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Environmental Information Document

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SITE INVESTIGATIONS AND REMEDIAL ACTION ALTERNATIVES LOVE CANAL

Task II
North Storm and Sanitary Sewers

For

Division of Solid and Hazardous Waste
New York State Department
of Environmental Conservation
Albany, New York

August 1983

DRAFT

By

Malcolm Pirnie, Inc.
Niagara Falls, Albany and White Plains, New York

MALCOLM
PIRNIE

MALCOLM PIRNIE, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

August 12, 1983

Norman H. Nosenchuck, Director
Division of Solid and Hazardous Waste
New York State Department of
  Environmental Conservation
50 Wolf Road
Albany, New York 12233

Re: Site Investigations and Remedial
    Action Alternatives, Love Canal

Dear Mr. Nosenchuck:

Submitted herewith is the Environmental Information Document (EID) for Task II, North Storm and Sanitary Sewers. As marked, this report is a draft and is subject to revision based upon your review, USEPA Region II comments, as well as the reviews performed by other cognizant New York State agencies.

A voluminous amount of detailed supporting documentation stands behind this EID. That back-up information which includes sampling logs, chain-of-custody forms, analytical data, QA/QC reports, and so on, will be submitted to you separately. Additionally, a summary document will be prepared to address all five project task areas. That summary document is intended to be submitted with the final EIDs.

We would be pleased to make a presentation to you concerning this report at your request. If either of the undersigned may be of further assistance to you, please feel free to contact us.

Very truly yours,

MALCOLM PIRNIE, INC.

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1.0 INTRODUCTION

The former chemical waste disposal site at Love Canal occupies a 16-acre rectangular plot of ground in the LaSalle District of Niagara Falls, New York. A regional map illustrating its location is presented as Figure 1-1.

The site is bounded by Colvin Boulevard on the north, 99th Street on the east, Frontier Avenue on the south, and 97th Street on the west. Two roads, Read and Wheatfield Avenues, crossed the landfill in an east-west direction. A public elementary school, known as the 99th Street School, occupied a portion of the land between Read and Wheatfield Avenues and was built adjacent to the eastern boundary of the landfill. The southermost portion of the site is approximately 1,500 feet north of the Niagara River.

The first signs of serious chemical contamination at Love Canal became evident in 1975, and by November 1976 the frequency and magnitude of the problems cited by area residents prompted an investigation of the site by the New York State Department of Environmental Conservation (NYSDEC). As a result of this investigation, a barrier drain, a clay cap over the former canal, and permanent on-site leachate treatment facilities were completed by the end of 1979.

The primary objectives of this initial remedial construction at Love Canal were to halt further lateral contaminant migration from the landfill, prevent runoff of contaminated surface water, and to minimize leachate generation. A U.S. Environmental Protection Agency (USEPA) study, released in May 1982 concluded that the barrier drain was functioning effectively to halt the lateral transport of contaminants through the soil.

FIGURE 1-1

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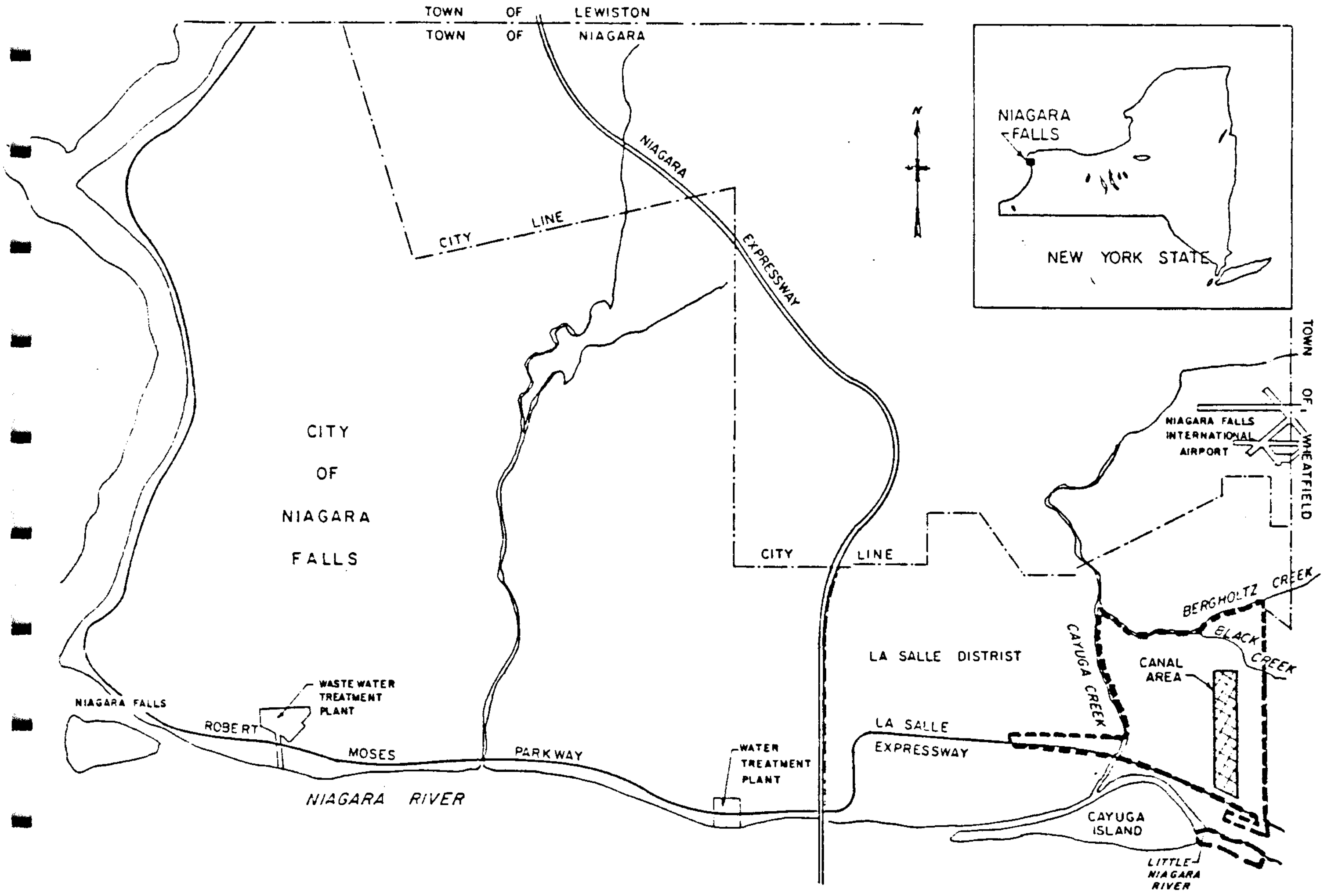

LOVE CANAL
SITE INVESTIGATIONS AND REMEDIAL
ACTION ALTERNATIVES
REGIONAL MAP

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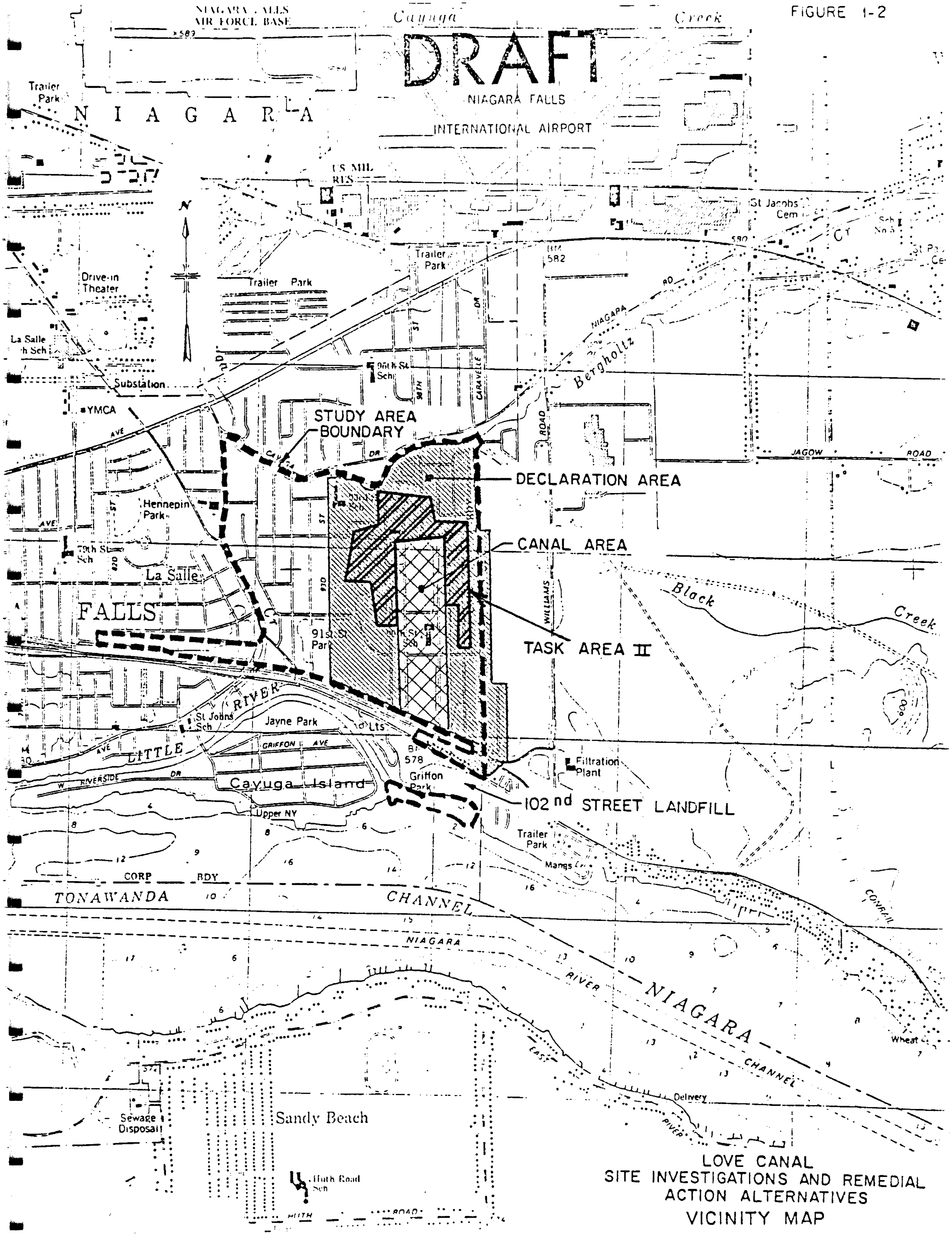
In January 1983 five engineering investigations were initiated in areas adjacent to Love Canal. These engineering investigations were conducted by Malcolm Pirnie, Inc. as part of seven additional Love Canal remedial projects being administered by the NYSDEC Division of Solid Waste under a cooperative agreement with the USEPA. Task Areas II, IV and VII address contamination in adjacent storm and sanitary sewers, while Task Areas III and VI are concerned with contaminated sediments in Black and Bergholtz and Cayuga Creeks and in the Niagara River near the 102nd Street storm sewer outfall. The study area comprised of the five task areas, the area encompassed by the May 1980 emergency declaration, and the immediate canal area (i.e. Rings 1 and 2 inside the fence) are illustrated in the vicinity map presented as Figure 1-2.

This Environmental Information Document (EID) presents a detailed contamination assessment and evaluates remedial alternatives for Task Area II, the North Storm and Sanitary Sewers. EIDs addressing the four other task areas have been prepared separately.

FIGURE 1-2



LOVE CANAL
SITE INVESTIGATIONS AND REMEDIAL
ACTION ALTERNATIVES
VICINITY MAP

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2.0 PROJECT OBJECTIVES

2.1 Overall Program

The overall objective of the project was to develop the most environmentally sound and economically feasible remedial action plan for any Love Canal-related contamination which has migrated away from Rings 1 and 2. The specific work items associated with each of the five task areas are summarized below:

- Determination of the extent of contamination in both storm and sanitary sewers in the task area;
- Identification of the pathways for migration of contaminants into and away from the task area;
- Assessment of contaminants in and migrating from the task area;
- Development of remedial alternatives to prevent further contamination of the environment from the contamination in the task area;
- Evaluation of the implementability of each alternative; and
- Recommendation of the alternative to be implemented.

2.2 Specific Task Area II Objectives

Task Area II, the North Storm and Sanitary Sewers, is generally bounded by Black Creek on the north, 102nd Street on the east, 95th Street on the west and Wheatfield Avenue on the south as illustrated on Figure 1-2.

In addition to the general objectives stated in Section 2.1, specific objectives of the engineering investigation of Task Area II are summarized as follows:

- Verify the degree and extent of contamination in the storm sewers flowing north into Black Creek. The 96th Street and Colvin Boulevard storm sewers in particular were identified as contaminated in previous studies.

- Develop a data base to determine if contamination migration occurred in sanitary sewers which were originally connected to 97th Street, 99th Street and Wheatfield Avenue. Only one sanitary manhole had been sampled in the Declaration Area by the USEPA prior to this engineering study.

- Determine extent and degree of contamination in portions of Black Creek diverted through large corrugated steel pipelines between 98th and 102nd Street.

- Determine if contaminants are actively migrating from the canal area via 97th and 99th Street sewers.

- Evaluate if significant contaminant migration is occurring in storm sewers during storm events.

- Determine the degree and extent of contamination of pipe bedding materials and assess the potential of bedding material to act as a migration pathway.

- Determine the potential for volatilization of contaminants in the sewers and the potential impact of chemical volatilization upon remedial efforts.

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3.0 BACKGROUND INFORMATION

3.1 Site History (Summarized from EPA Monitoring Report)

The Love Canal landfill takes its name from William T. Love, whose plan was to dig a power canal between the upper and lower Niagara River to provide cheap hydroelectric power for a proposed model industrial city. The Model City project and partially dug canal were abandoned before the turn of the century. In 1942, the Hooker Chemicals and Plastics Corporation entered into an agreement with the Niagara Power and Development Company (then owner of the canal) to purchase Love's unfinished canal. Hooker has acknowledged that it used the canal between 1942 and 1953 for the disposal of at least 21,800 tons of various chemical wastes. It is also know that the City of Niagara Falls disposed of solid wastes (mainly in the portion of the canal bounded today by Read and Wheatfield Avenues) in Love Canal.

Shortly after Hooker terminated disposal activities at Love Canal in 1953 the land was acquired by the Niagara Falls Board of Education for the purpose of constructing an elementary school on the site. In 1955, the 99th Street Elementary School located adjacent to the eastern edge of the landfill on 99th Street between Read and Wheatfield Avenues was completed and opened.

As early as 1938, a number of private residences were located near the northeast corner of Love Canal. By 1952 approximately 6 to 10 houses existed on 99th Street (the backyards of these houses faced toward the active dumping in the canal), mainly located around the central and south-central portions of the canal. By 1962 virtually all of the 99 houses on 97th and 99th Streets whose backyards faced the former canal, the so-called "Ring 1" houses, were completed. In general, residential development around Love Canal occurred primarily from the mid-1950's through the early 1970's. By 1966, all evidence of earlier excavation at the site had been eliminated by subsequent construction activities.

In the mid 1970's a number of problems in the general Love Canal area were noticed by residents. These problems included: unpleasant chemical odors, oily and corrosive residues in basement sumps, ponded surface water, physical subsidence, and surfaced drums in the landfill itself.

Numerous investigations conducted between 1976 and 1980 showed that serious contamination and potential health risks existed in residences adjacent to Love Canal. As a result of these investigations and related events New York State eventually purchased all homes within Rings 1 and 2, and most homes included in the May 1980 emergency declaration (the so-called Declaration Area). These actions led to the permanent relocation of canal area residents and the initiation of USEPA Love Canal environmental monitoring studies described in Section 3.2.

Since the latter part of 1978, a series of remedial construction activities have been undertaken in the Canal Area. A leachate collection system was installed around the entire perimeter of the former canal in order to prevent continuing lateral migration of contaminants from the landfill. Lateral trenches were dug from the main barrier drain trench towards the former canal and filled with sand to hasten dewatering of the site and to facilitate construction. A clay cap was also installed over portions of the landfill to minimize volatilization of contaminants, prevent human contact with hazardous wastes, prevent runoff of contaminated surface water, and to minimize the amount of precipitation infiltrating the landfill and thus reduce the generation of leachate. Leachate collected on the site is treated at a permanent activated carbon facility which became operational at the end of 1979. In July and August of 1982, all Ring 1 and 2 houses within the fenced canal area were demolished to make way for a more complete cap over the landfill.

In February of 1983, work began on a permanent cap consisting of clay and synthetic materials, and on an impermeable barrier wall to further restrict contaminant transport through upper soil strata. More recently, in June of 1983, the 99th Street School was also demolished to accommodate the final cap.

3.2 USEPA Love Canal Monitoring Study

The most recent and comprehensive report on environmental contamination, "Environmental Monitoring at Love Canal," was published by the USEPA in May 1982. The report was based on extensive analyses of air, water, sediment and biota samples collected during August, September and October 1980. The USEPA data revealed a limited pattern of environmental contamination in the area immediately adjacent to the canal, probably caused by "localized and highly selective migration of toxic substances from the former canal to the vicinity of certain Ring 1 houses." The data also revealed that contamination was present in storm sewer lines which originated near the former canal. No evidence of Love Canal-related contamination was found in storm sewers which were isolated from direct canal area flow.

A total of 26 sampling sites within the study area were included in the storm sewer portion of the monitoring program.

A pattern of direct Love Canal-related contamination was evident in storm sewer lines connected to the sewers on 97th and 99th Streets. Numerous compounds were detected including chlorinated benzenes and toluenes, and several pesticides including Lindane and other isomers of hexachlorocyclohexane (BHC). The ranges of contaminant concentrations in storm sewer sediments were 0 to 169 ppb, 0 to 237 ppb and 0 to 79 ppb for benzenes, toluenes and Lindane, respectively. Contaminant concentrations in sewer sediment samples were generally higher than those detected in sewer water samples, and were also generally found to decrease with increasing distance from the canal area.

Similar to other Love Canal-related contaminants, the presence of 2,3,7,8-tetrachlorodibenzo-p-Dioxin (2,3,7,8-TCDD) was detected in a number of storm sewer sediment samples with decreasing concentrations as distance from the former canal increased. 2,3,7,8-TCDD was detected at concentrations up to 650 ppb.

Apart from these findings, the monitoring data revealed no clear evidence of environmental contamination in the area encompassed by the emergency declaration order that was directly attributable to the migration of substances from Love Canal. Furthermore, the data revealed that the barrier drain system surrounding the landfill was effectively intercepting substances migrating laterally from Love Canal, and was drawing near-surface ground water back to the drains for collection and subsequent treatment.

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3.3 Other Pertinent Reports and Findings

3.3.1 Storm and Sanitary Sewers

Residences in the LaSalle District, which encompasses the entire study area, originally used septic tanks and tile fields to dispose of sanitary wastewater. When storm sewers were installed prior to annexation of the District by the City of Niagara Falls in 1927, many of the septic systems were connected to the storm sewers. Installation of sanitary sewers began shortly after the annexation and continued as the area was further developed and as needs arose (see "Report to City of Niagara Falls, LaSalle Infiltration/Inflow Analysis," November 1975). Most sanitary sewers in the study area are between 45 and 50 years old, except for those serving the Griffon Manor housing development which were installed around 1973. Shortly after the canal was filled in 1953, Read and Wheatfield Avenues were built across the landfill. In 1960, the City of Niagara Falls installed a storm sewer line under Read Avenue, which entered the canal site from 97th Street and ended in a catch basin located approximately midway between 97th and 99th Streets. Field inspection notes reported that only excavated soils were used to fill the trench. City records do not identify the construction of storm sewer laterals on Wheatfield Avenue connecting into storm sewer lines on 97th and 99th Streets. However, field inspection notes reported that storm sewer laterals were built along Wheatfield Avenue from both 97th and 99th Streets, each running towards the former canal for approximately 170 feet. As with other sewer lines installed by the City of Niagara Falls around Love Canal, these were also reportedly backfilled with excavated soils.

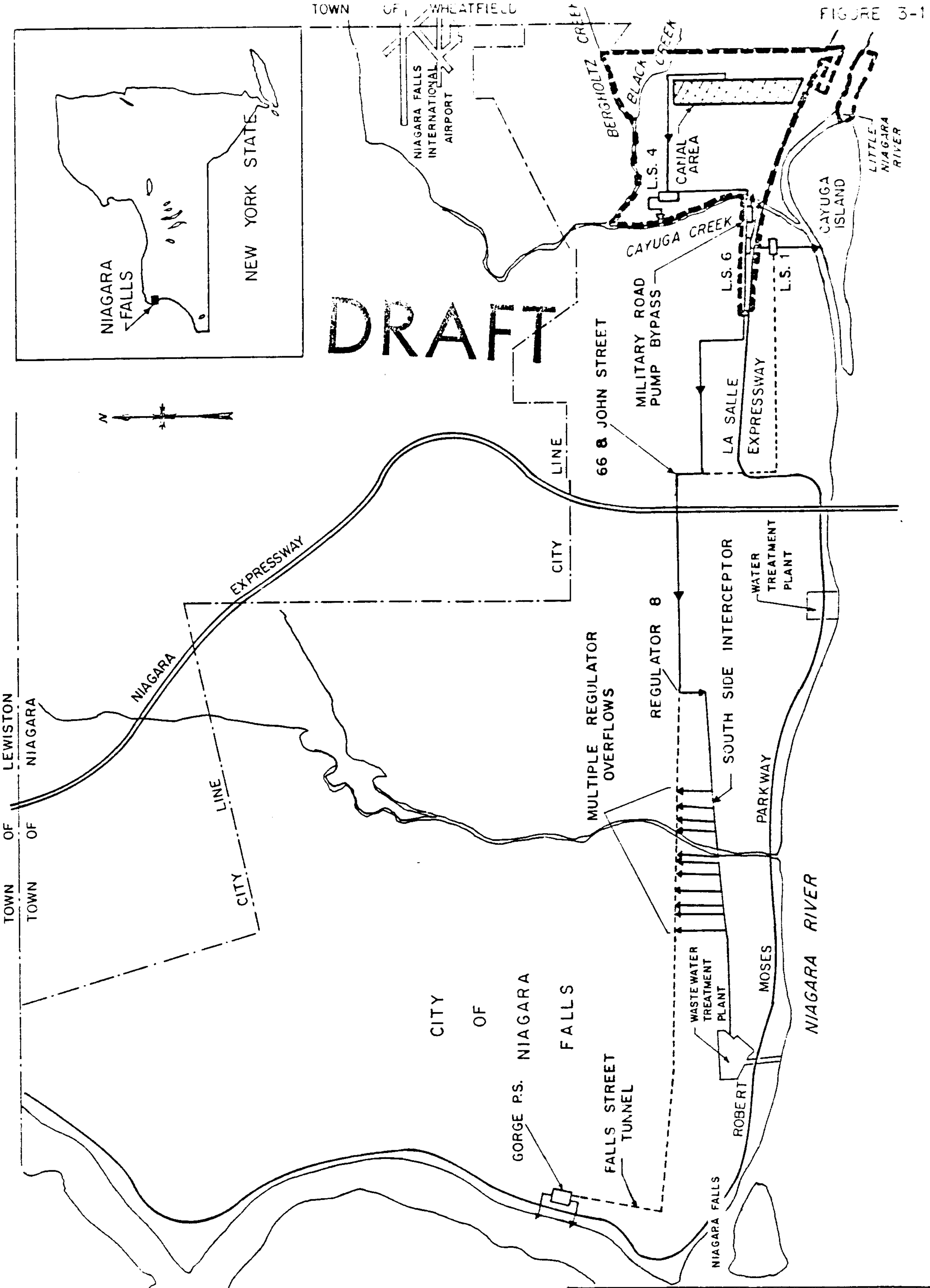
The western limits of the entire study area (Task Areas II, IV, and VII) is Lift Station No. 6. Once the flow reaches Lift Station No. 6, there are two potential routes to the City of Niagara Falls Wastewter Treatment Plant. These routes are shown on Figure 3-1 and described below.

The vast majority of the wastewater leaves Lift Station No. 6 in a westerly direction via the gravity sanitary sewer on Frontier Avenue. At 74th Street the wastewater turns north and flows to Girard Avenue where the wastewater turns west and flows to 66th Street.

At very infrequent intervals, the wastewater from Lift Station No. 6 can overflow into Lift Station No. 1. From Lift Station No. 1, the wastewater heads west by gravity along Stephenson Avenue. At 66th Street, the wastewater turns north and flows to Girard Avenue. At the intersection of Girard Avenue and 66th Street, the wastewater from both potential flow routes combines into one sewer. At this point, wastewater from the northern industrial area of the City of Niagara Falls combines with the wastewater stream from the study area. This industrial contribution would hinder any attempts at identifying specific Love Canal contaminants beyond this point.

From Girard Avenue and 66th Street, the wastewater flows north by gravity to John Street. At John Street, the wastewater turns west and flows via gravity to 47th Street and Royal Avenue at which point the Southside Interceptor begins.

FIGURE 3-1



LOVE CANAL FIVE ENGINEERING STUDIES
SANITARY SEWER OVERFLOWS

During dry weather conditions the wastewater in the Southside Interceptor flows directly to the City of Niagara Falls Wastewater Treatment Plant. During high flow periods, normally caused during rainfall periods, the Southside Interceptor can overflow through regulators into the Falls Street Tunnel. The Falls Street Tunnel flows to the Gorge Pumping Station where the wastewater is pumped to the City of Niagara Falls Wastewater Treatment Plant or bypassed directly to the Niagara River.

3.3.2 Previous Contamination Investigations

Numerous documents exist which directly or indirectly address Love Canal, nearby inactive hazardous waste disposal sites, and their effect on the environment. The following summarizes the findings of these previous reports on the extent of contamination in the study area sewers.

- A liquid sample collected by the City in May 1980 at the 99th Street and Wheatfield sanitary sewer indicated concentrations of 89 ppm, 22 ppm and 1.5 ppm of chlorinated benzenes (total all species), lindane and Hexachlorobutadiene (C-46) respectively (see memos from John Westendorf, chemist for City of Niagara Falls, New York). These high contaminant concentrations prompted the City to plug the Wheatfield sanitary sewer at 99th Street in October 1980. Subsequent samples collected from the Lift Station No. 4 influent after the Wheatfield sanitary sewer was plugged show steadily decreasing contaminant concentrations with a large seasonal and weather-dependent variability.

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- An analytical survey was conducted for USEPA, Region II, between March 25 and May 30, 1980 (see "Survey of Chemical Contaminants in Love CAnal Storm Sewers," USEPA 1980). The survey dealt with storm sewers flowing from the Love Canal area northward into Black Creek. A total of 10 manhole sediment samples, 5 Black Creek sediment samples, 13 catchbasin sediment samples, and 37 air samples (all locations) were collected. The air samples were taken to provide data to be used in planning the decontamination efforts so as to minimize the health risks to workers and area residents.

