FEASIBILITY STUDY

80 LISTER AVENUE

SUBMITTED TO

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

PREPARED BY

IT CORPORATION

FOR

DIAMOND SHAMROCK CHEMICALS COMPANY

OCTOBER 1985

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EXECUTIVE SUMMARY

This feasibility study was conducted to identify the recommended remedial action for 80 Lister Avenue and portions of 120 Lister Avenue in Newark, New Jersey. The Lister Avenue sites are located in the Ironbound section of Newark, New Jersey and have been under continuous industrial development and use since the 1870s. Chemical manufacturing took place on the site from 1914 to 1977 and involved largely agricultural and other specialty organic chemicals.

A comprehensive site investigation conducted during 1984 and 1985 identified two chemical compounds of predominant potential concern to public health and the environment at the site. They are 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin) and dichlorodiphenyltrichloroethane (DDT), which are contained in the soils and pore fluid immediately underlying the site and the existing site structures.

Based on the results of the site investigation, the feasibility study was completed in compliance with applicable portions of Administrative Consent Orders (ACOs) I and II executed March 13, 1984 and December 20, 1984, respectively, between Diamond Shamrock Chemicals Company (Diamond Shamrock) and the New Jersey Department of Environmental Protection (NJDEP). The elements of the ACO related to the feasibility study are:

- Identify and evaluate all potentially viable remedial action alternatives for the site
- Complete a comparison of all alternatives on the basis of the following:
  - Environmental and public health impacts
  - Degree of confidence in success
  - Time required for implementation
  - Costs
- Recommend the remedial action alternative deemed best suited to remove the chemicals of concern from the site such that the remaining levels on the site following removal do not constitute a significant risk to public health or the environment

- Recommend the remedial action alternative deemed best suited to contain the chemicals of concern on the site in a manner that will eliminate, to the maximum extent technically practical, the potential for public contact and migration into the environment in the event that removal of the chemicals of concern is not practical.

The feasibility study was also conducted in accordance with Comprehensive Environmental Response, Conservation and Liability Act (CERCLA) and U.S. Environmental Protection Agency (EPA) requirements and guidance (U.S. EPA, 1985). According to the EPA guidance document, the EPA requires that the development of response action alternatives for potential remedial measures be derived from the objectives defined by the remedial investigation/site assessment. The objectives of this feasibility study as depicted herein are:

- Eliminate, to the maximum extent practicable, exposure to surface soils. Concentrations of dioxin in the surface soils are at levels sufficiently higher than those established by the EPA, Center for Disease Control (CDC), and NJDEP for public health and environmental protection to warrant site remediation.
- Reduce mass transport of chemicals in the ground water to potential concentration levels less than 5×10^{-5} microgram per liter (μg/ℓ) for dioxin and 0.23 μg/ℓ for DDT at the nearest off-site well at some time in the future. These values represent recommended exposure (10^{-5} cancer risk) levels for ingestion of water.
- Remove the source of potential particulate dioxin emissions associated with existing buildings.
- Eliminate mass transport of chemicals from the site to the Passaic River.
- Implement remediation without significant risk to site workers and off-site populations.

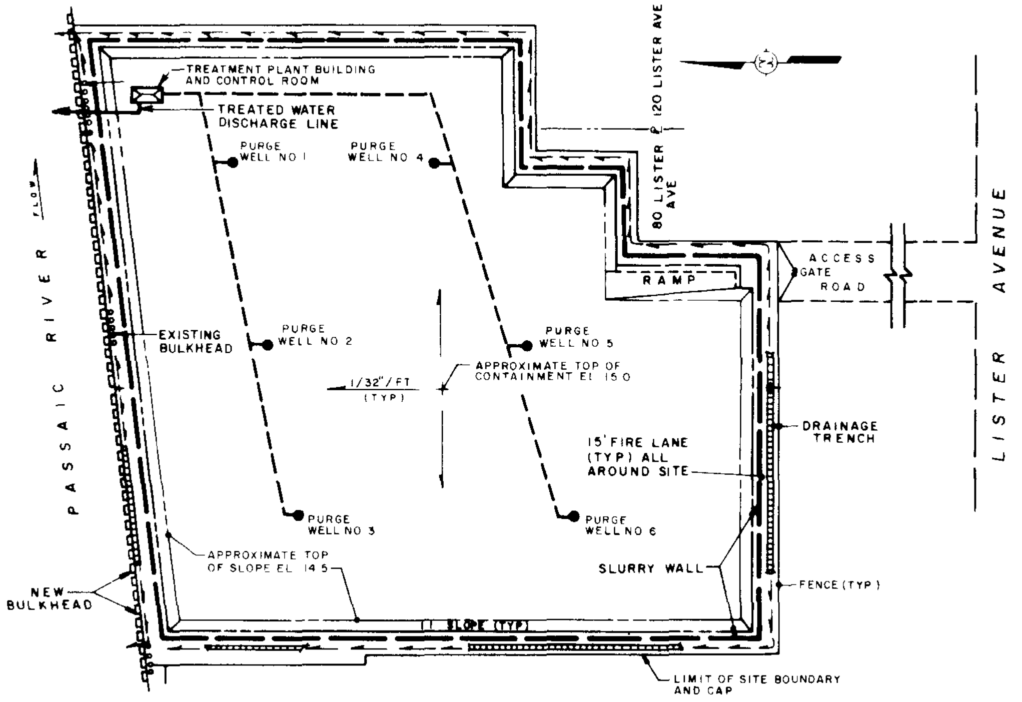
Potential remedial measures must address source control (i.e., measures designed to prevent or minimize migration of hazardous substance from the source) and/or migration management measures (i.e., measures designed to mitigate the impact of contaminants that have or will migrate into the environment).

Technologies, methodologies, and approaches applicable to satisfying the remedial objectives are then coalesced to form alternatives addressing the complete site. From this group of potential remedial measures, an alternative is chosen. This is regarded by the EPA as the end product of a feasibility study.

For the Lister Avenue site, the recommended remedial action resulting from this feasibility study consists of pumping and treatment of ground water and in situ containment of contaminants with a slurry wall and cap. The proposed remediation includes the following components:

- Replace the existing bulkhead
- Disassemble and decontaminate all salvageable tanks, vessels, and reactors
- Locate and plug inactive underground conduits and reroute active systems
- Construct a slurry wall around the perimeter of the site
- Demolish structures and facilities, spread the resulting rubble over the site, and compact; decontaminate salvageable structural steel
- Haul, empty, spread, and compact contaminated materials presently stored at 120 Lister Avenue; decontaminate and salvage the shipping containers
- Stabilize and immobilize the 570 drums of contaminated materials presently stored on site
- Construct a cap over the site that meets requirements of the Resource Conservation and Recovery Act (RCRA)
- Install, operate, and maintain a ground water withdrawal and treatment system
- Provide continued monitoring.

Figure ES-1 depicts a conceptual overall plan and section of the selected remedial alternative.



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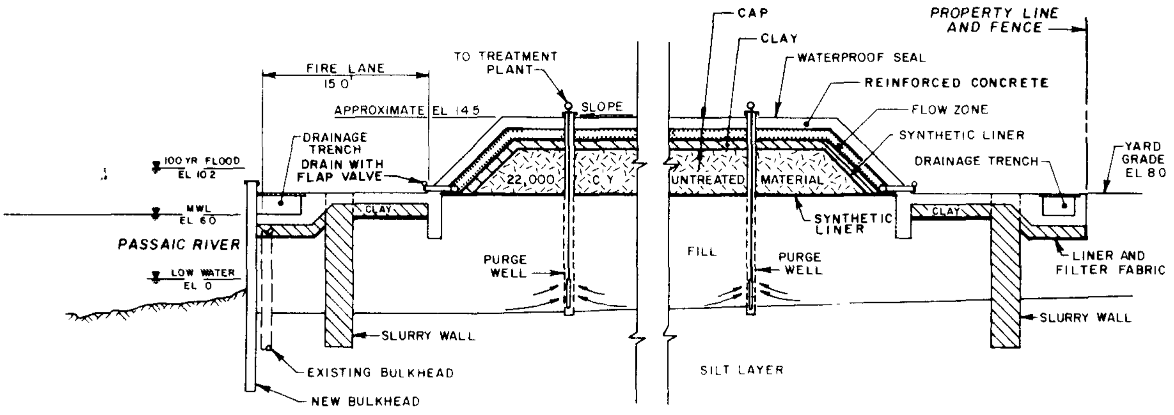


SECTION

CONCEPTUAL PLAN AND SECTION OF THE SELECTED REMEDIAL ACTION

The proposed remediation was selected based on an extensive screening of available technologies which were later reduced to six remedial action alternatives. These six remedial action alternatives were compared to assess how well they achieve the remediation objectives that were defined by a conservative risk assessment.

The six alternatives considered included:

- No-action alternative
- In situ slurry wall with cap
- Pumping ground water and treatment with in situ slurry wall with cap
- Excavation and thermal treatment of materials with over 7 parts per billion (ppb) dioxin coupled with in situ slurry wall and cap
- Excavation and development of an on-site vault for the materials with over 7 ppb dioxin coupled with a slurry wall and cap
- Excavation, loading, and transportation of contaminated on-site materials and off-site commercial disposal; a slurry wall will be built for stability and ground water control during excavation, and to mitigate migration of dioxin remaining below the 7 ppb level after remediation.

The no-action alternative is not considered responsive to the remediation objectives because:

- In time, seepage of dioxin and DDT through the fill, the underlying silt, and lower sand layer could exceed levels recommended by the risk assessment
- Potential exposure of the public and environment to dioxin-contaminated surface soils remains
- Potential dioxin-contaminated particulate emissions from buildings and other on-site structures remains.

The recommended alternative of pump, treat, and containment was selected over the other five because:

- The cap alone controls exposure to dioxin-containing surface soils.

- The combination of slurry wall, cap, and ground water pumping and treatment removes mobile contaminants and eliminates off-site contaminant migration to the maximum extent technically practical. Off-site ground water migration is essentially eliminated by the supplemental pumping and treatment system through gradient reversal.

- Site geologic conditions and the two primary contaminants of interest are well suited to in situ containment. The site is underlain by high-permeability manmade fill which is, in turn, underlain by a low-permeability, high carbon content silt which is continuously present over the site. The silt layer and the upward hydraulic gradient from the lower glaciofluvial sands mitigate downward migration of contaminants. Furthermore, dioxin and DDT have very high soil sorption coefficients and their rate of migration in a medium with organic content and clay is many orders of magnitude slower than normal ground water flow.

- A slurry wall keyed into the underlying silt layer results in a horizontal and vertical barrier of low permeability and high sorption capacity for dioxin and DDT, thus enclosing the site. Adding a cap to this enclosure virtually eliminates subsequent infiltration.

- The selected alternative does not preclude further remediation if an effective technology becomes available and can be implemented.

- Construction is simplified, proven technology is used, and direct exposure to chemicals from excavation is minimized.

Generally, the selected alternative is preferred over all the alternatives requiring excavation because:

- The excavation of 50,000 cubic yards of fill, much of which is below the water table and attendant subsurface obstructions (i.e., piling), will require dewatering of the fill and special handling constraints because of the limited space available for stockpiling on the site. In practice, it may not be feasible to construct a vault because of the space constraints.

- Special procedures would be required to stabilize the sidewalls of the excavation and adjacent structures.

- Logistical problems will be associated with simultaneous demolition of structures, excavation of the fill, and construction of the vault over a 3.4-acre site.

- There is an increased potential for exposure resulting from excavation of the fill during remediation.
- Because of the high potentiometric surface in the glaciofluvial sand unit, especially adjacent to the Passaic River, the removal of the fill material results in the potential for heaving and disturbance of the silt layer. Movement of the silt layer will affect the integrity and continuity of this layer as a barrier for the downward migration of chemical constituents from the site.

The vault alternative has the following additional problems:

- Even though the fill would be contained in a vault, the underlying silt layer would still contain dioxin, necessitating the construction of a slurry wall and cap to mitigate migration from the site.
- The on-site vault requires greater restrictions to future land use than the preferred alternative because the majority of the land is occupied by the vault.

A vault does not provide a decrease in potential risk over the preferred alternative because a leachate collection system would be required, exposure would be increased during the construction period, and the existing silt barrier could be breached.

The selected alternative is also preferred over thermal treatment of contaminated materials because of the excavation difficulties and the following problems:

- Thermal treatment must take place on site because permitted off-site facilities do not exist.
- Air emissions will result from thermal treatment in a heavily populated urban area.
- A technologically proven thermal treatment method of commercial capacity does not exist for dioxin.
- The time and testing required to develop and demonstrate an environmentally sound incineration plant would add significantly to the remediation time.
- Preparing and securing the various permits required for operation of an incineration plant would greatly increase the remediation time period.

- Thermal treatment requires a longer operational time than in situ containment.
- Even though the fill would be removed and treated, the underlying silt layer would still contain dioxin, necessitating the construction of a slurry wall and cap to mitigate migration from the site.

The selected alternative was also preferred over off-site disposal because of excavation difficulties and:

- Long overland haulage distances crossing multiple state boundaries.
- The risk associated with off-site transport disposal is greater than leaving it on site.
- Off-site disposal creates many new, potentially significant environmental liabilities without eliminating those which currently exist.
- Even though the fill would be removed and treated, the underlying silt layer would still contain dioxin, necessitating the construction of a slurry wall and cap to mitigate migration from the site.
- At the present time, a disposal facility does not exist which can receive dioxin-containing waste. Thus, this alternative is not currently viable.

The feasibility study was conducted in accordance with the ACO directives and CERCLA requirements and guidelines. The study has resulted in the selection of a technically feasible and cost-effective alternative: in situ containment and ground water pumping and treatment.

1.0

1.0 INTRODUCTION

This report presents the results of a feasibility study completed for Diamond Shamrock Chemicals Company (Diamond Shamrock) regarding the 80 Lister Avenue and portions of 120 Lister Avenue sites in Newark, New Jersey. This feasibility study has been completed to comply with specific portions of Administrative Consent Orders (ACO) I and II executed March 13, 1984 and December 20, 1984, respectively, between Diamond Shamrock and the New Jersey Department of Environmental Protection (NJDEP). The focus of interactions, including the above-referenced ACOs between Diamond Shamrock and the NJDEP, regards the 80 Lister Avenue site as a possible public health hazard due to potentially high levels of 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin).

The levels of dioxin-concentration triggering remediation are those established in these ACO's. The approach taken in the risk assessment is biased toward health protection. Various assumptions are made as to the validity of health-risk criteria and their underlying premises. The U.S. Environmental Protection Agency (U.S. EPA) and Center for Disease Control (CDC) dose response relationships used to derive the carcinogenic potency index are based on animal data and are assumed to be valid for humans. The feasibility study assumes as valid (1) the extrapolation of toxic effects observed at the high doses necessary to conduct animal studies to effects that might occur at much lower, real-life doses, and (2) the extrapolation from animals to man. Estimates of potential future risk assume: there is no remediation; off-site migration occurs without attenuation through soil adsorption; off-site ground water will be affected in the future and consumed; and soil will be ingested. However, it should be noted:

- There is no indication in the records of the NJDEP that any well in the vicinity of the site is used for drinking water.
- There is no basis to conclude that the soil will be ingested in quantities sufficient to impose a risk.
- The attenuation of dioxin through soil adsorption is a documented fact.

The primary basis for this feasibility study is ACO I. ACO I defines the 80 Lister Avenue site as Block 2438, Lots 58 and 59, and contains a list of findings and orders. The most significant findings as related to this study are as follows:

- Diamond Shamrock operated a chemical manufacturing facility at the site from 1951 through 1969 which produced 2,4-dichlorophenoxyacetic acid (2,4-D); 2,4,5-trichlorophenoxyacetic acid (2,4,5-T); 2,4,5-trichlorophenol; and other chemicals.
- In 1983, the NJDEP determined that the soil at the site contained dioxin. After this discovery, Diamond Shamrock immediately implemented an interim site stabilization program.

The most significant orders in ACO I as related to this study include the following:

- Requirement to complete a comprehensive evaluation of the site to determine the levels of dioxin and other chemicals for 80 Lister Avenue
- Requirement to conduct a feasibility study of remedial actions for the site, including alternatives for removal or containment of drums and other materials stored at the site.

ACO I also provides a specific framework within which both the site evaluation and the feasibility study are to be accomplished. The site evaluation was completed and a report was submitted to the NJDEP in February 1985. The Site Evaluation Report provides much of the data upon which the results of this feasibility study are based. The most significant elements within the ACO framework as related to the feasibility study are as follows:

- Identify and evaluate all potentially viable remedial action alternatives for the site
- Complete a comparison of all alternatives on the basis of the following:
  - Environmental and public health impacts
  - Degree of confidence in success
  - Time required for implementation
  - Costs

- Recommend the remedial action alternative deemed best suited to remove the dioxin and other chemicals from the site such that there is no significant risk to public health or the environment

- Recommend the remedial action alternative deemed best suited to contain the dioxin and other chemicals on site in a manner that will eliminate the potential for public contact and migration into the environment to the maximum extent feasible in the event that removal of the chemicals of concern is not practical.

The ACO specifies that the NJDEP shall make the determination as to what levels of dioxin and other chemicals constitute a significant risk to human health and the environment.

ACO II expanded the scope of the feasibility study by requiring the assessment and removal or containment of materials stored at 120 Lister Avenue, an adjacent property, also be addressed.

The 120 Lister Avenue site was also the subject of an extensive site assessment focusing on the collection and analysis of soil samples from buildings. The results of these activities were submitted to the NJDEP in May 1985 and indicate generally acceptable levels of chemicals over the site, except in areas near the 120 and 80 Lister Avenue boundary and one area near the center of the property. The cleanup of these areas is addressed in this feasibility study.

While the ACOs provided the direct framework for the completion of the feasibility study, additional direction was taken from a U.S. Environmental Protection Agency (EPA) guidance document on preparing feasibility studies (U.S. EPA, 1985). This document provides information on the preparation of feasibility studies designed to comply with the requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

This feasibility study focuses on the development of information in two broad areas and the integration of this information to select a solution for environmental problems associated with the site. These two areas include the identification and evaluation of appropriate actions to remediate site problems and the identification and evaluation of the nature and magnitude of risks associated with the site. Risks were evaluated on the basis of effects on public health and the environment for both on-site and off-site areas. In this fashion, a feasible remedial action alternative was selected that (1) fulfills the requirements of ACO I regarding protection of public health and the environment and that (2) minimizes risk and is technically proven.

The feasibility study report contained herein includes nine sections, each of which describes a major element in the remedial action alternative selection process. Section 2.0 presents a summary of information regarding site conditions and characteristics. Included are descriptions of the site; historical activities related to the site; site geologic, hydrologic, and other relevant conditions; the nature and extent of problems in various environmental media; and information on the types and volumes of wastes stored both on site and on 120 Lister Avenue. The information in this section was developed both from data contained in the Site Evaluation Report, also prepared to fulfill the requirements of ACO I, and additional data collection activities focusing on the extent of chemicals in ground water in deeper geologic zones.

Section 3.0 presents an assessment of the potential risks posed by the site to public health and the environment in both on-site and off-site areas. The major components of the risk assessment include a chemical evaluation, migration pathway analysis, and a quantitative assessment of potential risks posed by the site.

Section 4.0 identifies specific objectives for remedial actions to be implemented at the site. These objectives are based on the results and conclusions of the risk assessment and the specifications of ACO I.

In Section 5.0, the actions/technologies available for remediation of the site are examined and, through a two-stage screening process, these are reduced to a smaller number having the highest potential for successful application to site problems. The first stage of the screening is a process in which the major types of actions/technologies are evaluated for applicability to the identified site-related concerns. For the many treatment technologies examined, a second-stage screening has been conducted to identify which treatment technologies are most applicable. For each identified site concern, the most promising actions/technologies from the two-stage screening process have been summarized.

In Section 6.0, the combination of groups of remedial technologies into a series of remedial action alternatives is described. These alternatives represent combinations of various proven remedial technologies that are applicable to the site concerns. These alternatives encompass a wide range of actions associated with various levels of dioxin reduction, institutional compliance issues, protection of public health and environment, and costs. Additionally, the alternatives were selected to reflect the EPA's criteria for selection of remedial alternatives for uncontrolled hazardous waste sites (U.S. EPA, 1985). Detailed information on each of the alternatives is provided in Section 7.0.

In Section 8.0, a detailed evaluation of alternatives in terms of technical, institutional, public health, environmental, and cost considerations is provided. The recommended remedial action alternative which meets the objectives stated in Section 4.0 for the 80 Lister Avenue site is identified in this section. This alternative is defined by the EPA as the cost-effective remedial alternative; i.e., "the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection to public health, welfare, and the environment" (40 CFR 300.68(j)).

Section 9.0 contains all references cited. Three appendices have been included to provide supplemental information. These include the following:

- Supporting information for the risk assessment
- Hydrogeologic assessment of the alternatives
- Cost summary for the alternatives.

2.0

2.0 SITE CHARACTERIZATION

This section of the feasibility study provides data which define the configuration of facilities at the 80 Lister Avenue site, describe the history of the site relative to waste-producing activities, and describe the setting of the site with respect to such factors as physiography, hydrogeology, and demography.

A summary of the nature and extent of problems associated with the site is also provided. This summary is based on data obtained from the site evaluation, and reference is made to the Site Evaluation Report of February 1985. Results of chemical sampling are also discussed in this section. The data presented in this section and the analysis shown constitute the basis for the risk assessment (Section 3.0) and the selection of the recommended remedial action in accordance with the requirements of CERCLA (Sections 4.0 through 8.0).

2.1 SITE BACKGROUND DATA

2.1.1 Site Location and Configuration

The site is located in the Ironbound section of Newark, New Jersey. It occupies approximately 3.4 acres on the north side of Lister Avenue (Figures 2.1-1 and 2.1-2). It is nearly rectangular in shape, extending about 375 feet in an east-west direction and 305 feet north-south. The site, as shown in Figure 2.1-3, is bounded on the north by the Passaic River, on the east by the Thomasett Color Division of Hilton-Davis Corporation, at the southeast corner by the Duralac Company property, and on the south and west by Sherwin-Williams Company property. Vehicular access to the site is via a common right-of-way which enters the south side of the property and is owned by Duralac Company.

There are presently four major structures located on the site. These are the chemical manufacturing building, the process building, the warehouse, and the office and laboratory building. In addition, there are several tank farms associated with raw materials and finished products and minor structures such as the substation, pumphouse, and solvent shed. The locations and configurations of these structures and facilities are shown in Figure 2.1-4.

For purposes of remediation, as will be discussed later, a portion of the property to the east of the site (120 Lister Avenue) is included with the 80 Lister Avenue property (Figure 2.1-3). An old brick building is located on this addition to the site. Also considered in the remediation are shipping containers stored on the 120 Lister Avenue property. This is in accordance with ACO II. Currently, 345 containers are stored. It is expected that the total will be approximately 800 containers.

2.1.2 Site History

The site was originally tidal marsh and riparian land beside the Passaic River estuary. Industrial development on the site is reported to date from the 1870s. Drawings from 1914, revised in 1922, show the site to be part of the Lister Agricultural Chemical Company (Lister), which extended for some distance along the Passaic River and included other nearby industrial sites.

It was during the period of ownership by Lister that the site reached its present configuration. The south shore of the Passaic River was filled to form the northernmost 30 percent of the property. All of the remainder of the surface of the site is also underlain by the granular material reportedly used to fill the previous marshland. Several buildings were located on the site, including the Lister power plant, which remains today as the chemical manufacturing building.

When Lister ceased operations, the property was subdivided and sold largely along the lines that form the present property boundaries. A 1.8-acre parcel (the northeast portion of the present site) was eventually acquired by the Kolker Chemical Works, Inc. (Kolker), which, by the mid-1940s, was operating an agricultural chemicals plant on the site--this was the beginning of the manufacturing operations that are related to the current conditions at the site. A chart portraying ownership, products, and important site events is presented in Figure 2.1-5.

Kolker was an early producer of both dichlorodiphenyltrichloroethane (DDT) and the phenoxy herbicides. The exact dates when manufacture started are not known, but it is believed that DDT production was underway before the end of World War II and that herbicide production started by 1948. In addition to

DDT and the phenoxy herbicides, other products of interest made on the site included hexachlorobenzene (HCB), ovex (a miticide), Lindane, and low γ-benzene hexachloride (low γ-BHC). Table 2.1-1 lists the raw materials and finished products during the time that Kolker, Diamond Alkali Company, and Diamond Shamrock operated the plant.

Ownership by Kolker ceased in March 1951 when the Kolker property was acquired by Diamond Alkali Company (now Diamond Shamrock Chemicals Company). Between March 1951 and March 1969, the manufacture of several products was either transferred to other locations or discontinued, leaving the phenoxy herbicides as the only products of the plant. The changes started in 1955 with the transfer of Lindane manufacture to another location, and later the production of low γ-BHC was also relocated. The biggest change, however, was the transfer of DDT production, which was relocated in late 1958 and early 1959. During the late 1950s, several process changes were instituted to improve the operating efficiency of the plant. Among these was a change instituted in 1956 to the trichlorophenol (TCP) process to recycle trichloroanisole (TCA). A change in the handling of process effluent also occurred in 1956 with the installation of an industrial sewer connecting to the Passaic Valley Sewerage Commission (PVSC) Lister Avenue line. Following installation of that connection, the plant process wastes were discharged through the PVSC treatment plant.

An explosion in the TCP unit during February 1960 destroyed the large five-story building in which it and several other plant processes had been located. Following the explosion, a decision was made to limit future production to the phenoxy herbicides, ending output of HCB, ovex, and the benzene sulfonyl chloride derivatives. The plan locations of site facilities prior to the explosion are shown in Figure 2.1-6.

A larger site was required for rebuilding the plant on the scale desired, so an adjacent 1.6-acre parcel (the southwest portion of the present site) was leased from the Triplex Oil and Refining Company (later Walter Ray Holding Company) (Figure 2.1-7). This site, which had been used for reclaiming oil, had several buildings and large tanks which were razed to permit installation of a new laboratory and office building, a maintenance shop/warehouse building, and a tank farm for flammable raw materials along the west side of the property.

Following demolition of the remains of the damaged building, a new process building devoted to the manufacture of sodium trichlorophenol (NaTCP), 2,4-dichlorophenol (2,4-DCP), monochloroacetic acid (MCA), and by-product hydrochloric acid (HCl) was erected along the river. Following this construction, the manufacture of the intermediates was carried out in the new buildings and the old but undamaged chemical manufacturing building produced 2,4-D; 2,4,5-T; and their esters and amines. The layout of the plant, as reconstructed and in its approximate present configuration, is shown in Figure 2.1-4.

The process building remains largely unchanged to this day--the only addition was equipment installed in 1967 to purify the NaTCP by removing dioxin. The period 1963 to 1967 saw several major projects in the 2,4-D and 2,4,5-T manufacturing areas which were designed to improve working conditions, improve product quality, and expand capacity. Most significant among these changes were:

- 1963 - The 2,4-D acid process was rehabilitated. The process building roof was raised, permitting installation of new ventilating ducts to carry process fumes to a new and larger caustic scrubber.

- 1965 - The melt, washing, and drying process for the production of dry, flaked 2,4-D was installed, with a 40 percent increase in capacity. These changes also reduced personnel contact with the 2,4-D.

- 1967 - The final plant expansion saw the construction of a new and larger 2,4-D unit and the conversion of the former 2,4-D unit to the manufacture of 2,4,5-T. In addition, the TCP purification process for dioxin removal via carbon filtration was initiated.

Operation at the plant was discontinued in August 1969. As the plant shut down, the production units were cleaned and between September and December the remaining raw materials and products were sold and shipped. The plant was listed for sale and remained idle throughout 1970 until it was purchased by Chemicaland Corporation (Chemicaland) in March 1971.

Following purchase of the property by Chemicaland, equipment was installed for the manufacture of benzyl alcohol. Production of benzyl alcohol was not profitable, so Chemicaland attempted to expand their product line by manufacturing several specialty items and also by performing custom manufacture on a toll basis. These efforts were all unsuccessful and production ceased in mid-1973.

In September 1973, Chemicaland contracted to produce 2,4-D on a toll basis and started rehabilitating the plant so that it could again make 2,4-D. Rehabilitation of the plant was completed sometime during the spring of 1974 and production of 2,4-D resumed. Limited quantities of 2,4-D were produced during the summer of 1974. Operations were suspended and the plant staff was laid off in September 1974.

Arrangements were then made by Chemicaland to produce 2,4-D on a toll basis for a second time and work resumed in February 1975. Limited quantities of 2,4-D were being produced by April 1975. Production of 2,4-D continued for the next 22 months, but output varied widely. Chemicaland scavenged equipment from unused processes such as TCP purification and 2,4,5-T for use in their 2,4-D unit and made temporary repairs to bypass failed equipment. The only major addition to the process known to have been made by Chemicaland was the installation of a second 2,4-D reactor during May 1976. However, this addition was soon negated by the failure of the original reactor. The maximum monthly output of 2,4-D by Chemicaland was reported to be about 500,000 pounds.

In November 1976, while it was considering acquisition of Chemicaland, Occidental Chemical Company (Occidental) assumed control of the management of the plant and continued to manage the plant until February 24, 1977, when it returned control of the plant to Chemicaland. Chemicaland laid off all plant personnel and shut down the plant as it was on February 24, 1977.

The property remained idle through 1980, but the ownership changed as William Leckie (the successor to Walter Ray Holding Company) purchased the 1.8 acres owned by Chemicaland in a tax sale, consolidating ownership in his name. In March 1981, Mr. Leckie sold the site to Marisol, Inc. (Marisol).

Little is known of the use of the property by Marisol, but eventually this company started clearing and salvaging the site. Concerning these operations, it is known that:

- The product left in the equipment when the plant was shut down on February 24, 1977 was removed and placed in 55-gallon drums, of which 570 remain on site today.
- Some equipment known to be on the site following the shutdown was removed.
- Warehouse space and tankage were leased to SCA Corporation (SCA) and used in conjunction with waste disposal operations at their neighboring plant. The date that SCA started to use the site is not exactly known, but it was prior to the summer of 1982.

During the spring of 1983, SCA continued to lease and use a portion of the site, while Marisol was working to prepare the office building for occupancy. This was the situation in May 1983 when results of samples taken in April 1983 by the EPA showed high levels of dioxin on the site and the NJDEP moved to control access to the property. On June 2, 1983, New Jersey Governor Kean issued Executive Order No. 40 which has guided site control and cleanup activities since that date.

Following the investigation conducted by the EPA in May 1983 confirming the presence of dioxin within the site boundaries, Diamond Shamrock (at the direction of the NJDEP and EPA) took initial measures to control access to the property and to restrict possible dioxin-containing material from leaving the property. The principal measures were:

- A fence was installed around the 3.4-acre property, including the side adjoining the Passaic River.
- A 24-hour security guard was placed at the only gate providing access to the property. The duty of the guard is to control entry onto the premises and restrict it to authorized personnel.
- The entire site, excluding areas covered by buildings and equipment, was covered by a permeable geotextile fabric (Amoco No. 2002 polypropylene stabilization fabric). This fabric was weighted down by concrete blocks to prevent movement by wind.

In August 1984, Diamond Shamrock, under the terms of ACO I, initiated a detailed investigation of the site to supplement previous findings and to provide sufficient data to perform a feasibility study of remedial alternatives. This investigation was carried out in conformance with CERCLA requirements and comprised the following:

- Determination of site environmental setting - Climate and meteorology; geology and landforms; hydrology; flora and fauna; and demography
- Sampling - Ambient air; industrial hygiene; buildings, tanks, structures, and equipment; sewers and sumps; soils; ground water; background soils; drums; and river water and sediments
- Laboratory analytical testing
- Characterization of the site.

The results of these efforts were presented in the Site Evaluation Report, which was submitted to the NJDEP in February 1985. Additional data on hydrologic properties and ground water involvement were collected after the submittal of the Site Evaluation Report. Data from these investigations pertinent to the feasibility study are presented in this report and will be discussed in the following sections.

2.1.3 Climate

The climate in the site area is typified by moist, warm summers and moderately cold winters with winds of moderate velocity.

Prevailing winds are from the southwest, with only small seasonal variations in direction. Mean wind speeds are generally highest during the winter and spring months (10 to 12 miles per hour), while the lowest values (8 to 9 miles per hour) occur during the summer season. The predominant wind direction for the winter months is west-northwest (13 percent of the time), while southwest winds (12 percent of the time) predominate during the summer.

A summary of seasonal and annual occurrence of wind direction is presented in Table 2.1-2. Monthly average wind speed data and prevailing wind direction data are presented in Table 2.1-3, and average wind speeds for each wind direction are shown in Figure 2.1-8.

The average annual precipitation for the area is 41.45 inches, based on data from 1944 to 1983 [National Oceanographic and Atmospheric Administration (NOAA), 1983]. Precipitation falls fairly uniformly throughout the year, although the region is influenced by seasonal tropical storms and hurricanes. Monthly precipitation averages range from 2.82 inches (October) to 4.27 inches (August).

The average annual temperature in the Newark area between 1944 and 1983 was 53.9 degrees Fahrenheit, with the lowest monthly mean temperature of 31.4 degrees Fahrenheit occurring in January and the highest monthly mean of 76.5 degrees Fahrenheit occurring in July (NOAA, 1983). Table 2.1-4 summarizes the average monthly and annual temperature.

2.1.4 Geology and Soils

The site is located within the Piedmont Lowlands section of the Piedmont Physiographic Province, as shown in Figure 2.1-9. The province is located between the Atlantic Coastal Plain and the Ridge and Valley Province.

Lying about two miles upstream from the mouth of the Passaic River and in the southwestern portion of the Hackensack Meadows, the site was developed during the nineteenth century. It consisted of tidal marsh and riparian land beside the Passaic River estuary. Approximately 6 to 15 feet of random fill has been placed on the site behind the bulkhead located in the river. As a result, the present ground surface of the site varies approximately between seven and ten feet above sea level.

The bedrock underlying the site is the Passaic Formation (Olsen, 1980). It is more commonly known as the prebasalt portion of the Brunswick Formation. This formation consists chiefly of soft red shale and sandstone and underlies the site at a depth of approximately 90 feet. Above the bedrock at the site lies approximately 80 feet of stratified sand, clay, and gravel, which is the deposit of a glaciofluvial delta that formed on the western edge of extinct Pleistocene Lake Hackensack. When the terminal moraine damming the lake was breached, the lake drained, leaving the lake bed. The land developed into a flatland forest and a meadow now called the Hackensack Meadows.

The youngest natural deposit in the area around the site is the silt layer which separates the fill and the glaciofluvial unit. This layer varies in thickness, but averages approximately nine feet in thickness at the site.

Subsurface conditions at the site have been determined from geotechnical borings drilled on or near the site. Twelve borings, designated B-1 to B-9 and B-12 to B-14, were drilled in the initial site evaluation program (Figure 2.1-10). Data from these borings have been supplemented by data from six additional borings which were drilled on the site in early to mid-1985.

In addition, five borings have been drilled on the 120 Lister Avenue property as part of a separate investigation; data from these borings have also been used to define subsurface conditions. Five borings (B-1-60 to B-5-60), which were drilled for the Diamond Alkali Company in 1960, were also considered. Logs of all borings drilled on or near the site during the initial site evaluation program were provided in the Site Evaluation Report.

Based on the boring data described above, a general subsurface profile of the site (Figure 2.1-11) has been constructed using average thicknesses of the principal units, which are described in the following paragraphs.

Fill

The fill portion of the stratigraphic column beneath the site is generally loose to medium dense, gray to black sand and gravel fill of man-made origin. It contains bricks, wood fragments, glass, porcelain, organic material, ashes, and cinders. Occasional oily material and railroad ballast are also present. It exhibits no distinguishing changes in composition across the site.

The thickness of the fill ranges from six feet in the southeast corner of the property boundary to 15 feet in the northwest corner of the property (Figure 2.1-12). Along the western and northern boundaries of the site, the old river channel is inferred where the fill is over eight feet thick. Up to the point where the old river channel is again encountered north of Boring B-7, the fill gradually thickens from 8 to 15 feet (Figure 2.1-12). In the central portion of the site, the edge of the old river channel is defined just north of Boring B-11. Having a fairly uniform thickness of nine feet to a point just north of Boring B-11, the fill gradually increases in thickness in the direction of the bulkhead at the northern site boundary. It is 15 feet in thickness at Boring B-2. Along the eastern boundary of the site, the old river channel has not significantly intruded into the property. At the southeastern corner of the site, the fill is six feet in thickness. The fill increases only slightly to a thickness of nine feet at the bulkhead in the northeastern corner of the site with some channel fill apparent around Boring B-104.

Silt

The silt layer beneath the site consists of two units--an upper, highly organic peat/silt layer (referred to locally as "meadowmat") and a lower silt bed with interlayered clay and sand lenses with a small amount of organic material. These two units were identified in all borings advanced on site south of Boring B-11 and in Boring B-3. Total thicknesses of the two silt layers are shown in Figure 2.1-13.

The observed thickness of the organic layer ranges from less than one foot to three feet across the site with no identifiable trends in deposition. The organic silt layer is composed of decayed grasses rooted in organic material produced from earlier growth. It has decayed to the present deposit of fibrous, highly organic peat with intermingled silt and humus.

The lowermost layer of the silt deposit extends across the site and is probably the depositional result of tidal flat processes. It is a fine-grained sediment deposited in a low-energy environment. Intermingled in this layer are some roots and thin sand and gravel layers. The contact between the two silt units and the underlying glaciofluvial sands is generally gradational. The thickness of this lower unit varies from three to eight feet, with the thickest deposit detected on the Sherwin-Williams property to the south of the site.

Glaciofluvial Sands

The glaciofluvial sands underlying the site are part of the Pleistocene deposition of material from glacial meltwater. The resulting sediments (silts, sands, clays, and gravels) were sorted hydraulically prior to deposition and have formed discontinuous layers across the site. The thickness of the sand unit is approximately 80 feet. From published data, the sand tends to thicken toward the northwest, away from the site, following bedrock contours (Lovegreen, 1974).

Intermingled sand, silt, clay, and gravel lenses were identified in most borings penetrating the sand layer, but these could not be correlated continuously across the entire property. Information gained from these borings and wells in the area suggests that the unit becomes coarser with depth.

Bedrock

Soil borings at the site have not been advanced to a sufficient depth to clearly define the nature of the underlying bedrock; however, regional data in the area of the site show bedrock at the site consists of interbedded sandstones and shales of the Brunswick Formation. In general, this unit is highly fractured and is the principal bedrock aquifer in the area (Olsen, 1980). The depth to bedrock for the site has been established to range from 84 to 93 feet below the surface based on data from borings drilled as part of the site evaluation.

2.1.5 Surface Water Hydrology

Passaic River

The site is located in the Lower Valley portion of the Passaic River drainage basin. The Lower Valley is the southeasterly portion of the basin lying between the Central Basin and the mouth of Newark Bay. It is characterized as a flat, relatively narrow floodplain of 1,000 to 2,000 feet width, abutting low rolling hills. From Dundee Dam to the mouth of Newark Bay, the river is navigable.

Tidal elevations for the Passaic River at Newark have been reported by NOAA (1972). The mean tidal range (difference in height between mean high water and mean lower water) is reported by NOAA as 5.1 feet. The spring range (average semidiurnal range occurring semimonthly as a result of the moon being New or Full) is reported by NOAA as 6.1 feet with the mean tide level (midway between mean low water and mean high water) at 2.5 feet.

Using data obtained at the Little Falls gaging station and regression techniques developed by the U.S. Geologic Survey (USGS, 1984), the mean annual flow at the mouth of the Passaic River was determined to be approximately 1,400 cubic feet per second (cfs).

Flooding occurs at and around the site due to a relatively narrow flood channel that is constricted by many bridges, heavy urban development along the river banks, and generally flat slopes that are constrained by rock outcrops. The natural storage in the Central Basin reduces the contributing flood flows into the Lower Valley from the flash-flood susceptible highland tributaries (the Ramapo, Wanaque, Pequannock, Rockaway, and Whippany rivers).

Unlike upstream areas where flooding is controlled by rainfall events, flooding of the Passaic River at the site is controlled mainly by tidal influences. The greatest potential for inundation in the Lower Valley comes from the storm surge and tidal flooding associated with a major storm. The cross-sectional area of the channel in the tidal zone of the river is so great in relation to the discharge that any rise in water level as a result of rainfall is minimal when compared to elevation changes due to tides. According to the U.S. Army Corps of Engineers (COE) flood insurance study for the region, flood elevations for the 10-, 50-, 100-, and 500-year tides are 7.5, 9.3, 10.2, and 12.8 feet above mean sea level (MSL), respectively (COE, 1968). Partial inundation of the site grade at about Elevation 8.0 was reported from the Passaic River in 1983.

Site Surface Water

As an industrial area that has been occupied for over 100 years, the entire site has been built up with fill. Approximately 6 to 15 feet of cinders, bricks, sand, and rubble have been placed over natural materials. In this process, the site has been intentionally leveled. Total relief across the site is approximately three feet, with the lowest point along the railroad tracks at the southern boundary. Much of the site has been capped with either pavement or gravel, and currently the surface is covered with a geotextile material.

2.1.6 Ground Water

Regional Hydrogeology

Regional aquifers in the vicinity of the site are the bedrock of the Brunswick Formation of Triassic age and the unconsolidated glaciofluvial sands and gravel deposits overlying the bedrock.

The principal ground water source in the Newark area is the bedrock (Herpers and Barksdale, 1951). The shales and sandstones of this formation are generally capable of sustaining moderate to large yields [35 to 820 gallons per minute (gpm)], but the lower basalt and diabase strata are capable of only small to moderate yields (7 to 400 gpm). The unconsolidated Pleistocene sand and gravel deposits, although capable of sustaining large yields, are of somewhat limited extent in the vicinity of the site.

In the site vicinity, the sands and gravels occur as valley fill deposits occupying buried bedrock valleys. The sands and gravel are generally interlayered with till and clays. Where layers of coarse sand and gravel are encountered, wells yielding 175 to 600 gpm have been developed (Herpers and Barksdale, 1951).

Site Ground Water Conditions

To assess ground water conditions, monitoring wells have been installed on and around the site to determine piezometric levels, hydraulic conductivities, and the concentrations of contaminants in the ground water. The wells were finished in four zones, with the geologic zone being indicated by the letter following each monitoring well number. The stratum monitored and the corresponding letter are:

A	Fill
B	Glaciofluvial sand, just below the silt
C	Middle of glaciofluvial sand
D	Glaciofluvial sand, just above bedrock.

Figure 2.1-14 shows the plan locations of monitoring wells installed as part of site evaluation.

The fill material at the site is a water-bearing unit of limited extent; it ranges from 6 to 15 feet in thickness, averaging about 8 feet (Figure 2.1-12). The saturated thickness of the permeable zones in the fill ranges from about 2 to 8 feet. The fill layer is not a source of potable or industrial usage water.

The fill is underlain by an organic silt layer which ranges in total thickness from three to nine feet (Figure 2.1-13). The silt is significantly less permeable than the fill, as subsequently discussed, and significantly retards downward flow of ground water from the fill to the glaciofluvial sands underlying the silt.

The glaciofluvial deposits extend from an average depth of about 20 feet to a depth of 93 feet where bedrock is encountered. Lenses of silt, clay, till, and gravel are encountered in this unit; thus, permeabilities may vary widely with depth.

Bedrock was encountered at a depth of 93 feet in Boring B-7D and at a depth of 83.8 feet in Boring B-10D. No monitoring wells were installed in this formation. Based on the boring log data obtained, there is no low-permeability material between the glaciofluvial sands and bedrock which would restrict flow, although lenses of clay and silt at higher elevations might have this effect.

Piezometric Levels

A summary of shallow monitoring well data, including static water levels, is provided in Table 2.1-5. Approximate ground water contours in the fill are shown in Figure 2.1-15. As can be seen from the figure, ground water flows both north and south from a local high located near the center of the 80 Lister Avenue site.

Of the 13 monitoring wells and piezometers installed in the fill, three (MW-1A, MW-2A, and MW-3A), which are located along the Passaic River, showed variations in levels corresponding to the tidal fluctuations in the river. The remaining monitoring wells showed essentially no fluctuation. This suggests that silt probably limits ground water flow toward the river from the southern part of the site.

Piezometric levels from monitoring wells in the glaciofluvial sand indicate that, generally, the piezometric head in this unit is approximately five feet less than in the fill. A plot of ground water contours in the sand was not possible because of limited data. However, the data available indicate flow in a southerly direction with an average gradient of 0.002.

Hydraulic Conductivities

Estimates of the hydraulic conductivity for the fill were obtained from the results of both falling-head and rising-head permeability tests (slug tests) in Monitoring Wells MW-1A through MW-8A (Figure 2.1-14). Details of these tests were presented in the Site Evaluation Report. As might be expected for the heterogeneous fill layer, the hydraulic conductivity varies greatly from well to well. Depending on the location and method of analysis, mean hydraulic conductivities in the fill ranged from 3 feet per day (MW-4A) to 200 feet per day (MW-2A). Representative hydraulic conductivity values are provided in Table 2.1-6.

Hydraulic conductivities in the glaciofluvial sands average 0.3 foot per day (Table 2.1-7) with only one area (MW-10D) having a value much smaller. This is a moderate value which will not significantly retard the movement of ground water.

Based upon comparison with values reported for similar materials in the literature, it is estimated that 0.003 foot per day (1.0×10^{-6} centimeter per second) is a reasonable value for the average vertical hydraulic conductivity of the silt (Freeze and Cherry, 1979).

Ground Water Flow

Based upon ground water level measurements (Table 2.1-8) and results of slug tests performed in the eight monitoring wells, estimates of ground water flow directions and rates in the fill have been made. Estimates of the vertical downflow of ground water from the fill through the silt to the glaciofluvial sand have also been made. Flow directions and rates were also estimated for horizontal flow in the glaciofluvial sands.

Ground water flow velocities in the surficial fill at the site were computed from the gradients (change in piezometric head divided by distance) developed from Figure 2.1-15 and hydraulic conductivities presented in Table 2.1-6. Computed ground water velocities range from 0.6 to 4.0 feet per day from the center of the site north toward the Passaic River. Computed velocities from the center of the site toward the south range from 0.5 to 1.3 feet per day.

The average vertical hydraulic gradient of the silt layer was determined to be approximately 0.6. This vertical hydraulic gradient and estimates of the vertical hydraulic conductivity of the silt layer were used to calculate a range of possible ground water velocities from the fill through the silt into the glaciofluvial unit. Assuming a hydraulic conductivity of the silt between 0.001 and 0.003 foot per day, the computed velocities range from 2×10^{-3} to 6×10^{-3} foot per day. Thus, the silt layer appears to significantly retard the flow of ground water and any associated contaminants from the fill to the sand. Lateral flow in the silt is not a concern because the overlying fill and underlying sand have much higher hydraulic conductivities. This conclusion is further supported by the data on chemical migration discussed in Section 3.0.

The flow of ground water in the glaciofluvial sand in the vicinity of the site is generally in a southerly direction with an average gradient of 0.002 in the upper portion of the aquifer. For hydraulic conductivities in the range of 0.1 to 0.6 foot per day, the corresponding ground water velocities range from 0.0002 to 0.0012 foot per day.

2.1.7 Flora and Fauna

The land in the vicinity of the site consists of tidal marsh and built-up land which is classified primarily as urban industrial. The terrestrial ecology of the natural environment is restricted to the tidal marsh, which has been modified by its proximity to the urban industrialized area. The industrialized area consists of numerous buildings and an extensive amount of paved surface with very little exposed ground available to support flora or fauna.

The area of the site itself is industrialized, with only the slightest traces of natural flora and fauna commonly found in a highly developed urban environment. No unique or endangered species or habitats are known to occur at the site or in the surrounding vicinity.

Information obtained from the New Jersey Department of Health and the NJDEP Office of Science and Research indicates that fishing in the Passaic River in the vicinity of the site has been prohibited. A prohibition on sale and consumption of all fish and shellfish from the area between Dundee Dam and Newark Bay has been in effect since 1983. No known commercial fishing is presently being conducted in Newark Bay.

2.1.8 Land Usage and Demography

The area surrounding the site has been used by heavy industry for over 100 years. In the 1978 Newark Master Plan, the area in which the site is located is zoned for heavy industry. Land area zoned for residential use is approximately one-quarter mile south and southwest of the site.

The population within a one-mile radius of the site is approximately 10,000 based on the 1980 census data. The population within this area includes:

- Employees located at adjacent businesses
- Residents in nearby neighborhoods.

2.2 NATURE AND EXTENT OF CHEMICAL DISTRIBUTION AT THE SITE

The following subsections describe the sampling program which was conducted at the site, the analytical testing which was performed, and the results of the testing in terms of concentrations of dioxin, priority pollutants, and asbestos. The term "priority pollutants" as referred to in this report is defined as the 157 compounds comprising the acid/base/neutrals (semivolatiles), volatile organic compounds (VOCs), pesticides and polychlorinated biphenyls (PCBs), herbicides, metals, total cyanide, total phenols, plus 40 additional peak searches. This is sometimes referred to as "priority pollutants plus 40." A more complete description of the investigation program, including industrial hygiene and quality assurance aspects, was provided in the Site Evaluation Report.

2.2.1 Results of Site Evaluation

2.2.1.1 Ambient Air

Air sampling was conducted from the roof of the office/laboratory building, 10 meters above ground surface. Samples were collected over a 24-hour period for 31 consecutive days commencing at noon on September 8, 1984 and ending at noon on October 9, 1984. Wind speed and direction data were also obtained during this period. The purpose of the monitoring program was to establish baseline conditions, obtain information on the range of variation in parameters over time, and to compare metals concentrations with other NJDEP sites in the Newark vicinity.

All samples were analyzed for iron and manganese. Ten sets of samples having the highest iron and manganese concentrations were subjected to the following analyses as requested by the NJDEP:

- Total suspended particulate matter (TSP)
- Inhalable particulate matter (IPM)
- Metals
- VOCs
- Polycyclic aromatic hydrocarbons
- Asbestos
- Dioxin
- Pesticides and other chlorinated organics.

A complete listing of the analytical results was provided in the Site Evaluation Report in Tables 5.1-1 through 5.1-7. The information is summarized below.

For the ten sets of samples selected for analysis, the highest concentrations of TSP and IPM in the ambient air were observed on September 25, 1984. The TSP concentration on that date was 254 milligrams per cubic meter (mg/m^3) which exceeds the secondary 24-hour National Ambient Air Quality Standard (NAAQS) of 150 mg/m^3 for TSP, but is less than the 24-hour primary standard of 260 mg/m^3. The IPM concentration on September 25 was 196 mg/m^3 which is greater than the 150 mg/m^3 lower range for the proposed 24-hour IPM NAAQS.

Wind speed averaged no more than 6 miles per hour on September 25, with a maximum recorded gust of 16 miles per hour. Wind direction was generally from the southwest. There was no precipitation.

The concentrations of all metals except iron were less than one microgram per cubic meter ($\mu g/m^3$) for the ten days selected for analysis. The iron concentration ranged from 0.682 to 1.259 $\mu g/m^3$, with the maximum occurring on the day of maximum TSP and IPM concentrations. The relative concentrations of the various metals are consistent with those measured in Newark during the Airborne Toxic Elements and Organic Substances (ATEOS) studies, indicating that there is no significant contribution of metals to the air from the site.

On only two of the days chosen for analysis was any concentration of dioxin detected; the observed concentrations were 86 picograms per cubic meter (pg/m^3) on September 10, 1984 and 286 pg/m^3 on September 24, 1984. Wind speeds on September 10 were moderate, averaging in the range of 9 to 11 miles per hour for several hours; wind direction was generally southerly. On September 24, winds were light and from the west, averaging no more than 4 miles per hour. There was no precipitation on September 10 and only a trace on September 24. No obvious relationship exists between the reported dioxin levels and the meteorological conditions on the days when they occurred.

Vinyl chloride concentrations, found on five of the ten days chosen for analysis, ranged from 0.15 to 0.33 $\mu g/m^3$, which is well below the permissible exposure limit of 2,000 $\mu g/m^3$.

Total VOC concentrations ranged from 71 to 182 $\mu g/m^3$, with the highest concentration measured on September 25, 1984. Major constituents were xylene, toluene, and ethyl benzene, which are aromatic halocarbons commonly emitted from petroleum refineries and plants manufacturing coatings and solvents; they are also constituents of aviation fuel. (The site is located directly beneath one of the main landing approaches to Newark Airport, located approximately three miles to the southwest.) Other major constituents were trichloroethene and tetrachloroethene, which are solvents widely used for dry cleaning and degreasing. The data indicate that the site probably does not contribute to VOC in air.

For the ten sets of samples selected for analysis, asbestos fiber counts were all less than 0.01 fiber per cubic centimeter, which is well below the range of the proposed permissible exposure levels.

The maximum observed concentration of pesticides for the samples analyzed was 75 nanograms per cubic meter (ng/m^3) which occurred on September 8, 1984. This was primarily due to 4-methoxy benzene sulfonyl chloride, which was also the most prevalent pesticide measured in all ten samples. The maximum concentration of polynuclear aromatics (PNA) was 37 mg/m^3 measured on October 4, 1984. Forty-two percent of this concentration was due to perylene, which was the most prevalent PNA in all ten samples analyzed. The observed pesticide and PNA concentrations are all less than their permissible exposure levels.

