at 20 percent moisture content. Use of this unit is similar to the mobile AER's owned by J.M. Huber Corporation. Feed materials must be finely ground prior to treatment, and metals are encapsulated in a glass-like waste which may be difficult to delist. Testing of this unit with soils contaminated with 80 ppb of dioxin at Times Beach, Missouri resulted in a final product with a dioxin concentration of less than 0.1 ppb. (Ref. 2).

2.1.2.4 OFF-SITE THERMAL TREATMENT

There are many different types of fixed thermal treatment units which are capable of destroying organic contaminants in soils. CH_2M Hill investigated the feasibility of building a fixed thermal treatment facility at Love Canal and determined that this would only be feasible if the quantity of sediments to be treated would exceed 100,000 cu. yds. (Ref. 2). Since the proposed quantity of soil to be treated at the 93rd Street School site is much less than 100,000 cy. yds., construction of a fixed thermal treatment facility at the site would not be feasible.

As for the mobile units described previously, it is anticipated that the metals concentrations in the ash from fixed thermal destruction facilities might inhibit delisting without additional treatment. However, in the following sections, brief descriptions of existing fixed off-site thermal treatment facilities are presented.

2.1.2.4.1 OFF-SITE ROTARY KILN INCINERATION

Off-site rotary kiln incinerators would operate in a manner essentially the same as described for mobile rotary kiln incinerators. In an assessment of fixed off-site rotary kiln incinerators to be used for creek and sewer sediments, CH_2M Hill and EPA evaluated the following facilities (Ref. 2):

- Rollins Incinerator; Deer Park, Texas
- SCA Chemical Services Incinerator; Chicago, Illinois
- ENSCO Incinerator; El Dorado, Arkansas
- Pyrochem Co. Incinerator; Coffeville, Kansas

None of these facilities is currently permitted or certified to treat dioxin contaminated wastes. Because these facilities are located relatively far away from the site, they were determined to be unlikely alternatives for treatment of the 93rd Street School soils particularly since similar degrees of treatment could be achieved on-site with a mobile unit without the additional transportation costs and associated risks.

2.1.2.4.2 OTHER FIXED OFF-SITE TECHNOLOGIES

In addition to rotary kiln incinerator facilities, there are off-site facilities using thermal destruction technologies not currently available in transportable units. Brief descriptions of thermal treatment technologies which were not described previously are presented in the following paragraphs.

A multiple hearth incinerator consists of a waste feed system, a combustion chamber with a series of flat hearths encircling a central rotating shaft, an air blower, a central ash removal system, fuel burners and a flue gas scrubber system. Solid wastes can be treated in these incinerators at temperatures ranging from 1400° to 1800° F following removal or pulverization of larger particles. These incinerators tend to have high fuel efficiency and an ability to evaporate large quantities of water. Disadvantages of these incinerators, however, include the facts that heat transfer is not as complete as in rotary kilns, metals may be present as a vapor in the residual gases and in the ash, and wastes containing ash (such as the fill materials from the 93rd Street School site) often form solid masses in the incinerators which are difficult to remove.

Molten salt incinerators maintain salt baths at temperatures of approximately 1400 to 1800°F. Wastes which are placed in the molten salt undergo catalytic destruction. Hot gases resulting from this thermal destruction are passed through a secondary reaction zone and then through an air pollution control system. These incinerators have been proven capable of handling solid wastes and destroying complex organics including 2,4-D chlordane, chloroform, PCB's, trichloroethane, and more than 99.9999 percent decomposition has been achieved (Ref. 2). Disadvantages of these incinerators, however, include sensitivity to wastes with high ash content, disposal problems associated with spent molten salt, potential buildup of arsenic salts and the fact that as of 1985, no units were known to be in commercial use (Ref. 2).

Wet air oxidation systems involve destruction of organic compounds in an aqueous matrix by introducing the waste and oxygen into a relatively high temperature (150°-350°C) and high pressure (500-2500 psig) reaction vessel. This technology has been applied commercially to sludges and pulps, but research in the application of this technology to soil treatment is necessary particularly for treatment of organics which are strongly linked to soils. It is anticipated that use of this technology for soils would require that the soils be pulverized, mixed into a slurry, and then mixed with a fuel source. No data on treatment of dioxin contaminated soils by this technology was available.

Supercritical water oxidation processes use air or oxygen above their critical temperature and pressure (i.e., 374°C and 218 atm) to thermally destroy organics. Wastes are slurried, pressurized and mixed with a base then introduced into the reaction chamber. By-products generated include salts, water, CO_2, inert materials, and traces of organics. Based on information from CH_2M Hill, no commercial units were using this technology for treatment of contaminated soils as of 1985, and additional research on treatment of dioxin contaminated soils is necessary (Ref. 2).

At-sea incineration has typically been used to thermally destroy toxic liquid hazardous wastes in a liquid injection incineration unit. Wastes which have been incinerated at sea include toxic organochloride compounds, herbicides, and Agent Orange (Ref. 1). Problems associated with this process include dangers of spills, difficulty of monitoring and the fact that soils are not typically treated at-sea.

Finally, coincineration involves the use of combustible wastes in boilers or other incinerators as fuels. Energy from the waste is used both to destroy waste organics and to generate energy. Disadvantages of this technology for the 93rd Street School soils include the fact that they have low fuel value and that they could potentially damage a boiler system.

2.1.3 ASSOCIATED CONTROL TECHNOLOGIES

During implementation of remedial actions at the 93rd Street School site, it may be necessary to employ temporary control technologies to minimize air pollution, surface water pollution, and direct contact risks. These temporary control technologies are described in the following paragraphs.

2.1.3.1 AIR POLLUTION CONTROLS

If soils are to be excavated during remediation of the site, it ~~will probably~~ may be necessary to temporarily store these soils on-site prior to treatment, destruction, or disposal. To minimize the effects of air pollution resulting from emissions of volatiles or particulates, a number of control technologies may be employed. These technologies include construction of temporary caps and/or covers and use of dust control chemicals and/or equipment. These control technologies are described in the following paragraphs.

2.1.3.1.1 TEMPORARY CAPPING/CONTAINMENT

Procedures for placement and maintenance of long-term caps as remedial action technologies were described previously in this section. Short-term containment of wastes to prevent air pollution could be accomplished by covering waste piles with plastic sheeting, foam or other durable plastic or fabric; or by placing wastes inside a temporary storage container or inside a temporary storage facility. The feasibility of each of these options would depend upon the length of time for which storage was required.

2.1.3.1.2 DUST CONTROLS

Dust control technologies can be used to prevent contaminated particles from becoming airborne. Controls typically used include chemical dust suppressants, wind screens, water spraying and synthetic covers.

Chemical dust suppresants such as resins, bituminous materials and polymers can be used to temporarily strengthen the bonds between soil particles. These suppresants are typically applied from a wagon equipped with a water supply and spray system. While these technologies are typically reliable for short-term control (they can be very effective for periods up to 4 weeks (Ref. 1)), the length of time for which they are effective is affected by the frequency of soil disturbances due to heavy rains, traffic and plant growth. The primary disadvantages of this control technology are the potential for secondary contamination of soil and groundwater and modification of the waste in ways which will adversely affect its treatability or stability.

Windscreens are inexpensive screens which can be set up around an area being excavated or around a waste pile to control the wind velocity so that fewer particles become airborne. The primary drawback of these screens is that they are only partially effective in controlling inhalable sized particulate emissions.

Water spraying can be a very effective method for controlling dust emissions from waste piles, areas actively being excavated, and from uncovered containment vessels. Water must be reapplied relatively frequently to maintain effectiveness. The frequency of reapplication is controlled by factors such as humidity, temperature, and traffic level.

Finally, a number of other dust suppression techniques including maintaining proper slope and orientation of waste piles during excavation and covering waste piles with synthetic covers secured with tension cables can be used to minimize air pollution during site remediation.

2.1.3.2 SURFACE WATER CONTROLS

Surface water controls may be necessary during site remediation to prevent run-on and intercept runoff, to prevent infiltration, and to control site erosion. The technologies available for controlling surface waters include capping, regrading, revegetation, and construction of dikes/berms, channels/waterways, and terraces or benches. Capping controls were discussed previously in Section 2.1.1.2; therefore descriptions of the other surface water control technologies are presented in the following paragraphs.

2.1.3.2.1 REGRADING

Grading is typically performed in conjunction with capping activities to shape the surface of the cap so that surface water infiltration is minimized, runoff velocities are reduced, erosion is minimized, and surface soils are roughened and loosened for revegetation. Grading can be performed with conventional construction equipment. Cover materials for the 93rd Street School site could probably be obtained from a local supplier. Even if RCRA capping procedures were not going to be implemented, grading of a new soil cover could be used to significantly reduce the risk of exposure of wastes to surface water and humans and other life forms. However, long term monitoring and maintenance would have to be carefully and consistently performed to ensure that wastes did not become exposed due to erosion or begin leaching contamination into surface water runoff or groundwater.

2.1.3.2.2 REVEGETATION

Revegetation operations are typically performed following grading operations to decrease the risk of erosion caused by wind and surface water runoff and to increase the stability of surface soils. Activities typically performed in the revegetation process include selection of a suitable plant species, seed bed preparation, seeding/planting, mulching or chemical stablilzation, and fertilization and maintenance. Generally, revegetation is a relatively inexpensive method for controlling erosion. Plant species such as some forms of grasses can be selected which require very little maintenance. Over the long-term, however, some maintenance activities may be required including application of lime and/or fertilizer, replanting, and regrading.

2.1.3.2.3 DIKES AND BERMS

Dikes and berms are temporarily compacted earthen ridges or ledges constructed up-slope from or along the perimeter of contaminated areas. The primary purpose of these structures is to provide short-term protection (usually less than 1 year (Ref. 1)) of contaminated areas by intercepting and diverting runoff to drainage ways. Dikes and berms can also be used during excavation and removal operations to isolate contaminated soils temporarily stored on-site. The primary disadvantage of these structures at contaminated sites is that some of the soil may become contaminated due to contact with the waste. In addition, analysis of the soils may be required prior to removal.

2.1.3.2.4 CHANNELS AND WATERWAYS

Channels are ditches excavated at a site to collect and transfer runoff. They vary in cross section and construction. These channels can be stabilized with vegetation or rip-rap to increase design life.

Diversions are earthen channels excavated along the contours of a graded slope with a supporting earthen ridge constructed on the down slope edge of the channel.

Swales are channels with less steep side slopes and vegetation placed upon the perimeter of a site to prevent off-site runoff from entering the site or adjacent to landfills to transport surface runoff.

Pipes constructed of corrugated metal can be cut in half and used as channels. One or more of the above surface water controls may be desirable if wastes are to remain on-site permanently or if wastes will be excavated and temporary measures will be required to divert surface water runoff from entering the site. Whatever structure is used, it must be designed with sufficient capacity, and the ability to prevent excessive velocity of flow. Maintenance of vegetated channels will be required to maintain the cover crop.

2.1.3.2.5 TERRACES AND BENCHES

These structures can be employed for long-term erosion protection on slopes of covered landfills. They would only be considered for use at the 93rd Street School site if the site were to be capped in accordance with RCRA regulations or if an on-site landfill were to be constructed.

2.1.3.3 DIRECT CONTACT CONTROLS

Direct contact controls may be necessary at the site to prevent workers and the public from coming into direct contact with contaminated soils. Workers should be given protective clothing and decontamination equipment so that they will not ingest, inhale or come into direct eye or skin contact with contaminants on their clothing or equipment. Measures to prevent non-workers from coming into direct contact with contaminated soils include keeping the school closed until remedial actions have been completed and preventing access to the site prior to and during remedial action implementation with fences, signs and/or 24 hour security.

2.2 TECHNOLOGY SCREENING

Remedial action technologies which are not technically feasible based on compatibility with site and waste characteristics, which are not consistent with the objectives of remedial action, or which are extremely difficult to implement must be eliminated prior to development of potential remedial action alternatives. Therefore, the following sections summarize site, waste, and implementation criteria which affect technology feasibility. At the end of this section, a table summarizing all technologies, their status (i.e., whether or not they will be considered further) and comments describing why certain technologies were eliminated is presented.

2.2.1 COMPATIBILITY WITH SITE CHARACTERISTICS

There are a variety of site characteristics at the 93rd Street School site which could potentially affect the technical feasibility of the remedial action technologies discussed previously. These characteristics include the volume of waste affected (7,500 cu. yd.); the site configuration including the location of the school, adjacent creeks, and adjacent properties; the relatively cold climate and moderate precipitation; the relatively low soil permeability; the relatively high soil moisture; the topography at the site; the position of the existing drainage swale; the degree of contamination; the relatively slow rate of groundwater flow; and the groundwater contours. These site characteristics were addressed in Volume I-Remedial Investigation Summary and have been mentioned throughout the descriptions of potential remedial action technologies where they were believed to have a potential impact on the technical feasibility of a particular technology.

2.2.2 COMPATIBILITY WITH WASTE CHARACTERISTICS

There are a variety of waste characteristics at the 93rd Street School Site which could potentially affect the technical feasibility of the remedial action technologies discussed previously. These characteristics include the following:

- quantity and variety of chemical contaminants
- concentrations of contaminants
- toxicity of contaminants
- solubility of wastes
- volatility of wastes
- treatability of wastes

Waste characteristics were addressed in detail in Volume I - Remedial Investigation Summary for the site. These characteristics have been mentioned throughout the descriptions of potential remedial action technologies where they had a significant impact on the determination of the technical feasibility of a particular technology.

2.2.3 OTHER TECHNOLOGY LIMITATIONS

Technologies which are in the development stages and are not anticipated to be usable for treatment of contaminated soil within a reasonable time period were eliminated.

2.2.4 CONCLUSIONS

Table 2-1 on the following pages summarizes all remedial action technologies presented in this report, the status of each technology (i.e., Eliminated, or To Be Considered) with regard to further consideration during development of preliminary alternatives, and brief explanations describing why technologies which will not be considered further were eliminated.

TABLE 2-1 SUMMARY OF RESULTS OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES

REMEDIAL ACTION TECHNOLOGIES EVALUATED	STATUS	COMMENTS
I. CONTAINMENT		
A. Capping		
1. RCRA Cap	Eliminated	Treatment residuals will be delistable.
2. Non-RCRA Cap	To be Considered	
B. On-site Disposal		
1. Beneath Love Canal Cap	Eliminated	Treatment residuals will be delistable/Could pose unnecessary risks.
2. RCRA Landfill		
a. On Love Canal Cap	Eliminated	Treatment residuals will be delistable/Could pose unnecessary risks.
b. At 93rd St. School	Eliminated	Treatment residuals will be delistable.
3. Dispose in 93rd St. School	Eliminated	Building not suitable for use as storage facility.
4. Dispose in RCRA Concrete Vault		
a. At 93rd St. School	Eliminated	Treatment residuals will be delistable.
b. Elsewhere within EDA	Eliminated	Treatment residuals will be delistable.
C. Off-site Landfill Disposal	To be Considered	
II. TREATMENT		
A. In-situ		
1. Bioreclaimation	Eliminated	Will not adequately address all site contaminants.
2. Chemical		
a. Precipitation	Eliminated	Only addresses metal contaminants.
b. Chelation	Eliminated	Only addresses metal contaminants.
c. Polymerization	Eliminated	Organic Monomers not significant problem at site.
d. Neutralization	Eliminated	Soil pH adjustment not required.
e. Hydrolysis	Eliminated	Addresses contaminants which are not significant problem at site.
f. Oxidation	Eliminated	Successful implementation extremely difficult.
g. Reduction	Eliminated	Typically used for contamination not present at site.
h. Enzymatic Degradation	Eliminated	Typically used for contamination not present at site.

TABLE 2-1 SUMMARY OF RESULTS OF PRELIMINARY SCREENING OF REMEDIAL ACTION TECHNOLOGIES (Continued)

REMEDIAL ACTION TECHNOLOGIES EVALUATED	STATUS	COMMENTS
II. TREATMENT (Continued)		
i. Permeable Treatment Beds	Eliminated	Groundwater contamination not identified.
j. Chlorination	Eliminated	Not demonstrated effective for soil treatment.
k. Catalytic Oxidation	Eliminated	Toxicity of ruthenium tetroxide limits use.
l. Chloroiodide Degradation	Eliminated	Not demonstrated effective in large scale soil cleanup.
m. Dechlorination	Eliminated	Not demonstrated effective in large scale soil cleanup.
3. Physical		
a. In-situ heating	Eliminated	Will not result in delistable waste.
b. Artificial Ground Freezing	Eliminated	Temporarily isolates but does not treat wastes.
c. Vitrification		
i. In-situ	Eliminated	Groundwater table and waste depth unfavorable.
ii. Elsewhere within EDA	To Be Considered	
B. On-Site Stabilization/Solidification		
1. Cement Based Solidification	Eliminated	Will not result in delistable waste.
2. Silicate Based Solidification/ Stabilization	To Be Considered	
3. Sorbent Addition	Eliminated	Will not result in delistable waste.
4. Thermoplastic Solidification	To Be Considered	
5. Surface Microencapsulation	To Be Considered	
C. On-Site Thermal Treatment		
1. At 93rd St. School Site	To Be Considered	
2. At Love Canal	To Be Considered	
D. Fixed Off-Site Thermal Treatment	Eliminated	Facilities unable or unwilling to accept wastes.
III. NO ACTION	To Be Considered	

3.0 DEVELOPMENT AND SCREENING OF PRELIMINARY REMEDIAL ACTION TECHNOLOGIES ACTION ALTERNATIVES

The purpose of this section is to develop a number of preliminary remedial action alternatives by combining the remedial action containment and treatment technologies which were not eliminated in the previous section. Each of these alternatives as well as a "no action" alternative will be described briefly and then evaluated in terms of their overall effectiveness in minimizing threats to human health and the environment, their technical feasibility and cost. A table is presented at the end of this section which summarizes all preliminary alternatives considered, their status regarding further consideration, and reasons for eliminating those alternatives which will not be evaluated further.

3.1 DEVELOPMENT OF PRELIMINARY ALTERNATIVES

In the following sections, preliminary alternatives are developed and evaluated in accordance with current EPA guidance.

3.1.1 THE NO ACTION ALTERNATIVE

The no action alternative would involve leaving the wastes at the 93rd Street School site undisturbed and performing periodic monitoring of the groundwater, surface water, and air as well as simple site maintenance tasks including pavement and vegetative cover maintenance. No treatment orcontainment technologies would be implemented unless monitoring indicated a change in site characteristics resulting in increased public health and environmental risks.

3.1.2 CONTAINMENT ALTERNATIVES

Containment technologies which passed preliminary screening include construction of a low permeability cap on-site, and removal of hot spot soils followed by disposal at an off-site RCRA landfill. Preliminary containment alternatives developed from these technologies are described in the following paragraphs.