  The results of the air sampling indicate that no explosive gas mixtures were detected at any location. Concentrations of volatile indicator compounds in manhole airspaces were relatively low. Stirring of the sediment had no dramatic effect on the release of volatile indicator compounds in the air space except at the first manhole on 97th Street just south of Colvin Boulevard.

  All manhole samples were contaminated by at least one of the indicator compounds (BHC, TCP, and Dichlorobenzene). The maximum contaminant in any manhole was 24.7 ppm of 1,4 dichlorobenzene at the first manhole on 97th Street just south of Colvin Boulevard.

  Only catch basins within the present Canal Area were sampled. Contamination was found in each catch basin.

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- The New York State Department of Health and Environmental Conservation conducted an extensive sampling program in the spring and summer of 1979 involving collection and analysis of approximately 80 storm sewer water and sediment samples (see "Special Reporto to Governor and Legislature, Love Canal").

  Results from approximately 17 locations in Task Area II were reported. Most locations where Love Canal contaminants were found once had a direct connection to the Love Canal Area or are close to Black Creek where surcharging can occur. However, trace quantities were also found on 101st Street and 102nd Street south of Colvin Boulevard and in 99th Street and Moschel Court and Deuro Drive north of Black Creek.

- The USEPA took liquid samples from three storm manholes on August 14-18, 1978 (see NYPHD Document No. 49, "USEPA Study of Love Canal Area Storm Sewers, Chemical Analysis and Flow Measurement"). The manholes were at 96th and Colvin, 100th and Colvin, and 100th and Frontier. Trace quantities of Love Canal contaminants were found in each sample. Two of the manholes are in Task Area II. These sewers, at the time of this sampling, had a direct connection to the Love Canal area.

3.4 Other Abandoned Hazardous Waste Disposal Sites

Inactive hazardous waste disposal sites are believed to be a major source of persistent chemical substances that

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contribute to contamination of water supplies, fish and waterfowl in the Niagara River and Lake Ontario. Investigations by NYSDEC, Niagara River Toxics Project, and the Interagency Task Force on Love Canal have identified 155 disposal sites within three miles of the Niagara River (see Overview of Environmental Pollution in the Niagara Rontier, New York, 1982, and Hazardous Waste Disposal Sites in New York State, NYSDEC, 1980). Several sites are located close to the study area, thereby complicating planning for remedial activity in certain task areas.

3.4.1 Niagara County Refuse Disposal

This 50-acre site is located in the Town of Wheatfield east of Love Canal in the Black Creek watershed. While accurate information is unavailable, thousands of tons of hazardous wastes were disposed there, including some material excavated from Love Canal when Frontier Avenue was relocated in 1968. A recent inspection by the NYSDEC revealed heavy erosion and exposure of some dumped materials on the site. Recent water sampling has indicated chloroganics leaching from the site.

Contaminated runoff and groundwater contributions from this site could have an impact on remedial actions in Task Area II and Black and Bergholtz Creeks.

FIGURE 3-2

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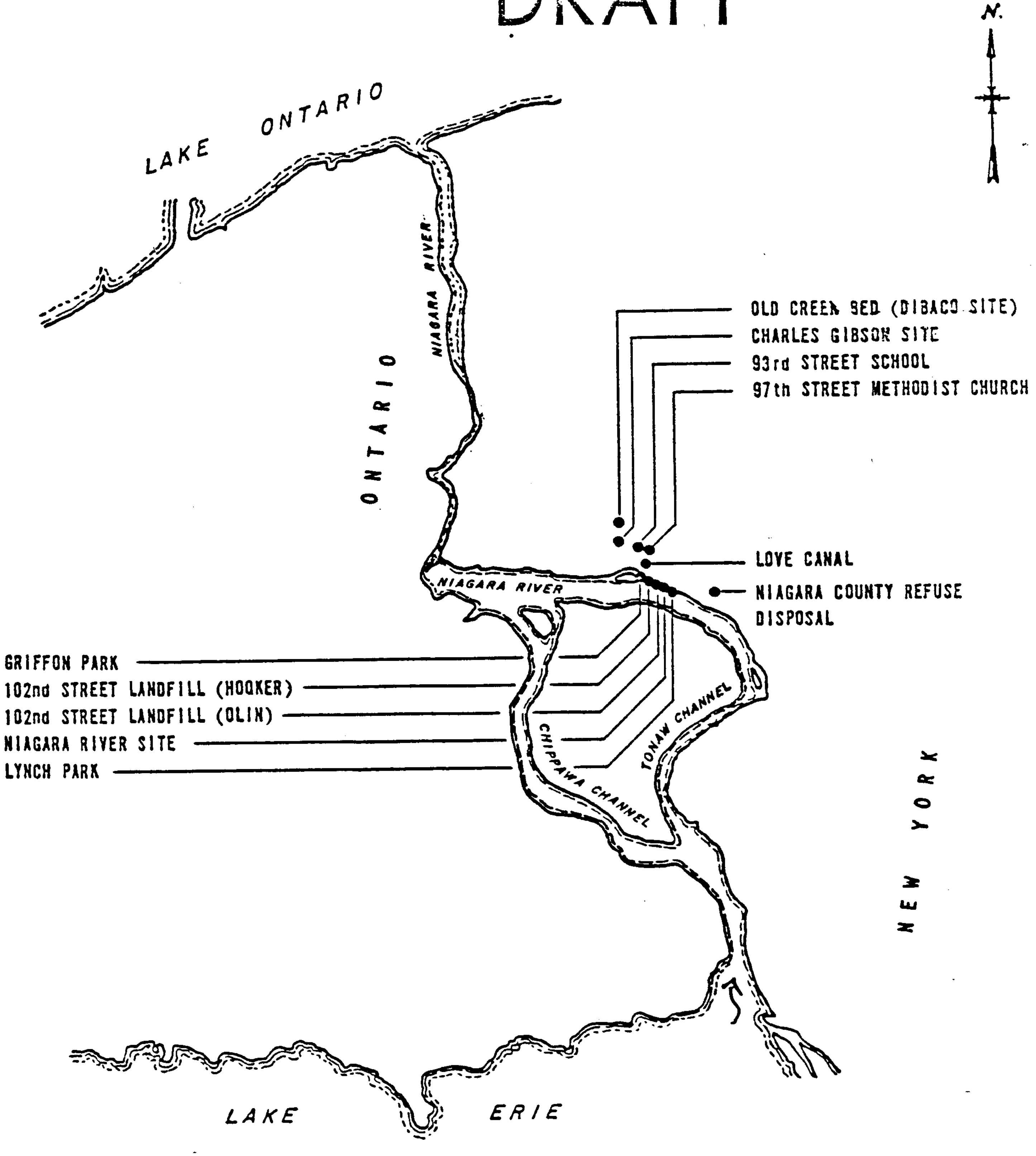

LOVE CANAL
FIVE ENGINEERING STUDIES

HAZARDOUS WASTE DISPOSAL SITES OF CONCERN

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4.0 FIELD INVESTIGATIONS

4.1 General Approach

4.1.1 Storm and Sanitary Sewers

Field investigations in Task Area II were conducted from January 3 to January 21, and March 10 and March 11, 1983. The investigations included collection of liquid, sediment and sewer bedding material samples; assessment of manhole condition; estimation of sewer sediment deposition; and visual inspection of stormwater catchbasins. Investigations were conducted by three man crews consisting of two environmental technicians working under the direction of an engineer.

Grab samples were manually collected at selected manholes during both dry weather and storm event conditions. The collection point within the manholes was typically in the actual pipe channel, although solids were collected from the manhole benches at locations where sediment deposition in the pipe was minimal.

Liquid samples were collected by submerging the sampling container directly into the ponded or flowing liquid, if sufficiently deep. Where this was not possible due to low flow conditions, the samples were collected using stainless steel scoops and poured into the sampling containers taking care to minimize volatilization due to agitation. All sediment samples were collected using stainless steel scoops and poured into the sampling containers after manually pouring off the bulk surface liquid in the scoop.

The following criteria were used in selecting sample locations:

- All storm and sanitary sewer lines originating in or adjacent to the canal;
- Approximately every 200 feet on straight runs, where physically possible;
- All affected junctions and bends;
- Storm sewer outfalls to Black Creek;
- Sewer reaches suspected of being contaminated based on visual inspection, discussions with City personnel or previous monitoring results;
- Known or suspected interconnections between sanitary and storm sewers;
- Areas of known surcharge.

All manholes on the selected sewer reaches of the task area were opened regardless of whether or not they were sampled to assess their condition, note pipeline material, depths, sizes and orientation, and to record the amount of sediment present. Storm sewer catch basins adacent to the canal area were also inspected for odors or oily deposits to determine if sampling was warranted.

Strict decontamination procedures were followed in the field to prevent cross contamination of samples by equipment or personnel. Collection, handling and analytical techniques utilized were in accordance with procedures established by

NYSDEC and USEPA. To ensure the integrity of the samples, strict chain of custody protocol was also followed throughout the course of the field investigation.

4.1.2 Bedding Material

In general, bedding material sampling locations were spread out over the task area and chosen close to earlier sewer sampling locations suspected of having contamination, sewer lines orginating from the Canal Area, or sewer lines suspected of having select granular bedding.

Each boring was supervised by an experienced inspector, under the immediate supervision of a Certified Professional Geologist. Worker safety was maintained in accordance with approved "Work and Safety Plan." The precise location to drill was determined in the field. The manhole crews, as part of their sampling process, painted onto the ground surface the centerline of the sewers which intersected the manholes to show their alignment and determined depth to the sewer invert. The borings were located off of the centerlines a distance of about 1 foot from the outside edge of the sewer pipe. A 2-mil thick sheet of plastic about 9 feet x 12 feet was centered over the boring location with a 1-foot diameter hole through which the boring was drilled. The boring was advanced to a predetermined depth approximately 12 inches below the sewer invert with hollow stem augers with a plug in the auger bit. The plug was removed and either a 2-inch or 3-inch diameter, 24 inches long, split spoon sample was taken. The 3-inch spoon was used in locations of known or suspected select granular bedding material (to assure that sufficient volume of sample was collected). In cases where the sewer lines were larger, or where the spoon samples did not confirm the bottom of the bedding material, a second sample was collected and blended with the first to form a single representative sample. Any "clean" soil from the boring after the augers were pulled out of the ground was swept off the plastic and tamped back down into the hole. The top 6 inches of a boring completed in a street were backfilled with a "ready mix" asphalt and tamped with a 140-pound hammer. Any soil suspected of containing contamination were shoveled into 55 gallon drums for proper disposal. Decontamination of the drilling equipment and workers was done in accordance with the approved "Work and Safety Plan."

4.2 Task Specific Approach and Sampling Rationale

The storm and sanitary sewer reaches and manholes selected for investigation in Task Area II are shown in Figures 4-1 and 4-2, respectively. A total of 46 liquid samples, 40 sediment samples and 13 bedding material samples were collected during the investigations.

4.2.1 Sanitary Sewers

No sanitary sewers were previously sampled in Task Area II, therefore, the sampling pattern was developed to collect samples from sewers which were shown to have a direct connection to the Canal Area. The sewers in Task Area II which had direct connection to the canal area were 101st Street between Wheatfield Avenue and Colvin Boulevard and Colvin Boulevard from 93rd Street to 101st Street. Other tributary sewers were also sampled to evaluate the effect of sewer surcharging (via backups) caused by:

FIGURE 4-1

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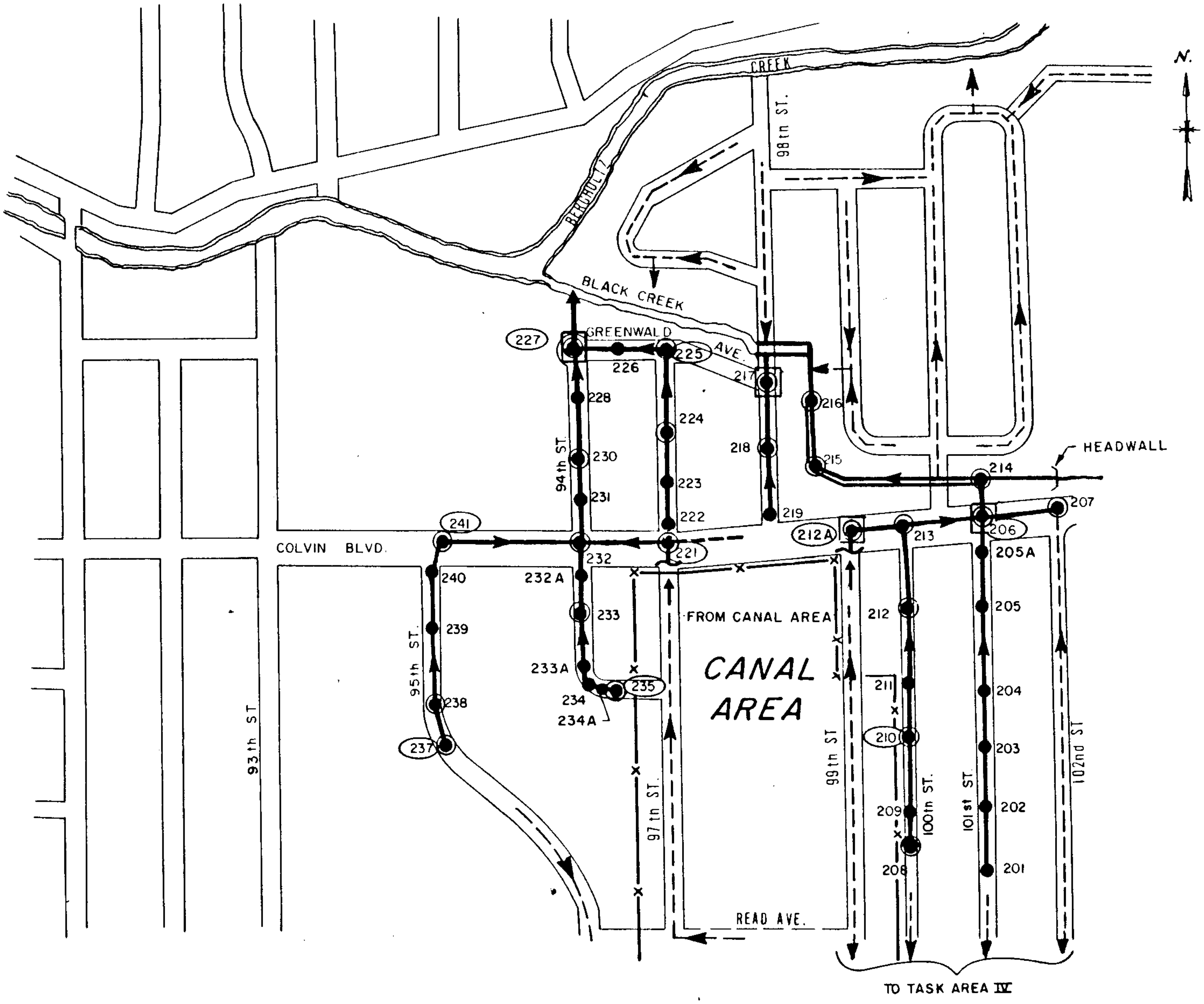

LOVE CANAL
FIVE ENGINEERING STUDIES
NORTH STORM SEWERS
TASK AREA II

SAMPLE LOCATION POINTS

FIGURE 4-2

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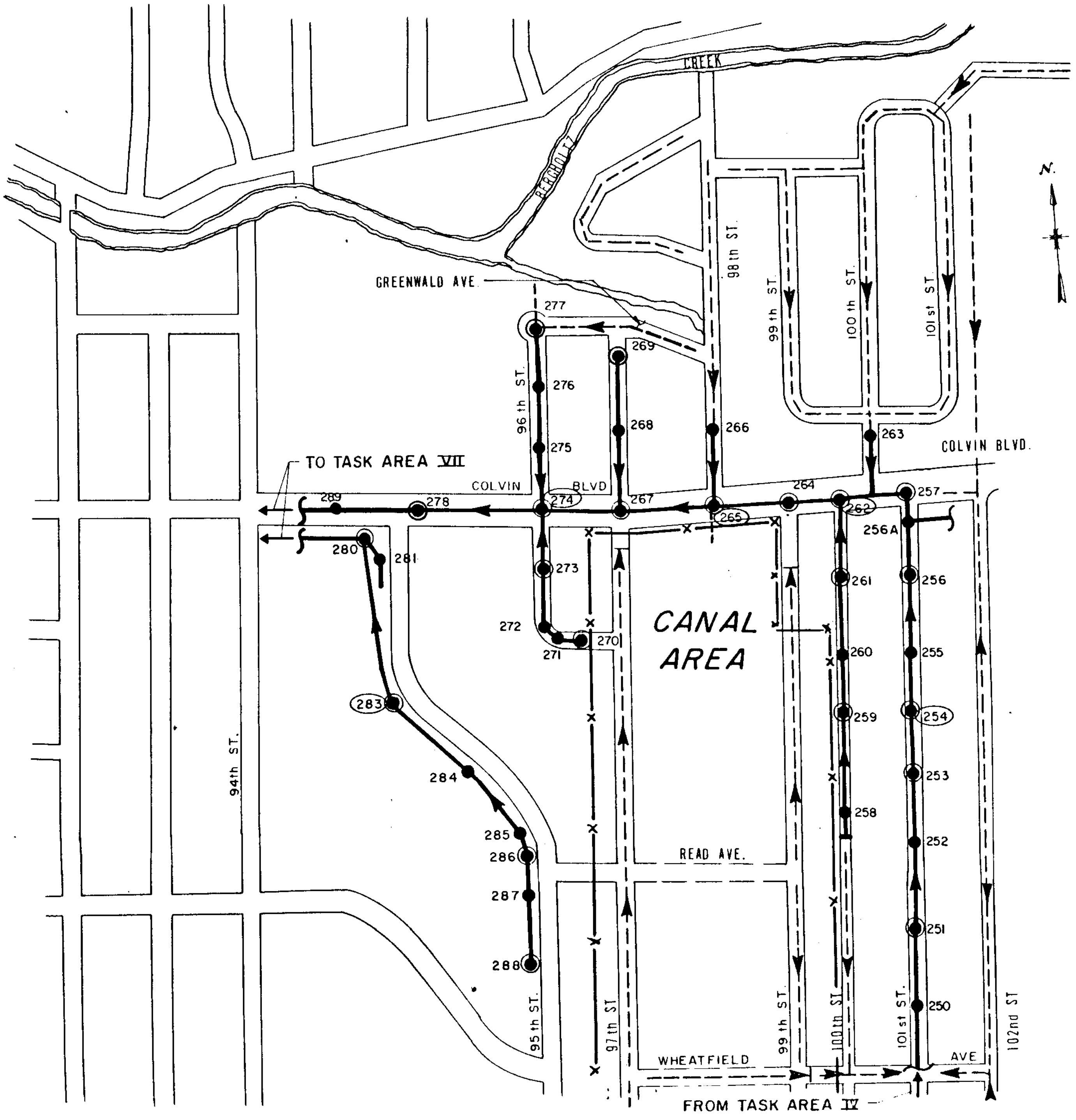

LOVE CANAL
FIVE ENGINEERING STUDIES
NORTH SANITARY SEWERS
TASK AREA II

SAMPLE LOCATION POINTS

- Insufficient hydraulic capacity
- Pipe constrictions (i.e., root intrusion or sediment deposition)
- Structural problems (i.e., collapsed pipe or offset joints)
- Excessive ground water infiltration
- Inflow (i.e., storm sewer interconnections, illegal house connections, etc.)

4.2.2 Storm Sewers

Storm sewer reaches of particular interest included Colvin Boulevard directly adjacent to the canal area and the three outfalls to Black Creek. Previous studies (Special Report to the Governor) had shown trace contamination in the storm sewers on Moschel Court and Deuro Drive which are north of Black Creek. However, the more recent EPA Monitoring Study did not find any contamination in this area, therefore these sewers were not included in the sampling program.

Liquid samples were collected during a storm event to access contaminant transport under increased storm sewer flows. Storm event sampling in Task Area II was limited to the three storm sewer outfalls to Black Creek. Based on previous studies and observations made during the initial field investigations, outfall sampling was considered adequate to give an indication of contaminant mobility during a storm event.

4.2.3 Bedding Material

Eight bedding material samples were collected along the storm sewer lines. Bedding material samples were collected near Manhole Nos. 206, 212A, 225, 221, 227 and 225 because they were downgradient or immediately adjacent to storm sewer lines exiting the canal area or previously indentified as contaminated. These locations were most likely to show the highest contamination if leakage was occurring from storm sewers into the bedding material. Bedding material samples were collected near Manhole Nos. 210, and 235 because these locations were adjacent to, but not directly connected to the canal area, and would indicate if any contaminant had migrated from the canal area through the soil into the storm sewer trenches on 100th Street and 96th Street. The other storm sewer bedding material sampling locations near MH Nos. 237 and 241 were chosen to determine if granular bedding material was utilized in the Griffon Manor area for which little previous information exists.

All five bedding material sampling locations along the sanitary sewer lines were chosen to provide sampling along the main sanitary sewer interceptor along 101st Street and Colvin Boulevard. These locations were the most likely to be indicative of the highest contaminant levels, if found.

4.3 Physical Findings

Task Area II consists of storm and sanitary sewers along Colvin Boulevard from 95th to 102nd Street; and 95th, 96th, 97th, 98th, 100th, and 101st Streets north of Wheatfield Avenue and south of Black Creek, excluding those inside the Canal Area fence.

4.3.1 Sanitary Sewers

Sanitary sewers in Task Area II flow toward Colvin Boulevard, then west beneath Colvin Boulevard to Lift Station No. 4 in Task Area VII. The sewers are generally 45 to 50 years old and constructed of vitrified clay pipe ranging from 8 to 18 inches in diameter. Depths vary from 6.5 feet below street level within Griffon Manor to 21 feet below Colvin Boulevard at 95th Street. The condition of the sanitary manholes was generally good, with few major cracks or leaks. Many had loose bricks near the cover frame which is a potential source of sediment and debris which could collect in the sewers. Detailed logs of each sanitary manhole (MH) sampling and inspection are presented in supporting documents.

Flows were generally low in the task area sewers, except on Colvin Boulevard downstream of 97th Street (MH 267) where the Love Canal leachate treatment plant was discharging its effluent at the time of sampling. Minimal flow was observed in 95th and 96th Street sewers south of Colvin Boulevard. This would appear logical since these areas currently have almost no resident population. The major contribution to the intermittent flow on 95th Street comes from construction and decontamination trailers located inside the canal fence at 97th Street and Read Avenue.

No surcharged sanitary manholes were encountered during the investigation. However, several manholes did exhibit evidence of past surcharge such as high water marks and/or excessive sediment on the benches. MH 256 on 101st Street and MH 283 on 95th Street both appeared to have been previously surcharged to a depth of about five feet. Manholes on 95th Street upstream of MH 283 also exhibited evidence of past surcharge to a lesser degree.

Previously unknown sewer lines running north from MH 277 on 96th Street, south from MH 265 on Colvin Boulevard, and east from MH 256A on 101st Street where also discovered. The lines entering MH 277 and MH 265 were significant findings in that they could potentially function as contaminant migration pathways since they appear to originate from the canal area.

Sediment distribution in Task Area II sanitary sewers is summarized in Table 4-1. Most sanitary manholes had some accumulation of sediment, usually more on the benches than in the channels. The sediment consisted of solids and residual material normally found in sanitary sewers. Areas of significant sediment accumulation include:

- 101st Street between Wheatfield Avenue and Colvin Boulevard (0.5 to 2 inches);
- Colvin Boulevard from 98th to 101st Streets (2 to 4 inches);
- 95th Street south of Colvin Boulevard (0.5 to 6 inches).

4.3.2 Storm Sewers

Storm sewers within Task Area II flow northward to three outfalls into Black Creek. The outfalls are located at 101st Street (MH 206), 98th Street (MH 217) and 96th

TABLE 4-1

SANITARY SEWER SEDIMENT QUANTITY IN TASK AREA II

Location/ Manhole	Sediment Depth (in.)	
	Channel	Bench
250	1	0-3
251	0	6
252	1	0-1
253	0	4
254	2	2
255	0	0-4
256	0	4-6
256A	0-2	0
257	0-1	0-1
258	1	0.25
259	0	0
260	0	0
261	0	0
262	0	2-4
263	0	0-4
264	0	2
265	0	2
266	0	0-2
267	0	2
268	0.5	0
269	0.5	0
270	2	0
271	0.5	0.5
272	0.5	0-1
273	0.25	0
274	0	0
275	0.5	0-0.5
276	0	0.5
277	1	0
278	0	6
280	2-3	2-3
281	0	0
283	6	6
284	0.5	0.5
285	0-0.5	6
286	1	0
287	0	0.5-4
288	2	2

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Street (MH 227). Task Area II also includes a 1400 foot portion of Black Creek between 98th and 102nd Streets which is enclosed in large corrugated steel pipes buried six to eight feet below ground level. Aprroximately 6 inches of sediment were found in these steel pipes.

Storm sewer pipes are constructed of various materials including vitrified clay (8 to 18-inch diameter), concrete (18 to 36inch diameter), and corrugated steel (48 and 72-inch diameter). Depths range from 3.5 to 10 feet below street level in the northwest section of the task area tributary to the 96th Street outfall. The northeast section of the task area tributary to the 101st Street outfall ranged from 4.5 to 6.5 feet below ground level. The condition of the storm manholes was generally good, similar to that of the sanitary manholes previously described. Detailed logs of the storm sewer sampling and inspection are presented in Appendix A.

Catch basins (or drop inlets) on streets adjacent to the canal fence were inspected visually and for odor during the dry weather sampling. Many of the catchbasins were clogged with what appeared to be deposits of leaves and sediment. Catchbasin samples were not collected in Task Area II since no odor or anomalies were observed and previous investigations had revealed catch basin contamination only within the fenced canal area.

As expected, low flow conditions generally prevailed during the dry weather sampling. Where zero flow conditions were encountered in upper tributaries of the storm system, liquid samples were often collected from standing water in the manhole pipe channel. MH 232A was the only location which exhibited past signs of surcharge conditions during this investigation.

Sediment distribution in the Task Area II storm sewers is summarized in Table 4-2. Most of the manholes had sediment accumulation on the benches and in channels, slightly more than in the sanitary system. Sediment consisted of silts and sands, gravel, and isolated pockets of decayed organic material. No visual evidence of chemical contamination was present. Sediment depths generally ranged from 1 to 6 inches in the northwest storm tributary, 4 to 8 inches in the Black Creek corrugated steel pipes, and 1 to 4 inches in the northeast storm tributary. Detailed logs of the storm sewer sampling program are found in supporting documents.