2.2.1.2 Buildings, Structures, and Equipment

A sampling program was conducted on buildings, structures, and equipment at the site to determine the presence and levels of dioxin. A biased sampling approach was employed, i.e., samples were taken at locations suspected to have high levels of dioxin. Samples of what appeared to be cement-asbestos paneling and insulation from piping were also collected for analysis.

Three types of samples were collected--bulk, wipe, and chip. Bulk samples were collected wherever significant quantities of dust or dirt had accumulated, or where sufficient quantities of unknown liquids, solids, or sludges were present in tanks or process vessels. Asbestos samples cut from paneling and pipe insulation were classified as bulk samples. Wipe samples were taken from smooth or painted surfaces that were potentially laden with dust or particulate matter. Chip samples were obtained from porous brick or concrete-type surfaces that were unsuitable for wipe samples. Table 2.2-1 summarizes the location, type, and number of samples collected.

The sampling program for structures and equipment on the site confirmed the presence of dioxin on the interior and exterior of all the on-site structures, as discussed in the following paragraphs. A complete listing of the analytical results is contained in the Site Evaluation Report.

Dioxin levels are highest in the process building, where all 29 samples collected yielded positive dioxin levels ranging as high as 41,600 ng/m^2 for wipe sample analysis and 1,580 parts per billion (ppb) for chip sample analysis. The chemical manufacturing building, with 27 out of 28 samples producing positive dioxin results, also has significant levels. The dioxin concentrations of interior wipe samples ranged from 233 to 7,000 ng/m^2, and the chip samples ranged from 0.93 to 1,280 ppb. The laboratory/office building, with 31 of the 38 samples analyzed producing positive dioxin results, is the least affected of the four major buildings. The highest dioxin concentration detected in the chip samples was 69.3 ppb from the laboratory floor, and a wipe sample on a laboratory hood measured 14,000 ng/m^2. The high concentration on the laboratory hood is undoubtedly related to its function. All chip and bulk samples collected from the stack, solvent shed, and pumphouse had detectable levels of dioxin ranging from 1.2 to 50 ppb.

In general, dioxin levels are greater on the interior surfaces of all the buildings than on the exterior surfaces. Roofs have the lowest dioxin concentrations, while floors usually have the greatest. The laboratory/office building exterior walls had no positive dioxin results above ground level except for one roof wipe sample which showed a dioxin concentration of 168 ng/m^2.

Because of the biased sampling strategy used, determination of the total amount of dioxin in the structures is not practical. However, an estimate of the volumes of various types of materials in each of the major buildings that is potentially contaminated with dioxin is provided in Table 2.2-2. The total volume of material from all major structures is estimated to be 5,258 cubic yards. Subsequent to the submittal of the Site Evaluation Report, the stack (which was found to contain low levels of dioxin) has been demolished and only the base remains.

Another major source of waste on the site is the material stored in tanks and vessels. Although all of the tanks, except Tank No. 5 which contained fuel oil, were empty when inspected, bulk samples of "heels" or residual solids were collected from 112 units. The estimated maximum quantity of waste material currently remaining in vessels is 45,000 pounds--36,000 pounds of solids and 9,000 pounds of liquids.

Tanks Nos. 1, 2, 3, and 4 in the east tank farm were cleaned for use as decontamination water collection tanks. Currently, one tank contains decontamination waters from continuing site investigation and remediation operations.

Positive results for asbestos were found in 9 of 14 samples analyzed. Most samples were taken from insulation around ductwork and piping in the site buildings. A sample from a wall in the warehouse building indicated positive results. Chrysotile was the most frequently indicated asbestos fiber.

2.2.1.3 Drums

Five hundred and seventy 55-gallon drums containing process wastes are currently stored on site. Thirty-five drums are stored on the second floor of the chemical manufacturing building; the remaining 535 are currently located in the warehouse.

The drum contents were removed from various pieces of equipment and process vessels on the site in 1981. The wastes include liquids, pastes, sludges, and a variety of solids. Four hundred and seventy-six of the drums were determined to be full, with the remaining 94 partially full. The estimated quantity of material stored in the drums is 245,000 pounds, with 76,000 pounds characterized as solids or sludges and 169,000 pounds as liquid. The drummed material taken from a common source (reactor, sump, tank, etc.) had common lot or group markings. Fifty different lot or group designations were identified and documented during the site investigation.

The drums were tested for gross physical properties or waste categorization parameters. Composite samples were prepared with no more than six drums represented in a composite. The composites were synthesized from wastes exhibiting similarities such as pH, drum content, and physical appearance. The composite samples and certain individual drums were tested for:

- Water reactivity-solubility
- Water reactivity-temperature change
- Percent lower explosive limit
- pH
- Presence of oxidizable material
- Presence of peroxides
- Sample type
- Open-cup ignitability
- Open-cup flash point
- Presence of halogens.

The results of the waste characterization were summarized in Appendix I of the Site Evaluation Report. They indicate that the drums can be handled safely without risk of fire or explosion. A few samples ignited during the open-cup ignitability test, but these generally had flash points above 140 degrees Fahrenheit (one sample was 130 degrees Fahrenheit).

Twenty-two drums representing 21 different lots were analyzed for dioxin. Drums to be tested were selected by one of two criteria--either the drum was representative of a major group of drums or it had some particular association with the manufacturing process. If the result for a particular drum was positive for dioxin, all the drums in its associated group were also considered positive. Fifteen of the analyses representing 371 drums were positive, i.e., greater than one ppb.

The highest dioxin concentrations were detected in a drum containing solids and sludge labeled Lot "Pit 3" (36 drums were included in this lot) at 8,750 ppb and in a drum containing yellow crystalline powder labeled Lot "CQ" (11 drums were included in this lot) at 12,200 ppb. A weighted average of the lots determined to have positive dioxin concentrations indicates an estimated 230,000 pounds of material containing 940 ppb dioxin, or 98 grams of dioxin. The 47 drums of "Pit 3" and "CQ" material contribute 93 grams of the total estimated quantity of dioxin.

In addition to the drums discussed above, an additional 790 drums are stored in the warehouse. Thirty-five of the drums contain materials generated by the EPA during various site investigations. Four hundred and nine drums contain materials resulting from the cleanup operation at SCA. These materials include carpets, desks, drapes, file cabinets, and office equipment. The remaining 346 drums contain soils, cement, and debris from drilling operations; water collected from the bailing of monitoring wells; trash, including bottles, polyethylene sheeting, boxes, and paper; disposable items such as gloves, towels, and Tyvek suits; and water and debris collected from the cleaning of decontamination water storage tanks and the diked areas around these tanks.

2.2.1.4 Containers

In accordance with ACO II, 352 shipping containers currently stored on the 120 Lister Avenue property are considered in the site remediation activities.

Dioxin-containing concrete, steel, wood, and soil from site remedial actions at 120 Lister Avenue, Brady Avenue, and the Conrail cleanup are stored in these containers. All material is considered to contain trace levels of dioxin. It is expected that a total of 845 containers will ultimately be stored there.

2.2.1.5 Soils

Two types of soil samples were collected during field investigations--near-surface soil samples and boring soil samples. Locations of near-surface sample points are shown in Figure 2.2-1. A plan of borings drilled on and near the site is provided in Figure 2.1-10.

Near-Surface Soil Sampling

Near-surface soil samples were collected at 21 locations on the site. Six samples were collected at each of 14 locations; at seven locations, refusal occurred at depths of 36 to 48 inches, which resulted in 11 samples not being collected for archive. A total of 115 near-surface soil samples were collected.

Thirty-nine samples were collected from exterior locations. Samples were obtained from depths of 0 to 6 inches, 6 to 12 inches, and 12 to 24 inches. All samples were analyzed for dioxin and 26 were analyzed for priority pollutant parameters. Eighteen samples were collected from the same depth intervals at locations beneath the existing buildings. (Depths were measured from the bottom of the concrete floor slabs.) All of the samples were analyzed for dioxin and 12 samples were analyzed for the priority pollutant parameters. For all 21 sampling locations, an additional 46 samples were collected from depth intervals of 24 to 36 inches, 36 to 48 inches, and 48 to 60 inches wherever possible. These samples were archived for possible later analyses.

The samples obtained from Borings B-10 and B-11, which were drilled to determine the depth of the silt layer, were also considered as near-surface soil samples. Six samples from these two borings (0 to 6, 6 to 12, and 12 to 24 inches at each location) were analyzed for dioxin; three deeper samples from each of the two borings were archived.

Of the 63 near-surface soil samples analyzed for dioxin, all had identifiable dioxin concentrations. For 22 of the 63 samples (35 percent), reanalyses of smaller sample aliquots (one gram) or dilutions were required to provide results within the calibration range of the instrument.

Forty-two near-surface soil samples were analyzed for priority pollutants. Of the 69 semivolatile compounds identified, 28 (41 percent) were identified one or more times in the depth intervals of 0 to 6 and 12 to 24 inches. At 0 to 6 inches, 24 compounds were identified. For 12 to 24 inches, 26 compounds were identified.

Thirteen (34 percent) of the 38 VOCs identified were identified one or more times. Methylene chloride and acetone were identified most frequently of the 13 compounds identified (42 of 42 and 28 of 42 samples, respectively). However, these concentrations are typically attributable to background levels due to handling either during collection, shipping, or in the laboratory. Excluding methylene chloride and acetone values at zero to six inches, five compounds were identified; at the 12- to 24-inch depth interval, 11 compounds were identified.

Of the 35 herbicide, pesticide, and PCB compounds identified, seven (20 percent) were identified one or more times. Of the 13 metals identified, only thallium was not identified in the near-surface samples. Nineteen near-surface soil sample locations had positive cyanide results. Positive results for total phenols were obtained for 20 of the 0- to 6-inch samples and 21 of the 12- to 24-inch samples.

Boring Soil Samples

Boring soil samples were collected at 13 locations on site (B-1 through B-13); five samples were obtained for designated analyses at each of seven locations. At Boring B-2 (Figure 2.1-10), a silt sample was not recovered, resulting in only four samples at that location. A schedule of samples obtained in the fill and analyses performed is provided in Table 2.2-3. These samples were obtained with split-spoon samplers.

Below the fill, the silt layer was sampled continuously with Shelby tubes. The second Shelby tube from the silt was analyzed for dioxin. When a dioxin level greater than one ppb was observed, selected additional Shelby tube samples from the same boring were also tested for dioxin. The remaining tubes were archived. Figure 2.2-2 shows borings and cross-section locations. The locations of the borings and dioxin concentrations are shown in Figures 2.2-3 to 2.2-6.

Of the 39 boring soil samples analyzed for dioxin, 35 (90 percent) samples had identifiable dioxin concentrations. Reanalyses of smaller sample aliquots (one gram) or dilutions were required to yield results within the instrumental calibration range for nine of the 39 (23 percent) samples. At depths of 0 to 6 inches, the dioxin concentrations ranged from 19.7 ppb to 2,700 ppb. At 6 to 12 inches, the dioxin concentrations ranged from 7.5 ppb to 3,510 ppb and, at 12 to 24 inches, the dioxin concentration ranged from 4.7 ppb to 830 ppb. Samples from directly above the silt had dioxin concentrations ranging from 0.36 ppb to 71.8 ppb, with one of eight samples having no detectable dioxin. Samples from the silt zone had dioxin concentrations ranging from 0.49 ppb to 2.8 ppb with three of seven samples not having detectable concentrations of dioxin.

Twenty-four boring soil samples above the silt were analyzed for priority pollutants plus 40 compounds; samples in the silt layer were not so analyzed. Of the 69 semivolatile compounds identified, 27 (39 percent) were identified one or more times in the samples from 0 to 6 inches, 12 to 24 inches, or above the silt. At 0 to 6 inches, 20 compounds were identified; at 12 to 24 inches, 27 compounds were identified. In the soil samples taken from above the silt, 17 compounds were observed.

Of the 38 VOCs identified, 10 (26 percent) were identified one or more times in the samples from 0 to 6 inches, 12 to 24 inches, and above the silt. As discussed for the near-surface soil samples, methylene chloride and acetone are widespread contaminants in the site area and are not included as part of this discussion. At 0 to 6 inches, three compounds were identified; at 12 to 24 inches, eight compounds were identified. For samples from above the silt, seven compounds were identified.

Ten (29 percent) of the 35 herbicides, pesticides, and PCB compounds identified were identified one or more times in the samples from 0 to 6 inches, 12 to 24 inches, and above the silt. At 0 to 6 inches, nine compounds were identified; at 12 to 24 inches, nine compounds were identified; and in the samples from above the silt, eight compounds were identified.

Of the 13 metals identified, only selenium and thallium were not identified. At 0 to 6 inches, ten metals were identified; at 12 to 24 inches, 11 metals were identified; and in the samples from above the silt, 11 metals were identified. All samples had positive cyanide results; phenol was positive in seven samples.

Quantity of Dioxin in the Soil

The quantity of dioxin in the top 24 inches of soil at the site has been estimated using various techniques. Because samples were generally obtained in locations with anticipated high concentrations, the reported dioxin results reflect a bias to higher concentrations than are considered typical of the site. Additionally, samples were not taken at plant locations in close proximity to the high observed concentrations so that the variation with distance could be assessed.

Using both interpolation from geologic cross sections and geostatistical projections, quantities of dioxin in the soil were estimated at various depths down to the silt layer.

Estimates of the quantity of dioxin below 24 inches of soil depth and in the silt are complicated by the paucity of data in this depth range. Only 21 samples from the 11 on-site borings were analyzed for dioxin at depths of greater than 24 inches. Nine of these samples were from the silt layer. As with the near-surface samples (0 to 24 inches), the observed concentrations of dioxin varied greatly with depth (from nondetectable in Boring B-6 to 11.8 ppb in Boring B-10).

Table 2.2-4 presents the predicted dioxin loading in each two feet of soil between the surface of the 80 Lister Avenue site and the silt layer. An estimate of the number of cubic yards of fill containing greater than 7 ppb dioxin is also given in this table. Interpolating using the geologic cross sections as a base and the statistical method resulted in a similar estimate of dioxin quantity of 96.2 pounds.

2.2.1.6 Background Soils

Background soil samples were taken at four locations off site. One soil boring (B-14) was located on the Sherwin-Williams property approximately 100 feet south of the site boundary. Five samples were collected at the same intervals and analyzed in the same manner as described in Subsection 2.2.1.5.

Samples were obtained at three additional locations in the city of Newark within a two-mile radius of the site (Figure 2.2-7). At each location, five samples were collected from an area approximately three feet by three feet using a hand trowel. The samples were obtained at an approximate depth of six inches and were composited to create a single sample. The samples from the three locations were analyzed for the priority pollutants and dioxin.

Sherwin-Williams

Five samples were obtained from Boring B-14 on the Sherwin-Williams property for analysis. Three of the five samples had detectable concentrations of dioxin. Concentrations ranged from 1.2 to 5.1 ppb in the three positive sample reports. Dioxin was not, however, detected in samples deeper than 24 inches at detection limits of 0.57 and 0.76 ppb at the 11- to 12.5-foot and the 95- to 97-foot depths, respectively.

Three soil samples were analyzed for the priority pollutants. The results were as follows: of the 69 acid/base/neutral compounds identified at the site, 20 (29 percent) were reported one or more times; of the 38 VOCs identified, three (8 percent) were reported one or more times; of the 35 herbicide, pesticide, and PCB compounds identified, two were reported one or more times; and of the 13 metals identified, 11 were reported all three times.

Newark

Dioxin was not detected in any of the three soil samples at a detection level of less than 1 ppb. Of the 69 semivolatile compounds identified at the site, 16 were identified in the Newark background samples one or more times. Methylene chloride was the only compound reported at all three locations. Of the 35 herbicide, pesticide, and PCB compounds identified at the site, three were detected one or more times. Of the site-identified 11 metals, all were identified one or more times. Positive total cyanide and phenol results were reported for four of the six samples analyzed.

2.2.1.7 Sewers and Sumps

Associated with the site buildings are a number of sumps and an industrial sewer system. All of the sumps inspected during the site investigation had been previously cleaned or emptied to some degree. However, enough residual material remained in each to enable the collection of bulk samples. Samples were collected using a hand trowel if the material to be sampled was dry and easily accessible. Deeper samples, or those containing water, were sampled with a long-handled, perforated scoop. Eight samples were taken from sumps, and four sewer samples were collected from manholes accessible on the site. Sample locations are shown in Figure 2.2-8.

Positive dioxin results were obtained for all 12 samples. The sumps generally had higher levels of dioxin than the sewers, especially those near the process building, where levels ranged from 105 to 9,160 ppb; sewer results ranged from 19.5 to 4,040 ppb. Concentrations of dioxin in the sewer system decrease with distance from the process and chemical manufacturing buildings toward the laboratory/office building.

2.2.1.8 Ground Water

Sampling of ground water for chemical analysis was initially performed on October 9 and October 30, 1984. Based upon preliminary dioxin results, Monitoring Well MW-2A was again sampled on December 14, 1984, and analysis was performed for dioxin only.

The ground water samples were analyzed for priority pollutants and dioxin. Analysis of samples taken from the eight shallow monitoring wells (MW-1A to MW-8A) has confirmed that the ground water in the fill contains a number of chemicals. Complete analytical results for this first phase of testing may be found in Appendix F of the Site Evaluation Report.

Additional ground water samples were collected and analyzed from existing and newly installed monitoring wells in the fill and glaciofluvial sand units. These analyses are presented in Tables 2.2-5 to 2.2-7.

Dioxin was present in 15 of 17 water samples collected from the fill, ranging from 0.0059 ppb in Monitoring Well MW-5A to 10.4 ppb in MW-2A. The results indicate that concentrations are greatest at the north end of the site along the river near the process and chemical manufacturing buildings. Monitoring Wells MW-5A, MW-6A, and MW-7A, located at the south and southwestern portions of the site, consistently had the lowest dioxin levels, ranging from not detected to a maximum of 0.016 ppb; Monitoring Wells MW-4A and MW-8A along the eastern edge at the site had dioxin levels ranging from 0.20 to 1.1 ppb; and Monitoring Wells MW-1A, MW-2A, and MW-3A located on the northern edge of the site showed levels ranging from 0.03 to 10.4 ppb dioxin.

Three ground water samples from Monitoring Well MW-2A in the center of the north end of the site had dioxin results of 7.9, 4.3, and 10.4 ppb, all significantly higher than any other ground water sample dioxin result. These very high levels of dioxin in water are probably the result of a dioxin-bearing solvent or other carrier in the ground water, or dioxin-containing colloidal soil particles suspended in the water.

Dioxin was present in two of three water samples from the glaciofluvial sand. Monitoring Wells MW-2B and MW-7B had dioxin concentrations of 0.0042 and 0.0034 ppb, respectively (Table 2.2-5). Dioxin was undetected (detection limit of 0.005 ppb) in the deep Monitoring Well MW-10D located about 115 feet off site.

Results of the priority pollutant analyses also confirmed the presence of a number of compounds in the ground water from the fill. The highest concentrations of semivolatile organic and chlorinated herbicide compounds occur in the northernmost monitoring wells. Ground water samples from Monitoring Well MW-2A, which had the highest dioxin concentration results, also had the highest priority pollutant concentrations of the on-site wells sampled.

In general, the most prevalent compounds found in the ground water from the fill in significant concentrations are the chemicals associated with the manufacture that took place on the site, i.e., chlorinated phenols, 4,4'-DDT, 2,4-D, and 2,4,5-T.

Ground waters collected from the upper glaciofluvial sand contain fewer compounds than are found in ground waters sampled in the fill unit (Tables 2.2-6 and 2.2-7). The deepest well sampled (MW-10D) contains only six organic compounds which are present at very low concentrations.

2.2.1.9 Passaic River

Extensive sampling of both the water and sediments in the Passaic River has been carried out as part of the site evaluation. Low levels of dioxin were found in the river water, but significant levels were observed in the sediments.

2.2.2 Special Considerations Related to the Site

The only special consideration is the presumed toxic nature of the dioxin detected at the site. Any remedial actions employed at the site must take into account the toxicity of dioxin so that human and environmental exposure is minimized.

2.2.3 Present Condition of Materials and Structures

The chemical manufacturing and process buildings, following 15 years with minimal maintenance and eight years of sitting idle, are in very poor condition. The buildings exhibit extensive corrosion of the floor steel and other structural members, collapse of the roofs in several places, and acid attack of the concrete floors and the block or brick walls at many points. The roof of the boiler house is in imminent danger of collapsing. Throughout the plant, the carbon steel vessels are heavily rusted, with generally severe loss of metal; stainless steel and other alloy vessels are in somewhat better condition.

The office and laboratory building and the maintenance shop/warehouse building are in much better condition. These buildings show signs of leaking roofs and other evidence of inadequate maintenance and care, but they appear structurally sound.

Most of the raw material tanks on the west side of the property and the product tanks on the east side of the property are in fairly good condition. The remaining intermediate storage tanks are in questionable condition.

The drums stored are being monitored by weekly inspections. If any stored drum(s) starts to leak, the drum(s) is immediately overpacked using recovery drums.

2.2.4 Changes in Site Conditions

Several significant changes in site conditions have occurred since the investigation by the EPA which led to the site evaluation and feasibility study. These are:

- The ground surface at the site has been covered with a geotextile material to prevent surface erosion and migration of dust
- The stack has been demolished (Figure 2.1-4)
- A partial remediation of the 120 Lister Avenue property has taken place and 352 containers of dioxin-containing material from that and other cleanup activities associated with the 80 Lister Avenue site have been placed on this property; it is anticipated that 845 containers will ultimately be stored there.

2.3 SUMMARY

The analysis of the data shows that geologically the site is underlain by man-made fill which overlies a silt layer which in turn overlies a glaciofluvial unit. The glaciofluvial unit is underlain by bedrock. The fill layer is relatively pervious while the silt layer appears to significantly retard the flow of ground water and any associated chemicals from the fill to the glaciofluvial sand. Lateral flow in the silt is not a concern because the overlying fill and the underlying glaciofluvial sand have much higher lateral hydraulic conductivities. The flow of ground water in the glaciofluvial sand in the vicinity of the site is generally in a southerly direction with an average gradient of 0.002 in the upper portion of the unit. Ground water velocities are expected to be in the range from 0.0002 to 0.0012 foot per day in the lower sand unit. The major migration pathway through ground water is probably flow in the fill toward the Passaic River.

The area of the site itself is industrialized, with only the slightest traces of natural flora and fauna commonly found in a highly developed urban environment. No unique or endangered species or habitats are known to occur at the site or in the surrounding vicinity.

Results of the sampling program conducted to determine the presence of dioxin and other chemicals on the site have been presented. The results of this program coupled with the characteristics of the geologic environment as described above serve as the basis of the modeling to be done in the next section to define the risk posed by the site.

TABLES

TABLE 2.1-1

RAW MATERIALS AND FINISHED PRODUCTS DURING KOLKER, DIAMOND ALKALI, AND DIAMOND SHAMROCK OWNERSHIP

Raw Materials

Acetic acid
Acetic anhydride
*Acetaldehyde
*Benzene
*Monochlorobenzene
Tetrachlorobenzene
*Chlorosulfonic acid
Methanol
*Oleum (20%)
Phenol
Sulfuric acid
Dimethylamine (40%)
Triethylamine
Chlorine
2-Ethylhexanol
Butyl alcohol
Isopropyl alcohol
Butoxyethoxypropanol
*Nicotine
Sodium Hydroxide

Finished Products

2,4,5-trichlorophenoxy acetic acid
2,4-dichlorophenoxy acetic acid
2,4,5-trichlorophenol
2,4,6-trichlorophenol
2,4-dichlorophenol
Monochloroacetic acid
*Hexachlorobenzene
*Dichlorodiphenyltrichloroethane
*p-chlorophenyl-p-chlorobenzene sulfonate (ovex)
*1,1,1-trichloroacetaldehyde
*Benzensulfonyl chloride
*p-chlorobenzenesulfonyl chloride
*p-chlorobenzenesulfonamide
*4,4'-dichlorodiphenylsulfone
*p-acetylaminobenzene sulfonyl chloride
*p-methoxybenzene sulfonyl chloride
*1,2,4,5-tetrachlorobenzene
Amine salts of 2,4-D (dimethyl and triethyl amines)
Amine salts of 2,4,5-T (dimethyl and triethyl amines)
Esters of 2,4-D (butyl, 2-ethylhexyl, isopropyl, butoxyethoxypropyl)
Esters of 2,4,5-T (butyl, 2-ethylhexyl, isopropyl, butoxyethoxypropyl)
Amine salts of N-oleyl-1,3-propylenediamine
*Nicotine sulfates
Muriatic Acid
*2,5-dichlorophenyl-p-chlorobenzene sulfonate

NOTE: The asterisk denotes raw materials and products not used or made after the explosion in February 1960.

TABLE 2.1-2

SEASONAL AND ANNUAL OCCURRENCE OF WIND DIRECTION

WIND DIRECTION	OCCURRENCE (Percentage of Time)				
	SUMMER	AUTUMN	WINTER	SPRING	ANNUAL
N	3.3	3.7	4	4.3	3.8
NNE	7	10	8	7	8.0
NE	5.7	6.3	6.7	6.7	6.4
ENE	3.7	3.7	3.3	5.7	4.1
E	3.7	3	3	5.3	3.8
ESE	4	3.7	2	6	3.9
SE	3.7	2.7	1	3	2.6
SSE	6.7	4	2	4.3	4.3
S	5.7	4	2.7	3.7	4.0
SSW	11.7	10	7	7	8.9
SW	12	11.7	9.7	8	10.4
WSW	8	8	9.3	7.7	8.3
W	5.7	7	7.7	5.7	6.5
WNW	6.7	7.3	13	9	9.0
NW	5.7	6.7	11	8.3	7.9
NNW	5	6.3	9.3	7.7	7.1
	98.3	98.1	99.7	99.4	99.0

Reference: Woodward-Clyde Consultants, 1982.

TABLE 2.1-3

MONTHLY AVERAGE WIND SPEED AND PREVAILING WIND DIRECTION(a)

MONTH	MEAN WIND SPEED(b) (mph)	PREVAILING WIND DIRECTION(c)
January	11.2	NE
February	11.5	NW
March	12.0	NW
April	11.3	WNW
May	10.0	SW
June	9.3	SW
July	8.8	SW
August	8.6	SW
September	8.9	SW
October	9.3	SW
November	10.1	SW
December	10.8	SW
Annual	10.1	SW

(a)Recorded at Newark Airport.

(b)Length of record 35 years.

(c)Length of record 22 years.

Reference: Woodward-Clyde Consultants, 1982.

TABLE 2.1-4

AVERAGE MEAN, MAXIMUM, AND MINIMUM TEMPERATURE
NEWARK, NEW JERSEY

(Data Period 1944 - 1983)

	MEAN (°F)	MAXIMUM (°F)	MINIMUM (°F)
January	31.4	38.5	24.3
February	32.5	40.1	24.8
March	40.9	49.0	32.7
April	51.4	60.7	42.0
May	62.1	71.7	52.4
June	71.2	80.6	61.8
July	76.5	85.6	67.3
August	74.8	83.7	65.9
September	67.7	76.7	58.6
October	56.8	66.0	47.5
November	46.1	53.9	38.2
December	35.1	42.2	28.0
Annual	53.9	62.4	45.3

Reference: National Oceanographic & Atmospheric Administration, 1983.

TABLE 2.1-5

SUMMARY OF SHALLOW MONITORING WELL DATA

WELL NUMBER	DEPTH TO STATIC WATER LEVEL(a) (ft)	GROUND SURFACE ELEVATION(b) (ft)	DEPTH TO TOP OF SCREEN(c) (ft)	DEPTH TO BOTTOM OF SCREEN(c) (ft)	ESTIMATED SATURATED THICKNESS OPPOSITE WELL SCREEN (ft)	DEPTH INTERVAL OF SATURATED FILL (ft)
MW-1A	6.6	7.8	3.5	14.2	7.9	6.6 to 14.5
MW-2A	4.6	8.0	3.5	15.2	10.6	4.6 to 15.2
MW-3A	4.7	6.4	3.0	8.5	3.8	4.7 to 8.5
MW-4A	0.7	6.7	2.0	7.0	6.0	0.7 to 6.7
MW-5A	4.2	8.0	3.0	8.5	3.8	4.2 to 8.0
MW-6A	4.1	8.0	1.9	7.9	3.7	4.1 to 7.8
MW-7A	1.6	7.5	2.0	8.2	6.6	1.6 to 8.2
MW-8A	0.4	8.8	2.0	7.0	6.6	0.4 to 7.0

(a)Depths to static water level from ground surface at the time of slug tests (obtained from field log notebook).

(b)Elevations reported with reference to New Jersey Geodetic Vertical Datum.

(c)Depths are with respect to ground surface.

TABLE 2.1-6

REPRESENTATIVE HYDRAULIC CONDUCTIVITY VALUES(a) IN FILL ZONE

WELL NUMBER	MEAN HYDRAULIC CONDUCTIVITY (ft/day)	RANGE IN HYDRAULIC CONDUCTIVITY (ft/day)	GROUND SURFACE ELEVATION(b) (ft)	BELOW SURFACE DEPTH RANGE OF MOST PERMEABLE ZONE (ft)
MW-1A	10	5-15	7.8	6.6 to 14.5
MW-2A	200	100-300	8.0	6.5 to 11.5
MW-3A	40	20-60	6.4	4.7 to 8.5
MW-4A	3	2-4	6.7	0.7 to 6.7
MW-5A	20	10-30	8.0	4.2 to 8.0
MW-6A	30	20-40	8.0	4.1 to 7.8
MW-7A	10	5-15	7.5	1.6 to 3.5
MW-8A	10	5-15	8.8	0.4 to 5.0

(a)Hydraulic conductivities are estimated values assigned to the zone in which the monitoring wells are screened. Results were determined from field slug tests.

(b)New Jersey geodetic vertical control.

TABLE 2.1-7

RESULTS OF FALLING HEAD SLUG TEST ANALYSIS IN GLACIOFLUVIAL SAND

WELL NUMBER	HYDRAULIC CONDUCTIVITY OF PERMEABLE ZONE (ft/day)		
	METHOD OF COOPER BREDEHOEFT AND PAPADOPULOS	METHOD OF BOUWER AND RICE	
		USING DIAMETER OF CASING AND SCREEN	USING DIAMETER OF DRILLED HOLE
MW-2B	0.4	0.5	0.4
MW-2C	0.1	0.6	0.5
MW-4B	0.1	0.5	0.4
MW-7B	-	>0.3	-
MW-10D(a)	-	<0.0003	-

(a)Slug test data outside range of test procedure.

TABLE 2.1-8

GROUND WATER ELEVATION READINGS
(ELEVATION IN FEET, NEW JERSEY GEODETIC VERTICAL CONTROL)

WELL NUMBER	ELEVATION TOP OF WELL RISER PIPE (ft)	GROUND WATER ELEVATIONS (ft)					
		05/11/85	05/18/85	05/25/85	06/01/85	07/03/85	07/08/85
MW-1A(a)	9.72	-0.18	3.79	0.62	1.93	3.42	2.82
MW-2A(a)	9.81	-2.29	3.91	0.46	2.05	2.86	1.61
MW-2B	11.50					-0.55	-0.60
MW-2C	11.20					-0.60	-0.20
MW-3A(a)	9.21	2.81	4.71	2.86	3.97	4.01	2.81
MW-4A	10.14		7.44	7.54	7.55	7.29	6.94
MW-4B	10.10					-1.20	-1.60
MW-4C	10.30					-1.60	-1.35
MW-5A	10.97	4.97	5.37	5.72	5.60	5.87	5.27
MW-6A	10.91	4.61	4.81	5.31	5.03	5.71	5.01
MW-7A	10.97	6.97	7.95	7.97	8.21	8.07	7.02
MW-7B	10.40					-1.20	-1.50
MW-7D	10.60					-3.20	-2.10
MW-8A	9.59		7.39	7.44	7.51	7.39	6.99
MW-9A	9.06	2.76	2.76	3.51	3.38	4.06	3.26
MW-10A	9.80	3.46	3.36	3.76	3.57	3.60	4.00
MW-10B	9.70	-1.89	-1.04	-1.39	-1.20	-1.35	-1.70
MW-10D	10.00	-2.49	-1.97	-4.19	2.41	-16.00(b)	-8.50(b)

(a)May be influenced by tidal fluctuation.

(b)Anomalous reading.

TABLE 2.2-1

SAMPLE SUMMARY FOR BUILDINGS, STRUCTURES, AND EQUIPMENT

LOCATION	DESCRIPTION	NUMBER OF SAMPLES		
		WIPE	CHIP	BULK
Office Building				
Interior	Areas of first and highest exposure (lab, change room, etc.)	22	5	4 (asbestos)
Exterior	Primary contact areas near roads and sidewalks	1	10	-
Warehouse				
Interior	Areas of highest exposure (office, lunchroom, shop)	7	4	3 (asbestos)
Exterior	Contact areas (splashing and wind borne)	1	12	-
Manufacturing Building				
Interior	Packaging and reaction areas	4	14	2 (asbestos)
Exterior	Wind-borne contact	1	9	-
Process Building				
Interior	Reaction and carbon infiltration areas	12	3	3 (asbestos) 5 (dioxin)
Exterior	High source area (example, carbon filter)	2	7	-
Stack	Flue, sludge pit, outer surface	-	3	-
Solvent Storage Shed	Representative internal and external	-	1	1 (dioxin)
Pumphouse	Representative internal and external	-	2	-
Tanks (in buildings tank and farms)		28	-	112 (dioxin) 2 (asbestos)
TOTAL		78	70	132

TABLE 2.2-2

ESTIMATED VOLUME OF MATERIALS FROM MAJOR STRUCTURES

ITEM DESCRIPTION	DEMOLITION(a) MATERIAL (cubic yards)	STRUCTURAL STEEL(b) AND GRATING (tons)
Office and Laboratory	780	-
Warehouse	1,100	44
Process Building	850	75
Chemical Manufacturing Building	1,250	75
Old Brick Building	550	16
Smokestack	700	-
Pumphouse	14	-
Solvent Shed	14	-
TOTAL	5,258	210

(a)Demolition material includes brick, block, concrete, wood, plaster, roofing material, and other items associated with walls, floors, and roofs.

(b)Structural steel and grating includes only that steel inside the listed structures.

TABLE 2.2-3

BORING SAMPLES AND ANALYSES

DEPTH	ANALYSIS(a)
0 to 6 inches	Full priority pollutants and dioxin
6 to 12 inches	Dioxin
12 to 24 inches	Full priority pollutants and dioxin
24 inches below the surface to 18 inches above the bottom of fill	Selected dioxin
18 inches above the bottom of fill to 6 inches above bottom of fill	Full priority pollutants
6 inches above the bottom of fill to the bottom of the fill	Dioxin

(a)Full priority pollutants is defined as the 157 compounds comprising the acid/base/neutrals (semivolatiles), volatile organic compounds (VOCs), pesticides and polychlorinated biphenyls (PCBs), herbicides, metals, total cyanide, total phenols, plus 40 additional peak searches.

TABLE 2.2-4

ON-SITE DIOXIN LOADING VOLUMES WITH GREATER THAN 7 PPB DIOXIN(a)

DEPTH (feet)	DIOXIN LOAD (pounds)	ESTIMATED FILL VOLUME (cubic yards)
0-2	20.3	10,140
2-4	27.9	10,740
4-6	24.0	10,140
6-8	17.2	7,870
8-10	6.6	3,610
10-12	0.2	1,210
12-14	<0.1	380
14-16	<0.1	140

(a)Based on computerized statistical projections from site data.

TABLE 2.2-5

SUMMARY OF RECENT DIOXIN CONCENTRATIONS IN GROUND WATER IN GLACIOFLUVIAL SANDS

WELL NUMBER	SAMPLING DATE	RESULTS (ppb)
MW-2B	06/17/85	4.2×10^{-3}
MW-7B	06/17/85	3.4×10^{-3}
MW-10D	06/05/85	ND (<1×10^{-3} ppb)(a)

(a)Value reported in parenthesis is the detection limit of a sample reporting nondetectable.

TABLE 2.2-6

GROUND WATER ORGANIC PRIORITY POLLUTANT ANALYTICAL RESULTS

(μg/ℓ)

	MONITORING WELLS AND SAMPLING DATES						
COMPOUND	MW-2B	MW-7B	MW-10A	MW-10A	MW-10B	MW-10B	MW-10D
	06/17/85	06/17/85	12/14/84	01/08/85	12/14/84	01/08/85	06/25/85
Benzene	1,200	24	200	160	610	360	ND(a)
Chlorobenzene	9,100	720	1,600	570	8,500	5,500	4
Methylene Chloride	280	120	640	170	4,100	2,800	40
Toluene	850	ND	ND	ND	ND	ND	1
Acetone	ND	ND	550.0	ND	ND	ND	ND
2,4,6-Trichlorophenol	1,500	ND	ND	ND	ND	ND	ND
2-Chlorophenol	160	ND	ND	ND	ND	12	ND
2,4-Dichlorophenol	7,200	ND	ND	ND	ND	ND	ND
Phenol	290	ND	ND	ND	ND	ND	ND
2,4,5-Trichlorophenol	1,500	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND	12	ND
1,2-Dichlorobenzene	ND	5	260	ND	1,300	240	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	64	ND
1,4-Dichlorobenzene	200	22	810	ND	4,700	1,300	ND
Bis(2-ethylhexyl)phthalate	ND	8	ND	ND	ND	3	ND
Di-N-Octylphthalate	ND	25	ND	ND	ND	ND	ND
Aniline	ND	ND	9,300	18,000	70	ND	ND
2-Methylnaphthalene	ND	2	ND	ND	ND	ND	ND

See footnote at end of table.

TABLE 2.2-6
(Continued)

	MONITORING WELLS AND SAMPLING DATES						
COMPOUND	MW-2B	MW-7B	MW-10A	MW-10A	MW-10B	MW-10B	MW-10D
	06/17/85	06/17/85	12/14/84	01/08/85	12/14/84	01/08/85	06/25/85
4,4'-DDT	ND	ND	ND	ND	17.0	ND	ND
4,4'-DDE	0.15	ND	ND	ND	ND	ND	ND
4,4'-DDD	0.32	12.0	ND	ND	1.5	ND	ND
Alpha-BHC	ND	ND	ND	ND	7.5	ND	ND
Beta-BHC	ND	ND	ND	ND	1.9	ND	ND
Delta-BHC	ND	3.6	ND	ND	4.8	ND	ND
Dalapon	ND	ND	ND	2.0	ND	2.0	8.0
Dicamba	ND	ND	1.0	ND	ND	1.0	1.0
MCPP	ND	ND	ND	ND	ND	1,000	ND
MCPA	ND	ND	ND	ND	ND	1,000	ND
Dichloroprop	ND	ND	ND	2.0	ND	ND	ND
2,4-D	613.0	2.0	ND	2.0	ND	5.2	2.0
2,4,5-T	123.0	1.76	ND	ND	ND	2.0	ND
2,4-DB	ND	ND	ND	ND	ND	4.0	ND

(a)ND - Not detected.

TABLE 2.2-7

GROUND WATER INORGANIC PRIORITY POLLUTANT ANALYTICAL RESULTS (ppm)

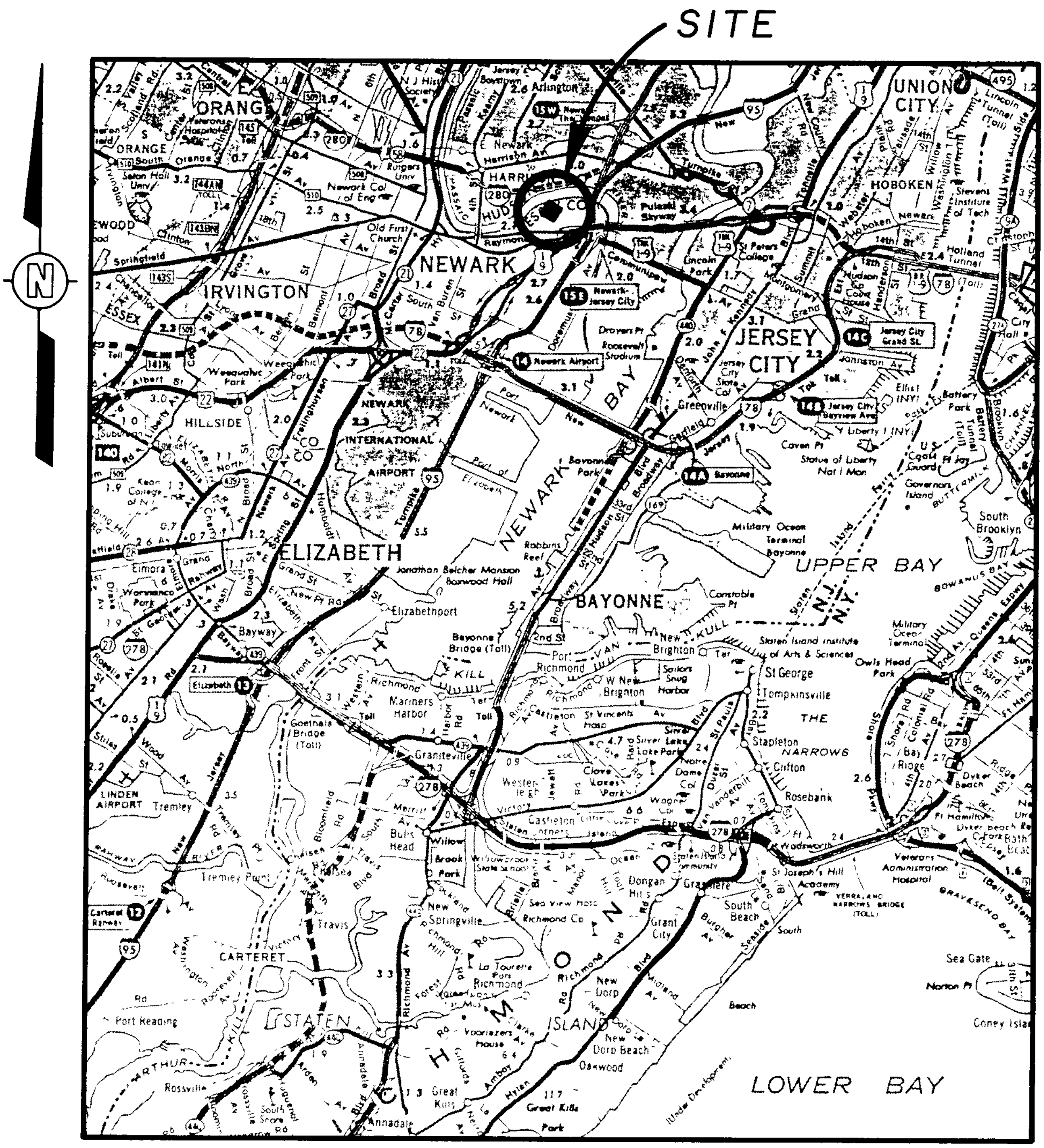
MONITORING WELLS AND SAMPLING DATES

PARAMETER	MW-2B	MW-2B	MW-2C	MW-4B	MW-4C	MW-7B	MW-7B	MW-10A	MW-10A	MW-10D	MW-11B	MW-11B
	06/17/85	06/25/85	06/25/85	06/25/85	06/25/85	06/17/85	06/25/85	12/14/84	01/08/85	06/25/85	12/14/84	01/08/85
Antimony	<0.001	0.003	0.003	<0.001	<0.001	0.001	<0.001	<0.002	0.005	0.007	0.001	0.002
Arsenic	0.011	0.011	0.024	0.022	0.047	0.063	0.041	0.010	0.015	0.004	0.011	0.044
Beryllium	<0.002	0.003	0.005	0.002	0.005	0.003	<0.002	<0.002	0.003	<0.002	<0.002	0.006
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.003	0.014
Chromium	0.12	0.04	0.03	0.05	0.16	0.19	0.03	0.04	0.08	0.10	0.03	0.23
Copper	0.020	0.013	0.025	0.050	0.168	0.294	0.020	0.052	0.138	0.112	0.058	0.251
Lead	0.04	<0.01	<0.01	<0.01	0.04	0.08	<0.01	0.76	1.2	0.07	0.02	0.11
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.004	<0.001	<0.001	<0.001
Nickel	0.06	0.03	<0.01	0.03	0.12	0.15	<0.01	0.02	0.05	0.05	0.03	0.16
Selenium	0.006	<0.004	<0.008	<0.004	<0.01	0.005	<0.004	<0.03	0.007	<0.008	<0.006	<0.004
Silver	<0.002	0.026	0.021	0.059	<0.002	<0.002	<0.002	0.003	<0.002	0.003	<0.002	<0.002
Thallium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc	0.045	0.042	0.045	0.079	0.378	0.632	0.048	1.7	1.5	0.156	0.690	2.7
Total Cyanide	NA(a)	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
Total Phenols	NA	11.4	2.3	0.6	0.06	0.02	0.02	0.12	0.17	0.01	0.05	0.10

(a)NA - Not analyzed.

FIGURES

DRAWN BY cjb/ 4-17-84
CHECKED BY RL 4-17-84
APPROVED BY DT 10-30-85
DRAWING NUMBER 84-6248-A4



ROAD CLASSIFICATION:

- HEAVY DUTY
- MEDIUM DUTY
- LIGHT DUTY

SCALE
0 2 4 MILES

INTERSTATE
STATE ROUTE
U.S. ROUTE

FIGURE 2.1-1

SITE LOCATION MAP
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

65360

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IT ...Creating a Safer Tomorrow

DRAWING NUMBER 850032-A9

DRAWN BY mel 8-13-85

CHECKED BY VAN 9-17-85

APPROVED BY DT 10-30-85

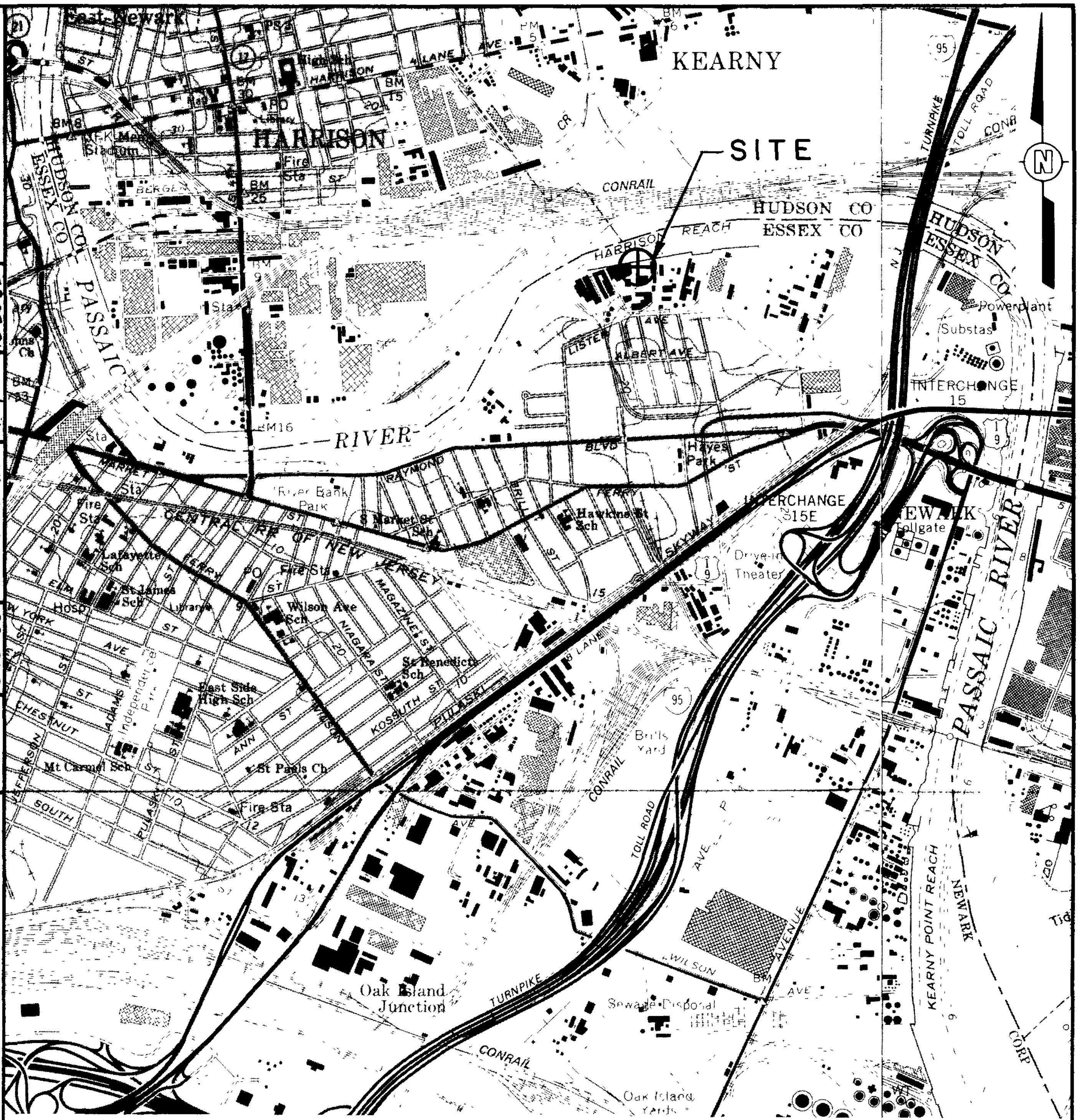

FIGURE 2.1-2

SITE VICINITY MAP
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

SCALE

0 2000 4000 FEET

REFERENCE:

7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE
MAPS OF: ELIZABETH AND JERSEY CITY, N.J. - N.Y.
DATED: 1967, PHOTOREVISED: 1981, SCALE: 1" = 2000'.