3.2.2.1 LOW PERMEABILITY CAP

Placement of a low permeability cap at the site would be conducted to minimize direct contact risks associated with all identified contaminated soils at the site. It is anticipated that the cap would have to cover a maximum area of approximately eight acres. Placement of the cap would require that retaining walls be built along the edges of the paved areas and that the existing parking lots overlying contaminated soils be repaved. A number of special considerations would have to be included if this alternative were implemented since there would be a substantial increase in the elevation of the capped area (a minimum two foot elevation increase would occur). This increase would make it necessary to raise the existing monitoring wells and possibly to provide stairways for access to the capped area. In addition, capping of the wastes on-site would require that the site be inspected every six months, that the groundwater be monitored on a quarterly basis, and that the cap, retaining walls, paved areas, and monitoring wells be maintained properly. Finally, every five years, a detailed assessment of the effectiveness of the cap would have to be performed.

3.1.2.2 OFF-SITE RCRA LANDFILL DISPOSAL

Disposal of hot spot soils at an off-site RCRA landfill would involve excavation of the hot spot site soils followed by transportation of these soils to an approved off-site RCRA landfill. Following excavation, clean fill would be placed in the excavated areas, and then a low permeability cap would be placed at the site. Long-term mintenance and monitoring requirements would be similar to those described previously for the low permeability capping alterna- tive except monitoring requirements might be reduced since hot spot soils would no longer be present at the site. It should be noted that one potentially limiting factor for this alternative is the fact that prior to disposal at the off-site RCRA landfill, it would have to be demonstrated that the hot spot soils could pass the dioxin TCLP test. Without prior treatment, it is possible that they would fail the TCLP test and, therefore, land disposal of these soils after November 8, 1988 would not be allowed.

3.1.3 TREATMENT ALTERNATIVES

Treatment technologies which passed preliminary screening include solidification/stabilization (either silicate based, thermoplastic or surface microencapsulation), on-site thermal treatment, thermal treatment at Love Canal and off-site vitrification. Treatment alternatives developed from these technologies are described in the following paragraphs.

3.1.3.1 SOLIDIFICATION/STABILIZATION

Solidification/stabilization of contaminated site soils would involve excavation of hot spot soils followed by solidification/ stabilization on-site. Following treatment, samples of the treated soils would be collected and analyzed to verify that they could either be delisted or meet hybrid closure requirements prior to disposal. Then the treated wastes would be placed in the excavated areas, and a low permeability cap would be placed over the entire site. Long-term maintenance and monitoring requirements would be similar to those described previously for the low permeability capping alternative except monitoring requirements might somewhat reduced since hot spot soils would be rendered less toxic or non-toxic during treatment.

3.1.3.2 ON-SITE THERMAL TREATMENT

On-site thermal treatment would involve procuring a mobile thermal treatment unit capable of destroying soil organics and vaporizing or stablizing soil inorganics. Initial steps involved in implementation of this alternative would include excavating the hot spot soils, thermally treating these soils, and determining the status of the residual ash and other thermal treatment byproducts as hazardous, delistable, or capable of meeting hybrid closure requirements. If the byproducts were determined to be hazardous, they could be handled in one of the following ways:

- CASE I: Transport byproducts to off-site RCRA landfill for disposal/Refill excavated area/Place low permeability cap over site/Monitor and maintain site as described previously in Section 3.1.2.2.
- CASE II: Solidify/Stabilize byproducts on-site/Deposit treated byproducts on-site/Place low permeability cap over site/Monitor and maintain site as described in Section 3.1.3.1.

If the byproducts were found to be delistable or capable of meeting hybrid closure requirements, however, they would be handled as follows:

- CASE III: Redeposit the byproducts on-site/Place low permeability cap over site/Monitor and maintain site as described previously in Section 3.1.3.1.

3.1.3.3 OFF-SITE THERMAL TREATMENT

EPA has proposed that creek and sewer sediments from the vicinity of Love Canal be treated via a mobile thermal treatment unit at Love Canal. This unit could also be used to treat soils from the 93rd Street School site. Thermal treatment at Love Canal would involve the same steps as on-site thermal treatment. However, transportation of the hot spot soils to the thermal treatment facility and transportation of the treated byproducts either back to the 93rd Street School site or to an off-site RCRA landfill would also be required.

3.1.2.4 OFF-SITE VITRIFICATION

Off-site vitrification would involve procuring an approved off-site location, excavating trenches at that location, then excavating the hot spot soils at the 93rd Street School site, transporting these soils to the off-site location, depositing them in the trenches, covering the soils with clean fill and vitrifying. At the school site, it would be necessary to refill the excavated areas and then to place a low permeability cap at the site. Long-term maintenance and monitoring requirements at the 93rd Street School site would be similar to those described previously in Section 3.1.2.2. In addition, long-term monitoring might be required at the vitrification site if analysis in the vicinity of the vitrified waste indicates that unacceptable levels of contaminants are still present in soils, groundwater, or surface water.

3.2 PRELIMINARY ALTERNATIVES SCREENING

In this section, preliminary alternatives are screened to eliminate those alternatives which will not provide adequate protection of public health or the environment as well as those which are significantly more expensive but which do not provide significantly better protection of the public health and the environment. Following this screening, the remaining final alternatives will be analyzed in greater detail in Section 4.

3.2.1 ENVIRONMENTAL AND PUBLIC HEALTH SCREENING

The effectiveness of each of the preliminary remedial action alternatives in protecting human health and the environment is assessed in the following sections. Following these assessments, alternatives which are determined to have significant adverse impacts in comparison to other similar alternatives or which will not adequately protect human health and the environment are eliminated from further consideration.

As determined previously in Section 6 of Volume I - Remedial Investigation Summary, the primary source of concern at the 93rd Street School site is the presence of contaminants in the hot spot area soils and other contaminated soils in the vicinity of the historic swale which pose a direct contact risk by the following exposure pathways:

(1) Dust (i.e., fugitive particles) may be carried into the air from the ground surface

(2) Direct contact between contaminated soils and humans or other life forms may occur

Additional exposure pathways which are of lesser concern include emission of volatiles and transport of contaminated particulates in surface water at the site.

The potential receptors who could be affected by the contaminated soils, estimates of the exposure point concentrations to which these receptors might be exposed, and the potential impacts of these exposures on the receptors were discussed previously in Section 6 of Volume I - Remedial Investigation Summary. It was concluded that the potential receptors at greatest risk of exposure to site contaminants would be children who might play at the school site which is not secured to prevent direct contact. As a result of direct contact with site soils over long periods of time, it is possible that significant health risks could develop.

Assessments of the effectiveness of each of the preliminary alternatives in preventing adverse impacts on the environment and human health are presented in the following sections.

3.2.1.1 AIR QUALITY

Air quality at the site was evaluated during the remedial investigation by Phoenix Safety Associates, Ltd. (PSA) to ensure worker safety during site sampling. A review of the daily logs kept by PSA during sampling revealed that throughout drilling operations and well development, no significant levels of volatile contaminants above background levels were detected in the breathing zone of the workers. In addition, even directly above the borings and monitoring wells, readings did not typically exceed background levels by more than 2 ppm. It must be noted, however, that in a few cases when borings were first drilled and when well caps were first removed, readings as high as 10 ppm above background levels were detected. These relatively high readings were found directly above the borings and wells, and they dropped rapidly (i.e., within one to two minutes) as vapors dissipated. It is believed that these volatiles originated in the contaminated soils since the groundwaters at the site were found to be free of high levels of volatile contaminants. In conclusion, the results of air monitoring indicated that if site soils remain in place and undisturbed, the short-term risk of volatile emissions will be virtually negligible. In addition, even if the soils are disturbed due to erosion or excavation, it was asserted in the risk assessment that risks due to volatile emissions would be insignificant in comparison to particulate emission or direct contact tisks.

Particulate emissions could pose a threat to persons who might inhale the contaminated dust or ingest contaminated dust from dirty hands, foods, or other sources if the site were disturbed due to erosion or excavation.

It is anticipated that if the no-action alternative were implemented, it would not be effective in preventing short-term particulate emissions released by wind erosion. In addition, the effectiveness of this alternative in preventing particulate emissions might decrease with time due to the effects of erosion.

An alternative which would provide greater short-term protection against particulate releases is placement of a low permeability cap.

During implementation of this alternative, the soil would remain undisturbed (i.e., no excavation would be required); thus short-term volatile and particulate emissions would be minimal. Once in-place, the cap would serve as a very effective long-term barrier for preventing releases of particulates from underlying contaminated soils.

All other alternatives involve excavation of hot spot soils. During excavation, the short-term risk of volatiles emissions would increase, and site monitoring would be prudent to confirm that volatiles were not present at levels that would make respiratory protection for workers necessary. Because any volatile emissions would be expected to dissipate rapidly, however, effects off-site would be negligible. In addition, the dust control measures described previously in Section 2 should be used to effectively reduce potential emissions of contaminated particulates if excavation is performed to minimize risks associated with inhalation or ingestion of contaminated dust.

Off site landfilling of the hot spot soils would impose risks associated with excavation as well as risks of short-term off-site exposures during transport of the hot spot soils to the RCRA landfill and during disposal of these soils at the landfill. Once the hot spot soils were removed, however, the long-term exposure risk at the 93rd Street School site would be decreased since the hot spot soils would no longer be present at the site.

Solidification/stabilization of the hot spot soils would impose risks associated with excavation as well as risks during handling of the soils on-site during treatment. Air pollution controls should be used during handling and treatment to minimize these risks. Long-term risks of air emissions would be much lower than those posed by the no action alternative since the hot spots would be treated and the treated soils and other contaminated soils would be covered with a low permeability cap. However, periodic inspection of the site would be necessary to ensure that erosion resulting in dispersion of contaminated dust did not develop.

The on-site thermal treatment alternative would pose the greatest short-term exposure risks to workers at the site and possibly to nearby residents since, in addition to excavation related air releases, air releases could potentially occur during feed preparation operations such as soil drying or pulverizing and during release of off-gases potentially contaminated with hazardous decomposition products and metal fumes. It should be noted that if a thermal treatment system is selected, it should be demonstrated effective in preventing air emissions. The most desirable thermal treatment units would not require feed preparation, would generate fewer toxic decomposition products and/or metal fumes, or would be equipped with highly effective emission control systems. Additional short-term risks of this alternative would depend upon whether or not the byproducts were found to be hazardous. If the byproducts were found to be hazardous and were then transported and disposed at a RCRA landfill (Case I), there would be an increased short-term risk of particulate emissions during transport and disposal of the ash. If the ash was found to be hazardous and was then solidified/stabilized and redeposited on-site (Case II), there would be an increased short-term risk of particulate emissions during solidification/ stabilization. Finally, if the byproducts were found to be delistable or capable of meeting hybrid closure requirements and were then reburied at the site (Case III), particulate emissions during disposal would not pose a significant hazard to site workers or nearby populations. The long-term effectiveness of Cases I to III for this alternative in preventing air related exposures are therefore anticipated to be as follows:

- CASE I - The long-term effectiveness would be similar to that of off-site disposal of the untreated hot spot soils at a RCRA landfill except that the risk of potential volatile emissions during transportation of byproducts and at the off-site landfill would be reduced.
- CASE II - The long-term effectiveness would be similar to that of solidification/stabilization except that the potential future risks of volatile or particulate emissions from hot spot soils would be reduced.
- CASE III - The long-term effectiveness would be relatively good since the hot spot soils would no longer contain significant levels of hazardous volatile or particulate contaminants, and untreated contaminated soils would be capped.

The thermal treatment at Love Canal alternative would pose somewhat reduced short-term risks at the 93rd Street School site since any emissions during feed preparation operations or during release of off-gases would occur off-site. Additional short-term risks, however, might be imposed on residents of houses on the route between the site and the thermal treatment facility and on residents of houses near the thermal treatment facility. The long-term effectiveness for each of the three cases (i.e., Cases I, II and III) of off-site thermal treatment would be essentially the same as those described previously for on-site thermal treatment.

Off-site vitrification of the contaminated soils would require that the soils be excavated and transported to a suitable off-site location. Short-term air pollution risks would include risks associated with hot spot soil excavation; potential exposure of people living along the route between the school site and the vitrification site; and potential exposures at the vitrification site during burial of the contaminated soil and during vitrification. The temperatures at which the soil would be vitrified would be greater than the boiling points of both the metals and organics of concern. Therefore, metal as well as organic vapors could potentially filter up through the overlying soils during vitrification. Vapors reaching the atmosphere would have to be carefully collected and treated in the off gas collection hood and treatment system. In addition, the overlying soils would have to be tested to determine if hazardous levels of metal vapor were deposited in these soils during vitrification which could eventually be released to the atmosphere due to wind erosion. If the overlying soils were determined to be hazardous and removal was deemed necessary, further airborne particulate exposures could occur during excavation and transport of contaminated overlying soils to an off-site hazardous waste landfill. The long-term effectiveness of this alternative in preventing air pollution at the off-site location would depend upon whether or not overlying soils were rendered hazardous during vitrification. The long-term effectiveness at the school site, however, would be similar to that of the off-site landfill disposal alternative since there would no longer be any hot spot soils at the site.

3.2.1.2 SURFACE WATER QUALITY

As described previously, based on the current results of the remedial investigation of the 93rd Street School site, the groundwater and surface water (i.e., the water in the existing swale) do not appear to be contaminated with significant levels of any of the parameters of concern. Thus it is likely that contaminants in site soils are not leaching readily into waters at the site, and it is not anticipated that leaching will occur in the near future providing that the soils remain undisturbed. This will be verified during the sampling and analysis of groundwater to be performed during the remedial design phase. It is possible, however, that although significant surface water contamination has not been identified, contaminated particulates could be carried off-site into Bergholtz Creek via surface water runoff. Therefore, precautions should be taken to prevent direct contact between contaminated surface soils and runoff.

The no action alternative would be ineffective for preventing either short or long-term risks of surface water erosion. Placement of a low permeability cap over the contaminated soils, however, would reduce both the short and long-term risks of particulate migration via surface water for the following reasons;

- Surface water runoff would no longer be in direct contact with contaminated surface soils since a minimum of two feet of vegetated, compacted, clean soil would separate the contaminated former surface soils from the new site surface.
- The elevation of the majority of the site would be raised by a minimum of two feet thus reducing the possibility of floodwaters carrying away contaminated soils.

Other alternatives would be somewhat less effective on a short-term basis than the low permeability cap in preventing migration of contaminated particulates in surface waters because of excavation activities. To minimize these short-term risks, many of the surface water control technologies discussed previously could be used to reduce run-on and to control runoff during excavation.

The long-term effectiveness of almost all of these alternatives is anticipated to be very good for the following reasons:

- Off-Site Landfilling would result in reducing the risk of surface water contamination at the 93rd Street School site since the hot spot soils would no longer be present at the site.
- Solidification/Stabilization would result in effective immobilization of hot spot soils at the site and would therefore result in reduced long-term exposure risks.
- On-Site and Off-Site Thermal Treatment
- Case I would result in reducing the risk of surface water contamination at the 93rd Street School site since the hot spot soils would no longer be present at the site
- Case II would result in approximately the same long-term effectiveness as the solidification/stabilization alternative.

- Case III would result in reducing the risk of surface water contamination at the 93rd Street School site since the hot spot soils would be rendered delistable or appropriate for hybrid closure.
- Off-Site Vitrification would result in reducing the risk of surface water contamination at the 93rd Street School site, since the hot spot soils would no longer be present. At the vitrification site, however, if surface soils were rendered hazardous and not taken to an off-site landfill or covered with a cap, surface water contamination could potentially occur.

3.2.1.3 DIRECT CONTACT RISKS

Direct contact with the contaminants at the 93rd Street School site would result in the greatest threat to human health. As described previously, some of the contaminants identified in site soils during the remedial investigation are known or suspected carcinogens or are otherwise toxic to humans. These contaminants may enter the human body by primary routes including ingestion or inhalation, or by a variety of other routes. Detailed descriptions of the potential toxic effects of the soil contaminants and the potential routes of exposure to these contaminants were presented in Section 6 of Volume I - Remedial Investigation Summary. These descriptions indicated that the remedial action alternative selected should be effective in minimizing the risk of direct contact between humans and contaminated site soils with elevated levels of dioxin, PNAs, and arsenic.

The no action alternative poses a relatively high risk of direct contact exposure even though the school is not in operation since the site is not secured to prevent public access, and contaminants were identified in surface soils. If local children were to play at the abandoned school site, they would be at an increased risk of potentially harmful direct contact exposures because they might dig in the soil on the school grounds, play in a manner that would generate dust, generate heavy traffic on the vegetation thereby decreasing its viability, and neglect washing their hands increasing the risk of ingestion of contaminants. If the no action alternative were implemented and the school was allowed to reopen, the risk of direct contact exposures would be even greater.

Covering the site with a low permeability cap would greatly reduce both the short and long-term risks of direct contact exposures even if the school were reopened since the contaminated soils would be covered with a minimum of two feet of vegetated, compacted clean soil designed for long-term waste containment.

All other alternatives would involve excavation of contaminated site soils which would increase the short-term direct contact exposure risks for both workers on the site and potentially for any other persons entering the site. Protective clothing, safety and decontamination equipment should be used to reduce direct contact risks for site workers. Unauthorized persons should be kept off-site during excavation to prevent them from coming into direct contact with contaminated soils. Short-term risks of direct contact exposures would be greater for those alternatives which would require more extensive handling and transportation of untreated or partially treated soils from the site.

The long-term effectiveness of each of these other alternatives in preventing direct contact exposures would be very similar to their effectiveness in preventing surface water contamination as described in the previous section.

3.2.1.4 CONCLUSIONS

The no action alternative would not be effective for preventing short-term risks of particulate emissions to the air, to the surface water, or direct contact risks. In addition, it has been determined that these risks may increase with time due to wind and surface water erosion and with the potential reopening of the school. Therefore, this alternative is not capable of adequately protecting human health and the environment. However, since EPA guidance recommends that the no action alternative be evaluated throughout the feasibility study, it will not be eliminated at this time.

Of the two preliminary containment alternatives, the low permeability capping alternative has been determined to be the most effective alternative for preventing short-term air, surface water and direct contact exposure risks. Because the off-site landfilling alternative requires excavation of hot spot soils and off-site landfilling of these soils, this alternative poses a greater short-term risk of emissions to the air and surface water and of direct contact.

The long-term effectiveness of the off-site RCRA landfill disposal alternative in minimizing exposure risks at the site would be better than that of the low permeability capping alternative since the hot spot soils would no longer be present at the site. In conclusion, of the two preliminary containment alternatives considered, the low permeability capping alternative is more effective for protecting the public health and the environment on a short-term basis, however, on a long-term basis, landfill disposal might be more effective.