4.3.3 Bedding Material

None of the storm sewer bedding samples showed any select granular bedding. Samples collected from MH Nos. 221, 225, 235, 236 and 241 were red-brown clays with either pieces of concrete debris or road fill mixed in. It is probable the concrete and road fill fell into the clay as it was backfilled in the trench. Samples collected from MH Nos. 206, 210 and 227 were red-brown clay. The clay was laminated and the blow counts were sufficiently high to indicate the samples were not of the bedding materials. It is probable that the shallow trench was dug very narrow making it difficult to obtain a bedding material sample without breaking the sewer pipe.

One sanitary sewer bedding sample in the task area indicated the presence of select granular bedding material. The sample from near MH 283 showed a bedding material of 2 to 3-inch crushed stone. This section of sanitary sewer is located in the Griffon Manor area. Since sewers in the Griffon Manor area are of more recent vintage than those located throughout the rest of the study area, they

TABLE 4-2

STORM SEWER SEDIMENT QUANTITY IN TASK AREA II

Location/ Manhole	Sediment Depth (in.)	
	Channel	Bench
201	0-1	0
202	2	0
203	0.5	0
204	4	0
205	1-2	0
205A	-	-
206	0	0
207	4	6
208	4-6	0
209	3	1
210	2	0
211	2	0
212	6	0
212A	-	-
213	0.5	0
214	8	8
215	4-5	4-5
216	6	6
217	0	0
218	0	0
219	2	0
221	0	2
222	1	0
223	2	0
224	2	0
225	0	0
226	0.5	0
227	0	0
228	0.5	0
230	0	0
231	0.5	0
232	0	2
232A	3-4	3-4
233	0-1	0.5
233A	1	0
234	0.5	0
234A	0.5	0
235	0	0.5
236	-	-
237	0	0
238	0.5	0.5-2
239	4-6	4-6
240	1.5	1.5
241	15	15

were likely to have been installed by a single contractor. Since no other sanitary sewer bedding samples were collected in the Griffon Manor area, it may be possible that other sanitary sewers with the Griffon Manor area were constructed using granualar bedding material.

All of the other sanitary sewer bedding samples were red-brown clay with coarse sand or gravel mixed in. This is an indication that original trench material was used for backfilling.

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5.0 ANALYTICAL METHODS

The next aspect of the site investigation for the Love Canal involved the generation of chemical analysis data on samples collected from the site. These data were used to establish the presence or absence of contaminants. Further, where contamination was indicated, the data were essential to establish the type and magnitude of that contamination. The use of the analytical data was for the determination of contaminant migration pathways, development and evaluation of alternatives to deal with that presence and migration, and ultimately to recommend remedial action alternatives to minimize impacts from that contamination.

The challenge to the analytical laboratory was manifold: to keep the time required to analyze a large number of samples to a minimum; to design a program to minimize the total number of samples; to design an analytical program which would maximize information output on all samples while limiting detailed quantitative analyses to only those samples indicating a need for such work; and finally, to execute that analytical program for maximum benefit-to-cost ratio and maximum quality.

The analytical scheme which evolved to address these challenges was a two-phase program executed in a sequential manner. The first phase required the "screening" of a representative and therefore large population of samples from the five specific task areas under study. The objective of the screening analysis phase was to expeditiously, and inexpensively feed back preliminary analytical data to the engineer. These data were used as a decision-making tool to select only those samples with a likelihood of producing significant positive results after undergoing more costly, detailed quantitative analysis.

The second phase of the analytical effort was the detailed qualitative and quantitative analysis of selected samples for targeted and nontargeted contaminants. The analytical effort of this phase was comprised of three parts: qualitative and quantitative analysis of organic compounds; quantitative analysis for 2,3,7,8-TCDD (Dioxin); and quantitative analysis for inorganics (toxic elemental metals).

5.1 Contaminant Screening Analysis by GC/MS

The screening of all samples from the Love Canal site was necessary to determine the location and magnitude of contaminated areas for more detailed study. Given the history of materials disposed at the site, the screen had to be capable of detecting a wide variety of different chemicals at widely varying concentrations. The screening approach implemented was a solvent extraction of the sample followed by direct injection of the extract for GC/MS (gas chromatography/mass spectrometry) analysis. While other screening techniques were available, they were not as informative as the extraction -- GC/MS analysis method ultimately used.

The specific methodology involved the extraction of both liquid and solid (sludge, soil, sediments) matrices with the solvent hexadecane using mechanical agitation. After extraction, the solvent portion was separated from the sample and internal standards were added to the extract. These standards served two purposes: as retention time markers to classify contaminants as volatile or semi-volatile components, and as a benchmark from which estimated concentrations of contaminants could be established.

After sample preparation, the hexadecane extract was directly injected into the GC/MS instrument. The controlling

GC/MS software examined the number, location (with respect to retention time), and magnitude of contaminants present in each sample screened.

The data output from the contaminant screening analysis was formatted in such a way as to allow the rapid and justifiable selection of a subset of samples to be subjected to full and detailed quantitative analysis. The tabular output indicated the sample identification, number of volatile and/or semi-volatile contaminants detected above a threshold value and the concentration range of each of those contaminants. A reconstructed ion chromatogram was also presented for each sample.

5.2 Organic and Inorganic Analyses

5.2.1 Introduction

After completion of the contaminant screening phase of the project, specific samples from the total population were selected to undergo detailed and extensive chemical analysis. This section discusses two components of that work: quantitative and qualitative GC/MS analysis for both target and nontarget organic compounds and instrumental analysis of ICAP (inductively coupled argon plasma) for toxic elemental metals.

5.2.2 GC/MS Analysis of Organics

5.2.2.1 Conceptual Approach

The analysis for organic constituents required that specific target compounds be quantitated against authentic calibration standards. Additionally, a qualitative and semi-quantitative analysis was carried out for any other nontarget compounds present in the sample above a threshold level. The target compounds were those 113 organics commonly referred to as the "Priority Pollutants" (40 CFR 136, Appendix I). These compounds were quantitatively analyzed as two classes of compounds: volatiles and semivolatiles.

The nontarget compounds were any other organic constituents present in the sample which were not a member of the set of 113 compounds. These compounds were qualitatively identified by comparison of the mass spectrum of the unknown with a computer library of over 30,000 spectra of organic chemicals. Additionally, an estimated concentration of each of these nontarget compounds was computed.

5.2.2.2 Analytical Method

Each sample subjected to quantitative analysis underwent two separate preparatory and instrumental techniques: one for volatiles, and one for semivolatile compounds. The volatile sample preparation differed depending on whether the sample was a liquid or solid matrix. For liquid samples, preparation was minimal and simply involved aliquoting a portion of the original sample into a sparging vessel attached to the GC/MS. Appropriate surrogates and internal standards were added to each sample to monitor sparging efficiency and allow accurate quantitation respectively. After sparging the sample, the sparged constituents were trapped within the instrument and subsequently desorbed into the GC section of the GC/MS. Constituents were consequently

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chromatographed and then introduced into the mass spectrometer for generation of the mass spectral data. After data acquisition, the mass spectra of the components in the sample were compared to spectra of authentic calibration standards of the priority pollutants. Spectral and retention time matches of a sample component with a calibration standard resulted in the subsequent identification of that component as a priority pollutant. If such a match occurred, that component was then quantitated using the method of internal standard calculation.

Sample preparation for solids required a significantly different technique due to the special challenges presented with solid matrices. Solids, by defintion, are not as homogeneous as liquids. Consequently, special efforts must be employed to obtain as representative a solid sample as possible for volatile analysis. The approach utilized by the laboratory was two-fold. First, the "as-received" solid sample was mechanically composited to present as uniform a sample as possible to the second stage of preparation. That stage consisted of an extraction of the volatile constituents from the solid using tetraglyme (tetraethylene glycol dimethyl ether). The solid/liquid extraction was carried out by either vortexing or sonification of the mix. As with liquid volatiles, surrogate standards were added prior to the extraction. An aliquot of the tetraglyme extract was added, along with internal standards, to 5 milliliters of water in a sparging vessel attached to the GC/MS.

The instrumental analysis for volatiles in solids proceeded as previously described for volatiles in liquids. Both utilized a 1 percent SP1000 on 6/80 mesh carbopack gas chromatographic column.

Any constituents present in the sample which were not identified as a volatile priority pollutant underwent a mass spectral library search to attempt to identify that unknown constituent. The library search was carried out if the peak of interest had a peak height to of 25 percent or greater of the height of the nearest internal standard (this criterion was established to prevent searching peaks which were components of the natural "noise" level of the sample). If the match of the unknown peak mass spectrum to the spectrum of the compound in the spectral library were of high enough quality, an estimated concentration of the tentatively identified peak was computed by comparison of the peak height of the nearest internal standard (of known concentration) to the peak height of the identified compound.

The second subset of the 113 priority pollutant compounds prepared and analyzed were the semi-volatiles. The subset is comprised of 82 compounds with different chemical characteristics which required that two separate extractions be undertaken to provide the most reliable data. For liquid samples, a liquid/liquid extraction was performed using methylene chloride as the extraction solvent. The extraction was carried out in a separatory funnel. The extraction process on any sample resulted in the generation of two final extracts. The preparation involved adding one liter of original sample to a two liter separatory funnel. The pH was first adjusted to 11 or greater using sodium hydroxide. Surrogate standards and methylene chloride were then added after which the extraction of base/neutral/pesticide compounds was undertaken. This extract was set aside while the pH was again adjusted to 2 or less with sulfuric acid. Again, methylene chloride was added and the second extraction for acid extractable compounds was undertaken.

After the acid and base/neutral pesticide extracts were obtained, the extracts were independently concentrated in constant temperature water baths in a Kuderna-Danish apparatus with an evaporative flask and concentrator tube attached. The extracts were concentrated to a final volume of 1 ml. After concentration, internal standards were added to both concentrates prior to analysis.

After sample preparation was concluded, both concentrates underwent quantitative analysis by GC/MS for the target priority pollutant compounds. Further, the qualitative and semi-quantitative analyses for nontarget compounds were accomplished by GC/MS in conjunction with the quantitative analysis. Unlike the sample introduction technique used for volatile compounds, the semi-volatile compounds were introduced to the GC/MS by directly injecting 1 microliter of the concentrate into the gas chromatograph section of the GC/MS. A separate injection was performed for the acid fraction and the base/neutral/pesticide fraction on different instruments tuned and calibrated for the compounds of interest in each fraction. The qualitative, quantitative and semi-quantitative instrumental analysis proceeded in the same fashion as described for the volatile instrumental analysis.

5.2.2.3 Data Output

The data output from the GC/MS organics analysis was compiled into a summary data report for ease and speed of reference. Each data report included a laboratory chronicle providing the history of events which the sample underwent. For the quantitative analysis, a compound list displayed each of the 113 target compounds. For each compound, the detection limit achieved on that sample was displayed. If the compound was detected at or above the detection limit, the actual quantitated value was given along with the scan number for that compound peak on the reconstructed ion chromatogram.

For the library search output, the name of the tentatively identified compound was provided if the quality (purity) of the spectrum match was above 800 (out of a possible maximum value of 1,000). The computed estimated concentration and scan number for that peak was given. The organic fraction which contained the nontargeted peak was also indicated. Summary results are presented in Appendix A.

5.2.3 Analysis of Inorganics

5.2.3.1 Conceptual Approach

The inductively coupled argon plasma (ICAP) instrument was utilized for the analysis of elemental metals except for mercury. Mercury analysis was conducted by an automated cold vapor technique. The elements of interest were the 13 priority pollutant toxic metals. With the large numbers of samples involved, high anticipated concentrations, and varying matrices, the ICAP technique represented both the most cost and time-effective approach to the project. Mercury, having special physio-chemical characteristics was best addressed with the cold vapor technique.

5.2.3.2 Analytical Method

The sample preparation for both liquid and solid matrices is similar. A measured volume or mass of sample was placed into appropriate glassware. The aliquot was subjected to a solution of nitric acid which initiates the digestion of the metals present in the sample. The digestion solution was then taken to near dryness and the cycle was repeated until the digestion process was completed. The final digestion solution was then diluted with pure water and subsequently filtered to remove solids. The filtrate was then taken to final volume with pure water. The prepared sample was now ready for instrumental analysis.

The instrumental analysis was carried out using a sequential multi-element ICAP. The procedure involved producing an aerosol of the digestion solution. This aerosol is then introduced into the argon plasma torch which produces characteristic atomic-line emission spectra if elements are present.

When produced, the spectra are dispersed and wavelengths and intensities are compared to the wavelength and intensity of authentic calibration standards. Through this comparison, the presence and concentration of elements was established.

5.2.3.3 Data Output

The data output for the elemental metals analysis was straightforward. A compound list of the 13 elements of interest was prepared for each sample. The concentration of each element detected at or above the detection limit was provided. The detection limit for each element was also displayed. Summary results are presented in Appendix A.

5.2.4 2,3,7,8-TCDD (Dioxin) Analysis

5.2.4.1 Conceptual Approach

The analytical approach to the analysis for 2,3,7,8-TCDD went through several stages of evolution before the final methodology was selected and executed. Originally, a qualitative analysis by GC/MS was to be performed. The analysis was to be run on a split from the base/neutral/pesticide concentrate with 1,2,3,4-TCDD being added to the sample prior to extraction. The split extract was to be cleaned up to eliminate potential intereferences, then, the concentrate would be analyzed for GC/MS in the selected ion monitoring (SIM) mode to search specifically for ions of 2,3,7,8-TCDD. The 1,2,3,4 isomer was to be used as a retention time marker and surrogate for the 2,3,7,8 isomer. This technique was to simply detect the presence or absence of the 2,3,7,8

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isomer. If detected, that sample would then undergo a re-extraction specific to the TCDD compound and then be subjected to quantitative GC/MS analysis.

The quantitative GC/MS technique was to be performed by application of EPA Method 613, adapated to accommodate solid matrices. The use of Cl isotopically labeled 2,3,7,8-TCDD was envisioned for the internal standard while 1,2,3,4-TCDD was to be added as a surrogate standard.

During the project time frame, Region VII, USEPA was developing methods specific to the analysis of TCDD in conjunction with studies they were undertaking at Times Beach, Missouri. The methods developed were then provided to laboratories qualified by and under contract to the EPA. One such protocol was published in February 1983 and colloquially came to be called the "February Protocol."

In the ensuing period, it was agreed that all samples which displayed positive contaminant screening reuslts and were then relegated to full quantitation would also undergo full quantitation for TCDD. No screening for the presence of TCDD would be performed -- all would be quantitated.

When the final decision was received to proceed with the quantitative analysis of TCDD, a new protocol has been published called the "May Protocol." As it was desired to use the most recent EPA dioxin protocol for the Love Canal study, the May protocol was specified. Unfortunately, the May protocol has not been in the hands of the EPA contract laboratories long enough to confirm that all details of the methodology were effective and appropriate. As experience was gained, it was determined that the GC column specified in the May protocol (an SP2340) was not adequate for the analysis. A dioxin workshop sponsored by EPA in mid-July 1983 supported this conclusion.

Because of this fact, the Love Canal samples were analyzed using the DB-5 column specified in the February protocol but employing sample preparation, cleanup, and analytical procedures specified in the May protocol.

5.2.4.2 Analytical Method

The method employed utilizes high resolution gas chromatography/low resolution mass spectrometry in the SIM mode. As most samples were solid matrices, the following discussion relates to that matrix. Differences appropriate for water matrices will be highlighted.

All samples were spiked with isotopically labeled 2,3,7,8-TCDD. The $^{37}\text{Cl}_{40}$ isotope was used as a surrogate standard while $^{13}\text{C}_{12}$ isotope was used as the internal standard. After spiking, anhydrous sodium sulfate was mixed with the sample prior to adding a mixture of methanol and hexane. The sample was then extracted using the jar technique with a platform mechanical shaker. After extraction, a phase separation was undertaken for solid samples to obtain the final extract. This extract was then

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concentrated prior to application of any cleanup procedures or instrumental analysis.

The method provided for the application of four concentrate cleanup procedures in the event of analytical interferences, difficulty with concentration, difficulty in achieving desired detection limits, or coloration, viscosity or cloudiness of the concentrate. The specific options included acid and base washes, and column chromatography using silica gel, activated alumina, or activated carbon. The actual instrumental analysis was executed by injecting 1 to 3 ul of concentrate into the GC/MS. The SIM mode was used to search for specific ions of both isotopically labelled isomers of 2,3,7,8-TCDD and native 2,3,7,8-TCDD. If the proper ions were observed in the proper ratio, the presence of native 2,3,7,8 was confirmed. Once confirmed, quantitation was based on the response of native TCDD relative to the isotopically labeled TCDD internal standard. Method performance is assessed by monitoring the isotopically labeled surrogate standard results.

5.2.4.3 Data Output

The data output for the TCDD analysis is straightforward. The compound was listed along with the detection limit achieved on each sample. If detected above that limit, the concentration quantitated was given. Each sample output also displays the level of recovery of the surrogate standard. The summary reports for Dioxin are shown in the supporting documents. All dioxin hits, however, are shown on the hot spot maps of Section 6.

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5.4 Summary of Quality Assurance and Quality Control Programs

5.4.1 Intent and Purpose of QA and QC Programs

Mead CompuChem, the analytical subcontractor, has an established Quality Assurance Program which covers all projects. The objective of the QA program is to provide the desired level of data quality for the customer. This is accomplished by specifying criteria for methods and performance on samples received, and by providing appropriate standards for referencing results against absolute values. Project-specific quality control programs are designed to determine that the criteria established for specific methods and sample types are met. These include control limits for blanks, spikes, duplicates, and surrogate recoveries, as well as criteria for review of data prior to release to customers. As part of the criteria, corrective actions are required if data exceed control limits.

5.4.2 QA Programs in Effect for this Study

For this study, standards were prepared at the Research Triangle Park, North Carolina (RTP) location, tested, and shipped weekly to the Cary, Illinois facility for organics analysis. Metals standards were prepared and tested for use in the RTP lab. Standard Operating Procedures were written and analysts were trained in their use prior to sample receipt. Methods used were evaluated for their applicability to the matrices in the study, using approved analytical techniques referenced above in Sections 5.2 and 5.3. Acceptance criteria for the quality control samples associated with the study were established and applied.

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5.4.2.1 QC Program for Screening Analysis

For the organic screening analyses, blanks, spikes and duplicates were prepared and analyzed. This procedure is qualitative and semi-quantitative; it is intended to determine whether certain classes of organic compounds are present, and the approximate numbers and concentration levels of these classes. Then a decision could be made to whether or not to analyze them for particular compounds. For these analyses, blanks were run with each set of samples prepared to verify there was no laboratory contamination during preparation. Spiked and duplicate samples were prepared and analyzed at the rate of 5 percent each, to verify that consistent and accurate results were produced by the methods applied. The spike mixtures consisted of several levels of organic volatile and semi-volatile compounds added to samples.

5.4.2.2 QC Programs for Organic Priority Pollutant Analyses

For analysis of volatile and semi-volatile organic compounds using EPA-approved methods, the quality control program specified 5 percent of samples prepared in duplicate, 5 percent spiked, and a blank prepared each time samples were extracted. Calibration multipoint standards were analyzed prior to initiating work, and at least one standard per 8-hour shift was run on each instrument used during the study. Each instrument met a tuning calibration specification each 8-hour shift. The spike compound recoveries and duplicate precision were monitored for each fraction. Surrogate compounds in 100 percent of all sample fractions were spiked prior to preparation for analysis; surrogate recoveries were evaluated to monitor the extraction efficiencies of these and similar classes of compounds from the samples. Recoveries could be effected by sample matrix type, or other extraction conditions. Those fractions with recoveries or precision outside control limits were examined for such effects and possible repeat analysis to confirm the causes of such recoveries or precision.

5.4.2.3 QC Programs for Inorganic Priority Pollutants Analyses

Inorganic samples were prepared as described in the above-referenced methods. Blanks were prepared with each batch of samples. Spikes were prepared at the rate of 5 percent. Standards were analyzed (at least 3 levels) before and after each set of samples to establish a calibration curve. Known values of reference standards (EPA or NBS) were compared to those obtained and prepared by CompuChem to document accuracy.

5.4.2.4 QC Programs for TCDD (Dioxin) Analyses

Dioxin samples were analyzed using the most recent EPA methodologies. Standards were obtained from and/or referenced against EPA solutions, whose levels had been established from interlaboratory studies. Blanks were prepared with each set of samples. Spikes and duplicates were prepared at the rate of 5 percent each. Each instrument was required to be calibrated each 8-hour shift, following initial multipoint calibration at at least three levels of standards. Criteria for calibration and analytical acceptability applied were those in the EPA methodology.

5.4.3 Summary of Acceptability of QC Results

The quality control data generated from the screen, organics, inorganics, and TCDD analyses demonstrated that the analytical performance was within acceptance criteria limits, and that the analytical systems were operating as desired to produce data of appropriate quality.

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6.0 CONTAMINATION ASSESSMENT

The contamination assessment is a crucial element of the investigation since it provides the basis for selection of remedial action. Priority areas have been mapped based on the results of the contamination assessment. "Hot spot" maps identifying dioxin contamination of have also been prepared.

The contamination assessment provides an approach whereby a large number of samples containing a range of compounds at varying concentrations and with differing toxicities and persistence characteristics can be numerically evaluated. The results of these evaluations are considered in light of the potential for human exposure on a site-specific basis and other contaminant-related considerations to arrive at an estimate of the relative contamination at one sample site compared to another.

6.1 Objective

The objective of the contamination assessment is to serve as a decision-making tool for the selection of remedial action alternatives. The intent is to rank or prioritize areas so that appropriate remedial action can be recommended and not to make an absolute determination of the risk to human health. The utility of the approach is as a method for organizing the large amount of analytical information, as an aid in interpreting the significance of the analytical results and as a basis for evaluating remedial action alternatives.

6.2 Discussion of Approach

6.2.1 Overall Concept

The contamination assessment examines, for each sample site, the following factors:

- Contaminants detected
- Concentrations of individual contaminants
- Toxicity of individual contaminants, represented primarily by drinking water standards or water quality criteria for the protection of human health
- Persistence of individual contaminants, as indicated by physical/chemical/biological properties
- Factors affecting potential exposure pathways

The two conceptual components of the contamination assessment are a toxicity assessment and an exposure assessment. Toxicity is the ability of a chemical to affect living orgamisms adversely and, as such, is an intrinsic property of a contaminant. Exposure (the actual contact with a chemical) is affected by properties of the contaminant(s) in question (nonsite-specific factors) which determine persistence and mobility and by site-specific factors (noncontaminant-specific) which determine potential pathways of exposure. Intrinsic properties of the contaminant(s) which determine toxicity and persistence have been expressed in a quantitative manner in a "matrix" (Table 6-1). Input to the matrix consists, for each sample, of the contaminants identified and their concentrations. The calculations in the matrix are completed (to account for toxicity and persistence) resulting in a "score" for the sample. The "scores" are then indicated on the intermediate "work maps." The expo-

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SAMPLE MATRIX

TABLE 6-1
LOVE CANAL CONTAMINATION ASSESSMENT FOR HYPOTHETICAL SAMPLE SITE

CONTAMINANT	CONCENTRATION ug/KG or ug/L	CRITERION ug/L	PERSISTENCE SCORE	PRODUCT = conc./crit. x pers.
CARCINOGENS				
A.BHC isomers				
alpha-BHC	1000	.092	11	119565
beta-BHC	1000	.163	11	67485
delta-BHC	1000	.147	11	81633
gamma-BHC	1000	.186	12	59140
			A.Subtotal	327822
B.PAH				
phenanthrene	1000	.028	9	321429
anthracene	1000	.028	9	321429
pyrene	1000	.028	11	392857
chrysene	1000	.028	12	428571
benzo(a)anthracene	1000	.028	12	428571
			B.Subtotal	1892857
C.Monocyclic aromatics				
benzene	100	6.6	6	909
hexachlorobenzene	1000	.0072	12	1666667
2,4,6-trichlorphenol	1000	12	9	750
			C.Subtotal	1668326
D.Halogenated aliphatics				
1,2-dichloroethane	100	9.4	6	638
1,1,1-trichloroethane	1000	2	7	3500
1,1,2,2-tetrachloroethane	100	1.7	9	5294
trichloroethylene	1000	27	7	259
tetrachloroethylene		8	7	875
carbon tetraclhloride	1	4	7	1750
chloroform	100	1.9	7	3684
bromoform	100	1.9	8	4211
trichlorofluoromethane	100	1.9	7	3684
methylene chloride	100.	1.9	6	3158
hexachlorobutadiene	100	4.5	9	2000
			D.Subtotal	29054
E.Miscellaneous				
1,2-diphenylhydrazine	1000	.422	10	23697
bis(2-chloroethyl)ether	1000	.3	8	26667
			E.Subtotal	23697
CARCINOGEN SCORE: (Sum A-E Subtotals)				3941756

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TABLE 6-1 (Cont'd)
LOVE CANAL CONTAMINATION ASSESSMENT FOR HYPOTHETICAL SAMPLE SITE

SAMPLE MATRIX

CONTAMINANT	CONCENTRATION ug/KG or ug/L	CRITERION ug/L	PERSISTENCE SCORE	PRODUCT = conc./crit. x pers.
NON-CARCINOGENS				
F.PAH				
naphthalene	1000	1000	8	8
fluoranthene	1000	42	12	286
		F.Subtotal		294
G.Metals				
arsenic	1000	50	12	240
chromium	1000	50	14	280
cadmium	1000	10	15	1500
antimony	1000	146	13	89
mercury	100	.146	11	75342
lead	10	50	12	240
nickel	1000	13	12	896
thallium	1000	13	15	1154
copper	1000	1000	14	14
zinc	1000	5000	15	3
		G.Subtotal		79758
H.Monocyclic aromatics				
chlorobenzene	1000	480	7	15
1,4-dichlorobenzene	1000	400	9	23
1,2-dichlorbenzene	1000	400	9	23
1,3-dichlorbenzene	1000	400	9	23
1,2,4-trichlorobenzene	1000	100	10	100
1,2,3-trichlorobenzene	1000	100	10	100
1,2,3,4-tetrachlorobenzene	1000	38	10	263
1,2,4,5-tetrachlorobenzene	1000	38	10	263
pentachlorobenzene	1000	74	11	149
ethylbenzene	1000	1400	6	4
toluene	1000	1350	6	4
phenol	1000	3500	7	2
2,4-dichlorophenol	1000	3090	8	3
pentachlorophenol	1000	1010	13	13
p-chloro-m-cresol	1000	1010	9	9
		H.Subtotal		992
I.Phthalates				
dimethyl phthalate	1000	313000	10	0
diethyl phthalate	1000	350000	11	0
dibutyl phthalate	1000	34000	13	0
bis-2-ethylhexylphthalate	1000	15000	13	1
butylbenzyl phthalate	1000	15000	12	1
di-n-octyl phthalate	1000	15000	14	1
		I.Subtotal		3
J.Miscellaneous				
2-chloronaphthalene	1000	15	10	667
		J.Subtotal		667
NON-CARCINOGEN SCORE:	(Sum F-J Subtotals)			81714
TOTAL SCORE (carcinogen + non-carcinogen)				4023470

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sure pathways factors and a discussion of other considerations related to specific contaminants are integrated with the maps to identify the relative hazard at each site (or groups of sites). The final output is task area contamination assessment maps which reflect the integration of exposure pathway factors, sample scores and other contaminant-related considerations. Additionally, "hot spot" maps are created by plotting concentration data for dioxin a contaminant of special concern. In conjunction, the contamination assessment maps and the "hot spot" maps serve as the basis for determining levels of remedial action. Figure 6.1 depicts the overall approach of the contamination assessment.