65360

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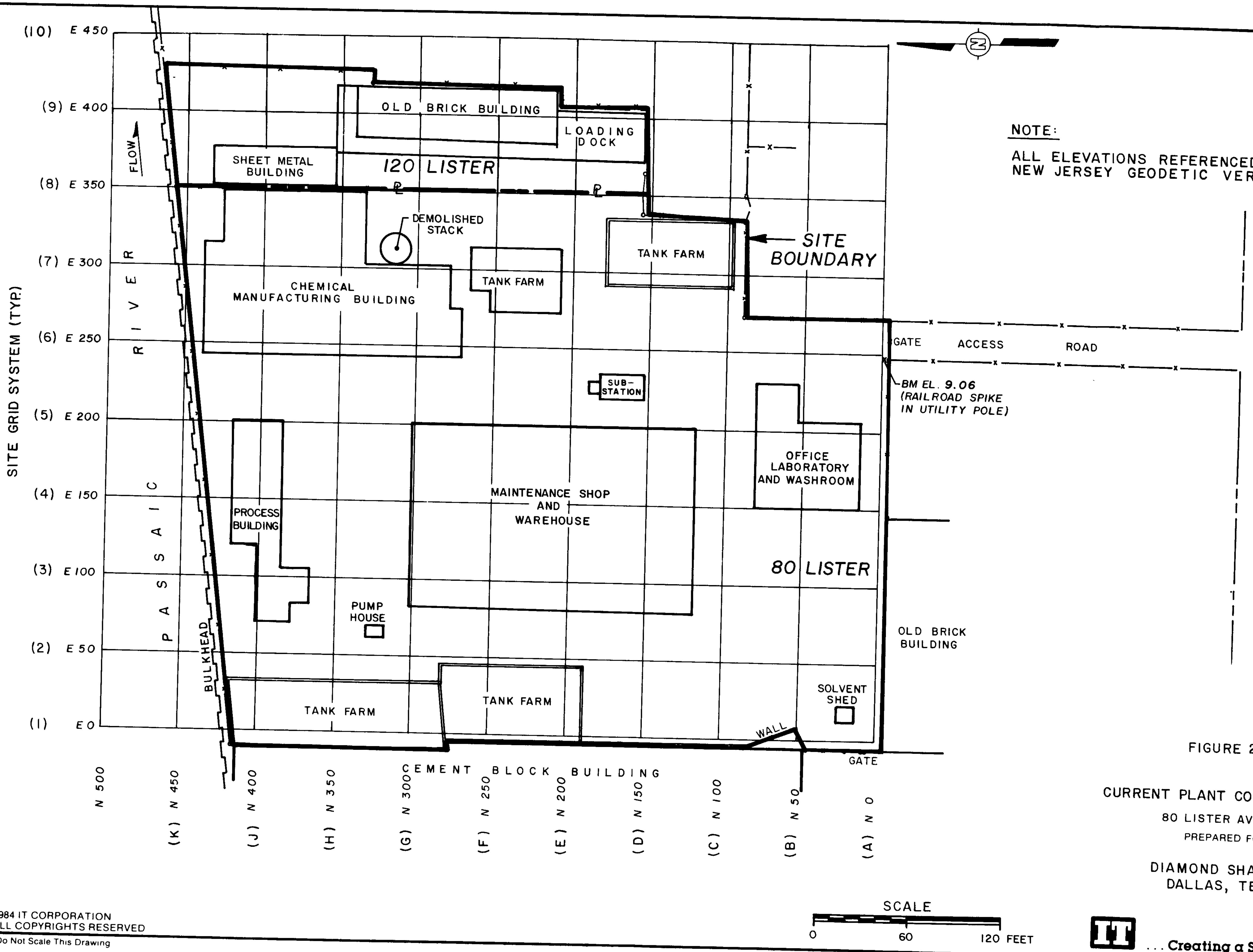

NOTE:

ALL ELEVATIONS REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

FIGURE 2.1-4

CURRENT PLANT CONFIGURATION
80 LISTER AVENUE
PREPARED FOR
DIAMOND SHAMROCK
DALLAS, TEXAS

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DRAWN BY	J. LOGRECO 7·26·85	CHECKED BY	JAD 9-17-85
		APPROVED BY	
DRAWING NUMBER	850032-B1		

65360

"Do Not Scale This Drawing

DRAWING NUMBER 84-6248-A6

10-30-85

DT

CHECKED BY APPROVED BY

DRAWN BY RW 6-15-84

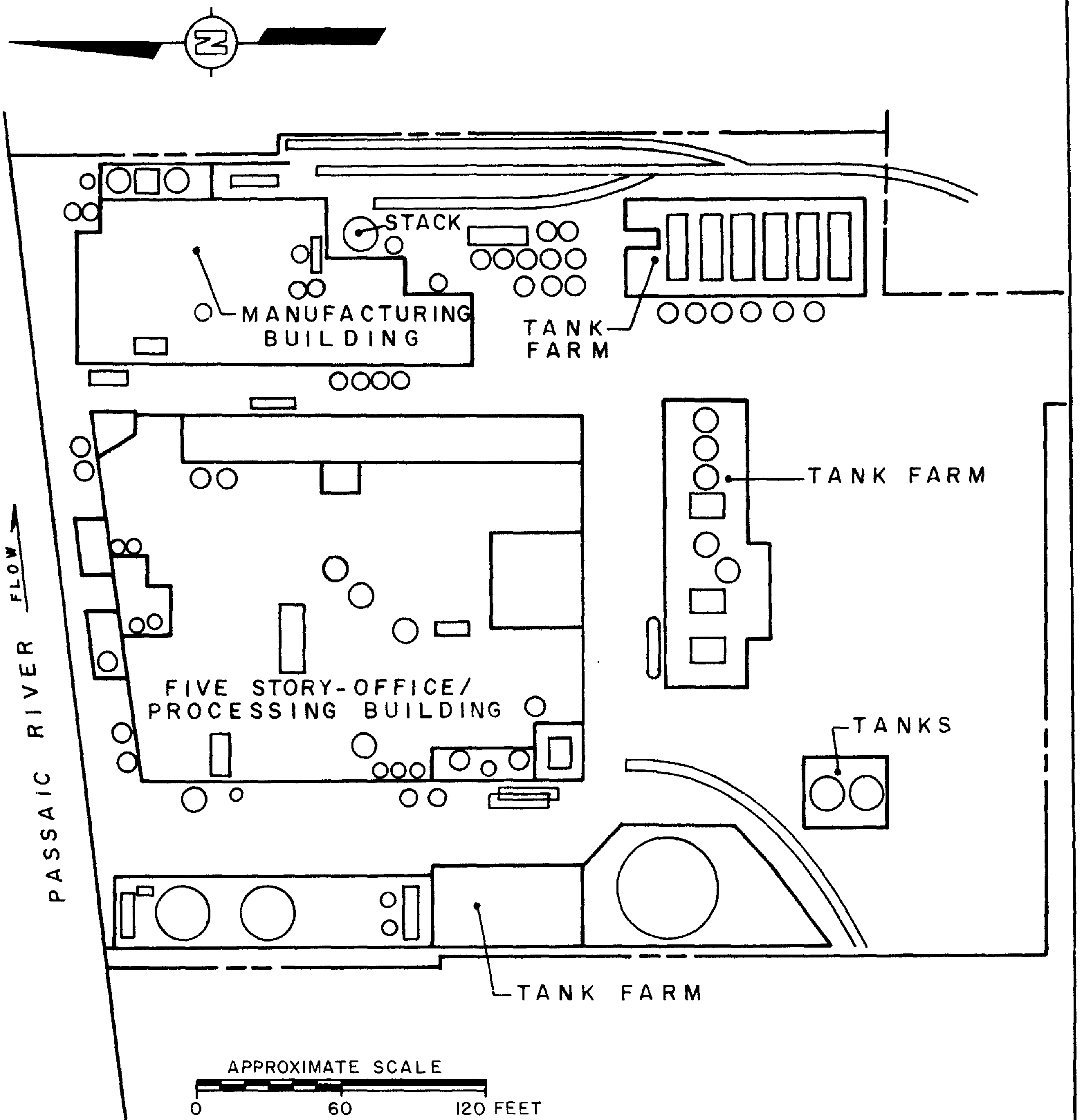

FIGURE 2.1-6

80 LISTER AVENUE
FACILITY LAYOUT
PRIOR TO EXPLOSION
FEBRUARY, 1960

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

LEGEND

------ 80 LISTER AVENUE PROPERTY BOUNDARY

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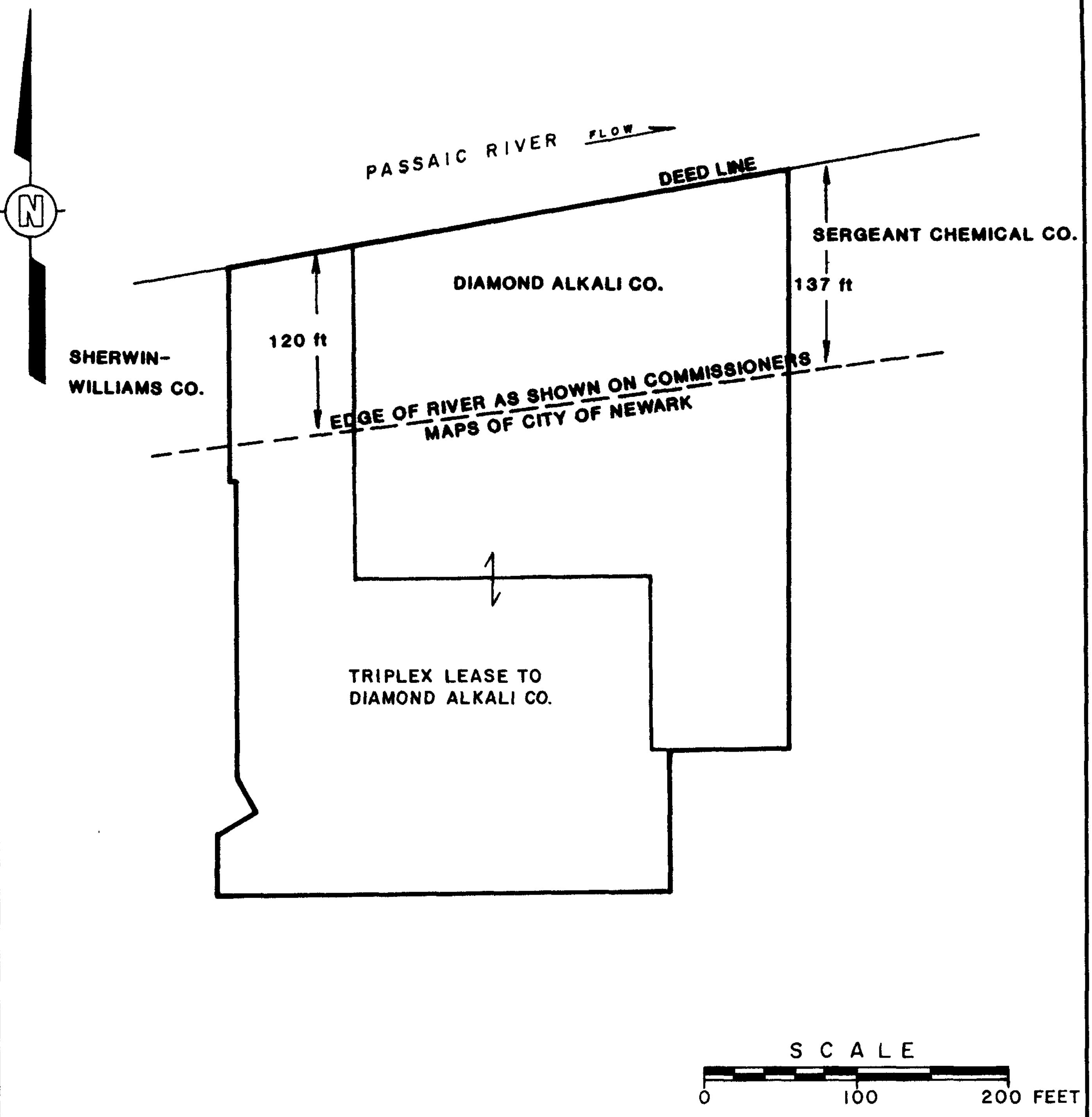

FIGURE 2.1-7

PLAT PLAN OF CURRENT
80 LISTER AVENUE SITE
SHOWING ORIGINAL LOCATION
OF RIVER EDGE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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DRAWING NUMBER 846248-A18

CHECKED BY JTO 2-13-85

APPROVED BY

DRAWN BY JJL 1·24·85

65360

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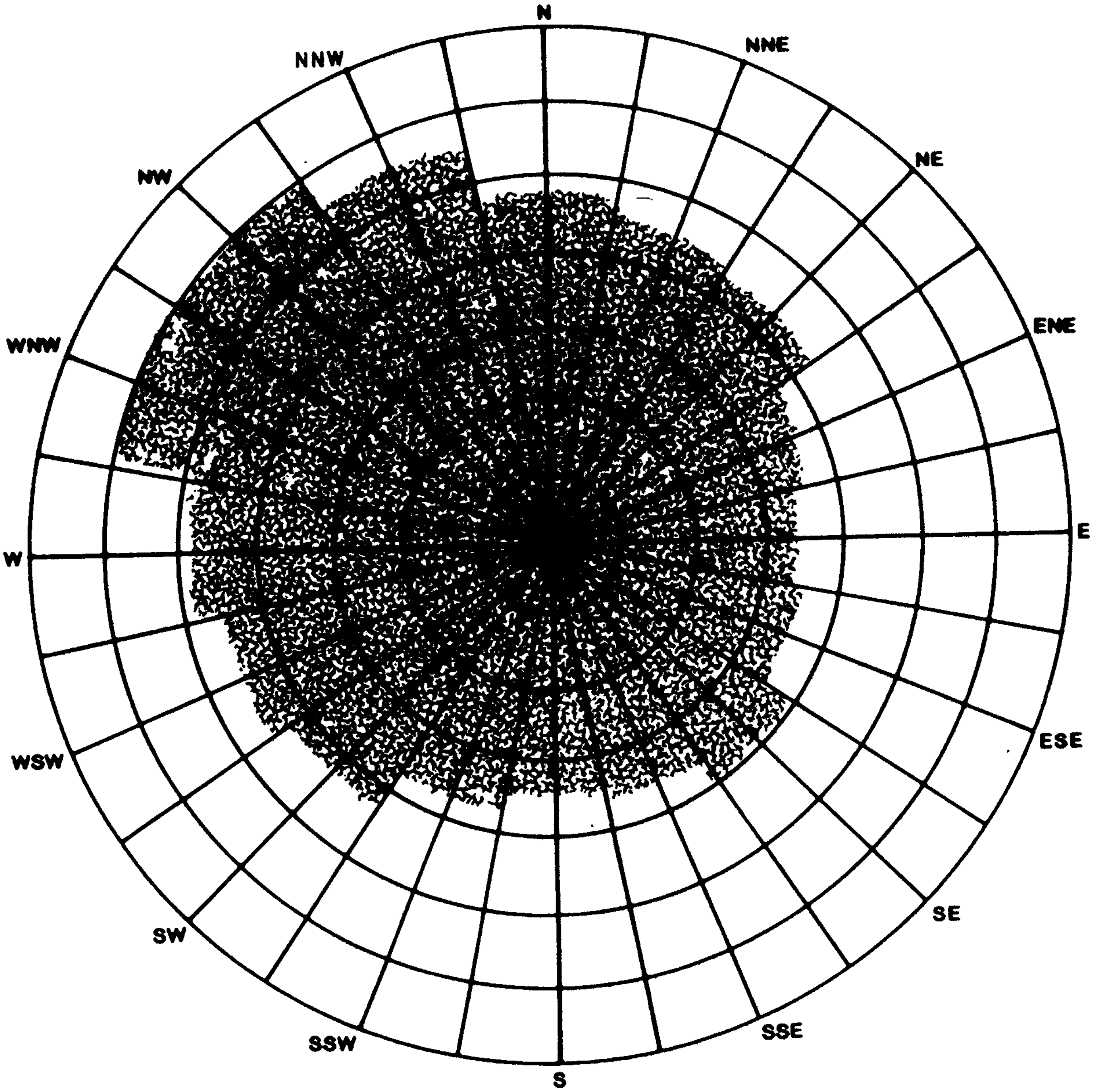
DRAWN BY	JJL	CHECKED BY	JTO	2-13-85	DRAWING NUMBER 846248-A16
	1-24-85	APPROVED BY	DT	10-30-85	



REFERENCE: NOAA, 1978

FIGURE 2.1-8

AVERAGE WIND SPEED
FOR WIND DIRECTION
1965-1974 NEWARK, N.J.
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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"Do Not Scale This Drawing"

DRAWN BY RW 1-24-85

CHECKED BY JTC 2-13-85

APPROVED BY DT 10-30-85

DRAWING NUMBER 846248-A15

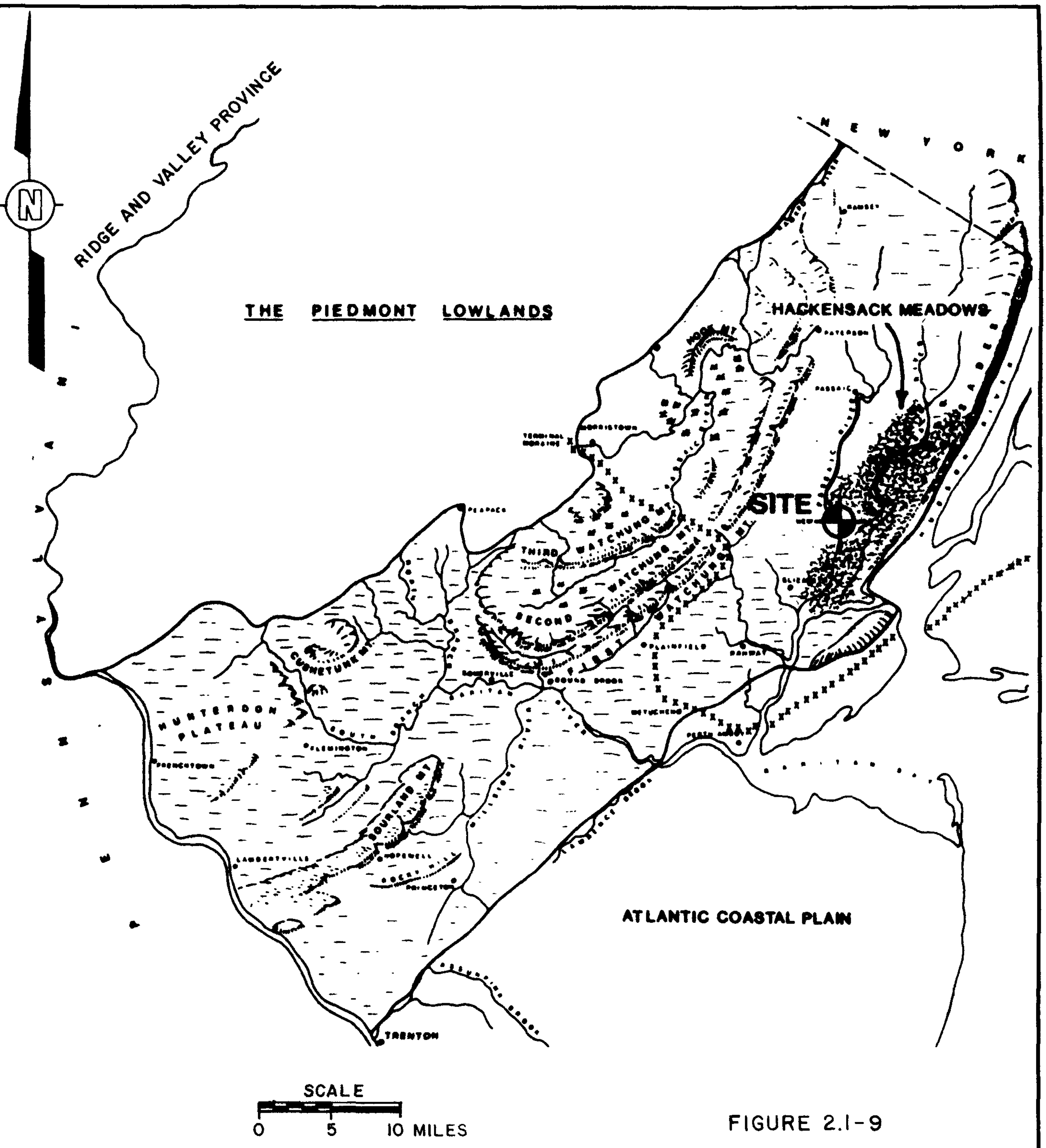

FIGURE 2.1-9

LANDFORM MAP OF THE PIEDMONT LOWLAND PROVINCE

80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

REFERENCE:

WOLFE, 1977.

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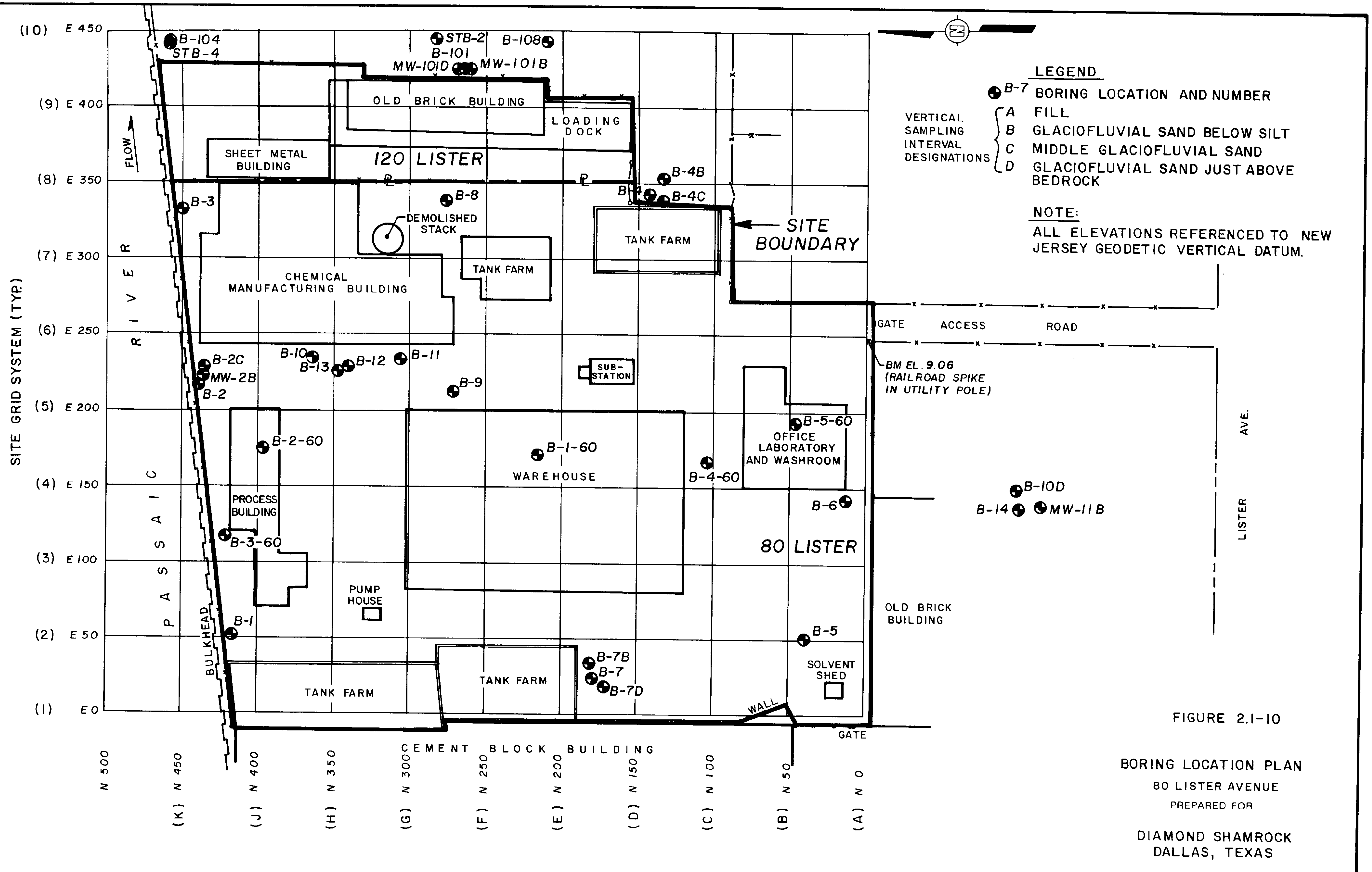

FIGURE 2.1-10

BORING LOCATION PLAN
80 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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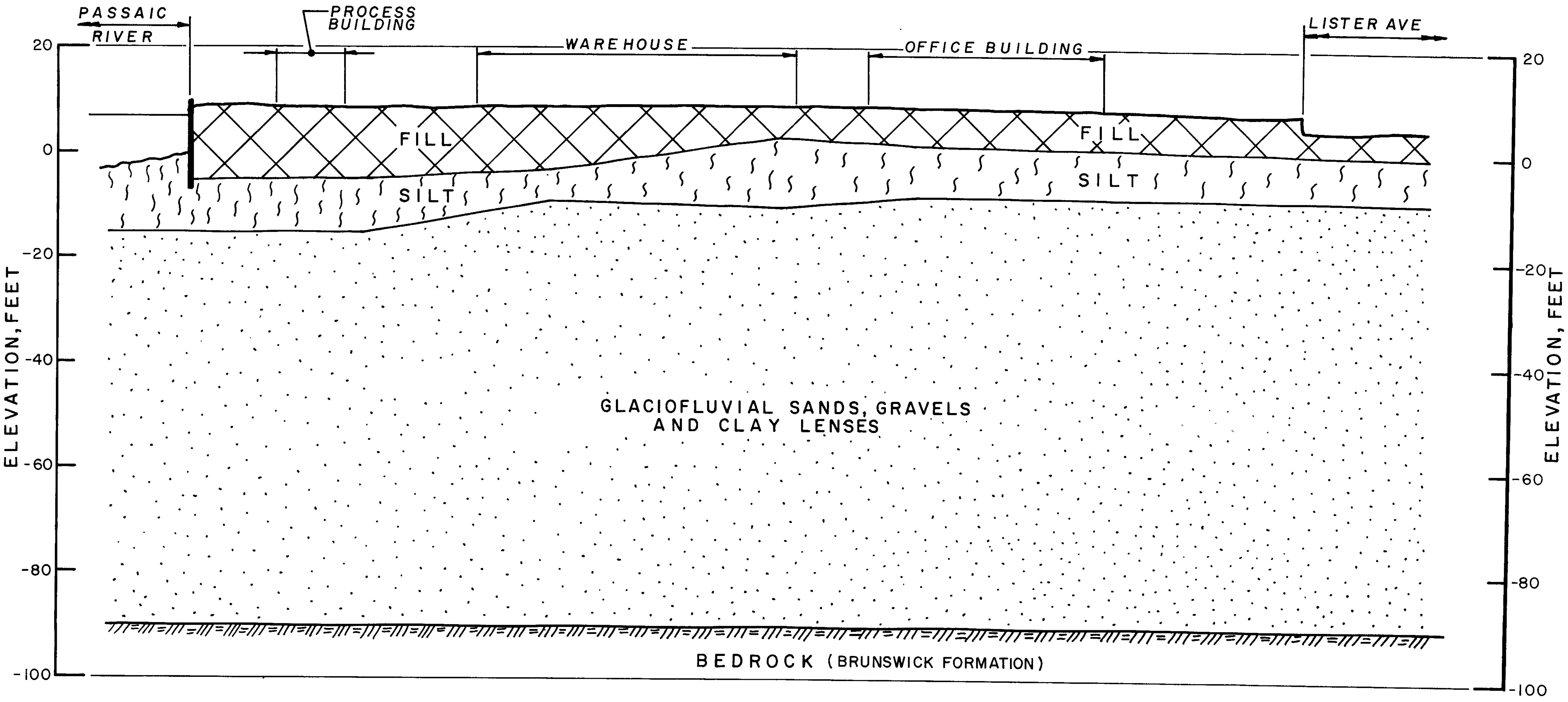
"Do Not Scale This Drawing

65360

DRAWN BY	J. LOGRECO 7 26 85	CHECKED BY	JAD	APPROVED BY	4-17-85	DRAWING NUMBER	850032-B2

DRAWN BY	D.Weick	2-4-85	CHECKED BY	APPROVED BY	JJO	[illegible]	2-15-85	[illegible]	DRAWING NUMBER	846248-B22



(CROSS SECTION LOOKING EAST)

VERTICAL SCALE 0 20 40 FEET

HORIZONTAL SCALE 0 60 120 FEET

VERTICAL EXAGGERATION 3X

NOTE:

ALL ELEVATIONS REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM

FIGURE 2.1-11

GENERALIZED GEOLOGIC CROSS SECTION OF SITE
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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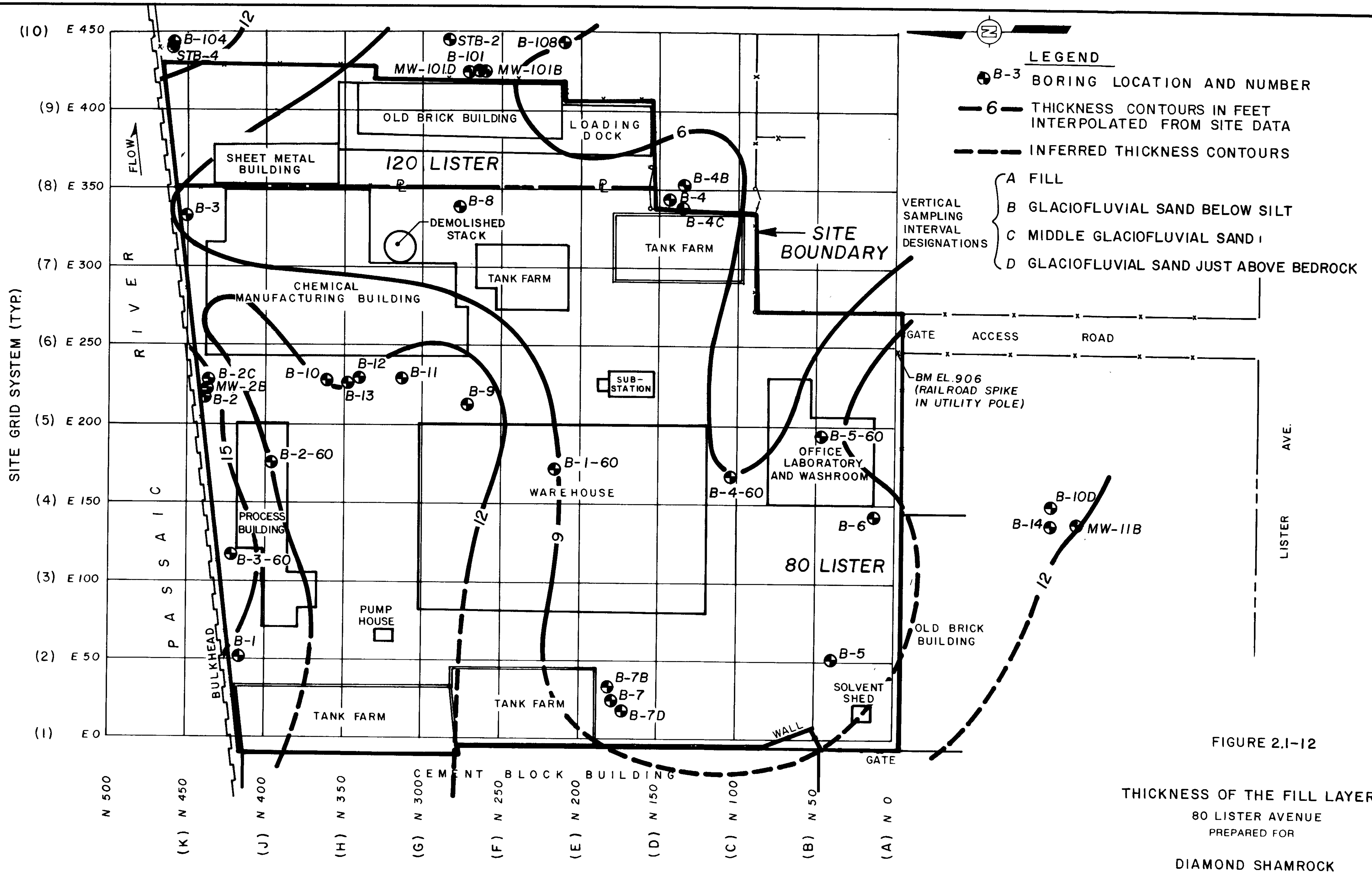
"Do Not Scale This Drawing"



NOTE:
ALL ELEVATIONS REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

SCALE
0 60 120 FEET

FIGURE 2.1-12

THICKNESS OF THE FILL LAYER
80 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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DRAWN BY	J. LOGRECO 7 26 85	CHECKED BY	VAD 4-17-85	APPROVED BY	[illegible]	DRAWING NUMBER	850032-B7

65360

Do Not Scale This Drawing

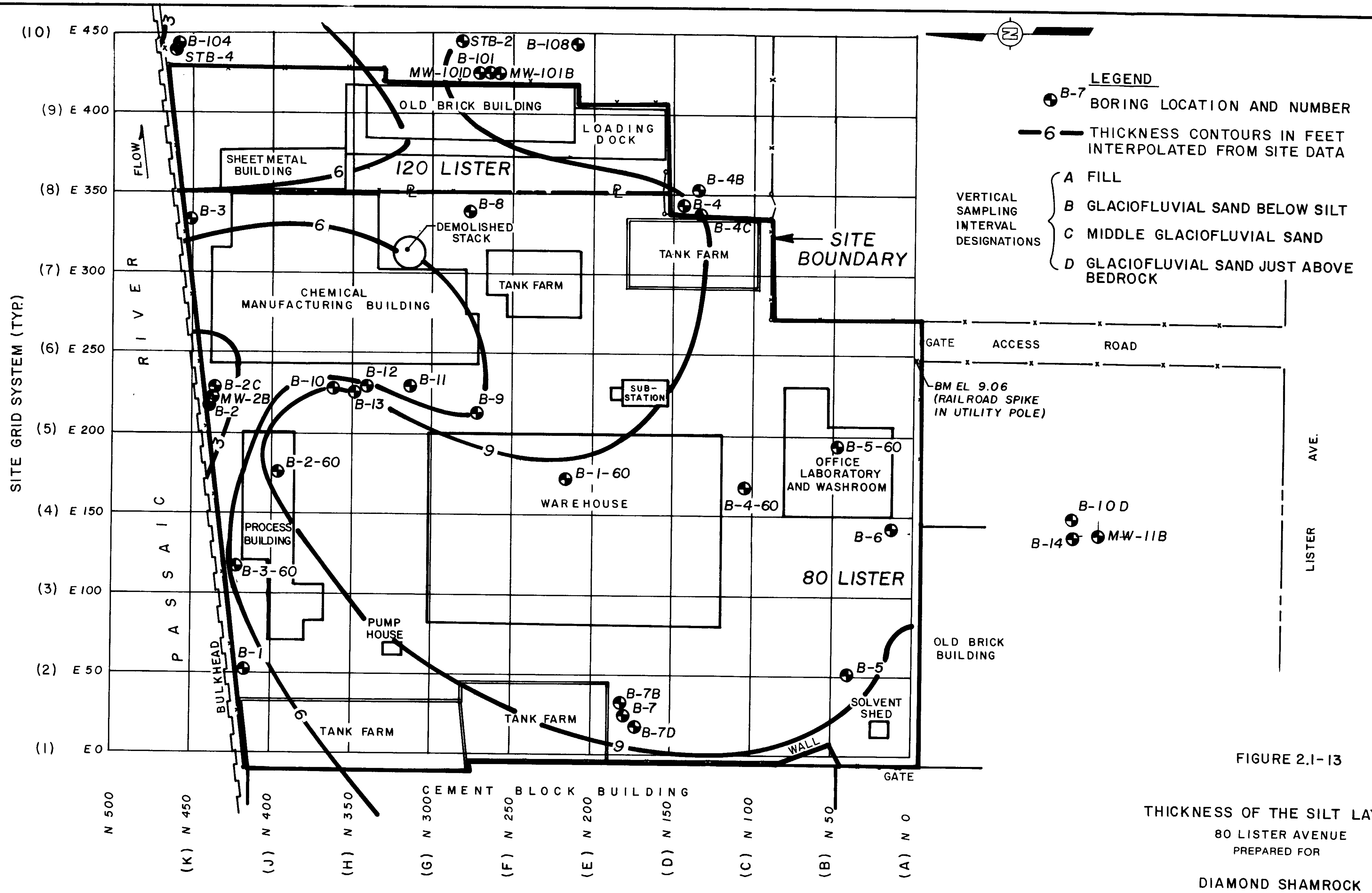

FIGURE 2.1-13

THICKNESS OF THE SILT LAYER
80 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

NOTE:
ALL ELEVATIONS REFERENCED TO
NEW JERSEY GEODETIC VERTICAL DATUM.

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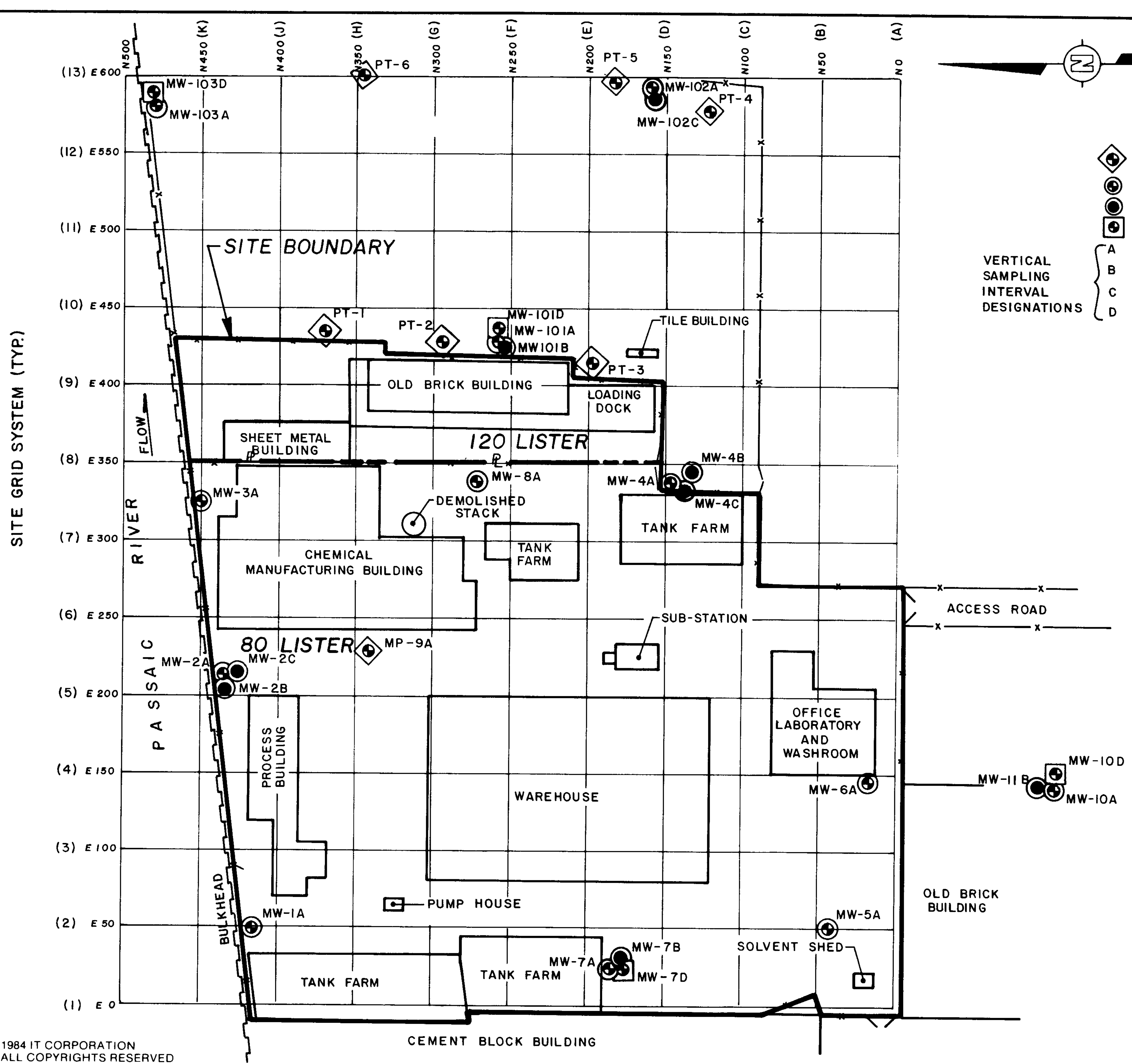
DRAWN BY	J. LOGRECO 7 26 85
CHECKED BY	UAD 9-12-85
APPROVED BY	
DRAWING NUMBER	850032-B8

65380

DRAWN BY	RW/mel	CHECKED BY	JAD	9-12-85	DRAWING NUMBER	850032-B27
	9-6-85	APPROVED BY	717	[illegible]		



LEGEND

- MP-9A PIEZOMETER LOCATION AND NUMBER
- MW-1A SHALLOW DEPTH MONITORING WELL
- MW-11B, MW-2C INTERMEDIATE DEPTH MONITORING WELL
- MW-7D DEEP MONITORING WELL

VERTICAL SAMPLING INTERVAL DESIGNATIONS
- A FILL
- B GLACIOFLUVIAL SAND BELOW SILT
- C MIDDLE GLACIOFLUVIAL SAND
- D GLACIOFLUVIAL SAND JUST ABOVE BEDROCK

SCALE

0 60 120 FEET

FIGURE 2.1-14

MONITORING WELL
LOCATION PLAN
80 AND 120 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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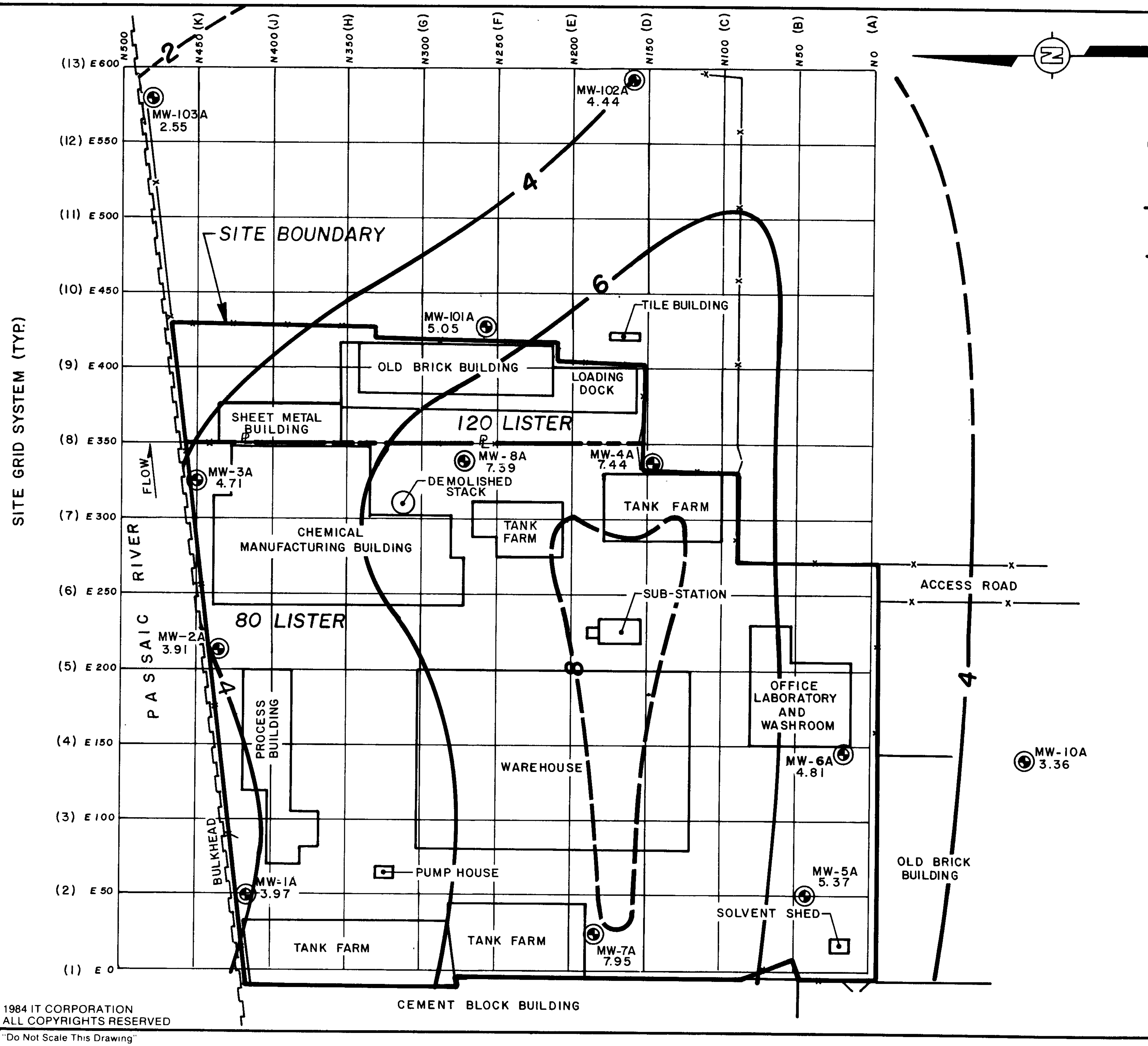
65360

"Do Not Scale This Drawing"



LEGEND

● MW-10A 3.36 SHALLOW DEPTH MONITORING WELL AND WATER LEVEL EL. ON MAY 18, 1985.

—4— POTENTIOMETRIC CONTOUR INTERPOLATED FROM SITE DATA

— — — INFERRED POTENTIOMETRIC CONTOUR

NOTE:

ALL ELEVATIONS REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

SCALE

0 60 120 FEET

FIGURE 2.1-15

SHALLOW MONITORING WELLS AND POTENTIOMETRIC CONTOURS OF GROUND WATER
80 AND 120 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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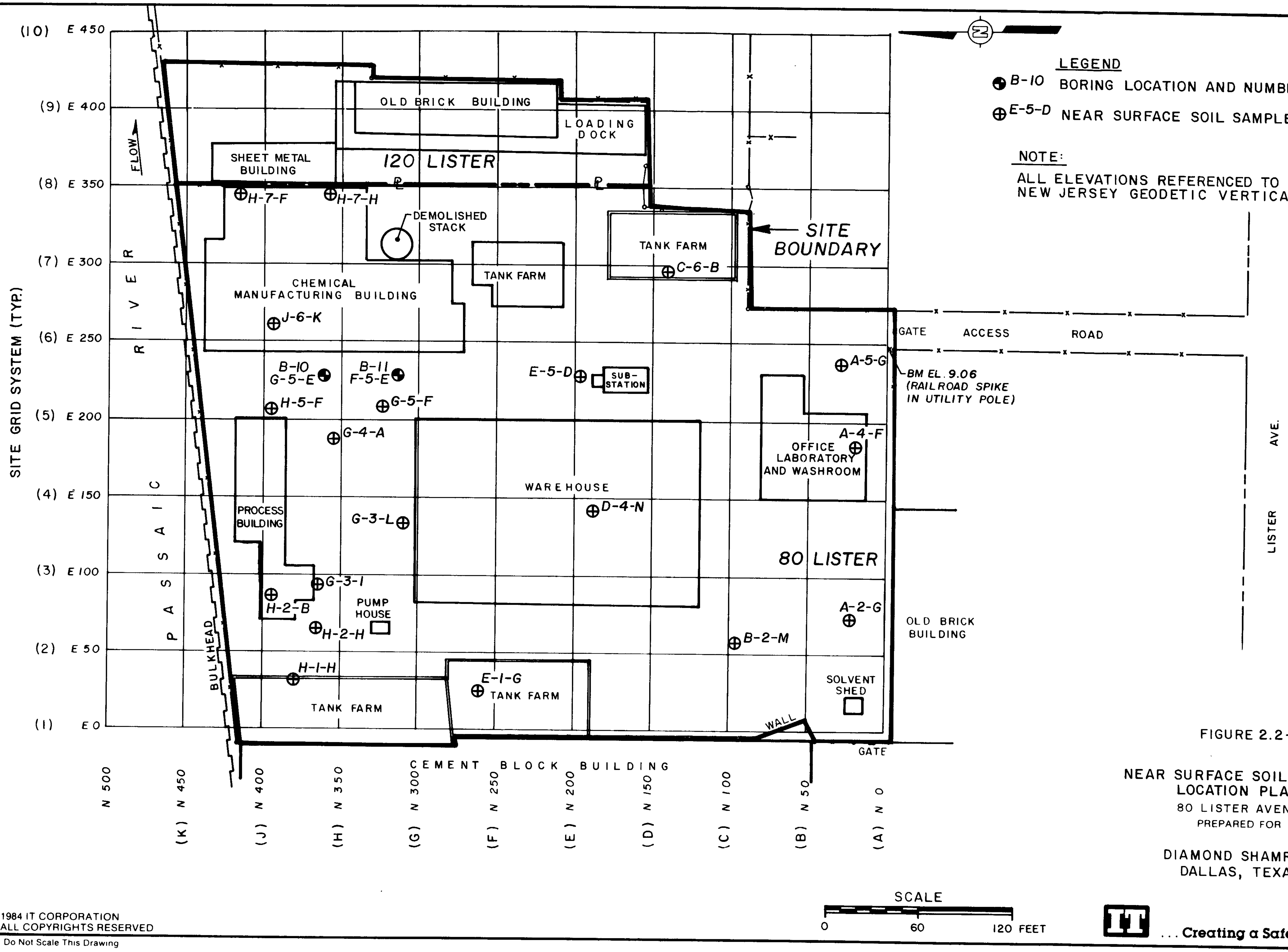
26B	DRAWN BY	J.LOGRECO 9/10/85	CHECKED BY / APPROVED BY	JAD	9-17-85	DRAWING NUMBER	850032-B28

65360



LEGEND

● B-10 BORING LOCATION AND NUMBER

⊕ E-5-D NEAR SURFACE SOIL SAMPLE AND NUMBER

NOTE:
ALL ELEVATIONS REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

FIGURE 2.2-1

NEAR SURFACE SOIL SAMPLE LOCATION PLAN
80 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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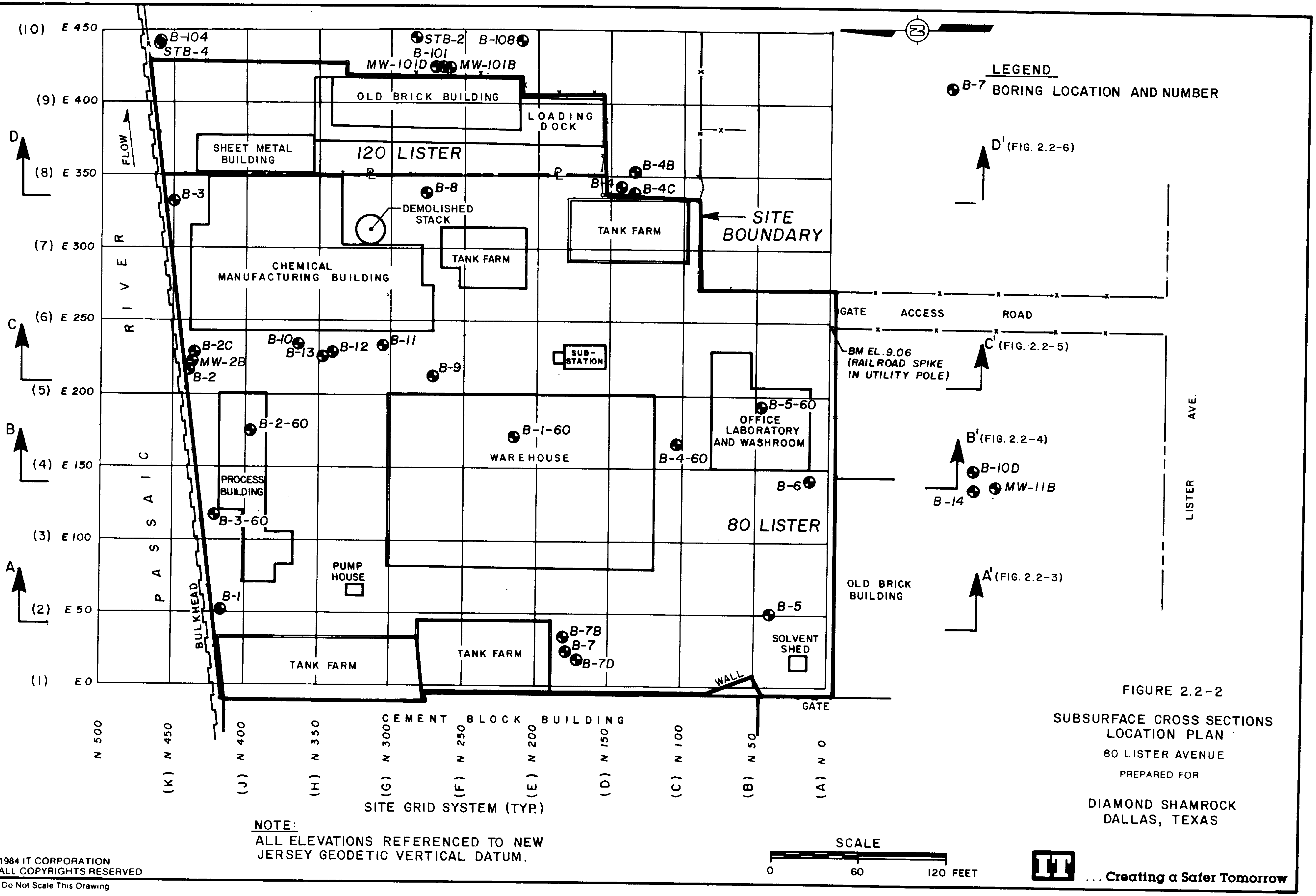
DRAWN BY	J. LOGRECO 7-26-85	CHECKED BY APPROVED BY	[illegible]	9-17-85	DRAWING NUMBER 850032-B6



NOTE:
ALL ELEVATIONS REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

FIGURE 2.2-2

SUBSURFACE CROSS SECTIONS
LOCATION PLAN
80 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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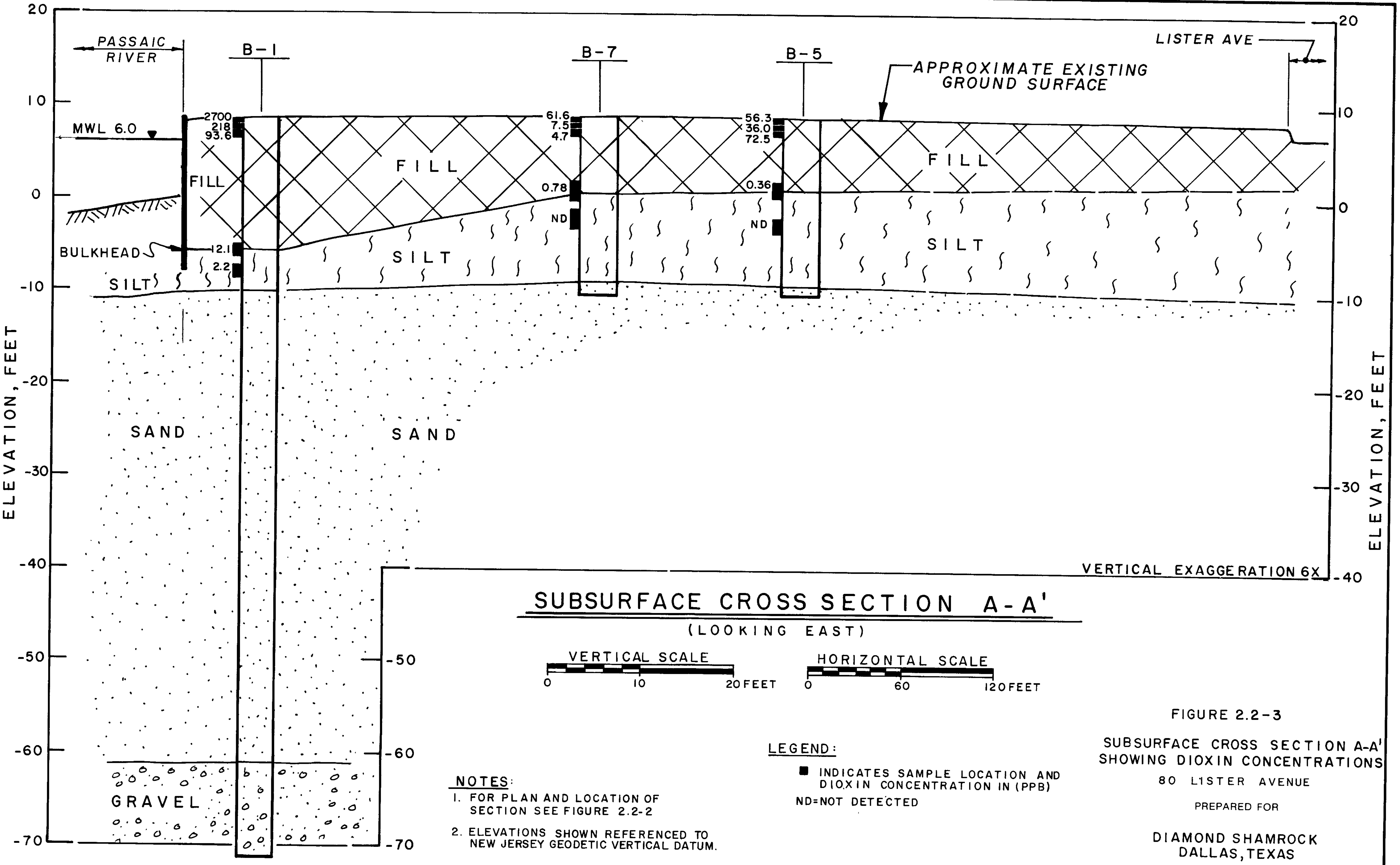
DRAWING NUMBER	850032-B5
CHECKED BY	
APPROVED BY	
DRAWN BY	J. LOBRECO 7-26-85