Of the four preliminary treatment alternatives, it has been determined that solidification/stabilization would pose the least risk of short-term exposures since it does not involve thermal treatment. The greatest short-term risks of exposure at the 93rd Street School site would be posed by the on-site thermal treatment alternative; however, the greatest overall risks would result if the off-site vitrification alternative were selected. Off-site vitrification would result in potential emissions and direct contact risks during excavation at the 93rd Street School site, transportation of the untreated soils to an off-site location for vitrification, drying of the soils, reburial of the untreated soils, and vitrification. Even following treatment, potential impacts could occur if the soils overlying the vitrified wastes were found to contain elevated levels of contaminants. It is concluded, therefore, that off-site vitrification of the soils would be the least effective of the preliminary treatment alternatives considered in protecting human health and the environment. In addition, the final product following vitrification might not justify the additional risks. Therefore, off-site vitrification will be eliminated from further consideration at this time.

In conclusion, the followilng preliminary remedial action alternatives will be considered further:

- No Action
- Low Permeability Cap
- Off-Site RCRA Landfill
- Solidification/Stabilization
- On-Site Thermal Treatment (Cases I, II, and III)
- Thermal Treatment at Love Canal (Cases I, II, and III)

3.2.2 ORDER OF MAGNITUDE COST COMPARISON

EPA guidance as described in the document entitled "Guidance on Feasibility Studies Under CERCLA", June 1985 requires that preliminary remedial action alternatives be evaluated on the basis of cost. The purpose of this evaluation is to eliminate those alternatives which have costs an order of magnitude greater than those of other similar alternatives but which do not provide greater environmental or public health benefits or greater reliability. Because this evaluation is only a preliminary screening tool, it is recommended by the guidance that costs be estimated to a level of accuracy within 50 to 100 percent of true costs. Following preparation of a cost estimate for each alternative, the alternatives can then be subjected to a present worth analysis to determine if any are an order of magnitude more expensive than the others. In the following sections, the cost estimates for preliminary alternatives, results of present worth analysis, and conclusions based on the order of magnitude cost comparison are presented.

3.2.2.1 COST ESTIMATES

Cost estimates for each of the preliminary alternatives have been prepared based upon readily available cost data presented in EPA publications, Mean's Building Construction Cost Data, and other sources identified during the screening of remedial action technologies. A complete list of the references used during preparation of cost estimates is presented in Appendix A. It should be noted that where 1988 costs were not available, the Implicit Price Deflators of the Gross National Product (GNP) were used to adjust cost data accordingly. A summary of these Implicit Price Deflators for 1981 through 1987 is presented in Table 3-1. Because an Implicit Price Deflator Multiplier Value for 1988 will not be available until January 30, 1989, an estimated multiplier of 1.03 was used.

Cost estimates for each of the following preliminary remedial action alternatives are presented in Tables 3-2 to 3-7, respectively:

- No Action
- Low Permeability Cap
- Off-Site RCRA Landfill
- Solidification/Stabilization
- On-Site Thermal Treatment (Cases I to III)
- Thermal Treatment at Love Canal (Cases I to III)

Descriptions of how these cost estimates were developed are presented in the following paragraphs. It should be noted that all costs presented in this Section were rounded off to the nearest $25,000.

Table 3-2 presents the cost estimates for the no-action alternative. It should be noted that there would be no capital expenses associated with this alternative. Periodic expenses that will be associated with the no action alternative will include environmental monitoring for surface water, groundwater and air quality; general site maintenance including pavement repair and lawn care; and a detailed five year evaluation of alternative performance. These expenses were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a total estimated annual cost of $25C,000 for the no action alternative.

TABLE 3-1 - IMPLICIT PRICE DEFLATORS OF THE GNP

TO CONVERT	TO	MULTIPLY BY
1981 Dollars	1982 Dollars	1.09
1982 Dollars	1983 Dollars	1.06
1983 Dollars	1984 Dollars	1.04
1984 Dollars	1985 Dollars	1.04
1985 Dollars	1986 Dollars	1.03
1986 Dollars	1987 Dollars	1.03
1987 Dollars	1988 Dollars	1.03*

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* The official value for this multiplier will not be available until January 30, 1989. For the purposes of this study, however, an estimate of 1.03 was used.

TABLE 3-2 - PRELIMINARY COST ESTIMATE FOR THE NO ACTION ALTERNATIVE

CAPITAL EXPENSE ITEMS	COST
1. None	$0

PERIODIC EXPENSE ITEMS	COST/YR
1. Environmental Monitoring	$150,000
2. Site Maintenance	$25,000
3. Detailed Evaluation (every 5 years)	$25,000
Sub Total:	$200,000
20% Eng. and Reg. Contingency:	$50,000
TOTAL:	$250,000

Table 3-3 presents the capital and annual cost estimates for the low permeability capping alternative. Capital expenses associated with this alternative will include purchase, transport, spreading and compaction of the required cap layers; hydroseeding, lime spreading and fertilizing; construction of retaining walls; repair and reinforcement of paved areas; raising of existing monitoring wells and final survey. Periodic expenses include semi-annual site inspections; quarterly groundwater monitoring; detailed five year evaluations of cap performance; and site maintenance including pavement repair, cap repair, monitoring well repair, retaining wall repair and other maintenance tasks. Both the capital and annual estimated costs were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $1,325,000 for the capital cost and $~~25,000~~ 225,000 for the annual cost of the low permeability capping alternative.

Table 3-4 presents the capital and annual cost estimates for the off-site RCRA landfill disposal alternative. Capital costs associated with this alternative will include excavation, transport and disposal of 7,500 c.y. of hot spot soils at a RCRA landfill; purchase, transport, and placement of 7,500 c.y. of clean fill; reconstruction of paved areas and placement of a low permeability cap. Annual expenses will be the same as those described for the low permeability capping alternative except monitoring costs may be somewhat lower. The capital and annual estimated costs for this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a total estimated capital cost of $3,750,000 and a total estimated annual cost of $150,000 for the off-site RCRA landfill disposal alternative.

TABLE 3-3 - PRELIMINARY COST ESTIMATE FOR THE LOW PERMEABILITY CAPPING ALTERNATIVE

CAPITAL EXPENSE ITEMS	COST
1. Purchase, transport, and placement of cap layers	$800,000
2. Hydroseeding, Lime Spreading and Fertilizing	25,000
3. Construction of Retaining Walls	175,000
4. Repair and Reinforcement of Paved Areas	50,000
5. Raising of existing monitoring wells & misc. activities	25,000
6. Final Survey	25,000
Sub Total:	$1,100,000
20% Eng. and Reg. Contingency	225,000
TOTAL:	$1,325,000

PERIODIC EXPENSE ITEMS	COST/YR.
1. Site Inspection (semi-annual) and Maintenance	$25,000
2. Groundwater Monitoring (quarterly)	125,000
3. Detailed Evaluation (every 5 years)	25,000
Sub Total:	$175,000
20% Eng. and Reg. Contingency:	50,000
TOTAL:	$225,000

TABLE 3-4 - PRELIMINARY COST ESTIMATE FOR THE OFF-SITE RCRA LANDFILL DISPOSAL ALTERNATIVE

CAPITAL EXPENSE ITEMS	COST
1. Excavation of Hot Spot Soils and Overlying Pavement	$ 75,000
2. Transport of Hot Spot Soils	750,000
3. Disposal of Hot Spot Soils	1,000,000
4. Purchase, Transport and Placement of Clean Soils	150,000
5. Construction of Low Permeability Cap	1,100,000
6. Reconstruction of Paved Areas	50,000
Sub Total:	$3,125,000
20% Eng. and Reg. Contingency:	625,000
TOTAL:	$3,750,000

PERIODIC EXPENSE ITEMS	COST/YR.
1. Site Inspection (semi-annual) and Maintenance	$25,000
2. Groundwater Monitoring (quarterly)	75,000
3. Detailed Evaluation (every 5 years)	25,000
Sub Total:	$125,000
20% Eng. and Reg. Contingency:	25,000
TOTAL:	$150,000

Table 3-5 presents the capital and periodic cost estimates for the solidification/stabilization alternative. Capital costs associated with this alternative include excavation of 7,500 c.y. of hot spot soils and pavement above these soils; solidification/stabilization of these soils; a sampling and analysis program to verify that treated soils can be placed beneath a low permeability cap; disposal of the treated hot spot soils on-site; placement of a low permeability cap; and reconstruction of paved areas. It should be noted that a cost range of $75/ton to $225/ton and a weight of 11,250 tons (assuming the weight of soils from the site is 1.5 tons per c.y.) was used to determine the 1988 cost for solidification/ stabilization. Periodic expenses be the same as those described for the low permeability capping alternative except for the fact that monitoring costs may be somewhat lower. Both the capital and annual estimated costs were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $2,250,000 to $3,650,000 for the capital cost and $150,000 for the annual cost of the solidification/stabilization alternative.

Table 3-6 presents the capital and annual cost estimates for the on-site thermal treatment alternative. Variations in the cost estimates for this alternative will occur depending upon whether the byproducts are handled as a hazardous waste and disposed off-site (Case I), are solidified/ stabilized and then disposed on-site (Case II), or are determined to be delistable or capable of meeting hybrid closure requirements and are disposed on-site (Case III). Costs for each of these three cases are presented individually.

The capital costs associated with Case I include excavation of approximately 7,500 c.y. of hot spot soils and the pavement above the soils; thermal treatment of the soils; costs for incinerator mobilization/demobilization, preliminary test burn, storage, solids handling,

TABLE 3-5 - PRELIMINARY COST ESTIMATE FOR THE SOLIDIFICATION/STABILIZATION ALTERNATIVE

CAPITAL EXPENSE ITEMS	COST
1. Excavation of Hot Spot Soils and Pavement	$ 75,000
2. Solidification/Stabilization of Hot Spot Soils	575,000 to 1,700,000
3. Sampling and Analysis of Treated Soils	25,000
4. Redisposal of Solidified/Stabilized Soils	50,000 to 75,000
5. Placement of a Low Permeability Cap	1,110,000
6. Reconstruction of Paved Areas	50,000
Sub Total:	$1,875,000 to 3,025,000
20% Eng. and Reg. Contingency	375,000 to 625,000
TOTAL:	$2,250,000 to 3,650,000

PERIODIC EXPENSE ITEMS	COST/YR.
1. Same as Off-Site RCRA Landfill Disposal Alternative	$150,000

TABLE 3-6 - PRELIMINARY COST ESTIMATE FOR THE ON-SITE THERMAL TREATMENT ALTERNATIVE

CASE I:

	CAPITAL EXPENSE ITEMS	COST
1.	Preliminary Testing	$ 500,000
2.	Hot Spot Soil and Pavement Excavation	75,000
3.	Mobilization/Demobilization of Mobile Treatment Unit and Misc. Expenses	1,000,000
4.	Thermal Treatment	3,750,000
5.	Sampling/Analysis of Byproducts	25,000
6.	Transport Byproducts to Off-Site Hazardous Waste Landfill	750,000
7.	Dispose Byproducts at Off-Site Hazardous Waste Landfill	1,025,000 ~~750,000~~
8.	Clean Fill at Site	125,000
9.	Placement of Low Permeability Cap	1,100,000
10.	Reconstruction of Paved Areas	50,000
	Sub Total:	$8,400,000
	20% Eng. and Reg. Contingency:	$1,700,000
	TOTAL:	$10,100,000

	PERIODIC EXPENSE ITEMS	COST/YR.
1.	Same as for Off-Site RCRA Landfill Disposal	$150,000

CASE II:

	CAPITAL EXPENSE ITEMS	
1.	Items 1,2,5,9,10 Same as Case I	$1,750,000
2.	Mobilization/Demobilization of Mobile Treatment Unit	1,000,000
3.	Thermal Treatment	3,750,000
4.	Dispose of Byproducts on Site	50,000 to 75,000
5.	Solidification/Stabilization and Associated Activities	575,000 to 1,700,000
	Sub Total:	$7,125,000 to 8,275,000
	20% Eng. and Reg. Contingency:	1,425,000 to 1,675,000
	TOTAL:	$8,550,000 to $9,950,000

	PERIODIC EXPENSE ITEMS	COST/YR.
1.	Same as Stabilization/Solidification	$150,000

TABLE 3-6 - PRELIMINARY COST ESTIMATE FOR THE ON-SITE THERMAL TREATMENT ALTERNATIVE (Cont'd)

CASE III:

CAPITAL EXPENSE ITEMS		COST
1.	Items 1,2,5,9,10 Same as Case I	$1,750,000
2.	Mobilization/Demobilization of Mobile Treatment Unit	1,000,000
3.	Thermal Treatment	3,750,000
4.	Dispose Byproducts on Site	50,000
	Sub Total:	$6,550,000
	Eng. and Reg. Contingency:	1,325,000
	TOTAL:	$7,875,000

PERIODIC [redacted] EXPENSE ITEMS		COST/YR.
1.	Same as Solidification/Stabilization	$150,000

and thermal treatment; a sampling and analysis program to determine whether residual ash and other thermal treatment by-products are hazardous; transport and disposal of approximately 7,500 c.y. of by-products to a RCRA landfill; placement of 7,500 c.y. of clean fill at the site, construction of a low permeability cap and replacement of paved areas. It should be noted that a cost of $500.00 per ton of soil was used for the cost of mobile unit thermal treatment; and costs of $125 per c.y. and $80 per c.y. were used for transportation and off-site disposal of hazardous residuals. Annual expenses for this alternative would be the same as those described for the off-site RCRA landfill disposal alternative. The capital and annual estimated costs for this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $10,100,000 for the capital cost and $150,000 for the annual cost of the on-site thermal treatment (Case I) alternative.

The capital costs associated with Case II include excavation of approximately 7,500 c.y. of contaminated soils and the pavement above the soils; thermal treatment of the soils; costs for thermal treatment unit mobilization/ demobilization, preliminary test burn, storage, solids handling, and thermal treatment; a sampling and analysis program to determine whether the residual ash and other thermal treatment by-products are hazardous; solidification/stabilization of byproducts; testing of treated byproducts; redisposal of the treatment by-products on-site; placement of a low permeability cap and reconstruction of paved areas. Periodic expenses will be essentially the same as those described previously for the solidification/stabilization alternative. The estimated capital and annual costs associated with this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $7,125,000 to $8,275,000 for the capital cost and $150,000 for the annual cost of the on-site thermal treatment alternative (Case II).

The capital costs associated with Case III include excavation of 7,500 c.y. of contaminated soils and the pavement above the soils; thermal treatment of the soils; costs for thermal treatment unit mobilization/demobilization, preliminary test burn, storage, solids handling, and thermal treatment; a sampling and analysis program to verify that the residual ash and by-products are delistable or capable of meeting hybrid closure requirements; redisposal of the thermal treatment by-products on-site; placement of a low permeability cap and reconstruction of paved areas. Annual expenses associated with this alternative would be similar to those of the solidification/stabilization alternative except monitoring costs would be reduced. The estimated capital and annual costs associated with this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $7,875,000 for the capital cost and $150,000 for the annual cost of on-site thermal treatment (Case III).

Finally, Table 3-7 presents the capital and annual cost estimates for the off-site incineration alternative. As for the on-site incineration alternative described previously, variations in cost will occur depending on how the treatment byproducts are disposed (i.e., via Case I, II or III). Costs for each of the three cases are presented individually.

The capital expense items associated with off-site thermal treatment (Case I) are identical to those for on-site thermal treatment (Case I) with the exception of the additional costs of transport of the untreated soils to the off-site facility and the subtraction of ~~unincurred~~ mobilization/demobilization costs of the thermal unit. Annual costs for this

TABLE 3-7 - PRELIMINARY COST ESTIMATE FOR THE OFF-SITE THERMAL TREATMENT ALTERNATIVE

CASE I:

CAPITAL EXPENSE ITEMS	COST
1. Same as on Site Case I ----See Table 3-6--------------- Items 1,2,5-10	$3,650,000
2. Thermal Treatment (Including Transportation of Soil to Off-Site Treatment Unit)	3,775,000
Sub Total:	$7,425,000
20% Eng. and Reg. Contingency:	1,500,000
TOTAL:	$8,925,000

PERIODIC EXPENSE ITEMS	COST/YR.
1. Same as on Site Thermal Treatment Case I	$150,000

CASE II:

CAPITAL EXPENSE ITEMS	
1. Same as On Site Case II ----See Table 3-6------------- Items 1,4,5	$2,375,000 to 3,525,000
2. Thermal Treatment (Including Transportation of Soil to Off-Site Treatment)	3,775,000
3. Transport of Byproducts Back to Site	25,000
Sub Total:	$6,175,000 to $7,325,000
20% Eng. and Reg. Contingency:	1,250,000 to 1,475,000
TOTAL:	$7,425,000 to 8,880,000

PERIODIC EXPENSE ITEMS	COST/YR.
1. Same as On-Site Thermal Treatment Case II	$150,000

TABLE 3-7 - PRELIMINARY COST ESTIMATE FOR THE OFF-SITE THERMAL TREATMENT ALTERNATIVE(Cont'd)

CASE III:

CAPITAL EXPENSE ITEMS	COST
1. Same as On-Site Case III -----See Table 3-6------------ Items 1,4	$1,800,000
2. Thermal Treatment (Including Transportation of Soil to Off-Site Treatment Unit)	3,775,000
3. Transport of Byproduct Back To Site	25,000
Sub Total:	$5,600,000
20% Eng. and Reg. Contingency:	1,125,000
TOTAL:	$6,725,000

PERIODIC EXPENSE ITEMS	COST/YR.
1. Same as On-Site Thermal Treatment----See Table 3-6------ Case III	$150,000

alternative would be the same as for on-site thermal treatment (Case I). The estimated capital and annual costs for this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $8,925,000 for the capital cost and $150,000 for the annual cost of the off-site thermal treatment alternative (Case I).

The capital costs associated with Case II are identical to those for on-site thermal treatment (Case II) with the exception of the additional costs of transportation of the untreated soils to the off-site thermal treatment facility, additional costs of transport of the by-products back to the 93rd Street School site and the subtraction of unincurred mobilization/demobilization costs of the thermal unit. The annual costs for this alternative would be the same as those for on-site thermal treatment (Case II). Thus the estimated capital and annual costs for this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $7,425,000 to $8,800,000 for the capital cost and ~~$125,000~~ $150,000 for the annual cost of the off-site thermal treatment alternative (Case II).