6.2.2 The Matrix

A matrix has been developed to organize and interpret the extensive amount of analytical data. It is used to evaluate contaminant concentrations in terms of toxicity and persistence in order to provide an overall numerical value for each sampling site. An example of the matrix is attached as Table 6-1. The individual components of the matrix, as indicated by the column headings in Table 6-1, are explained below.

6.2.2.1 Contaminants

The left hand column is the list of "CONTAMINANTS." Under the column heading, the word "CARCINOGENS" appears. On the second page of the table is the heading "NONCARCINOGENS." Contaminants are classified into either category based upon their classification in the EPA's 1980 Water Quality Criteria (discussed further in 6.2.2.3); these classifications were

FIGURE 6-1

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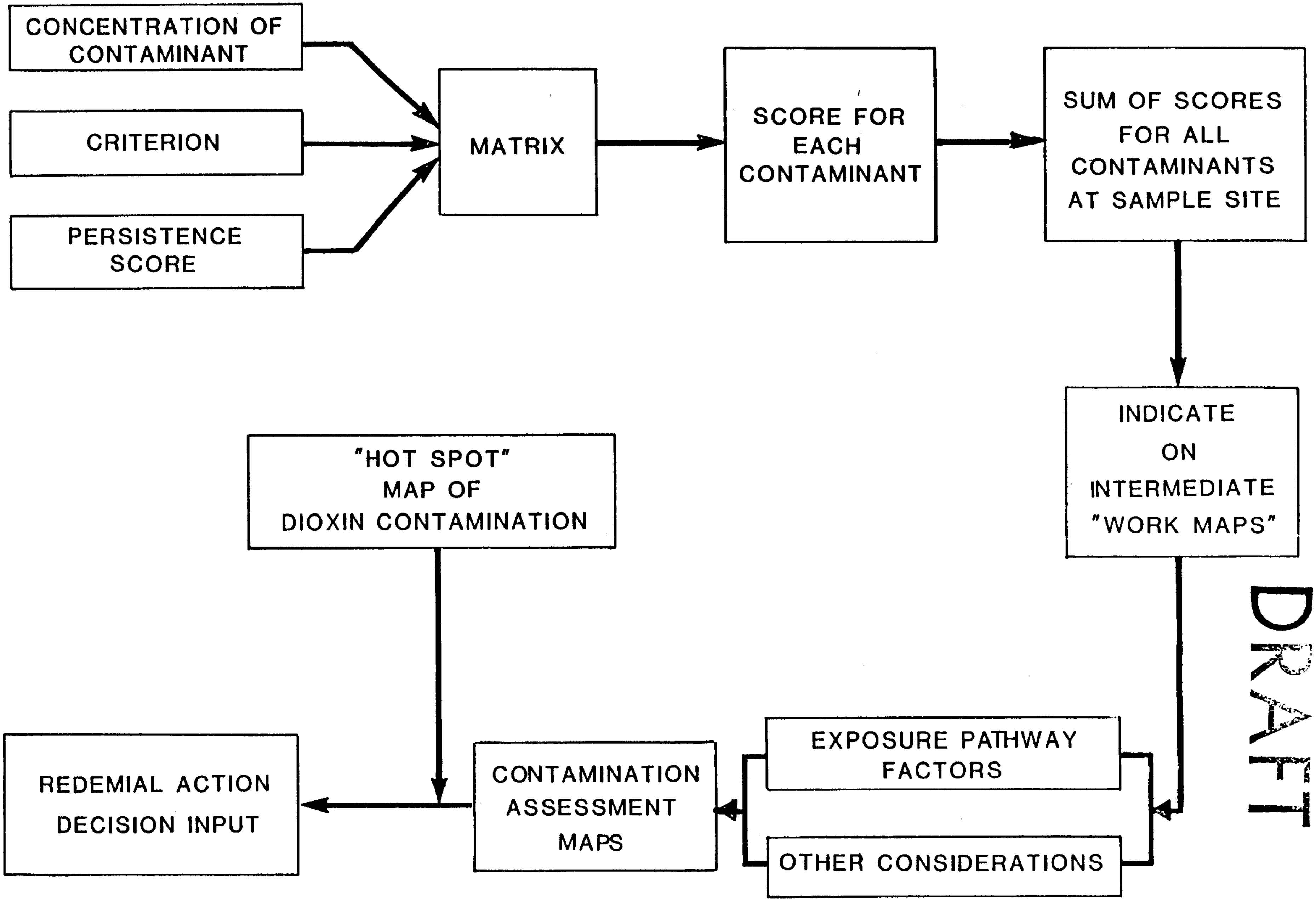
OVERVIEW OF CONTAMINATION ASSESSMENT METHODOLGY



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reviewed by consultants from the Department of Environmental Medicine at the Mt. Sinai Medical Center. Scores are computed separately for the carcinogens and the non-carcinogens since the Water Quality Criteria are derived differently for these two types of contaminants.

Within each group (carcinogens and non-carcinogens), related contaminants are placed in groups designated by alphabetic letters, such as "A. BHC isomers," "B. PAH (Polynuclear Aromatic Hydrocarbons)," etc. The matrix contains the names of all the contaminants detected in the samples taken in the five task areas. Only those compounds which were identified to a confidence level of 80 percent or greater were included in the matrix. Compounds which were identified by a "library search" but for which the confidence level was less than 80 percent were not included, since contaminant identification was less certain and the concentrations measured were only estimates.

The resultant carcinogen and non-carcinogen scores are added to yield a total score for the sample. Because the criteria values for the carcinogens are lower than for the non-carcinogens, the carcinogen score invariably dominates the total score. The purpose of grouping related contaminants within the two larger categories and calculating subtotals is to provide a clear picture of which contaminants are contributing most to the total score.

6.2.2.2 Concentration

The concentration data, in ug/kg (ppb) or ug/L (ppb), is entered into the matrix. On the example attached, all concentrations have been arbitrarily set at 1000 for illustrative purposes.

6.2.2.3 Criterion

The third column heading, "CRITERION," refers, in most cases, to the available water quality criterion for each contaminant. Units are ug/L (ppb). For organic contaminants, these values were taken from:

> USEPA
> Water Quality Criteria Documents:
> Availability. Federal Register,
> Vol. 45, No. 231, Nov. 28, 1980

This publication refers to criteria developed for 64 toxic pollutants or pollutant categories pursuant to Section 304(a)(1) of the Clean Water Act. A separate document exists for each pollutant (or pollutant category) describing recommended maximum permissible pollutant concentrations consistent with the protection of aquatic organisms and human health. These criteria are not rules and have no regulatory impact.

The values entered in the "CRITERION" column are taken directly from the EPA publication. "Criteria for suspect or proven carcinogens are presented as concentrations in water associated with a range of incremental cancer risks to man...(since) there is no scientific basis for estimating "safe" levels for

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carcinogens." "Criteria for non-carcinogens represent levels at which exposure to a single chemical is not anticipated to produce adverse effects in man" (USEPA, Water Quality Criteria Documents; Availability, 1980).

The inclusion of the criterion value serves two purposes. First, it takes into consideration the relative toxicity of the various contaminants; the criteria values were derived based upon the best toxicity information available at the time. Second, dividing the concentration data by the criteria values serves to "normalize" the concentrations, insuring that the significance of a highly toxic contaminant does not get obscured by virtue of a detected low concentration, or, conversely, the significance of a minimally toxic contaminant does not get over-emphasized by virtue of a detected high concentration. The EPA's Water Quality Criteria were chosen to "normalize" the concentration data for the following reasons:

- They are fairly recent (1980).
- They are most applicable to exposure via water, as opposed to Threshold Limit Values for occupational exposure via inhalation.
- They are most comprehensive in that criteria exist for a majority of the contaminants detected. SNARLs (Suggested No Adverse Response Level) or ADIs (Acceptable Daily Intakes) exist for a much more limited list of substances, and it was necessary to have consistency in the normalization procedure.

For most of the inorganics (heavy metals) EPA Interim Primary Drinking Water Standards exist. These are generally identical to the EPA Water Quality Criteria.

However, where these values differed, the drinking water standards, which are enforceable regulations, were selected. Drinking water standards were not available for antimony, nickel or thallium; water quality criteria were used for these contaminants.

It is acknowledged that the criteria used in the matrix are for water and not sediment; however, there are no recognized criteria or guidelines for contaminants in sediment.

As stated, the EPA has expressed the criteria for carcinogens as concentrations associated with an increase in cancer risk of 10^{-7}, 10^{-6} or 10^{-5}, meaning one additional cancer in a population of ten million, one million and 100,000, respectively. The value entered in the matrix for each contaminant is the criterion corresponding to an incremental cancer risk of 10^{-5}. This was arbitrarily chosen, and could just as well have been the criterion for a 10^{-6} or 10^{-7} increase in risk, since the objective is to compare the contaminants <u>relative</u> to one another. This is <u>not</u> an attempt to establish a level of acceptable risk, which is a matter of policy.

The human health criteria for non-carcinogens are presented as concentrations not expected to cause adverse effects in man. Derivation of both

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no-effect (non-carcinogen) and specified risk (carcinogen) concentrations are based upon extrapolation from animal toxicity or human epidemiology studies; details of the methods used to derive the criteria are given in "Guidelines and Methodology Used in the Preparation of Health Effect Assessment Chapters of the Consent Decree Water Criteria Documents, Appendix C, Federal Register, Vol. 45, No. 231, Friday, November 1980, pp. 79347-79357.

For each contaminant (carcinogen or non-carcinogen), the EPA has expressed the criterion for the protection of human health in two ways: 1) based upon ingestion of contaminated water and aquatic organisms, and 2) based upon consumption of aquatic organisms only. The former value was selected.

There were no EPA Water Quality Criteria for the following compounds:

- naphthalene
- acenaphthene
- p-chloro-m-cresol
- butylbenzyl phthalate
- di-n-octyl phthalate
- 2-chloronaphthalene

The procedures used to determine appropriate criteria for these compounds are discussed in the Supporting Documents. These derived criteria values were reviewed by consultants from the Department of Environmental Medicine at Mt. Sinai Medical Center. The Mt. Sinai team also recommended the use of more rigorous criteria than the EPA's Water Quality

Criteria for two compounds, as discussed in the Supporting Documents.

6.2.2.4 Persistence Score

The next column heading, "PERSISTENCE SCORE" refers to the persistence score calculated for each contaminant. This score represents the relative environmental persistence of each contaminant based upon its partitioning between air and water (expressed as Henry's Law Constant), partitioning between water and sediment/soil (expressed as the log of the octanol: water partition coefficient) and biodegradability.

Each contaminant is rated for each of these three factors and the ratings are summed. The lowest possible score (least persistent contaminant) is a 3, while the highest possible score (most persistent contaminant) is a 15.

Various literature sources were searched for information on the Henry's Law Constant, octanol:water partition coefficient and biodegradability of each contaminant. These values were calculated and/or recorded for each contaminant, and rated as detailed below.

- Volatility was expressed in terms of H, the Henry's Law Constant, where

  $$H = \frac{\text{Partial Pressure in atmosphere, Pa}}{\text{water solubility, gm}^{-3}\text{/molecular weight}}$$

  The values were rated as follows, with a 1 representing the most volatile (least persistent) contaminant:

Value of H	Rating
J1000	1
100-999	2
10-99	3
1-9	4
F1	5

- A high octanol:water partition coefficient indicates a high tendency to adsorb onto sediments (particularly sediments high in organic content) and a high tendency to bioaccumulate. The most common expression of this value is as a logarithm, log Kow. The values were rated as follows, with a 1 representing the least tendency to adsorb onto sediment (least persistent):

Value of log Kow	Rating
J6	6
5-5.99	5
4-4.99	4
3-3.99	3
2-2.99	2
F2	1

- Biodegradability scores are based primarily upon scores given in "Methodology for Rating the Hazard Potential for Waste Disposal Sites," JRB Associates, which appears in the "National Oil and Hazardous Substances Contingency Plan," USEPA, 1982. Information from other sources (Callahan, et al., 1979, Water Related Environmental Fate of 129 Priority Pollutants, and Geating, 1981, Literature Review of Biodegradability of Organic Compounds) was also used. The ratings are on a scale of 1 to 4, as follows:

	Rating
Highly resistant to biodegradation	4
Resistant, but biodegradation is known or believed to occur in some cases	3
Amenable to biodegradation	2
Readily biodegradable	1

The ratings in each of the three categories are added together to yield the persistence score. Persistence scores are presented in Table 6-2.

6.2.2.5 Subtotals and Totals

As indicated on the sample matrix, subtotals are calculated for the individual contaminant groups. The subtotals for the carcinogen groups are added, yielding the CARCINOGEN SCORE. The same procedure is applied to the non-carcinogens, yielding a NON-CARCINOGEN SCORE. These two scores are added, yielding the TOTAL SCORE.

6.2.2.6 Matrix Output

The calculated TOTAL SCORES are represented visually on intermediate "work maps" to provide a pictorial indication of the matrix results. In the next step, the potential pathways for contaminant exposure are examined and other considerations related to various contaminants in the study area are discussed.

TABLE 6-2

CALCULATION OF PERSISTENCE SCORES

Contaminant	H	H Rating	Log Kow	Log Kow Rating	Biodegrad-ability Rating	Sum of Ratings
Alpha-BHC	0.595	5	3.81	3	3	11
Beta-BHC	0.016	5	3.80	3	3	11
Delta-BHC	0.031	5	4.14	4	3	12
Gamma-BHC	0.05	5	3.72	3	3	11
phenanthrene	12.52	3	4.46	4	2	9
anthracene	63.5	3	4.45	4	2	9
pyrene	0.13	5	4.92	4	2	11
chrysene	est. 0.015	5	5.61	5	2	12
benzo(a)anthracene	0.011	5	5.61	5	2	12
benzene	555.2	2	2.13	2	2	6
hexachlorobenzene	172.3	2	6.18	6	4	12
2,4,6-trichlorophenol	32.9	3	3.38	3	3	9
1,2-dichloroethane	92.6	3	1.48	1	2	6
1,1,1-trichloroethane	3557	1	2.17	2	4	7
1,1,2,2-tetrachloroethane	38.6	3	2.56	2	4	9
trichloroethylene	922	2	2.29	2	3	7
tetrachloroethylene	2063	1	2.88	2	4	7
carbon tetrachloride	2351	1	2.64	2	4	7
bromoform	use 106	est. 2	2.30	2	est. 4	8
chloroform	343	2	1.97	1	4	7
trichlorofluoromethane	11114	1	2.53	2	4	7
hexachlorobutadiene	1044	1	3.74	3	4	8
methylene chloride	323	2	1.25	1	3	6
1,2-diphenylhydrazine	"low"	est. 4	3.03	3	est. 3	10
bis(2-chloroethyl) ether	1.34	4	1.58	1	3	8
naphthalene	24.41	3	3.31	3	2	8
fluoranthene	1.03	4	5.33	5	3	12
arsenic	can be impt. in reducing envir.	4	4.35 calc	4	4	12
chromium	not impt.	5	5.23	5	4	14
cadmium	not impt.	5	6.68	6	4	15
lead	vol. poss. in	4	4.17	4	4	12
nickel	not impt.	5	3.93	3	4	12
thallium	not impt.	5	6.50	6	4	15
copper	not impt.	5	5.93	5	4	14
antimony	vol. poss.	4	5.71	5	4	13
mercury	1155	1	6.36	6	4	11
zinc	not imp.	5	6.03	6	4	15
chlorobenzene	398	2	2.84	2	3	7
1,4-dichlorobenzene	276	2	3.38	3	4	9
1,2-dichlorobenzene	197	2	3.38	3	4	9

TABLE 6-2 (Cont'd)

CALCULATION OF PERSISTENCE SCORES

Contaminant	H	H Rating	Log Kow	Log Kow Rating	Biodegradability Rating	Sum of Ratings
1,3-dichlorobenzene	267	2	3.38	3	4	9
1,2,4-trichlorobenzene	144	2	4.18	4	4	10
1,2,3-trichlorobenzene	approx. 144	est. 2	est. 4.18	est. 4	4	10
1,2,3,4-tetrachlorobenzene	approx. 567	est. 2	est. 4.93	est. 4	est. 4	10
1,2,4,5-tetrachlorobenzene	567	2	4.93	4	est. 4	10
pentachlorobenzene	no data	est. 2	5.63	est. 5	est. 4	11
ethylbenzene	652	2	3.15	2	2	6
toluene	601	2	2.49	2	2	6
phenol	0.132	5	1.46	1	1	7
2,4-dichlorophenol	0.58	5	2.75	2	3	13
pentachlorophenol	0.026	5	5.01	5	3	13
p-chloro-m-cresol	low	est. 5	2.95	2	2	9
dimethyl phthalate		est. 5	2.12	2	3	10
diethyl phthalate		est. 5	3.22	3	3	11
dibutyl phthalate		est. 5	5.2	5	3	13
bis (2-ethyhexyl) phthalate	0.026	5	5.3	5	3	13
butyl benzyl phthalate	0.108	5	4.8	4	3	12
di-n-octyl phthalate		est. 5		est. 6	3	14
2-chloronaphthalene	54.7	3	4.01	4	3	10
bis (2-chloroethyl) ether	1.34	4	1.58	1	3	8

6.2.3 Exposure Pathways

This subsection describes potential pathways for human exposure to contaminants originating from the Love Canal area and identifies which of these potential pathways appear to be active based on the sampling results. An active pathway indicates that Love Canal-related contaminants are presently found there and that the transport of contaminants through this medium appears to occur. In terms of the potential for actual human exposure to contamination via the active pathways, this discussion considers the theoretical worst-case potential only, assuming no remedial action is taken.

In Task Area II, both the sanitary and storm sewers may serve as potential pathways for contaminant transport and human exposure. The primary potential pathway for exposure in the sanitary sewers is the sewer line on Colvin Boulevard heading west from MH 257. This line transports flows from all sewer lines in Task Area II, including those on 95th through 101st Streets, westward past MH 289 to Lift Station No. 4 in Task Area VII. Exfiltration from sewer lines to ground water or discharges into surface waters resulting from surcharged sanitary sewer overflow bypasses could be potential secondary pathways for contaminant transport and human exposure.

The primary potential pathways for human exposure to contaminants in the storm sewer system in Task Area II are the outfalls on Black Creek at 96th, 98th and 101st Streets. The 98th Street outfall and the 101st Street outfall discharge into the piped portion of Black Creek, while the outfall at 96th Street discharges into the open portion of Black Creek. To a lesser degree, other potential exposure pathways include exfiltration from sewer lines to ground water or discharges into surface waters from sanitary sewer overflow bypasses into storm sewers.

Based on the sampling results, the sanitary sewer on Colvin Boulevard is an active pathway for the transport of Love Canal-related contaminants from sewer lines in Task Area II. As such, it provides a pathway for potential human exposure to contamination as a result of downstream lift station overflows into storm sewers. The task area was found to contain contaminated sediments at numerous sampling locations, although organic contamination was found in only one liquid sample. In the area storm sewers, contaminants were detected in sewer sediment samples but in no liquid samples. Active pathways for the exposure of Love Canal-related contaminants in area storm sewers were not confirmed by the sampling results. Love Canal-related contaminants were not found in the samples taken at or near the outfalls in Task Area II. The potential for human exposure via direct or indirect skin contact via ingestion to contaminated sediment in the storm and sanitary sewers is remote. However, since contaminants could migrate into the surface waters in the area, as discussed in Section 6.3, exposure could potentially occur via surface water pathways, as discussed in the report of investigations in Task Area III. Human exposure to contaminants in the sewers could also potentially result from the inhalation of volatile compounds subsequent to their partitioning from sediment to liquid although this possibility is quite remote. Moreover, only several samples were found to contain contaminants considered volatile.

Exfiltration from sanitary and storm sewer pipes to bedding material in Task Area II does not appear to be an active pathway for contaminant transport to ground water based on the sampling data. The potential for human exposure to bedding material is extremely remote.

6.2.4 Other Considerations

Two groups of contaminants, the phthalate esters and the inorganics, were found consistently in the Task II Study Area. Phthalate esters and inorganics were also found in samples from outside of the influence of Love Canal (the "upstream" samples on Black and Bergholtz Creeks taken in conjunction with Task III investigations). In some samples, the only compounds detected were inorganics and phthalate esters. It was not felt that, in the absence of other organic contaminants which are more likely to be of Love Canal origin, and considering the potential exposure pathways, such samples would necessitate remedial action. An explanation of the rationale for this decision follows.

6.2.4.1 Phthalate Esters

Two compounds belonging to a class of chemicals known as phthalate esters or phthalic acid esters were detected in the samples taken in the Task II Study Area. Of these compounds bis(2-ethylhexyl) phthalate was detected fairly consistently throughout the study area, but not rarely in concentrations exceeding the criteria values used in the matrix for this compound. Bis(2-ethylhexyl) ptthalate was also found in the "upstream" samples taken in Black Creek and Bergholtz Creek at concentrations similar to those found in sampling areas potentially influenced by Love Canal.

It is not surprising that phthalate esters were found throughout the sampling area. They are recognized to be ubiquitious in the environment. They are used as plasticizers in building and construction, home furnishings, clothing, cars, food wrappings and medical supplies, and as nonplasticizers in pesticides, cosmetics, fragrances and oils. Phthalate ester residues in foods such as margarine, cheese and milk may, in fact, reach 50 ppm (EPA Ambient Water Quality Criteria for Phthalate Esters, 1980).

Phthalate esters have also been detected in soil, water, and air and in fish flesh and animal and human tissue. They have been detected in varied matrices and in areas remote from industrial sites, including the Sargasso Sea (EPA Ambient Water Quality Criteria for Phthalate Esters, 1980).

Several factors contributed to a decision that the presence of phthalate esters at a sampling location did not in and of itself warrant remedial action. These factors are:

- Presence of phthalate esters in upstream sediment samples in Black and Bergholtz Creeks at concentrations similar to those found in sampling areas potentially influenced by Love Canal.

- Ubiquitous occurrence of phthalate esters in the environment in general.

- Phthalate esters were detected in only eight of the 155 liquid samples analyzed in the various task area investigations. Moreover, the likelihood of ingestion of contaminated water in sewer lines is remote.

- Phthalate esters are believed to be capable of absorption through the skin, which is only a remotely potential route of exposure for the sediment. Moreover, phthalate esters are considered to be of a low order of toxicity (EPA, Ambient Water Quality Criteria for Phthalate Esters, 1980).

6.3.4.2 Inorganics (Heavy Metals)

Inorganics were found in the majority of the samples throughout the Task II Study Area. Concentrations of inorganics detected in study area sediment samples are comparable, to a large degree, with levels found in samples collected upstream on the Black and Bergholtz Creeks and with levels found in sediments in "control" areas during the EPA Monitoring Study (EPA 1982).

Several factors contributed to a decision that the presence of inorganic constituents at a sampling location did not in and of itself warrant remedial action. These factors were:

- Presence of inorganics in upstream sediment samples in Black and Bergholtz Creeks at concentrations similar to those found in sampling areas potentially influenced by Love Canal.
- Ubiquitous and natural occurrence of heavy metals in the environment in general.
- Heavy metals were detected in only one of the eight liquid samples from the investigations of the various task areas for which inorganics analyses were performed. Moreover, the likelihood of ingestion of contaminated water in sewer lines is remote.
- Heavy metals, in the forms in which they are likely to occur in the sediments, do not present a significant concern via the exposure route of direct or indirect skin contact.

6.2.5 Contamination Assessment Maps

The product of the contamination assessment is a set of contamination assessment maps (Figures 6-2 and 6-3) for the Task II Study Area. These maps depict areas of relative low, medium and high priority. These rankings were determined by evaluating the matrix results, the work maps, the potential exposure pathways and other considerations. The lows, mediums and highs are relative rankings and are used to identify areas where some form of remedial action should be considered.

The low, medium and high rankings are defined as follows:

- Low: Low matrix score, indicating inorganic compounds occurring at or near "upstream" concentrations; organic compounds, if any, not specifically Love Canal-related; and/or existing contaminants appear to have minimum potential for human exposure.

- Medium: Intermediate matrix score, indicating a limited number of Love Canal-related compounds occurring at low to moderate concentrations; and/or existing contaminants appear to have moderate potential for human exposure.

- High: High matrix score, indicating several or numerous Love Canal-related compounds occurring at significant concentrations; and/or existing contaminants appear to have a high potential for human exposure.