65360



SUBSURFACE CROSS SECTION A-A'

(LOOKING EAST)

VERTICAL SCALE 0 10 20 FEET

HORIZONTAL SCALE 0 60 120 FEET

NOTES:
1. FOR PLAN AND LOCATION OF SECTION SEE FIGURE 2.2-2
2. ELEVATIONS SHOWN REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

LEGEND:
- ■ INDICATES SAMPLE LOCATION AND DIOXIN CONCENTRATION IN (PPB)

ND=NOT DETECTED

FIGURE 2.2-3

SUBSURFACE CROSS SECTION A-A'
SHOWING DIOXIN CONCENTRATIONS
80 LISTER AVENUE

PREPARED FOR

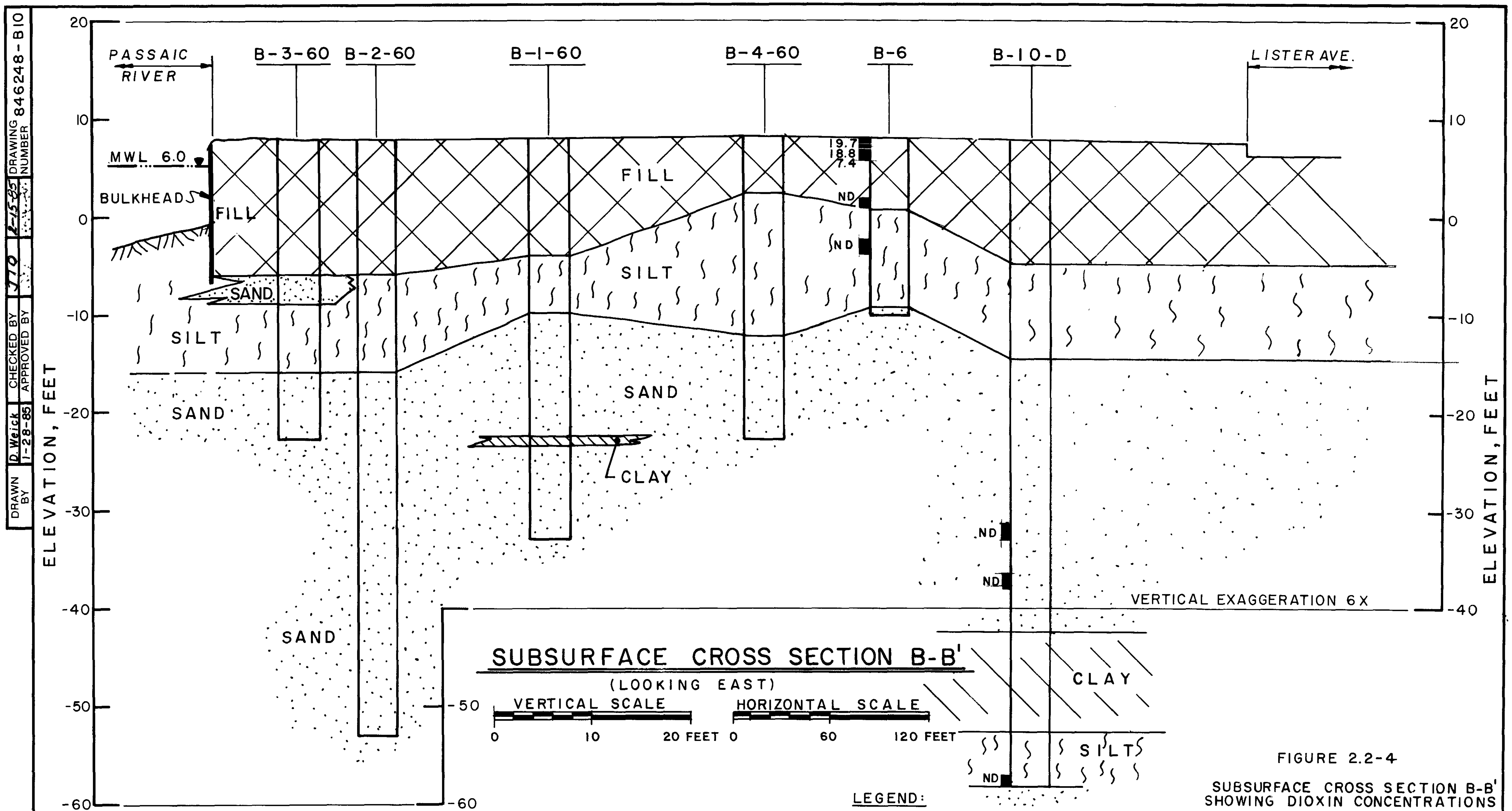
DIAMOND SHAMROCK
DALLAS, TEXAS

IT ...Creating a Safer Tomorrow

DRAWN BY	D. Weick	1-28-85
CHECKED BY APPROVED BY	J70	2-15-85
DRAWING NUMBER	846248-B9	

65360

DRAWN BY	D. Weick 1-28-85	CHECKED BY APPROVED BY	JTO	2-15-85	DRAWING NUMBER 846248-B10



LEGEND:

■ INDICATES SAMPLE LOCATION AND DIOXIN CONCENTRATION (PPB)

ND INDICATES NOT DETECTED

NOTES:

1. FOR PLAN AND LOCATION OF SECTION SEE FIGURE 2.2-2.
2. ELEVATIONS SHOWN REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

FIGURE 2.2-4

SUBSURFACE CROSS SECTION B-B' SHOWING DIOXIN CONCENTRATIONS

80 LISTER AVENUE

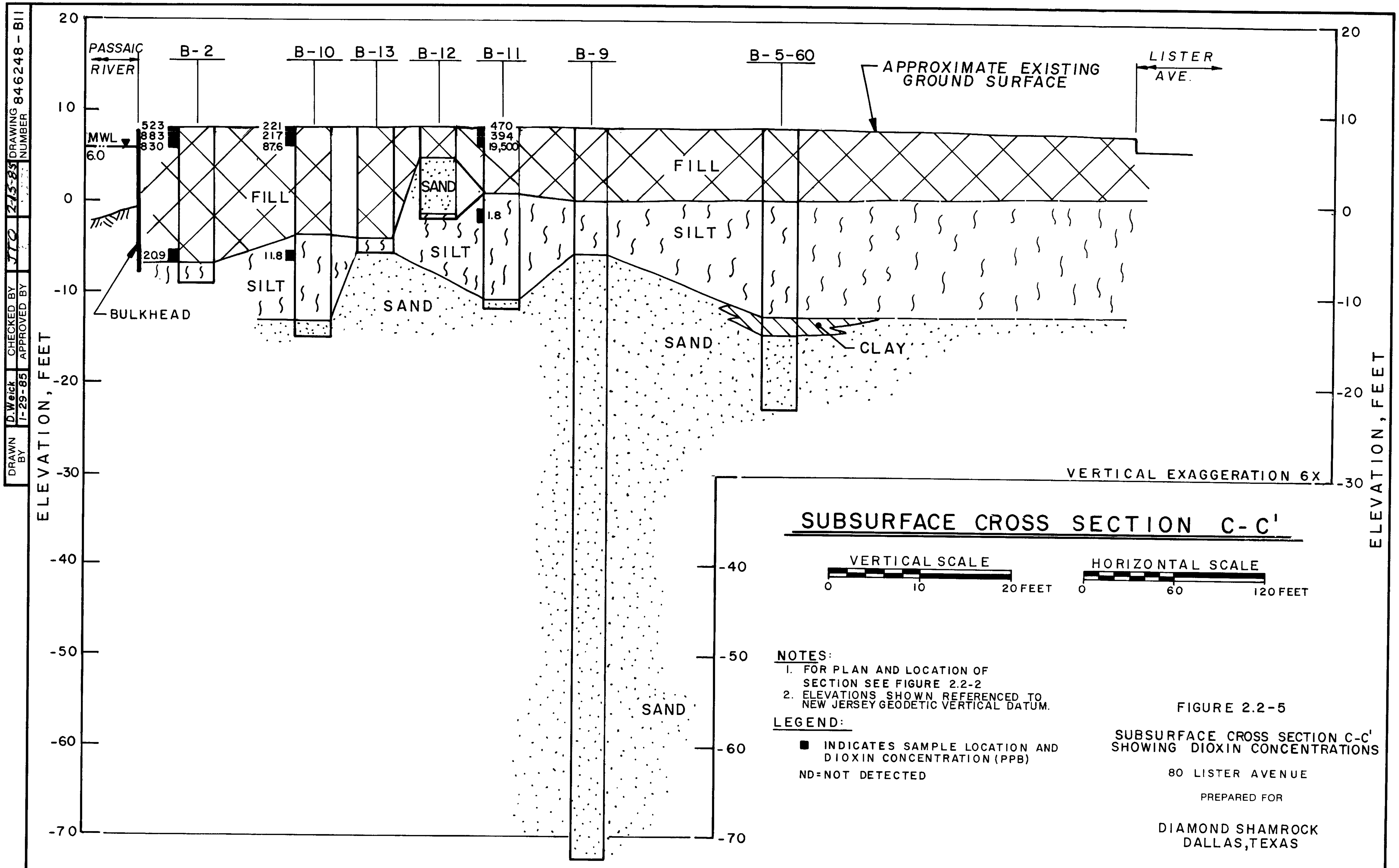
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

IT ...Creating a Safer Tomorrow

85360

"Do Not Scale This Drawing"



SUBSURFACE CROSS SECTION C-C'

VERTICAL SCALE
0 10 20 FEET

HORIZONTAL SCALE
0 60 120 FEET

NOTES:
1. FOR PLAN AND LOCATION OF SECTION SEE FIGURE 2.2-2
2. ELEVATIONS SHOWN REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

LEGEND:

■ INDICATES SAMPLE LOCATION AND DIOXIN CONCENTRATION (PPB)

ND=NOT DETECTED

FIGURE 2.2-5

SUBSURFACE CROSS SECTION C-C'
SHOWING DIOXIN CONCENTRATIONS

80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

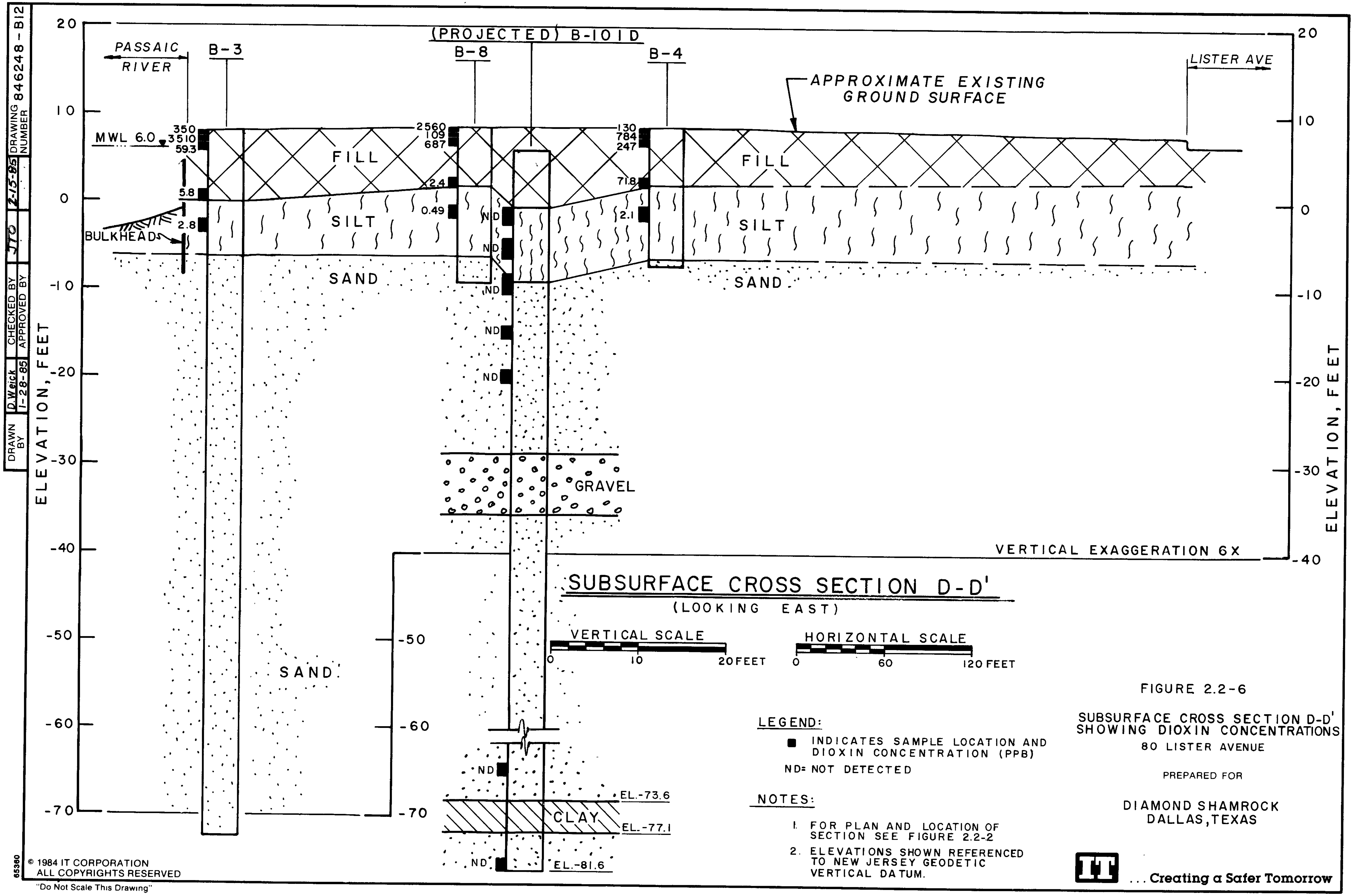
IT ... Creating a Safer Tomorrow

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
D.Weick 1-29-85	JTO	2-15-85	846248-B11

65360

"Do Not Scale This Drawing"

DRAWN BY	D.Weick 1-28-85	CHECKED BY APPROVED BY	JTO	2-15-85	DRAWING NUMBER 846248-B12



SUBSURFACE CROSS SECTION D-D'

(LOOKING EAST)

VERTICAL SCALE
0 10 20 FEET

HORIZONTAL SCALE
0 60 120 FEET

LEGEND:

■ INDICATES SAMPLE LOCATION AND DIOXIN CONCENTRATION (PPB)

ND= NOT DETECTED

NOTES:

1. FOR PLAN AND LOCATION OF SECTION SEE FIGURE 2.2-2
2. ELEVATIONS SHOWN REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM.

FIGURE 2.2-6

SUBSURFACE CROSS SECTION D-D'
SHOWING DIOXIN CONCENTRATIONS
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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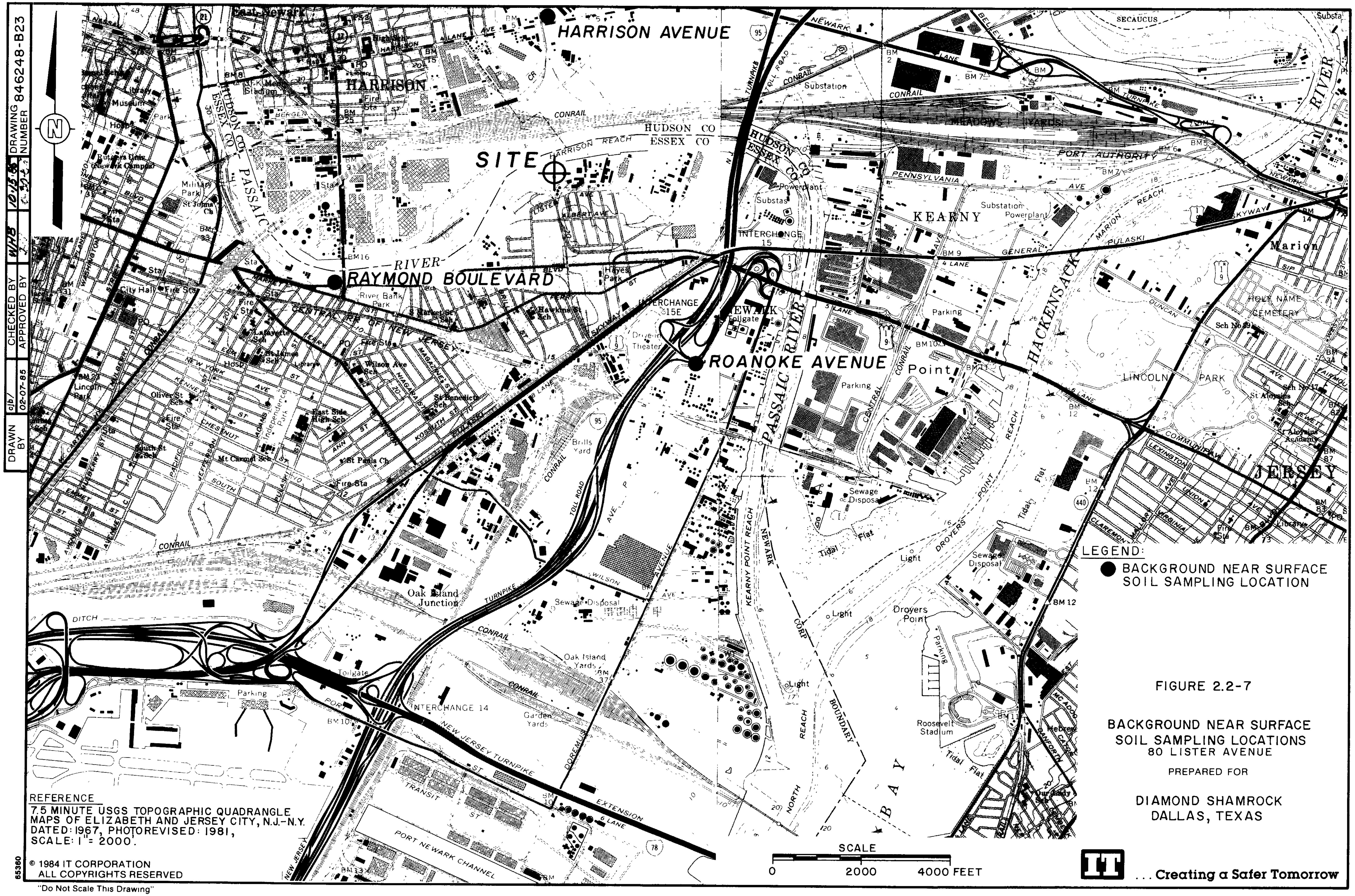
"Do Not Scale This Drawing"



LEGEND:

● BACKGROUND NEAR SURFACE SOIL SAMPLING LOCATION

FIGURE 2.2-7

BACKGROUND NEAR SURFACE SOIL SAMPLING LOCATIONS
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

SCALE
0 2000 4000 FEET

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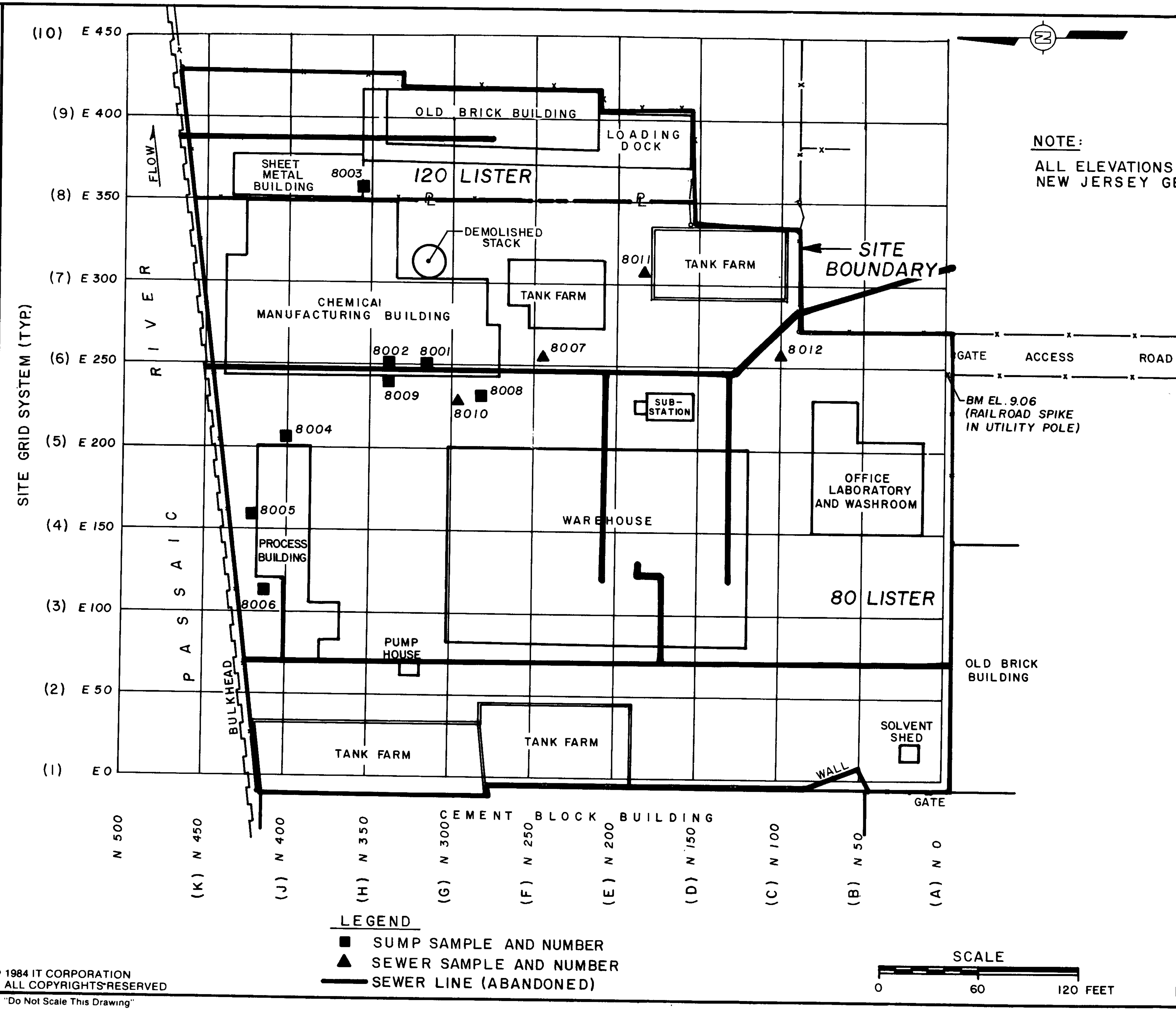
REFERENCE
7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE
MAPS OF ELIZABETH AND JERSEY CITY, N.J.-N.Y.
DATED: 1967, PHOTOREVISED: 1981,
SCALE: 1" = 2000'.

65360

"Do Not Scale This Drawing"

DRAWN BY	cjb/	CHECKED BY	WHB	10-15-85	DRAWING NUMBER 846248-B23
	02-07-85	APPROVED BY	[illegible]	[illegible]	



LEGEND
- ■ SUMP SAMPLE AND NUMBER
- ▲ SEWER SAMPLE AND NUMBER
- ━ SEWER LINE (ABANDONED)

NOTE:

ALL ELEVATIONS REFERENCED TO NEW JERSEY GEODETIC VERTICAL DATUM

FIGURE 2.2-8

SEWER AND SUMP SAMPLING LOCATIONS AND APPROXIMATE LOCATIONS OF ABANDONED SEWER LINES
80 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

IT ...Creating a Safer Tomorrow

DRAWN BY	J. LOGRECO 7-26-85	CHECKED BY	[illegible]	APPROVED BY	[illegible] 0-12-85	DRAWING NUMBER	850032-B26

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3.0

(1) [illegible] predictable

(2) Table 3.4-7 no excess cancer risk above 10^{-5}

[illegible] assumptions [illegible] non-acceptable effects
b) no risks greater than 10^{-5} for any [illegible]
c) [illegible] used a dioxin potency of 10^4 instead of 10^5, Did not do RA on air. Dioxin on particulate even though [illegible] [illegible]

3.0 RISK ASSESSMENT

3.1 APPROACH

The purpose of this risk assessment is to estimate the potential hazards to public health and the environment that may result from release of hazardous substances from the site as it exists today. This risk assessment will assist in establishing remedial objectives for long-term corrective action.

exceptional assumption

(3) [illegible] 3.4 [illegible]

p. 4-20 dioxin [illegible] in air 168 mg/[illegible] dioxin

Interim remedial measures to reduce the potential for chemical exposure were taken shortly after dioxin was detected in soil from 80 Lister Avenue. These measures consisted of installing a geofabric covering on the ground to reduce the potential for chemical transport via surface runoff and airborne particulates, a fence, and a 24-hour-per-day security guard to control access to the site.

14,000 mg/m dioxin

The site was the subject of an in-depth environmental study, the results of which were reviewed in the previous section of this feasibility study. The site investigation confirmed concentrations of dioxin in surface soils. Potential human exposures to chemicals contained in surface soils predominantly arise from wind and water erosion mechanisms. However, chemicals contained in subsurface soils generally present an exposure potential by leaching into ground and surface waters. These exposure pathways are addressed separately in this assessment.

0.25 ng TCDD/m³ is action level for 10^{-6} risk

office & lab building

(5) assumes an acceptable risk of 10^{-5}

(6) air exposure criteria: onsite offsite [illegible]

The approach taken in this assessment conforms to U.S. EPA guidance (Morgan, et al., 1984). Furthermore, the approach is biased toward health protection. For example, the fact that a chemical found on site is or is presumed to be a carcinogen is given more weight in the analysis than its prevalence on the site. This biased approach has the effect of emphasizing the long-term hazards in conclusions of the assessment process. Since each step builds on the previous one, the overall effect of biased assumptions is much more likely to overestimate risks than to underestimate them. These conservative health protective assumptions are summarized in Table 3.1-1. The rationale for each assumption is addressed on a case-by-case basis as they arise throughout this section. Overall, the biased approach more than compensates for risk assessment uncertainties and provides a conservative approach to the recommendations

(7) They use a Dioxin potency of 10^4 I have used 10^5

of remedial actions that follow. In this section, the worst-case approach has consistently been tailored to the specific site conditions, permitting a protective bias to be built into the calculations. In addition, these calculations are not intended to represent currently existing exposures or health risks. Rather, they are projections that may occur only if all the worst-case assumptions are realized.

Figure 3.1-1 is a flow chart illustrating the sequential approach taken in evaluating the potential risks posed by the site. The data base presented in the Site Evaluation Report and summarized in Section 2.0 is reviewed and combined with information on the environmental chemistry of each compound found (Section 3.2). Fifteen indicator chemicals (one from each of the 15 chemical classifications) were selected from the total of 70 susceptible to off-site migration and these represent the chemicals of major concern from the 15 chemical classifications. These 15 chemicals are used to perform a migration pathway analysis to characterize the possible magnitudes and patterns of off-site migration (Section 3.3). Potential exposure scenarios are developed and combined with data from the pathway analysis to make quantitative estimates of possible human exposure. Environmental and health criteria are compared with the exposure estimates to evaluate potential health risks (Section 3.4). Where the potential health risks appear unacceptably high, recommendations are made for reducing these potential risks (Section 3.5).

Sections 3.2 and 3.3 are supported by information contained in a separate report prepared by Woodward-Clyde Consultants entitled "Exposure Assessment for 80 Lister Avenue, Newark, New Jersey, August 1985."

3.2 SELECTION OF INDICATOR CHEMICALS

3.2.1 General

Indicator chemical selection is an objective screening process designed to reduce the total number of chemicals found at the site to a smaller, more manageable number for evaluation purposes. However, it is important that the selected chemicals still represent all the significant health and environmental risks of the groups so that the screening process does not affect the quality of the assessment. The first step is to identify the field of chemicals to be considered for selection. The total chemical inventory is comprised of all chemicals found at the site, including those containerized in 55-gallon drums. The fact that some of the chemicals are isolated in a secured drum storage area prevents their environmental transport in air and water with subsequent exposure of human receptors. Those that are not contained could migrate to off-site locations with potential exposure of receptors. These compounds thereby compose the "migratory" chemical inventory. This group is made up of 70 chemicals (Table 3.2-1) to be evaluated in this assessment.

The next step in conducting the risk assessment is to select a smaller number of representative compounds to facilitate analysis. Information concerning the physical-chemical properties (Table 3.2-2) associated with transport mechanisms and the toxicity was reviewed for the 70 chemicals amenable to air or water transport. These properties were collated to aid in the selection of a smaller number of indicator chemicals representing the 70 compounds for assessing risk. The screening criteria used to select this subset of chemicals include the extent of the site-related problem in the pertinent environmental media, toxicity, and factors that influence migration. This selection process was carried out separately for each potential route of exposure.

3.2.2 Selection Methodology

3.2.2.1 Overview

A set of selection criteria was applied to the 70 chemicals with migration potential for the purpose of obtaining a smaller group of indicator chemicals that adequately represent the hazards and potential exposure associated with the site (n equals 15). This approach is summarized in Table 3.2-3 and is described below:

- The 70 potentially mobile chemicals in Table 3.2-2 are separated into 15 different categories as listed in Table 3.2-3. They include 13 organic groups and two inorganic classes. Organic chemicals are grouped by toxicological characters and environmental behavior. Observed concentrations and distribution patterns were not a major consideration in the categorization rationale.

- Where a chemical class contained only one chemical, this chemical was automatically selected as the indicator chemical.

- The multiple member categories were evaluated for carcinogenicity. If only one chemical in a group was a known or suspected carcinogen, this compound was selected as the indicator. Carcinogenicity is based on the findings of the National Toxicology Program (NTP) as reported in the Third Annual Report on Carcinogens [U.S. Department of Health and Human Services (DHHS), 1984], and on the carcinogenic potency reported by the Carcinogen Assessment Group (U.S. EPA, 1984).

- Multiple chemical groups with more than one known or suspected carcinogen were then reviewed to select the compound with the highest reported carcinogenic potency.

- Multiple chemical categories with no known carcinogens were reviewed for (1) the degree of acute and chronic toxicity using American Conference of Governmental Industrial Hygienists (1984) Threshold Limit Values (TLV), U.S. EPA's Ambient Water Quality Criteria (AWQC), or National Interim Primary Drinking Water Standards (U.S. EPA); (2) water solubility; (3) volatility; and (4) the reported concentration in near-surface soils.

3.2.2.2 Categorization and Indicator Chemical Selection

Categorization of potentially mobile chemicals into groups and selection of an indicator chemical from each are summarized in Table 3.2-3. A detailed explanation of these processes is presented in Appendix A. The 15 representative chemicals and their index numbers are HCB (8); 2,4,6-TCP (1); cyanide (61); dioxin (63); 2-hexanone (40); arsenic (50); benzo(a)anthracene (16); 2,4-dimethylphenol (2,4-DMP) (3); bis(2-ethylhexyl) phthalate (DEHP) (14); phenol (62); benzene (29); chloroform (31); 2,4,5-T (48); DDT (42); and β-BHC (64).

3.2.3 Water

Potential pathways of exposure to chemicals from the site include surface water and subsurface (ground water) routes and will be discussed in Section 3.3. All of the 15 chemicals were judged in the context of potential exposure levels and corresponding health risks.

3.2.4 Air

Chemicals transported through air generally exist in two basic forms, a gas/vapor or a solid (particulates). The chemicals of concern that have the potential for significant volatilization under ambient conditions are 2,4-DMP (3); DEHP (14); benzene (29); chloroform (31); and 2-hexanone (40) (Table 3.2-4). The representative chemicals that are in a solid or particulate form are 2,4,6-TCP (1); HCB (8); benzo(a)anthracene (16); DDT (42); 2,4,5-T (48); arsenic (50); cyanide (61); phenol (62); dioxin (63); and β-BHC (64).

The exposure determination and risk assessment (Sections 3.3 and 3.4) will assess the potential hazard associated with vapors and particulates in the ambient air. In order to evaluate the worst case for air-related problems, representatives from each class were chosen using additional parameters as described below and summarized in Table 3.2-4.

3.2.4.1 Volatile Air Pathway Compounds

The compounds 2,4-DMP (3); DEHP (14); benzene (29); chloroform (31); and 2-hexanone (40) were ranked by decreasing vapor pressure as a high value is indicative of volatility. Benzene (29) and chloroform (31) were ranked significantly higher than 2,4-DMP (3) and DEHP (14). Benzene (29) is a human carcinogen and chloroform (31) an animal carcinogen. Based on their relatively high vapor pressures and carcinogenicity, both benzene (29) and chloroform (31) were selected as air pathway indicator chemicals. It should be noted that benzene (29) is a ubiquitous ambient air compound.

3.2.4.2 Particulate Air Pathway Chemicals

The representative chemicals that could adsorb on airborne particulates under normal conditions include 2,4,6-TCP (1); HCB (8); benzo(a)anthracene (16); DDT (42); 2,4,5-T (48); arsenic (50); cyanide (61); phenol (62); dioxin (63); and β-BHC (64). All but 2,4,5-T (48), cyanide (61), and phenol (62) have some reported carcinogenic potential. Dioxin was chosen to represent all particulates since its carcinogenic potency of eight is four or more orders of magnitude higher than the other compounds in this group.

3.3 EXPOSURE ASSESSMENT

3.3.1 Introduction

The purpose of this section is to describe the exposure pathways related to chemical transport and the potential exposure of receptors. The primary purpose of an exposure assessment is to determine the concentration levels over time and space in each environmental media where human and environmental receptors may come in contact with the chemicals of concern. The three components of an exposure assessment are:

- Pathway analysis
- Identification of exposure scenarios
- Estimation of exposure.

Each exposure pathway, such as surface runoff into the Passaic River or fugitive dust emission, is characterized using the elements listed above and the data base presented in Section 2.0. A generalized pathway receptor model is shown schematically in Figure 3.3-1. The potential exposure pathways subsequently described are as follows:

- Transport of adsorbed and dissolved chemicals in runoff and recharge into the Passaic River
  - Site surface
  - Fill area
- Ground water pathway
  - Vertical leakage
  - Off-site transport
- Air pathway
  - Volatile emissions
  - Particulate emissions.

A detailed analysis of the assumptions and parameters used in each and all calculations is presented in Appendix A. A review of all the pathways and corresponding models as shown in Figure 3.3-1 is given in this section.

The Passaic River comprises the northern boundary of the site. The river is a receptor and is being addressed separately. In regard to the river, the present report will address the potential for future migration of chemicals from the site into the river.

3.3.2 Runoff and Recharge Into the Passaic River

A schematic of the principal surface water and ground water transport pathways, including those associated with runoff and recharge, is shown in Figure 3.3-2 and listed in Table 3.3-1. These elements are discussed separately, beginning with surface runoff from the fill area and recharge into the Passaic River.

3.3.2.1 Surface Runoff

The runoff volume from a given surface during a given precipitation event depends on the intensity and amount of rainfall, ground surface properties, and initial moisture conditions. These factors were developed for site-specific circumstances to permit calculation of the potential runoff from direct precipitation on the site (Appendix A). The average storm in the area is calculated to have a rainfall of 0.37 inch with an average duration of 6.7 hours, for an average intensity of 0.055 inch per hour.

Two scenarios were developed to set boundaries on the actual site conditions relative to these factors. In the first case, the site is assumed to contain only pervious surfaces (soil), even though approximately 50 percent is pervious (Table 3.3-2). Direct precipitation and runoff from building gutters and surfaces will drain onto pervious surfaces, and therefore no runoff from the site is generated during an average storm. In this case, the precipitation rate does not exceed the infiltration capacity and all of the precipitation would enter the unsaturated zone. At the opposite extreme, the second case assumes all surfaces are paved and nearly all of the precipitation remains on the surface in puddles and/or leaves the site as surface runoff.

Most of the runoff will enter the Passaic River directly or through storm sewers. Discharge into the river will be diluted by mixing with river water both upstream and downstream, depending on tidal conditions. A simplified dilution analysis (Appendix A) permits calculation of a dilution factor for runoff from an average storm into the river to be approximately ten thousand times.

Using the hydrological factors discussed in the previous paragraphs, the site's capability for adsorbing all of the direct precipitation exceeds the expected precipitation from average storm events by a factor of 1.50. Therefore, in the absence of any significant hydraulic gradient, all of the precipitation can move vertically through the fill. This is consistent with the assumption that the entire site area (3.4 acres) is pervious. The precipitation rate (0.055 inch per hour) does not exceed the infiltration capacity of soils found at the site (0.24 inch per hour for soils with moderate infiltration rates) (U.S. Bureau of Reclamation, 1974). Therefore, surface runoff is not considered to be an important migration pathway.

3.3.2.2 Recharge From the Fill Area to the Passaic River

The most significant migration path for water at the site appears to be precipitation moving through the unsaturated zone, to the saturated ground water system in the fill, and then to the Passaic River to the north. Flow off site to the south may enter storm sewers and thence discharge to the river, infiltrate into sanitary sewers, travel horizontally further off site, or move into deeper ground water zones.

Assumptions and parameter values as specified in Appendix A permit a calculation of discharge to the river to the north (and an equal amount to the south) of 0.012 cfs for a maximum of 2,100 cubic feet per day leaving the site. The dilution factor for ground water flow near the point of discharge to the river is calculated to be approximately 6.1×10^6.

Table 3.3-3 provides calculated off-site concentrations of indicator chemicals in surface water. In-stream concentrations for the Passaic River were estimated by using the mean and maximum concentrations detected in the shallow wells and diluting by a factor of six million, which is the dilution factor for ground water flow from the fill area to the river. As shown in this table, DDT concentrations are relatively high, with a mean of 1.6 parts per million (ppm) and a maximum of 22 ppm. This maximum concentration occurred in Monitoring Well MW-2A, which is three to five feet from the bulkhead along the Passaic River. DDT is highly insoluble in water and is strongly adsorbed to soils or suspended particles containing some small carbon fraction. Consequently, the estimated concentrations of DDT in the river are values inferred using worst-case assumptions and do not represent measured or even expected values.

Monitoring Wells MW-1A and MW-3A, also along the bulkhead, did not contain DDT at detectable concentrations, indicating there may be a "hot spot" around Monitoring Well MW-2A. Since the interest was in loading from the entire site and not from one area, an average concentration based on values found in the three shallow wells was used for estimation purposes. An average concentration of 7,333 ppb, if the distribution of DDT in ground water is uniform, yields an estimated river concentration value of 0.044 ppb DDT.

3.3.3 Ground Water Pathway

There are two primary pathways when characterizing the potential for chemical migration in ground water:

- The rate (feet per year) of migration of chemicals in ground water as characterized by a plume with a moving front edge, from the fill area to the glaciofluvial sands below
- The rate (feet per year) of migration of chemicals from the glaciofluvial sands to areas where potential exposure may take place off site.

3.3.3.1 Vertical Migration Analysis

The vertical rate of migration must be defined to characterize off-site migration by the ground water pathway. The well data from the fill area and glaciofluvial sands indicate that the highest chemical concentrations are found in the fill area. Relatively low concentrations are found in the sands below, indicating that the rate of migration is slow and/or that the chemicals could originate from an off-site source.

The organic silt layer (or meadowmat) may serve as a barrier or constraint on vertical migration because of its low permeability of 10^{-3} foot per day, as shown in Section 2.1.6. In other words, the maximum vertical migration velocity of a chemical (no retardation factor) would be approximately one foot per year. Using an average silt layer thickness of nine feet, it would take a compound at least nine years to move through the silt layer to reach the top of the sands. However, for chemicals with high soil adsorption coefficients, such as DDT and dioxin, and thus high retardation factors (on the order of thousands), the rate of movement will be considerably slower.

A retardation factor is an estimate of the resistance to movement a chemical is likely to encounter in the environment in relation to ground water flow (i.e., the ratio of the velocity of ground water flow to the velocity of chemical movement). Retardation factors have not been used in estimating chemical transport in ground water to add conservatism and because of the unknown solvent influence that coexisting chemicals might have on the retardation. However, Jackson, et al. (1985), examined the leaching potential of dioxin-containing soil from the fill layer on 80 Lister Avenue. The effects of co-existing chemicals were also considered. The authors concluded that, although dioxin dissolution appears to be regulated by the presence of these other chemicals, the rates of dioxin movement are still very slow. Based on these data, a retardation factor of 2,500,000 for dioxin in 80 Lister Avenue soil was calculated in Appendix B. Retardation factors based on octanol-water partitioning coefficients were also estimated in Appendix B. The estimates were 340,000 and 38,000 for dioxin and DDT, respectively. The estimates strongly suggest that these two chemicals will move at least several thousands of times slower than ground water movement. Furthermore, the calculated sorption capacity of the soil greatly overwhelms the total quantity of dioxin estimated to be on the site and could prevent significant migration of this chemical.

As shown above, a hydraulic gradient exists between the ground water in the fill and the glaciofluvial sands below. A similar gradient has been found between the top and bottom of the sands. However, this downward gradient can be affected by a clayey silt layer that seems to average 15 feet in thickness at a depth of about 50 feet below the surface. This layer appears to be discontinuous across the site, thus it constitutes a partial barrier to downward migration of chemicals from the site.

3.3.3.2 Ground Water Transport Off Site

The potential for introducing chemicals to the aquifers below the fill exists even though the vertical migration of compounds is low. Therefore, an appraisal of chemical movement through the glaciofluvial sands and bedrock was performed to determine the future potential exposure, which may occur by ingestion of ground water that has moved off site. An overview of the geologic conditions of the glaciofluvial sands and bedrock aquifers is presented in Appendix A.

Unlike the upper fill zone where there are few, if any, pumping wells that affect flow, the hydrology in the glaciofluvial sands and bedrock aquifers in the site vicinity may be influenced or altered by high-capacity pumping wells. In order to determine potential exposure from ingestion of water, a high-capacity well was identified that potentially could be used as drinking water, and whose cone of influence encompasses the site. A list of the bedrock water supply wells within one mile of the site is presented in Appendix A, Table A-2 and Figure A-1.

Although ground water below the site can potentially be drawn into the pumping wells, concentrations of compounds will be considerably attenuated. Ground water from the site will constitute only a small portion of the total intake to the well because the total intake includes water from all radial directions. Using a simplified flow net analysis, described in detail in Appendix A, a worst-case estimate of the expected concentration of chemicals in product water was made. This analysis was used in conjunction with the area's hydrogeology to determine the pollution potential of the site to the production wells. Supply Well No. 9 (Table A-2) was determined to be the well most likely to intercept chemical migration due primarily to its proximity to the site. A dilution factor of 1,085 was estimated from the flow analysis (Appendix A) and this factor was used in further analyses.

This dilution factor is underestimated since it does not consider attenuation of chemicals through biological and physicochemical reactions with the soil or attenuation due to dispersion in the ground water. As discussed previously, these retardation and dispersion factors reduce concentrations of compounds during transport from the on-site area to the surrounding environment.

Furthermore, this analysis does not consider the effects of the subsurface stratigraphy. Discontinuous layers of silt and other low-permeability layers within the glaciofluvial sands would be obstacles to the downward migration of chemicals from the near-surface soils and their eventual migration to the primary potential ground water industrial use.

Data from the shallow wells (i.e., in the fill area) were used to develop the following analyses. Data from deep Monitoring Well 10-D show that dioxin (63) and DDT (42), the two major chemicals for ground water migration, were not present above the detection limit (detection limit of 0.005 ppb for dioxin and 0.1 ppb for DDT), thus further substantiating that these chemicals are relatively immobile.

The mean and maximum concentrations of the representative chemicals found in the shallow on-site well ground water samples are shown in Table 3.3-4. The maximum concentrations of compounds found in these samples were used to provide a very conservative starting point for evaluating worst-case concentrations off site. The mean concentrations provide a more reasonable basis for estimating off-site concentrations. Together, they provide a range of concentration estimates extending from a site-specific worst case to a more probable value.

3.3.4 Air Pathway

This section describes the characterization of exposure potential associated with airborne particulates emanating from buildings, and volatile emission releases. These pathways are indicated in the pathway model shown in Figures 3.3-1 and 3.3-2, and also in Table 3.3-1.

3.3.4.1 Particulates From Buildings

The primary chemical in the context of particulate releases is dioxin because of its low solubility and preference for sorption onto particulates. These contaminated particulates may be eroded from outside building surfaces and subsequently transported by the wind. The geofabric ground covering has essentially eliminated surface soil wind erosion. However, the potential for dioxin-containing particulate emissions from the outside surfaces of buildings and structures still exists.

A comprehensive assessment of particulate-associated dioxin emission and transport was not conducted at the site. However, thirty-one 24-hour air particulate samples were collected over a continuous 31-day period. The objective of the air sampling was to establish the "existing baseline conditions." The data were to be "used for comparison to the air monitoring to be conducted during future site remediation activities" (80 Lister Avenue Work Plan). To fulfill this objective, a single dioxin sampler was placed on top of the office/laboratory building. This location was chosen because it was out of the way of the intense on-site sampling activities, and the roof was judged the safest of the on-site structures for the frequent access to the samplers. Two important points must be considered: (1) the sampling protocol was designed as a screening process and (2) the sampling was not designed to project exposure levels either on or off site. Therefore, the sampling methodology was not appropriate for use in calculating risk estimates.

Ten of the 31 air particulate samples were analyzed for dioxin under the guidance of the NJDEP. The results of the air sampling performed during heavy site activity indicated that two samples of the ten analyzed had detectable dioxin concentrations. There is no information available regarding an emission source of the dioxin. It is unlikely that the measured airborne dioxin concentrations are from fugitive emissions of dioxin-containing soil since the site has been covered with geofabric continuously since 1983, including during the sampling. The source of the detected airborne dioxin could have been from an off-site source, from the buildings and structures on the site, or could have been a result of some of the site investigation activities.

For example, a wipe sample obtained from the roof parapet showed a dioxin concentration of 168 ng/m^2. Furthermore, the exhaust for the laboratory fume hood is also located on the roof. A wipe sample taken from inside the laboratory fume hood inside the building contained 14,000 ng/m^2 of dioxin. There was potential, due to an air updraft created by opening and closing doors in the building during site activities, to release dioxin-containing particulates from the fume hood into the air above the roof. Site activities carried out on the days when dioxin was measured in the air included wipe and chip sampling in the office building, drum sampling, sediment sampling, tank sampling, tank cleaning, and work on the dike.

The limited number of sample data points, the presence of site activities with significant disturbances, the location of the sample on top of the laboratory building, and the use of one sampler all contribute uncertainty to the significance of these numbers. Although quantitative estimates are not possible, the potential for release of dioxin-containing particulates from the buildings does exist. Of course, any building demolition or soil excavation would increase the potential for dioxin-containing particulate emissions. These disturbances should be given consideration in the evaluation of remedial alternatives.

3.3.4.2 Vapor Release

Soils on the site have the potential for releasing chemicals in the form of vapors notwithstanding the geofabric covering the site. An evaluation of the potential for volatilization of chemicals from the soil of the site was performed. This evaluation covered benzene (29) and chloroform (31), which are the more volatile of the indicator chemicals (Table 3.3-5). The on-site concentrations were estimated to be 0.083 mg/m^3 (max) and 0.042 mg/m^3 (midrange) for benzene (29); and 0.0042 mg/m^3 (max) and 0.0021 mg/m^3 (midrange) for chloroform (31).

Off-site concentrations at approximately 200 meters downwind from the site were estimated to be 0.033 μg/m^3 (max) and 0.016 μg/m^3 (midrange) for benzene (29); and 0.17 μg/m^3 (max) and 0.083 μg/m^3 (midrange) for chloroform (31). Volatile chemical releases would be expected to be higher during any on-site excavation activities.

Exposure estimations of vapor releases were also developed for a number of secondary pathways, i.e., evaporation from ground water and the evaporation from the Passaic River. The first potential air exposure to be considered is evaporation of volatile compounds from surface water to ambient air. Problems related to surface water were discussed in Section 3.3.2. Based on that analysis, precipitation would not exceed infiltration; precipitation from the average storm seeps into the ground and would enter the vadose (unsaturated) zone. No surface runoff is expected to leave the site. Under these circumstances, compounds may be washed off buildings and structures on site, but would not be carried off site. Some ponding of water would occur in some of the impervious soil surface areas and could contain some compounds. This would not be expected to result in significant emissions of chemicals to ambient air. Under average conditions, there will be no significant runoff from the site and potential exposure via the air route will be minimal. The chemical concentrations in the river that could result due to runoff would be extremely low. Consequently, the potential for exposure via the air pathway from surface water is expected to be minimal.

Another potential air exposure route is from volatilization of organic substances from ground water. This route considers chemicals migrating to off-site ground water wells that are used for various industrial or other purposes. In general, the exposures of concern (for the air route) would be vaporization of volatiles, which could occur depending on chemical levels and water use. Some activities, such as excavation, that enhance the release of volatile organics to air would be expected to have greater potential for exposure. A review of the estimated concentration levels of the representative chemicals (Table 3.3-4) in off-site wells indicates low levels in the low ppb for benzene (29) and chloroform (31). These low concentration estimates would have relatively low volatilization rates and result in extremely low concentrations in the air.

The third potential exposure route is transfer of volatile organics from the river to ambient air. This is a secondary route that conditionally requires the migration of volatile compounds to the river and then volatilization to enter the air medium. The transport mechanisms to the air could be volatilization from the water surface or mobilization of fugitive dust from deposits of material above the waterline on shore. A review of the estimated concentrations of the chemicals of concern in the river (Table 3.3-3) indicates extremely low estimated concentrations of these substances in the river water. Benzene (29) and chloroform (31) would be of greatest concern due to their higher vapor pressures. However, the estimated concentrations are quite low (2×10^{-4} ppb to 4.7×10^{-2} ppb) and would also be reduced by additional mixing and dilution during periods of turbulent flow of river waters. These low concentrations in the water would result in very low emission rates to the air, and after atmospheric advection and dispersion would result in extremely low concentrations of the chemicals in ambient air. Deposition of chemicals along the river shoreline would also result in negligible impacts on air quality concentrations. Many of the nonvolatile chemicals in the solid form would be expected to be suspended in the water column or settle out in sediments before becoming available for deposition along the shorelines. Any compounds deposited along the shoreline would be subject to the variable conditions of wind erosion and dispersion, but may be in the wetted condition that is not amenable to wind erosion. Tidal influences may expose the shoreline chemicals of concern but the twice daily changes in river water level will keep the sediment in a wet condition.

3.4 HEALTH RISK ESTIMATES

3.4.1 Approach

Health risk estimation quantitatively defines the general magnitude of human health risks posed by a defined set of circumstances. The precision of such estimates is limited by the size and quality of the data base. Often, these limitations can be overcome by defining a range of extremes. However, the overriding uncertainties associated with estimating risks that may result from chemical exposure are (1) the extrapolation of toxic effects observed at the high doses necessary to conduct animal studies to effects that might occur at much lower, "real world" doses, and (2) the extrapolation from animals to man (i.e., animals are different from man).

The approach taken in this assessment is biased toward health protective assumptions that exaggerate any risks. For example, in the estimation of potential exposures in Section 3.3, assumptions were consistently made that tend to overestimate rather than underestimate exposure whenever informational deficiencies were encountered. The health risk estimates described in this section are derived in a similar manner. This biased approach for managing uncertainties has a magnifying effect on the outcome of the risk assessment process. Since each step builds on the previous one, the overall result of biased assumptions is to overestimate risks rather than underestimate them. This worst-case approach compensates for risk assessment uncertainties and provides a safety margin for the recommendations of remedial actions that follow. In this section, the worst-case approach has consistently been modified to take into account specific site conditions while permitting a protective bias to be built into the calculations.

The emphasis of this exposure assessment is placed on public health risks. The population potentially at greatest risk is the occupational population in the immediate vicinity, and the closest residential population identified as being approximately 200 meters off site. The environment surrounding the site is highly industrialized, leaving the only potential environmental risk relating to the river. A separate characterization addressing dioxin in the river is ongoing.

3.4.2 Assumptions

3.4.2.1 Basic Assumptions

- At present, the site is covered with geofabric, is fenced, and has a 24-hour-per-day guard. This assessment assumes, for the purposes of judging exposure potential, that the present conditions will continue and there will be no further remediation of the site.

- The U.S. EPA and Center for Disease Control (CDC) dose-response relationships used to derive the carcinogenic potency index based on animal data are assumed to be valid for humans. This assumption has not been scientifically proven.

- Of the half-dozen dose-response extrapolation models available, the one selected by the enforcement agencies is designed to define an upper bound condition. It is likely to overestimate the actual risk rather than underestimate it.

- Cancer risks were estimated from projected dioxin exposures without making adjustments for bioavailability. Fries and Marrow (1975) report that 50 to 60 percent of the dioxin added to feed in rat studies is absorbed by rats. However, studies by Umbreit, et al. (1985), suggest that less than 0.05 percent of the dioxin in soil from 80 Lister Avenue is absorbed by rats.