Finally, capital costs associated with Case III are identical to those for on-site thermal treatment (Case III) with the exception of the additional costs of transportation of the untreated soils to the off-site thermal treatment facility, transportion of the non-hazardous ash and other by-products back to the 93rd Street School site and the subtraction of unincurred mobilization/demobilization costs of the thermal unit. Annual expenses associated with this alternative will be the same as for the on-site thermal treatment alternative (Case III). The estimated capital and annual costs for this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of

TABLE 3-8 - PRESENT WORTH ESTIMATES FOR PRELIMINARY REMEDIAL ACTION ALTERNATIVES

Alternative		Est. Capital Cost (1988 Dollars)	Est. Annual Cost (1988 Dollars)	Present Worth* (1988 Dollars)
No Action		$0	$250,000	$ 2,275,000
Low Permeability Cap		$ 1,325,000	2,250,000	3,375,000
Off-Site RCRA Landfill		3,750,000	150,000	5,125,000
Solidification/Stabilization		2,250,000 to 3,650,000	150,000	3,625,000 to 5,025,000
On-Site Thermal Treatment				11,475,000
Case I	- Off-Site Ash Disposal	10,100,000	150,000	11,475,000
Case II	- On-Site Ash Disposal/ Solidification/ Stabilization	8,550,000 to 9,950,000	150,000	9,925,000 to 11,325,000
Case III	- On-Site Ash Disposal	7,875,000	150,000	9,250,000
Off-Site Thermal Treatment				
Case I	- Off-Site Ash Disposal	8,925,000	150,000	10,300,000
Case II	- On-Site Ash Disposal Solidification/ Stabilization	7,425,000 to 8,800,000	150,000	8,800,000 to 10,175,000
Case III	- On-Site Ash Disposal	6,725,000	150,000	8,100,000

* Based on a discount rate of 10 percent and a performance period of 25 years; P/A factor is equal to 9.077.

$6,725,000 for the capital cost and $150,000 for the annual cost of the off-site thermal treatment alternative (Case III).

3.2.2.2 PRESENT WORTH ANALYSIS

EPA guidance requires that a present worth analysis be performed to evaluate expenditures which occur over different time periods by reducing all future costs to their present worth. This makes it possible to compare the costs of remedial action alternatives on the basis of a single monetary figure representing the amount of money which, if invested at the present time and used as needed, would be sufficient to cover all of the costs associated with a particular remedial action alternative over its planned life. EPA guidance recommends that a discount rate of 10 percent (before taxes and after inflation) should be assumed, and that the time period of performance over which alternatives are evaluated should not exceed 30 years. Thus, the preliminary alternatives for the 93rd Street School site were evaluated based on a discount rate of 10 percent and a performance period of 25 years. Results of this present worth analysis as well as estimated capital and annual costs for each alternative are summarized in Table 3-8, and conclusions are presented in the following section.

3.2.2.3 CONCLUSIONS

The estimated present worth of the preliminary alternatives as presented in Table 3-8 indicate that the no action alternative has the lowest present worth in comparison to other alternatives. It should be noted, however, that this alternative has been determined to be under protective of human health and the environment and is only being evaluated further because this is required by EPA guidance.

The containment alternatives (i.e., low permeability cap and off-site RCRA landfill disposal) were determined to have present worths of $3,375,000 to $5,125,000, respectively. Both of these alternatives will be evaluated further since neither is a magnitude of cost greater than the other, and EPA guidance requires the evaluation of at least one containment alternative.

The treatment alternatives (i.e., solidification/stabilization, on-site thermal treatment, and off-site thermal treatment) cover a wide range of costs. Solidification/stabilization has the lowest estimated present worth of $3,625,000 to $5,025,000 while off-site thermal treatment (Case I) has the highest estimated present worth of $11,475,000 ~~$10,300,000~~. Although the solidification/stabilization alternative will have the lowest overall cost, it has been determined that thermal treatment should still be considered further since the possibility exists that thermal treatment could result in permanent destruction of hot spot soil contaminants.

In conclusion, Table 3-9 on the following page summarizes the preliminary alternatives discussed in this section, the status of each preliminary alternative with regard to further evaluation, and brief explanations of why preliminary alternatives which will not be considered further were eliminated.

TABLE 3-9 SUMMARY OF RESULTS OF SCREENING OF PRELIMINARY REMEDIAL ACTION ALTERNATIVES

PRELIMINARY ALTERNATIVES EVALUATED	STATUS	COMMENTS
I NO ACTION	To be considered	
II CONTAINMENT		
A. LOW PERMEABILITY CAP	To be considered	
B. OFF-SITE RCRA LANDFILL DISPOSAL	To be considered	
III TREATMENT		
A. SOLIDIFICATION/STABILIZATION	To be considered	
B. OFF-SITE VITRIFICATION	Eliminated	Less protective than other treatment alternatives
C. ON-SITE THERMAL TREATMENT	To be considered	
1. Case I	To be considered	
2. Case II	To be considered	
3. Case III	To be considered	
D. OFF-SITE THERMAL TREATMENT		
1. Case I	To be considered	
2. Case II	To be considered	
3. Case III	To be considered	

4.0 EVALUATION OF FINAL REMEDIAL ACTION ALTERNATIVES

The purpose of this section is to present detailed descriptions of each of the remedial action alternatives which passed preliminary screening. Then these 'final' alternatives are compared on the basis of the following criteria:

- Protection of Public Health and the Environment
- Compliance with ARAR's
- Reduction of Toxicity, Mobility or Volume
- Short-term Effectiveness
- Long-Term Effectiveness and Permanence
- Implementability
- Cost
- Community Acceptance
- State Acceptance

4.1 FINAL ALTERNATIVES DESCRIPTIONS

Final remedial action alternatives which were not eliminated during preliminary screening include no action, low permeability capping, off-site RCRA landfill disposal, solidification/stabilization, on-site thermal treatment and thermal treatment at Love Canal. Descriptions of these alternatives including the following information are presented in this section:

- the intent of the alternative
- key features
- control, storage, treatment and/or disposal requirements
- time considerations
- technical, administrative and health and safety factors
- maintenance and monitoring requirements

4.1.1 No Action

The intent of the no action alternative would be to leave the contaminated soils in place in an uncontained and untreated condition. This alternative could only be implemented if it was believed that public health and the environment would not be adversely affected. However, it was determined in the risk assessment presented in Section 6 of Volume I that the no action alternative would result in potential exposures of humans to contaminants resulting in an unacceptable level of risk. Over time, risks of these exposures might increase as more contaminated soils would become exposed due to wind and surface water erosion. Therefore, this alternative does not appear feasible since it would not be capable of adequately protecting human health and the environment.

If the no action alternative were selected, extensive monitoring of site, surface water and groundwater and periodic monitoring of dust levels would be required to ensure that nearby residents were not being exposed to potentially dangerous levels of site contaminants (i.e., levels exceeding ARARs). It is anticipated that detailed assessments of the monitoring data collected would have to be performed periodically to ensure that any trends of increasing levels of contamination in air, surface waters, and surface soils would be identified early so that measures to mitigate these increasing levels could be implemented quickly. In addition, site maintenance would also be required to minimize the potential effects of wind and surface water erosion on the vegetative cover and pavements currently overlying identified contaminated soils.

4.1.2 LOW PERMEABILITY CAP

Construction of a low permeability cap at the 93rd Street School site would be performed with the intent of containing the wastes on-site thereby preventing impacts associated with migration of contaminants via air or surface water at the site and to prevent direct contact risks. The cap would be designed and constructed so that it would have the following capabilities:

(1) Provide long-term minimization of migration of liquids through the underlying contaminated soils

(2) Function with minimum maintenance

(3) Promote drainage and minimize erosion or abrasion of the cover

(4) Accommodate settling and subsidence so that the cover's integrity is maintained

(5) Have a permeability less than or equal to the permeability of the natural subsoils underlying the contaminated fill materials.

The vegetative top layer should consist of at least a four inch thick layer of soils capable of supporting vegetation. The top slope of this layer should be one percent (after settling and subsidence) to promote runoff and prevent the formation of erosion rills or gullies. The vegetation selected for the site should not require application of fertilizer, water, or mowing once plant growth is established. In addition, the vegetation should have a root system that will not penetrate beyond the base of the vegetative layer.

The low permeability layer would consist of a two foot thick layer of native clay material compacted such that the permeability was less than or equal to the permeability of the natural subsoils of the site. It was estimated previously in Section 4 of Volume 1 that the natural subsoils at the site have permeabilities ranging from 10^{-3} to 10^{-7} ft/sec.

Drawing S-~~4~~3 in Appendix C shows the approximate extent of the proposed low permeability cap and a typical profile. It is anticipated that the cap would cover an area of approximately eight acres based on preliminary computations.

Implementation of this alternative would not result in a need for handling of the contaminated soils for treatment, storage, or disposal purposes. Some limited control technologies, however, would be required to prevent workers from coming into direct contact with the surface soils or from inhaling or ingesting contaminants prior to placement of the low permeability layer. Controls including use of appropriate respiratory protection and protective clothing should be used if this alternative is selected. In addition, noise control barriers may be desirable to reduce construction noise impacts on nearby residents.

Technical factors which could complicate implementation of this alternative might occur due to the increase in elevation of the capped area. It is anticipated that in order to have a top slope of approximately one percent, some areas of the site may increase in elevation by as much as approximately seven feet, and a minimum increase of ~~five~~ two feet will occur throughout the capped area. This change in elevation will make it necessary to raise existing monitoring wells, construct retaining walls (if the school is to remain in place), and to construct tree wells, access stairways and possibly other structures to compensate for the increase in elevation. Other factors such as the potential reopening of the school might also affect the feasibility of this alternative since the eastern end of the site might be used as a playground, and the height of portions of the cap and required retaining walls might obstruct the view from some school windows.

It is anticipated that quarterly monitoring for groundwater quality would be required to ensure that contaminants were not leaching into the groundwater. In addition, a detailed assessment of the performance of the cap would be required every five years. Inspections of the cap and related structures would be required at least every six months. Any damage to the cap or related structures would have to be corrected soon after detection to prevent more serious degradation of the cap from occurring.

Finally, it is anticipated that this alternative would be effective both on a short and long-term basis in minimizing potential hazards due to migration of volatile and particulate emissions and direct contact exposures.

4.1.3 OFF-SITE RCRA LANDFILL DISPOSAL

Off-site RCRA landfill disposal of the hot spot soils from the 93rd Street School would be performed with the intent of removing all identified hot spot soils from the 93rd Street School site (with the possible exception of any contaminated soils located beneath the school itself which were not addressed by this study) and permanently containing these soils at an EPA approved off-site RCRA landfill.

It has been estimated previously that the quantity of hot spot soils requiring remediation at the school site would be approximately 7,500 cu. yds. Following excavation, the excavated areas would be filled with clean fill from an off-site location, then a low permeability cap would be placed over the site as shown on Drawing S-~~4~~3.

The hot spot soils would be loaded onto trailers approved by EPA and transported by a licensed hazardous waste hauler in accordance with the applicable EPA and State regulations to an EPA approved off-site RCRA landfill for disposal.

Control technologies that would be required during implementation of this alternative would include respiratory and protective clothing for workers at the site; decontamination equipment; dust controls potentially including water spraying and windscreening and temporary surface water controls to prevent migration of contaminants into Bergholtz Creek. Noise control barriers might also be desirable to reduce potential construction noise impacts.

Implementation of this alternative may be difficult if EPA approved landfills are not willing or able to accept the hot spot soils. Two local landfills were contacted to determine whether or not they would be willing to accept these contaminated soils. CECOS of Niagara Falls, New York would not be willing to accept the contaminated soils at their New York facility because of the contaminants involved. They might, however, be willing to accept the soils at their Ohio facility, although they anticipate that the fact that there might be a few isolated portions of the soils which contain low levels of dioxin may hinder the acceptability of the soils for land disposal at any facility even if subsamples of the soils pass the TCLP test.

SCA of Lewiston and Porter, New York was also contacted. It was determined that SCA would not be willing to accept the soils unless it could be proven that they did not contain dioxin. This would be virtually impossible since in previous studies of the site, NUS and RECRA both identified dioxin in the hot spot area at levels exceeding 1 ppb. In addition, even if the soils could pass the TCLP test, SCA felt that the quantity of soils was relatively large and that it might be difficult for them to accept the entire 7,500 cu. yds.

Maintenance and monitoring at the 93rd Street School site would [redacted] be required after excavation of the soils and disposal off-site since other less contaminated soils would be present at the site beneath the low permeability cap.

On a short-term basis, this alternative would result in greater potential risks of emissions of volatiles, particulates, and of direct contact. Surface water and dust controls could be used to minimize particulate emissions to the air and surface water, and direct contact controls such as limiting access to the site could be used to reduce direct contact risks. Although volatile emissions would be almost impossible to control, it is anticipated that risks associated with these emissions would be low as described previously in the public health and environmental risk assessment.

4.1.4 SOLIDIFICATION/STABILIZATION

Solidification/stabilization of hot spot soils would be implemented to stabilize wastes to reduce the potential for volatile and particulate emissions and direct contact risks. Steps that would be required would include excavation of hot spot soils; ~~surface~~ solidification/stabilization of the soils; sampling and analysis to verify that treated soils are delistable or meet hybrid closure requirements; placement of the treated soils on-site; and placement of a low permeability cap.

There are a number of solidification/stabilization systems which could be used at the site including processes developed by Hazcon, Inc., Soliditech, Inc., Chemfix Technologies, Inc., Waste Chem Corporation, Environmental Protection Polymers and the United State Gypsum Co. Most of these processes were described in detail in Section 2 (refer to Section 2.1.2.2.2 for descriptions of the Hazcon, Soliditech and Chemfix technologies and to Section 2.1.2.2.4 for a description of the Wast Chem technology). Since detailed descriptions of surface microencapsulation technologies were not described previously in Section 2, information about these technologies is presented in the following paragraphs.

One surface microencapsulation process developed by Environmental Protection Polymers would involve placing the hot spot soils into high density polypropylene overpacks onto which covers would be spin welded using a special mobile welding apparatus. The resulting encapsulate would be seam free and capable of preventing volatile and particulate emissions and direct contact risks on a long term basis. Costs of this particular technology were estimated by Environmental Protection Polymers as $50 to $70 per 80 gallon drum in 1983 dollars (Ref. 1).

Another method developed by Environmental Protection Polymers would involve mixing 1,2-polybutadiene with the hot spot soil particles to form a free flowing mass of dry resin coated particulates (after solvent evaporation). These coated particulates would then be mixed with high density polyethylene to form a ductile mass. Finally, a thin high density polyethylene jacket would be mechanically and chemically locked onto the surface of the ductile mass thereby encapsulating the wastes. The cost of this technology was estimated by Environmental Protection Polymers as $90 per ton in 1983 dollars (Ref. 1). It is anticipated that this method would result in a greater volume increase than the first method described.

Finally, United States Gypsum Co. has developed an encapsulation technology in which a polymer modified gypsum cement called Envirostone Cement is mixed with wastes (typically oils and radioactive wastes) along with emulsifiers and ion exchange resins. Following mixing, the cement hydrates to form a free standing mass in which both organic and inorganic wastes are stabilized. Discussion of this method with a representative of the United States Gypsum Co. revealed that this particular technology would not be appropriate for encapsulation of the contaminated soils from the 93rd Street School for the following reasons:

- this technology has not been demonstrated effective in treating contaminated soils
- the moisture content of the soils would be too high for proper curing of the cement
- even if the soils were dried, and then microencapsulated, it would not be appropriate to dispose of the microencapsulated materials on-site unless a RCRA grade containment was built to house them.

Each solidification/stabilization technology would have to be subjected to a detailed evaluation prior to selection to ensure that it would be capable of mitigating the potential risks associated with volatile and particulate emissions and direct contact on a long-term basis and that it would not require RCRA grade secondary containment for redisposal at the site. If, as a result of pilot testing it was determined that a particular technology could not render the hot spot soils either delistable or capable of meeting hybrid closure requirements, that technology would be eliminated from further consideration.

Control technologies required during implementation of this alternative would be essentially the same as those described previously for off-site RCRA landfill disposal of the soils. Additional storage requirements might be necessary depending upon the time required to treat the wastes. Therefore, it would be preferable to select a solidification/stabilization technology which could be performed as the soils were excavated so that construction of a temporary hazardous waste storage facility would not be required.

It is anticipated that even if a solidification/stabilization technology were selected which would render hot spot soils delistable, placement of a low permeability cap as shown on Drawing S-~~4~~3 would still be necessary because of underlying contaminated soils. In addition, it is also anticipated that quarterly groundwater monitoring and detailed five year assessments of the performance of the site would be required to ensure that the contaminants were not migrating from the treated hot spot soils or untreated identified contaminated soils.

In conclusion, on a short-term basis, this alternative would result in greater potential risks of emissions of volatiles and particulates as well as greater short-term direct contact risks than for the no action, low permeability capping or off-site landfill disposal alternatives. As described previously, it is anticipated that particulate emissions and direct contact risks could be controlled during excavation and handling of hot spot soils. The long-term effectiveness of this alternative, however, is anticipated to be better overall than that of the containment or no action alternatives.

4.1.5 ON-SITE THERMAL TREATMENT

On-site thermal treatment would be performed with the intent of permanently treating the hot spot soils so that treatment byproducts would be delistable or would meet hybrid closure requirements (Case III). If, however, no mobile treatment unit was available which could achieve this result, then a unit capable of reducing the levels of contaminants in the soils might be selected. Following treatment, the partially treated byproducts could then be disposed either at an approved off-site landfill (Case I) or on-site following treatment via a solidification/stabilization technology capable of rendering the byproducts delistable or acceptable for hybrid closure (Case II). It should be noted that some thermal treatment units might be capable of generating a delistable ash while also generating small quantities of hazardous air emission control byproducts. Disposal of wastes from such units would require a combination of the disposal strategies used in Cases I to III.