6.2.6 Hot Spot Mapping

A separate "hot spot" map (Figure 6-4) have been prepared for dioxin, a contaminant of particular concern. The map identifies the sampling locations where this compound was found and the concentrations detected. The "hot spot" map has been used in conjunction with the contamination assessment maps in determining appropriate

FIGURE 6-2

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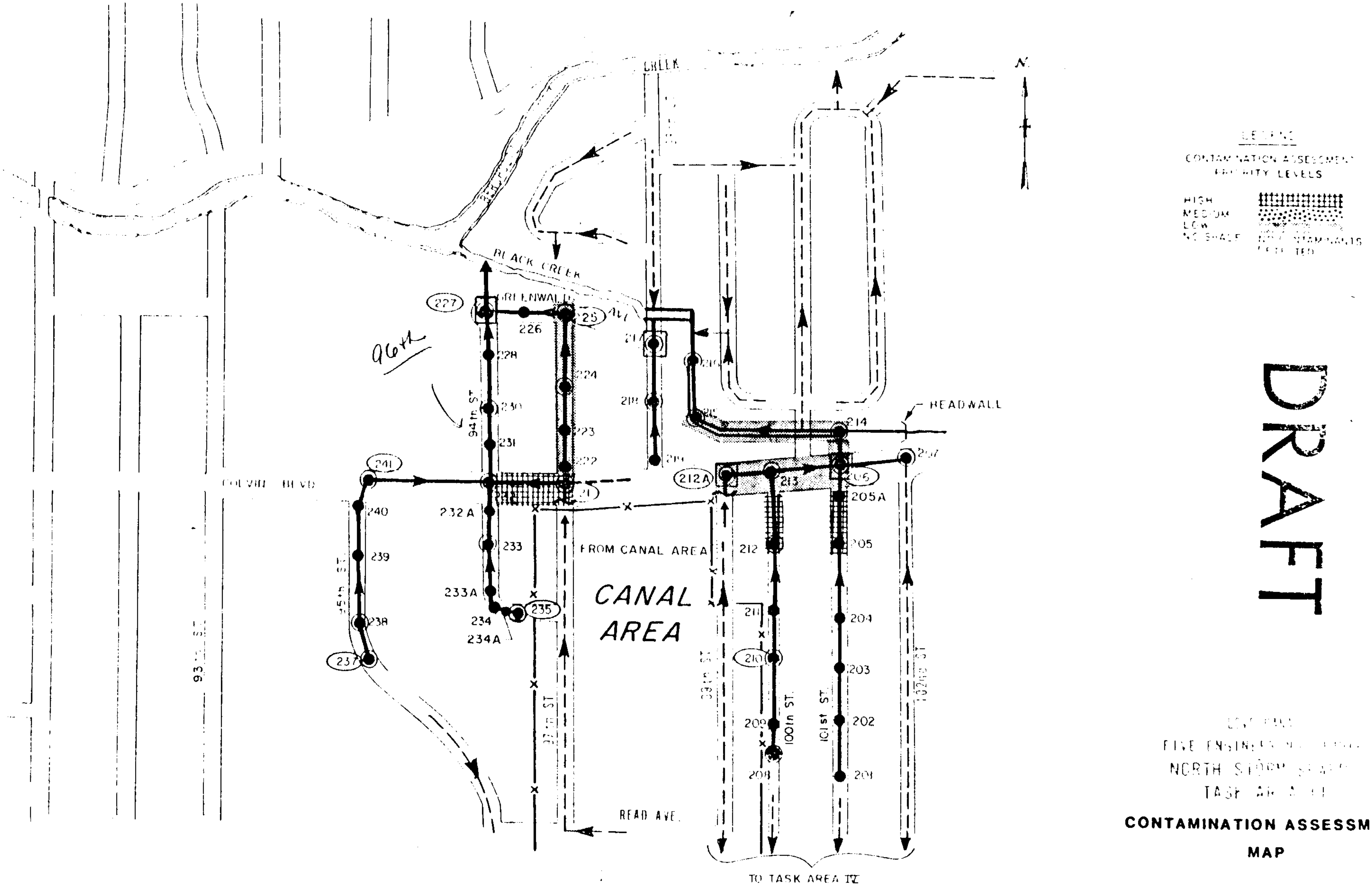
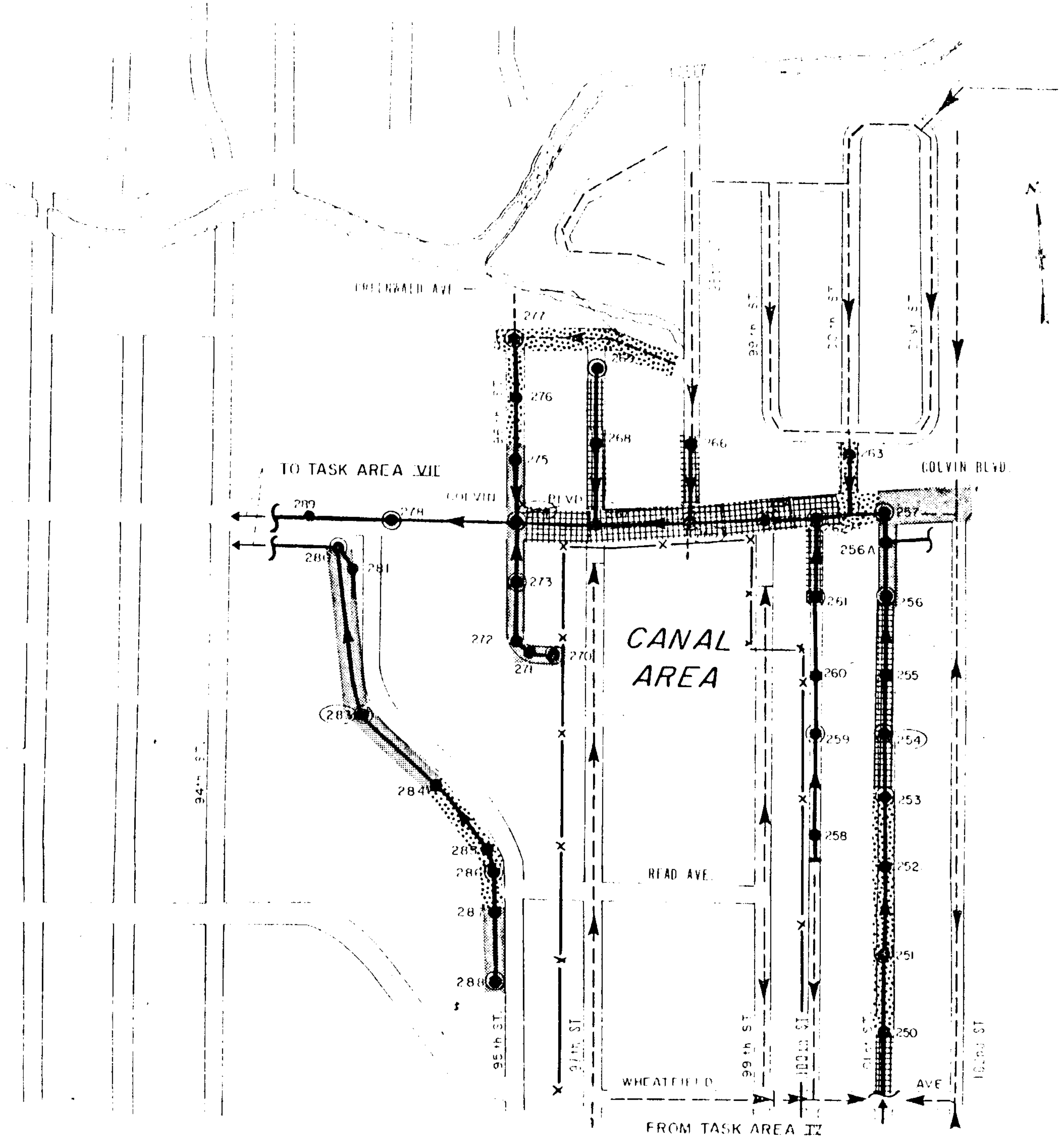


FIVE ENGINEERS
NORTH STORM SEWER
TASK AREA III

CONTAMINATION ASSESSMENT MAP

FIGURE 6-3



LEGEND

CONTAMINATION ASSESSMENT PRIORITY LEVELS

HIGH	▦
MEDIUM	▒
LOW	░
NO SHADE	NO CONTAMINANTS DETECTED

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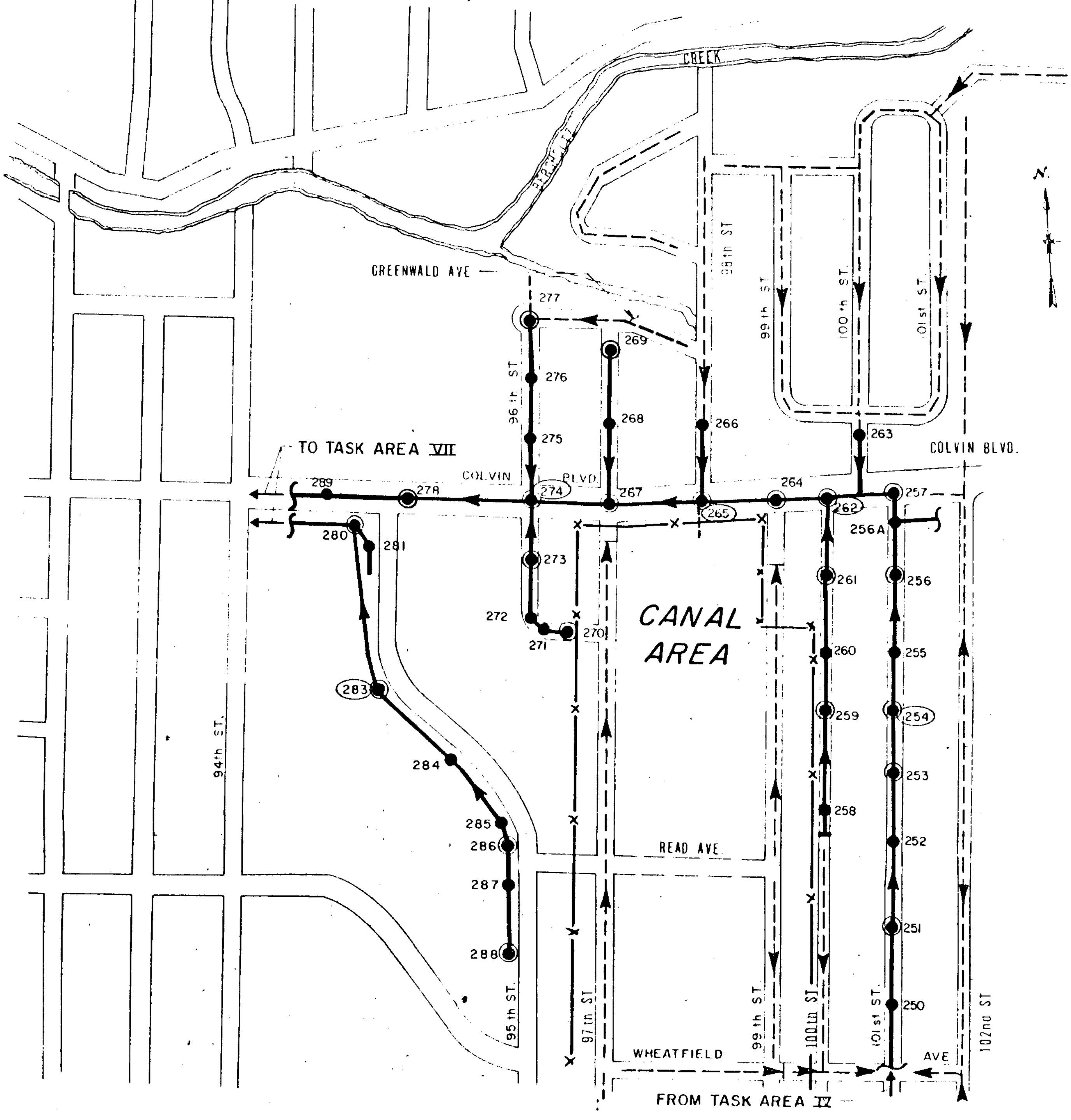
[illegible]
FIVE ENGINEERING, [illegible]
NORTH SANITARY SEWERS
TASK AREA II

CONTAMINATION ASSESSMENT MAP

FIGURE 6-4



DIOXIN HOT SPOTS

LOCATION	CONCENTRATION (ppb)
MH-264	30.0

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LOVE CANAL
FIVE ENGINEERING STUDIES
NORTH SANITARY SEWERS
TASK AREA II

remedial measures for the task area. The "hot spot" maps have been used in conjunction with the final maps in determining appropriate remedial measures for the task area.

6.3 Discussion of Results

6.3.1 General

This subsection explains the method used to graphically interpolate from the contaminant assessment priority levels at each sample location to produce the contamination assessment maps shown on Figures 6-2 and 6-3.

Each manhole location sampled which passed the screening analysis was designated as a high, medium or low contamination assessment priority level based upon the results of the quantitative analysis subjected to the contamination assessment methodology (the matrix) previously described in Section 6.2. Samples that did not pass or exceed the qualitative screen are presumed not to be contaminated.

The convention used in preparing the contamination assessment maps is based on the conservative assumption that the analytical results and the associated contamination assessment priority level at each manhole or sampling location are indicative of the level of contamination for the entire sewer reach. Using the results of the contamination assessment, the upstream and downstream sewer reaches were shaded in each direction from a sampled manhole up to the next manhole or sample location. If the adjacent manhole did not show contamination, the shading was terminated at that manhole. Where samples obtained in adjacent manholes indicated the same level of contamination in each, the shading was continued at that level. For the case where contamination levels differ for adjacent manholes or the subsequent sample manhole, the shading was continued at the appropriate level to a point halfway between each location. At the single location where quantifiable amounts of Love Canal-related contaminants were obtained for a liquid sample, the adopted convention was to assign a high contamination assessment priority level based on the assumption that contaminated liquid indicates an active contaminant migration pathway or extremely high concentration of contaminants in the underlying sediments.

At all sample locations with quantifiable contaminant levels (i.e. low, medium, or high), the detailed analytical results were re-examined to verify the contamination assessment priority level in the context of the sample medium (i.e. sediment, soil, or liquid).

During the Task Area II sampling program, 13 sewer bedding material samples, 40 dry weather storm and sanitary sewer sediment samples, 42 dry weather storm and sanitary sewer liquid samples, and 4 storm weather storm sewer liquid samples were collected.

Later in this section, the nature and distribution of contaminants and contamination migration pathways are discussed. Primary migration pathways are those pathways which have or had a known direct connection to a canal area sewer. Secondary migtation pathways are those pathways which are not known to be directly connected to a canal area sewer (i.e., surcharged sewers, ground water migration, creek flooding, etc.).

6.3.2 Storm Sewers

6.3.2.1 Nature and Distribution of Contamination

Five storm sewer sampling locations in this task area exhibited varying degrees of contamination. The storm sewer sediment samples which exhibited low levels of contamination were found at MH Nos. 224, 206, 214 and 213. The low level contamination consisted primarily of heavy metals and phthalates. No quantifiable amount of Love Canal-related contamination were found in storm sewer manholes designated as having low contamination assessment priority levels.

MH 221, which exhibited high levels of sediment contamination, was the only storm sewer sampling location in Task Area II that contained quantifiable amounts of Love Canal-related contaminants. The predominant compounds identified in this sediment sample were chlorinated benzenes (primarily trichloro and hexachloro species) and lesser amounts of volatile compounds.

No quantifiable amounts of contamination were discovered during the storm weather sampling period. This finding suggests that significant migration of contaminants was not actively occurring in the storm sewers during that relatively mild rainfall event. Similarly, no liquid samples exhibited quantifiable amounts of contaminants indicative of active migration.

6.3.2.2 Contamination Migration Pathways

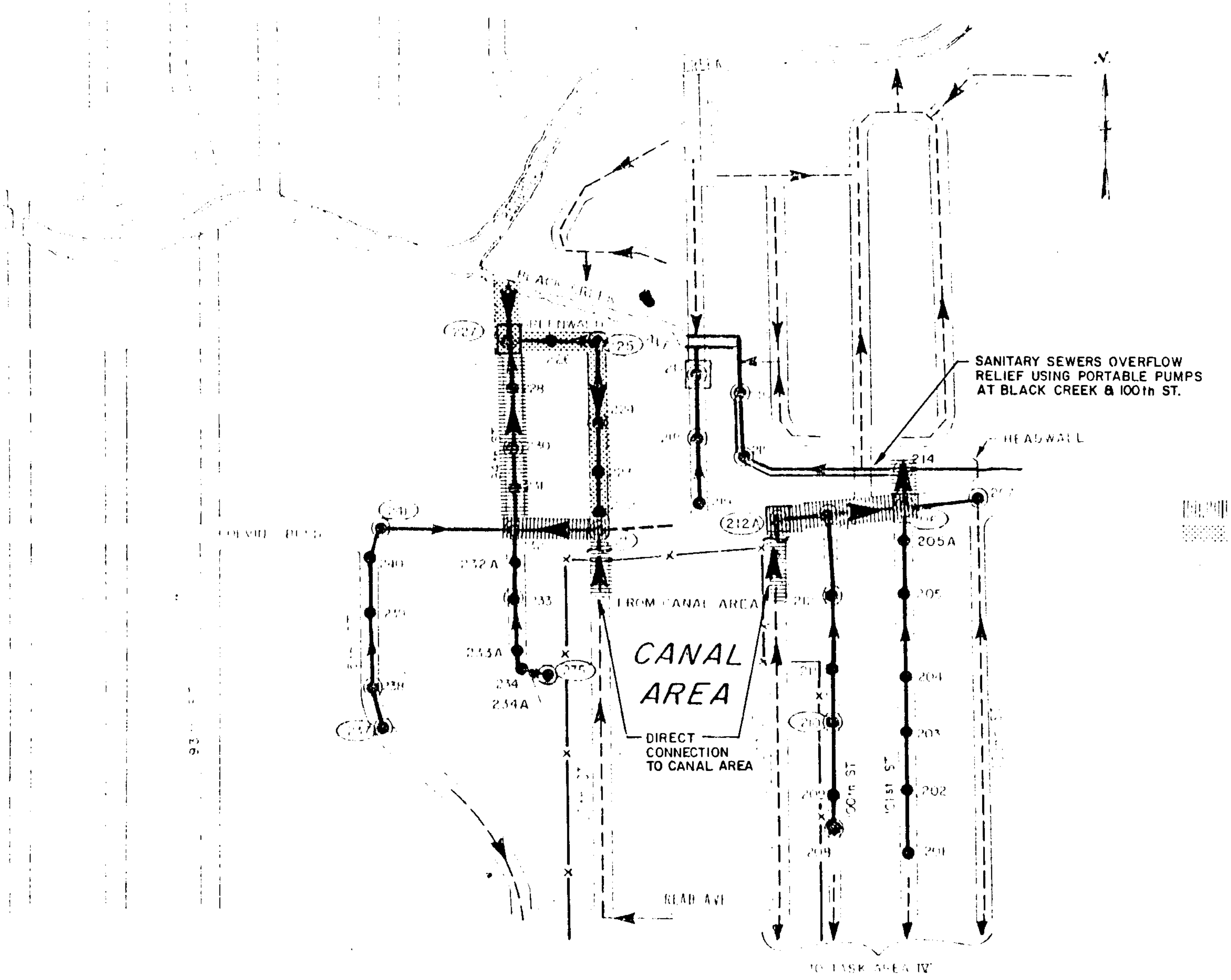
The storm sewers in Task Area II appear to have become contaminated through two primary migration pathways and one secondary as shown on Figure 6-5.

One apparent primary migration pathway began at a direction connection to the canal area at 99th Street and Colvin Boulevard. From this point, the storm water flows easterly along Colvin Boulevard to 101st Street where the storm sewer turns north flowing into the enclosed section of Black Creek. This pathway explains the low contamination assessment priority level along Colvin Boulevard from MH 212A to MH 206.

The other primary migration pathway began as a direct connection to the canal area at 97th and Colvin Boulevard. From this point, the storm water flows west on Colvin Boulevard to 96th Street where the storm sewer turns north flowing along 96th Street to where it discharges into the Black Creek.

A secondary migration pathway may be caused by high water levels in Black Creek which surcharge the storm sewers on 96th Street. Because the sediment in the creek has been found to be contaminated, the possibility exists that the high water levels in the creek could transport creek sediments into the storm sewers near the outfall.

FIGURE 6-5



CONTAMINANT MIGRATION PATHWAYS

6.3.3 Sanitary Sewers

6.3.3.1 Nature and Distribution of Contamination

Eleven sanitary sewer sampling locations exhibited varying degrees of contamination. Eleven contaminated sediment samples and one contaminated liquid sample were found.

The sanitary sewer sediment samples which exhibited low contamination assessment priority levels, were found at MH Nos. 283, 288, 257 and 273. These manholes are spread throughout the task area and do not present any identifiable contamination pattern. The contamination on these low priority samples consisted primarily of metals and phthalates. Love Canal-related contamination was not found in these samples.

The sanitary sewer sediment samples which exhibited medium or high contamination assessment priority levels were found primarily along the main interceptor route from the canal area. MH 262, MH 265, MH 264 and MH 267 have been identified as highly contaminated because of high concentrations of several Love Canal-related contaminants found in the sediments. 2,3,7,8-TCDD (dioxin) was found in MH 264. Compounds prevelant in the sediments from MH 265 were hexachlorobenzene and trichlorobenzene. Trace levels of trichlorobenzene (0.019 ppm) were also found in the liquid sample taken at this manhole. In MH 262, hexachlorobenzene, hexachlorobutadiene, dichlorobenzene and trichlorobenzene were found in the sediments. MH 267 exhibited levels of hexachlorobenzene and trichlorobenezene in the sediment.

MH 251 also on the main interceptor route, has been designated as a medium contamination assessment priority. This manhole contained quantities of trichlorobenzene.

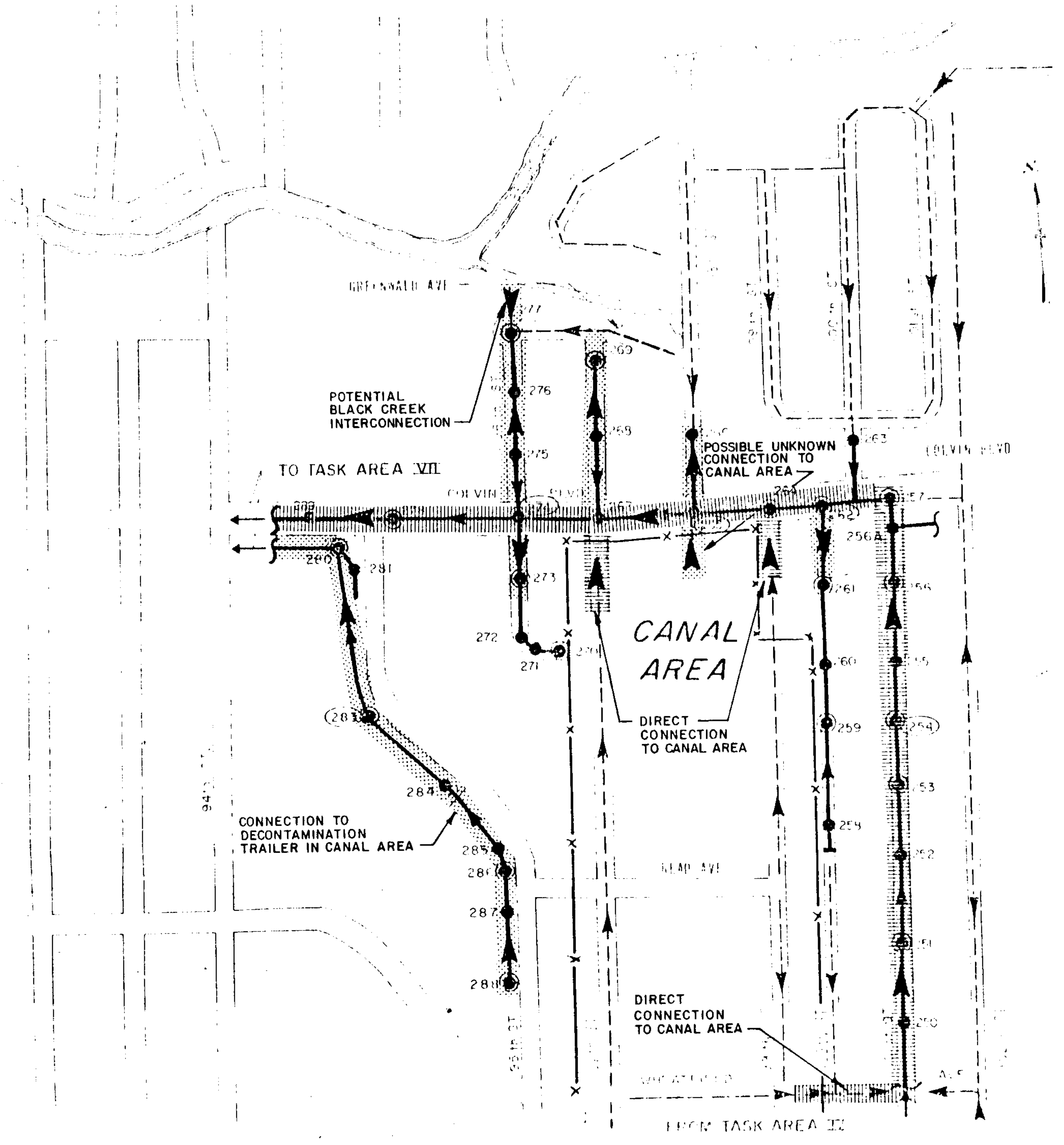
MH 285 and MH 277 were also assigned medium contamination assessment priority levels. However, these manholes were not located in the main interceptor route. MH 285 had quantifiable levels of dichlorobenzene and toluene in the sediment. MH 277 had concentrations of pyrene and fluoranthene in the sediments.

6.3.3.2 Contamination Migration Pathways

The sanitary sewers in Task Area II apparently became contaminated through one primary and several secondary migration pathways as shown on Figures 6-6.

The primary contamination pathway begins as a direct connection to the canal area at Wheatfield Avenue and 99th Street. From this point, the wastewater flows east to 101st Street then north on 101st Street to Colvin Boulevard. The wastewater then turns west and and continues on Colvin Boulevard into Task Area VII. Other direct connections from the canal area connect to this main interceptor route at MH 267 and MH 264. A possible connection may also exist at MH 265. This primary migration pathway explains the source of contamination on 101st Street between Wheatfield Avenue and Colvin Boulevard and it also explains the contamination on Colvin Boulevard between MH 257 and Task Area VII.

FIGURE 6-6



LEGEND
▨ PRIMARY MIGRATION PATHWAY
▒ SECONDARY MIGRATION PATHWAY

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CONTAMINANT MIGRATION PATHWAYS

A secondary migration pathway is the probable cause of contamination on 95th Street between Read Avenue and Colvin Boulevard. The decontamination trailers for the various contractors working at the Love Canal area is connected to this sewer. Additionally, unknown connections may exist from the canal area to this sewer.

Surcharging of the main interceptor route is also considered a secondary migration pathway. Surcharging is the probable cause of potential contamination on 100th Street, 98th Street, and 96th Street.

High water levels in Black Creek are also a possible secondary migration pathway into MH 277.

6.3.4 Bedding Materials

The bedding materials were found to have low levels of contamination in several location throughout the task area. The contaminants found in the bedding material (i.e., heavy metals, methylene chloride, and phthalates) are not believed to be Love Canal-related contaminants such as those found throughout the sanitary sewers in sediments. This contamination may be caused by localized exfiltration of contaminated liquid, broken pipes, and leaking joints.

However, considering the types of contaminants, their concentrations, their ubiquitous nature, and their extremely low exposure potential, bedding material samples are not considered to be of concern and have not been assigned any contamination assessment priority ratings.

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7.0 REMEDIAL ALTERNATIVES

7.1 General

Sewer rehabilitation alternatives suitable for levels of contamination identified in previous sections range from relatively simple remedial activities to complex combinations of several methods. An alternative or combination of alternatives suitable for one task area or sewer reach may not be the best action for another. Each of the unit operations which together could comprise a remedial alternative is described below. An evaluation of these remedial actions is presented in Section 8.

7.2 No Action

In areas of limited or no contamination and limited or no migration potential, indicative of no significant environmental impacts, the "no action" alternative may be appropriate.

7.3 Monitor

Periodic sampling of storm and sanitary sewer flows and sediments at strategic locations, must be required subsequent to any remediation in affected storm and all sanitary sewers in the Study Area. Such post-remediation monitoring of sewers will be necessary in order to:

- Ascertain the efficacy of sewer remediation.
- Determine if contaminant migration from the canal containment area to the sewers is occuring in the future.

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- Determine if contaminant migration from sources outside the canal containment area is occurring in the future.