- All estimated exposure levels are based on a chemical source that is not affected by chemical adsorption to soil. However, adsorption processes are known to greatly decrease the environmental mobility of materials such as dioxin and DDT.

- Only on-site air, soil, and ground water data were used to project anticipated off-site concentrations.

- Due to the proximity of residential populations to the site, the off-site air modeling projected exposure levels at a distance of only 200 meters. Individuals working or residing at distances greater than 200 meters would be exposed to considerably smaller concentrations.

- The site is assumed to be the sole source of the chemicals detected in the site investigation studies, even though it may not be the sole source of the chemicals detected in the environmental media.

3.4.2.2 Ground Water Exposure Pathway Assumptions

The level and character of chemicals in the ground water predicted for the closest well were developed in Section 3.3. This well is an industrial well. If the water were used for drinking, it would be ingested at the rate of no more than one liter per eight-hour day during the occupational lifetime of a worker. This is a health protective assumption used for estimating potential risk that may be present sometime in the future. However, there is no indication in the records of NJDEP that any well in the vicinity of the site is currently used for drinking water.

Estimation of excess cancer risk associated with the ground water exposure pathway is based on the following specific assumptions (derivation described in detail in Appendix A), in addition to the basic assumptions (Section 3.4.2.1) previously enumerated:

- Exposure duration = 9,240 days
- Ingestion rate = 1 liter per day
- Body weight = 70 kilograms
- Occupational lifetime = 38.5 years.

3.4.2.3 Air Exposure Pathway Assumptions

The air exposure pathway is considered for both on- and off-site exposure to vapors. On-site exposure is considered to be limited to the occupational population. Off-site exposure is developed for the closest residential population.

The following assumptions were used in developing the on-site air exposure (occupational scenario, Appendix A):

- Exposure duration = 9,240 days
- Inhalation rate = 10 cubic meters per day
- Body weight = 70 kilograms
- Occupational lifetime = 38.5 years
- Absorption fraction = 1.0 (vapor).

The off-site air exposure criteria and risk estimates used the following specific assumptions for residential exposure (Appendix A):

- Exposure duration = 25,550 days
- Inhalation rate = 23 cubic meters per day
- Body weight = 70 kilograms

- Lifetime = 70 years
- Absorption fraction = 1.0 (vapor).

A range is reported for the air pathway indicators due to the variability in chemical concentration in the soil and the range of exposure days caused by weather conditions. Values reported for dioxin also reflect the range in cancer potency values presently reported in the literature as well as these other factors.

3.4.3 Risk Estimates

The risk estimates projected in this section are calculated in Appendix A. They are based predominantly on cancer risk. Due to the regulatory agency's position on the nonthreshold theory of carcinogenesis, cancer risk estimation almost always results in the most stringent exposure criteria relative to other health effects. Therefore, by protecting against cancer, protection is afforded for other types of health end points.

The term "cancer risk" is defined as risks in excess of existing background incidence. This "excess" is an important distinction since the estimated "excess" risks discussed in several of the following sections are thousands-fold lower than the U.S. human population cancer incidence of 25 percent or the cancer mortality of 20 percent (Epstein, 1979).

The Carcinogen Assessment Group (U.S. EPA, 1984) uses a prescribed protocol to evaluate animal data to estimate human cancer potencies. The model utilized is the linearized multistage extrapolation model which provides a mathematical derivation of the dose-response slopes. This model is biased in that the scientific community recognizes that its use most likely overestimates the actual risk. Deliberate use of the model that is considered biased is a public policy decision by the agency. No altogether conclusive evidence exists to validate selection of any of the other models that yield lower estimates of risk. Furthermore, in publishing its slope estimates, the Carcinogen Assessment Group does not base the projections on the line of best fit of the data. Rather, it chooses to use the lower 95 percent confidence interval, which represents the "upper bound" of the risk estimate. This significantly exaggerates the risk related to a given dose or exposure. For example, the dose related to the lower confidence interval for dioxin is about tenfold lower than the line of best fit (Kimbrough, et al., 1984). Also, because the slope estimates are based on animal data, many compounds (e.g., dioxin) which have not been shown to be human carcinogens have higher potency values than those that are known human carcinogens (e.g., vinyl chloride).

The cancer potency slope for dioxin is reported to be 1.56×10^5 per milligram per kilogram per day $(mg/kg/day)^{-1}$. Kimbrough, et al. (1984), utilized the same methodology, the same animal study involving rats, and the same interpretation of the histopathological data to calculate the cancer potency slope. The Kimbrough approach differed from the EPA approach in that the curve fit was based on contaminant concentrations in the liver at terminal sacrifice rather than on administered dose. Also, Kimbrough, et al., did not adjust the data for high early mortality of the test animals. The result is that Kimbrough, et al. (1984), calculated the cancer potency slope to be almost 4.5 times lower (i.e., less potent) at 3.6×10^4 $(mg/kg/day)^{-1}$. The lower potency slope reflects a calculated decrease in the carcinogenic potency of the compound. Both of these models were developed using reputable and scientifically valid approaches. The differences reflect the unknown factors which govern the extrapolation of animal data to human exposure as mentioned earlier in this section. The risk estimates for dioxin are based on both of these cancer potency slope values.

A further consideration in the development of both of these potency slopes was the use of data from female rats only. Although use of all available data could lower the estimated potency values by about 500 times, the current models utilize only the most sensitive animal organ in which the health end point is manifested, in this case the female rat liver. To date, no cancer has been linked to dioxin exposure of people. Chloracne, a reversible skin condition, is the only adverse effect observed in humans that is consistently linked to dioxin exposures.

3.4.3.1 Recommended Exposure Criteria

Recommended exposure criteria for the indicator chemicals were developed separately for ground water and air. Detailed calculations for developing these criteria are shown in Appendix A and the results are summarized in

Table 3.4-1. A number of factors were considered in developing these criteria.

These recommended exposure criteria are based on a lifetime incremental risk level of 1 x 10^{-5} (i.e., 1 in 100,000) over background. This is an incremental risk; that is, an excess over the background cancer mortality frequency of one in five in the United States population (Epstein, 1979). In other words, a 10^{-5} incremental risk raises the cancer mortality risk factor from 0.20000 to 0.20001. This incremental risk may be put into perspective by comparing circumstances that relate to annual mortality risks on the order of 10^{-5} (Table 3.4-2). These include smoking 14 cigarettes (cancer, heart disease), living 20 days in New York (air pollution), and many others. Annual risks differ from lifetime risks by a factor of 70, assuming the average life expectancy is about 70 years. Therefore, a 10^{-5} lifetime risk, which is the basis of the recommended criteria in Table 3.4-1, is equivalent to about a 10^{-7} excess annual risk. This means that for strict comparative purposes with the recommended criteria, the exposure values in Table 3.4-2 could be lowered by a factor of 70. For example, a 10^{-5} excess lifetime risk of cancer due to smoking is theoretically accrued by smoking 0.2 cigarette per year for a total of 14 cigarettes in a lifetime.

This one in 100,000 risk level may be related directly to the site locale. The most recent census (1980) reports that within one-half mile from the site there are less than 1,000 residents (Table 3.4-3). Within a one-mile radius, there are 10,000 people. In this area, one would not be able to predict even one excess cancer incidence at these levels set for acceptable exposures. A population of 100,000 individuals spans a distance of 2.5 miles from the site. Exposure potential decreases with increasing distance from the source due to greater dilution of chemical concentrations which lowers the potential cancer risk. Before one would be able to project one excess cancer, a population of about 100,000 would need to be exposed daily to the defined exposure.

3.4.3.2 Health Risk Estimates for Noncarcinogens

The risks associated with the noncarcinogens DEHP (14); 2,4,5-T (48); cyanide (61); and phenol (62) are negligible since the projected exposure concentrations (Table 3.3-4) are far lower than recommended criteria in Table 3.4-1.

3.4.3.3 Excess Cancer Risk Estimates for Ground Water

The estimated concentrations of the indicator chemicals in the closest well as calculated in Section 3.3 and summarized in Table 3.4-4 were taken as the potential exposure concentration for the occupational population. These data were divided by the recommended acceptable exposure criteria (Table 3.4-1) to calculate an estimated excess cancer risk above background levels that might occur without further remediation of the site (Table 3.4-4). When the risks are projected to be greater than 1×10^{-5}, further evaluation of the exposure potential was conducted to determine the significance of the excess risk. The risk estimates are reported in ranges which reflect the ranges developed for Table 3.4-1. The ground water pathway exposure analysis projects a potential risk for dioxin (63) and DDT (42) in the off-site well. Dioxin is projected to provide an excess cancer risk of 9.5×10^{-5} to 8×10^{-3} and DDT 6.5×10^{-5} to 8.8×10^{-4}.

As discussed in Section 3.3.3, the exposure projections, and consequently the risk estimates, are calculated without considering the reduction that adsorption has on ground water transport of chemicals. For example, the retardation factor for dioxin was estimated to be in the range of 340,000 to 2,500,000 (Appendix B). Furthermore, the calculated sorption capacity of the soil may prevent significant migration of dioxin.

3.4.3.3.1 Arsenic in Ground Water

Cancer risks associated with arsenic (50) are considered differently from the other indicator compounds because arsenic is an element which occurs naturally in the earth's crust. Detection of arsenic on site must be considered in relation to background levels.

Throughout the United States, arsenic levels in soils span the range from 0.1 to 40 ppm. The average concentration is 6 ppm. Background soil samples taken throughout Newark as part of this project (reported in the 80 Lister Avenue Site Evaluation Report) show a range of 4.6 to 14 ppm, with a mean of 9 ppm. Forty-two soil samples taken on site from 0 to 2 feet show a range of 0.5 to 23 ppm with a mean of 7 ppm. These data fall well within both the national and local background ranges.

Arsenic has been measured in a number of rivers and lakes throughout the world (Ferguson and Gavis, 1972; Wagemann, 1978). In the United States, arsenic has been found in the range of 1.6 to 1,100 micrograms per liter (μg/ℓ). The average is around 1.6 to 64 μg/ℓ.

In the ground water on the site, arsenic was measured in the range of 15 to 630 μg/ℓ, with an average of 230 μg/ℓ. Although the ground water concentrations on site fall within the range for background in surface waters, the two sets of data are not strictly comparable. Arsenic is subject to changes in species which may affect observed concentrations in ground water. In addition, the analytical protocol specified analysis of a total sample with its associated particulate material. Therefore, the proportion that was soluble in the ground water samples is unknown.

Considered together, the available evidence for arsenic levels in the soils and the ground water indicates that arsenic on site falls within the ranges one might find anywhere as background in the United States. Therefore, no excess risk exists due to arsenic levels recorded on the site.

3.4.3.4 Health Risk Estimates for Air

Excess cancer risk estimates for the air pathway were determined by comparing the estimated exposure concentrations (Table 3.3-5) to the recommended acceptable exposure criteria (Table 3.4-1). The off-site acceptable exposure criteria were calculated using cancer potency slopes. The on-site exposure criteria are those set by the Occupational Safety and Health Administration (OSHA) for on-site occupational exposure. There are no excess cancer risks greater than 1×10^{-5} estimated for off-site chemical vapor exposure (Table 3.4-4). The on-site concentrations of benzene (29) and chloroform (31) are approximately three and five orders of magnitude, respectively, lower than OSHA standard for on-site occupational exposure.

3.4.3.5 Health Risk Estimates for Soil

Health risk estimates for soil were not made because the site is a secured area (fenced and manned by a 24-hour-per-day security guard) and is covered with a geofabric. These measures have essentially eliminated direct soil contact (via dermal or inhalation routes). However, site investigation activities have confirmed the presence of elevated concentrations of dioxin in the surface soils. Since the greatest potential for human exposure associated with unremediated sites is contact with surface soils, this exposure pathway should be eliminated on a long-term basis.

3.4.3.6 Additive Cancer Risks

When considering the potential for cancer incidence in a given exposure scenario, the estimated cancer risks may be considered additive. The additivity of cancer risks has a questionable theoretical basis. This is especially true of carcinogens that affect different organ systems and may have different mechanisms of action, as is the case with many of the carcinogens discussed in this risk assessment. The philosophy behind many regulatory agencies' desire to add cancer risks in health risk assessment is to provide an indication of the overall risk associated with circumstances that have the potential for multiple chemical exposures. Although it is an attractive concept to develop a "single number" that represents all the risks, this is not possible due to the complexities surrounding environmental contamination. Consideration of combined risks only applies when the potential multiple exposure involves common receptors in the same exposure scenario. However, there are many pathways and many exposure possibilities associated with the chemicals found on 80 Lister Avenue. The primary pathway of excess cancer risks is the ground water pathway. An approximation of the possible magnitude of combined cancer risks would require a considerable comparative analysis of each combination of carcinogens. The results would still be scientifically questionable, making such an analysis unwarranted.

3.5 CONCLUSIONS AND RECOMMENDATIONS

- Since the greatest potential for human exposure to dioxin arises from contact with the surface soils, it is recommended that potential exposure to surface soils from the site be eliminated.
- The buildings and other structures on site retain the potential for particulate-associated dioxin emissions. Therefore, the recommendation is that the buildings and structures be contained or demolished so as to prevent possible emissions of particulates.

- The ground water modeling coupled with the health risk assumptions project a potential for an elevated risk for dioxin (63) and DDT (42) in the closest off-site well at some time in the future. The recommendation is that mass transport of chemicals in the ground water be lowered to reduce the potential risk from ingestion of these compounds. The recommended conservative acceptable exposure level not to be exceeded for a 10^{-5} excess cancer risk is 5×10^{-5} μg/ℓ for dioxin (63) and 0.23 μg/ℓ for DDT (42).

- The worst-case modeling assumptions used in this section have resulted in a projection that estimated transport of site-associated compounds to the Passaic River (Table 3.3-4) could exceed the criteria for dioxin and DDT. It is recommended that the plans for remediation of the site include an awareness of the potential need for reducing mass transport of these compounds to the river.

- Remedial actions should be evaluated, selected, and implemented with appropriate consideration given to the increased potential for chemical exposure of surrounding populations that is inherent with some activities such as excavation.

The following sections will factor these recommendations into the selection of the appropriate remedial alternative for this site.

TABLES

TABLE 3.1-1

SUMMARY OF HEALTH PROTECTIVE ASSUMPTIONS

CHEMICALS

- In the selection of indicator chemicals, more weight was given to those classed as carcinogens than was given to prevalence of the chemicals on site (i.e., a small amount of a suspected or known carcinogen was more important than a larger quantity of a noncarcinogen).

- All chemicals found during site investigations were assumed to be from the site even though other sources may be involved.

EXPOSURE

- Surface Water Runoff - In one case, the site is considered totally pervious, which exaggerates ground water contamination. In a second case, the site is considered totally impervious, which exaggerates river contamination. Runoff was calculated not only from normal rainfall, but also from intense rainfall and flooding of the site which maximizes erosion and river contamination.

- Ground Water Exposure -

  (1) The nearest well was assumed to be for drinking water even though this is an industrial well and not permitted for drinking use (nor are any wells in the vicinity permitted for drinking water).

  (2) Factors that may dilute the chemicals through biological or physicochemical reactions were not taken into account. These factors would tend to reduce any calculated risk associated with the chemicals. In addition, the dilution factor is underestimated. The subsurface layers contained in the glaciofluvial sands which are discontinuous and would be obstacles to the downward migration of chemicals from the surface are not considered (even though dioxin and DDT have not been detected in the deep wells). In fact, the mean and maximum concentrations detected in the shallow on-site well samples were employed for making the exposure estimates.

TABLE 3.1-1
(Continued)

- Dioxin bioavailability was not factored into exposure estimates even though the dioxin in the Lister Avenue soil was about a thousand-fold less bioavailable to rats than was the dioxin in the feed from rat studies on which the cancer potency of dioxin is based. The adsorption of dioxin on soils greatly decreases the likelihood that these chemicals will be available for absorption into the body.

- Estimates of exposure are based on a site that contains an ongoing source (still producing) whereas, in reality, the site is inactive with a finite amount of chemicals.

CANCER POTENCY

- The dose-response relationships for materials such as DDT and dioxin that are based on animal data are assumed to be valid for humans even though extensive studies have not linked human cancers with exposure to these compounds.

- The cancer risk assessment model used for low dose extrapolation was the linearized multistage model which tends to overestimate risk. Other models are not as conservative in all respects. In addition, the line of best fit was not used, but the lower 95 percent confidence interval was used which further exaggerates risk.

TABLE 3.2-1

NAMES AND ASSIGNED INDEX NUMBERS OF ALL CHEMICALS SUSCEPTIBLE TO OFF-SITE TRANSPORT

CAS NO.(a)	CHEMICAL NAME	RISK ASSESSMENT INDEX NO.
83-32-9	Acenaphthene	6
208-96-8	Acenaphthylene	20
67-64-1	Acetone	37
959-98-8	Alpha-endosulfan	45
120-12-7	Anthracene	21
	Antimony	49
	Arsenic	50
71-43-2	Benzene	29
56-55-3	Benzo(a)anthracene	16
205-99-2	Benzo(b)fluoranthene	18
191-24-2	Benzo(g,h,i)perylene	22
50-32-8	Benzo(a)pyrene	17
65-85-0	Benzoic acid	4
100-51-6	Benzyl alcohol	70
319-85-7	Beta-BHC (beta-hexachlorocyclohexane)	64
	Beryllium	51
117-81-7	Bis(2-ethylhexyl)phthalate	14
78-93-3	2-Butanone	38
	Cadmium	52
75-15-0	Carbon disulfide	39
108-90-7	Chlorobenzene	30
67-66-3	Chloroform	31
91-58-7	2-Chloronaphthalene	69
95-57-8	2-Chlorophenol	68
	Chromium	53
	Copper	54
218-01-9	Chrysene	19
	Cyanide	61
94-75-7	2,4-D (2,4-Dichlorophenoxyacetic acid)	47
94-82-6	2,4-DB (2,4-Dichlorophenoxybutyric acid)	66
72-54-8	4,4'-DDD (Dichlorodiphenyldichloroethane)	44
72-55-9	4,4'-DDE (1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethylene	43
50-29-3	4,4'DDT (Dichlorodiphenyltrichloroethane)	42
75-99-0	Dalapon	46
132-64-9	Dibenzofuran	27
1918-00-9	Dicamba	65
95-50-1	1,2-Dichlorobenzene	9
541-73-1	1,3-Dichlorobenzene	10
106-46-7	1,4-Dichlorobenzene	11
120-33-2	2,4-Dichlorophenol	2
105-67-9	2,4-Dimethylphenol	3
84-74-2	Di-N-butylphthalate	15
88-85-7	Dinoseb (DNBP)	67
100-41-4	Ethylbenzene	32
206-44-0	Fluoranthene	12
86-73-7	Fluorene	23
118-74-1	Hexachlorobenzene	8
519-78-6	2-Hexanone	40
193-39-5	Indeno(1,2,3-CD)pyrene	25
	Lead	55
	Mercury	56
91-57-6	2-Methylnaphthalene	28
75-09-2	Methylene chloride	33
91-20-3	Naphthalene	13
	Nickel	57
85-01-8	Phenanthrene	24
108-95-2	Phenol	62
129-00-0	Pyrene	26
	Selenium	58
	Silver	59
93-76-5	2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)	48
1746-01-6	2,3,7,8-TCDD (2,3,7,8-Tetrachlorodibenzo-p-dioxin)	63
79-34-5	Tetrachloroethane	34
108-88-3	Toluene	36
120-82-1	1,2,4-Trichlorobenzene	7
79-01-6	Trichloroethene	35
95-95-4	2,4,5-Trichlorophenol	5
88-06-2	2,4,6-Trichlorophenol	1
95-47-6	Xylene	41
	Zinc	60

(a)CAS numbers are assigned by Chemical Abstracts Service to organic compounds only.

TABLE 3.2-2

PHYSICAL AND CHEMICAL CHARACTERISTICS OF ORGANIC CHEMICALS SUSCEPTIBLE TO OFF-SITE TRANSPORT(a)

INDEX NO.	NAME	MOLECULAR WEIGHT	SOLUBILITY IN WATER (mg/L)	VAPOR PRESSURE (mm Hg)	LOG OCTANOL/ WATER PARTITION COEFFICIENT	SPECIFIC GRAVITY	REF.
1	2,4,6-Trichlorophenol	197.46	800	1 (76.5°)	3.38	1.49 (75°)	1,5
2	2,4-Dichlorophenol	163.01	4,500	1	2.75	1.383(60°)	1,5
3	2,4-Dimethylphenol	122.16	17,000	0.062	2.50	1.036	1,5
4	Benzoic Acid	122.1	2,900	1 (96°)	1.87	1.27	1,4
5	2,4,5-Trichlorophenol	197.46	1,190	1 (72°)	3.06, 3.72	1.678	1,4
6	Acenaphthene	154.21	3.88	0.03	4.33	1.069	1,5
7	1,2,4-Trichlorobenzene	181.46	19	0.42	4.26	1.454	1,4,5
8	Hexachlorobenzene	284.80	0.004, 0.006, 0.11	10^{-5}	6.18	2.044	1
9	1,2-Dichlorobenzene	147.01	100, 145	1, 1.5	3.38	1.305	1
10	1,3-Dichlorobenzene	147.01	123, 69	2.28	3.38	1.288	1,5
11	1,4-Dichlorobenzene	147.01	49, 79	0.6	3.39	1.458	1
12	Fluoranthene	202	0.1	$10^{-6} - 10^{-4}$	5.33	-	1,5
13	Naphthalene	128.16	30	0.492	3.01, 3.45	1.152	1,5
14	Bis(2-ethylhexyl)phthalate	390.54	0.285	2×10^{-7}	5.3, 8.73	0.99	1,5
15	Di-n-butylphthalate	278.34	400, 4,500	0.1 (110°)	5.2	1.0465	1,5
16	Benzo(a)anthracene	228	0.01, 0.04	5×10^{-9}	5.61	-	1,5
17	Benzo(a)pyrene	252.3	0.003	5×10^{-9}	6.5	-	1,2,5
18	Benzo(b)fluoranthene	252	-	$10^{-11} - 10^{-6}$	6.57	-	1,5
19	Chrysene	228.2	0.006	$10^{-11} - 10^{-6}$	5.61	1.274	1,5
20	Acenaphthylene	152.2	3.93	0.001 - 0.01	4.07	0.899	1,5
21	Anthracene	178.23	0.075	0.04	4.45	1.25	1,4
22	Benzo(g,h,i)perylene	276	0.00026	10^{-10}	7.10	-	1,2,5
23	Fluorene	166.21	1.9	0.012	4.47, 4.12	1.202	1,2,3
24	Phenanthrene	178.22	1.18, 0.816	0.0034	4.46	1.025	1,5
25	Indeno(1,2,3,-CD)pyrene	276.34	-	10^{-10}	7.66	-	1,5
26	Pyrene	202.26	0.16, 0.032	6.85×10^{-7}	4.88	-	1,2,4,5
27	Dibenzofuran	168.2	-	-	-	-	4
28	2-Methylnaphthalene	143	-	-	-	0.994	1

TABLE 3.2-2
(Continued)

INDEX NO.	NAME	MOLECULAR WEIGHT	SOLUBILITY IN WATER (mg/L)	VAPOR PRESSURE (mm Hg)	LOG OCTANOL/ WATER PARTITION COEFFICIENT	SPECIFIC GRAVITY	REF.
29	Benzene	78.11	1,780	76	2.13	0.8786	1
30	Chlorobenzene	112.56	500	8.8, 11.8	2.84	1.1066	1
31	Chloroform	119.38	8,000, 9,300	160	1.97	1.489	1
32	Ethylbenzene	106.17	152	7	3.15	0.867	1
33	Methylene chloride	84.93	20,000	349	1.25	1.326	1,5
34	1,1,2,2-Tetrachloroethane	167.86	2,900	5	2.56	1.60	1,5
35	Toluene	92.1	515	22	2.69	0.867	1
36	Trichloroethene	131.5	1,100	60	2.29	1.46	1,5
37	Acetone	58.08	Miscible	270 (30°)	-0.24	0.791	1,3
38	2-Butanone	72.1	353,000 (10°)	77.5	0.26	0.805	1
39	Carbon disulfide	76.14	2,300	260	1.84, 2.16	1.263	1
40	2-Hexanone	100.2	35,000	2	1.38	0.830 (0°)	1
41a	o-Xylene	106.17	175	5	2.77	0.88	1
41b	m-Xylene	106.17	-	6	3.20	0.864	1
41c	p-Xylene	106.17	198	6.5	3.15	0.86	1
42	4,4'-DDT	354.5	0.003	2×10^{-7}	6.19	-	1,5
43	4,4'-DDE	318.0	0.040, 0.065	6.5×10^{-6}	4.28, 5.69	-	1,5
44	4,4'-DDD	320.1	0.16	10.2×10^{-7} (30°)	5.99	-	1,5
45	Alpha-endosulfan	406.95	0.15, 0.6	10^{-5}	3.55	-	3,5
46	Dalopon	142.97	500,000	-	-	1.4014	1,3
47	2,4-D	221.04	890	-	2.81	1.416	1,3
48	2,4,5-T	255.49	278	-	-	1.80	1,3
62	Phenol	94.11	93,000	0.2	1.46	1.07	1,5
63	2,3,7,8-TCDD	322	0.0002	$10^{-6} - 10^{-7}$	7.14	-	1,5,6
64	Beta-BHC	290.85	5.0	2.8×10^{-7}, 5×10^{-3}, 0.17	3.80	-	1,5
65	Dicamba	221.04	7,900	2×10^{-5}	-	-	1,2,3
66	2,4-DB	249.09	46	-	-	-	2

TABLE 3.2-2
(Continued)

INDEX NO.	NAME	MOLECULAR WEIGHT	SOLUBILITY IN WATER (mg/L)	VAPOR PRESSURE (mm Hg)	LOG OCTANOL/ WATER PARTITION COEFFICIENT	SPECIFIC GRAVITY	REF.
67	Dinoseb (DNBP)	240.22	50	5 X 10^{-5}	-	1.29 (30°)	1,2,3
68	2-Chlorophenol	128.56	28,500	5	2.15, 2.19	1.241 (18°/ 15°)	1,5
69	2-Chloronaphthalene	162.61	6.74	0.017	4.12	-	2,5
70	Benzyl alcohol	108.13	35,000	1 (58°)	1.10	1.05 (15°)	1

(a)Properties are given for temperatures in range of 20 to 25°C. If property was measured at other temperature, temperature is given in parentheses.

Source: (1) Verschueren, 1983.
(2) Windholz et al., 1983.
(3) Lyman et al., 1982.
(4) Sax, 1979.
(5) USEPA, 1979.
(6) ASME, 1981.

TABLE 3.2-3

INDICATOR CHEMICAL SELECTION

RANKING

FAMILY	CARCINOGEN(a)	TLV(b)	WQC(c)	NIPDWS(d)	SOLUBILITY	CONCENTRATION IN NEAR SURFACE SOIL	INDICATOR CHEMICAL
Chlorinated benzenes 7,8,9,10,11,30	8						8 Hexachlorobenzene
Chlorinated phenolics 1,2,5,68	1						1 2,4,6-Trichlorophenol
Cyanides 61							61 Cyanide
Dioxins 63	63						63 2,3,7,8-TCDD
Ketones 37,38,40		40 38 37				40 38 37	40 2-Hexanone
Metals 49,50,51,52,53,54 55,56,57,58,59,60	50,51,52,57		50 51 52 57				50 Arsenic
PAHs 6,12,13,16,17,18,19 20,21,22,23,24,25,26, 28	16,17,18,25						16(e) Benzo(a)anthracene
Phenolics (nonchlorinated)							3 2,4-Dimethylphenol

TABLE 3.2-3
(Continued)

RANKING

FAMILY	CARCINOGEN(a)	TLV(b)	WQC(c)	NIPDWS(d)	SOLUBILITY	CONCENTRATION IN NEAR SURFACE SOIL		INDICATOR CHEMICAL
Phthalate esters 14,15	14						14	Bis(2-ethylhexyl) phthalate
Total phenols 62							62	Phenol
Volatile aromatics 29,32,35,41	29						29	Benzene
Volatile chlorinated organics 31,33,34,36	31						31	Chloroform
Miscellaneous 4,27,39,45,46,64,67 69,70	64						64	Beta-BHC
Chlorinated phenoxy and related compounds 47,48,65,66				48 47 65,66 (f)	65 66 48 47	48 47 65,66 (g)	48	2,4,5-T

TABLE 3.2-3
(Continued)

RANKING

FAMILY	CARCINOGEN(a)	TLV(b)	WQC(c)	NIPDWS(d)	SOLUBILITY	CONCENTRATION IN NEAR SURFACE SOIL	INDICATOR CHEMICAL
DDT and metabolites 42,43,44	→	→	→	→	→	42 44 43	→ 42 4,4'DDT

(a)Carcinogenicity based on DHHS (1983) and USEPA (1984).

(b)TLVs taken from Threshold Limit Value (TLV) for Chemical Substances and Physical Agents in the Work Environment, ACGIH, 1984.

(c)USEPA Water Quality Criteria (WQC), 1980, Federal Register Vol. 45, No. 231.

(d)National Interim Primary Drinking Water Standard.

(e)Chemical No. 16 (Benzo(a)anthracene) was selected because it was the only carcinogenic PAH that was detected in the well water.

(f)Chemicals Nos. 65 and 66 do not have drinking water standards.

(g)Dicamba (No. 65) and 2,4-DB (No. 66) were not detected in the near-surface wells.

TABLE 3.2-4

SELECTION OF AIR PATHWAY CHEMICALS

VOLATILES

RANKED BY VAPOR PRESSURE(a)	RANKED BY CANCER POTENCY(b)	SELECTED CHEMICALS
31 - Chloroform - (160)	31 - Chloroform (8)	Chloroform
29 - Benzene - (76)	29 - Benzene (4)	Benzene
40 - 2 - Hexanone (2)	14 - Bis(2-ethylhexyl)-phthalate(c)	
3 - 2,4-Dimethylphenol (0.062)		
14 - Bis(2-ethylhexyl)-phthalate (2 X 10^{-7})		

PARTICULATES

RANKED BY CANCER POTENCY(b)	SELECTED CHEMICALS
63 - 2,3,7,8-TCDD (5 X 10^{7})	63 - 2,3,7,8-TCDD
17 - Benzo(a)pyrene (3 X 10^{3})	
42 - 4,4' - DDT (3 X 10^{3})	
50 - Arsenic (2 X 10^{3})	
8 - Hexachlorobenzene (5 X 10^{2})	
1 - 2,4,6-Trichlorophenol (4)	
64 - Beta-BHC(c)	

(a)Vapor pressure (mm Hg) in parentheses. See Table 3.2.
(b)Potency index in parentheses (USEPA, 1984).
(c)No potency evaluation by Carcinogen Assessment Group.

TABLE 3.3-1

AIR, SURFACE, AND GROUND WATER MIGRATION PATHWAYS - NUMBERS REFER TO FIGURE NO. 3.3-2

1. Precipitation - evaporation from surface
2. Infiltration - evaporation
3. Flow from unsaturated zone to saturated zone
4. Vertical flow from upper fill zone to/into/through semiconfining layer into glaciofluvial sands
5. Vertical flow to/into/through discontinuous semipermeable layers within the glaciofluvial sands
6. Vertical flow from glaciofluvial sands to/into/through semiconfining layer (where present) into bedrock aquifer
7. Surface runoff directly into storm sewers
8. Seepage into and out of storm sewers by way of cracks and other discontinuities in sewers
9. Ground water seepage between river and fill
10. Flow into and out of (depending on tide conditions) storm outfalls, tide gates, industrial river intakes
11. Flow between Passaic River and glaciofluvial sands
12. Surface runoff into Passaic River
13. Seepage between sanitary sewers and fill
14. Flow into industrial water well
15. Flow into domestic water well
16. Mixing, dispersion, and flow upstream and downstream in Passaic River
17. Infiltration, delayed runoff, and evaporation from ponded water on site
18. Surface runoff into the site from adjacent areas
19. Emissions to air from exterior surfaces of buildings, structures, or tanks
20. Emissions to air through vents in buildings, structures, or tanks
21. Air emissions from the Passaic River water surface
22. Air emissions from well water.

TABLE 3.3-2

APPROXIMATE AREAS OF ACTUAL SURFACE TYPES ON SITE

STRUCTURES	AREA (acres)	PERCENT OF TOTAL
Buildings (4)	1.02	30
Tank farms (concrete, diked)	0.2	6
Asphalt or compact gravel	0.44	13
Soil	1.74	51
Totals	3.40	100

TABLE 3.3-3

ESTIMATED OFF-SITE CONCENTRATIONS OF INDICATOR CHEMICALS IN SURFACE WATER (µg/ℓ)

CHEMICAL ID NUMBER	INDICATOR CHEMICAL	MEASURED AT SITE(a)		ESTIMATED IN PASSAIC RIVER(b)	
		MEAN	MAXIMUM	MEAN	MAXIMUM
50	Arsenic	232	629	1.4×10^{-3}	3.8×10^{-3}
29	Benzene	1,063	7,900	6.4×10^{-3}	4.7×10^{-2}
16	Benzo(a)anthracene	0.5	8	3.0×10^{-6}	4.8×10^{-5}
31	Chloroform	34	240	2.0×10^{-4}	1.4×10^{-3}
42	4,4'-DDT(c)	1,620	22,000	9.7×10^{-3}	1.3×10^{-1}
8	Hexachlorobenzene	102	860	6.1×10^{-4}	5.2×10^{-3}
63	2,3,7,8-TCDD	1.57	10.4	9.4×10^{-6}	6.2×10^{-5}
1	2,4,6-Trichlorophenol	1,481	11,000	8.9×10^{-3}	6.6×10^{-2}
40	2-Hexanone	ND(d)	ND	-	-
14	Bis(2-ethylhexyl)phthalate	10	75	6.0×10^{-5}	4.5×10^{-4}
64	Beta-BHC	ND	ND	-	-
48	2,4,5-T	714	5,600	4.3×10^{-3}	3.4×10^{-2}
61	Cyanide	80	630	4.8×10^{-4}	3.8×10^{-3}
62	Phenol	17,000	102,000	1.0×10^{-1}	6.1×10^{-1}
3	2,4-Dimethylphenol	ND	ND	-	-

(a)Based on data reported in 80 Lister Avenue Site Evaluation Report.

(b)Based on dilution factor of 6.1×10^{6}.

(c)Average of three concentrations in wells along bulkhead = 7333 µg/ℓ. Estimated concentration in Passaic River = 4.4×10^{-2}.

(d)ND indicates not detected.

TABLE 3.3-4

ESTIMATED OFF-SITE CONCENTRATIONS OF INDICATOR CHEMICALS IN GROUND WATER (μg/ℓ)

CHEMICAL ID NUMBER	INDICATOR CHEMICAL	MEASURED AT SITE(a)		ESTIMATED IN CLOSEST WELL(b)	
		MEAN	MAXIMUM	MEAN	MAXIMUM
50	Arsenic	232	629	0.21	0.58
29	Benzene	1,063	7,900	0.98	7.28
16	Benzo(a)anthracene	0.5	8	4.6×10^{-4}	7.4×10^{-3}
31	Chloroform	34	240	3.1×10^{-2}	0.22
42	4,4'-DDT(c)	1,620	22,000	1.49	20.3
8	Hexachlorobenzene	102	860	9.4×10^{-2}	0.79
63	2,3,7,8-TCDD	1.57	10.4	1.5×10^{-3}	9.6×10^{-3}
1	2,4,6-Trichlorophenol	1,481	11,000	1.36	10.1
40	2-Hexanone	ND(c)	ND	-	-
14	Bis(2-ethylhexyl)phthalate	10	75	9.2×10^{-3}	6.9×10^{-2}
64	Beta-BHC	ND	ND	-	-
48	2,4,5-T	714	5,600	0.66	5.2
61	Cyanide	80	630	7.4×10^{-2}	0.58
62	Phenol	17,000	102,000	15.7	94.0
3	2,4-Dimethylphenol	ND	ND	-	-

(a)Based on data reported in 80 Lister Avenue Site Evaluation Report.

(b)Based on dilution factor of 1,085.

(c)ND indicates not detected.

TABLE 3.3-5

ESTIMATED CONCENTRATIONS OF INDICATOR CHEMICALS FOR THE AIR PATHWAY (g/m^3)

CHEMICAL ID NO.	INDICATOR CHEMICAL	ESTIMATED ON SITE		ESTIMATED OFF SITE	
		MIDRANGE	MAXIMUM	MIDRANGE	MAXIMUM
29	Benzene	4.2×10^{-5}	8.3×10^{-5}	1.6×10^{-8}	3.3×10^{-8}
31	Chloroform	2.1×10^{-6}	4.2×10^{-6}	8.4×10^{-8}	1.7×10^{-7}

TABLE 3.4-1

RECOMMENDED EXPOSURE CRITERIA FOR INDICATOR CHEMICALS

INDICATOR CHEMICAL		ACCEPTABLE CONCENTRATION(a) AIR (mg/m^3)				
ID NUMBER	INDICATOR CHEMICAL	GROUND WATER AT CLOSEST WELL (µg/ℓ)	PARTICULATES		VAPOR	
			ON SITE	OFF SITE	ON SITE	OFF SITE
50	Arsenic	0.13	b	b	c	c
29	Benzene	36	b	b	30(d)	[(0.6 to 1.3) X 10^{-3}]
16	Benzo(a)anthracene	0.16	b	b	c	c
31	Chloroform	28	b	b	240(d)	[(0.43 to 1.0) X 10^{-3}]
42	4,4'-DDT	0.23	b	b	c	c
8	Hexachlorobenzene	1.2	b	b	c	c
63	2,3,7,8-TCDD	[(1.2 to 5.5) X 10^{-5}]	[(5.3 to 5.4) X 10^{-9}]	[(0.82 to 8.3) X 10^{-9}]	c	c
1	2,4,6-Trichloro-phenol	97	b	b	c	c
40	2-Hexanone	e	b	b	c	c
14	Bis(2-ethylhexyl) phthalate	15,000(f)	b	b	c	c
64	Beta-BHC	e	b	b	c	c
48	2,4,5-T	100(f)	b	b	c	c
61	Cyanide	200(f)	b	b	c	c
62	Phenol	3500(f)	b	b	c	c
3	2,4-Dimethylphenol	e	b	b	c	c

(a)Calculation based on cancer potency slopes (USEPA, 1984) for carcinogens at the 1 in 100,000 (10^{-5}) excess risk level unless otherwise noted.

(b)Not applicable to air because it was not selected as a particulate indicator chemical.

(c)Not applicable to air because it was not selected as a vapor indicator chemical.

(d)OSHA standard for an acceptable daily exposure concentration for the occupational lifetime. Benzene ACGIH TLV = 30 mg/m^3 and chloroform ACGIH TLV = 50 mg/m^3.

(e)Not applicable to ground water because none was detected in any ground water samples.

(f)Ambient Water Quality Criteria for noncarcinogens.

TABLE 3.4-2

EXPOSURES ESTIMATED TO INCREASE THE ANNUAL RISK OF DEATH BY 10^{-5} (1 in 100,000)

ACTIVITY	CAUSE OF DEATH
Smoking 14 cigarettes	Cancer, heart disease
Living 20 months with a cigarette smoker	Cancer, heart disease
Drinking 5 liters of wine	Cirrhosis of the liver
Spending 10 hours in a coal mine	Black lung disease
Spending 30 hours in a coal mine	Accident
Living 20 days in New York or Boston	Air pollution
Traveling 60 minutes by canoe	Accident
Traveling 100 miles by bicycle	Accident
Traveling 1,500 miles by car	Accident
Living 20 months in Denver on vacation from New York	Cancer caused by cosmic radiation
Living 20 months in average stone or brick building	Cancer caused by natural radioactivity
Ten chest X-rays taken in a good hospital	Cancer caused by radiation
Drinking 300 12-oz cans of diet soda	Cancer caused by saccharin
Eating 1,000 charcoal-broiled steaks	Cancer from benzopyrene

Adapted from Fischhoff et al., 1981.

TABLE 3.4-3

POPULATION PROFILE INFORMATION AT VARIOUS DISTANCES FROM THE 80 LISTER AVENUE SITE(a)

DISTANCE	NUMBER OF INDIVIDUALS	CUMULATIVE POPULATION	NUMBER OF HOUSEHOLDS
Up to One Mile:			
0.50	978	978	335
0.75	4,203	5,181	1,394
1.00	4,844	10,025	1,692
Up to Four Miles:			
1.50	28,281	38,306	9,911
2.00	35,357	73,663	12,576
2.50	45,820	119,483	16,361
3.00	79,290	198,773	27,813
3.50	121,422	320,195	43,717
4.00	138,789	458,984	49,167

(a)Based on 1980 Census Tract Data.

(LAT: 40° 44' 22", LONG: 74° 08' 13")

TABLE 3.4-4

EXCESS CANCER RISK ESTIMATES

CONTAMINANT	AIRBORNE	GROUND WATER
Off Site		
2,3,7,8-TCDD	a	$9.5 - 800 \times 10^{-5}$
4,4'-DDT	b	$6.5 - 88 \times 10^{-5}$
Benzo(a)anthracene	b	$2.9 - 46 \times 10^{-8}$
Benzene	$1.2 - 5.5 \times 10^{-7}$	$2.7 - 20 \times 10^{-7}$
Chloroform	$8.4 - 40 \times 10^{-7}$	$1.1 - 7.9 \times 10^{-8}$
2,4,6-Trichlorophenol	b	$1.4 - 10 \times 10^{-7}$
Hexachlorobenzene	b	$7.8 - 66 \times 10^{-7}$
On Site		
2,3,7,8-TCDD	a	c
4,4'-DDT	b	c
Benzo(a)anthracene	b	c
Benzene	d	c
Chloroform	d	c

(a)Not a chemical subject to the vapor pathway.

(b)Not an indicator chemical for this pathway.

(c)No on-site receptors.

(d)Cancer risk estimation not applicable since OSHA standard applies to on-site exposure scenario. Benzene is three orders of magnitude and chloroform four orders of magnitude below their respective OSHA standards.

FIGURES

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CHECKED BY IAD 9-13-85
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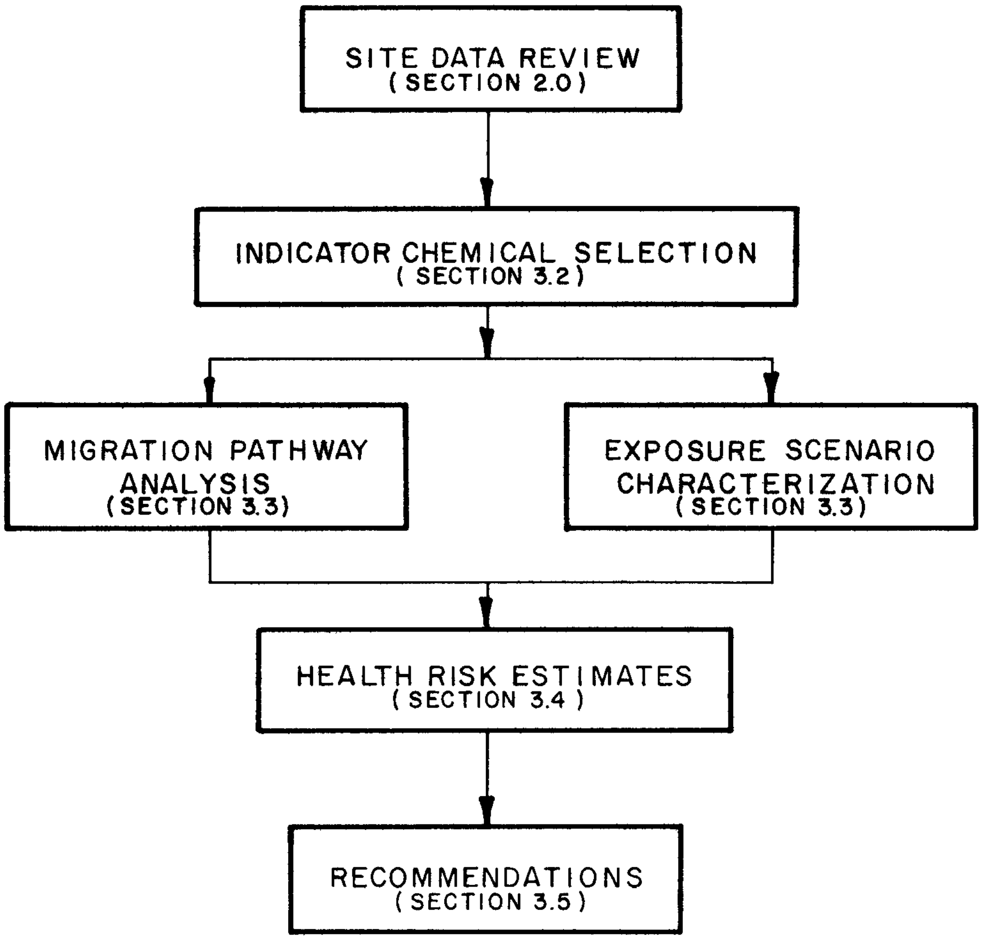

FIGURE 3.1-1

FLOW CHART OF THE RISK ASSESSMENT PROCESS
80 LISTER AVENUE
PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

...Creating a Safer Tomorrow

65360

"Do Not Scale This Drawing"

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DRAWING NUMBER 850032-A11

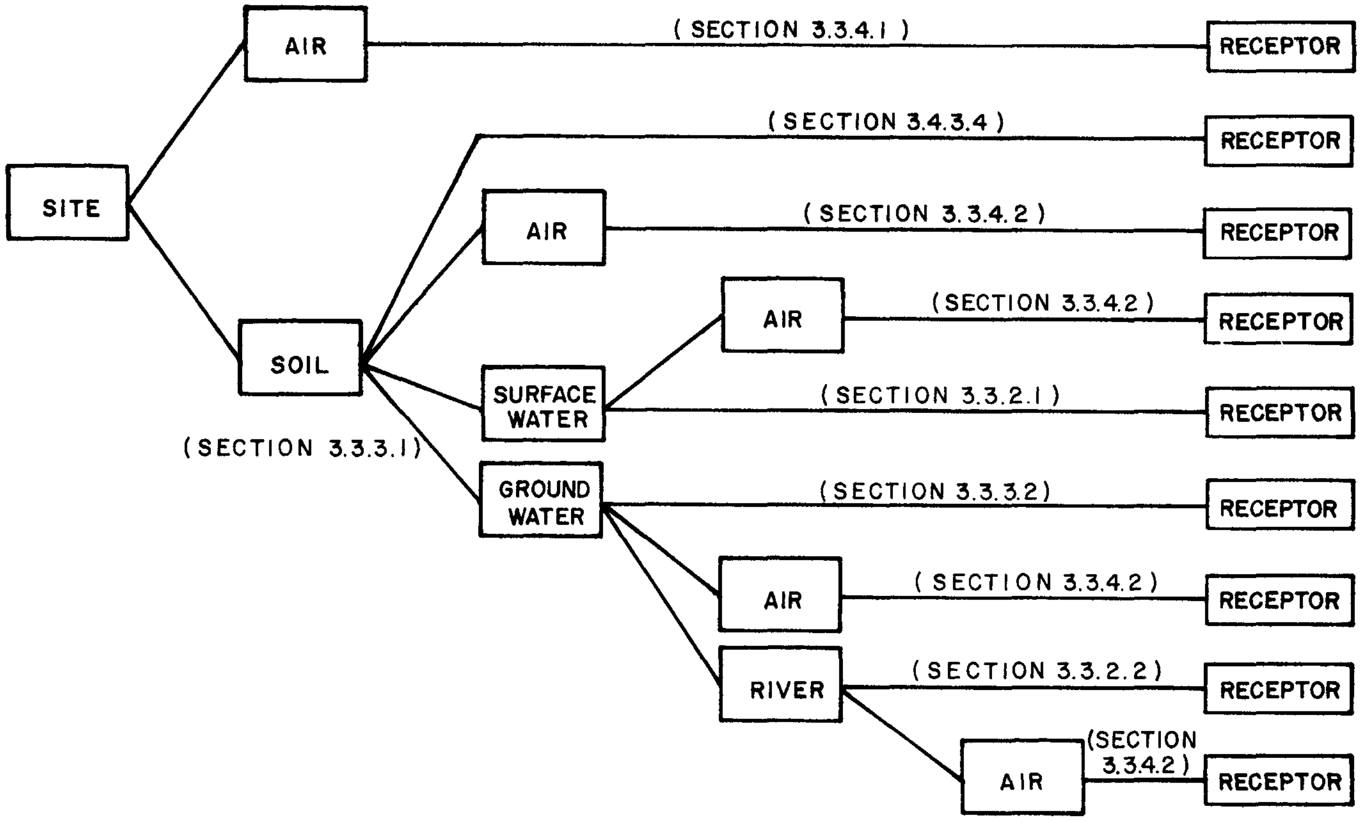

FIGURE 3.3-1

PATHWAY/RECEPTOR MODEL
80 LISTER AVENUE

PREPARED FOR

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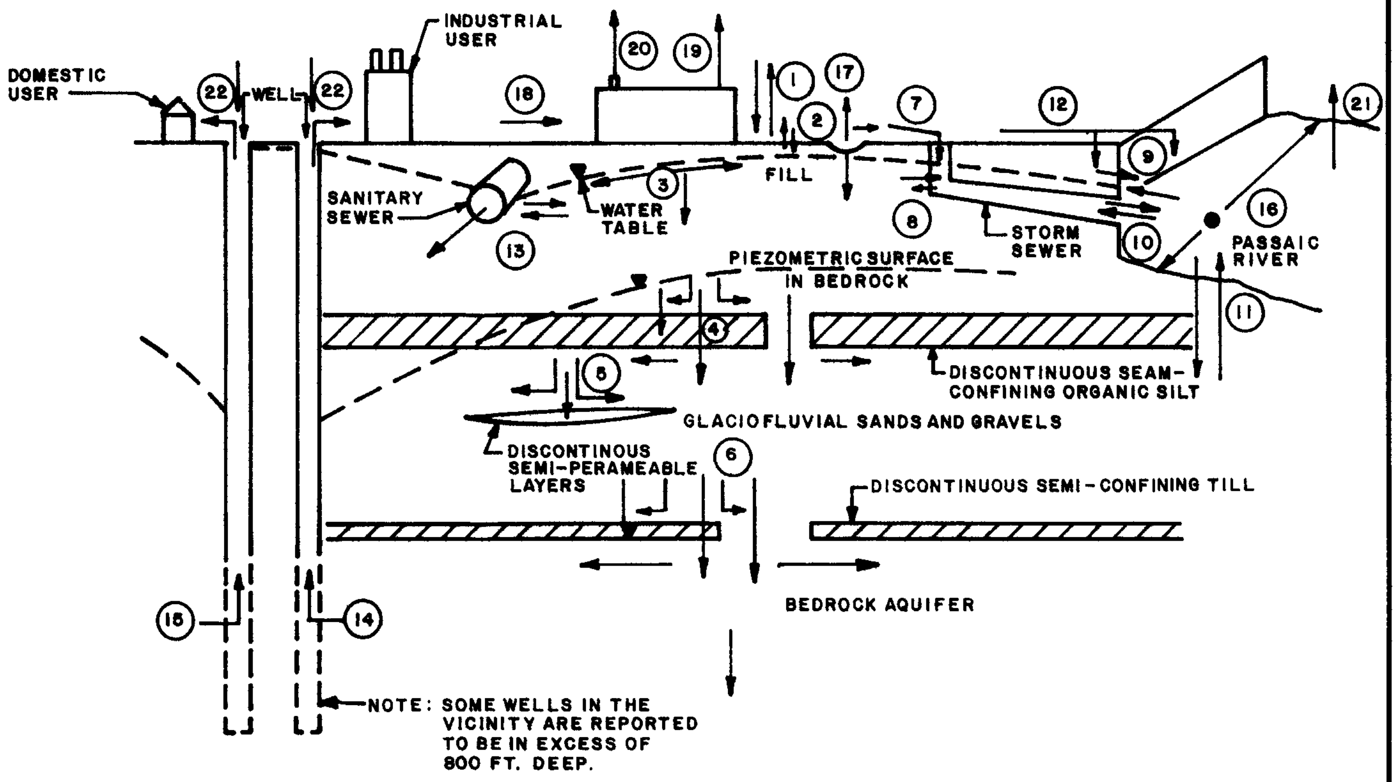

NOTE: SOME WELLS IN THE VICINITY ARE REPORTED TO BE IN EXCESS OF 800 FT. DEEP.

NOTE:
SEE TABLE 3.3-1 FOR EXPLANATION OF NUMBERS.

FIGURE 3.3-2

SCHEMATIC OF SURFACE AND GROUND-WATER MIGRATION PATHWAYS
80 LISTER AVENUE
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4.0

4.0 REMEDIAL ACTION OBJECTIVES

This feasibility study was necessitated by the determination that dioxin in the soil at the 80 Lister Avenue site could represent a potential hazard to public health and the environment. Soon after it was determined by the NJDEP in 1983 that site soils contained dioxin, Diamond Shamrock undertook an interim remedial measures program. This interim program included the installation of a geofabric over the site, the construction of a fence around the site, and the deployment of a security guard. These measures were implemented until the nature and magnitude of the problem could be determined and an appropriate remedial action could be identified. The feasibility study reported herein is the mechanism for the selection of the appropriate remedial action.