Steps involved in implementing this alternative would include excavation of hot spot soils, followed by thermal treatment and residual waste disposal. The activities involved would vary depending upon the mobile thermal treatment unit selected. A recent listing of some of the available (or potentially available) units is presented in Table 4-1 (from EPA, Ref. 4). Brief descriptions of the key features of these units were presented previously in Section 2. Based on these descriptions, it was determined that the ideal

NOTE: Clearer copies of this table will be put in final report

TABLE 4-1 PLANNED AND EXISTING TRANSPORTABLE THERMAL TREATMENT SYSTEMS (From EPA, Ref. 4)

UNIT	EXISTING YES/NO	PLANNED DATE OF COMPLETION DESIGN	PLANNED DATE OF COMPLETION FABRIC	ACCEPTABLE WASTE	OPERATING CONDITIONS TEMPERATURE (°F)	OPERATING CONDITIONS COMBUSTION ZONE RETENTION TIME	APPROX. SOILS CAPAC. (TONS/HR) AT 20% MOIST.	BURN DATA TYPE/RESULTS	PERMIT STATUS PENDING PERMIT/DATA/AGENCY	COMMENTS
1-OGDEN ENVIRON. SERVICES San Diego, CA (Circulating Bed Combustion (CBC) Incinerator)										
-16-inch ID, 2MMBtu/hr transportable CBC pilot unit exists	Yes			liquid, solids	1400 to 1800	Solids-minutes to hours gases-2 sec.	1.0	TSCA-Conducted on transp. pilot unit 5/85. DRE ≥ 99.9999% for PCB 1248 and 1260 at 10,000ppm & trichlorobenzene at 1,000ppm.	RD&D permit for transp. pilot unit in EPA Reg. IX. (2/87). TSCA- Transportable units approved for PCB soils 3/86.-EPA HQ	
-16-inch ID, 2MMBtu/hr transportable CBC unit	Yes		late 1985	"	"	"				The 16-in. ID unit has been delivered to a Canadian organiz.
-36-inch ID 6-9MMBtu/hr transportable CBC unit in construction	No	4/86	Aug-Sept 1987	"	"	"	2.5			Expect to conduct burns with the 36-inch ID unit under the SITE program at a Reg. IX site(summer '87)
2-ENSCO/PYROTECH Franklin, TN (Rotary Kiln Incinerator)										
-100MMBtu/hr rotary kiln, waste fired boiler fired facility	Yes									
-Two 10MMBtu/hr liquid injection mobile incinerator	Yes									
-Three 35MMBtu/hr rotary kiln transportable incinerators-(MWP-2000)										
Unit 1	Yes	11/83	12/84	liquids, solids	kiln-1200 to 1800 2°dary-1600- Combust. 2400	Solids-20 min. to 1 hour gases-2 sec.	5.0			Unit 1 has burned seepage and contaminated oil. It is being retrofitted for work at an Illinois RCRA site.
Unit 2	Yes	11/83	7/85	"	"	"	"	Unit 2 RCRA-Conducted Reg. VI trial burn 3/86. Achieved four 9's for RCRA surrogate. Need to repeat tests with a new dioxin surrogate since all tests didn't reach six 9s. TSCA- (3/86) trial burn results indicate seven 9's DRE for PCB contaminated liquids and soils.	Unit 2 RCRA- Permit application and demonstration test plan approved by OIS; HQ TSCA-Same status with Reg. VI. Expect decision on TSCA permit (5/87).	Expect unit 2 to operate at the Vertac dioxin site.
Unit 3	Yes	11/83	3/86	"	"	"	"	Unit 3 DOD demonstration burn results for dioxin contaminated soils due 4/87.	Unit 3 RD&D permit for DOD cleanup.	Unit 3 is at the Gulfport, MS Dept. of Defense dioxin site.
Unit 4	No	11/83	7/87	"	"	"	"			
Unit 5	No	11/83	9/87	"	"	"	"			

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TABLE 4-1 PLANNED AND EXISTING TRANSPORTABLE THERMAL TREATMENT SYSTEMS (Continued)
(From EPA, Ref. 4)

UNIT	EXISTING YES/NO	PLANNED DATE OF COMPLETION DESIGN	FABRIC	ACCEPTABLE WASTE	OPERATING CONDITIONS TEMPERATURE (°F)	COMBUSTION ZONE RETENTION TIME	BUILT CAPAC. (TONS/HR) AT 20% MOIST.	BURN DATA TYPE/RESULTS	PERMIT STATUS GRANTED PERMIT/DATA/AGENCY	COMMENTS
3-J.M. HUBER * Borger, TX (Advanced Electric Reactor (AER) Pyrolysis)										
-3-inch core AER field demonstration unit-mounted in a single 45ft. trailer	Yes							3 inch unit has dioxin soil burn data from Times Beach testing. Both the 3 inch and 12 inch have burn data for octachlorodibenzo dioxin. 12 inch unit achieved six 9's plus, with PCB contaminated soils.	RCRA- Both the 3 inch and 12 inch units have Part B's(including dioxin),10/85-Texas Water Commission. TSCA- 12 inch unit has TSCA for PCBs, 3/84-EPA Region VI.	Pretreatment system included to crush and grind solids to a fine material. Solids must contain less than 3% moisture.
-6-inch core fixed AER in Borger, TX. Used for certif. tests	No	complete	10/86							
-12-inch core fixed AER in Borger, TX. Commercial size, but used for R+D and certification tests	Yes						1.5			
-24-inch core AER is possible if demanded	No	depends on demand					6.0			
-Transportable AER	No	design is 95% compl.	Indefin. Would req 9-12 mo.	liquids, solids	3600 to 4500	less than 2 seconds	2.5			Huber will not finalize the design & begin fabrication of a transportable unit until they procure a full-scale commercial job for it.

* Huber is no longer accepting any toxic or hazardous waste at either their fixed or transportable units for at least the next two years. This decision is based on poor market conditions.

TABLE 4-1 PLANNED AND EXISTING TRANSPORTABLE THERMAL TREATMENT SYSTEMS (Continued)

(From EPA, Ref. 4)

UNIT	EXISTING YES/NO	PLANNED DATE OF COMPLETION DESIGN	FABRIC	ACCEPTABLE WASTE	OPERATING CONDITIONS TEMPERATURE (F)	COMBUSTION ZONE RETENTION TIME	APPROX. SOILS CAPAC. (TONS/HR) AT 20% MOIST.	BURN DATA TYPE/RESULTS	PERMIT STATUS EXISTING PERMIT/DATA/AGENCY	COMMENTS
4-SHIRCO INFRARED SYSTEMS Dallas, TX (Infrared Furnace)										
-(3) Existing mobile Pilot Units (100#/hr)	Yes			liquids, solids	Pri. chamber 1600 to 2000 After burner 1800 to 2300	Primary chamber 5 to 90 minutes. After burner 2.2 seconds	100lbs/hr.	RCRA-4/86-Confidential 5/86-Confidential 6/86-Confidential 8/86-Confidential TSCA-3/86-Confidential 4/85-Simulated creosote and Pentachlorophenol contaminated soils test burn-five 9's DRE for pentachlorophenol at detection level. 3\85-Times Beach dioxin contaminated soil results indicate six 9's DRE were achieved. TCDD in ash and scrubber water was non-detect at 0.4ppb and 1.0ppb detection levels respectively. 11/85-Creosote and Penta-chlorophenol and dioxin contaminated soils test burn for International Paper Co.-MO. Six 9's DRE achieved on various POHC's.		A mobile pilot unit was used at EPA Region I Tibbetts Rd. Superfund site in 11/86 on dry of dioxin-contaminated soils. Results expected 4/87. EPA [illegible] has a Shirco unit in storage (300 lb. soil/hr). Shirco infrared systems are also used for regenerating activated carbon. First full-scale transportable unit was purchased by Haztech Inc. and is being used at the Peak Oil Superfund site(PCB-contaminated) in Florida. Three additional full-scale transp. units purchased by O.H. Materials, IT Corp. and Reidel Inc. are expected to be completed fabrication in mid-1987. Additional transp. units will be fabricated upon demand.
-Existing fixed Pilot Unit (100#/hr)	Yes			•	•	•	100lbs/hr.			
-Transportable Unit 5 tons/hr- 50MBtu/hr	Yes			•	•	•	5.0 to 8.0			
-3 addit. trans. units 5tons/hr- 50MBTU/hr	No	Complete	Jun-Aug 1987	•	•	•	•			
-1 tons/hr transp.	No	Complete	Fall 1987	•	•	•	1.0 to 1.5			
5-DETOXCO Pittsburg, CA (Rotary kiln incinerator)										
-Transportable rotary kiln incinerator 9MMBtu/hr.	No	complete	Would req. approx. 10 months	liquids, solids	kiln-1800. secondary combust.-2200.	gases-12 sec.	15.0	None. Although EPA mobile incinerator permit status and burn data may be of some benefit.	None. (see Burn Data column)	This unit design is a scaled-up version of EPA's mobile unit, which DETOXCO fabricated. The new design reflects experience gained in operation of the mobile unit. Fabrication of a unit is about to begin for operation overseas.

TABLE 4-1 PLANNED AND EXISTING TRANSPORTABLE THERMAL TREATMENT SYSTEMS (Continued)
(From EPA, Ref. 4)

UNIT	EXISTING YES/NO	PLANNED DATE OF COMPLETION DESIGN	FABRIC	ACCEPTABLE WASTE	OPERATING CONDITIONS TEMPERATURE (°F)	COMBUSTION ZONE RETENTION TIME	APPROX. SOILS CAPAC. (TONS/HR) AT 20% MOIST.	BURN DATA TYPE/RESULTS	PERMIT STATUS GRANTING PERMIT/DATA/AGENCY	COMMENTS
6-EPA MOBILE INCINERATOR										
-Mobile rotary kiln incinerator-150#'s/hr.	Yes			liquids, solids	kiln-1800 secondary combust.-2200	gases-12 sec.	1.0	Successful PCB and dioxin burn data.	National RCRA and TSCA. Region VII for dioxin. Ash has been delisted.	Capacity is not great enough to justify treating the Creek sediment. The units hardware is currently being upgraded to increase capacity and overall efficiency.
7-PEDCO Cincinnati, OH (Cascading Rotary Incinerator)										
-3ft. inner diameter 20ft. long pilot unit is operating at Rollins, NJ	Yes			liquids solids	1400 to 1700	solids- 15 to 20 minutes. gases-12 sec.	1.0 to 2.0	Rollins has used the unit for test burns. Availability of this data is questionable. Test burns of chlorinated solvents co-fired with coal were conducted. in the fall of 1986.		The unit was designed and fabricated by PEDCO. It was owned by Rollins of NJ. PEDCO now owns the unit and plans to convert it to a mobile unit.
-6ft. inner diameter 25ft. long unit is serving as a coal fired boiler in Ohio.	Yes			•	•	•				
-Additional units could be completed if demand is present.	No	Indefin. Would req. 6 months.		•	•	•				
8-WESTINGHOUSE PLASMA SYSTEMS (Plasma Arc Pyrolysis)										
-One completed plasma arc mobile unit exists (NYSDEC)	Yes			liquid (pumpable) organic wastes	9000	atomization zone (a few thousands of a second. recombination zone 1 to 2 seconds	soils-N/A liquids-1 to 2.5 gal/min.	The unit has successfully burned carbon tetrachloride, methyl ethyl ketone and PCBs in Canada. Results indicate six 9's were achieved.	Compliance with substantive requirements of NEPA and RCRA is being reviewed by EPA Region 2 and NYSDEC.	NYSDEC will demonstrate the existing unit at Love Canal. It should be noted that present plans call for the unit to treat Love Canal leachate treatment plant sludge only.
-Another plasma arc mobile unit planned for commercial use.	Yes		late 1986	•	•	•	soils-N/A liq.- 3 gal/ min.			
-Electric Pyrolyzer				solids			5.0 tons/day	Test burned surrogate materials in Reg. IV. Results are not yet available.		Similar to Huber/Thagard AER. Trying to upgrade to 30 tons/day.

TABLE 4-1 PLANNED AND EXISTING TRANSPORTABLE THERMAL TREATMENT SYSTEMS (Continued)

(From EPA, Ref. 4)

UNIT	EXISTING YES/NO	PLANNED DATE OF COMPLETION DESIGN	FABRIC	ACCEPTABLE WASTE	OPERATING CONDITIONS TEMPERATURE (°F)	COMBUSTION ZONE RETENTION TIME	APPROX. SOILS CAPAC. (TONS/HR) AT 20% MOIST.	BURN DATA TYPE/RESULTS	PERMIT STATUS GRANTING PERMIT/DATA/AGENCY	COMMENTS
9-THAGARD RESEARCH CORP. Costa Mesa, CA (High Temperature Fluid-Wall (HTFW) Reactor Pyrolysis)										
-12-inch core mobile unit is presently in storage.	Yes			liquids solids	4000		1.5 to 2.0	Six 9's with hexa-chlorobenzene. See also Huber AER burn data.		Huber's 12" AER was designed and built by Thagard. Feed material must be ground finely.
10-FULLER POWER CORP. Bethlehem, PA (Rotary kiln incinerator)										
-Transportable rotary kiln incinerators. -2 tons/hr. -4 tons/hr. -8 tons/hr. -Additional units available upon demand	No	complete		liquids solids	kiln- 1800 to 2000 second. combust. 2200 to 2400	gases 12 sec.				Fuller will not fabricate a unit unless a full-scale job is procured. 8 to 10 mo. are required to fabricate.
11-IT CORP. Knoxville, TN	IT Corp. failed to respond to the questionnaire. They are, however, currently pursuing the potential for utilization of conventional incineration of liquids and solids at hazardous waste sites. These units will be transportable and have recently completed the detailed design stage. Fabrication of a unit is expected to be completed in 1987.									

unit would be capable of addressing both the metal and organic contaminants present in site soils; require minimal feed preparation which could result in increased air emissions and noise pollution; generate minimal hazardous byproducts such as ash and air emissions; and function efficiently to minimize treatment time requirements.

Extensive control technologies would be required if this alternative were implemented. Controls required during excavation would be similar to those described previously for the off-site RCRA landfill disposal or solidification/stabilization alternatives. If feed preparation operations such as pulverization or drying were required, then controls would be required to minimize worker contact with the soils during handling operations, to minimize particulate and possibly volatile emissions, and to minimize noise pollution. During thermal treatment, air pollution controls would be required to prevent potential escape of hazardous byproducts. Finally, if the treatment byproducts were hazardous, workers would have to be equipped with the appropriate respiratory and other protection equipment to handle the partially treated ash and scrubber waters.

Temporary storage of the untreated hot spot soils may be required prior to thermal treatment. In addition, if the residual ash and other treatment byproducts are determined to be hazardous, these wastes may also have to be stored on-site prior to treatment and/or disposal. Although some of the mobile treatment units are equipped with temporary storage containments, it is anticipated that temporary storage of all 7,500 cubic yards of hot spot soils to be excavated may pose a problem at the site. It may be necessary to excavate small portions of the site at a time rather than excavate all hot spot soils at once to reduce storage requirements for untreated hot spot soils.

The time required for treatment of the hot spot soils would vary from approximately a few months to two years based on 24 hr/day, 365 day/year operation depending upon the mobile unit selected. The units listed in Table 4-1 were capable of treating 1 to 16 tons/hr at 20 percent moisture content. It is possible, however, that units not included on this list may be capable of handling even more than 16 tons/hr. However, these units may be larger and therefore they may have longer mobilization and demobilization times.

It is anticipated that a "test burn" would be required prior to selection of a final thermal treatment unit for use at the site to determine the level of treatment attainable, the effectiveness of air pollution controls, the time required for treatment, and to identify any problems associated with thermally treating the hot spot soils from the 93rd Street School site. Analysis of the byproducts from a test burn could be used to establish whether or not they would be considered hazardous, delistable, or capable of meeting hybrid closure requirements and therefore whether off-site RCRA landfill disposal (Case I), solidification/stabilization (Case II) or direct on-site disposal (Case III) would be allowed.

Maintenance and monitoring requirements for all cases would include maintenance of the mobile thermal treatment unit, and monitoring of emissions and byproducts to ensure protection of public health and the environment. Depending upon the disposal method allowed, long-term monitoring and maintenance requirements would vary. For Cases I and II, requirements will be essentially the same as those described previously for the off-site RCRA landfill disposal and solidification/stabilization alternatives, respectively. For Case III, however, it is anticipated that long-term maintenance and monitoring at the site will be approximately the same as that for the off-site landfill disposal alternative.

In conclusion, the potential short-term effectiveness of this alternative in protecting human health and the environment is worse than for all other alternatives due to the potential for emissions during excavation as well as during storage of untreated soils, feed preparation, thermal treatment, and hazardous byproducts disposal. The long-term effectiveness, however, will be better than that of other alternatives.

4.2 COMPARISON OF FINAL REMEDIAL ACTION ALTERNATIVES

4.2.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

CERCLA as amended by SARA requires that remedial action alternatives be protective of human health and the environment. Protection should be ensured by selecting an alternative which will reduce threats to acceptable levels and which will not result in potential future impacts on human health and the environment via any exposure pathway.

In Section 3, most alternatives which were judged to be under-protective of human health and the environment were eliminated from further consideration. Thus almost all of the final alternatives being evaluated in this section are considered to be protective of human health and the environment in varying degrees with the exception of the no-action alternative and the possible exceptions of the low permeability capping and off-site RCRA landfill disposal alternatives which do not provide for treatment of hot spot soils.

It has been determined that the no action alternative will not be capable of adequately protecting human health and the environment on a short term basis due to the fact that particles in contaminated surface soils may become airborne, may be transported via surface water runoff or may come into direct contact with humans and other life forms at the site. Over time, it is anticipated that potential exposure risks may increase due to the fact that wind and surface water erosion could expose greater portions of the contaminated soils.

The low permeability capping alternative will provide the greatest level of protection on a short-term basis since excavation and handling of the contaminated soils will not be required, and as soon as the low permeability soils are placed, the short-term risks associated with the no action alternative will be mitigated. A site specific plan for worker health and safety should be drafted and implemented to protect workers during site remediation. Occupational Safety and Health Administration (OSHA) as well as more stringent state regulations should also be followed by workers at the site to minimize the potential for harmful exposures and remediation related accidents. The long-term effectiveness of this alternative is anticipated to be adequate for protection of human health and the environment providing that the cap is properly maintained and the site is inspected and monitored on a regular basis. If contaminated soils in the hot spot area are eventually exposed, however, significant health risks may be posed by the site.

Off-site RCRA landfill disposal of the hot spot soils will require that these soils be excavated, loaded onto trailers, and transported to an EPA approved off-site landfill. As for the low permeability capping alternative, a plan for protection of worker health and safety as well as pertinent OSHA and more stringent state standards should be followed throughout remediation of the site. It is anticipated that workers at the site can be adequately protected from potentially harmful exposures. In addition, it is also believed that nearby residents can be adequately protected from airborne particulates, surface water contamination and direct contact with contaminated soils providing the proper controls are employed. The long-term effectiveness of this alternative will be good at the 93rd Street School site since hot spot soils will be removed from the site. At the off-site landfill, however, the long-term effectiveness will be dependent upon the proper maintenance of the containment.

Solidification/stabilization of the wastes at the site would result in only slightly greater short-term exposure risks than those described previously for the off-site RCRA landfill disposal alternative providing that the appropriate worker health and safety and OSHA and more stringent state are followed throughout site remediation. Long-term risks will vary depending upon the degree of permanence of the solidification/stabilization treatment selected. During preliminary testing, therefore, it should be demonstrated that deterioration of the solidified/stabilized hot spot soils will not occur such that the residuals will pose a significant risk as a result of erosion.