- Act as an early warning system to detect substantial contaminant accumulation in the sewers. This would allow for protection against the health and environmental impacts of the release of and exposure to these contaminants in the event of a remediation failure or incomplete remedial response.

As an alternative to physical remediation measures, periodic sampling could be performed at selected storm and sanitary sewer reaches and storm sewer outfalls to the creeks and river to monitor movement of contaminants. This would obviously result in the continued migration of toxic pollutants away from the study area. Migration would continue, until such time that the source(s) of these contaminants has been eliminated and naturally-occurring phenomenon, such as sediment transport and to a lesser extent volatilization, purge contaminants from the sewers. While the rate of contaminant transport is difficult, if not impossible, to ascertain and is beyond the scope of this study, there was evidence of contaminant migration from the Canal area nearly six years ago. It is not unreasonable to assume that this migration will continue for an extended period of time even after all sources of contamination have been eliminated.

The acceptability of this alternative for the storm sewers must be evaluated in the context of the potential impacts of this continued migration on the receiving water bodies in Task Area II (i.e. Black Creek).

7.4 Abandonment In Place

Where contaminated storm or sanitary sewer sediment is found to have moved only a short distance from the canal, it may be appropriate to cut off and/or plug that sewer line and abandon it. This option is most appropriate in areas not needed to support any current or future demand.

Construction worker safety considerations for this alternative would include the use of respiratory protection for workers in manholes and/or trenches, hard hats and boots, goggles, and disposal coveralls.

The environmental impact of abandonment in place is that any contaminants present could migrate from their present locations and enter the surface or groundwater in the area. Additional hazards to construction workers excavating in-situ contaminants in the future would also be posed by this alternative.

7.5 Television Inspection and Other Physical Inspection Methods

7.5.1 Television Inspection (see Figure 7-1)

While it is not an actual remediation measure, television inspection is a valuable diagnostic tool used prior to any type of sewer system repair or replacement. Television inspection is normally used to locate sources of infiltration such as offset joints, root intrusions, broken or collapsed pipe, leaky laterals and service connections, etc. A television camera specifically designed for this service is pulled through the pipe section to be examined on a sled and the problem areas located with

FIGURE 7-1

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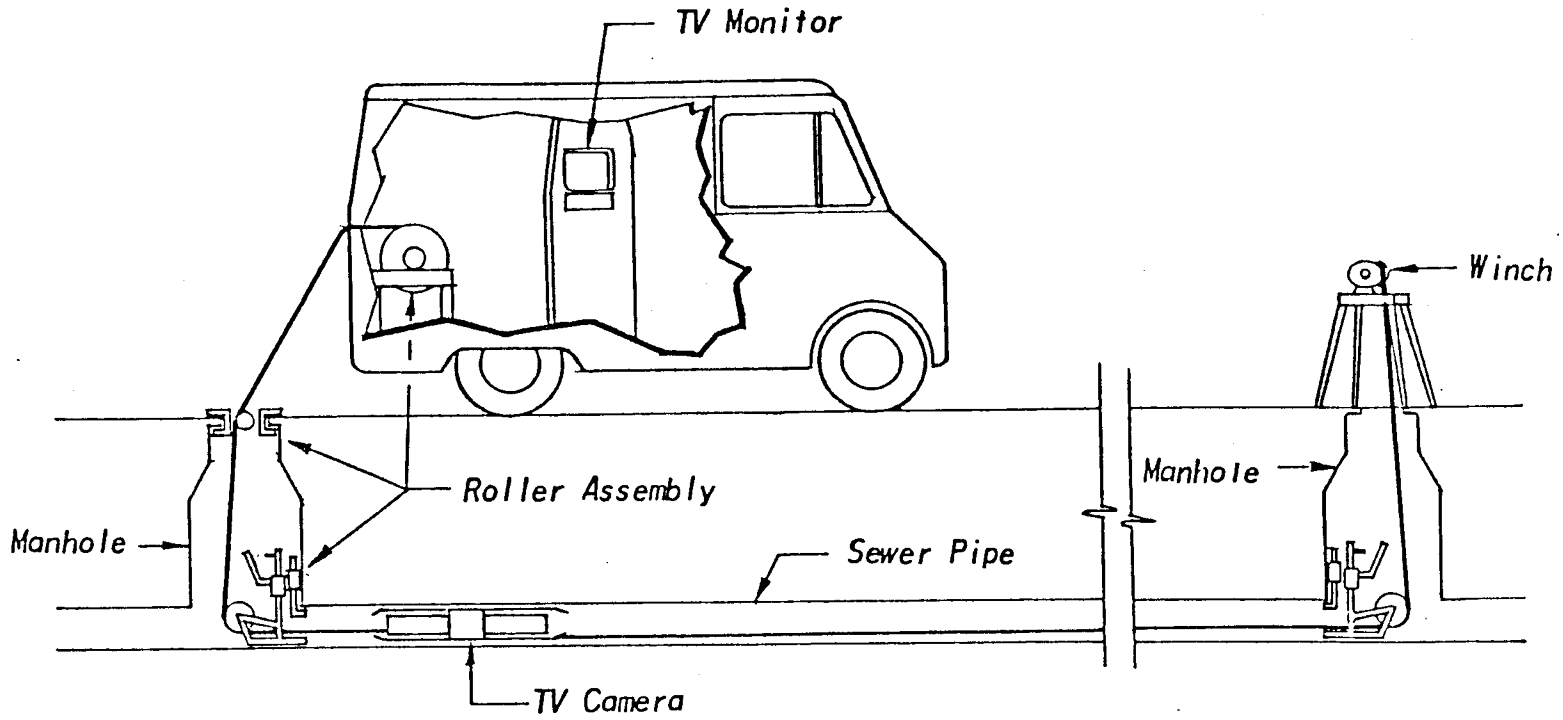

Typical Arrangement for Television Inspection of Sewer Lines

(Source: USEPA, 1975)

respect to the manholes via the footage counter on the T.V. cable feeder. The camera can be stopped at any time so that still photographs may be taken of the monitoring screen. Usually the entire inspection is recorded on videotape for subsequent playback and review.

Prior to any remedial sewer repairs it is usually necessary to televise the sewers to locate specific problem areas and determine the extent of repairs which will likely be necessary. Television inspection may also be used to document causes of sewer surcharging and to verify that sewers which have been blocked off in the past are not active pathways of migration.

Environmental impacts of television inspection are temporary and minimal and can be mitigated by following proper safety and decontamination procedures. Use of half-face respirators, disposable gloves, shoe covers and outer garments would be appropriate for the television crews.

7.5.2 Other Physical Inspection Methods

Two other methods are commonly used to determine if illegal connections exist or determine the water flow direction. These methods are smoke testing and dye testing. Smoke testing involves forcing smoke via gasoline-powered blowers into confined sections of sewer and visually locating any smoke escaping from the sewer. Dye testing involves the injection of dye into the flow stream to determine the flow pathway.

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7.6 Sewer Cleaning

The methods used to remove accumulated sediment and other deposits from existing sewer lines are well established. Available sewer cleaning techniques include power rodding, hydraulic scouring and flushing, bucket dredging, suction cleaning with pumps or vacuums, chemical treatment, or a combination of these methods. Access to sewer lines for interior cleaning and repair is most commonly made through manholes.

The choice of cleaning techniques for rehabilitating contaminated sewer lines depends on a number of variables including:

- Depth of deposition
- Degree of root intrusion
- Degree of cleanliness required
- Extent of contamination
- Chemical and physical nature of the contaminants
- Costs and availability of different cleaning services
- Ease of access to contaminated areas
- Immediacy of any potential public health hazards
- Specific legal issues that may complicate a given cleanup strategy.

Interior cleaning of contaminated pipes will facilitate the location of structural deficiencies such as cracks, joint failures, and collapsed pipes which ultimately may require repair to prevent infiltration of contaminated soil and ground water and eliminate surcharging. Cleaning must also be performed before television inspection and grouting of sewers. Figures 7-2 through 7-4 illustrate the various methods of cleaning.

7.6.1 Mechanical and Hydraulic Cleaning

Mechanical cleaning is effective in removing obstacles such as roots, stones, corrosion nodules, grease and sludges from sewers. In the case of sewer lines infiltrated by contaminated runoff or leachate, interior scouring may be necessary to loosen or remove solidified masses of chemical residues or contaminated sediment which are then flushed or dredged from the line. Mechanical cleaning techniques include the use of power rodding machines (i.e. "snakes"), which pull or push scrapers, augers, and brushes through the obstructed line.

Hydraulic flushing of contaminated lines can be achieved by running high-pressure cleaning nozzles into sewer lines through manholes and flushing out contaminated sections of the sewer. This technique is often used after mechanical devices have cleared the line of solid debris or loosened contaminated sediments and sludges coating the inner surface of the pipe.

The mechanical cleaning techniques have the advantage of removing heavy root intrusions and being able to penetrate or remove blockages from the line without using the large quantities of water required for the hydraulic equipment. The hydraulic flushers, however,

FIGURE 7-2

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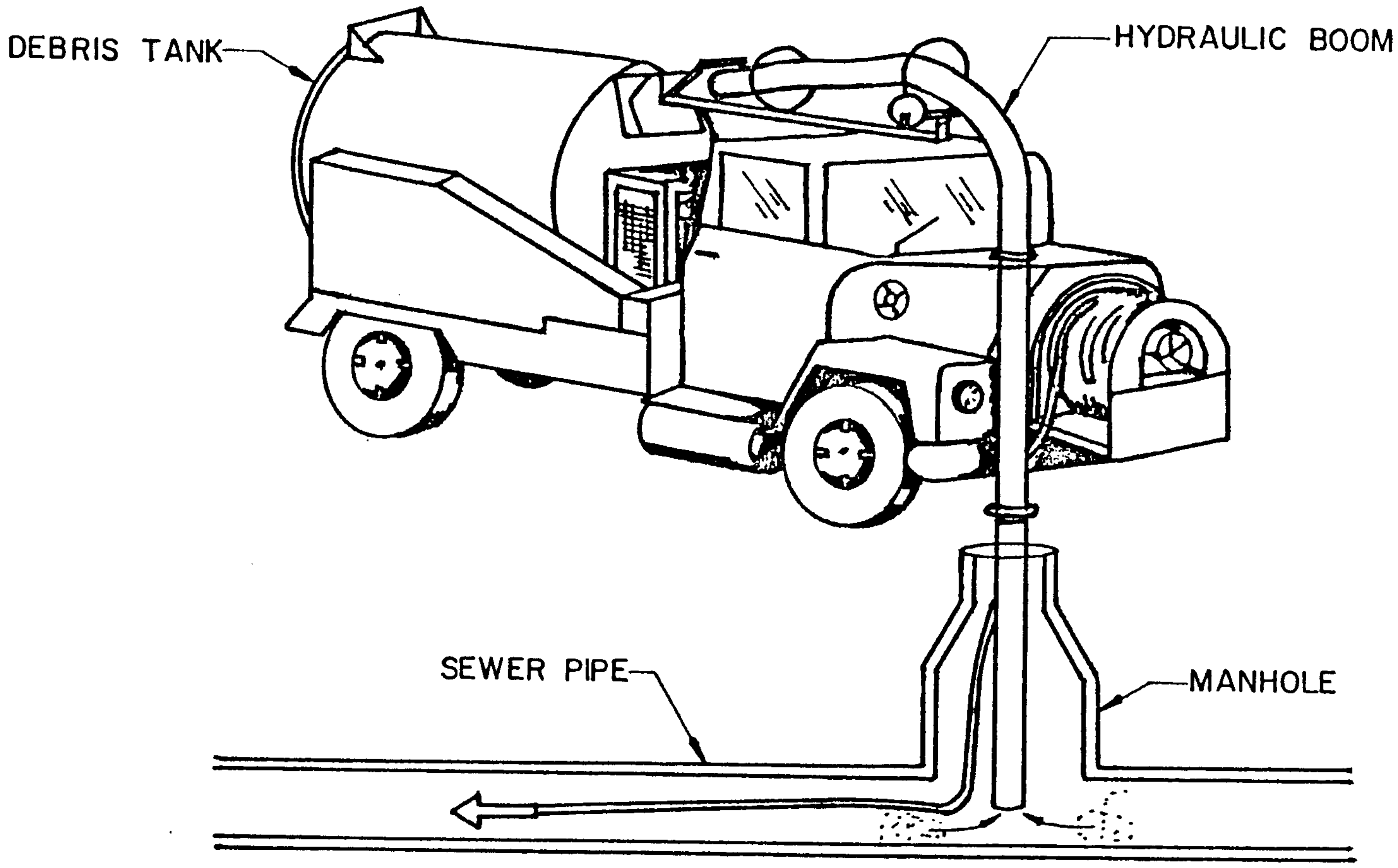


BACKFLUSHING AND VACUUMING - SIMULTANEOUS OPERATIONS are more useful for moving the loosened debris to the manhole for removal from the system.

7.6.2 Bucket Dredging and Suction Equipment

A bucket machine can be used to dredge grit or sediment from a sewer line. Power winches are set up over adjacent manholes with cable connections to both ends of the collection bucket, which is pulled through the sewer until loaded with debris. The same technique can be used to pull "sewer balls" or "porcupine scrapers" through obstructed pipes.

The main advantage of using bucket cleaning equipment is that this method can remove heavy accumulations of solids from the manhole and deposit them into disposal vehicles without using flushing water. One of the main disadvantages is that significant amounts of solids and water from the manhole can be splashed or sprayed on workers and the area adjacent to the manhole.

Suction devices such as pumps or vacuum trucks also may be used to remove accumulated solids from the manholes. These devices can also be used to remove flushing water associated with hydraulic cleaners. Manholes provide easy access for the setup and operation of such equipment.

7.6.3 Vapor Control

Vapor control may be required in conjunction with the above cleaning alternatives in sewer lines having high concentrations of volatile contaminants in the sediment. This measure is very expensive, but may be necessary to minimize the exposure risk to workers and

POWER RODDING MACHINE

(Source: Hammer, 1975)

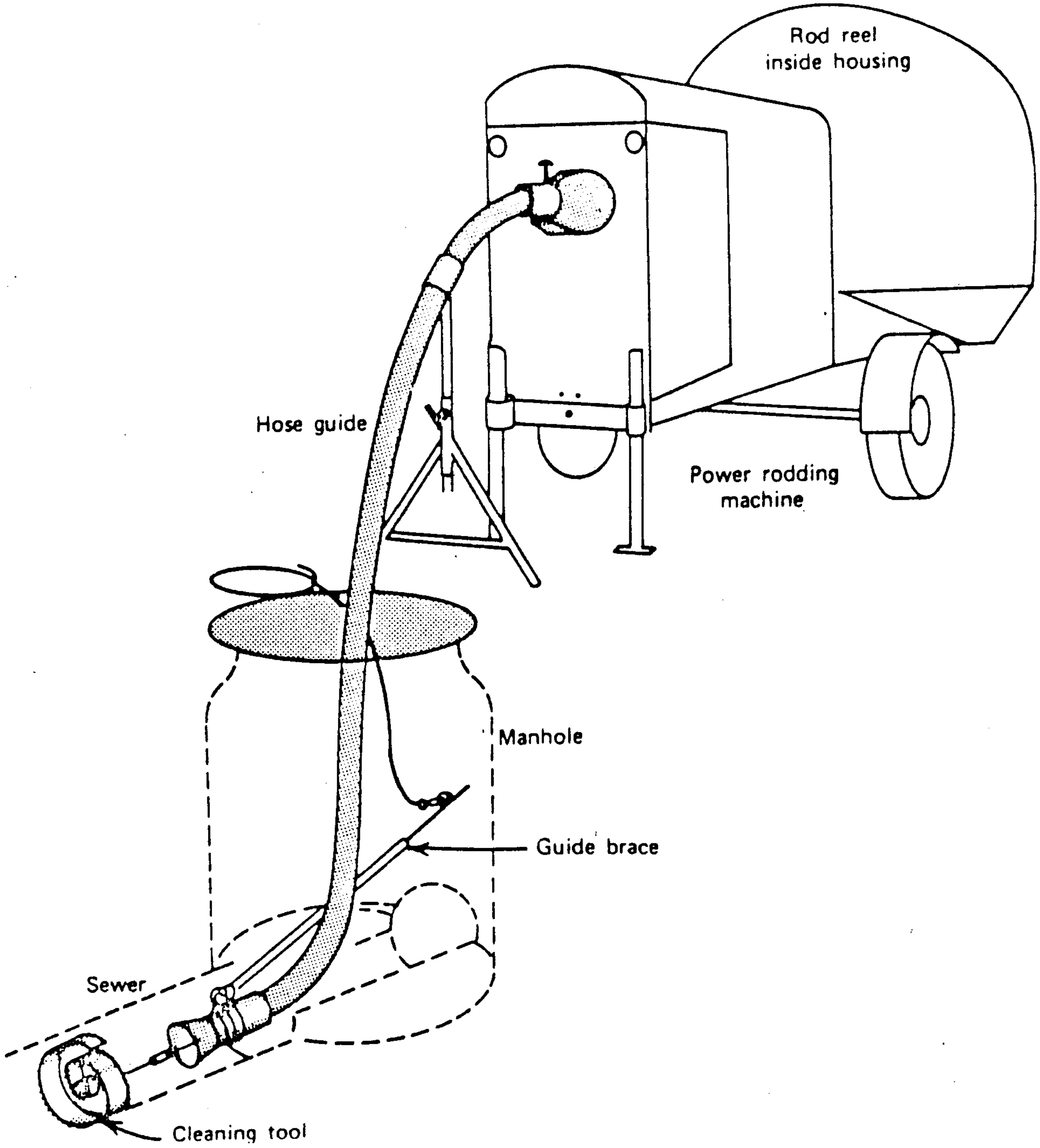
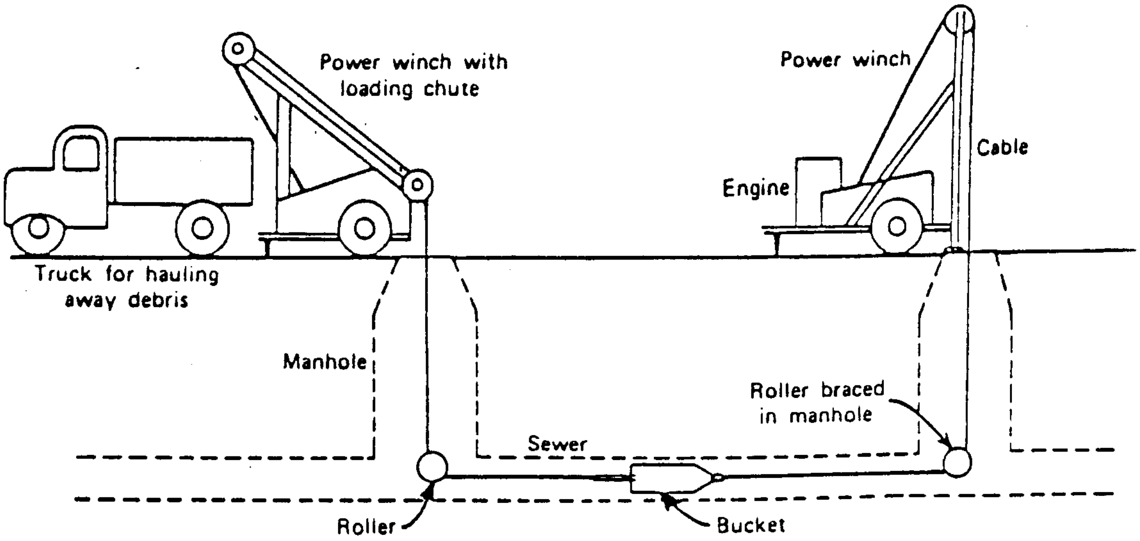


FIGURE 7-4

SCHEMATIC OF BUCKET MACHINE CLEANING

(Source: Hammer, 1975)



area residents during sewer cleaning operations. Control enclosures incorporating granular activated carbon adsorption equipment would be set up over the affected manholes. Contaminated gases volatilized during cleaning operations would be adsorbed on the activated carbon, thus preventing release to the ambient atmosphere. Temporary vapor barriers also would be installed to prevent migration of contaminated vapor from the cleaning area.

7.6.4 Residuals Treatment, Handling and Disposal

As previously stated, cleaning equipment other than bucket machines does not remove materials from manholes and catchbasins, therefore a vacuum or pumping system is needed to complement most cleaning methods. The options for ultimate disposal of residual solids and any wash water generated from the cleaning operation, include dewatering at the leachate treatment facility with on-site disposal of solids in the canal area or hauling to a permitted commercial waste processor for dewatering and secure burial.

7.6.4.1 On-Site Disposal

On-site disposal requires separation of the liquid/solid fraction using a filter press, clarifiers, or pressure filters prior to treatment of the liquid fraction using the leachate treatment plant. The separation of the liquid and solids is mandated by the limitations of the leachate treatment facility to handle solids. Problems with the air lift pump in the plant claifier and plugging of the carbon itself could be expected without some type of solids removal pretreatment. All solids removed would be drummed for disposal beneath the existing clay cap at the canal site.

7.6.4.2 Off-Site Disposal

Off-site disposal would entail use of tank trucks or similar equipment to transport all material, solid and liquid to a local commercial waste processing facility for dewatering, treatment of the liquid fraction using granular activated carbon and drummed disposal of the residual solids at a permitted and NYSDEC approved hazardous waste disposal facility. Prior to burial, the residual solids must be sufficiently dewatered so that there is no free water with the solids and the solids concentration must be 20 percent or greater.

7.7 Sewer Repair

7.7.1 Grouting

One method of in-place repair is to grout fractured or leaky joints to seal them from groundwater infiltration and sewage exfiltration.

Chemical grouts for sealing sewer lines are generally acrylamide resins or silica gels, which are applied to leaking joints from the interior following detection by television inspection. A sealing packer is pulled through the sewer line ahead of the closed circuit camera, which is used to position the packer. The sealing packer is then inflated at each end leaving an open pocket in the area of the joint. Chemical grout is then pumped into the open space under pressure and the central portion of the packer is inflated, thereby forcing the grout through the break or opening into the surrounding soil and sealing the leak. After the grout has had time to set, the ends of the packer are deflated and the operation repeated at the next leaky joint. The joints repaired in this manner are usually air tested before and after the grouting operation by forcing low pressure air into the space between the ends of the sealing packer and observing the drop in pressure. If the pressure drop exceeds established limits indicating that the grout has not taken, the grouting operation is repeated until a successful test result is achieved. Grouting and testing of lines simultaneously in this manner is known as "test and seal." A typical grouting operation is illustrated on Figure 7-5.

Environmental impacts of grouting are low as all of the grouting work is performed below grade without the need to excavate and disturb the surrounding area. The grouts are inert upon curing and would not be expected to contaminate the sewers via leaching of base compounds. There is an exposure potential to the grout catalyst from volatilization during the mixing of the grout; however, the airborne concentration would be low. Use of half-face respirators and protective clothing would mitigate any adverse impact.

7.7.2 Pipe Relining

Relining is another method of sealing that can inhibit infiltration and exfiltration in pipelines. Interior lining of sewers can be performed in addition to chemical grouting to ensure a high level of pipeline integrity and low future risk of groundwater or leachate infiltration. Large sections of badly cracked or deteriorating sewer lines can be relined with high density

FIGURE 7-5

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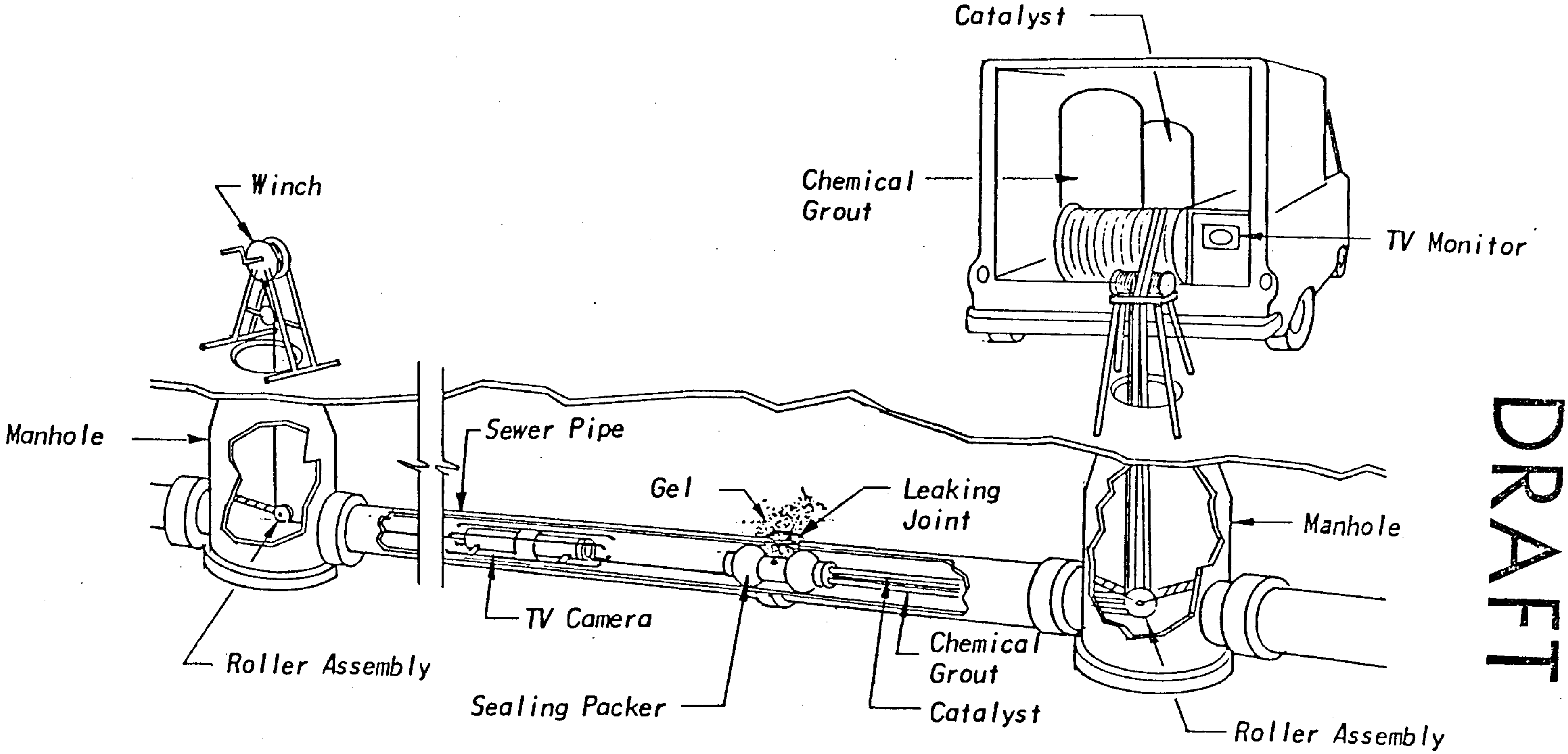

Typical Arrangement for Chemical Grouting
(Source: USEPA, 1975)

polyethylene piping, a technique commonly called slip-lining. Lengths of polyethylene pipe are fused together above ground and pulled into place within the pipeline from strategically located excavations along the existing sewer (see Figure 7-6). Normally a sewer length of 2 to 3 manhole sections can be lined from a single excavation. Connection of the house service lines to the new liner is then accomplished using a remote cutting tool or by excavating to install a more conventional saddle joint.