ACO I, as subsequently quoted, governs the feasibility study for the 80 Lister Avenue property and requires that the study shall recommend (1) "the remedial action alternative deemed best suited to remove the dioxin and other chemicals from the site such that the levels of dioxin or other chemicals remaining on the site following the removal do not constitute a significant risk to public health or the environment," and (2) "if the feasibility study concludes, and the Department agrees, that the removal of the dioxin and other chemicals is not practicable, the feasibility study shall recommend the remedial action alternative deemed best suited to contain the dioxin and other chemicals on-site in such a manner that the potential for public contact or migration into the environment is and will be eliminated to the maximum extent technically practicable." ACO II addresses the alternatives for the 120 Lister Avenue property and requires that they be accomplished pursuant to this feasibility study as described in ACO I.

Accordingly, the overall goals for remedial actions at the site include elimination or minimization of:

- Public health risks both on and off site
- Environmental risks both on and off site.

Section 3.0 of this report identified potential public health and environmental risks posed by the site under existing conditions. The approach used in the formulation and completion of the risk assessment was very conservative so that protection of public health and welfare was given appropriate consideration. Based upon the conclusions of the risk assessment presented in the preceding section, the following specific remedial action objectives have been identified to both fulfill the overall remedial goals and the requirements of ACOs I and II:

- Eliminate, to the maximum extent practicable, exposure to surface soils. Concentrations of dioxin in the surface soils are at levels sufficiently higher than those established by the EPA, CDC, and NJDEP for public health and environmental protection to warrant site remediation.
- Reduce mass transport of chemicals in the ground water to potential concentration levels less than 5×10^{-5} μg/ℓ for dioxin and 0.23 μg/ℓ for DDT at the nearest off-site well at some time in the future. These values represent recommended exposure (10^{-5} cancer risk) levels for ingestion of water.
- Remove the source of potential particulate dioxin emissions associated with existing buildings.
- Reduce mass transport of chemicals from the site to the Passaic River.
- Implement remediation without significant risk to site workers and off-site populations.

These specific objectives will serve to guide the selection process for the recommended cost-effective remedial action alternative as contained in the sections that follow.

5.0

5.0 SCREENING OF TECHNOLOGIES

5.1 INTRODUCTION

The U.S. EPA has developed guidelines for the selection of a remedial alternative/action at an uncontrolled hazardous waste site (U.S. EPA, 1985). The EPA guidance complies with the requirements of CERCLA and provides a step-by-step process so that: (1) all available technologies for remediating a site are properly considered, (2) all technologies that are viable are combined into remedial action alternatives capable of achieving the site remediation objectives, and (3) the recommended remedial alternative is derived from a careful consideration of technical, institutional, and cost factors. The most effective alternative is defined by the EPA as the lowest cost alternative that is technologically feasible and reliable and which effectively mitigates and minimizes damage to and provides adequate protection of public health, welfare, and the environment.

The process described for selecting this alternative is depicted in Figure 5.1-1. The process begins with a step to formulate and develop alternatives and technologies. The second step is to screen the technologies available to define those which have potential application to the monitoring, control, or remediation of the site. The second step is the subject of this section. Specific remediations are identified and the potential application of the technologies is considered. The technologies have been grouped into six categories ranging from monitoring to destructive treatment. A two-stage screening process has been applied to eliminate technologies which have no application and those which have serious shortcomings. The result is the identification of those technologies which have the greatest potential for implementation.

The technologies identified in this section represent the basis for the development of several site remedial action alternatives which are analyzed and compared in detail in Sections 6.0 to 8.0 of this report. Section 8.0 contains the decision analysis for the selection of the recommended remedial action, referred to in this study as the remedial action. The no-action alternative is carried through the entire process for comparative purposes and in compliance with EPA guidance (U.S. EPA, 1985).

5.2 SITE CONCERNS

The previously prepared 80 Lister Avenue Site Evaluation Report and Section 2.0 of this report provide detailed data relative to concentrations of chemicals at the site. From a remediation standpoint, five concerns have been identified which require response:

- Structures and equipment
- Drummed and containerized wastes
- Soil
- Ground water
- Sewers.

5.2.1 Structures and Equipment

Dioxin occurs on the inside and outside of the major site structures: the process building, chemical manufacturing building, warehouse, and laboratory/office building. Dioxin is also present on the remaining buildings on 120 Lister Avenue. Minor structures such as the pumphouse and solvent shed also contain dioxin. The stack, which contained low levels of dioxin, has been demolished subsequent to the submittal of the Site Evaluation Report. Additionally, the inactive, on-site deep well will be grouted.

Tanks, storage vessels, pumps, and other equipment associated with the manufacturing and raw materials or finished product tank farms are also included in this category of structures and equipment.

5.2.2 Drummed and Containerized Wastes

There are 570 drums of process waste material on the site. These materials were left in the plant tanks and vessels after manufacturing was terminated and placed in the drums. The drums were divided into 22 lots and tested for dioxin. Fifteen of the analyses representing 371 drums were positive for dioxin, i.e., greater than one ppb. In addition to the waste-containing drums, 790 drums of material (Tyvek suits, other disposable health and safety equipment, and debris from cleanup of nearby sites) are stored on the site.

Additionally, there are currently 352 shipping containers with debris such as soil, concrete, and steel from the cleanup of nearby sites stored on 120 Lister Avenue. It is expected that a total of 845 containers will ultimately be stored there. The debris contains dioxin, or is presumed to contain dioxin, and, in accordance with ACO II, has been included in the feasibility study.

5.2.3 Soil

The subsurface profile at the site consists of 6 to 15 feet of fill overlying a layer of silt 3 to 9 feet thick which is underlain by glaciofluvial sands. In general, the fill contains dioxin, particularly in areas where herbicide manufacturing took place. Dioxin levels generally decrease with depth, but organic chemical concentrations have been found to increase with depth, extending to the top of the silt. In those portions of the site located away from the manufacturing process, the fill contains lower levels of dioxin. Dioxin has been detected in the silt layer but has not been detected in the glaciofluvial sand.

5.2.4 Ground Water

The ground water in the fill contains dioxin and semivolatile organic and chlorinated herbicide compounds. Dioxin and other organic compounds have also been detected in ground water in the upper portion of the sand unit which underlies the fill. However, dioxin was undetected in the lower portion of the sand layer.

5.2.5 Sewers

Dioxin has been detected in sumps and sewers associated with the process and chemical manufacturing buildings. It is noted that, in 1983, the NJDEP and the EPA sampled off-site street sewers, and dioxin was not detected.

5.3 GENERAL RESPONSE ACTIONS

A listing of remedial technologies which have possible application to the site is provided in Table 5.3-1. The technologies are grouped into five categories for use in the screening process. Each of these categories is discussed below.

5.3.1 No Action

The no-action response represents the lowest level of possible activity. Only monitoring and security activities are considered in this category.

5.3.2 Receptor Modification

The receptor modification response eliminates the possibility of receptor contact with chemicals through actions involving the receptors. In extreme cases, this could include population relocation or provision of a new water supply. Receptor modification is not applicable for this site because of the results of the risk assessment presented in Section 3.0 regarding potential exposure of the public, and no water supply used for drinking has been affected by the site.

5.3.3 Control, Containment, and Storage

This category of general response action involves control or containment such that chemical migration is restricted and potential impact to receptors is minimized.

Controls

Controls encompass activities such as dust prevention, diversion, and collection of surface waters to prevent contact with dioxin, and ground water pumping to prevent migration. Controls by themselves are not responsive to the ACO and are thus not considered a viable technology for the screening criteria.

Containment

Containment involves putting physical barriers between the chemicals of concern and the environment. Specific measures which may have application to the site include capping, construction of slurry walls, grout curtains or grout injection, and construction of sheet pile cutoff walls. Containment is considered in the screening process.

Storage

Storage involves the placement of dioxin-containing materials in a container to prevent contact with the environment. This type of measure would generally be short-term. Storage is not considered a viable technology because it is short-term and thus has not been included in the scoring criteria.

5.3.4 Removal

This category of response action encompasses physical removal of material containing dioxin and associated restoration of the area. Typical activities would be excavation of soil or buried structures, demolition and removal of structures and facilities, and removal and subsequent disposal of drummed wastes. Removal activities will normally involve some other activity such as containment, storage, treatment, or disposal. For this reason, removal is not evaluated as a technology.

5.3.5 Treatment and/or Disposal

Treatment

A number of treatment technologies are known or proposed for hazardous wastes and dioxin. Treatment is considered to be the physical or chemical alteration of materials. The major types of treatment are:

- Thermal
- Chemical
- Physical
- Solidification, stabilization, fixation
- Bioreclamation.

Numerous technologies are listed under these major types of treatment in Table 5.3-1. These are in various stages of development, as subsequently indicated in the screening process.

Disposal

Two major types of disposal are considered. The first is land disposal, which most frequently is entombment. Both on-site and off-site facilities are considered. Deep well injection, either on site or off site, is also evaluated.

5.4 SCREENING

The purpose of screening the identified actions/technologies is to eliminate obviously inappropriate actions/technologies from consideration before actual remedial alternatives are developed from these technologies. Because the remedial alternatives are evaluated in detail, it is important that the technologies included in the remedial alternatives have a high potential for successful remediation of site problems. The screening of actions/technologies is presented in the following subsections.

The screening of actions/technologies has been conducted as a two-stage process. In the first stage, the general response actions and the major subcategories thereunder have been evaluated as to whether they are clearly applicable, possibly applicable, or not applicable at all. Since applicability for these is relatively well defined, a nonnumerical method was used. An explanation of the basis for all designations is provided.

For the many treatment technologies and containment options considered, a second stage of screening has been applied. Screening criteria, as well as a scoring system, have been developed. A numerical system was used because of the large number of available techniques and the considerable variability in stages of development. The treatment technologies and containment options which receive high scores in this screening process will be potential candidates for inclusion in the remedial action alternatives.

5.4.1 Site Concerns Versus General Response Actions

As discussed in Subsection 5.2, five specific site concerns requiring remediation have been identified at the site. As developed in Subsection 5.3, there are six basic categories of general response action. A matrix showing which general response actions may apply to identified concerns is provided in Table 5.4-1.

For all studies of this type, the no-action response provides a baseline for comparison to other remedial alternatives and thus applies to all site concerns. Only monitoring and security activities are considered in the no-action response.

Receptor modification is not considered an applicable concern for this site.

Control, containment, and storage could potentially be applied to all of the site concerns. Most of the identified actions/technologies associated with control and containment have primary application to soil, ground water, and sewer concerns. Storage has potential application primarily to structures, equipment, and drummed wastes.

Removal is considered a potential response for all of the identified site concerns. However, removal in this context does not necessarily mean removal from the site, which is discussed as part of disposal.

Treatment and disposal have potential application to all the identified site concerns.

5.4.2 First-Stage Screening

The first stage of screening was conducted for the major actions/technologies listed under the general response actions in Table 5.3-1. An evaluation was made of the applicability of each of these actions/technologies to the individual identified concerns. The results of this evaluation are presented in Table 5.4-2.

For each action/technology which was clearly applicable to one of the identified concerns, a Y (yes) was entered. For possibly applicable actions/technologies, a P was entered, and an N was entered for inapplicability. The selection of the response is based on the action/technology acting by itself, not in combination with other actions/technologies.

For the treatment and containment options, a second stage of screening was applied to identify which among these technologies have the most potential for site remediation. The second-stage screening is described in Subsection 5.4.3.

A description of the first-stage screening process is provided in the following subsections.

5.4.2.1 No Action

The no-action response must be considered for each of the identified concerns at the site, because this provides a basis for comparison to other responses. The only actions associated with the no-action response are monitoring of the conditions at the site and providing for site security. Ground water levels, chemical concentrations in the ground water, and concentrations of chemical constituents in the air and surface water (Passaic River) will be monitored and the site will be inspected.

One or more of these activities apply to each of the identified site concerns. Physical inspection is applicable to the structures and facilities, drummed wastes and decontamination waters, and the sewers. Ground water monitoring is applicable to soils, ground water, and sewers. Air monitoring, surface water monitoring, and security measures have application to all of the site-related concerns.

5.4.2.2 Receptor Modification

Receptor modification is not considered applicable to this site.

5.4.2.3 Control, Containment, and Storage

Control

Control actions/technologies include the following:

- Dust abatement
- Grading for surface water control/collection
- Subsurface drains
- Pumping of ground water..

In general, these measures have primary application to subsurface concerns such as soil, ground water, and sewers (Table 5.4-2).

Dust abatement is applicable to structures chiefly because of the potential transport of masonry dust. Control of surface dust from soil is applicable. Dust abatement is not a concern for drummed wastes, ground water, and sewers. Also, if soils are excavated, dust abatement must be considered.

Grading could be used to prevent surface water contact with structures and facilities and to prevent or reduce infiltration affecting the soil, ground water, and sewers. It is not applicable to drummed wastes.

Subsurface drains could be applicable to structures and facilities to collect runoff. This technology would theoretically be applicable to soils, ground water, and sewers. Drains are not applicable to the drummed wastes.

Pumping of ground water has applications in controlling the movement of chemicals in soil and ground water or liquids leaking from sewers. It has no application to structures and facilities and drummed wastes.

Containment

The containment actions/technologies apply to all of the subsurface concerns (soil, ground water, and sewers), but not to structures and facilities or drummed wastes.

Capping with clay or other surficial material will prevent or limit surface infiltration and thus limit subsurface migration. It will also prevent dust from being spread by winds.

Slurry walls are trench-type excavations backfilled with a low-permeability soil mixture with a high sorption capacity which limits the movement of subsurface chemicals. Slurry walls are applicable to the soil, ground water, and sewer problems.

Grouting is used to fill soil voids and thus reduce permeability and limit the movement of ground water-borne chemicals in a similar manner to slurry walls. Rather than create a grout curtain, the method can be used in an areal pattern to simply immobilize the area. The applicability of grouting is the same as for slurry walls.

Sheet piling cutoff walls also can be used as a barrier to limit the movement of ground water and associated wastes from soils or sewers.

Plugging has application to subsurface pipelines and sewers and thus is an appropriate option for the site sewers.

Storage

Storage is the containerization of wastes for temporary holding. The container system is designed to prevent infiltration of water and leakage of the contents of the individual containers. Such a system could be used to store rubble from demolition of structures or sewers, drummed wastes, and hot-spot soils. Storage of ground water is neither practical nor desirable.

5.4.2.4 Removal

Removal means taking material from its in situ location prior to some further action such as storage or treatment. Removal actions/technologies are as follows:

- Excavation
- Demolition
- Decontamination
- Pumping of ground water.

Excavation is applicable to soils and sewers. Demolition is applicable to structures and facilities. Decontamination has application to structures and facilities and sewers, and pumping has application to the extraction of ground water.

5.4.2.5 Treatment and Disposal

Treatment and disposal refer to processes for modification of materials or for long-term storage or isolation from the environment.

Treatment

Treatment technologies fall into the general categories of thermal; chemical; physical; solidification, stabilization, fixation; and bioreclamation. Thermal treatment involves heating to high temperature. It is considered applicable to all of the identified site concerns. Crushing or grinding of large pieces of rubble would be required for structures, buried obstructions, and sewers. Similar reduction would be required for chemical treatment of structures, sewers, soil, and ground water. Drummed wastes may be treatable by chemicals.

Physical treatment has application to ground water and possible application to soils, but not to structures or sewers. Similarly, solidification, stabilization, and fixation have application to drummed wastes, ground water, and soils and possibly sewers, but are not suitable for structures. Coating of structures may be feasible.

Bioreclamation has possible application to soil, ground water, decontamination fluids, and sewers.

Disposal

Land disposal is the entombment of hazardous materials in a vault with appropriate liners. This measure is directly applicable to all of the identified site concerns except ground water. If soil is removed, subsequent ground water quality will be improved by removing the source of contamination and, thus, a possible application is assigned to this problem.

Deep well injection has application to ground water and possible application to drummed wastes in liquid form. It is not applicable to solid forms such as soil, sewers, and structures.

5.4.2.6 Summary of First-Stage Screening

An evaluation was made of the applicability of each action/technology to individual site concerns. The actions/technologies which have direct application to the identified site concerns are:

- No action
- Treatment
- Combined actions
  - Containment
  - Capping
  - Storage
  - Pumping and treatment.

5.4.3 Second-Stage Screening

A wide range of technologies is available in the treatment and containment options. Therefore, additional screening beyond the first stage has been conducted for the following technologies:

- Thermal
- Chemical
- Physical
- Solidification, Stabilization, Fixation
- Bioreclamation
- Containment.

Each technology in the categories listed above has been screened against other technologies in the same category. Because the technologies under each category above are very similar in purpose and application, the screening methodology is a very effective way to determine the most applicable technologies.

5.4.3.1 Evaluation Criteria

Nine evaluation criteria were selected for screening the technologies. These criteria are as follows:

- Suitability for Hazardous Waste
- Proven Technology for Dioxin
- Stage of Development of the Technology
- Effectiveness/Efficiency
- Time to Accomplish Remediation
- Negative Impacts
- Technology Applicability
- Cost
- Site-Specific Constraints.

In general, all technologies considered are suitable for hazardous waste, but some are not proven effective for dioxin. Many of the technologies are at a relatively early stage of development.

The time to accomplish remediation includes both technological development of the process to the scale required for site applicability and the remediation time. Negative impacts refer to the creation of toxic by-products or undesirable releases due to the process itself during remediation, or the potential for undesirable releases due to equipment malfunction. Technology applicability refers to the number of identified site problems for which the technology is applicable. Cost represents remediation cost on a unit basis, including estimated development or scale-up expenses. Site-specific constraints represent a consideration of the factors that would affect the implementation of the technology at this particular site.

Several other evaluation criteria, such as public acceptance and licensability/permitability issues, are also important. These two issues are related, and it was determined that their consideration is more appropriate for combinations of technologies representing remedial action than for individual treatment alternatives. Therefore, consideration of these criteria is deferred to Sections 7.0 and 8.0.

5.4.3.2 Scoring System

A scoring system, as described in the following paragraphs, was developed for the screening process. The scoring rules are presented in Table 5.4-3. For each technology, each criterion has been scored in the range of zero to four, where four is the most desirable score and zero the least. The scores were determined by a committee of experts and were independently reviewed by other experts in the field of treatment technologies.

The total of the scores in all nine criterions has been summed and divided by four so that the maximum score is nine. Adjustments have been made to the nine-scale score to penalize for multiple low individual criterion scores. This adjustment has been done to reflect the fact that technologies with multiple deficiencies have far less potential than those with few and only minor problems.

Specifically, if a zero score is received in the proven for dioxin category, the total score is automatically zero. For zeros in other criteria scores, two points are deducted. For ones in any criterion score, one point is deducted for each one rating. No total score is reduced below zero. For the adjusted total scores, a result above four indicates significant potential as a remedial technology; scores below four indicate minimal potential. Generally, the best technologies screened received a 4.5 or better, while the others are four or less.

5.4.3.3 Determination of Criteria Scores

Scores for each criterion range from zero to four as described above. For each criterion, a range of conditions was established corresponding to each numerical score. These are presented in Table 5.4-4 and are discussed in the following paragraphs.

Suitability for Hazardous Waste

For this criterion, a four was assigned to technologies which have proven application to hazardous waste. Technologies which have never been used for hazardous waste were given zeros. No intermediate score was used.

Proven for Dioxin

A four was assigned to technologies which have been successfully used to treat dioxin; a three was assigned if PCBs have been successfully treated. If the technology has been used to treat chlorinated organics, a two was entered. Technologies which might work on dioxin with modifications were given a one and inapplicable technologies were given a zero.

Stage of Development

This category considers the current status of the advancement of a process, giving four points to treatment processes that have been demonstrated at commercial or full scale to effectively treat hazardous waste.

Existing full scale processes that would require minimal modifications to handle hazardous waste were given a value of three.

Processes that were reported to be in the pilot stage or under commercial development were assigned a value of two.

Bench scale or laboratory stage processes were assigned a value of one.

In some cases, a process under development may have been placed on indefinite hold or abandoned completely. A process in this situation was given a zero.

Effectiveness/Efficiency

The scoring for effectiveness/efficiency relates to the ability to destroy dioxin for treatment technologies, or the ability to restrict movement of dioxin for containment technologies. Effectiveness or efficiency in destruction of dioxin has been scored on a simple percentage scale. Technologies which achieve 99.99 percent or greater destruction were assigned a four; 98 to 99.99 percent a three; 50 to 98 percent a two; and 1 to 50 percent a one. If the technology will not treat dioxin, a zero was assigned. For containment technologies, a score of four is given to those which totally immobilize dioxin, three to those which are very effective, two for moderately effective, one for slightly effective, and zero for ineffective.

Time to Accomplish Remediation

The time to accomplish remediation is considered to be the entire time required, including any development needed to bring the process to the scale where it can be applied to the site problems. In some cases, this could amount to many years for theoretical technologies. The scoring used was four for up to one year, three for one to two years, two for two to three years, one for three to five years, and zero for times estimated to exceed five years.

Negative Impacts

Negative impacts include such factors as generation of toxic by-products during remediation or incomplete solution of a problem. The scoring adopted was four for no negative impacts expected, three for only minor impacts, two for significant negative impacts, one for a serious negative impact or many minor ones, and zero for many serious negative impacts.

Technology Applicability

Technology applicability is a measure of how many of the identified site problems can be treated by the technology under consideration. A four was assigned to technologies which could treat all five identified site concerns, a three corresponds to four concerns, a two to two or three concerns, a one to one concern, and a zero was assigned if the technology must be used in conjunction with another process to resolve a single concern.

Cost

Costs were evaluated on a unit weight of remediated material basis. A four was assigned for a cost range of $0 to $100 per ton, a three corresponded to $100 to $200 per ton, a two corresponded to $200 to $300 per ton, a one corresponded to $300 to $1,000 per ton, and a zero was assigned for costs exceeding $1,000 per ton. These costs include required technological development and/or scale up.

Site-Specific Constraints

Site-specific constraints were evaluated on the basis of anticipated difficulties in implementing the technology at this site. Factors included in the consideration were such characteristics as the size of the site and constraints on construction. A four was assigned to technologies that can be easily implemented. A three was assigned to those that can be implemented with only minor difficulty and a two to those with moderate difficulty. A one was given to technologies that can be implemented with only great difficulty and a zero to those for which the site may provide insurmountable difficulties.

The results of the second-stage screening process are provided in the following pages. A summary of the results for the technologies is also presented in Table 5.4-5.

5.4.3.3.1 Thermal Treatment

Suitability for Hazardous Waste

Of the various types of treatment technologies, those in the thermal category (16 total) are the most commonly applied to the treatment of hazardous waste. All of the existing and emerging thermal processes screened for this study have reportedly been tested on various types of hazardous waste and were assigned a value of four for this criterion.

Proven for Dioxin

Rotary kiln, mobile incineration (mobile rotary kiln), liquid injection, high-temperature fluid wall, thermal desorption, and ocean incineration have all been proven effective for destroying dioxin under certain operating conditions during controlled testing. Each was given a score of four for the "proven for dioxin" criterion. Cement kiln, molten salt, plasma arc, microwave plasma, and corona glow have all been demonstrated to destroy PCBs and were given a score of three. Fluidized bed, multiple hearth, pyrolysis, and radio frequency heating were judged as possibly being able to destroy dioxin with modifications and were assigned a value of one. Industrial boilers/furnaces are inappropriate devices to handle wastes containing dioxin and were given a score of zero and eliminated from further scoring.

Stage of Development of the Technology

A number of thermal treatment processes including rotary kiln, multiple hearth, liquid injection, and ocean incineration have been developed full scale and were assigned a score of four. Cement kiln, mobile incinerator, and fluidized bed are almost to full scale or require only minor modifications and thus were assigned a three. Pilot scale units have been developed for radio frequency heating, pyrolysis, molten salt, high-temperature fluid wall, and thermal desorption and these were given a score of two. Plasma arc and corona glow, according to the literature, are still in the laboratory scale stage and were given scores of one. The microwave plasma process has been reportedly abandoned by the developer and was consequently assigned a zero.

Effectiveness/Efficiency

Thermal processes produce the most effective destruction efficiencies of all of the technologies evaluated for this report. All but two of the thermal processes have reported efficiencies in excess of 99.99 percent and were assigned a score of four. Microwave plasma systems have reported efficiencies of approximately 99 percent, which is a score of three for this criterion. Radio frequency heating has been demonstrated to be 75 to 80 percent effective and was given a score of two.

Time to Accomplish Remediation

None of the thermal processes evaluated were considered capable of completing the remediation in less than one year. The rotary kiln, mobile incinerator, fluidized bed, multiple hearth, liquid injection, thermal desorption, and ocean incineration could accomplish remediation in three to five years for a score of one. The cement kiln would require modifications or supplemental equipment and was given a score of zero.

Plasma arc, pyrolysis-starved combustion, molten salt, radio frequency, high-temperature fluid wall, corona glow, and microwave plasma, because of their early development stage, were judged to take a considerably longer time than five years and were also given a score of zero.

Negative Impacts

High-temperature fluid wall, thermal desorption, molten salt, plasma arc, corona glow, radio frequency heating, and microwave plasma were judged to create some minor waste streams during processing of waste and were assigned a score of three. All of the remaining thermal processes were assigned values of two because they generate air, water, and solid waste streams requiring some form of add-on treatment.

Technology Applicability

Those thermal processes incorporating a rotary kiln incineration system can handle all of the problems identified on the site (soil, water, structures, drummed waste, sewers) and were given a score of four for technology applicability. Fluidized bed and microwave plasma can be used to treat two or three of the problems and were given a score of two. Corona glow can only be used to destroy chemicals in the vapor phase, thus requiring another treatment process to be incorporated, and was therefore given a score of zero. The remaining thermal processes were given a score of one because their applicability is limited to only one or two site problems. These processes require liquid phase input such as water, liquefied soils, liquid chemicals, or relatively small, free-flowing particle-sized solids.

Cost

Virtually all of the thermal destruction treatment processes have high associated costs. Most range from $300 to $1,000 per ton for treatment. All processes were assigned a score of one.

Site-Specific Constraints

Virtually all of the thermal destruction techniques have associated with them major difficulties in terms of implementation at the site. Most of these difficulties are associated with the size of the area needed for setup of the necessary equipment and the logistics of setting up the operation. The only thermal treatment technique that would be relatively easy to set up at the site is mobile incineration. However, all thermal treatment methods would require excavation and material handling equipment with resultant severe site limitations.

Summary

Second-stage screening of thermal processes resulted in highest scores for rotary kiln (3.3) and mobile incineration (4.3).

5.4.3.3.2 Chemical

Suitability for Hazardous Waste

Ten chemical treatment processes have been screened for this study. All have been demonstrated to be suitable for the treatment of hazardous waste and were given a score of four for that criterion.

Proven for Dioxin

Seven of the ten chemical treatment processes were judged to be able to treat dioxin, PCBs, or chlorinated organics effectively, with ultraviolet (UV) photolysis, catalyzed wet oxidation (CWO), and alkaline polyglycoxide scoring fours; Modar supercritical water oxidation (MSWO), oxidation, and PCB reagents scoring three; and hydrazine a two. The three remaining chemical processes--neutralization, precipitation, and hydrolysis--were judged to be ineffective in treating the site dioxin problems. They were assigned a score of zero and eliminated from further scoring.

Stage of Development of the Technology

Of the seven technologies remaining in the screening process, UV photolysis and PCB reagents can be commercial with modifications and were rated a three. CWO, alkaline polyglycoxide, and MSWO were rated as being in the pilot stage of development and were assigned a score of two. Hydrazine and oxidation were judged to be in bench or lab scale and were given scores of one.

Effectiveness/Efficiency

Modar supercritical water oxidation reportedly has achieved destruction efficiencies in excess of 99.99 percent and was the only chemical process to be rated a four. UV photolysis, CWO, and PCB reagents have reported efficiencies between 98 and 99.99 percent and were assigned a score of three. Alkaline polyglycoxide, hydrazine, and oxidation with efficiencies less than 98 percent were given scores of two.

Time to Accomplish Remediation

All of the chemical processes were estimated to require significant lengths of time for remediation. Only UV photolysis was estimated to be capable of being completed in two to three years and was assigned a score of two. All other processes are estimated to require in excess of three years and were given scores of one.

Negative Impacts

MSWO is the only technology without major negative impacts and was assigned a score of three. The remaining chemical technologies excluding hydrazine were assigned a score of two corresponding to significant negative impacts because of reaction products. Hydrazine was given a score of one because of insufficient available data.

Technology Applicability

Only MSWO and alkaline polyglycoxide can be applied to two or three of the identified concerns and were given scores of two. The other five chemical processes were rated a one because they can only be adapted to one or two of the identified site concerns.

Cost

All of the chemical treatment processes evaluated have reported costs in excess of $300 per ton or the costs were unknown. As a result, each was assigned a score of one for this criterion.

Site-Specific Constraints

All of the chemical treatment technologies were determined to be implemented at the site with either minor or moderate difficulty.

Summary

Second-stage screening of chemical processes resulted in UV photolysis and MSWO having the highest adjusted scores of 3.8.

5.4.3.3.3 Physical

Suitability for Hazardous Waste

Nine physical treatment technologies were screened for this study. All have been successfully applied to various types of hazardous waste and were given a four for this criterion.

Proven for Dioxin

Three processes have been demonstrated on dioxin or PCBs. Carbon adsorption and extraction (soil washing) are proven for dioxin and were assigned a four, while volatilization has been used for PCBs and was assigned a three.

The remaining physical processes, including flocculation, sedimentation, ion exchange, reverse osmosis, filtration, and liquid-liquid extraction, are unable to treat the dioxin-related problems identified on the site. As a result, these six physical processes were assigned scores of zero and were not screened further.

Stage of Development of the Technology

The three remaining physical treatment processes are similar in a number of respects. Carbon adsorption is a commercial technology and received a score of four. The other two are considered to be in the pilot stage of development and were assigned a score of two.

Effectiveness/Efficiency

The removal efficiency of carbon adsorption exceeds 98 percent and a score of three was assigned. Removal efficiencies for the remaining technologies are estimated to be in the 50 to 98 percent range; therefore, a score of two was assigned to each.

Time to Accomplish Remediation

Carbon adsorption and extraction are estimated to require two to three years for remediation and were assigned a score of two. Volatilization is judged to require more time and was given a score of one.

Negative Impacts

Carbon adsorption used to treat ground water containing dioxin and other chemicals could generate significant quantities of spent carbon requiring additional treatment and/or disposal. A score of two was assigned. Extraction of soil could introduce other materials (solvents) to the site or provide a vehicle for the transport and movement of existing chemicals on the site; thus, a one was assigned. Volatilization could generate volatile air emissions and significant residual levels could remain in the processed ground water. A score of two was assigned.

Technology Applicability

Because all three physical processes remaining in consideration treat only liquid phase materials, a low score of one was assigned to each.

Cost

Carbon adsorption of ground water was considered the cheapest of the physical processes evaluated and was given a score of three. In-place extraction of soil would cost significantly more and was assigned a score of two. Volatilization costs for ground water remediation are estimated to be high and a score of one was assigned.

Site-Specific Constraints

Carbon adsorption was judged to be relatively easy to implement at the site while extraction and volatilization were determined to be very difficult to implement due to materials handling problems.

Summary

Carbon adsorption received an adjusted score of 4.8. Although it is applicable to liquid phase materials only, when combined with other actions/ technologies it could be a suitable method of treating ground water.

5.4.3.3.4 Solidification/Stabilization/Fixation

Three technologies in this treatment category were screened: organic-based stabilization, inorganic-based stabilization, and vitrification or glassification.

Suitability for Hazardous Waste

All of these technologies have been demonstrated on hazardous waste and each was subsequently scored a four.

Proven for Dioxin

Each of the technologies has been used in the treatment of chlorinated organics and thus a score of two was assigned to each.

Stage of Development of the Technology

The organic- and inorganic-based stabilization processes have been successfully applied in field tests and a score of three was assigned. Vitrification is considered to be at a lower stage of development and was scored a two.

Effectiveness/Efficiency

These technologies do not destroy contamination but immobilize it. [However, it was not judged that resulting immobilization would be a significant improvement over the current site conditions.] Therefore, these technologies were rated as a one.

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Time to Accomplish Remediation

The organic- and inorganic-based stabilization would require two years for completion of remediation. The vitrification process would require more than two years, including development, and was screened a two.

Negative Impacts

The scores were three for inorganic-based stabilization, two for organic-based stabilization, and one for vitrification.

Technology Applicability

Because these technologies are primarily applicable only to soils and drummed wastes, with some potential benefit to ground water and sewers. A score of two was assigned to each.

Cost

Costs for the organic and inorganic techniques were estimated to be approximately $100 per ton for a score of three. Vitrification costs, including the costs to remove any subsurface metal pipes to enable the process to work, were judged to be in excess of $200 per ton corresponding to a score of two.

Site-Specific Constraints

All of the stabilization techniques can be implemented only with great difficulty and received a score of one.

Summary

Second-stage screening of solidification/fixation/stabilization resulted in organic- and inorganic-based stabilization receiving adjusted total scores of 3.3 and 3.5, respectively.

5.4.3.3.5 Bioreclamation

Suitability for Hazardous Waste

Bioreclamation is an effective treatment for various types of organic waste and was assigned a score of four.

Proven for Dioxin

Recent work by Bumpus, et al. (1985), has demonstrated that the white rot fungus is capable of degrading dioxin in laboratory experiments. This process was assigned a score of four.

Stage of Development of the Technology

Currently, the process has only been tested at the laboratory level and was thus assigned a score of one. The EPA plans a small field study in late 1985 or early 1986.

Effectiveness/Efficiency

Based upon current, limited data, the efficiency is expected to be less than 50 percent and a score of one was assigned.

Time to Accomplish Remediation

The process is expected to require more than five years to accomplish and thus received a score of zero.

Negative Impacts

Based upon laboratory experiments, few negative impacts are anticipated. Bioreclamation received a score of three.

Technology Applicability

Introduction of the white rot fungus on the site is expected to treat four of the identified site problems. Only treatment of structures and equipment by this technology would not be feasible. Therefore, a score of three was assigned.

Cost

The costs associated with this treatment process are estimated to be $200 to $300 per ton of material. A score of two was assigned.

Site-Specific Constraints

Bioreclamation was judged to be implemented with only minor difficulties and was given a score of three.

Summary

Second-stage screening of the bioreclamation process resulted in an adjusted total score of 1.3. It is still at the laboratory scale and has a low destruction efficiency. In addition, time required for remediation is expected to exceed five years.

5.4.3.3.6 Containment

Suitability for Hazardous Waste

All four of the containment methods evaluated have been used for and are suitable for the containment of a variety of hazardous wastes; therefore, all were given a score of four.

Proven for Dioxin

Vaulting has been applied to dioxin wastes. The other methods appear suitable because of the immobility of dioxin and because these methods have been applied to PCBs and chlorinated wastes. Sheet piling was given a score of two because of the additional need to seal the sheeting interlocks.

Stage of Development

All four techniques are widely used and available.

Effectiveness/Efficiency

Slurry walls and vaults are generally the most effective of the containment techniques, with slurry walls judged only slightly less secure than vaults. Grout injection and sheet pile cutoff walls are somewhat less effective. In using grout injection, there is a risk that the grout will not fill all void spaces. In using sheet piling, there is leakage through the wall until the seams have time to plug. This can be overcome through the use of injected sealer.

Time to Accomplish Remediation

Slurry walls and sheet piling cutoff walls are straightforward operations requiring a minimum of materials handling and preparation as compared to vault construction. Grout injection is a more complicated procedure requiring a longer time period to implement and hence to accomplish remediation. The same is true of vault construction.

Negative Impacts

Negative impacts associated with all of the containment methods were judged to be minimal. Slurry walls were judged as having the least negative impacts, while the sheet piling was judged as having the most.

Technology Applicability

The technologies were scored solely on the basis of direct application to the site concerns presented in Section 5.2. These technologies will meet all site concerns when coupled with actions such as demolition.

Cost

Both slurry walls and sheet piling cutoff walls are relatively inexpensive techniques. Vault construction is more expensive (expected cost of $100 to $200 per ton), while grout injection is estimated to cost between $200 and $300 per ton.

Site-Specific Constraints

It is expected that a slurry wall containment system could be easily implemented at the site. Moderate difficulty would likely be encountered in using a grout injection system. Large buried objects (e.g., pilings, etc.) at the site would cause severe difficulties for sheet piling, and the small size of the site and volume of material to be handled could preclude the use of a vault.

Summary

Based on the second-stage screening, the most appropriate containment option for the site is a slurry wall with cap which received an adjusted score of 7.8. The related options of grout injection and sheet piling cutoff would encounter difficulties in the implementation phase.

5.5 SUMMARY OF POTENTIALLY APPLICABLE ACTIONS/TECHNOLOGIES

As a result of the two stages of screening, several actions/technologies have been identified as having potential further consideration for remediation of the identified site problems. These are summarized in the following paragraphs. The results are presented by identified site problem for the first-stage screening and, where a specific type of treatment process is indicated, the most promising of these technologies determined from the second-stage screening are also listed. Mobile incineration is the only thermal technology considered to have passed the second stage of screening. Carbon adsorption received the highest score of the physical technologies but its applicability is limited to treatment of liquids; therefore, it is not considered applicable unless combined with, or as a part of, other actions/technologies. All of the containment options are viable based on the scoring criteria. Slurry wall and cap received the highest score of the containment methods.

5.5.1 Structures and Equipment

The following actions/technologies will form the basis for the development of remedial action alternatives related to structures and equipment:

- No Action
- Dust Abatement
- Grading for Surface Water Control/Collection
- Demolition
- Decontamination
- Storage
- Thermal Treatment
  - Mobile Incineration
- Containment
- Land Disposal.

5.5.2 Drummed and Containerized Wastes

The following actions/technologies will form the basis for the development of remedial action alternatives related to drummed and containerized wastes:

- No Action
- Storage
- Thermal Treatment
  - Mobile Incineration
- Land Disposal
- Containment
- Stabilization.

5.5.3 Soil

The following actions/technologies will form the basis for the development of remedial action alternatives related to soils at the site:

- No Action
- Dust Abatement
- Grading for Surface Water Control/Collection
- Pumping of Ground Water

- Capping
- Slurry Walls
- Grout Curtains/Grout Injection
- Sheet Piling Cutoff Walls
- Excavation
- Storage
- Thermal Treatment
  - Mobile Incineration
- Land Disposal.

5.5.4 Ground Water

The following actions/technologies will form the basis for the development of remedial action alternatives related to ground water at the site:

- No Action
- Pumping of Ground Water
- Capping
- Slurry Wall
- Grout Curtains/Grout Injection
- Sheet Piling Cutoff Walls
- Thermal Treatment of Soil
  - Mobile Incineration
- Deep Well Injection
- Carbon Adsorption.

5.5.5 Sewers

The following actions/technologies will form the basis for the development of remedial action alternatives related to site sewers:

- No Action
- Grading for Surface Water Control/Collection
- Pumping of Ground Water
- Capping
- Slurry Walls
- Grout Curtains/Grout Injection
- Sheet Piling Cutoff Walls
- Plugging of Pipelines/Sewers
- Decontamination
- Excavation
- Storage
- Thermal Treatment
  - Mobile Incineration
- Land Disposal.

TABLES

TABLE 5.3-1

GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

I. NO ACTION
- Monitoring

II. RECEPTOR MODIFICATION
- Relocation
- Alternative Water Source

III. CONTROL, CONTAINMENT, AND STORAGE
- Control
  - + Dust Abatement
  - + Grading for Surface Water Control/Collection
    - ● Dikes and Berms
    - ● Ditches, Diversions, and Waterways
    - ● Terraces and Benches
    - ● Chutes and Downpipes
    - ● Levees
    - ● Seepage Basins and Ditches
    - ● Sedimentation Basins/Ponds
  - + Subsurface Drains
  - + Pumping of Ground Water
    - ● Well-Point System
    - ● Deep Wells
- Containment
  - + Capping
  - + Slurry Walls
  - + Grout Curtains/Grout Injection
  - + Sheet Piling Cutoff Walls
  - + Plugging of Pipelines/Sewers
- Storage

IV. REMOVAL
- Excavation
- Demolition
- Decontamination
- Pumping of Ground Water

V. TREATMENT AND DISPOSAL
- Treatment
  - + Thermal
    - ● Rotary Kiln
    - ● Cement Kiln
    - ● Mobile Incineration
    - ● Fluidized Bed
    - ● Multiple Hearth
    - ● Pyrolysis-Starved Combustion (Pyrolyzing Rotary Kiln)
    - ● Molten Salt
    - ● High-Temperature Fluid Wall Reactor (Huber)

TABLE 5.3-1
(Continued)

        - Plasma Arc Pyrolysis
        - Microwave Plasma
        - Radio Frequency (Microwave) Heating
        - Liquid Injection
        - Industrial Boiler/Furnace
        - Thermal Desorption
        - Ocean Incineration
        - Corona Glow
    - Chemical
        - UV Photolysis
        - Catalyzed Wet Oxidation
        - Alkalide Polyglycoxide
        - Hydrazine (Reduction)
        - Oxidation (Ruthenium Tetraoxide)
        - PCB Reagents (Dechlorination)
        - Modar Supercritical Water Oxidation
        - Neutralization
        - Precipitation
        - Hydrolysis
    - Physical
        - Carbon Adsorption
        - Extraction (Soil Washing)
        - Volatilization (Steam Reformation)
        - Flocculation
        - Sedimentation
        - Ion Exchange
        - Reverse Osmosis
        - Filtration
        - Liquid-Liquid Extraction
    - Solidification, Stabilization, Fixation of Soil
        - Organic-Based Chemical Stabilization
        - Inorganic-Based Chemical Stabilization
        - Vitrification (Glassification)
    - Bioreclamation
- Disposal
    - Land Disposal
    - Deep Well Injection

TABLE 5.4-1

GENERAL RESPONSE ACTIONS VERSUS IDENTIFIED SITE PROBLEM AREAS

RESPONSE ACTION	IDENTIFIED CONTAMINATION PROBLEMS				
	STRUCTURES AND EQUIPMENT	DRUMMED WASTES AND DECONTAMINATION WATERS	SOIL	GROUND WATER	SEWERS
I. No Action	X	X	X	X	X
II. Receptor Modification				X	X
III. Control, Containment, and Storage	X	X	X	X	X
IV. Removal	X	X	X	X	X
V. Treatment and Disposal	X	X	X	X	X

TABLE 5.4-2

INITIAL SCREENING OF ACTIONS/TECHNOLOGIES

	IDENTIFIED CONCERNS				
ACTION/TECHNOLOGY	STRUCTURES AND EQUIPMENT	DRUMMED WASTES AND DECONTAMINATION WATERS	SOIL	GROUND WATER	SEWERS
I. No Action					
- Monitoring	Y	Y	Y	Y	Y
II. Receptor Modification					
- Relocation	N	N	N	N	N
- Alternative Water Source	N	N	N	N	N
III. Control, Containment, and Storage					
- Control					
+ Dust Abatement	Y	N	Y	N	N
+ Grading for Surface Water Control/Collection	Y	N	Y	P	Y
+ Subsurface Drains	P	N	P	P	P
+ Pumping of Ground Water	N	N	Y	Y	Y
- Containment					
+ Capping	N	N	Y	Y	Y
+ Slurry Walls	N	N	Y	Y	Y
+ Grout Curtains/Grout Injection	N	N	Y	Y	Y
+ Sheetpiling Cutoff Walls	N	N	Y	Y	Y
+ Plugging of Pipelines/Sewers	N	N	N	N	Y
- Storage	Y	Y	Y	N	Y
IV. Removal					
- Excavation	N	N	Y	N	Y
- Demolition	Y	N	N	N	N
- Decontamination	Y	N	N	N	Y
- Pumping of Ground Water	N	N	N	Y	N
V. Treatment and Disposal					
- Treatment					
+ Thermal	Y	Y	Y	Y	Y
+ Chemical	Y	P	Y	Y	Y
+ Physical	N	N	P	Y	N
+ Solidification, Stabilization, Fixation	P	Y	P	Y	P
+ Bioreclamation	N	N	P	P	N
- Disposal					
+ Land Disposal	Y	Y	Y	P	Y
+ Deep-Well Injection	N	P	N	Y	N

Note: 1. Y (yes) indicates clearly applicable action/technology.
2. P (possible) indicates possibly applicable action/technology.
3. N (no) indicates nonapplicable action/technology.

TABLE 5.4-3

CRITERIA SCORING RULES

1. Individual criteria are scored in the range of zero to four (see Table 5.3-4).

2. The criteria scores are summed.

3. The summed scores are divided by four to convert to a zero to nine range.

4. Any technology which receives a zero in "Proven for Dioxin" is given an adjusted total score of zero. This has been done because dioxin is the contaminant of greatest concern at the site. Thus, technologies which will not treat dioxin are of little value.

5. If a zero occurs in any other criterion score, a two-point deduction is made to the score in Item 3 for each occurrence. The deduction is made to reflect the difficulty associated with a major deficiency.

6. If a one occurs in any criterion score, a one-point deduction is made to the score in Item 3 for each occurrence.

7. No score is adjusted below zero.

As in Item 5 above, the deduction is intended to reflect the difficulties associated with technologies with serious deficiencies when compared to technologies without similar problems.

TABLE 5.4-4

CRITERIA SCORING

1. Suitability for Hazardous Waste

4	Proven applications on hazardous waste
0	Used for other commercial or experimental purposes but not proven for hazardous waste

2. Proven for Dioxin

4	Has been used to treat dioxin-containing waste
3	Has been used to treat PCB's
2	Has been used to treat chlorinated organics
1	Might work on dioxin waste with modifications
0	Will not treat dioxin

3. Stage of Development of the Technology

4	Commercial or full scale
3	Commercial with modifications
2	Pilot scale
1	Benchscale/laboratory
0	Abandoned

4. Effectiveness/Efficiency

For treatment technologies:

4	99.99 percent plus
3	98 to 99.99 percent
2	50 to 98 percent
1	1 to 50 percent
0	Will not effectively treat dioxin

For containment technologies:

4	Total immobilization
3	Very effective immobilization
2	Moderately effective immobilization
1	Slightly effective immobilization
0	Ineffective

TABLE 5.4-4
(Continued)

5. Time to Accomplish Remediation

4	0 to 1 year
3	1 to 2 years
2	2 to 3 years
1	3 to 5 years
0	>5 years

6. Negative Impacts

4	None expected
3	Minor negative impacts
2	Significant negative impacts
1	Multiple negative impacts
0	Many serious negative impacts

7. Technology Applicability

4	Will treat all identified site problems
3	Will treat four identified site problems
2	Will treat two or three identified site problems
1	Will treat one or two identified site problems
0	Can only be used in conjunction with another treatment process

8. Cost

4	0 to 100 dollars per ton
3	100 to 200 dollars per ton
2	200 to 300 dollars per ton
1	300 to 1,000 dollars per ton
0	>1,000 dollars per ton

9. Site-Specific Constraints

4	Can be easily implemented
3	Can be implemented with only minor difficulties
2	Can be implemented with a moderate amount of difficulty
1	Can be implemented with only great difficulty
0	Site conditions pose almost insurmountable implementation problems

TABLE 5.4-5

SECOND-STAGE SCREENING
A. THERMAL DESTRUCTION

SCREENING CRITERIA

ACTION/TECHNOLOGY	SUITABILITY FOR HAZARDOUS WASTES	PROVEN FOR DIOXIN	STAGE OF DEVELOPMENT	EFFECTIVENESS/ EFFICIENCY	TIME TO ACCOMPLISH REMEDIATION	NEGATIVE IMPACTS	TECHNOLOGY APPLICABILITY	COST	SITE-SPECIFIC CONSTRAINTS	TOTAL	TOTAL ÷ 4	ADJUSTED TOTAL
Rotary Kiln	4	4	4	4	1	2	4	1	1	25	6.3	3.3
Cement Kiln	4	3	3	4	0	2	4	1	0	21	5.3	0.3
Mobile Incineration	4	4	3	4	1	2	4	1	2	25	6.3	4.3
Fluidized Bed	4	1	3	4	1	2	2	1	1	19	4.8	0.8
Multiple Hearth	4	1	4	4	1	2	1	1	1	19	4.8	0
Pyrolysis	4	1	2	4	0	2	4	1	2	20	5.0	1.0
Molten Salt	4	3	2	4	0	3	1	1	2	20	5.0	1.0
High-Temperature Fluid Wall	4	4	2	4	0	3	1	1	2	21	5.3	1.3
Plasma Arc	4	3	1	4	0	3	1	1	2	19	4.8	0
Microwave Plasma	4	3	0	3	0	3	2	1	2	18	4.5	0
Radio Frequency Heating	4	1	2	2	0	3	1	1	0	14	3.5	0
Liquid Injection	4	4	4	4	1	2	1	1	1	22	5.5	1.5
Industrial Boiler or Furnace	4	0	-	-	-	-	-	-	-	-	-	0
Thermal Desorption	4	4	2	4	1	3	1	1	2	22	5.5	2.5
Ocean Incineration	4	4	4	4	1	2	1	1	2	23	5.8	2.8
Corona Glow	4	3	1	4	0	3	0	1	2	18	4.5	0

Note: 1. See Table 5.4-3 for criteria scoring rules.
2. See Table 5.4-4 for criteria scoring.

TABLE 5.4-5
(Continued)

SECOND-STAGE SCREENING
B. CHEMICAL

ACTION/TECHNOLOGY	SCREENING CRITERIA											
	SUITABILITY FOR HAZARDOUS WASTES	PROVEN FOR DIOXIN	STAGE OF DEVELOPMENT	EFFECTIVENESS/ EFFICIENCY	TIME TO ACCOMPLISH REMEDIATION	NEGATIVE IMPACTS	TECHNOLOGY APPLICABILITY	COST	SITE-SPECIFIC CONSTRAINTS	TOTAL	TOTAL ÷ 4	ADJUSTED TOTAL
UV Photolysis	4	4	3	3	2	2	1	1	3	23	5.8	3.8
Catalyzed Wet Oxidation	4	4	2	3	1	2	1	1	3	21	5.3	2.3
Alkaline Polyglycoxide	4	4	2	2	1	2	2	1	2	20	5.0	3.0
Hydrazine	4	2	1	2	1	1	1	1	2	15	3.8	0
Oxidation	4	3	1	2	1	2	1	1	3	18	4.5	0.5
PCB Reagents	4	3	3	3	1	2	1	1	2	20	5.0	2.0
Modar Supercritical Water Oxidation	4	3	2	4	1	3	2	1	3	23	5.8	3.8
Neutralization	4	0	-	-	-	-	-	-	-	-	-	0
Precipitation	4	0	-	-	-	-	-	-	-	-	-	0
Hydrolysis	4	0	-	-	-	-	-	-	-	-	-	0

Note: 1. See Table 5.4-3 for criteria scoring rules.
2. See Table 5.4-4 for criteria scoring.

TABLE 5.4-5
(Continued)

SECOND-STAGE SCREENING
C. PHYSICAL

ACTION/TECHNOLOGY	SCREENING CRITERIA											
	SUITABILITY FOR HAZARDOUS WASTES	PROVEN FOR DIOXIN	STAGE OF DEVELOPMENT	EFFECTIVENESS/ EFFICIENCY	TIME TO ACCOMPLISH REMEDIATION	NEGATIVE IMPACTS	TECHNOLOGY APPLICABILITY	COST	SITE-SPECIFIC CONSTRAINTS	TOTAL	TOTAL ÷ 4	ADJUSTED TOTAL
Carbon Adsorption	4	4	4	3	2	2	1	3	4	27	6.8	4.8
Extraction (Soil Washing)	4	4	2	2	2	1	1	2	1	19	4.8	1.8
Volatilization (Steam Reforming)	4	3	2	2	1	2	1	1	1	17	4.3	0.3
Flocculation	4	0	-	-	-	-	-	-	-	-	-	0
Sedimentation	4	0	-	-	-	-	-	-	-	-	-	0
Ion Exchange	4	0	-	-	-	-	-	-	-	-	-	0
Reverse Osmosis	4	0	-	-	-	-	-	-	-	-	-	0
Filtration	4	0	-	-	-	-	-	-	-	-	-	0
Liquid-Liquid Extraction	4	0	-	-	-	-	-	-	-	-	-	0

Note: 1. See Table 5.4-3 for criteria scoring rules.
2. See Table 5.4-4 for criteria scoring.

TABLE 5.4-5
(Continued)

SECOND-STAGE SCREENING
D. SOLIDIFICATION, STABILIZATION, FIXATION

ACTION/TECHNOLOGY	SCREENING CRITERIA SUITABILITY FOR HAZARDOUS WASTES	PROVEN FOR DIOXIN	STAGE OF DEVELOPMENT	EFFECTIVENESS/ EFFICIENCY	TIME TO ACCOMPLISH REMEDIATION	NEGATIVE IMPACTS	TECHNOLOGY APPLICABILITY	COST	SITE-SPECIFIC CONSTRAINTS	TOTAL	TOTAL ÷ 4	ADJUSTED TOTAL
Organic Based	4	2	3	1	3	2	2	3	1	21	5.3	3.3
Inorganic Based	4	2	3	1	3	3	2	3	1	22	5.5	3.5
Vitrification (Classification)	4	2	2	1	2	1	2	2	1	17	4.3	1.3
E. BIORECLAMATION												
Bioreclamation	4	4	1	1	0	3	3	2	3	21	5.3	1.3

Note: 1. See Table 5.4-3 for criteria scoring rules.
2. See Table 5.4-4 for criteria scoring.