On-site and off-site thermal treatment of the contaminated soils would result in the same excavation related risks as those described previously for the off-site RCRA landfill disposal and solidification/stabilization alternatives. Additional risks of vapor and particulate emissions would occur for the on-site thermal treatment alternative during soils handling, storage, feed preparation, and thermal treatment. It is anticipated that workers at the site (for on-site treatment) or at Love Canal (for thermal treatment at Love Canal) could be adequately protected throughout site remediation by following a worker health and safety plan and the appropriate OSHA and more stringent state standards. Through implementation of air emission, surface water and direct contact controls, it is also anticipated that nearby residents could be adequately protected from exposure to airborne particulates, water borne particulates, and direct contact with contaminated soils.

The long-term effectiveness of these alternatives is dependent upon whether or not the contaminated soils can be treated so that they are delistable or disposable under hybrid closure standards (Cases II and III). If this goal can be achieved, then either on-site thermal treatment or thermal treatment at Love Canal will provide the greatest long-term protection of human health and the environment. If, however, the residual ash remains hazardous, and is disposed at an off-site RCRA landfill (Case I), then the long term effectiveness at the 93rd Street School site will be the same as that of the off-site RCRA landfill disposal alternative.

It should be noted that another potential impact of site remediation on nearby residents is noise pollution. While not life threatening, noise related to construction activities and remedial treatment implementation could be an irritation. The least noise pollution would occur if the no action alternative were implemented. All other alternatives, however, would involve noises related to trucks bringing materials and equipment to and from the site and site work. Although sound barriers could be constructed to minimize on-site noise pollution, noise control for trucks entering and leaving the site would be virtually impossible. The alternatives that may generate the greatest noise impact are solidification/stabilization and on-site thermal treatment since additional noise pollution may occur during feed preparation (particularly if pulverization is required) and during treatment. If the thermal treatment unit is to be operated on a 24 hour per day basis, then the noise may be particularly disturbing to nearby residents. Therefore, if on-site thermal treatment will be performed, noise reduction capabilities of the proposed thermal treatment unit should be evaluated.

4.2.2 COMPLIANCE WITH ARARS

Section 121(d) of CERCLA as amended by SARA requires that Fund-financed, enforcement, and Federal facility remedial actions comply with legally applicable or relevant and appropriate requirements (ARARs) of federal laws and more stringent promulgated state environmental and public health laws. These ARARs typically fall into the following categories:

- Contaminant specific ARARs (e.g. NYSDEC air, surface water, groundwater standards, etc.)
- Location specific ARARs (e.g. restrictions on actions at historic preservation sites, in areas of seismic activity etc.)
- Action specific ARARs (e.g. RCRA requirements for incineration, closure, etc.)

It should be noted that in some cases, alternatives that do not attain ARARs may be acceptable if they are included in one or more of the six waiver categories allowed by SARA in 121(d)(4).

"Applicable" requirements include cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site. "Relevant and appropriate" requirements, however, include cleanup standards, standards of control and other environmental protection requirements, criteria, or limitations promulgated under Federal or state law that are not applicable but do address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the site.

Ambient or chemical specific ARARs are set based on health or risk related concentration limits or ranges of hazardous substances, pollutants or contaminants in various environmental media such as air or water. For the 93rd Street School site, NYSDEC Ambient Water Quality Standards could be used to determine what levels of surface water and groundwater contamination would be acceptable, while National Ambient Air Quality Standards (NAAQSs) or more stringent NYSDEC Air Quality Standards could be used to determine what levels of air emissions would be acceptable. Additional chemical specific health based advisory levels could be used for contaminants for which the ARARs mentioned above are not available. Table 4-2 on the following page lists examples of possible ambient and chemical specific ARARs applicable to the 93rd Street School site for the parameters of concern. Public health and environmental risks associated with site contaminants were discussed previously in Section 6 of Volume I - Remedial Investigation Summary.

TABLE 4-2 - EXAMPLES OF AMBIENT AND CHEMICAL SPECIFIC ARARs

Contaminant	AIR NYSDEC Air Guideline, mg/m^3	GROUNDWATER NYSDEC WQ GA Std & Guides. ug/l	SURFACE WATER NYSDEC WQ Class A Std & Guides. ug/l
Antimony	6.7×10^{-4}	3	3
Arsenic	6.7×10^{-4}	25	50
Lead	1.5×10^{-3}	25	50
Mercury	3.3×10^{-4}	2	2
Benzo (a)anthracene		0.002	0.002
Benzo (b)fluoranthene		0.002	0.002
Benzo (a)pyrene		ND	0.002
Chrysene		0.002	0.002
Indeno [1,2,3-cd] pyrene		0.002	0.002
Dioxin		0.000035	0.000001

Locational ARARs set requirements for the locations where certain remedial action activities can be performed depending upon the characteristics of the site and its immediate surroundings. Federal locational standards for permitted hazardous waste facilities are presented in 40CFR264.18. While these standards are not applicable to the 93rd Street School site, certain standards may be relevant and appropriate including standards for RCRA facilities located within the 100 year flood plain (portions of the contaminated soils to be covered with a low permeability cap would lie at the edge of the 100 year flood plain) and potentially with standards for facilities in areas of seismic activity (Niagara Falls is located in an area of significant seismic activity). The requirements of any additional more stringent NYSDEC locational ARARs should also be met.

Performance, design or other action specific ARARs should be used to restrict or control activities related to management of hazardous substances, pollutants or contaminants. Examples of these standards which would be applicable to the remedial action alternatives being considered for use at the 93rd Street School site include the following:

- RCRA regulations and more stringent state regulations pertaining to hazardous waste generators (40CFR262 and 6NYCRR Part 372, respectively).
- RCRA regulations and more stringent state regulations pertaining to hazardous waste disposal units (40CFR264 and 6NYCRR Part 373, respectively).
- RCRA regulations and more stringent state regulations pertaining to incinerators (40CFR264, Subpart O)

Finally, it should be noted that CERCLA 121(e) exempts any on-site response action from having to obtain a Federal, state or local permit. However, the substantive requirements of permit regulations must be followed.

new paragraph

Because it is impossible to describe in detail all ARARs that should be considered, Table 4-3 which lists New York State ARARs has been included for reference purposes.

TABLE 4-3
NEW YORK STATE ARAR's

New York State Department of Environmental Conservation

° Division of Solid and Hazardous Waste

- Description of Difference - EPA/State Regulations
- 6NYCRR Part 360 - Solid Waste Management Facilities
  361 - Siting of Industrial Hazardous Waste Facilities
- Article 27, Title 11 of the ECL - Industrial Siting Hazardous Waste Facilities
- 6NYCRR Part 364 - Waste Transporter Permits
- Proposed Amendments to 6 NYCRR Part 370 and 373
- 6 NYCRR Part 370 - Hazardous Waste Management System: General
  371 - Identification and Listing of Hazardous Wastes
  372 - Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities
- 6 NYCRR Subpart 373-1 - Hazardous Waste Treatment, Storage & Disposal Facility Permitting Requirements
  Subpart 373-2 - Final Status Standard for Owners and Operators of Hazardous Waste TSD Facilities
  Subpart 373-3 - Interim Status Standards for Owners and Operators of Hazardous Waste Facilities
- 6 NYCRR Part 374 - Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities
  375 - Inactive Hazardous Waste Disposal Sites
  621 - Uniform Procedures
  624 - Permit Hearing Procedures

• Division of Water

- 6 NYCRR Part 703 - NYSDEC Groundwater Quality Regulation
- 6 NYCRR Part 750-757 - Implementation of NPDES Program in NYS
- 6 NYCRR - Parts 701
  702 - Surface Water Quality Standards
  704
- 6 NYCRR Part 701.15 (d) and (e) Empowers DEC to Apply and Enforce Guidance where there are no Promulgated Standard
- Technical and Operations Guidance Series (TOGS)
  - 85-W-40; July 12, 1985 - Analytical Detectability for Toxic Pollutants
  - 1.1.1; April 1, 1987 - Ambient Water Quality Standards and Guidance Values
  - 1.2.1; May 19, 1987 - Industrial SPDES Permit Drafting Strategy for Surface Waters
  - 1.2.1; May 22, 1987 - Waste Assimilative Capacity Analysis for Setting Water Quality Based Effluent Limits
  - 1.3.2; April 1, 1987 - Toxicity Testing in the SPDES Permit Program
  - 1.3.4; April 1, 1987 - BPJ Methodologies
  - 1.6.1; April 1, 1987 - Regional Authorization for Temporary Discharges
  - 2.1.2; April 1, 1987 - Underground Injection/Recirculation (UIR) at Groundwater Remediation Sites

TABLE 4-3 (Continued)
NEW YORK STATE ARAR's

- Division of Air
  - 6 NYCRR Part 200 (2006) - General ~~p~~Provisions
  - 6 NYCRR Part 201 - Permits and Certificates
  - 6 NYCRR Part 211 (211.2) - General Prohibitions
  - 6 NYCRR Part 212 - General Process Emission Sources
  - 6 NYCRR Part 257 - Air Quality Standards
  - Air Guide 1 - Guidelines for the Control of Toxic Ambient Air Contamina~~te~~nts

- Division of Marine Resource, Bureau of Marine Habitat Protection
  - Chapter 10 of 6 NYCRR Part 661 Tidal Wetlands - Land Use Regulations

- Division of Fish and Wildlife
  - 6 NYCRR Part 608 - Use and Protection of Waters
  - 6 NYCRR Parts 662 - Freshwater Wetlands - Interim Permits
    - 663 - Freshwater Wetlands Permit Requirements
    - 664 - Freshwater Wetlands Maps and Classifications
    - 665 - Local Government Implementation of the Freshwater Wetlands Act and State Wide Minimum Land-Use Regulations for Freshwater Wetlands
  - 6 NYCRR Part 182 - Endangered & Threatened Species of Fish and Wildlife
  - ECL Article 24 and Article 71, Title 23 - Freshwater Wetlands Act

- Division of Mineral Resources
  - 6 NYCRR Part 420 - General
    - 421 - Permits
    - 422 - Mined Land-Use Plan
    - 423 - Reclamation Bond
    - 424 - Enforcement
    - 425 - Civil Penalties
    - 426 - Hearings

  - Title 27 - NYS Mined Land Reclamation Law

New York State Department of Health

- NYSDOH PWS 69 - Organic Chemical Action Steps for Drinking Water
- NYSDOH PWS 159 - Responding to Organic Chemical Concerns at Public Water Systems
- The 10 ppt criterion for 2,3,7,8-TCDD in fish flesh
- The Binghamton State Office Building clean-up criteria for PCDDs, PCDFs and PCBs

TABLE 4-3 (Continued)
NEW YORK STATE ARAR's

- Part 5 of the State Sanitary Code, Drinking Water Supplies
- Part 170 of Title 10 of the NYCRR, Water Supply Sources
- Appendix 5-A of Part 5 of the State Sanitary Code (Recommended Standards for Water Works)
- Appendix 5-B of Part 5 of the State Sanitary Code (Rural Water Supply)
- Five Environmental Health Manual items dealing with chemical contamination of public drinking water supplies
- Draft documentation for the generic organic chemical standards in drinking water
- NYSDOH Interim Report on Point-of-Use Activated Carbon Treatment Systems
- Part 16 draft limits on the disposal of radioactive materials into sewer systems
- Criteria for the development of health advisories for sport fish consumption
- Tolerance levels for EDB in food.

New York State Department of Labor

12 NYCRR 50 - Lasers
12 NYCRR 38 - Ionizing Radiation Protection

New York State Department of Agriculture and Markets

1 NYCRR Part 371 - Notice of Intent

• Coastal Management

- Part 600 - Department of State, Waterfront Revitalization and Coastal Resources Act

- State Coastal Policies
- State Consistency Process
- Federal Consistency Process
- NYS Coastal Policies
- NYS Coastal Management Program
- Federal Register, June 25, 1979-Part V-Department of Commerce - Federal Consistency Regulations

4.2.3 REDUCTION OF TOXICITY, MOBILITY OR VOLUME

Another key criteria which must be evaluated when comparing alternatives is the degree to which alternatives employ technologies which will reduce the toxicity, mobility or volume of waste.

Implementation of the no action alternative will not result in a reduction of contaminated soil toxicity, mobility or volume. Therefore, this alternative does not satisfy this evaluation criteria.

Placing a low permeability cap on-site would not reduce the toxicity or volume of hot spot or other identified contaminated soils. It would, however, significantly reduce the mobility of contaminated particulates. In a similar fashion, off-site RCRA landfill disposal would not decrease the toxicity or volume of hot spot or other identified contaminated soils. The mobility of all soil contaminants both at the landfill and at the school site, however, would be significantly reduced once the soils were appropriately covered.

Solidification/stabilization of the wastes would reduce the mobility of volatile and particulate contaminants and the toxicity of most contaminants (depending upon the additives involved). The volume of wastes, however, may increase significantly depending upon the technology selected. Volume increase estimates from manufacturers of solidification/stabilization technologies ranged from a possible slight reduction to a 70 percent increase. In all cases, preliminary testing will be necessary to accurately determine volume changes as a result of treatment.

Thermal treatment of the contaminated soils would reduce their toxicity. The volume of the soils, however, would not be significantly reduced since the soils consist primarily of inert materials. The volume of the vegetative layer soils from the hot spot ~~over~~ area, however, might be significantly reduced because of the higher percentage of organic materials. Since the hot spot soils would be rendered either less toxic or non-toxic, the mobility of hot spot contaminants would be either significantly lower or non-existant, respectively. The short-term mobility of hot spot contaminants would increase, however, due to materials handling and thermal treatment emissions. Thus the control technologies discussed previously would be required to minimize contaminant mobility on a short-term basis.

4.2.4 SHORT-TERM EFFECTIVENESS

The short-term effectiveness of the alternatives should be assessed based on the following factors:

- Magnitude of reduction of existing risks
- Short-term risks which might be posed to the community, workers, or the environment during implementation of an alternative including potential threats to human health and the environment associated with excavation, transportation, and redisposal or containment

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- Time to implement the remedy

As described previously, the no action alternative would not reduce existing risks, and it is anticipated that these risks would increase with time due to the effects of erosion. Since full protection would not be achieved by this alternative, no time can be established for achievement of this goal.

The low permeability capping alternative would virtually eliminate existing risks on a short-term basis since it would not be necessary to disturb the contaminated soils. There might, however, be a slight risk of exposure during use of construction equipment on the surface prior to placement of the bottom layer of the cap. The estimated time to implement this alternative as well as the other final alternatives is presented on Table 4-4. At this time, it is estimated that implementation of this alternative could take to years.

The off-site RCRA landfill disposal alternative would greatly reduce existing risks at the site once the hot spot soils had been removed and transported off-site, and the low permeability cap was placed. Short-term risks which could be incurred during implementation of this alternative were discussed in detail previously. In summary, it was estimated that workers at the site could be adequately protected from all exposure sources by wearing the appropriate respiratory protection and protective clothing while nearby residents and the environment could be protected from airborne and water borne particulates and direct contact by implementation of the appropriate controls. Control of volatile emissions during excavation, transportation and redisposal of the contaminated soils, however, would be virtually impossible but these emissions would not be expected to impose significant risks as described previously in the risk assessment. As many as 375 20 c.y. truck loads of hot spot soils would have to be transported to the off-site landfill. There is a risk that if a truck were to overturn or experience other damage, spillage of the hot spot soils could occur. Finally, the time required to implement this alternative is anticipated to be approximately 35 to 54 months as shown on Table 4-4.

The on-site surface solidification/stabilization alternative would significantly reduce existing risks at the site once the hot spot soils were excavated and treated. The short-term risks associated with this alternative would be essentially the same as those incurred during hot spot soils excavation discussed previously as well as additional risks associated with increased soils handling prior to and during treatment. The time required to implement this alternative has been estimated as 47 to 94 months depending upon whether or not the selected technology would be capable of treating the hot spot soils as they were excavated.

The on-site thermal treatment and thermal treatment at Love Canal alternatives would ~~virtually eliminate~~ significantly decrease existing risks at the site once the hot spot soils were excavated, thermally treated, and disposed. The degree to which

TABLE 4-4 ESTIMATED REMEDIAL ACTION IMPLEMENTATION TIMES

		FINAL ALTERNATIVES		
IMPLRMENTATION ACTIVITIES	NO ACTION	LOW PERM. CAP	RCRA LANDFILL	SOLID/STAB.
1. Signing of Record of Decision	3 mo.	3 mo.	3 mo.	3 mo.
2. Procurement of Design Contractor	NA	4-6 mo.	4-6 mo.	4-6 mo.
3. Completion of Remedial Design	NA	9-12 mo.	9-12 mo.	9-12 mo.
4. Procurement of Remediation Contractor	NA	4-6 mo.	4-6 mo.	4-6 mo.
5. Preliminary Testing	NA	NA	NA	1-2 mo.
6. Delisting or Hybrid Landfill Disposal or RCRA Landfill Disposal Approvals	NA	NA	6-12 mo.	12-24 mo.
7. Mobilization/Demobilization	NA	NA	NA	1-2 mo.
8. Treatment	NA	NA	NA	4-24 mo.
9. Residuals Testing	NA	NA	NA	NA*
10. Approvals for Residuals Disposal	NA	NA	NA	NA*
11. Residuals Disposal	NA	NA	NA	NA*
12. Placement of Low Permeability Cap	NA	9-15 mo.	9-15 mo.	9-15 mo.
TOTAL: (assuming no concurrent activities)	3 mo.	29-43 mo.	35-54 mo.	47-94 mo.