7.8 Removal and Replacement

Removal and/or replacement of sewer lines consists of excavation under carefully controlled conditions to expose and remove contaminated piping and bedding material for disposal at a permitted and NYSDEC-approved hazardous waste landfill. This option is necessary when the degree of bedding contamination is sufficiently high to preclude the no-action alternative or when structural damage prevents the proper operation of the recommended remedial measure. Replacement is also required if the removed pipeline is needed for current or future service. Removal and/or replacement is the most expensive remedial option, but in some cases may be the only choice to assure protection of the environment and public health.

This alternative has the most significant short-term impact on the environment as it involves excavation in residential neighborhoods, disruption of traffic patterns, and would create airborne dust and noise from construction equipment.

Mitigating measures include the use of haul vehicle covers to minimize dust during transportation of contaminated soils, use of protective clothing by construction workers, requiring sound limiting devices such as mufflers on all construction equipment, and dust control measures such as street sweeping and soil wetting on a frequent basis during excavation.

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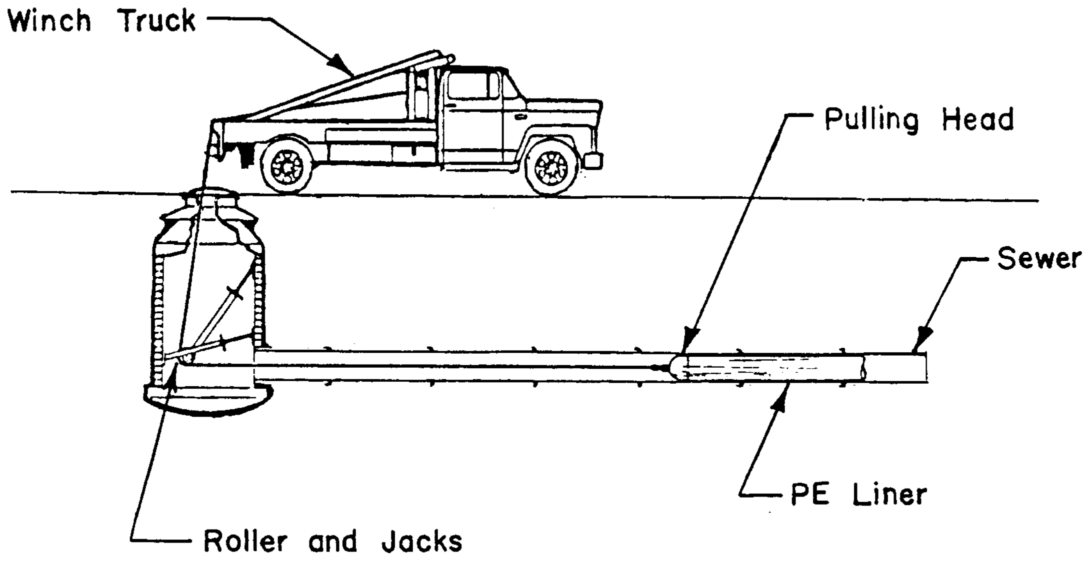
INTERIOR RELINING WITH PE
(Source: USEPA, 1982)



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8.0 EVALUATION OF ALTERNATIVES

8.1 Preliminary Screening of Alternatives

A matrix analysis of the remedial alternatives is presented as Table 8-1. The alternatives listed in the left-hand column are arranged from top to bottom in increasing order of complexity, i.e., no action is the least complex and removal and replacement is the most complex. The criteria used for rating the alternatives (highly effective, moderately effective, not effective or not applicable) were established based on the actual physical findings discovered during the sampling program.

Where more than one remedial measure was assigned the same score for a particular sewer condition, other factors must be included in evaluating the alternatives. These factors include long and short-term environmental impacts, cost effectiveness, worker and community safety, public acceptability, future rehabilitation plans for the area, scheduling constraints and impact of other remedial activity.

This preliminary evaluation of each alternative is intended to indicate the relative assessment of the usefulness of each alternative. The suitability of each approach has been evaluated in the context of a particular application within the task area. Section 8.2 provides a detailed evaluation of each alternative with respect to the environmental impacts, cost effectiveness and other factors referenced above and provides the unit costs used in the evaluation.

8.2 Detailed Evaluation

Each of the matrix elements will be discussed below in terms of their specific applicability to problems in Task Area

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TABLE 8-1

REMEDIAL ALTERNATIVE MATRIX

REMEDIAL ALTERNATIVES \ REASONS FOR SEWER REMEDIATION	Small to Medium Amts of Sediment Accumulation in pipe (i.e. < 2 in)	Medium to Large Amts. of Sidiment Accumulation in Pipe	Sediment Accum. in Manhole or Drop Inlet	Root Intrusion/Blockage	Slightly Moderately damaged Sewers (i.e. cracked pipe or offset joint)	Severely Damaged Sewers (i.e. broken or collapsed pipe)	Leaking Joints	Location of Suspected or known cross connections, Contaminant sources, and/or Sructural problems	Remediation of Contaminated Sewer Bedding Material	NOTES (SEE NEXT PAGE)
No Action	-	-	-	-	-	-	-	-	-	None
Monitoring Only	-	-	-	-	-	-	-	-	-	None
Physical Inspection/ Testing Methods										
a. Television	-	-	-	-	-	-	-	x	-	3, 14
b. Dye Testing	-	-	-	-	-	-	-	o	-	None
c. Smoke Testing	-	-	-	-	-	-	-	o	-	None
Sewer Cleaning										
a. Hydraulic	x	o	x	-	-	-	-	-	-	1, 5, 8, 10
b. Power Rodding	o	o	-	x	-	-	-	-	-	4, 6, 11
c. Bucket Cleaning	o	x	-	o	-	-	-	-	-	2, 3, 7, 11, 14
Sewer Repair										
a. Grouting	-	-	-	-	-	-	o	-	o	14, 3
b. Slip Lining	-	-	-	-	x	-	x	-	o	12, 14
Remove and Replace Sewer	x	x	x	x	x	x	x	-	x	10, 12

Legend:

x	-	Highly effective
o	-	Moderately effective
-	-	Not effective or not applicable

Notes:
1. Require large quantities of flushing water.
2. Can cause pipe damage.
3. Cannot be used in damaged pipe, offset joints, protruding service laterals.
4. Cannot transport heavy solids.
5. Can clean manhole walls and bench.
6. Best for dislodging roots and blockages.
7. Best for dislodging, transporting and removing sand, gravel, rocks, bricks, and roots.
8. Best for dislodging and transporting sludge, mud, sand and gravel.
9. Manhole access not critical.
10. Generates large quantity of contaminated residuals which must be properly handled, treated and diposed of.
11. Requires hydraulic flushing as final step to assure high degree of cleanliness.
12. Requires excavation.
13. Long-term effectiveness not proven.
14. Requires that sewer be threaded via flushing or rodding machine prior to starting.

II. Some alternatives will be eliminated from further consideration, while others will be combined to give maximum effectiveness and utility to remedial action.

8.2.1 No Action

As previously discussed, this alternative is considered acceptable only in sewers with no past or present contaminant indications, and where no upstream sections were determined to be contaminated. Subject to these limitations, the no action alternative is potentially applicable to storm sewers on 95th Street (MH 237-241, 800 lf), Colvin Boulevard (MH 241 and MH 232, 450 lf), and 98th Street (MH 217-219, 550 lf).

The long and short-term environmental impacts of no action include the possible migration of contaminants into the local ground and surface waters and subsequent exposure to local residents. This alternative could also cause contamination or recontamination of downstream areas such as the creeks and river which may be remediated in the future. Public acceptance of no action would certainly be unfavorable and revitalization plans for the neighborhood would be negatively impacted by this alternative.

Mitigating measures to reduce the negative impacts associated with no action include the use of public information campaigns to educate the local citizens to the degree of potential hazard posed, and the use of periodic monitoring to substantiate the acceptability of no action.

8.2.2 Monitor

Monitoring of storm and sanitary sewers as a separate remedial alternative is not applicable to Task Area II based on the results discussed in Section 6.2. The levels of contamination determined in the storm and sanitary sewer require removal of the contaminants from the sewers to prevent discharge of these compounds to the surface or ground waters in the area.

Longterm monitoring is considered necessary, however, subsequent to remedial action where major contaminant migration pathways previously existed.

Monitoring of the sanitary sewers in Task Area II will not be required on a continuing basis as the post-remediation sampling program for the sanitary sewers will focus on the downstream lift station Nos. 4 and 6 in Task Area VII, and the sanitary manhole at 101st Street and Wheatfield Avenue (MH 457) in Task Area IV.

Storm sewers to be sampled on a long term basis include MH 227 on 96th Street, MH 217 on 98th Street and MH 206 on Colvin Boulevard. Each of these three locations serve as the terminus of storm sewers which served as migration pathways for canal contaminants, as discussed in Section 6.3.

Environmental impacts associated with monitoring are similar to those for no action and include continued migration of contamination as well as possible exposure to these contaminants by workers cleaning sewers and taking samples. Problems with adverse public reaction to

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monitoring as a separate remedial alternative, possible negative impact (contamination) on related downstream clean-up activities and concern about what and where contamination may be detected in the future as a result of monitoring would also inhibit future rehabilitation of the area.

Mitigating measures to protect the health and safety of cleaning and or monitoring crews include use of respiratory and dermal protection, such as disposable footwear and outergarments, and general safety protocol for working in sewer and manholes.

No costs have been developed for the monitoring program because monitoring for storm and sanitary sewers should be included in the entire Love Canal area monitoring program being undertaken by the NYSDEC.

8.2.3 Abandon In Place

Abandonment in place is an effective measure following cleaning of the sewers to remove contaminants and prevent possible future contaminant migration. Pipes taken out of service should be replaced with new facilities to meet existing or future demand. As there are current residents throughout Task Area II, it would not be possible to abandon storm or sanitary sewers without replacing the sewers or moving the existing residents.

At the present time there is no clear indication of what future the area land use will be. Without such evidence to show a lack of future need, abandonment cannot be considered as an applicable alternative.

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Abandonment in place, if not preceded by cleaning, would allow contamination to remain at its present location for an intermediate time period.

Future excavation for utilities in the area and abandoned sewers could potentially cause exposure of construction crews to any remaining contaminants. Also, infiltration and exfiltration through leaking joints or cracked or broken pipe could liberate contaminants in the future. Safety measures for construction crews working in the vicinity of abandoned Love Canal Sewers should include use of respiratory protection for workers in manholes or trenches, hard hats, boots, goggles, and disposable coveralls.

The costs for abandoning the sewers in place are very site specific depending on location number and size of pipes, manholes, catch basins, etc., and the method used to abandon the facilities, i.e., sandbags, concrete plugs, etc.

8.2.4 Television Inspection and Other Physical Inspection Methods

Inspection by closed circuit television has the advantage of being easily accomplished while providing additional information and a permanent record of the sewer system. However, it is not feasible unless pipelines have first been cleaned.

A potential location requiring television inspection is the sanitary sewer on 95th Street (MH 283-288, 1200 lf), to verify connections to this sewer.

Related techniques for detection of cross-connections between storm and sanitary sewers and for tracing the origins and terminal points of sewers not shown on the drawings are smoke and dye testing. Smoke testing involves forcing smoke into sewers via gasoline-powered blowers which straddle the manholes. Smoke emmissions along the route of the pipe help to indicate alignment, pipe breaks, leaky laterals, and connection points to other pipes and manholes.

Dye testing is often used to verify the results of smoke tests. Liquid dye tracer compounds are poured into the manholes or catch basins, etc., and flushed into the pipes using water. The downstream manholes are simultaneously observed for signs of dye indicating a connection.

There is no environmental impact of television inspection other than possible contamination of the equipment and the clothing of the television crew. Use of appropriate decontamination procedures for equipment such as swabbing with an organic solvent, and use of respirators, gloves, goggles, and disposable garments by personnel performing the work would mitigate the impact of possible exposure. It is not anticipated that use of television inspection or any physical inspection methods will cause negative public reactions, nor interfere with scheduling constraints, revitilization plans, or other remedial activity.

There are no significant long term environmental impacts of smoke or dye testing. Short term impacts include possible momentary smoke inhalation due to basements filling with smoke via sanitary sewer house laterals, and possible dyeing of short sections of the creeks from discharge of dyed waters via storm sewer outfalls. Both the dye and the smoke, however, are nontoxic, and nonstaining, and are not hazardous to human, animal or plant life.

The costs for television inspection have been estimated at $1.40/l.f. This cost was developed by contacting Buffalo area television inspection contractors. Smoke and dye testing are estimated to cost $0.25/l.f. and $0.10/L.F., respectively, if large areas (several thousand feet) are to be tested. For small areas, the site-specific costs must be developed.

8.2.5 Sewer Cleaning

Of the three sewer cleaning alternatives examined, high pressure hydraulic flushing is the most suitable, although it generates large quantities of wastewater. It is also less effective than mechanical methods in removing roots or extremely adhesive solids. Power rodding machines and buckets effectively remove the tougher solids, but must be followed by hydraulic flushing to completely remove waste material. Since no evidence of root intrusion or unnatural solids was found in Task Area II, the most applicable method of sewer cleaning is high pressure hydraulic flushing. Power rodding or bucket cleaning are both suitable for areas having roots or adhesive solids, if such areas are encountered during hydraulic cleaning.

The portion of Black Creek which is channeled through two 48-inch corrugated metal pipes was not considered contaminated according to the three sediment samples taken for the contamination assessment. However, the possibility exists that contamination may have entered this portion of the creek because City personnel occasionally relieve the surcharged sanitary sewer at 100th Street and

Black Creek by pumping from the sanitary sewer (which was once directly connected to the canal area) into the creek. During the field sampling period, approximately 6 inches of sediment was found in this sewer. The sampling was performed by a sewer sampling crew which only took one grab sample from each sampling location without attemtping to obtain a composite sample from varying depths. Because so much sediment exists in these computated metal pipes, it is possible that contaminated sediments exist in this reach of Black Creek. There are three alternatives for dealing with the potentially contaminated sediment in this portion of Black Creek. These alternatives include:

- No Action - This is the least costly alternative, however, the possibility of contamination migrating from these pipes would still exist.

- Clean entire ength of Black Creek within corrugated metal pipe - This option would be very expensive and could possibly be wasted effort in the event that no contamination exists.

- Initiate Additional Sampling - Additional sampling in this portion of Black Creek would verify the existence of contamination at a minimal costs when compared to the cost of cleaning this entire length of corrugated metal pipe.

The environmental impacts of sewer cleaning vary, depending on the method and equipment used and location being cleaned. The impact of using either flushing machines or power rodding equipment is more significant than bucket machines from the standpoint of the quantities of residuals to be disposed of as both methods rely on the use of flushing water to complete the operation. Bucket machines have a potentially larger impact on the surrounding area if proper operation procedures are not followed. If the bucket machines are used to transport debris from the manhole directly to a disposal vehicle, splashing of liquid, solids and slurries onto crew members and adjacent areas could occur. The impact of using any cleaning method which does not remove all sediment (in this case bucket cleaning) would also be quite significant since some of the contaminants would be left in the sewer and could subsequently migrate to downstream locations causing contamination or recontamination at those locations.

Mitigating measures to offset the negative impact of sewer cleaning on cleaning crew workers include use of respiratory and dermal protection, goggles, gloves, boots, and disposable coveralls, etc.

Mitigating measures to avoid leaving contamination in the pipes following cleaning includes using hydraulic flushing following bucket cleaning or power rodding to assure that the pipes are completely scoured.

This need to supplement mechanical cleaning methods with flushing techniques despite the large volume of presumably contaminated washwater generated is overwhelming justification for recommending use of hydraulic flushing as the primary cleaning mode.

It is not anticipated that any of the cleaning methods evaluated if properly implemented, would create problems in regard to public acceptance. Each cleaning alternative would positively impact on revitalization of the area because the contamination would be removed.

All hydraulic cleaning must be performed in the summer or fall due to infiltration problems in the springtime and ice-related problems during the winter months. Additionally, the sequence and scheduling of cleaning storm sewers should be coordinated with cleanup activity in the creeks and in the Niagara River to preclude the possibility of recontamination.

Hydraulic cleaning has been estimated at $5.50/L.F. Bucket cleaning and power rodding are significantly more expensive than hdyraulic cleaning and would cost approximately $7.50/L.F.

Costs of sewer cleaning were obtained from both western New York and nationwide sewer cleaning contractors and from the 1982 EPA Manual on Remedial Action at Hazardous Waste Sites. These costs were than averaged to obtain representative costs for this project.

8.2.6 Sewer Repair and Replacement

Grouting is not a reliable longterm repair alternative, because the grout can shrink or crack over time and is not effective in sealing longitudinal cracks. Of the sewer repair alternatives examined, only slip lining is considered effective. However, the excavation required to make house lateral connections in sanitary sewers and the relatively high cost of relining short sections of pipe makes slip lining less attractive.

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Removal and replacement is similar in cost to pipe relining for remediation of short sections of sewer, and is significantly more effective. Further, since no bedding material contamination was found in Task Area II, excavation would not expose large quantities of contaminated material.

In the event that short sections of structurally deficient sewers are encountered during remedial activity in Task Area II, removal and replacement is considered the most suitable alternative. Pipe relining would be suitable for repair of long sections of storm sewer, or sanitary sewer without service connections, which is not generally believed to be the case in Task Area II.

Removal and replacement of the structurally damaged sewer is the most effective method of sewer rehabilitation. This alternative removes all contamination from the site. This alternative has the longest expected life of any rehabilitation option.

No adverse environmental impacts would be created by this option. All contamination would be removed from the site if this option is chosen. All contaminated excavated material should be disposed at a NYSDEC approved hazardous waste facility.

The removal and replacement option would not interfere with the operation of any other remedial task.

For estimating purposes, the costs for removal and replacement of 10 to 15-inch diameter sewers (similar to those found in the study area) has been at $100/l.f. This cost was developed by review of recent bid tabulations in the Niagara Falls area. The cost for disposal of contaminated excavated material has been estimated at $100/cubic yard. This cost was developed through discussion with local hazardous waste disposal facility operators.

8.2.7 Residuals Disposal

The residuals disposal alternatives evaluated include onsite and offsite disposal. Based on discussions with NYSDEC personnel, the need to erect onsite dewatering facilities, the limited capacity of the existing leachate treatment plant, and the need to excavate and remove a portion of the existing clay cap over the canal make on-site disposal unfeasible. Accordingly, offsite disposal at one of several local hazardous waste facilities is considered the best method of residuals handling.

The recommended method of residuals disposal at a NYSDEC approved hazardous waste landfill should not create any adverse environmental impacts. These landfills have been created for the specfic purpose of providing a long term, controlled, and environmentally safe area for the disposal of hazardous wastes.

The possibility exists that workers transporting this waste could become contaminated if direct contact is made with these wastes. However, if proper handling and protective procedures are followed, no contamination should occur. The waste transporting firm selected to do the work should be a NYSDEC approved hazardous waste transporter and should follow all of the applicable regulations.

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The costs of residual disposal have been estimated at $0.35/galllon. These costs were developed through discussions with hazardous waste landfill operators in the vicinity of Niagara Falls. The costs for residual transportation has been estimated at $1.40/l.f. This costs was developed through discussion with sewer cleaning and waste hauling contractors in the vicinity of Niagara Falls.

The feasibility of segregation of liquid and solid wastes from sewers to be cleaned which were not sampled during the field work, was also evaluated. By segregating and testing these wastes prior to final disposal, it would be possible to determine if the wastes were indeed hazardous, thereby requiring treatment of the flushing water and burial of the solids in a secural burial facility. If testing determined that these wastes were not hazardous, the liquid could be discharged to the sanitary sewers and solids landfilled in a sanitary landfill, both at significant cost savings. However, based on the quantity of solids involved, segregation of the wastes is not cost effective.

The recommended method of residuals disposal at a NYSDEC approved hazardous waste landfill should not create any adverse environmental impacts. These landfills have been created for the specfic purpose of providing a long term, controlled, and environmentally safe area for the disposal of hazardous wastes.

The possibility exists that workers transporting this waste could become contaminated if direct contact is made with these wastes. However, if proper handling and protective procedures are followed, no contamination should occur. The waste transporting firm selected to do the work should be a NYSDEC approved hazardous waste transporter and should follow all of the applicable regulations.

8.2.8 Vapor Control

Vapor control will not generally be required during remedial activities, since only isolated pockets of volatile contaminants were detected in Task Area II. It was estimated that if gross volatilization of contaminants were to occur during cleaning in these isolated areas, the airborne contaminant concentrations would not exceed permissible exposure limits established by the Occupational Safety and Health Administration for prolonged exposure. Further, all workers involved in remedial activities will be equipped with respiratory and dermal protection to minimize the risk of exposure to airborne contamination. Based on the above, no provision for vapor curtains or scrubbers need be included in the remedial action plan.

9.0 RECOMMENDATIONS

9.1 General

Figures 9-1 and 9-2 illustrate the recommended remediation plan for the storm and sanitary sewers, respectively in Task Area II. As shown on the figures, the primary recommendation is to utilize hydraulic flushing techniques to remove all contaminated sediments from the storm and sanitary sewers.

As shown on Figure 9-1, many of the storm sewers in Task Area II are recommended for remediation. Most of these storm sewers recommended for remediation are located downgradient of previously known connections to the canal area at 97th and 99th Streets and were found to contain significant levels of Love Canal-related contaminants. Several storm sewers tributary to these pathways have also been recommended for remedial action due to known or suspected surcharging that may have transported contaminated sediment into the tributary sewers.

As shown on Figure 9-2, all sanitary sewers in Task Area II are recommended for remedial action due to the sporatic but widespread contamination throughout the task area.

Smoke testing is recommended for the sewers in several areas. Additional monitoring is recommended for that 1,400-foot portion of Black Creek which is enclosed in the corrugated metal pipes.

9.2 Detailed Engineering Description

9.2.1 General

The cleaning of the storm and sanitary sewer system should be accomplished utilizing a high velocity water flushing machine

FIGURE 9-1

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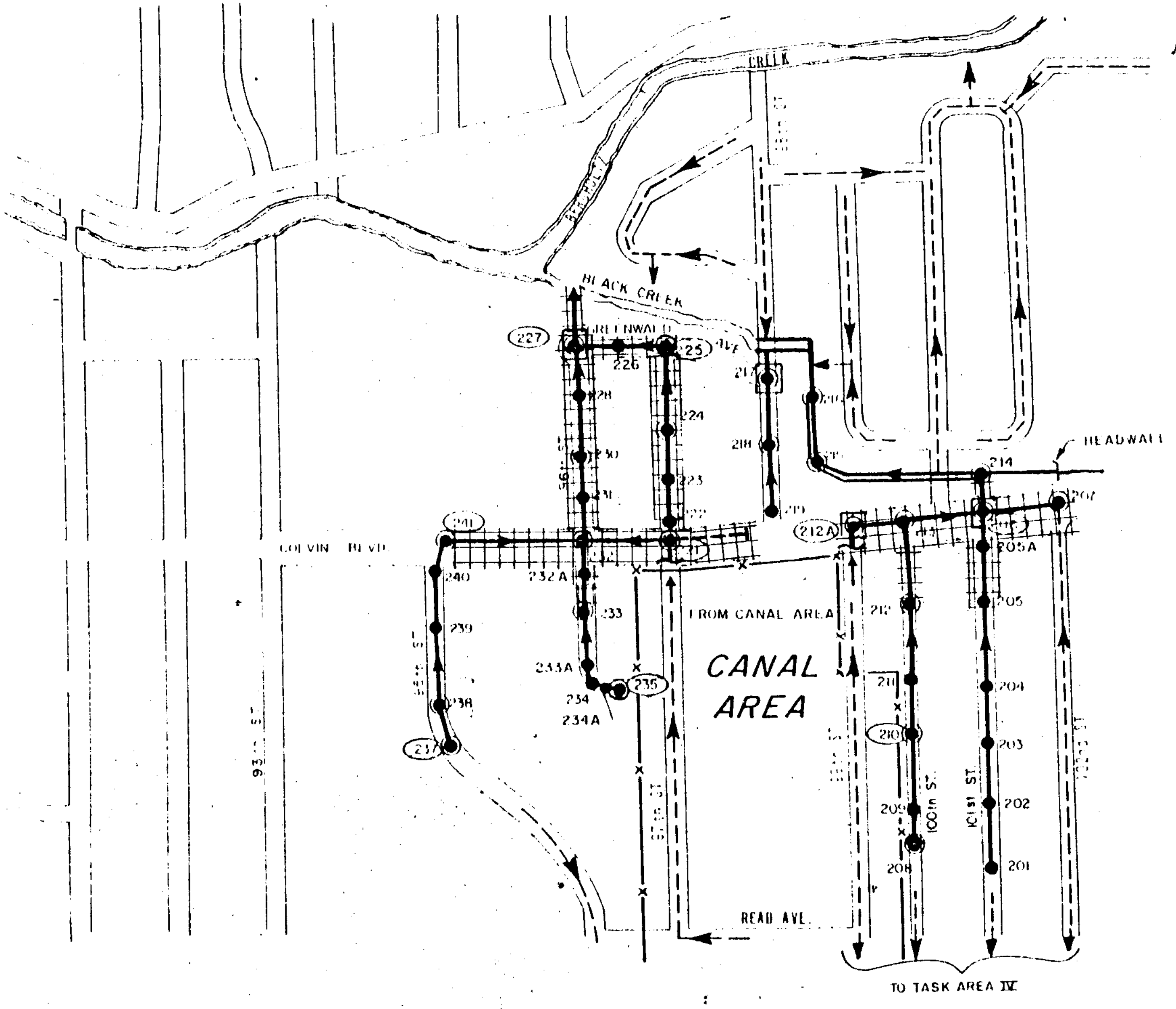