TABLE 5.4-5
(Continued)

SECOND-STAGE SCREENING
F. CONTAINMENT

	SCREENING CRITERIA											
ACTION/TECHNOLOGY	SUITABILITY FOR HAZARDOUS WASTES	PROVEN FOR DIOXIN	STAGE OF DEVELOPMENT	EFFECTIVENESS/ EFFICIENCY	TIME TO ACCOMPLISH REMEDIATION	NEGATIVE IMPACTS	TECHNOLOGY APPLICABILITY	COST	SITE-SPECIFIC CONSTRAINTS	TOTAL	TOTAL + 4	ADJUSTED TOTAL
Slurry Wall with Cap	4	3	4	3	4	4	2	4	3	31	7.8	7.8
Grout Injection with Cap	4	3	4	2	2	3	2	2	2	24	6.0	6.0
Sheet Piling Cutoff with Cap	4	2	4	2	4	2	2	4	1	25	6.3	5.3
Vault	4	4	4	4	2	3	2	3	0	26	6.5	4.5

Note: 1. See Table 5.4-3 for criteria scoring rules.
2. See Table 5.4-4 for criteria scoring.

FIGURE

DRAWING NUMBER 850032-A17

CHECKED BY WHB 10-5-85
APPROVED BY DT 10-30-85

DRAWN BY clb/ 09-30-85

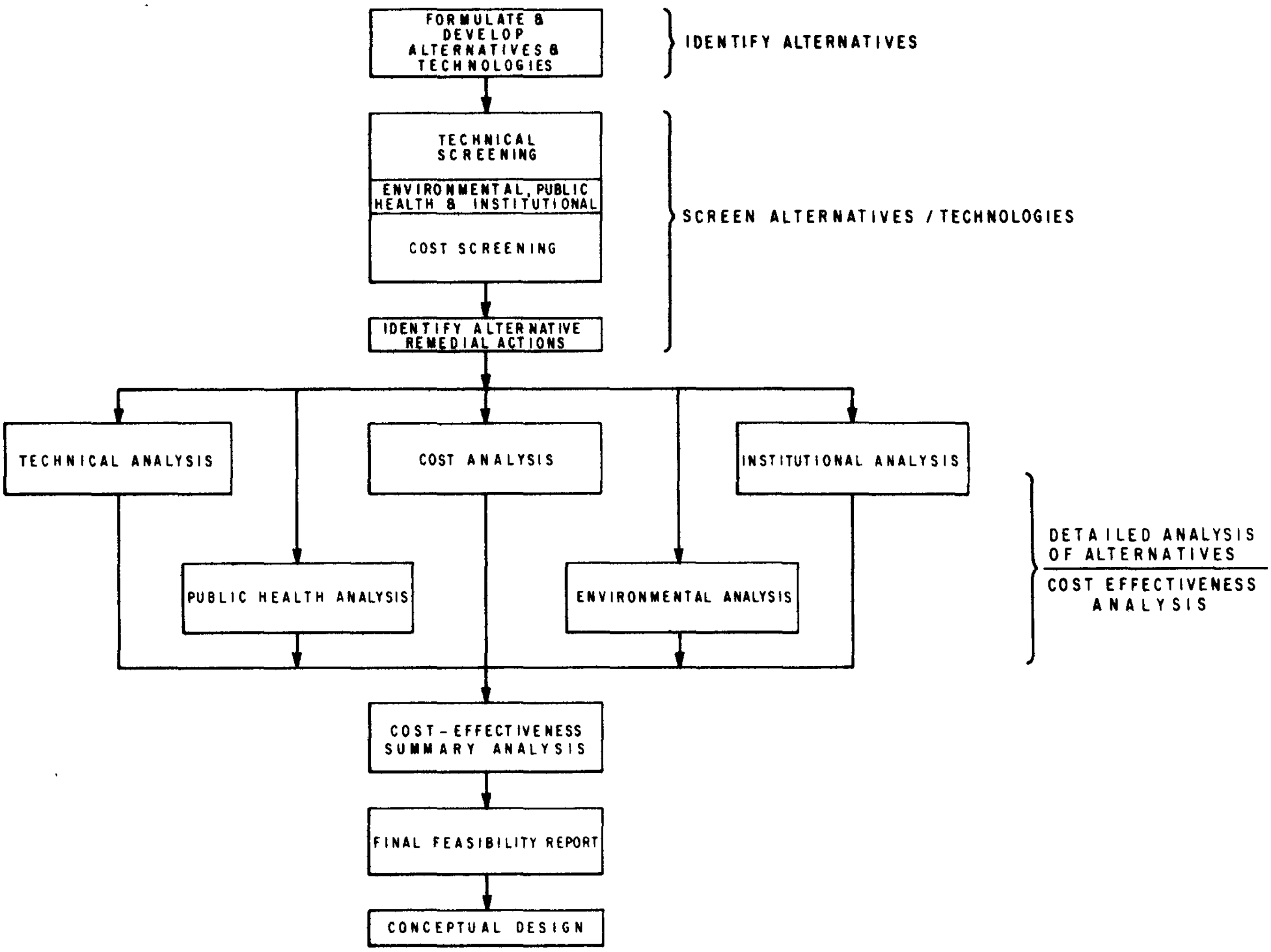

FIGURE 5.1-1

SELECTION OF REMEDIAL ALTERNATIVES
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

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"Do Not Scale This Drawing"

6.0

6.0 ALTERNATIVES FOR REMEDIATION

6.1 REQUIREMENTS

In the preceding section, a screening of the technologies that are capable of being applied to the remediation of the various areas of concern at the 80 Lister Avenue site was accomplished. The purpose of this section is to group the applicable technologies into remedial action alternatives in accordance with the EPA feasibility study guidance process (U.S. EPA, 1985). The EPA recommends that, in a feasibility study, the remedial action alternative list contain at least one alternative of each of the following categories:

1. No-action alternative
2. Alternatives which do not attain applicable or relevant public, health, or environmental standards but which reduce the likelihood of present or future threat from the hazardous substances
3. Alternatives for treatment or disposal at an off-site facility approved by the EPA
4. Alternatives which attain applicable and relevant public health or environmental standards
5. Alternatives which exceed applicable and relevant public health or environmental standards.

6.2 IDENTIFICATION OF POTENTIAL REMEDIAL ACTION ALTERNATIVES

Identification of the remedial action alternative is a process that begins with the potentially applicable technologies resulting from the screening step (Section 5.5). Figure 6.2-1 depicts the combinations possible for all applicable technologies to remediate each of the problem areas identified in Section 5.0. From Figure 6.2-1, the remedial action alternatives (in addition to the no-action alternative) fall into the following alternatives:

- Alternative 1 - No action
- Alternative 2 - Demolition of structures, decontamination, grading, and in situ containment of all waste with a slurry wall and cap
- Alternative 3 - Demolition of structures, decontamination, grading, and in situ containment of all waste with a slurry wall and cap, with continued pumping and treatment of the ground water

- Alternative 4 - Demolition of structures, decontamination, grading, excavation, on-site treatment of ground water, and thermal treatment of all site waste and soils containing dioxin above 7 ppb with in situ containment of the remaining site soils and treated material with a slurry wall and cap

- Alternative 5 - Demolition of structures, decontamination, grading, excavation, on-site treatment of ground water, and vault encapsulation of all site waste and soils containing dioxin above 7 ppb with in situ containment of the remaining site soils with a slurry wall and the vault

- Alternative 6 - Demolition of structures, decontamination, grading, excavation, on-site treatment of ground water, and hauling of waste and soils containing dioxin above 7 ppb to an off-site facility for landfill disposal or thermal treatment; soils remaining with dioxin levels below 7 ppb would be contained by a slurry wall.

Each of these alternatives is described in detail in Section 7.0. The decision process to select the recommended remedial action is contained in Section 8.0. Category 3, "Alternatives for treatment or disposal at an off-site facility approved by the EPA," is not presently feasible because an off-site facility could not be found which is permitted to dispose or treat (incinerate) dioxin.

FIGURE

DRAWING NUMBER 850032-A18

CHECKED BY
APPROVED BY DT 10.30.85

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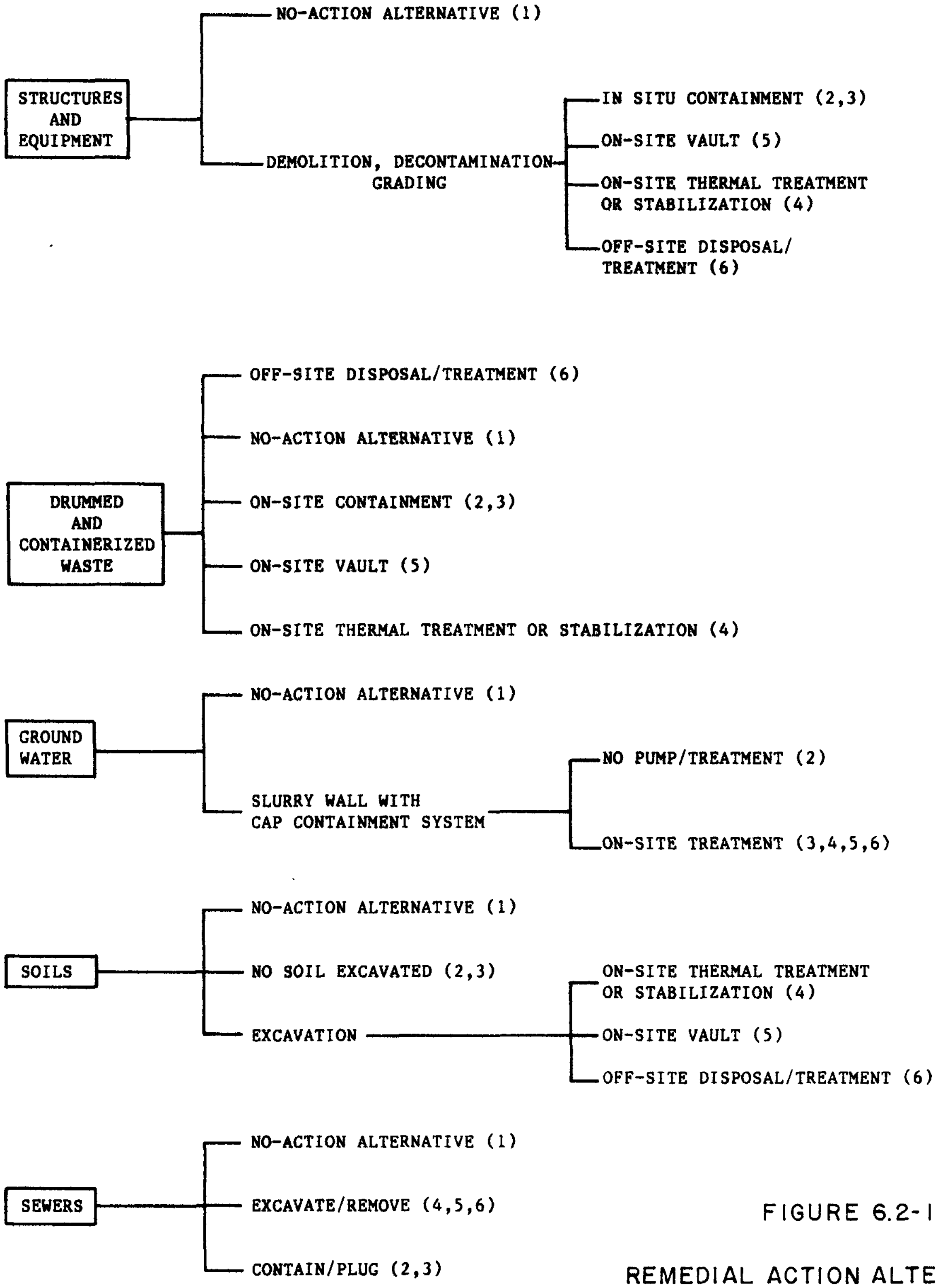

FIGURE 6.2-1

REMEDIAL ACTION ALTERNATIVES
FOR EACH PROBLEM AREA
80 LISTER AVENUE

PREPARED FOR

DIAMOND SHAMROCK
DALLAS, TEXAS

(NUMBERS REFER TO THE DESIGNATION OF ALTERNATIVES
FOR FURTHER CONSIDERATION)

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7.0

7

Dr. Rich Spear 201-321-6686

Carol Price EPA 321-6714

Aerial Surveillance / EROS

DEP has an interagency Agreement with DEP

Jamie Schnitzer - DEP is point contact with Mary Morris - HSMA

he can call down to EPIC

they probably can carry out the Aerial Work

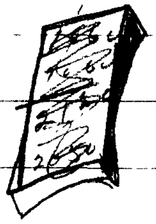
Mary Morris 4-3068

has an IAG with EPIC in Warrenton Va.

talk to Wernard Webb
or Frank Wolle

703-557-3110

VINT HILL FARMS
PO Box 1587
Warrenton Va 22186



2 each time

2 each time

[June 22 & 23, 1983
1984 - NO]

7.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

Section 5.0 presented and evaluated technologies applicable to the remediation of the Lister Avenue site. Based on the results of the screening criteria in Section 5.0, the technologies receiving the highest scoring are developed into remedial action alternatives in Section 6.0. Section 7.0 discusses the steps (specific activities) that would be taken for each alternative to achieve remediation.

Many of the steps are applicable to several alternatives; therefore, the remainder of this section is presented as follows:

- Section 7.1 discusses the steps common to more than one alternative, common features of application, and differences of application. If a remediation step applies to only one remediation alternative, or if the application of the step is very dependent upon the alternative, the step is discussed in Section 7.2. Steps 2, 13, 14, 17, 18, 19, and 20 are discussed in Section 7.2.
- Section 7.2 summarizes the steps taken for each alternative. Remediation steps applicable to only one alternative are presented, and the actions taken in a step which is highly dependent upon the alternative are presented.

The steps are generally discussed in the sequence they would be performed during remediation. Table 7.0-1 lists the steps, a brief description of each step, and the alternatives for which it is applicable. Application of the steps to the alternatives is also shown in Figure 7.0-1.

7.1 DESCRIPTION OF REMEDIATION STEPS

Following are descriptions of the work which will be performed for each remediation step. The steps are as presented in Table 7.0-1. Those steps which are applicable to only one remedial alternative, or for which the application is highly dependent upon the alternative, are discussed in Section 7.2.

Step 1 - Design

Alternatives 2 through 6 will require the preparation of design documents before remediation can be accomplished at the site.

The following designs would be necessary for Alternative 2 and are the initial designs for Alternatives 3 through 6:

- Sewer plugs.
- Drum handling facility and stabilization method testing.
- Slurry wall. Includes testing programs to determine suitable soil mix and bentonite addition to achieve desired permeability, and compatibility of slurry wall mix with ground water. Also, includes plans for layout of expected depth of wall, method of excavation, working pad for wall construction, and soil handling and slurry mixing area.
- Design of the new bulkhead at the site's north boundary with the Passaic River.
- Cap, including liners, and flow zone for intercepting infiltration.
- On-site drainage system.
- Decontamination facilities, including pads and washdown areas for equipment and components that are decontaminated (such as structural steel and containers) and subsequently taken off site.
- Development of work plan.
- Development of monitoring program to be implemented during and subsequent to remediation.

For Alternative 3, the following additional designs are needed:

- Purge well design for continued pumping, including piping for collection and transport to the treatment facility
- Seals for well penetrations through cap
- Water treatment system, including handling of spent carbon and testing of removal efficiency in pilot stage
- Installation of utilities.

For Alternative 4, the following supplement the above common designs which were presented for Alternative 2:

- Crushing/grinding facility for preparation of building materials, sewers, piles, foundations, and other buried obstructions prior to thermal treatment
- Dewatering system needed for excavation, including additional subsurface investigation
- Method of excavation for fill layer
- Development of protocol for control of odors and volatile emissions during excavation
- Handling equipment for excavated materials
- Means for replacing and compacting treated material, including compaction criteria
- Utilities
- Survey adjacent structures/property and design supporting systems, such as underpinning, as needed
- Design of the thermal treatment plant
- Laboratory testing program to determine character of ash and ability to delist for use as backfill.

Alternative 5 includes the following, in addition to the above common Alternative 2 designs:

- Dewatering system needed for excavation, including additional subsurface investigation
- Method of excavation for fill layer
- Development of protocol for control of odors and volatile emissions during excavation
- Survey of adjacent structures/property and design supporting systems, as needed
- Construction sequence, including excavation, stockpiling of fill, placement of clean backfill (including compaction test program so that adequate bearing is provided for the vault), and vault construction; sequencing is extremely critical to the success of this alternative

- Vault, including compaction of materials in the vault, flow zone under the cap, leachate collection/detection system, and cap.

Alternative 6 adds the following designs:

- Dewatering system needed for excavation, including additional subsurface investigation
- Method of excavation for fill layer
- Development of protocol for control of odors and volatile emissions during excavation
- Survey of adjacent structures/property and design supporting systems, as necessary
- Transport loading facility for materials shipped off site for disposal/treatment
- Backfilling of clean material, including compaction criteria.

Step 3 - Drummed Process Wastes

For Alternative 1, the drummed wastes will be retained in storage and inspected at regular intervals. If deterioration is detected, the drum(s) involved will be overpacked.

For Alternatives 2, 3, and 5, the 570 drums of process waste will be stabilized and contained with the balance of the site materials.

For Alternative 4, the wastes would be thermally treated with the balance of the site materials.

For Alternative 6, the drums would be overpacked (if needed) and shipped off site for disposal.

Step 4 - Demolish Buildings

Existing structures and facilities at the 80 and 120 Lister Avenue sites include six buildings and two tank farms. The buildings are in generally poor condition and, because dioxin has been detected in the masonry, cleaning of the structures is impractical. As a result, the buildings and tank farms will be disassembled and the nonsalvageable structures will be demolished for Alternatives 2 through 6.

The six buildings on 80 and 120 Lister Avenue include the warehouse, process, chemical manufacturing, office/laboratory buildings on 80 Lister Avenue, and the two brick buildings on 120 Lister Avenue.

For Alternatives 2 through 6, the buildings will be demolished and disposed of in accordance with the alternative. For all alternatives, the buildings will be sprayed as demolished to control dust. Structural steel and steel tanks, vessels, reactors, etc., will be segregated for decontamination and shipment off site.

For Alternatives 2 and 3, building materials disposed of below the cap will be reduced to adequate size so that the resulting rubble can be placed and soils compacted around the rubble to prevent voids from occurring. The same technique will be used in placing rubble in the vault (Alternative 5). Alternative 6 will require the demolished buildings to be reduced to sizes suitable for off-site transport.

Alternative 4 will require crushing/grinding of the building rubble prior to treatment.

The estimated volume of rubble is approximately 8,000 cubic yards, depending on the material bulking resulting from demolition and the amount of equipment/materials which can be salvaged.

Step 5 - Containerized Wastes

The containerized wastes include materials from the various off-site areas for which remedial actions were performed under the requirements of ACO II. As such, they contain soils, scrap metal, and other miscellaneous debris. It is estimated that 845 containers will be stored at 120 Lister Avenue.

For Alternative 1, the containers would be moved onto the 80 Lister Avenue site and inspected periodically as part of the inspection and maintenance program.

For Alternatives 2 through 5, the containers would be taken to 80 Lister Avenue where the contents would be segregated and handled with the other site materials. Large metal parts would be decontaminated and scrapped if possible. The containers would be cleaned and disposed of as scrap metal. For Alternative 6, the containers would be shipped as is.

Step 6 - Underground Conduit Plugging

For Alternatives 2 through 6, a trench will be excavated around the site boundary to a depth sufficient to intercept the conduits entering and exiting the site. Conduits include sewers and other underground piping. All conduits exiting the property will be plugged with concrete to the outside of the site line. This would complete the action necessary for Alternatives 4 through 6 because the on-site excavation will remove the buried piping.

The trench for locating and plugging the conduits will be approximately 1,600 feet in length. It is not expected that trenching will be required below a six-foot excavation depth. If any currently active conduits transverse the site, they will be rerouted to maintain service. Figure 2.2-8 shows the known sewers associated with the 80 Lister Avenue site.

Step 7 - Grouting of Underground Conduits

For Alternatives 2 and 3, the conduits on site located as part of Step 6 will be grouted completely full using appropriate materials such as cement grout. This is necessary to prevent void spaces under the cap and prevent potential future leaching from the lines.

Step 8 - Construction of the Passaic River Bulkhead

Prior to slurry wall construction and dewatering (as applicable to Alternatives 2 through 6), a new bulkhead wall will be erected along the north site boundary adjacent to the Passaic River. The existing bulkhead is considered inadequate for providing the lateral stability due to the increased ground surface loads associated with Alternatives 2, 3, 4, and 5 and the external lateral loads due to excavation for Alternatives 4, 5, and 6. The bulkhead will be approximately 400 feet in length and will be constructed on the river side of the existing bulkhead and will provide the stability required by the site during remediation. It is expected that the wall will be constructed of marine grade sheet piling and extend 35 to 40 feet below existing site grade.

Step 9 - Install Slurry Wall

A slurry wall is required for Alternatives 2 through 6. The wall will be approximately 1,600 feet in length and two feet wide. For Alternatives 2 and 3, it is expected that a soil-bentonite wall (permeability of 10^{-7} centimeter per second or less) will be constructed and keyed into the silt layer. Alternatives 4, 5, and 6 may require a structural cement-bentonite wall (permeability of 10^{-6} centimeter per second or less) to provide lateral stability for the excavation. Further, Alternatives 4, 5, and 6 may require the slurry wall adjacent the river to extend beyond the silt layer, possibly to rock, to provide seepage control as part of the dewatering systems.

For all alternatives, the slurry wall will follow the alignment established by the trench which was excavated for the plugging of sewers.

In Section 5.0, several means were considered for constructing a lateral barrier. A slurry wall is the most appropriate. It is questionable whether sheet piling can be driven because of unknown buried obstructions. Further, sheet pile interlocks would require sealing to reduce leakage. The development of a barrier by grouting should be effective in the fill; however, it is difficult to totally grout an area, particularly considering possible buried obstructions, and to demonstrate that grouting has been successful.

Step 10 - Support of Adjacent Structures/Property

If Alternatives 4, 5, or 6 are implemented, during design a survey of adjacent structures and property would be required to estimate horizontal and vertical movement resulting from excavation of the site. As necessary, supporting systems would be constructed prior to excavation. Support could include underpinning, grouting, or grade beams. The need for control of movement could also be the deciding factor for specifying a structural slurry wall. The amount and types of support required cannot be estimated at this time.

Step 11 - Dewatering and On-Site Treatment During Remediation

Alternatives 4, 5, and 6 will require a dewatering system during excavation and the subsequent placement of backfill. Dewatering will be required within the fill so that excavation can proceed beyond the natural water table. Significant pumping and treatment of large volumes of water will be required outside of the slurry wall to control the pressure head on the silt layer from the underlying glaciofluvial sand. Careful control of this fluid head is required to minimize the potential for disturbance (heave) of the silt layer.

As stated in Step 9, the slurry wall may be extended below the silt layer to help in controlling ground water movement from the Passaic River to the excavation.

During dewatering, water pumped from the fill will be treated prior to discharge in accordance with New Jersey Pollutant Discharge Elimination System (NJPDES) requirements. Initially, the water pumped (estimated at 100 gpm or greater) from outside of the slurry wall will be treated. This pumped water will be sampled and analyzed to determine if treatment must be continued. If treatment can be discontinued, the outside pumped water will continue to be sampled and analyzed to demonstrate it meets discharge requirements. It is expected that the minimum treatment will be carbon adsorption.

The dewatering system will be of sufficient capacity to handle estimated storm events.

Step 12 - Excavation

For Alternatives 4, 5, and 6, the staging of excavation relative to the alternative remediation method will be different because of the need to balance excavation, stockpiling, and backfill in a limited area. The 3.4-acre size of the site precludes the normal excavation process of excavating, stockpiling, and then backfilling. For this site, the available stockpile area will be very small (possibly nonexistent for Alternative 5) so that all steps of the process must occur simultaneously.

The staging of excavation with the construction of a vault (Alternative 5) will be the most difficult to accomplish and, in fact, may not be possible. It is questionable whether this alternative can be properly sequenced because all of the fill beneath the vault location must be excavated and clean backfill placed beneath the entire vault area before the base of the vault can be completed. This will require the stockpiling of an appreciable volume of excavated fill, possibly 30,000 or more cubic yards.

For Alternative 4, it is expected that the excavated material will be transported directly to the treatment plant (considering capacity of the plant) for processing and then placed as backfill or temporarily stored.

Alternative 6 will require rehandling of the excavated fill for shipment. Shipment should be staged with excavation so that stockpiling is not required. Clean backfill will be placed as soon as practical in excavated areas.

For all alternatives requiring excavation, it is anticipated that earth-moving pans or front-end loaders and trucks will be used. Where obstructions such as piling and sewers are encountered, backhoes and/or front-end loaders and trucks will be required. Piling that penetrates the silt layer will be carefully cut off at the top of the silt layer and sealed, such as with concrete.

The excavation will include sufficient material so that the remaining material will have a level of dioxin of 7 ppb or less. It is expected that all of the fill will be removed, a quantity of 50,000 cubic yards.

Excavation may result in the release of odors and volatile emissions so that a control system could be required during this step.

Step 15 - Backfill of Excavated Area

As stated in Step 12, excavation and backfilling must be carefully staged for Alternatives 4, 5, and 6. For Alternative 4, the treated fill material will be replaced as backfill. This will require delisting as discussed in Step 1. Alternatives 5 and 6 will use clean material from off site as backfill.

For all excavation alternatives, the top of the silt layer will be cushioned prior to backfill placement. The cushion is required to minimize the pumping of water through the silt and to reduce rutting of the silt by construction equipment. It is expected that the cushion will consist of at least a layer of sand, and possibly a geofabric between the silt and cushion sand.

All backfill will be placed in accordance with predetermined compaction criteria to control settlement of the backfill. This is particularly critical for Alternative 5 because the backfill must support the vault.

Step 16 - Construction of the Cap

Alternatives 2, 3, and 4 include the construction of a cap over the site area to minimize the infiltration of water due to precipitation or flooding into the subsurface. In Alternative 5, the vault also serves the purpose of a cap to control infiltration. The cap will be tied to the slurry wall to further provide an effective seal.

A concrete-based cap is proposed in combination with clay for the following reasons:

- Decreases site erosion potential
- Eliminates the possibility of infiltration and contaminant transfer through vegetation root systems
- Maximizes usable area by increasing the side slopes
- Increases the security of the site
- Increases the strength of the cap for greater usability
- Protects the site during a 100-year flood
- Clay provides ductility relative to cap movement due to settlement.

The height of the cap relative to the height of the existing buildings can be seen in Figure 7.2-5, for Alternatives 2, 3, and 4.

The cap for Alternatives 2, 3, and 4 will extend above existing site grade because of the placement of building debris, materials stored in containers, and treated drummed process wastes which are placed above existing grade.

The cap will be designed and constructed so precipitation will run off the cap to the perimeter drains.

Prior to placement of the cap, a cushion, such as a layer of clay, will be placed on the material to be covered to prevent puncture of the cap by buried material such as building debris.

The cap will be built in accordance with Resource Conservation and Recovery Act (RCRA) requirements. These requirements include a cover of low permeability and a flow zone. The low-permeability layer is expected to be either concrete, clay, or clay and concrete. The flow zone will collect infiltration which does penetrate the cap. In addition, a synthetic liner such as high-density polyethylene will be used. This liner will be placed directly on the cushion material.

Step 21 - Ongoing Monitoring and Maintenance

Each of the alternatives will require some level of ongoing monitoring and maintenance. The inspections, sampling, and measurements required for each alternative are presented in Figure 7.1-1.

The most extensive inspection and monitoring program is required for Alternative 1. All structures, site cover, containerized materials, etc., would be monitored weekly. On- and off-site wells would require sampling for chemical constituents and measurement of piezometric head on a quarterly basis as required by RCRA.

Alternative 2 would require a reduced inspection and monitoring program. A quarterly inspection and sampling program is anticipated.

Alternative 3 would require inspection and monitoring of additional facilities because of the ongoing treatment facility. The monitoring program of Alternative 2 will also be implemented.

Alternatives 4, 5, and 6 require inspection and monitoring on a quarterly basis initially. If the wastes were delisted under RCRA in Alternative 4, then the monitoring could be reduced to once or twice per year.

Alternative 6 would require the least inspection and monitoring. Initially, the off-site wells would be monitored quarterly. After demonstrating that migration of constituents is at acceptable levels, the monitoring could be reduced and eventually eliminated.

Chemical parameters for monitoring will be dioxin and DDT.

A detailed monitoring plan, including sampling and analytical protocols and frequency of sampling, will be prepared as part of the work plan for the selected alternative.

Step 22 - Security

Security measures will be required for all alternatives. However, the measures vary widely with the selected action.

Alternative 1 will continue the current level of security measures. These include:

- Fencing to control access to the site
- Lighting at the access gate
- Security guards on a 24-hour/7-day per week basis
- Clock stations at strategic points on the perimeter of the site.

Because of the lack of visibility which would exist on site after the containers are moved from 120 to 80 Lister Avenue, a remote television camera and monitor system would provide visual coverage of the site. All buildings used for drum storage will be padlocked.

For Alternatives 2 through 5, perimeter fences will be maintained. In addition, Alternative 3 would require that the control/treatment building be fenced and lighted. A break-in alarm system would be provided because the site would be unattended.

All alternatives require the maintenance of monitoring wells. Monitoring wells will have steel caps with padlocks on an outer casing set in concrete. The locks will be maintained on all wells remaining in service after the installation of the selected alternative.

7.2 FEATURES OF EACH ALTERNATIVE

In this section, each remedial alternative is discussed individually. The remediation steps discussed in Section 7.1 are not repeated herein; however, steps are discussed if their application is highly dependent upon the alternative, or if the step is applicable to only one alternative. Finally, as part of this section, a separate subsection is included which discusses the anticipated public perception/acceptance of the remedial alternatives.

7.2.1 Alternative 1 - No Action

The no-action alternative includes the maintenance of the site fence, geotextile fabric, security systems, and the establishment of an ongoing monitoring program. The site will essentially remain as it currently exists (Figure 2.1-4) except that all materials remaining on 120 Lister Avenue (east of the fence separating 80 Lister Avenue from 120 Lister Avenue) with dioxin concentrations in excess of 7 ppb will be transferred to 80 Lister Avenue for storage.

Implementation of this alternative will not result in any changes which will impact significantly the site or the environment. However, the buildings are in poor condition and further deterioration will increase the risk of public exposure through airborne dust emissions.

Seepage from the fill, through the silt, and into the sand unit will remain at its present rate of approximately 1.4 gpm resulting in a calculated concentration of dioxin at the nearest possible receptor well of 1.5×10^{-4} μg/ℓ. It should be noted that this concentration does not take into account any retardation of dioxin by soil organic or mineral matter. In addition, these numbers are based upon measured concentrations of dioxin in fill ground waters that contained particulate matter. True dissolved dioxin concentrations will be lower. As shown in the figures in Section 2.0, dioxin was not detected in the glaciofluvial sand unit. Ground water flow in the fill unit will continue northward towards the Passaic River and southward off site.

Buildings on the 80 Lister Avenue site will be inspected periodically and maintained. The existing geofabric will also be maintained. Currently, the site poses no excess health risk for the air pathway. This is not anticipated to change.

In terms of the remedial objectives stated in Section 4.0, this alternative only meets the stated objective related to remediation without significant risk to site workers and off-site population.

For Alternative 1 to be implemented, a RCRA permit must be obtained. The permit governs the treatment, storage, and disposal of hazardous wastes.

7.2.2 Alternative 2 - In Situ Containment of All Waste With a Slurry Wall and Cap

This alternative will include in situ containment of all wastes by the construction of an impermeable barrier (slurry wall) and a cap meeting RCRA requirements (Figures 7.2-1 and 7.2-2).(1) The buildings will be demolished and the rubble spread and compacted over the site. The contents of the shipping containers will be emptied and also spread and compacted over the site. Underground conduits, including utility lines and sewer systems, will be located by perimeter excavation, will be plugged to the exterior of the site, and will be completely filled to the interior of the site with grout. Several tanks and major structural steel components will be cleaned and hauled off site for reclaim, resale, or disposal as nonhazardous waste. A new bulkhead will be installed to increase the stability of the river materials. Drummed liquids and process wastes will be stabilized and immobilized. A monitoring program will be established and maintained during the post-implementation period.

The underlying design principle of this alternative is to substantially reduce the movement of chemical constituents, especially dioxin and DDT, by in situ containment of the waste. The site geologic and hydrogeologic conditions coupled with the geochemical characteristics of dioxin and DDT make this alternative a suitable remedial option for the containment of these materials on site. A low-permeability silt layer with an average thickness of about nine feet underlies the fill and mitigates the downward migration of the chemical constituents. Furthermore, dioxin has a very high partition coefficient for organic and mineral matter and its rate of migration in media with organic content and clay (such as the silt layer) is at least 1,000 times slower than

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(1)Note: These figures, and those for succeeding alternatives, are conceptual only and not intended to portray final design information.

its rate of migration in ground water. The behavior of DDT in these media is similar. Therefore, the silt layer provides an excellent natural barrier to mitigate downward migration of dioxin and DDT.

The slurry wall will provide a lateral barrier and, with the cap, will encapsulate the wastes. The slurry wall is constructed of clay and bentonite and has a permeability of 10^{-7} centimeter per second or less. Because the enclosed volume no longer can receive significant recharge from the surface, due to the low-permeability cap, the enclosed volume will begin to drain and the gradient across the walls will decrease; that is, water from the surrounding fill will slowly flow into the enclosed volume. Tidal fluctuation from the river will affect the gradient. In addition, as the head within the volume decreases, seepage will be reduced from an estimated 1.4 gpm to almost zero. If the cap's synthetic liner and leachate collection system should fail, the seepage might reach 0.2 gpm. Therefore, a slurry wall is ideally suited to mitigate the migration of dioxin. The cap, together with the slurry wall and natural silt layer, will substantially reduce the seepage of ground water into the sand aquifer.

As presented in Appendix B, the construction of a slurry wall and cap will reduce the dioxin loading to the sand aquifer to less than 1.7×10^{-3} gram per year from the entire site. Adjustment of the dilution factor calculated in Appendix A for the reduced volume of water within the contained volume results in an ultimate concentration of dioxin at the receptor well of 2.4×10^{-4} µg/ℓ or less. Dioxin is partitioned strongly to organic matter, as described in Appendix B. Because the calculated dilution factor assumes no retardation, it is reasonable to conclude that dioxin will be absorbed prior to reaching the receptor well and the calculated concentration represents an upper, conservative limit.

Similarly, applying the recalculated dilution factor of 6,500, the ultimate concentration of DDT at the receptor well will be less than 0.25 µg/ℓ. The initial concentration detected at the receptor well will decrease as the seepage rate from the contained volume decreases. Again, because the calculated dilution factor assumes no retardation, the actual concentration at the receptor well will be much less or nonexistent.

The site presently poses no excess risk on or off site for volatile and semivolatile compounds for the air pathway. However, further reductions in emissions of these compounds will occur following implementation of this alternative. The upward migration of vapors from the soil will be greatly retarded by the synthetic liner and cap.

Air exposure will be reduced significantly following the implementation of this alternative. Volatile and semivolatile compounds known to be present in the fill will be isolated from the surrounding environment by encapsulation.

Referring to Section 4.0, this alternative does not meet the objective regarding mass transport of dioxin in the ground water if retardation is not considered.

Alternative 2 will require a RCRA hazardous waste permit and a U.S. COE permit to construct the bulkhead.

7.2.3 Alternative 3 - In Situ Containment of All Waste With a Slurry Wall and Cap With Continued Pumping and Treatment of the Ground Water

This alternative is similar to Alternative 2 except purge wells will be installed in the containment area to pump ground water for treatment. This pumping will, in effect, reverse flow inwardly to the contained area. Off-site ground water migration will be essentially eliminated as a result of recharge reduction and gradient reversal (Figures 7.2-3 and 7.2-4).

Presently, the potentiometric surface in the sand unit is an average of five feet below the water level in the fill area. This head difference generates a downward gradient through the silt layer; however, the sand unit is confined by the silt layer. The potentiometric surface in the fill is, on the average, two feet above the confining layer. Therefore, if the water level within the fill is reduced to the top of the silt layer, the flow will be reversed and ground water from the sand unit will move upward into the containment area. This inward movement will reduce any downward migration of dioxin, DDT, and other chemicals from the fill into the silt. This concept is employed in development of the pumping and treatment program for this alternative. Installation of a cap and slurry wall will reduce inward seepage. Most of the water within the containment area will come from the sand unit. The site is adjacent to the Passaic River and the water level of the river is above the silt layer. This will aid in maintaining an upward gradient through the silt. Based on the hydrogeologic conditions observed at the site, a pumping rate of approximately 20 gpm will be required to maintain this upward flow and the accompanied reduction of the water level will minimize the off-site migration of chemical constituents.

Similarly, as discussed in Alternative 2, the construction of a cap will eliminate public exposure and inhalation risks.

After all the waste material is in place but before the cap is constructed, ground water withdrawal wells will be installed within the contained area (Figure 7.2-3). The number of purge wells will be established during the design phase for the system. The wells will penetrate the fill but not the underlying silt. The system effluent, after treatment with activated carbon, will then be discharged to the local publicly owned treatment works (POTW) or to the Passaic River in accordance with an NJPDES discharge permit.

The cap will be constructed after the wells are installed so that an effective seal can be provided with the wells penetrating the cap. Each well will have its own pump wired to a water level detection system. When the water table rises, the pumps will turn on to withdraw ground water. As the water table drops, the pumps will turn off, thus maintaining a steady-state flux of ground water flow toward the site.

All pipelines associated with the withdrawal network will be installed in a manner so they are protected against cold weather and vandalism. A control building will be constructed to house all control instrumentation and the treatment system. The total organic carbon loading to the treatment system is anticipated to be low and, as a result, maintenance of the system will be minimal. The adsorbent generated during the post-implementation treatment period will be stored in an approved storage facility for future treatment.

The costs associated with purchase and installation of the withdrawal and treatment system are included as part of the alternative's total capital cost.

The equipment, materials, and labor associated with the operation and maintenance of this system will, however, be an annual operating cost.

In addition to the permits required for Alternative 2, an NJPDES will be required for the discharge of treated water.

7.2.4 Alternative 4 - Excavation and Thermal Treatment of All Waste Material

This alternative includes the excavation and on-site thermal treatment of all soils and site waste containing dioxin above 7 ppb (Figures 7.2-1 and 7.2-6). This includes building rubble, contents of shipping containers, excavated soil and buried piling, and other miscellaneous site waste. Several tanks and major structural steel components from the on-site buildings will be cleaned and either disposed of off site as nonhazardous waste or salvaged. Crushing/grinding will be required to reduce debris to a size suitable for treatment. A slurry wall will be installed prior to excavation. The thermally treated material will be placed back onto the site and a cap meeting RCRA requirements will be constructed over the treated material. A new bulkhead will be installed to increase the stability of the river bank and a monitoring program will be established and maintained during the post-implementation period. To implement this alternative, the fill and underlying sand unit will be dewatered and treated during remediation.

To clean the site to a 7 ppb dioxin level, essentially all of the fill above the silt layer must be excavated. To dewater the excavation, the slurry wall will extend at least to the silt layer. The slurry wall may be required to extend to rock adjacent to the river to reduce inflow of ground water. The slurry wall will reduce the horizontal ground water flow into the excavation pit. However, because of the high potentiometric surface in the glaciofluvial sand unit, especially adjacent to the Passaic River, the removal of the fill material, without adequate control, would be expected to cause disturbance (heave) of the silt layer. This phenomenon will affect integrity of the silt layer which has been acting as a barrier against the downward migration of the dioxin. To control this phenomenon, the potentiometric head within the glaciofluvial sand unit must be lowered below the level of the silt layer. This will require extensive dewatering of the sand unit and treatment of the pumped ground water prior to discharge.

Because the silt layer retards the downward migration of dioxin, it will not be excavated. However, it should be noted that the upper portion of silt has an average dioxin concentration of roughly 6.0 ppb (based on statistical analysis).

After excavation of the fill to the 7 ppb dioxin level, dioxin and DDT will still be present in the silt layer and ground water seeping into the sand unit will still contain these chemicals. The downward seepage will be similar to Alternative 2, although the mass of dioxin and DDT will be substantially less than Alternative 2 because of the treatment of the fill layer. Therefore, the dioxin and DDT concentrations observed at the receptor well will be less than the values calculated for Alternative 2.

As indicated in Section 5.0, the highest ranking method of thermal treatment is a mobile incinerator. Currently, a mobile incinerator unit is not available which has commercial capacity for the on-site treatment of dioxin. To use a mobile incinerator would require complete design and an extensive trial burn program of the mobile incinerator and material handling equipment.

For thermal treatment to be considered successful, the treatment would need to be sufficient to allow delisting of the treated site wastes and the fill layer as hazardous materials.

To implement Alternative 4, it is expected that the following permits will be required: RCRA Parts A and B; COE for bulkhead construction; NJPDES water discharge; air permit; and delisting of treated materials.

7.2.5 Alternative 5 - Excavation and Disposal of All Waste Above 7 ppb in a Secure Isolation Vault

This alternative includes the excavation of all soil containing dioxin above 7 ppb and disposing of this soil in an on-site, above-grade vault (Figures 7.2-7 and 7.2-8). The problems associated with excavation discussed for Alternative 4 (Section 7.2.4) apply to this alternative also. The vault will be constructed so that the bottom of the vault is one foot above the 100-year flood level (Elevation 10.2 feet). A lateral barrier (slurry wall) will be constructed along the site perimeter.

The construction of the slurry wall is necessary to reduce the volume of water infiltrating during excavation and requiring treatment. In addition, the sand unit will be dewatered to reduce the piezometric pressures in the glaciofluvial sand to minimize potential disturbance of the silt layer.

On-site building demolition material, material stored in containers, and other site wastes will also be disposed of in the vault. Some tanks and major structural steel components will be cleaned and either disposed of off site as nonhazardous waste or salvaged. The vault will be lined--top, sides, and bottom--to meet RCRA requirements.

Clean fill will be purchased and placed in the excavation to return the excavated fill layer to existing ground surface. Because excavation will proceed to the 7 ppb level in the fill and dioxin is present in the silt layer, ground water seeping from the site will still contain dioxin, but at reduced levels from present conditions. Dioxin concentrations at the receptor well will be similar to Alternative 4. The excavation, stockpiling, and backfilling must be finished before the vault can be completed; therefore, this alternative is extremely difficult, if at all feasible, because of the limited site size and the fact that the vault is expected to cover the entire site.

To raise the vault above the 100-year flood elevation, an additional 4.5 feet of soil will be required above existing grade. Coupled with the excavation backfilling, this represents the purchase and hauling of approximately 77,000 cubic yards of clean fill.

Alternative 5 is expected to require the following permits: RCRA Parts A and B; COE for bulkhead construction; and NJPDES for treated water discharge during remediation.

7.2.6 Alternative 6 - Transport and Off-Site Disposal/Treatment

At present, permitted facilities do not exist which can accept dioxin-containing materials. However, for this study, it has been assumed that the alternative is viable so that a complete comparison of remediation alternatives can be presented.

The basic premise of Alternative 6 is that all materials containing dioxin levels above 7 ppb will be excavated and transported off site. The shipping containers from 120 Lister Avenue will be shipped as is because they are presently sealed. Drummed wastes would be shipped as is, or in overpack drums for existing drums that are deteriorated. Building debris would be reduced to adequate size for shipment and the excavated soils and subsurface debris would be shipped. The problems associated with excavation discussed for Alternative 4 (Section 7.2.4) apply to this alternative also. All shipments will be in sealed carriers.

The alternative considers that the materials transported from the site would be disposed of by thermal treatment (incineration) or landfilling. Candidate sites for determining cost and transport method were selected on the basis of disposal or treatment facilities that would accept materials containing PCBs. A facility near Houston, Texas was identified for thermal treatment allowing transport by truck, rail, or barge. A landfill was identified near Emelle, Alabama which limits transport to truck.

The cost for the landfilling or thermal treatment of dioxin-containing waste was judged to be at least 30 percent greater than for PCBs. The actual cost is unknown.

The following permits must be obtained: Department of Transportation for off-site shipment, and NJPDES for the discharge of treated water pumped during remediation. Also, RCRA permits may be required.

7.2.7 Public Acceptance

This aspect of the remedial action to be taken at the 80 Lister Avenue site is very difficult to evaluate, although it is important to the overall success of the remediation because the selected alternative must be perceived favorably by the public. An evaluation of public acceptance is highly subjective and the perception discussed herein may or may not be correct. Also, public acceptance, while primarily concerned with the Ironbound area residents, must consider the acceptance in other areas as well.

Of the six alternatives resulting from the grouping of technologies in Section 6.0, the most acceptable to the Ironbound area residents is expected to be Alternative 6, transportation out of the area.

The actual removal of the material would require that approximately 5,365 truckloads of wastes be moved through the Ironbound area. Based on the location of areas that can accept PCB wastes, it is estimated that these trucks will travel an aggregate of approximately 5.4 million miles while loaded and 5.4 million miles while empty. Using an accident rate for trucks prepared by the Federal Highway Administration (1 per 12,900,000 miles), at least one accident can be expected in traveling this distance. An accident could result in the spillage of wastes on public roads. The Federal Highway Administration also reports an accident rate involving trucks in New Jersey of 1 per 130,000. Thus, a much higher probability exists for an accident occurring in New Jersey. This would not be acceptable to the public in the areas where the accidents occur. However, there are no sites permitted to accept the wastes.

Although Alternative 6 is expected to be attractive to area residents, the implementation requires the excavation of the entire site. This excavation could be a highly odoriferous operation due to the character of the materials contained in the soils. While it cannot be determined that excavation will constitute a health hazard, it will constitute a nuisance in the area; hence, any extensive excavation would be unacceptable after it was started. This consideration is equally applicable for Alternatives 4 and 5.

In addition, Alternative 4 will require the installation of a large thermal treatment unit (incinerator) on site. The potential exists for unit operation problems with the system which could result in emissions to the surrounding area, including regions some distance from the Ironbound. In the past, the residents have strongly opposed any incinerator in their neighborhood. It is unlikely that residents would accept an incinerator on this site; hence, Alternative 4 is judged unacceptable.

The construction of a vault (Alternative 5) is viewed as being unacceptable to residents because it only "stores" the problem and results in a large edifice which would serve as a reminder of the storage.

The only alternatives that do not have extensive adverse impacts during remedial activities are 1, 2, and 3. Alternative 1 is clearly not acceptable. Alternatives 2 and 3 are expected to be of equal acceptance; however, they will be viewed as less than the preferred option (removal) but better than incineration or vaulting. Alternative 3 would be preferred to Alternative 2 because of the elimination of ground water migration.

TABLE

TABLE 7.0-1

DESCRIPTION
APPLICATION OF REMEDIATION STEPS

STEP	DESCRIPTION	APPLICABLE REMEDIATION ALTERNATIVE(a)
1	Design	2, 3, 4, 5, and 6
2	Permitting	All
3	Drummed Process Waste	All
4	Demolish Buildings	2, 3, 4, 5, and 6
5	Containerized Waste	All
6	Underground Conduit Plugging	2, 3, 4, 5, and 6
7	Grouting of Underground Conduits	2 and 3
8	Construction of the Passaic River Bulkhead	2, 3, 4, 5, and 6
9	Install Slurry Wall	2, 3, 4, 5, and 6
10	Support of Adjacent Structures/Property	4, 5, and 6
11	Dewatering and On-Site Ground Water Treatment During Remediation	4, 5, and 6
12	Excavation	4, 5, and 6
13	Install Pump and Treat System	3
14	On-Site Thermal Treatment	4
15	Backfill of Excavated Area	4, 5, and 6
16	Construction of the Cap	2, 3, and 4
17	Construct On-Site Vault	5
18	Off-Site Transport	6
19	Off-Site Disposal	6
20	Off-Site Thermal Treatment	6
21	Ongoing Site Monitoring/Maintenance	All
22	Site Security	1, 2, 3, 4, and 5

(a)Remediation alternative as presented in Section 6.0.

FIGURES

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CHECKED BY DGT 10.15.85
APPROVED BY DJ 10.30.85
DRAWING NUMBER 850032-A19

ALTERNATIVE No. \ STEP No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1		●	●		●																●	●
2	●	●	●	●	●	●	●	●	●							●					●	●
3	●	●	●	●	●	●	●	●	●				●			●					●	●
4	●	●	●	●	●	●		●	●	●	●	●		●	●	●					●	●
5	●	●	●	●	●	●		●	●	●	●	●			●		●				●	●
6	●	●	●	●	●	●		●	●	●	●	●			●			●	●	●	●	

NOTE:
SEE TABLE 7.0-1 AND SECTIONS 7.1 AND 7.2 FOR DESCRIPTION AND DISCUSSION OF STEPS AND ALTERNATIVES.

FIGURE 7.0-1

APPLICATION OF REMEDIATION STEPS
TO REMEDIAL ALTERNATIVES

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APPROVED BY DT 10-30-85

ALTERNATIVE No.	INSPECTIONS						SAMPLING / MEASUREMENTS								
							ON SITE WELLS				OFF SITE WELLS				
							CHEMICAL PARAMETER		PHYSICAL PARAMETER		CHEMICAL PARAMETER		PHYSICAL PARAMETER		
	SITE COVER	SEWERS	STRUCTURES	DRUMS/CONTAINERS	AIR (PERIMETER)	CAP INTEGRITY	FILL	SAND	FILL	SAND	FILL	SAND	FILL	SAND	DISCHARGED H_2O
1	●	●	●	●	●		●	●	●	●	●	●	●	●	●
2						●					●	●	●	●	
3			●			●			●		●	●	●	●	●
4						●					●	●	●	●	
5						●						●		●	
6												●		●	

FIGURE 7.1-1

ONGOING SITE MONITORING PROGRAM

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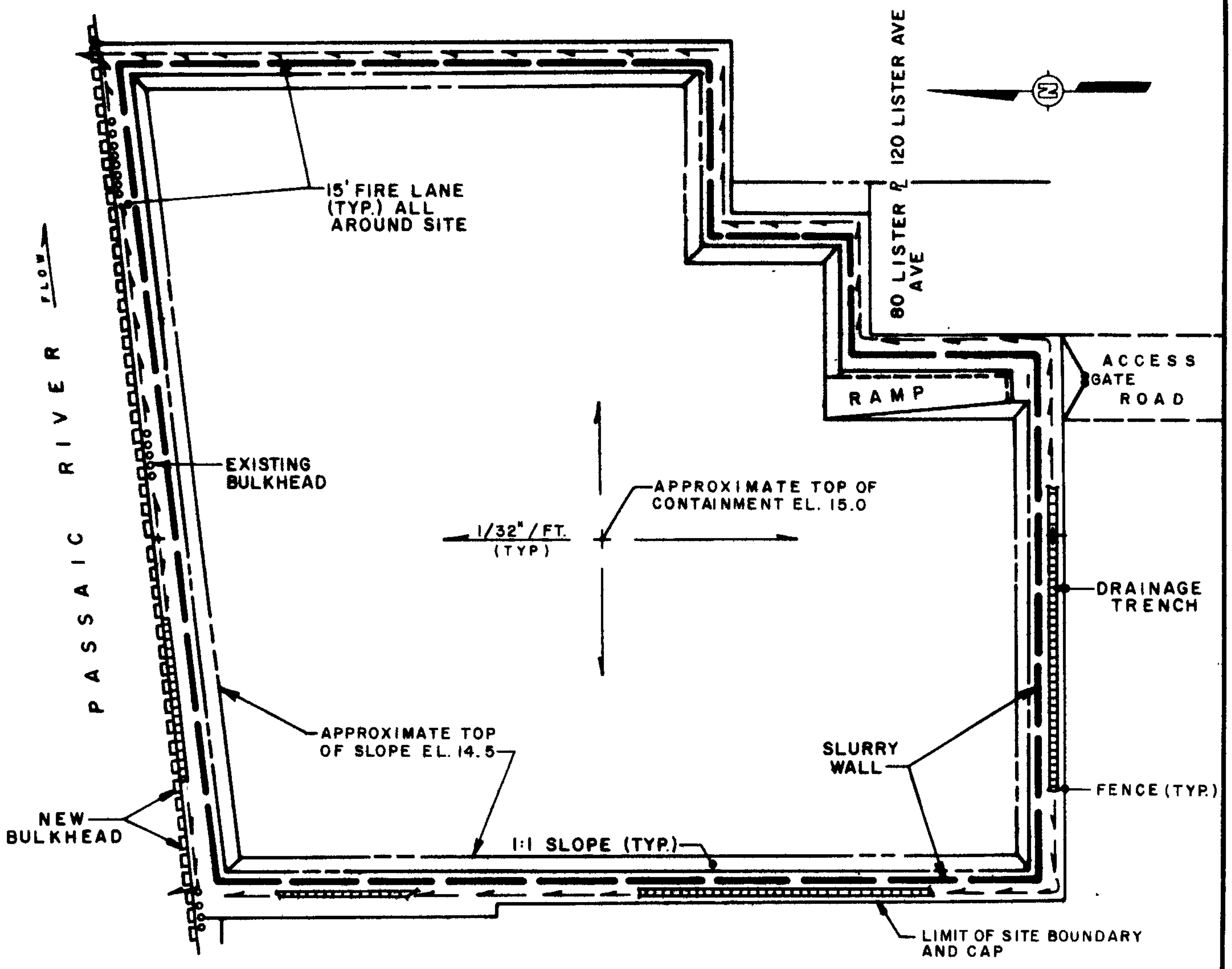

NOTE:

THIS PLAN IS CONCEPTUAL AND THE DETAILS OF THE DESIGN WILL BE FINALIZED PRIOR TO IMPLEMENTATION.