*Included in Treatment

TABLE 4-4 ESTIMATED REMEDIAL ACTION IMPLEMENTATION TIMES (Continued)

IMPLEMENTATION ACTIVITIES	FINAL ALTERNATIVES ON-SITE THERMAL TREATMENT CASE I	CASE II	CASE III	THERMAL TREATMENT AT LOVE CANAL CASE I	CASE II	CASE III
1. Signing of Record of Decision	3 mo.	3 mo.	3 mo.	3 mo.	3 mo.	3 mo.
2. Procurement of Design Contractor	4-6 mo.	4-6 mo.	4-6 mo.	6-10 mo.	6-10 mo.	6-10 mo.
3. Completion of Remedial Design	9-12 mo.	9-12 mo.	9-12 mo.	9-12 mo.	9-12 mo.	9-12 mo.
4. Procurement of Remediation Contractor	4-6 mo.	4-6 mo.	4-6 mo.	6-12 mo.	6-12 mo.	6-12 mo.
5. Preliminary Testing	5-16 mo.	5-16 mo.	5-16 mo.	5-16 mo.	5-16 mo.	5-16 mo.
6. Delisting or Hybrid Landfill Disposal or RCRA Landfill Disposal Approvals	4-7 mo.	4-7 mo.	4-7 mo.	4-7 mo.	4-7 mo.	4-7 mo.
7. Mobilization/Demobilization	8-12 mo.	8-12 mo.	8-12 mo.	8-12 mo.	8-12 mo.	8-12 mo.
8. Treatment	4-12 mo.	4-12 mo.	4-12 mo.	4-12 mo.	4-12 mo.	4-12 mo.
9. Residuals Testing	4-12 mo.	NA*	4-12 mo.	4-12 mo.	NA*	4-12 mo.
10. Approvals for Residuals Disposal	6-12 mo.	NA*	12-24 mo.	6-12 mo.	NA*	12-24 mo.
11. Residuals Disposal	4-13 mo.	NA*	4-12 mo.	4-13 mo.	NA*	4-13 mo.
12. Placement of Low Permeability Cap	9-15 mo.	9-15 mo.	9-15 mo.	9-15 mo.	9-15 mo.	9-15 mo.
TOTAL: (assuming no concurrent activities)	64-126 mo.	50-89 mo.	70-138 mo.	68-136 mo.	54-99 mo.	74-160 mo.

* Included in treatment

risks would be reduced would depend upon whether or not any byproducts which could not be delisted or disposed by the hybrid approach were generated during thermal treatment. If no such byproducts were generated, the byproducts could be disposed on-site (Cases II and III). If, however, the residual ash and other byproducts could not be delisted or disposed by the hybrid approach, it would be necessary to dispose of these wastes at an off-site RCRA landfill (Case I). As described previously, in addition to excavation and transportation related short-term risks, the on-site thermal treatment alternative would also result in additional short-term risks during feed preparation and thermal treatment. Strict controls would have to be employed to minimize emissions prior to and during thermal treatment for either of these alternatives. The estimated time required to implement these alternatives r~~na~~anged from 50 to 160 months as shown on Table 4-4.

4.2.5 LONG-TERM EFFECTIVENESS AND PERMANENCE

In this section, the long-term effectiveness and permanence of the alternatives are assessed based on the following factors:

- Magnitude of residual risks in terms of amounts and concentrations of waste remaining following implementation of remedial action.
- Type and degree of long-term management required including monitoring and operation and maintenance
- Potential for exposure of human and environmental receptors to remaining wastes considering the potential threats to human health and the environment associated with excavation, transportation, redisposal, or containment
- Long-term reliability of the engineering and institutional controls, including the uncertainties associated with land disposal of untreated or partially treated soils
- Potential need for replacement of the remedy.
- Time until acceptable level of protection is achieved.

It has been determined that the no action alternative would result in the greatest long-term risks since all identified contaminated soils would remain on-site in an uncontained and untreated condition. Potential risks associated with site contaminants were computed and described in Section 6 of Volume I - Remedial Investigation Summary. Based on these computations, it was determined that if the no action alternative were implemented, unacceptable direct contact risks would be imposed. In addition, this alternative would require that the site be carefully monitored for signs of potential contamination of air, surface water and groundwater at levels exceeding ARARs. Detailed assessments of monitoring data would be required to ensure that levels of contamination were not increasing. Maintenance would also be necessary to minimize the effects of wind and surface water erosion on the vegetative cover at the site and the effects of weathering on pavements overlying contaminated soils. It is likely that even if careful monitoring and maintenance of the site were provided, the local human population and the environment would still be potential receptors of air and water borne contaminated particulates. In addition, if access to the site was not limited, then direct contact exposures could also occur. In conclusion, it is likely that if the no action alternative were selected, it would be found inadequate for protecting human health and the environment and would therefore have to be replaced by another remedy.

The long-term effectiveness of the low permeability capping alternative would be significantly better than that of the no-action alternative. Because this alternative would be capable of separating the identified contaminated soils from air, surface water and direct contact with humans and other life forms; long-term risks of exposure to soil contaminants would be relatively low. However, since the wastes would remain untreated, it would be necessary to monitor the groundwater. It would also be necessary to perform a detailed assessment of alternative performance at least every five years. Maintenance activities would be required to ensure the integrity of the cap and associated components. Providing that monitoring and maintenance were effectively performed, it is anticipated that long-term exposure risks would be minimal. It is also anticipated that the cap would be effective for a very long time period. There are, however, uncertainties involved should a major earthquake or flood of a magnitude greater than 100 years occur. Thus, it is possible that eventually the cap or portions of the cap might have to be replaced.

The long-term effectiveness of the off-site RCRA landfill disposal alternative would be very good at the 93rd Street School site since the hot spot soils would be removed from the site. At the off-site RCRA landfill, it is anticipated that the waste would be disposed and then covered with a RCRA cap which would also be effective for a very long time period.

The long-term effectiveness of the solidification/stabilization alternative is somewhat uncertain since performance will vary depending upon the particular technology selected. The technology selected should be capable of treating the hot spot soils such that they are delistable or capable of meeting hybrid closure requirements. This would ensure that wastes would be adequately contained for a long time providing that severe flooding or seismic activity did not occur. It is possible, however, that the solidified/stabilized soils would eventually deteriorate. It is anticipated that the deterioration would be detected during routine monitoring and that at that time the solidified/stabilized soils could either be treated, placed in a more extensive containment, or a new remedial action could be selected.

The long-term effectiveness of the on-site and off-site thermal treatment alternatives would be excellent if the contaminated soils and treatment byproducts could be rendered delistable of capable or meeting hybrid closure rerquirements and therefore decrease the potential for a threat to human health or the environment. Maintenance and monitoring would be required, however, since identified contaminated soils would still be present at the site. If the residual byproducts were hazardous, they would still be somewhat less hazardous than the untreated soils depending upon the degree of treatment attained. Thus disposal of the residual ash at an off-site landfill (Case I) would result in slightly reduced long-term risks as compared to disposal of the untreated soils at the off-site landfill. Solidification/stabilization of the residual byproducts followed by disposal on-site and construction of a low permeability cap (Case II) would result in slightly reduced long-term risks as compared to covering of the untreated hot spot soils or solidified/stabilized hot spot soils with an on-site low permeability cap.

4.2.6 IMPLEMENTABILITY

In this section, the implementability of each of the final alternatives is assessed based on the following factors:

- Degree of difficulty associated with constructing the technologies
- Expected operational reliability of the technologies
- Need to coordinate with and obtain necessary approvals and permits from other offices and agencies
- Availability of necessary equipment and specialists
- Available capacity and location of needed treatment, storage, and disposal services.

Implementation of the no action alternative would involve simply leaving the wastes in place at the site uncontained and untreated. As described previously, the operational reliability of this alternative for mitigating site problems would be poor since naturally occuring erosion and weathering would degrade the cover materials and eventually lead to migration of contaminants.

It should be noted, however, that it is anticipated that equipment and specialists for site maintenance and monitoring could easily be acquired in the Niagara Falls area.

Implementation of the low permeability capping alternative would require relatively extensive construction at the site. In addition to construction of the cap, provisions for construction of retaining walls, raised monitoring wells, tree wells, access stairways and other features would be required because of the significant rise in site elevation. If reuse of the site as a schoolyard was desired, the complexity would increase since parking areas and play areas would have to be considered in the design. The anticipated operational reliability of the low permeability capping alternative would be good providing that adequate maintenance and monitoring were performed. Approvals for covering of the contaminated soils might be required from both the state and EPA. This might prove extremely difficult since soils known to contain greater than 1 ppb dioxin would be present beneath the cap along with other hot spot soils which could pose a significant health risk at the site if ever re-exposed. Finally, it is anticipated that equipment and specialists required for cap design and construction, maintenance, and monitoring would be readily available in the Niagara Falls area.

Implementation of the off-site RCRA landfill disposal alternative would not be difficult technically, and it is anticipated that the operational reliability of the off-site landfill selected would be at least as effective as that of the low permeability cap described above. Obtaining the necessary approvals, transportation and disposal facilities might be difficult, however, since dioxin has been identified in the hot spot soils at the site at levels exceeding 1 ppb. As described earlier, CECOS would not be willing to accept the contaminated soils at their New York facility, and they might not be able to accept the soils at their Ohio facility. In addition, SCA would only accept the soils if it could be proven that they did not contain dioxin at detectable levels, and they might have difficulties accepting all 7,500 c.y. of hot spot soils excavated from the site.

Implementation of the solidification/stabilization alternative would vary in difficulty depending upon the technology selected. Since no technology would be used which would be less effective than a low permeability cap alone, the anticipated operational reliability of this technology would be good. Approval of the selected solidification/stabilization system would ~~might~~ be required from both the state and EPA as well as approval for disposing of the solidified/stabilized materials on-site. Availability of necessary equipment and specialists might be more limited than for other alternatives since at the present time, some of these technologies have not been widely accepted for permanently treating soils contaminated with hazardous constituents. Finally, it is anticipated that there would be adequate capacity for disposal of the solidified/stabilized hot spot soils on-site. The site would be somewhat elevated, however, as a result of placement of the low permeability cap over the treated hot spot soils.

Implementation of the on-site thermal treatment alternatives (Cases I-III) would vary in difficulty depending on the mobile unit selected and the disposal method required. Units requiring more extensive feed preparation, treatment of scrubber waters, and disposal of hazardous residuals would be more difficult to implement. The operational reliability of this alternative would also vary depending upon the unit selected.

Routine maintenance and monitoring of the mobile thermal unit would be conducted to ensure reliability and to minimize failure. If failure occurred, then the unit would have to be shut down until the problem could be corrected. It should be noted that thermal treatment units at other hazardous waste sites have been proven to be capable of meeting ARARs. In addition, some thermal treatment residues have been successfully delisted. However, according to EPA (Ref. 4), full scale operation of mobile ther al treatment units at hazardous waste sites has been limited, and some units have experienced extended periods of downtime.

Mobile units are currently available for use at the site, and there is sufficient capacity at the 93rd Street School site for disposal of residuals. If, however, the residuals are hazardous, it may be difficult to dispose of them at an off-site RCRA landfill since they initially contained low levels of dioxin. Finally, if hazardous scrubber waters are generated, it is anticipated that they could be transported to the Love Canal leachate treatment plant for treatment.

Implementation of the thermal treatment at Love Canal alternative will be similar to that described previously for the on-site thermal treatment alternative (Cases I-III). There are, however, some additional factors associated with this alternative which could affect its implementability. First, the possibility of including treatment of the 93rd Street School site hot spot soils at the transportable thermal destruction unit (TTDU) to be used at Love Canal for treatment of creek and sewer sediments was not discussed in the Declaration for the Record of Decision signed on October 26, 1987. Therefore, work would be required to coordinate treatment of the 93rd Street School site soils either before, along with or after treatment of the sewer and creek sediments. Also, if the 93rd Street School soils had to be stored prior to treatment, storage along with the creek and sewer sediments would have to be coordinated. Finally possible delays in the schedule for thermal destruction of the creek and sewer sediments could delay treatment of the 93rd Street School site as well if this alternative is selected.

4.2.7 COST

Estimated costs for preliminary remedial action alternatives were presented previously in Section 3. The intent of this section is to develop detailed cost estimates for each of the final alternatives. Included are detailed estimates of capital costs; operation, maintenance, monitoring and detailed assessment costs; and net present worths for each of the final alternatives. The Implicit Price Deflators of the GNP as presented in Table 3-1 were used in the development of cost estimates in this section where costs in 1988 dollars were not available. In addition, it should be noted that all capital costs presented in this section were rounded off to the nearest $5,000 while all annual costs were rounded off to the nearest $500.

Estimated costs for the no action alternative are presented in Table 4-5. There will not be any capital expenses associated with this alternative. Periodic expenses will include the costs of quarterly monitoring of the groundwater and surface water at the site; periodic air monitoring at the site; maintenance of the lawn and pavement overlying contaminated soils; and a detailed performance evaluation every five years to assess the effectiveness of this alternative. The quantities of samples to be collected during site monitoring were estimated based on quarterly sampling of the 13 existing monitoring wells at the site (i.e., wells 7135 to 7150 and SMW-1 to SMW-9), quarterly collection and analysis two surface water samples from the existing swale, and annual analysis of three air samples. These samples would be analyzed for a selected set of indicator parameters derived from the list of parameters of concern for the site. Additional groundwater contamination information to be obtained during the remedial design phase will be necessary to develop a final list of parameters. Therefore, at this time it will be assumed that all parameters of concern as defined in Volume I Section 3 should be included.

TABLE 4-5 - NO ACTION ALTERNATIVE COST ESTIMATE

CAPITAL EXPENSE ITEMS		TOTAL COST
1. None	TOTAL:	$0

PERIODIC EXPENSE ITEMS	QTY.	UNITS	COST	TOTAL COST
1. Quarterly Monitoring				
a. Groundwater	52	Sample/Yr.	$2,500.00	$130,000
b. Surface water	8	Sample/Yr.	2,400.00	19,500
2. Periodic Air Monitoring	3	Sample/Yr.	500.00	1,500
3. Site Maintenance				
a. Lawn	35,000	S.Y.	0.25	9,000
b. Paved Areas	5,500	S.Y.	1.00	5,500
4. Detailed Evaluation (every 5 years)	0.2	Eval./Yr.	100,000	20,000
			Sub Total:	$185,500
		20% Eng. and Reg. Contingency:		37,500
			TOTAL:	$223,000

Lawn and pavement maintenance would be performed in an attempt to minimize deterioration of the vegetative layer and pavement overlying contaminated soil. Finally, for this alternative as well as all other alternatives in which untreated wastes will remain on-site, a detailed performance assessment will be required at least every five years. Costs were estimated based on these assumptions, subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $223,000 for the annual cost of the no action alternative.

Estimated costs for the low permeability capping alternative are presented in Table 4-6. Capital expenses will include purchase, transport and placement of all necessary cap layers including underlying fill, low permeability soil for the low permeability layer, topsoil, and vegetation. Also included are capital expenses for raising monitoring wells, reinforcing paved areas overlying non hot spot contaminated soils, constructing necessary retaining walls, constructing tree wells, raising catch basins, and performing a final survey. Periodic costs will include semi-annual site inspections, quarterly groundwater monitoring, detailed five year assessments, and maintenance activities to ensure the integrity of the cap, monitoring wells, and other related structures. Cost estimates were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in an estimated capital cost of $1,305,000 and an estimated annual cost of $195,000 for the low permeability capping alternative.

Estimated costs for the off-site RCRA landfill disposal alternative are presented in Table 4-7. Capital expenses associated with this alternative will include the costs for excavating hot spot soils and overlying pavement, transporting the soils to an off-site RCRA disposal facility (assuming 375 loaded trips using 20 c.y. trucks to transport the soils 500 miles), disposal of

TABLE 4-6 - LOW PERMEABILITY CAP ALTERNATIVE COST ESTIMATE

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Clean Fill	25,000	C.Y.	$15.00	$375,000
2. Clay	17,500	C.Y.	20.00	350,000
3. Topsoil	3,000	C.Y.	25.00	75,000
4. Hydroseed, Lime, Fertilizer	8	Acre	1,500.00	15,000
5. Raise 5 Existing Monitoring Wells an Avg. of 4 Ft. each	20	Ft.	100.00	5,000
6. Reinforce Paved Areas	7,000	S.Y.	7.00	50,000
7. Retaining Walls	1,200	Ft.	150.00	180,000
8. Tree Wells	10	Wells	500.00	5,000
9. Raise Catch Basins	2	C.B.	500.00	5,000
10. Final Survey	500	Man.Hr.	50.00	25,000
			Sub-Total:	$1,085,000
	20% Eng. & Reg. Contingency:			220,000
			TOTAL:	$1,305,000

TABLE 4-6 - LOW PERMEABILITY CAP ALTERNATIVE COST ESTIMATE(Continued)

PERIODIC EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST/YR
1. Semi-Annual Site Inspection	50	Manhr/Yr	$50.00	$ 2,500
2. Quarterly Groundwater Monitoring	52	Sample/Yr	2,500.00	130,000
3. Detailed Evaluation (every 5 years)	0.2	Eval/Yr	100,000.00	20,000
4. Maintenance				
a. Cap Maintenance				2,500
b. Misc. Maintenance				7,500
			Sub-Total:	$162,500
		20% Eng. & Reg. Contingency:		32,500
			TOTAL:	$195,000

TABLE 4-7 - OFF-SITE RCRA LANDFILL DISPOSAL ALTERNATIVE COST ESTIMATE

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Hot Spot Soil Excavation	7,500	C.Y.	$5.00	$ 40,000
2. Hot Spot Pavement Excavation	3,000	S.Y.	8.00	25,000
3. Transport Hot Spot Soils	187,500	Loaded Mi.	4.00	750,000
4. Disposal of Hot Spot Soils	11,250	Ton	90.00	1,015,000
5. Clean Fill	7,500	C.Y.	15.00	115,000
6. Reconstruct Paved Areas				
a. Base	3,000	S.Y.	5.00	15,000
b. Pavement, 3" thick	3,000	S.Y.	7.00	25,000
7. Place Low Permeability Cap		See Table 4-6		1,085,000
			Sub-Total:	$3,070,000
		20% Eng. and Reg. Contingency:		615,000
			TOTAL:	$3,685,000

PERIODIC EXPENSE ITEMS				TOTAL COST/YR
1. Semi-Annual Site Inspection	50	Manhr/Yr	$50.00	$2,500
2. Quarterly Groundwater Monitoring	52	Sample/Yr	1,300.00	68,000
3. Detailed Evaluation (every 5 years)	0.2	Eval/Yr	100,000.00	20,000
4. Maintenance				
a. Cap Maintenance				2,500
b. Misc. Maintenance				7,500
			Sub-Total:	$100,500
		20% Eng. and Reg. Contingency:		20,500
			TOTAL:	$121,000

the hot spot soils at the off-site landfill (including necessary analyses and taxes); placement of clean fill in the excavated area; reconstruction of paved areas and placement of the low permeability cap. Costs for transportation and disposal were based on costs supplied by Chemical Waste Management, Inc. A 500 mile distance was assumed since it may be more difficult than initially anticipated to find a landfill willing or able to accept the contaminated soils. Annual costs associated with this alternative will be similar to those for the low permeability capping alternative except that groundwater monitoring requirements will be somewhat less extensive. In conclusion, estimated capital and annual costs for this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final capital cost estimate of $3,685,000 and a final annual cost estimate of $121,000 for the off-site RCRA landfill disposal alternative.