LEGEND

HYDRAULICALLY CLEAN
TELEVISION INSPECTION AND HYDRAULIC CLEANING
SMOKE OR DYE TEST
XXXXXXX REMOVE AND REPLACE

LOVE CANAL
FIVE ENGINEERING STUDIES
NORTH STORM SEWERS
TASK AREA II

REMEDIAL ACTION PLAN

FIGURE 9-2

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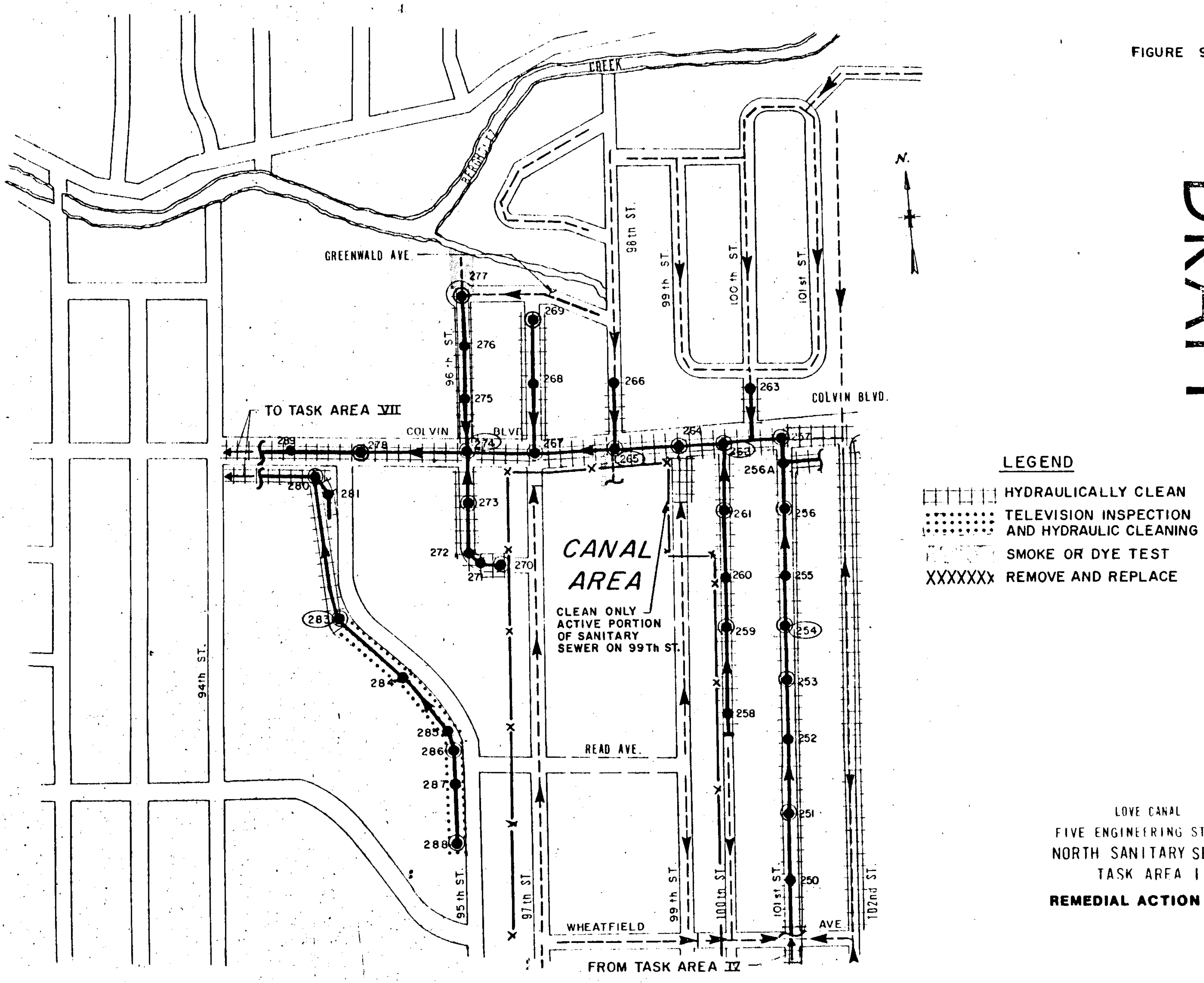

LOVE CANAL
FIVE ENGINEERING STUDIES
NORTH SANITARY SEWERS
TASK AREA II
REMEDIAL ACTION PLAN

which uses both the nozzle pressure (up to 15,000 psi) to remove encrusted debris combined with the force of the flow to transport the debris to the collection manhole. The debris is actually loosened on the initial pass of the cleaning jet while traveling upstream from the collection manhole and transported to the collection manhole on the return trip while the flusher is being reeled back in. The upstream and downstream manholes should be plugged during the entire cleaning operation to assume that no contaminated liquid or sediment debris is transported away from the designated collection manhole. The collection manholes should be established in the field at a distance of 500 to 1000 feet downstream of the flushing equipment to allow for convenient removal of flushing water while at the same time providing additional storage capacity to prevent surcharging of the sewers caused by flushing operations.

Contaminated waste material flushed from the lines should be collected and removed by using specific pipeline intersections as "catch manholes." Catch manholes are isolated from the rest of the system by the use of inflatable sewer plugs. Waste material would be transferred from the catch manhole to transport vehicles by using submersible pumps and vacuum nozzles. The estimated daily output for this method of hydraulic cleaning is 1000 linear feet per day.

Special precautions should be followed by the cleaning contractor to prevent the surcharging of sewers into house laterals. This problem should receive special consideration during the design phase of the remedial activities.

An estimated 6 to 7 gallons of liquid and sediment waste per linear foot is produced by hydraulic cleaning. Transport vehicles should haul the waste to a NYSDEC approved and permitted hazardous waste treatment facility for dewatering. Residual solids should be buried in a NYSDEC approved secure landfill and liquid filtrate should be treated by NYSDEC approved techniques.

No structurally damaged sewers were identified in Task Area II. However, isolated sections of structurally deficient sewers locations detected during cleaning activities should be removed and replaced if the damaged sewer prevents proper application of the recommended remedial measures. In the event of removal and replacement, any contaminated pipe and excavated material should be disposed of at a NYSDEC approved and permitted hazardous waste disposal facility.

During the hydraulic cleaning of the sewers in Task Area II, vapor controls are not expected to be required. Most of the contaminants found in Task Area II are nonvolatile.

Personnel employed to implement the remedial action plan should follow strict personal safety and decontamination protocols similar to those presently being used for remedial activity inside Rings 1 and 2. Workers should be equipped with appropriate respiratory and dermal protection, and should be trained to work in hazardous environments. Additionally, all confined environments in which men will be working should be continuously monitored for oxygen, hydrogen sulfide, combustibles and volatile chemicals.

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It has been estimated that 4,000 lf of storm sewer and 13,000 lf of sanitary sewer should be cleaned in Task Area II. Additionally, 1,200 lf of sanitary sewers should be televised.

9.2.2 Storm Sewers

An estimated 4,000 lf of storm sewer in Task Area II is recommended for cleaning at the locations identified in Figure 9-1. No areas of the Task Area II storm sewers have been recommended for inspection by television.

It is recommended that additional sampling be done in the 1,400-foot portion of Black Creek enclosed by the corrugated metal pipe. This sampling will verify if further remedial action is needed in this portion of Black Creek.

9.2.3 Sanitary Sewers

An estimated 13,000 lf of sanitary sewer in this task area is recommended for cleaning at the locations identified on Figure 9-2. An additional 1,200 lf of sanitary sewer on 95th Street have been recommended for television inspection. Smoke testing is recommended at MH 277 to determine if a connection to Black Creek exists and at MH 265 to identify the pipe which enters this manhole from an unknown source.

9.3 Estimated Cost of Remedial Action

Costs estimates (initially developed in Section 8.2) for the various elements of the remedial action plan for Task Area II are summarized in Table 9-1. Unit costs are based on

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TABLE 9-1

RECOMMENDED REMEDIATION COSTS
TASK AREA II - STORM AND SANITARY SEWERS

Item	Quantity	Unit Cost	Total
Hydraulic Cleaning	17,000 lf	$5.50/lf	$ 93,500
T.V. Inspection	1,200 lf	$1.50/lf	1,800
Residuals Transportation	17,000 lf	$1.40/lf	23,800
Smoke Testing	2 manholes	$500/ea.	1,000
Residuals Treatment and Disposal (7 gal/lf)	119,000 gal.	$0.35/gal.	41,650
		Subtotal	$161,750
Engineering, Contingency, Legal Administrative @ 30 percent			48,530
		Total	$210,280

quotations obtained from sewer cleaning and waste disposal contractors in the Western New York area.

The cost of hydraulic cleaning has been estimated at $5.50/lf. This hydraulic cleaning is a common procedure and can be accomplished by a number of local contractors. For estimating purposes, it has been assumed that vapor controls will not be necessary.

Television inspection has been estimated at $1.50/lf. Television inspection is a common procedure and can be accomplished by a number of local contractors. This task should be included in the same contract as the hydraulic cleaning thereby giving overall coordination responsibility to one contractor.

Waste transportation includes pumping the wastewater from the manholes to transport vehicles which will take the wastewater to the hazardous waste disposal facilities. This task should be performed by the hydraulic cleaning contractor. This task should not be bid separately because this would only create coordination and responsibility problems among contractors. This cost has been estimated at $1.40/lf.

The costs for disposal of cleaning residuals have been combined into a total unit cost. The quantities and associated disposal costs of dewatered solids from sewer cleaning operations will be minimal in comparision with the cost of dewatering the slurry and treating the filtrate wastewater. The total cost for sewer cleaning residuals treatment and disposal has been estimated at $0.35/gal. This price includes the cost of the dewatered residual solids disposal in a NYSDEC approved and permitted secure landfill.

Smoke testing has been estimated at $500 per manhole. This includes the cost of smoke bombs, sewer plugs and other equipment.

9.4 Implementation Scheduling

The remediation of storm and sanitary sewers in Task Area II should begin as soon as possible to minimize further contaminant migration and exposure potential.

Cleaning of the storm sewers is of higher priority than the sanitary sewers because significant amounts of contamination in the storm sewers can migrate to Black Creek. Before remediation begins some of the contamination in the sanitary sewer will likely be transported to the City of Niagara Falls Wastewater Treatment Plant, and some of the contaminated sanitary sewer sediment could enter Black, Bergholtz or Caguya Creek through lift station bypasses in Task Area VII or portable pumped bypasses to storm sewers within Task Area II.

The scheduling of storm cleaning operations in Task Area II will not interfere with sewer cleaning operation in any other task area. However, remediation of the storm and sanitary sewers should take place before the remediation of Black & Bergholtz Creek.

The sanitary sewers in Task Area II should be cleaned before the sanitary sewers in Task Area VII and afater the sewers in Task Area IV because Task Area II is upstream of Task Area VII and downstream of Task Area IV.

Hydraulic flushing involves the handling of large quantities of water, therefore, hydraulic flushing should not be scheduled during the winter months (November-March) because of

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the potential working hazards created by ice, cold weather, and poor visibility.

During the spring months (March-April), infiltration and inflow into the sewers is greatest due to snow melt, frequent rains, and a high ground water table. Since it will be necessary to dispose of all residual wastewater generated from the hydraulic cleaning operation, extraneous flows due to infiltration will increase the total disposal cost.

Consequently, the hydraulic flushing operation should be undertaken during the month of May through October provided this does not conflict with the remedial action schedules for the creeks and river.

APPENDIX A
SUMMARY OF ANALYSIS

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-1014S
Location ID: MH-206
CompuChem #: 2194

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	203	Benzene	2,100	2,000	461
	222	Methylene Chloride	2,400	2,000	152
Acid		None Detected			
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	7,600	4,000[1]	1490

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	6.8	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	23	1.0
106	Copper, Total	14	1.0
107	Lead, Total	82	1.0
109	Nickel, Total	3.4	1.0
112	Thallium, Total	4.5	1.0
113	Zinc, Total	120	1.0

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-1021S
Location ID: MH-213
CompuChem #: 2265

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	220	200	1523
	LS	Cyclotetrasiloxane, Octamethyl-	400	EC	622
	LS	Unknown	340	EC	740
	LS	Unknown	1,200	EC	858
	LS	Unknown	680	EC	963
	LS	Unknown	800	EC	1129

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	18	1.0
104	Cadmium, Total	1.3	1.0
105	Chromium, Total	17	1.0
106	Copper, Total	13	1.0
107	Lead, Total	73	1.0
109	Nickel, Total	7.1	1.0
112	Thallium, Total	7.4	1.0
113	Zinc, Total	83	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-1020S
Location ID: MH-214
CompuChem #: 2250

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	15,000	4,000 [1]	1490
	LS	Cyclotrisiloxane, Hexamethyl-	4,000	EC	464
	LS	Hydroxylamine, O-Decyl-	2,800	EC	838
	LS	Unknown	6,400	EC	846
	LS	Unknown	3,400	EC	951
	LS	Unknown	6,800	EC	1022

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	14	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	14	1.0
106	Copper, Total	9.3	1.0
107	Lead, Total	31	1.0
109	Nickel, Total	4.9	1.0
112	Thallium, Total	6.9	1.0
113	Zinc, Total	61	1.0

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-1013S
Location ID: MH-221
CompuChem #: 2205

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	219	Ethylbenzene	2,200	2,000	778
	222	Methylene Chloride	2,900	2,000	165
	225	Toluene	2,700	2,000	681
Acid	LS	Benzene,Pentachloro-	6,800	EC	1231
	LS	Unknown	5,400	EC	1266
	LS	Unknown	7,600	EC	1379
	LS	Unknown	10,000	EC	1387
	LS	Cyclohexane,1,2,3,4,5,6-Hexachloro-,(1.Alpha.,2.Alpha.,3.Beta.,4.Alpha	6,400	EC	1436
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	14,000	4,000 [1]	1547
	433	Hexachlorobenzene	9,200	4,000 [1]	1141
	446	1,2,4-Trichlorobenzene	26,000	4,000 [1]	806
	LS	Cyclohexane	52,000	EC	331
	LS	Benzene,1,2,3,5-Tetrachloro-	20,000	EC	946
	LS	Unknown	22,000	EC	1033
	LS	Unknown	31,000	EC	1060
	LS	Unknown	24,000	EC	1192

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-1013S
Location ID: MH-221
CompuChem #: 2205

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	9.7	1.0
104	Cadmium, Total	1.7	1.0
105	Chromium, Total	25	1.0
106	Copper, Total	48	1.0
107	Lead, Total	420	1.0
109	Nickel, Total	7.1	1.0
112	Thallium, Total	4.5	1.0
113	Zinc, Total	220	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-1012S
Location ID: MH-224
CompuChem #: 2204

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	1,2,4-Trithiolane	4,000	EC	851
	LS	Ethanamine,2,2'-Oxybis/N, N-Dimethyl-	5,000	EC	1181
	LS	Unknown	13,000	EC	1321
	LS	Unknown	7,000	EC	1450
	LS	Unknown	1,800	EC	1568
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	34,000	24,000 [1]	1548
	LS	Cyclotrisiloxane, Hexamethyl-	16,000	EC	490
	LS	3-Pentanamine	21,000	EC	1100
	LS	Unknown	11,000	EC	1145
	LS	Unknown	13,000	EC	1053

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-1012S
Location ID: MH-224
CompuChem #: 2204

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	17	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	21	1.0
106	Copper, Total	14	1.0
107	Lead, Total	140	1.0
109	Nickel, Total	4.0	1.0
112	Thallium, Total	6.3	1.0
113	Zinc, Total	110	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2015S
Location ID: MH-251
CompuChem #: 2121

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Benzene,1,2,4-Trichloro-	3,800	EC	912
	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	3,800	EC	1066
	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	4,200	EC	1078
	LS	Benzene,1,2,3,5-Tetrachloro-	3,400	EC	1141
	LS	Benzene,Pentachloro-	6,800	EC	1257
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	8,000	4,000 [1]	1525
	446	1,2,4-Trichlorobenzene	11,000	4,000 [1]	790
	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	5,600	EC	873
	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	6,000	EC	882
	LS	Unknown	6,000	EC	1219
	LS	Unknown	9,200	EC	1349
	LS	Unknown	100,000	EC	1542

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2015S
Location ID: MH-251
CompuChem #: 2121

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	13	1.0
104	Cadmium, Total	2.0	1.0
105	Chromium, Total	27	1.0
106	Copper, Total	170	1.0
107	Lead, Total	97	1.0
109	Nickel, Total	8.2	1.0
113	Zinc, Total	340	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2011S
Location ID: MH-257
CompuChem #: 2103

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	5,500	EC	923
	LS	Unknown	5,300	EC	989
	LS	Unknown	3,700	EC	1039
	LS	Unknown	11,000	EC	1182
	LS	Unknown	19,000	EC	1201
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	9,200	4,000 [1]	1543
	431	Fluoranthene	4,000	4,000 [1]	1310
	LS	3-Pentanamine	3,500	EC	984
	LS	Unknown	7,000	EC	1828

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2011S
Location ID: MH-257
CompuChem #: 2103

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	11	1.0
105	Chromium, Total	15	1.0
106	Copper, Total	37	1.0
107	Lead, Total	24	1.0
109	Nickel, Total	4.3	1.0
112	Thallium, Total	3.8	1.0
113	Zinc, Total	66	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2010S
Location ID: MH-262
CompuChem #: 2050

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	12,000	EC	1042
	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	10,000	EC	1054
	LS	Benzene,1,2,3,5-Tetrachloro-	12,000	EC	1073
	LS	Benzene,1,2,3,5-Tetrachloro-	44,000	EC	1118
	LS	Benzene,Pentachloro-	32,000	EC	1232
Base/Neutral/ Pesticide	403	Anthracene/Phenanthrene	5,200	4,000 [1]	1161 [2]
	433	Hexachlorobenzene	22,000	4,000 [1]	1126
	434	Hexachlorobutadiene	13,000	4,000 [1]	814
	444	Phenanthrene/Anthracene	5,200	4,000 [1]	1161 [2]
	446	1,2,4-Trichlorobenzene	39,000	4,000 [1]	790

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

[2] Indistinguishable isomers.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2010S
Location ID: MH-262
CompuChem #: 2050

ORGANICS, Cont'd.

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
	LS	Benzene,2,4-Dichloro-1 -(Chloromethyl)-	34,000	EC	873
	LS	Benzene,2,4-Dichloro-1 -(Chloromethyl)-	28,000	EC	882
	LS	Benzene,1,2,3,5-Tetrachloro-	32,000	EC	897
	LS	Benzene,1,2,4,5-Tetrachloro-	100,000	EC	932
	LS	Benzene,Pentachloro-	76,000	EC	1020

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	14	1.0
104	Cadmium, Total	2.2	1.0
105	Chromium, Total	21	1.0
106	Copper, Total	270	1.0
107	Lead, Total	68	1.0
109	Nickel, Total	8.3	1.0
113	Zinc, Total	330	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2009S
Location ID: MH-264
CompuChem #: 2049

ORGANICS

Fraction	Compound Number	Compound	ppb Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Benzene,Pentachloro-	1,800	EC	1255
	LS	Pentacosane	10,000	EC	1568
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	4,800	4,000 [1]	1495
	446	1,2,4-Trichlorobenzene	5,200	4,000 [1]	777
	LS	Cyclotrisiloxane, Hexamethyl-	4,200	EC	466
	LS	Unknown	5,100	EC	1002

INORGANICS

Compound Number	Compound	ppm Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	10	1.0
104	Cadmium, Total	2.3	1.0
105	Chromium, Total	27	1.0
106	Copper, Total	140	1.0
107	Lead, Total	90	1.0
109	Nickel, Total	7.7	1.0
112	Thallium, Total	3.1	1.0
113	Zinc, Total	390	1.0

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2008L
Location ID: MH-265
CompuChem #: 2016

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/l)	Detection Limit (ug/l)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	370	10	1556
	446	1,2,4-Trichlorobenzene	19	10	808
	LS	Unknown	230	EC	635
	LS	1H-Purine-2,6-Dione,3,7-Dihydro-1,3,7-Trimethyl-	440	EC	1199
	LS	Unknown	620	EC	1571

INORGANICS

Compound Number	Compound	Conc. (mg/l)	Detection Limit (mg/l)
	None Detected		

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2008S
Location ID: MH-265
CompuChem #: 2013

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Benzene,1,2,4-Trichloro-	19,000	EC	935
	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	9,400	EC	1043
	LS	Benzene,1,2,3,5-Tetrachloro-	10,000	EC	1074
	LS	Benzene,1,2,3,5-Tetrachloro-	28,000	EC	1118
	LS	Benzene,Pentachloro-	20,000	EC	1233
Base/Neutral/Pesticide	413	BIS (2-Ethylhexyl) Phthalate	10,000	4,000 [1]	1524
	421	1,3-Dichlorobenzene	4,800	4,000 [1]	653
	433	Hexachlorobenzene	20,000	4,000 [1]	1126
	434	Hexachlorobutadiene	18,000	4,000 [1]	814
	446	1,2,4-Trichlorobenzene	160,000	4,000 [1]	791

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2008S
Location ID: MH-265
CompuChem #: 2013

ORGANICS, Cont'd.

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Base/Neutral/ Pesticide	LS	Benzene,2,4-Dichloro-1-(Chloromethyl)-	40,000	EC	873
	LS	Unknown	35,000	EC	882
	LS	Benzene,1,2,3,5-Tetrachloro-	60,000	EC	897
	LS	Benzene,1,2,3,5-Tetrachloro-	160,000	EC	930
	LS	Benzene,Pentachloro-	110,000	EC	1019

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	14	1.0
104	Cadmium, Total	1.2	1.0
105	Chromium, Total	18	1.0
106	Copper, Total	84	1.0
107	Lead, Total	61	1.0
109	Nickel, Total	8.3	1.0
112	Thallium, Total	6.9	1.0
113	Zinc, Total	210	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2007S
Location ID: MH-267
CompuChem #: 2012

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Cyclohexane	24,000	EC	331
	LS	Benzene,1,2,3,5-Tetrachloro-	4,600	EC	1117
	LS	Benzene,Pentachloro-	10,000	EC	1232
	LS	Unknown	4,600	EC	1388
Base/Neutral/Pesticide	413	BIS (2-Ethylhexyl) Phthalate	5,200	4,000 [1]	1524
	433	Hexachlorobenzene	6,000	4,000 [1]	1126
	446	1,2,4-Trichlorobenzene	7,200	4,000 [1]	790
	LS	Benzene,1,2,3,5-Tetrachloro-	17,000	EC	930
	LS	Unknown	32,000	EC	1018
	LS	Unknown	13,000	EC	1301
	LS	Unknown	14,000	EC	1541
	LS	Unknown	11,000	EC	1731

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2007S
Location ID: MH-267
CompuChem #: 2012

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	8.5	1.0
104	Cadmium, Total	1.7	1.0
105	Chromium, Total	21	1.0
106	Copper, Total	260	1.0
107	Lead, Total	100	1.0
109	Nickel, Total	9.0	1.0
113	Zinc, Total	200	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2019S
Location ID: MH-273
CompuChem #: 2196

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	610	Phenol	500	500	718
	LS	Propanoicacid	2,800	EC	520
	LS	Phenol,2-Methyl-	1,300	EC	815
	LS	Dodecanoicacid	1,500	EC	1232
	LS	Unknown	3,300	EC	1372
	LS	Unknown	820	EC	1514
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	760	400 [1]	1548
	LS	Phenol,2-Methyl-	1,700	EC	711
	LS	1H-Indole,3-Methyl-	1,400	EC	943
	LS	Eicosane	890	EC	1372
	LS	Unknown	6,800	EC	2389
	LS	Unknown	3,800	EC	2492

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2019S
Location ID: MH-273
CompuChem #: 2196

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
101	Antimony, Total	3.0	1.0
105	Chromium, Total	8.7	1.0
106	Copper, Total	42	1.0
107	Lead, Total	790	1.0
109	Nickel, Total	4.8	1.0
113	Zinc, Total	28	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2020S
Location ID: MH-277
CompuChem #: 2197

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	12,000	EC	1184
	LS	Unknown	3,800	EC	1321
	LS	Unknown	3,200	EC	1358
	LS	Hexathiepane	4,600	EC	1388
	LS	Unknown	10,000	EC	1488
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	11,000	4,000 [1]	1490
	431	Fluoranthene	4,000	4,000 [1]	1278
	445	Pyrene	4,000	4,000 [1]	1306
	LS	Unknown	8,000	EC	1069
	LS	Unknown	11,000	EC	1088
	LS	Unknown	8,400	EC	1163
	LS	Unknown	36,000	EC	2200
	LS	Unknown	14,000	EC	2287

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2020S
Location ID: MH-277
CompuChem #: 2197

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	4.9	1.0
104	Cadmium, Total	11	1.0
105	Chromium, Total	40	1.0
106	Copper, Total	620	1.0
107	Lead, Total	290	1.0
109	Nickel, Total	10	1.0
112	Thallium, Total	1.6	1.0
113	Zinc, Total	300	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2002S
Location ID: MH-283
CompuChem #: 1977

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	4,400	EC	1206
	LS	Unknown	2,700	EC	1334
	LS	Unknown	2,300	EC	1432
	LS	Hexadecanol	6,000	EC	1468
	LS	1-Hexadecene	5,600	EC	1590
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	2,400	400 [1]	1553
	LS	Unknown	55,000	EC	994
	LS	Unknown	41,000	EC	1278
	LS	Unknown	65,000	EC	1841
	LS	Unknown	90,000	EC	2412
	LS	Unknown	87,000	EC	2510

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	1.9	1.0
106	Copper, Total	9.7	1.0
107	Lead, Total	2.5	1.0
113	Zinc, Total	21	1.0

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#:	II-2003S
Location ID:	MH-285
CompuChem #:	1978

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	222	Methylene Chloride	2,600	2,000	153
	225	Toluene	17,000	2,000	647
Acid	LS	Phenol,2-Methyl-	4,400	EC	817
	LS	Unknown	3,800	EC	1101
	LS	Unknown	15,000	EC	1257
	LS	Unknown	28,000	EC	1407
	LS	Unknown	60,000	EC	1557
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	19,000	4,000[1]	1493
	422	1,4-Dichlorobenzene	12,000	4,000[1]	646
	LS	Hexadecanol	68,000	EC	1157
	LS	1-Heptadecanol	84,000	EC	1247
	LS	Unknown	41,000	EC	1739
	LS	Unknown	164,000	EC	2219
	LS	Unknown	120,000	EC	2302

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2003S
Location ID: MH-285
CompuChem #: 1978

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
106	Copper, Total	14.7	1.0
107	Lead, Total	4.1	1.0
113	Zinc, Total	35	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2004S
Location ID: MH-288
CompuChem #: 1979

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Phenol,2-Methyl-	9,600	EC	818
	LS	Unknown	6,400	EC	1451
	LS	Unknown	10,000	EC	1499
	LS	Tricosane	4,400	EC	1510
	LS	1-Octadecene	4,600	EC	1572
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	7,600	4,000 [1]	1549
	LS	Hexadecanol	10,000	EC	1186
	LS	1-Hexadecene	6,400	EC	1276
	LS	Unknown	17,000	EC	2393
	LS	Unknown	14,000	EC	2489

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: II-2004S
Location ID: MH-288
CompuChem #: 1979

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	5.2	1.0
105	Chromium, Total	1.9	1.0
106	Copper, Total	22	1.0
107	Lead, Total	9.8	1.0
112	Thallium, Total	1.5	1.0
113	Zinc, Total	43	1.0

APPENDIX B

REFERENCES

APPENDIX B

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