Cost estimates for the solidification/stabilization alternative are presented in Table 4-8. Capital expenses for this alternative will include the costs for preliminary testing and approvals, excavating hot spot soils and overlying pavement, solidifying/stabilizing the soils on-site (including the costs of mobilization/demobilization, operation, and maintenance during operation), analysis of treated soils to verify delistability or ability to be disposed in a hybrid facility; redisposal of stabilized/solidified soils on site; reconstruction of paved areas; and placement of a low permeability cap. The cost range for solidification/stabilization was estimated based on information provided by the various manufacturers as $50 to $150 per ton. The cost of redisposal of the solidified/stabilized hot spot soils on site was based on an assumed volume increase range of 0 to 70 percent. It should be noted that depending upon the technology selected, the volume increase may vary significantly. Since the cost of redisposal is much less than that of the

TABLE 4-8 - SOLIDIFICATION/STABILIZATION ALTERNATIVE COST ESTIMATE

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Preliminary Testing & Approvals			$100,000	$100,000
2. Hot Spot Soil Excavation	7,500	C.Y.	$5.00	40,000
3. Hot Spot Pavement Excavation	3,000	S.Y.	8.00	25,000
4. Solidification/Stabilization	11,250	Ton	50.00 to 150.00	565,000 to 1,690,000
5. Sampling/Analysis of Treated Soils	15	Sample	1,000.00	15,000
6. Redisposal of Treated Soils	7,500 to 13,000	C.Y.	5.00	40,000 to 65,000
7. Reconstruct Paved Areas				
a. Base	3,000	S.Y.	5.00	15,000
b. Pavement, 3" thick	3,000	S.Y.	7.00	25,000
8. Place Low Permeability Cap - See Table 4-6 - - - - - - - - - -				1,085,000
			Sub-Total:	$1,910,000 to $3,060,000
20% Eng. and Reg. Contingency:				$ 385,000 to $ 615,000
			TOTAL:	$2,295,000 to $3,675,000

PERIODIC EXPENSE ITEMS	TOTAL COST/YR
1. Same as Off-Site RCRA Landfill Disposal Alternative	$ 121,000

solidification/stabilization processes, however, even if the volume were to increase by as much as 70 percent, it would [redacted] result in a relatively small percent increase in the total cost. Periodic expenses associated with this alternative will include costs for semi-annual site inspections, quarterly groundwater monitoring, detailed performance evaluations (every five years), and maintenance activities. It should be noted that monitoring costs for this alternative are anticipated to be somewhat less than those of the low permeability capping alternative since hot spot soils will have been rendered delistable or capable of meeting hybrid closure requirements. In conclusion, the estimated costs for this alternative were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of $2,295,000 to $3,675,000 for the capital cost and $121,000 for the annual cost of the solidification/stabilization alternative.

Cost estimates for the on-site thermal treatment alternative (Cases I to III) are presented in Table 4-9. Capital costs associated with Case I will include preliminary testing; excavation of hot spot soils and overlying pavement; mobilization/demobilization and miscellaneous expenses; thermal treatment (including solids handling) sampling and analysis of treatment byproducts; transport of byproducts to an EPA approved off-site RCRA landfill; disposal of byproducts at the off-site RCRA landfill; placement of clean fill; reconstruction of paved areas and construction of a low permeability cap. As described previously in Section 3, estimated costs for on-site thermal treatment using a mobile treatment unit were $450 per cubic yard plus $50 per cubic yard for solids handling. In addition, costs for transportation and disposal of treated byproducts at an off-site landfill were estimated based on the same assumptions presented previously in the discussion of the off-site RCRA landfill disposal alternative. Annual expenses associated with this alternative are the preliminary testing of this alternative indicates that the final product will not be permanently rendered delistable or suitable for hybrid landfill disposal, this alternative is recommended for remediation of the 93rd Street School site.

facility must be built at the site to contain the hot spot soils prior to treatment, the cost of this alternative is anticipated to be lower than that of almost all of the thermal treatment alternatives with the possible exception of thermal treatment at Love Canal (Case III).

The most effective of the thermal treatment alternatives considered are anticipated to be on-site thermal treatment (Case III) and thermal treatment at Love Canal (Case III) in which treatment byproducts will be rendered delistable or disposable in a hybrid landfill. If these criteria can be met, these alternatives will be capable of adequately protecting human health and the environment, meeting ARARs, and reducing the toxicity and mobility of contaminants. Significant volume changes are not expected. The short term effectiveness of these alternatives will be somewhat lower than that of the no action, containment or solidification/stabilization alternatives both because of increased solids handling and thermal treatment emissions. It is anticipated, however, that controls can be used to minimize short term risks. The implementability of the on-site thermal treatment alternative is expected to be similar to that of the solidification/stabilization alternative. The implementability of the thermal treatment at Love Canal alternative, however, may be complicated by the fact that consideration of thermally treating soils from the 93rd Street School site was not included in the development of the plan for remediation of the creek and sewer sediments. Finally, the costs of the on-site thermal treatment alternative (Case III) is anticipated to be significantly higher than that of the thermal treatment at Love Canal (Case III) as well as than that of the no action, containment, and solidification/stabilization alternatives.

In conclusion, it appears at this time that unless state and community acceptance of the solidification/stabilization alternative are unacceptable or alternative was not considered feasible for remediation of the 93rd Street School site.

Containment alternatives evaluated in this feasibility study were as follows:

- placement of a low permeability cap over both hot spot soils and other identified contaminated soils at the site
- disposal of hot spot soils at an approved off-site RCRA landfill followed by placement of a low permeability cap over other identified contaminated soils at the site

Since neither of these alternatives provide for treatment of the hot spot soils, the 1 ppb level of concern established for dioxin will not be addressed. As a result, it is anticipated that NYSDEC will not approve of the low permeability capping alternative. In addition, risks associated with leaving the other hot spot soils at the site are significantly greater if these soils are not treated primarily because of the PAHs and arsenic.

The solidification/stabilization alternative will only be selected if it can be proven during preliminary testing that the technology is permanent and capable of rendering the soils delistable or disposable in a hybrid landfill. If these criteria can be met, this alternative will be capable of adequately protecting human health and the environment, meeting ARARs, and reducing the toxicity and mobility of contaminants. In addition, although it is possible that volume increases could be as great as 70 percent, all manufacturers contacted during this study felt that volume increases would probably be in the range of 10 to 30 percent. The short-term effectiveness of this alternative will probably be less protective than for the no-action or containment technologies due to the need for increased solids handling. It is anticipated, however, that controls can be used to minimize the short-term risks. The implementability of this alternative is expected to be quite good since almost all manufacturers contacted believed that they could begin preliminary testing and treatment as soon as approvals were obtained. Finally, even if a storage

TABLE 4-9 - ON-SITE THERMAL TREATMENT ALTERNATIVE COST ESTIMATE
CASE I

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Preliminary Testing				$500,000
2. Hot Spot Soil Excavation	7,500	C.Y.	$5.00	40 ~~25~~,000
3. Hot Spot Pavement Excavation	3,000	S.Y.	8.00	25,000
4. Mobilization/Demobilization of Mobile Treatment Unit and Misc. Expenses				1,000,000
5. Thermal Treatment	7,500	C.Y.	500.00	3,750,000
6. Sampling/Analysis of Byproducts	15	Sample	1,000.00	15,000
7. Transport of Byproducts 375 trucks @ 500 loaded mi.	187,500	Loaded Mi.	4.00	750,000
8. Disposal of Byproducts	11,250	Ton	90.00	1,015,000
9. Clean Fill	7,500	C.Y.	15.00	115,000
10. Place Low Permeability Cap	----See Table 4-6----			1,085,000
11. Reconstruct Paved Areas				
a. Base	3,000	S.Y.	5.00	15,000
b. Pavement, 3" thick	3,000	S.Y.	7.00	25,000
			Sub-Total:	$8,335,000
	20% Eng. and Reg.		Contingency:	1,670,000 ~~1,260,000~~
			TOTAL:	$10,005,000 ~~$9,595,000~~

PERIODIC EXPENSE ITEMS		TOTAL COST/YR
1. Same as Off-Site RCRA Landfill Disposal Alternative	TOTAL:	$ 121,000

TABLE 4-9 - ON-SITE THERMAL TREATMENT ALTERNATIVE COST ESTIMATE
(Continued)
CASE II

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Thermal Treatment	7,500	C.Y.	$500.00	$3,750,000
2. Mobilization/Demobilization of Mobile Treatment Unit and Misc. Expenses				1,000,000
3. Thermal Treatment Associated Activities Same as Case I Items 1,2,3,6	----See Case I Cost Estimate---			580,000
4. Preliminary Solidification/ Stabilization Testing				100,000
5. Solidification/Stabilization	11,250	Ton	50.00 to 150.00	565,000 to 1,690,000
6. Sampling/Analysis of Treated Soils	15	Sample	1,000.00	15,000
7. Dispose Byproducts On-Site	7,500 to 13,000	C.Y.	$5.00	40,000 to 65,000
8. Place Low Permeability Cap----See Table 4-6 -----------------				1,085,000
9. Reconstruct Paved Areas				
a. Base	3,000	S.Y.	5.00	15,000
b. Pavement, 3" thick	3,000	S.Y.	7.00	25,000
			Sub-Total:	$7,175,000 to $8,325,000
	20% Eng. and Reg. Contingency:			1,435,000 to 1,665,000
			TOTAL:	$8,610,000 to $9,990,000

PERIODIC EXPENSE ITEMS		TOTAL COST/YR
1. Same as Solidification/Stabilization	TOTAL:	$121,000

TABLE 4-9 - ON-SITE THERMAL TREATMENT ALTERNATIVE COST ESTIMATE
(Continued)
CASE III

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Thermal Treatment	7,500	C.Y.	$500.00	$3,750,000
2. Mobilization/Demobilization of Mobile Treatment Unit and Misc. Expenses				1,000,000
3. Thermal Treatment Associated Activities Same as Case I Items 1,2,3,6	----See Case I Cost Estimate---			580,000
4. Dispose Byproducts On-Site	7,500	C.Y.	$5.00	40,000
5. Place Low Permeability Cap	----See Table 4-6------------------			1,085,000
6. Reconstruct Paved Areas				
a. Base	3,000	S.Y.	5.00	15,000
b. Pavement, 3" thick	3,000	S.Y.	7.00	25,000
			Sub-Total:	$6,495,000
	20% Eng. and Reg. Contingency:			1,300,000
			TOTAL:	$7,795,000

PERIODIC EXPENSE ITEMS		TOTAL COST/YR
1. Same as Off-Site RCRA Landfill Disposal	TOTAL:	$121,000

essentially the same as those for the off-site RCRA landfill disposal alternative. In conclusion, estimated capital and annual costs were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final estimate of ~~$9,595,000~~ $10,005,000 for the capital cost and $121,000 for the annual cost of on-site thermal treatment (Case I).

Capital costs for on-site thermal treatment (Case II) will include preliminary testing; excavation of hot spot soils and overlying pavement; thermal treatment (including soils handling); sampling and analysis of treatment byproducts; solidification/stabilization of byproducts; resampling and analysis of treatment byproducts; disposal of byproducts on-site; construction of the low permeability cap and related structures; and reconstruction of paved areas. The periodic expenses associated with this alternative will be the same as those estimated previously for the solidification/stabilization alternative. In conclusion, costs were subtotalled and added to a 20 percent engineering regulatory contingency resulting in final estimates of $8,610,000 to $9,990,000 for the capital costs and $121,000 for the annual cost of on-site thermal treatment (Case II).

Capital costs for the on-site thermal treatment alternative (Case III) include preliminary testing; excavation of hot spot soils and overlying pavement; thermal treatment (including solids handling); mobilization/demobilization and miscellaneous expenses; sampling and analysis of treatment byproducts; disposal of byproducts on site; placement of the low permeability cap and reconstruction of paved areas. Periodic expenses associated with this alternative will be essentially the same as those for the off-site RCRA landfill disposal alternative. Estimated capital and annual costs were subtotalled and added to a 20 percent engineering and regulatory contingency resulting in a final capital cost estimate of $7,795,000 and a final annual cost estimate of $121,000 for the on-site thermal treatment alternative (Case III).

Cost estimates for the thermal treatment at Love Canal alternative (Cases I-III) are presented in Table 4-10. These estimates are very similar to the estimates presented for on-site thermal treatment except that there are additional costs associated with transporting the hot spot soils to the Love Canal TTDU for Cases I and III, there are additional costs associated with transporting the treated residuals back to the site for Cases II and III, and the costs of treatment are slightly lower since the mobile TTDU will have already been approved and mobilized. Based on these assumptions, the estimated capital and annual costs were subtotaled and added to a 20 percent engineering and regulatory contingency resulting in the following final cost estimates for the thermal treatment at Love Canal alternative:

	Capital Cost	Annual Cost
Case I	$8,810,000	$121,000
Case II	$7,425,000 to 8,805,000	$121,000
Case III	$6,610,000	$121,000

TABLE 4-10 - THERMAL TREATMENT AT LOVE CANAL ALTERNATIVE
COST ESTIMATE
CASE I

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Same as On-Site Case I ------See Table 4-9------------------- (Items 1,2,3,6,7,8,9,10,11)				$3,585,000
2. Transport Untreated Hot Spot Soils to Love Canal TTDU (375 Trucks @ 1.5 loaded mi.)	563	Loaded Mi.	4.00	5,000
3. Cost of Treatment	7,500	C.Y.	500.00	3,750,000
			Sub-Total:	$7,340,000
	20% Eng. and Reg. Contingency:			1,470,000
			TOTAL:	$8,810,000

PERIODIC EXPENSE ITEMS		TOTAL COST/YR
1. Same as On-Site Case I	TOTAL:	$ 121,000

TABLE 4-10 - THERMAL TREATMENT AT LOVE CANAL ALTERNATIVE
COST ESTIMATE
Continued
CASE II

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Same as On-Site Case II------See Table 4-9------------------- (Items 3,4,5,6,7,8,9)				$2,425,000 to 3,575,000
2. Transport Untreated Hot Spot Soils to Love Canal TTDU (375 Trucks @ 1.5 loaded mi.)	563	Loaded Mi.	4.00	5,000
3. Cost of Treatment	7,500	C.Y.	500.00	3,750,000
4. Transport Thermal Treatment Byproducts Back to Site (375 Trucks @ 1.5 loaded mi.)	563	Loaded Mi.	4.00	5,000
			Sub-Total:	$6,185,000 to 7,335,000
		20% Eng. and Reg.	Contingency:	1,240,000 to 1,470,000
			TOTAL:	$7,425,000 to $8,805,000

PERIODIC EXPENSE ITEMS		TOTAL COST/YR
1. Same as On-Site Case II	TOTAL:	$ 121,000

TABLE 4-10 - THERMAL TREATMENT AT LOVE CANAL ALTERNATIVE
COST ESTIMATE
Continued
CASE III

CAPITAL EXPENSE ITEMS	QTY.	UNITS	UNIT COST	TOTAL COST
1. Same as On-Site Case III------See Table 4-9------------------- (Items 3,4,5,6)				$1,745,000
2. Transport Untreated Hot Spot Soils to Love Canal TTDV (375 Trucks @ 1.5 loaded mi.)	563	Loaded Mi.	4.00	5,000
3. Cost of Treatment	7,500	C.Y.	500.00	3,750,000
4. Transport Thermal Treatment Byproducts Back to Site (375 Trucks @ 1.5 loaded mi.)	563	Loaded Mi.	4.00	5,000
			Sub-Total:	$5,505,000
	20% Eng.	and Reg.	Contingency:	1,105,000
			TOTAL:	$6,610,000

PERIODIC EXPENSE ITEMS		TOTAL COST/YR
1. Same as On-Site Case III	TOTAL:	$ 121,000

Present worths for the final alternatives are presented in Table 4-11. These present worths were computed based on the same assumptions discussed previously in Section 3. In conclusion, the relative magnitude of these present worth estimates are very similar to those presented previously for the preliminary alternatives. The no-action alternative is the least costly, while the thermal treatment at Love Canal alternative in which the byproducts cannot be delisted and must be solidified/stabilized (i.e. Case II) will be the most costly. It should be noted that if a temporary RCRA grade storage facility must be built for storage of the hot spot soils prior to treatment either by solidification/stabilization or a mobile thermal unit, costs may be as much as 3 million dollars greater if a design similar to that proposed for containment of the creek and sewer sediments is used (Ref. 4). Therefore, an additional column has been added to Table 4-11 which includes construction of a storage facility at the 93rd Street School site for the solidification/stabilization and on-site thermal treatment alternatives.

4.2.8 COMMUNITY ACCEPTANCE

Community acceptance of the remedial action alternatives for the 93rd Street School site will be assessed following the public meeting to be held in April 1988.

4.2.9 STATE ACCEPTANCE

State acceptance of the various alternatives will be reflected in review comments on this final draft of the Remedial Investigation/Feasibility Study report for the 93rd Street School site.

4.2.10 CONCLUSIONS

The no action alternative will not provide for adequate protection of human health and the environment as proven in the risk assessment presented in Section 6 of Volume I - Remedial Investigation Summary. Therefore, this

TABLE 4-11 - PRESENT WORTH ANALYSIS OF FINAL ALTERNATIVE COST ESTIMATES

(Costs in Thousands)

ALTERNATIVE	EST. CAPITAL COST	EST. ANNUAL COST	PRESENT WORTH*	PRESENT WORTH* WITH STORAGE FACILITY
No Action	0	$223	$ 2,025	$2,025
Low Permeability Cap	$ 1,305	195	3,075	3,075
Off-Site RCRA Landfill Disposal	3,685	121	4,785	4,785
Solidification/ stabilization	2,295 to 3,675	121	3,395 to 4,775	6,395 to 7,775
On-Site Thermal Treatment				
Case I	10,005	121	10,695	14,105
Case II	8,610 to 9,990	121	9,710 to 11,090	12,710 to 14,090
Case III	7,795	121	8,895	11,895
Thermal Treatment at Love Canal				
Case I	8,810	121	9,910	9,910
Case II	7,425 to 8,805	121	8,525 to 9,905	8,525 to 9,905
Case III	6,610	121	7,710	7,710

*Based on a discount rate of 10 percent and a performance period of 25 years; P/A factor is equal to 9.077.

REFERENCES

1. Sampling For The Screening Of 2,3,7,8-tetrachlorodibenzo-p-dioxin, by NUS, Inc., August 1985

2. Engineering Investigations at Inactive Hazardous Waste Sites Phase II Investigation, by RECRA Research, August 1985

3. Draft Feasibility Study for Sinclair Landfill Site, by SMC Martin, Inc., August 1985

4. Heath, Ralph C., Basic Groundwater Hydrology, USGS Water Supply Paper No. 2220, 1983

5. Love Canal Additional Creek Sampling and Sanitary Sewer Inspection by Malcolm Pirnie, Inc., June 1987

APPENDIX B

DRAWING S-3

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