FIGURE 7.2-1

CONCEPTUAL SITE PLAN
ALTERNATIVES 2 & 4
80 LISTER AVENUE
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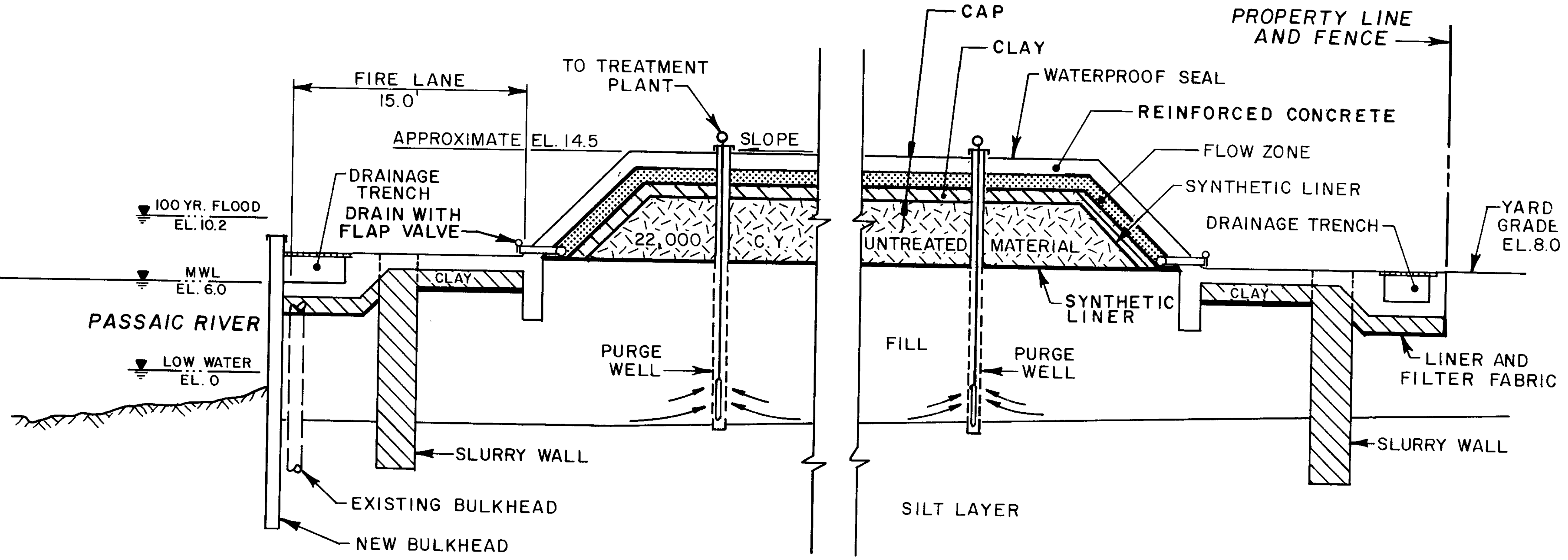

NOTE:
THIS CROSS SECTION IS CONCEPTUAL AND THE DETAILS OF THE DESIGN WILL BE FINALIZED PRIOR TO IMPLEMENTATION.

FIGURE 7.2-4

CONCEPTUAL CROSS SECTION
LOOKING EAST
ALTERNATIVE 3
80 LISTER AVENUE

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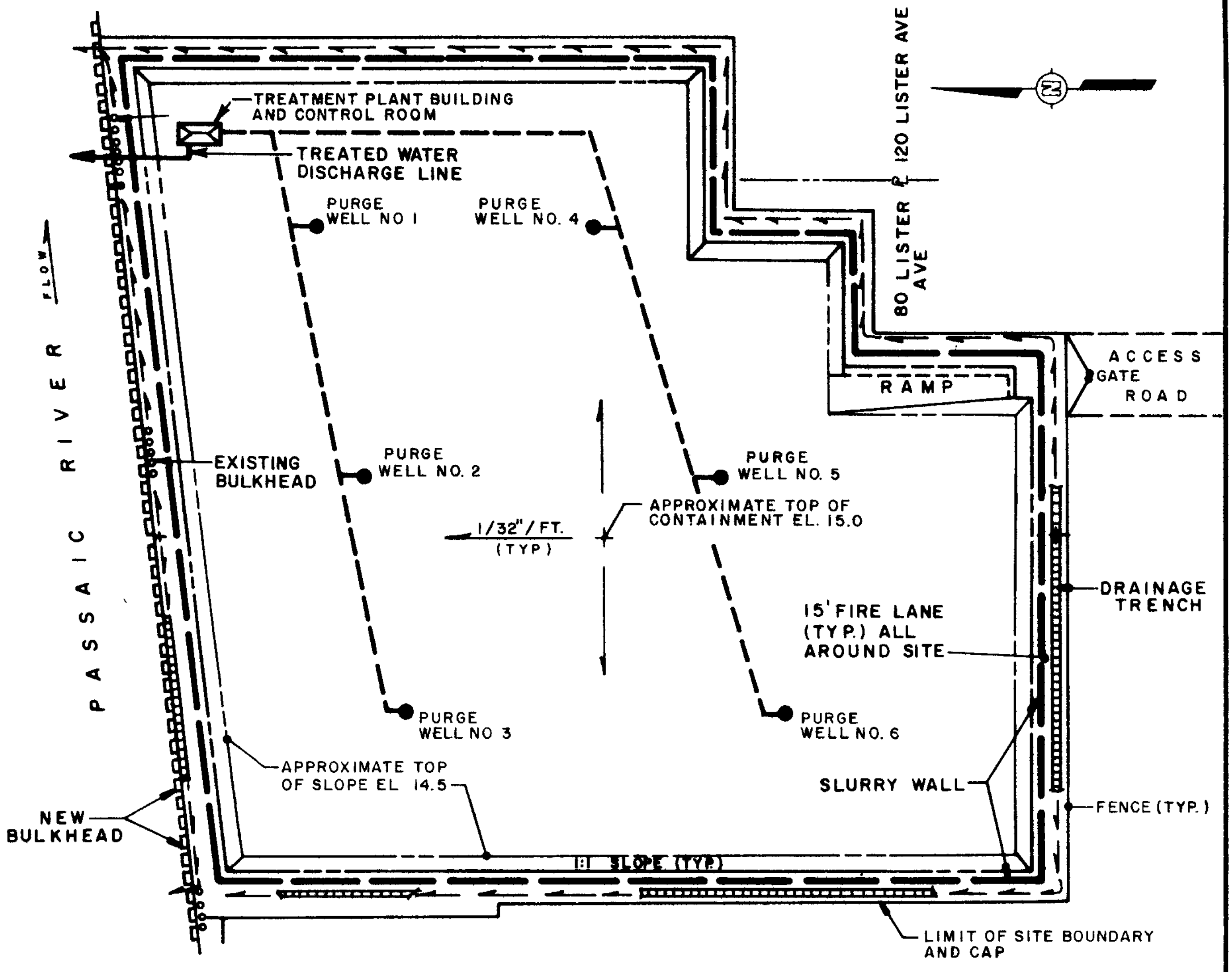
APPROVED BY	DT	10-30-85	



NOTE:
THIS PLAN IS CONCEPTUAL AND THE DETAILS OF THE DESIGN WILL BE FINALIZED PRIOR TO IMPLEMENTATION.

FIGURE 7.2-3

CONCEPTUAL SITE PLAN
ALTERNATIVE 3
80 LISTER AVENUE
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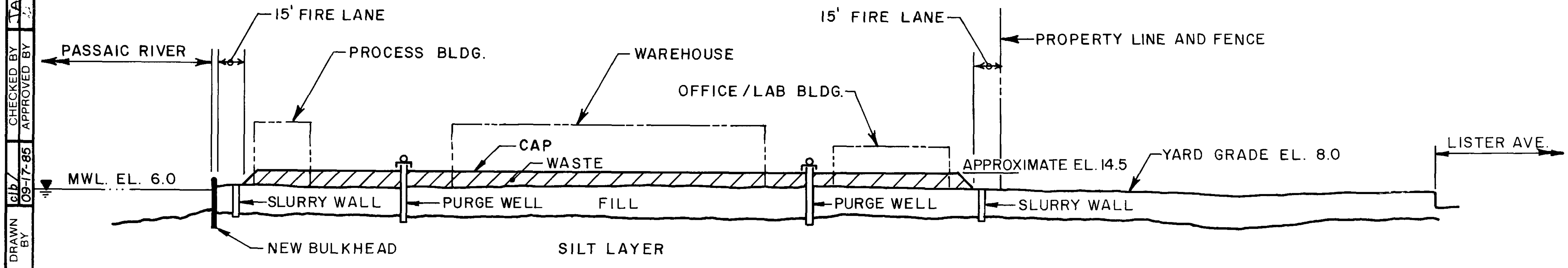

NOTE:
THIS CROSS SECTION IS CONCEPTUAL AND THE DETAILS OF THE DESIGN WILL BE FINALIZED PRIOR TO THE IMPLEMENTATION.

FIGURE 7.2-5

CONCEPTUAL VIEW OF
SITE REMEDIATION
ALTERNATIVE 3
80 LISTER AVENUE
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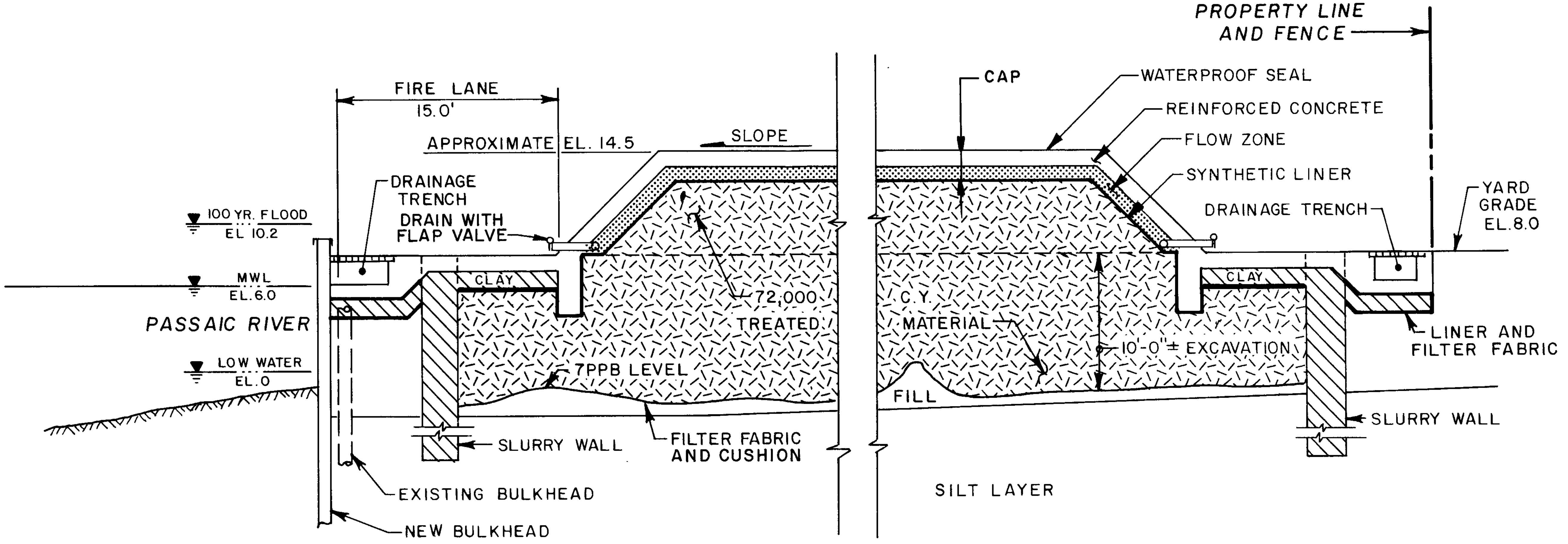

NOTE:
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FIGURE 7.2-6

CONCEPTUAL CROSS SECTION
LOOKING EAST
ALTERNATIVE 4
80 LISTER AVENUE
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RW 9-16-85	JAC 9-19-85	[illegible]	850032-B31

65380

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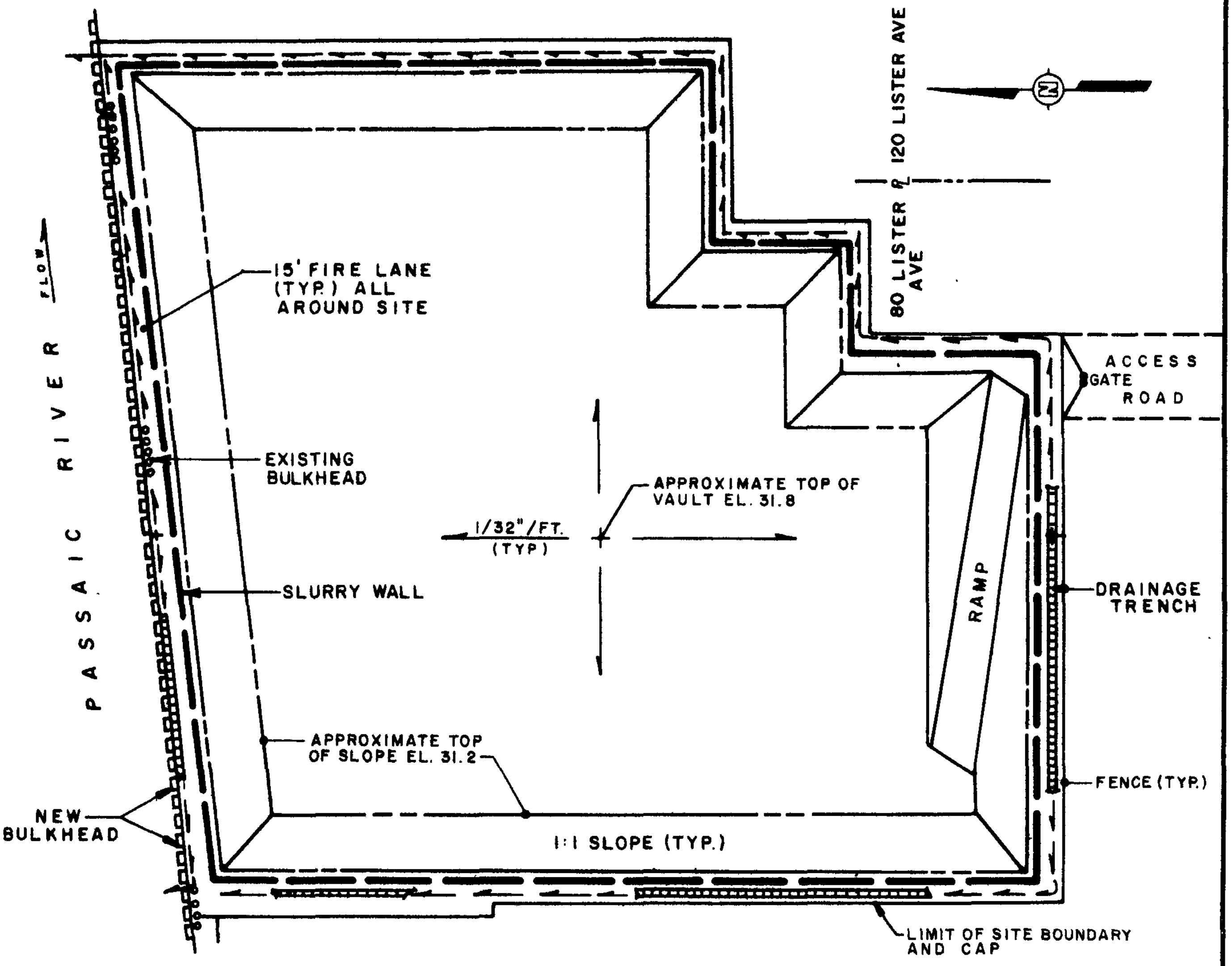
CHECKED BY	JAC 9-19-85
APPROVED BY	DT 10-30-85
DRAWING NUMBER	850032-A15



NOTE:

THIS PLAN IS CONCEPTUAL AND THE DETAILS OF THE DESIGN WILL BE FINALIZED PRIOR TO IMPLEMENTATION.

FIGURE 7.2-7

CONCEPTUAL SITE PLAN
ALTERNATIVE 5
80 LISTER AVENUE
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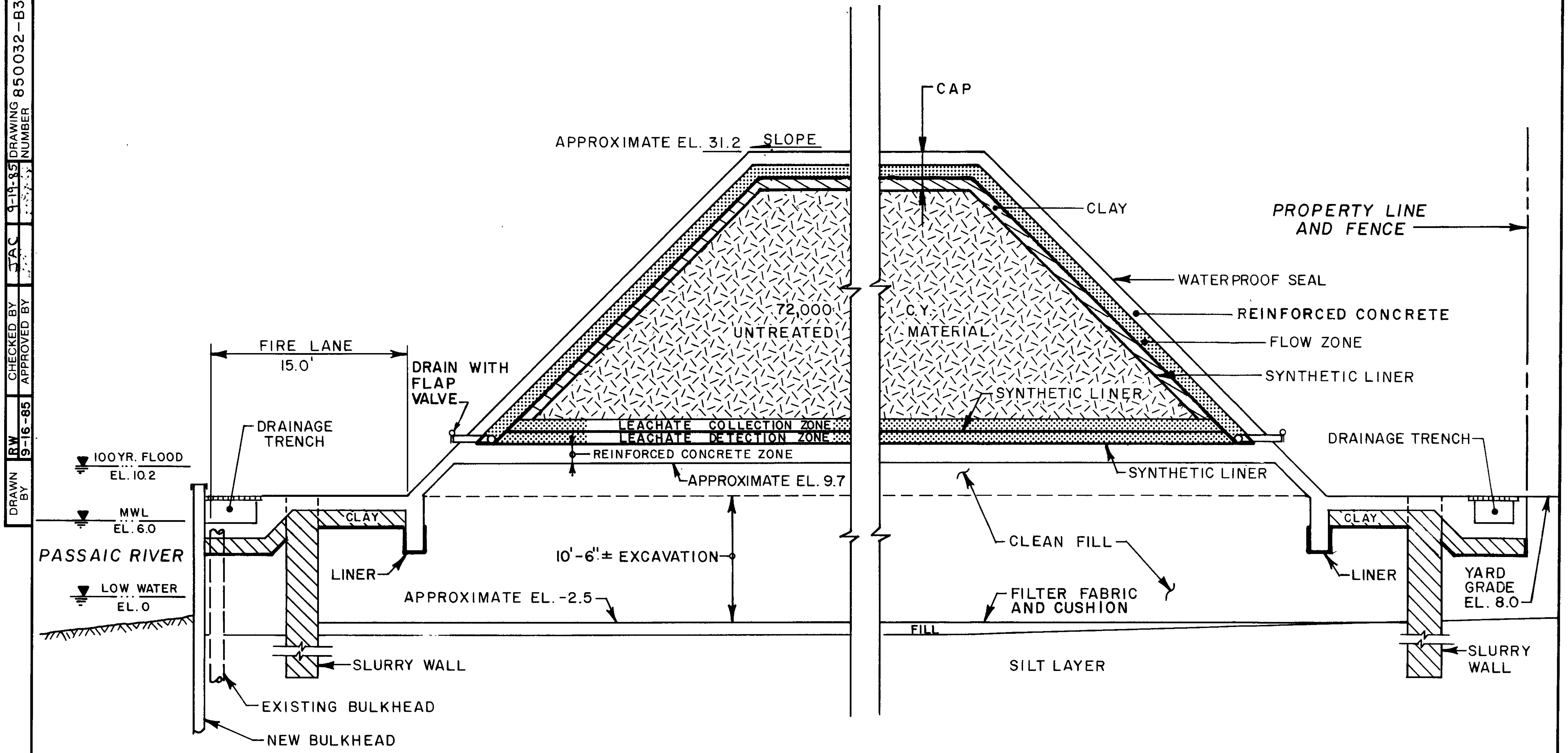

NOTE:
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FIGURE 7.2-8

CONCEPTUAL CROSS SECTION
LOOKING EAST
ALTERNATIVE 5
80 LISTER AVENUE
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RW 9-16-85	JAC [illegible]	9-19-85 [illegible]	850032-B32

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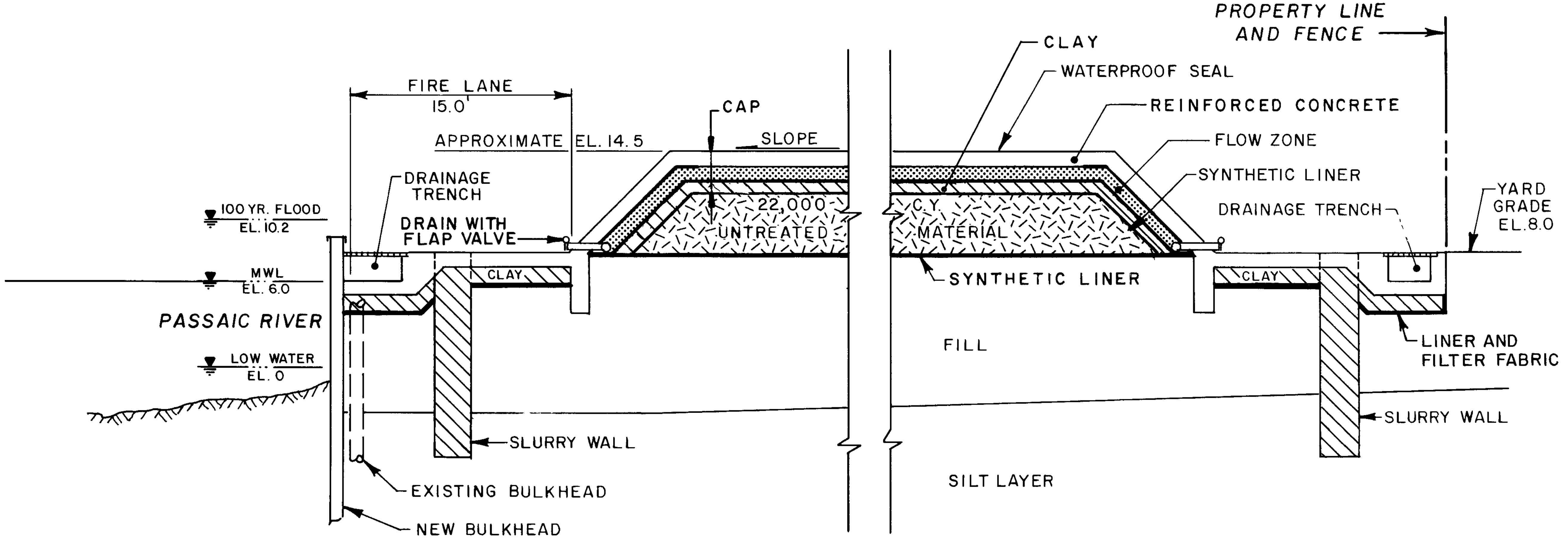
APPROVED BY
DRAWING NUMBER 850032-B29



NOTE:
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FIGURE 7.2-2

CONCEPTUAL CROSS SECTION
LOOKING EAST
ALTERNATIVE 2
80 LISTER AVENUE
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8.0

8.0 SELECTION OF THE REMEDIAL ACTION

The last step in this feasibility study is the process of deciding which one of the six alternatives identified and discussed in Sections 6.0 and 7.0 should be recommended as the remedial action.

Figure 5.1-1 showed the decision process to select alternatives that include considerations of technical, institutional, public health, environmental, and cost factors. In this section, the six alternatives identified in Section 7.0 are compared based on technical, institutional, public health, environmental, and cost factors to arrive at the selection of the remedial action. Appendix C contains costing data in support of the discussion contained in this section.

8.1 CONSIDERATIONS IN THE SELECTION PROCESS

8.1.1 Technical, Environmental, and Public Health Considerations

The technical, environmental, and public health considerations evaluate how well each remedial alternative achieves the recommended goals of the risk analysis presented in Section 3.0 and as summarized in Section 3.5. These goals serve as the performance measures against which we evaluate each remedial alternative. In summary, these are:

1. Eliminate or minimize potential exposure to surface soils where dioxin is present
2. Reduce the potential for mass transport off site through the ground water pathway by keeping the human exposure level through this pathway to less than a 10^{-5} excess cancer risk, i.e., keep the dioxin concentrations that could reach the nearest off-site well at some point in the future to less than 5×10^{-5} μg/ℓ and the DDT concentrations to less than 0.23 μg/ℓ
3. Contain or demolish existing buildings and other structures on site that have the potential for spreading particulates.

In addition, a number of other technical, environmental, and public health factors are considered in the selection process. These are:

- Reliability
  - Operation and maintenance requirements
  - Demonstrated performance

- Implementability
  - Constructibility
  - Time for implementation

- Safety of implementation

- Environmental effects

- Public health factors.

Each of these is discussed in the following subsections.

8.1.1.1 Reliability

Reliability was evaluated on the basis of two criteria--operation and maintenance requirements and demonstrated performance.

Operation and Maintenance Requirements

Remedial alternatives which have the fewest and simplest operation and maintenance requirements are considered to be more reliable than those which have extensive and complex requirements.

Demonstrated Performance

Demonstrated performance in similar applications is considered to be a key indicator of reliability. Thus, technologies which have been successfully used for years in hazardous waste applications are considered to have a higher degree of reliability than those technologies which have not been widely applied to hazardous materials management problems or those at an early stage of development.

8.1.1.2 Implementability

Implementability is a measure of how easily a remedial alternative can be implemented both with respect to physical constraints imposed by the site and with respect to the time required.

Constructibility

The ease of constructing any facilities and/or executing any excavation or demolition program must be considered. This consideration includes weighing material handling factors, equipment fabrication, construction problems, site stability considerations, and any specific problems which may be potentially associated with each remedial alternative under consideration.

Time for Implementation

Time is important to implementability both from the standpoint of the time required to put the remediation into effect and the time until beneficial results are achieved.

8.1.1.3 Safety of Implementation

Each remedial alternative will be evaluated with respect to safety hazards which could result from implementation or operation of the component technologies. These hazards could include exposure to hazardous wastes, construction accidents, fire, or explosion.

8.1.1.4 Environmental Factors

Each of the alternatives will be evaluated on the basis of potential effects on the environment. The evaluation includes consideration of both the beneficial and adverse effects of the alternatives. Particular attention will be focused on those alternatives which could cause an increase in airborne emissions and/or result in a new discharge to surface and ground waters. In cases where implementation of a remedial alternative could result in an air or water discharge, appropriate mitigative measures will be included in the alternative and these are evaluated along with the other components.

In the decision analysis, from an environmental factors standpoint, the consideration of changes in the release of materials from the site is the primary focus. No sensitive systems or resources are currently being affected by the site. Specifically, the following sensitive systems or resources do not exist in the vicinity of the site nor are they affected by it:

- Sole-source aquifers
- Wetlands

- Coastal zones
- Threatened or endangered species
- Critical habitat of threatened or endangered species
- Prime agricultural lands
- Federal, state, or local park lands
- National or state forests
- Wildlife sanctuaries or refuges
- Habitat of recreationally or commercially important species.

8.1.1.5 Public Health Factors

Each of the alternatives will be evaluated in terms of its ability to protect human health and welfare. The evaluation considers both short- and long-term effectiveness. The basis for this assessment is the site-specific risk assessment which was provided in Section 3.0. This risk assessment included a pathway analysis and exposure assessment, and assessed the risk currently posed by the site to potential receptors. As an integral part of the risk assessment, the potential effects on human populations were evaluated on the basis of toxicological data, public health criteria and standards, and other pertinent information. The information developed in the risk assessment and changes in risk magnitude associated with various alternatives formed the basis for the public health evaluation of each alternative. The public health factors constitute a measure of the overall performance of each remedial alternative.

8.1.2 Institutional Factors

There are many institutional factors that could be involved in the implementation of remedial action alternatives for this site. The evaluation of institutional factors for the various alternatives focused on the regulatory programs that are applicable and the appropriate regulatory approval and/or permitting process. The following subsections discuss those programs that are of greatest significance to this project. For convenience, the categories are itemized on the basis of federal and state jurisdiction.

8.1.2.1 Federal Programs

There are a large number of federal regulatory programs in addition to CERCLA that might be pertinent to one or more of the remedial alternatives under consideration. Some of the most relevant include:

1. RCRA and associated regulations - These govern the on-site storage, treatment, and/or disposal requirements associated with the alternatives. It is noted that the RCRA regulations have been revised specifically to include dioxins as a listed hazardous waste. This listing and special regulations governing dioxin disposal became effective July 15, 1985.

2. Clean Water Act - The discharge of water associated with certain of the alternatives which is regulated under the Clean Water Act is a state issue because New Jersey has primacy for the implementation of this federal statute through a corresponding state statute.

3. Clean Air Act - As with water discharges, discharges to the atmosphere associated with certain alternatives are a state issue because New Jersey has primacy for the federal program through a corresponding state program.

4. U.S. COE enforced programs regarding activities within streams and rivers - These would govern construction activities in the Passaic River which would be required for certain alternatives.

5. U.S. EPA Ground Water Protection Strategy - This strategy effects remedial actions at uncontrolled hazardous waste sites through ground water protection guidelines which are under development and through a ground water classification system, the framework of which is provided in EPA's feasibility study guidance document (U.S. EPA, 1985). Under this system, there are three classes of ground water--Classes 1, 2, and 3--and each class is associated with different priorities for remedial actions. Classes 1 and 2 represent current or potential drinking water supplies or supplies associated with other significant current or potential beneficial uses. Class 3 ground waters are those not considered to be potential sources of drinking water and are of limited beneficial use. According to the EPA, Superfund-financed remedial actions would not generally involve ground water cleanup in cases where the affected resource is a Class 3 ground water unless the water constituted a nonconsumptive use hazard to human health or the environment. Because the glaciofluvial sand aquifer underlying the site is used for industrial purposes, and domestic

purposes at a greater distance from the site, it is assumed that the resource is at least a Class 2 system and that the ground water protection strategy is a consideration for remediation at the site.

8.1.2.2 New Jersey Programs

The following New Jersey programs contain sections which must be considered in the implementation of the remedial alternatives identified in Section 7.0:

1. Solid and Hazardous Waste Management Regulations - These govern the on-site treatment and/or disposal components included in several of the alternatives.
2. Air Permit Rules and Ambient Air Quality Standards - These govern the emissions of particulates to the atmosphere. Specifically, on-site treatment would result in atmospheric discharges.
3. Water Discharge Rules and Standards - These govern the discharge of water which would be associated with certain of the alternatives. Specifically, several alternatives contain a ground water pumping, treatment, and discharge component.

8.1.2.3 Other Institutional Considerations

In addition to the aforementioned regulatory considerations, the process for selecting the remedial action includes considering potential land use restrictions and effect on adjacent land users. The compatibility of the remedial action during construction and after construction to activities in the vicinity of the site must be considered.

8.1.3 Cost Factors

Detailed cost estimates for each of the alternatives have been developed. The cost estimates, when coupled with the other evaluation criteria, provide the necessary basis for the identification of the cost-effective remedial alternative, referred to in this section as the remedial action. The actual overall value of each alternative in terms of the level of remediation versus cost can be determined readily with these data. The detailed cost evaluation consists of the following steps:

- Cost estimation
- Present worth analysis.

8.1.3.1 Cost Estimation

Cost estimates are developed for each of the alternatives. These cost estimates include capital, operation, and maintenance costs. The costs of various components are estimated on the basis of a number of available construction costing manuals and the experience of the project team members.

8.1.3.2 Present Worth Analysis

A present worth analysis for the alternatives is performed to allow a comparison of the costs of various remedial alternatives on the basis of a single figure representing the amount of money that, if invested prior to the remedial action implementation and disbursed as needed, would be sufficient to cover the costs of the remedial action. This analysis is based on a discount rate of 10 percent in accordance with the U.S. EPA guidelines (U.S. EPA, 1985).

8.2 TECHNICAL, ENVIRONMENTAL, AND PUBLIC HEALTH COMPARISON OF REMEDIAL ALTERNATIVES

The comparison of technical, environmental, and public health factors of the six remedial alternatives under consideration is the subject of this section. To begin, the six alternatives are compared using the case of the potential off-site well contamination described in Section 3.0. Table 8.2-1 shows the potential concentration in µg/ℓ at the off-site receptor for both dioxin and DDT. This table assumes no retardation. If retardation is not considered, only Alternatives 3, 4, 5, and 6 meet the recommended concentration goals. If retardation is considered, then it can be concluded confidently that Alternatives 2, 3, 4, 5, and 6 meet the recommended goals. The no-action alternative is nonresponsive regarding the recommended goals.

In subsequent paragraphs, each alternative is described with respect to the technical, environmental, and public health factors identified in Section 8.1.1.

8.2.1 Alternative 1 - No-Action Alternative

The no-action alternative does not meet the performance objectives of the risk assessment. It requires the maintenance of site fences, geotextile fabrics, security systems, and a site monitoring program. Reliability is a problem in that systems will have to be put in place to respond to deterioration of buildings, structures, and the geotextile fabric.

Implementability is not a consideration for the no-action alternative because the only action taken is the transport of containerized waste from 120 Lister Avenue to 80 Lister Avenue for storage, the implementation of a monitoring program, and the maintenance of site security. These actions are routine and can be implemented in a short time period.

The no-action alternative will not achieve the remedial action objectives of the risk assessment as pointed out above. Specifically, the chemical constituents present can continue to migrate from the site into the Passaic River and toward the sand aquifer. (Appendix B discusses the hydrogeological assessment that was conducted for the components of the various alternatives.) However, it should be noted that a review of both the present water quality data and the geochemical characteristics of dioxin and DDT shows that no measurable levels of these chemicals are currently present at the receptor wells due to off-site migration from this site. The high retardation factors of dioxin and DDT will reduce significantly the migration of these chemicals if no remedial action is taken. The soil and buildings, however, continue to have the potential to release vapor and fugitive dust to the environment.

8.2.2 Alternative 2 - Slurry Wall and Cap Alternative

When retardation is considered, the dioxin and DDT goals should easily be met because of the sorption affinity of the chemicals to materials such as the silt. Disregarding sorption, which is a very conservative assumption, the slurry wall and cap alternative does not fully meet the risk assessment recommended goal for ground water transport of dioxin and DDT to the receptor well if retardation is not considered. Without sorption, it comes within an order of magnitude of the risk assessment goal for dioxin and DDT. Therefore, this alternative probably meets the recommended performance requirements.

In addition, this alternative could be implemented effectively and reliably using prudent engineering and construction practices for the existing site conditions. Slurry wall construction is a proven and commonly applied technology that has been demonstrated to effectively contain migration, especially of chemical materials with moderate to high retardation factors such as dioxin and DDT. It is projected, with a high degree of reliability, that the slurry wall will mitigate the migration of dioxin and DDT specifically because of the low permeability of the slurry wall and the high retardation factors of these chemicals. For these chemicals, the slurry wall should have excellent durability.

The construction of a cap which meets RCRA requirements will be an effective method of essentially eliminating surface water infiltration on an ongoing basis. Periodic maintenance of the cap will be required. Field implementation of this alternative will take approximately two and a half years, which is the shortest of Alternatives 2 through 6.

Significant beneficial results will not occur immediately during the implementation of this alternative; rather, they will occur gradually as the site wastes and rubble are contained within the slurry wall and the cap is installed. Seepage of water will greatly and rapidly decrease over time after slurry wall installation and cap construction (Appendix B).

Potential environmental impacts associated with this alternative are very limited and easily mitigated. They include short-term negative impacts related to the dust generated during building demolition, slurry wall excavation, dumping, spreading and compacting of the material, and the cap construction activities. However, all short-term environmental and safety concerns are addressed easily and routinely by appropriate engineering precautions.

Site implementation, including sewer plugging, slurry wall construction, building demolition, soil excavation, and containerized material disposal, will be conducted in such a manner as to minimize the threat of fugitive dust generation. Buildings will be sprayed and demolition procedures, including material spreading and compacting, will be carried out in a manner that minimizes dust. In addition, this alternative minimizes the excavation required for site mitigation by containing the bulk of the materials in place. This procedure will minimize the emissions of odors and volatile organic compounds which could otherwise occur during soil excavation.

Once the remedial measures are completed, fugitive dust problems will be eliminated and there will be a significant reduction in ground water-borne migration of any chemical compounds off site (Appendix B).

No public health risk results from any activities connected with the implementation of this alternative. Installing a slurry wall and cap will reduce the migration of water from the site from an estimated present rate of 535 cubic feet per day to a projected rate of 6.1 cubic feet per day (0.03 gpm) (Appendix B). Capping the site will eliminate the risk associated with inhalation and direct contact.

8.2.3 Alternative 3 - Slurry Wall and Cap Combined With a Pump and Treat System Alternative

The slurry wall and cap alternative combined with a pump and treat system fully meets the performance recommendations of the risk assessment without consideration of sorption. This alternative will reverse the migration direction and remove the mobile materials currently present from the site by pump extraction and treatment. As noted, the preceding alternative (slurry wall and cap) should meet the recommendations for potential dioxin and DDT migration to an off-site well when sorption is taken into account and will meet the recommended goals. By adding wells in the containment area to pump ground water, the localized flow regime will be reversed toward the containment. Off-site transport of dioxin, DDT, and other chemicals in the containment area will be eliminated as a result of the pumping system. It is estimated that approximately six wells would be required to reduce and maintain the ground water level within the containment area to a point which results in a steady-state flux of flow toward and up through the site for removal and treatment. It is estimated that, at a pumping rate of 20 gpm, flow reversal will occur. With this reversal, any future effect on the sand aquifer will be controlled.

The pumped water will be treated via filtration and adsorption on activated carbon or other adsorbents. These are proven technologies for removing dioxin and other organic materials from water.

The technical feasibility of this alternative is similar to Alternative 2, except that this alternative will require the installation of wells and will include pumping and treatment of the ground water. Wells have been used effectively to withdraw water from water-bearing zones and constitute implementation of a proven existing technology.

The purge wells will be designed with stainless steel casing and screen. The pumped water will be treated for soluble dioxin, DDT, and other organic chemical constituents in water. The wells will be installed during the construction of the cap and water will be treated, as required, for the duration of the post-implementation period. The time to implement this alternative will be approximately two and a half years.

The installation of purge wells during the implementation period will not adversely impact the environment, and the operation of the purge well pump and treat system will control off-site ground water migration, including migration into the Passaic River.

Public health concerns for this alternative and Alternative 2 during the implementation phase will be similar. Public health considerations for Alternative 3 will be improved significantly during the post-implementation period because of the control of off-site ground water migration. Again, excavation is minimized when compared with Alternatives 4, 5, and 6 and the off-site odor and volatile emissions associated with Alternatives 2 and 3 are expected to be minimal.

8.2.4 Alternative 4 - Excavation and Thermal Treatment Alternative

The excavation and thermal treatment alternative meets all of the recommended goals of the risk assessment. However, from a technical feasibility standpoint, many questions must be answered regarding the viability of thermal destruction on a full-scale basis.

The success of thermal treatment of dioxin on a small scale is well documented; however, this method of treatment is in the early stages of development and has not been developed and used commercially. Thermal treatment of the demolition material and large items found in the excavated fill will be difficult because of the extensive pretreatment (demolition, handling, segregation, crushing/grinding) required. Following the permitting and construction of the thermal treatment unit, the time to implement this alternative will be at least six years.

Deep excavation of the site fill will be extremely difficult because of dewatering and buried obstruction problems and will substantially increase the risk of both environmental and public exposure for the following reasons:

- The site ground water must be dewatered to a point below the depth of excavation (approximately 13 feet over the site). This water will require filtration and carbon treatment.

- To reduce the handling and treatment of large volumes of infiltrating water, a slurry wall should be installed prior to dewatering and excavation. The quantity of water requiring treatment could be over 200,000 gallons per day if the slurry wall extends to the silt layer. If the slurry wall adjacent the Passaic River is extended to the top of rock to minimize the migration of water from the river, the estimated flow would be reduced.

- The fill excavated below the water table (approximately 35,000 cubic yards) will be very wet and will require dewatering prior to handling and thermal treatment. The resulting water will require treatment prior to discharge.

- The excavation of fill will be hindered by the presence of many deep piles both old and new (150 estimated). These piles are capped and extend through the silt into the deep sands. Movement of these piles during excavation will introduce undesirable paths for chemical migration by disrupting the integrity of the continuous silt layer underlying the fill. In addition to the piles, other buried obstructions such as sewers will complicate the excavation process.

- Deep excavation by the river side of the site will require extensive pumping exterior to the slurry wall to draw down the ground water level and equalize the pressure differential around the slurry wall. Otherwise, elevated pressures at the exterior of the slurry wall as a result of high water could cause movement of the silt layer and thus disrupt the integrity of this low-permeability layer.

- The excavation of fill, in addition to increased risk of air emissions resulting from dust, could result in the volatilization of many organic constituents found in the fill. These will be accompanied by chemical odors. It is anticipated that these odors will be detectable a long distance downwind from the site during extended excavation periods.

To successfully accomplish the deep excavation task without affecting the integrity of the continuous silt mat will be extremely difficult, very lengthy, and will generate a large volume of water from dewatering the site and the dewatering of excavated materials requiring treatment. The water generated will have a high concentration of colloidal suspended solids which will be difficult to remove without both physical and chemical treatment operations. The issue is further complicated because dioxin has a low solubility and high retention by solids. As a result of the above-mentioned activities associated with deep excavation, the risks from this alternative to both environmental and public exposure will substantially increase during the construction phase.

This alternative will eliminate, by thermal destruction, all affected building demolition material and on-site dioxin-containing soil with concentrations above 7 ppb.

During the implementation phase, the potential for fugitive dust emissions will increase as a result of the construction activities, grinding of structural and subsurface materials to suitable size for thermal treatment, and material transport to the thermal treatment facility. In addition, volatile compounds and odors will increase during the excavation and transport activities. Further, while the thermal treatment would be designed to effectively treat the material concerned, a malfunction of the treatment unit may result in the increased short-term emission of organic materials and dioxin-containing dust into the atmosphere upwind of the metropolitan areas adjacent to the site. In the event of a malfunction, public health risks will not increase significantly; however, it is perceived that the public would view such an event as a risk.

Once the remedial measures are completed, any fugitive dust problems will be eliminated. The material and soil are thermally treated and the source is essentially eliminated. Because of the elimination of the source of dioxin and construction of the slurry wall and cap, there will be a significant reduction in ground water migration off site and into the Passaic River. However, there is still a continued potential for the migration of resolubilized dioxin as a result of leaching from the nonexcavated, less than 7 ppb soils unless the pumping and treatment option is added to this alternative.

Traditional construction safety hazards associated with building demolition and heavy equipment will also exist. Implementation of this alternative will require the development of very careful contingency planning. Any malfunctioning in areas such as thermal treatment, materials storage and handling, and treatment of dewatering fluid will increase the risk of environmental and public exposure. The continued exposure potential to off-site receptors will be approximately six years or longer.

Thermal treatment of the excavated soil will eliminate the dioxin and other compounds contained and eventually will eliminate inhalation exposure. The slurry wall will minimize the migration of ground water. The cap will reduce infiltration of the area and will effectively eliminate the risk of inhalation of particulates containing chemicals from the site.

8.2.5 Alternative 5 - Excavation and Disposal in a Secure Vault Alternative

The excavation and disposal in a secure vault alternative includes the deep excavation of all affected soil containing dioxin above 7 ppb and disposing of this in an on-site, above-grade vault. The vault will be constructed so that the bottom of the vault is one foot above the 100-year flood level (Elevation 10.2 feet), and an impermeable barrier (slurry wall) will be constructed along the site perimeter.

On-site building demolition material will also be disposed of in the vault along with containerized wastes currently stored on 120 Lister Avenue. Some tanks and major structural steel components will be decontaminated and either disposed of off site as nonhazardous waste or salvaged. The vault will be capped in accordance with RCRA requirements.

Drummed liquids and process wastes will be stabilized, immobilized, and placed in the vault. A monitoring program will be established and maintained during the post-implementation period.

This alternative meets all the recommended goals of the risk assessment. In addition, the disposal of dioxin-containing waste in a waste isolation vault is a proven, technically feasible method of containing the material and isolating waste from the public and the environment. The disposal facility will have a dual synthetic/composite liner to virtually eliminate the migration of leachate to the ground water. Any leachate generated will be collected for treatment. The cap also provides protection from direct public contact of the material and is a proven and effective method of reducing surface water infiltration and, ultimately, leachate generation.

However, the deep excavation of affected soils will be extremely difficult and lengthy due to excavation, stockpiling, and backfilling of treated materials on a small site and will increase the risk of both environmental and public exposure. The difficulties in accomplishing this alternative are greater than those itemized for Alternative 4. In fact, a detailed study of the logistics of excavating, stockpiling, backfilling, and constructing the vault is expected to result in the alternative not being feasible because of the limited site area. Essentially, because the proposed vault covers the entire site area, and the base of the vault must be completed before most of the waste materials can be placed in the vault, there is no remaining area left on site to stockpile waste which is awaiting placement in the vault.

If it were feasible to construct a vault, construction of the vault must be carefully controlled so that proper effective construction techniques are followed. The time to implement this alternative is approximately five years.

During the implementation phase, because of the excavation of soil, building demolition, containerized waste dumping, and other construction activities, fugitive dust will increase. In addition, volatile compounds and odors will increase during excavation and transportation activities. Once the remedial measures are completed, however, the potential for fugitive dust problems will be eliminated.

There will be a significant reduction in ground water migration from the site. The vault will act as a cap for the site and, coupled with a slurry wall, will further help in meeting off-site acceptable concentration limits. However, there will still be a continued potential for the migration of resolubilized dioxin as a result of leaching from the nonexcavated, less than 7 ppb soils unless the pumping and treatment option is added to this alternative.

The exposure potential to the off-site population will be similar to but less than Alternative 4.

The installation of the slurry wall will minimize the migration of ground water off site and into the Passaic River, and disposing of the materials in a vault will effectively isolate the wastes from public and environmental contact. Capping the site virtually eliminates the potential for public contact and inhalation risk of particulates.

8.2.6 Alternative 6 - Excavation and Off-Site Disposal/Treatment

The off-site disposal or thermal treatment alternative would meet all of the goals of the remediation. However, as previously stated, this alternative is not presently viable because there is not a landfill or thermal treatment facility licensed at this time to receive dioxin-containing materials. The alternative has been considered in this study because a facility could exist in the future, and because consideration of the alternative, as if it were viable, completes the scope of the remedial alternatives considered.

Considering only the technical aspects of this alternative, results in the same difficulties related to excavation as Alternative 4. As for Alternatives 4 and 5, excavation would proceed to the 7 ppb dioxin level. In addition to the problems associated with excavation, transport of the materials produces the following difficulties:

- If shipment occurs by trucks with a 20-ton capacity, it is estimated that 5,365 trips would be required. This considers that the shipping containers located on 120 Lister Avenue would be hauled individually for a total of 845 trips. The drums would be hauled as is or in overpacks for a total of 20 trips. The estimated 60,000 cubic yards of excavated soil and building debris would require 4,500 trips.

- If shipment occurs by rail with a capacity of 50 tons per car, 2,150 carloads would be required. Assuming a unit train of 80 cars would require 268 unit trains. Also as part of rail shipment, it must be considered that transshipment from rail cars to trucks may be required to ship the materials from a rail head near the disposal/thermal treatment facility to the facility.

- As stated in Section 7.0, transportation statistics indicate that an accident, which would probably result in spillage, would occur.

- For the case of landfilling, the dioxin will still exist.

Finally, even though the bulk of dioxin-containing materials would be removed from the site, in situ materials with levels less than 7 ppb would still exist. This results in the same long-term concerns as discussed for Alternatives 4 and 5.

8.3 INSTITUTIONAL COMPARISON OF REMEDIAL ALTERNATIVES

From an institutional standpoint, the five alternatives can be compared as follows:

- Alternative 1 - No Action - The site is currently a Superfund site regulated under CERCLA. While the site is currently secured, the no-action option implies severe restrictions on land usage and would offer no guarantees that conditions would improve in the future. This does not appear to be a responsive approach from an institutional standpoint.

- Alternative 2 - Slurry Wall and Cap - The construction effort is straightforward. All technologies used have been extensively used before. Although the materials remain on site, they are well contained. This alternative also minimizes excavation and attendant potential exposure and materials handling problems. The work will require appropriate permits; however, no unusual requirements are anticipated. The construction of the bulkhead will require approval by the U.S. COE (Alternatives 2 through 6 will require this permit) and local zoning approval will be required for other construction activities such as demolition. From a land use standpoint, the site can be used for some low-density industrial uses.

- Alternative 3 - Slurry Wall and Cap Combined With a Pump and Treat System - From an institutional standpoint, this alternative will be viewed much as Alternative 2 except that (1) an NJPDES permit will be required to discharge treated water from the containment area and (2) by controlling effectively all of the off-site migration of contaminated ground water through pumping, greater public acceptance is anticipated.

- Alternative 4 - Excavation and Thermal Treatment - From an institutional standpoint, this is probably the most complex alternative. The thermal treatment technology for dioxin destruction has not been demonstrated in full-scale operations. Permits would have to be obtained with likely and extensive delays expected. Historically, the local Ironbound District residents have resisted all considerations of the installation of municipal and hazardous waste incinerators in this area. Because of increased potential for fugitive dust generation, atmospheric emissions from the site incinerator, and the long duration of implementation, public acceptance during the implementation phase of this alternative is likely to be unfavorable. Over the long-term, because a slurry wall and cap, and possibly a pump and treat system, are required, the same institutional concerns as for Alternatives 2 and 3 exist. Land use restrictions are comparable to Alternatives 2 and 3.

- Alternative 5 - Excavation and Construction of a Vault - All technologies used have been previously proven. The construction of the waste isolation vault will require state and federal approvals. Discharging of the treated ground water pumped during dewatering will require an NJPDES permit. Local zoning approval will be required for construction activities. Institutionally, the construction work for this alternative has the potential for dust generation. The material will remain on site in an above-grade vault over 20 feet in height covering the entire site. Future land use is severely limited with this alternative.

- Alternative 6 - Excavation and Off-Site Disposal/ Treatment - The technology required for on-site work is extensively proven. As for Alternatives 4 and 5, dust generation and the volatilization of organic chemicals associated with the fill layer are potential difficulties. Land use of the site would be relatively unrestricted because the fill layer will be replaced with clean backfill. In addition to an NJPDES permit, a Department of Transportation permit would be required for transport. Facilities for landfilling or thermal treatment would require permitting for dioxin, which does not currently exist.

8.4 COST COMPARISON OF REMEDIAL ALTERNATIVES

8.4.1 Capital and Annual Operation/Maintenance Costs

Capital costs are a summation of unit costs incurred for activities that are completed during the implementation phase of the project. These items include all equipment, materials, labor, engineering, and miscellaneous expenses for the activities which take place as the components of each alternative are executed. Operation and maintenance costs, on the other hand, include the costs necessary to provide the continued effectiveness of the remedial alternative throughout its lifetime. These costs occur during the post-implementation phase and include site security, analytical monitoring, and facilities operation and maintenance.

8.4.2 Cost Present Value

The cost present values have been calculated for each alternative. A net discount rate of 10 percent is assumed before taxes and after inflation (15 percent interest on investment, 5 percent inflation). This rate represents the average rate of return for private investments. The cost present values have been calculated for a 30-year period of performance for each alternative starting at the end of the implementation phase.

Capital costs, annual operation and maintenance costs, and cost present values for the aforementioned remedial action alternatives are summarized in Table 8.4-1. A more detailed itemization of capital and operation and maintenance costs for each alternative is provided in Appendix C. The following sections summarize the key components of the cost evaluations for each alternative.

The cost range for the alternatives (Table 8.4-1) was calculated by adding or subtracting the following percentages from the best estimate of the capital cost:

ALTERNATIVE	PERCENTAGES USED FOR COST RANGE
1	-10, +10
2	-20, +20
3	-20, +20
4	-10, +25
5	-20, +20
6	-10, +30

The high percentage addition to Alternative 4 reflects the high cost which would be incurred should a major problem develop in the thermal treatment unit. The high percentage addition to Alternative 6 reflects the uncertainty of landfilling/thermal treatment costs for dioxin should this be permitted in the future. The actual percentage could be much higher.

Alternative 1

The estimate of capital costs associated with the execution of Alternative 1 is $422,000. The bulk of this cost is the transportation of materials from 120 Lister Avenue to 80 Lister Avenue (which is a requirement of the ACO) with the remainder of the costs for the no-action alternative being for miscellaneous items such as additional lighting and enhanced security.

The estimated annual operating and maintenance costs for Alternative 1 total $237,000. The operating and maintenance costs include utilities (water, electric, sewage) for security systems, security and monitoring personnel, site inspections, and analytical monitoring of the air, ground water, and surface water. The need for continued inspection of the bulkhead for Alternative 1 increases the annual operating and maintenance cost. For all other alternatives, the bulkhead is replaced and the need for annual inspections is eliminated. The cost present value for this alternative was calculated to be $2,600,000.

Alternative 2

The best estimate of capital costs for Alternative 2 is $8,013,000. The major cost items for this alternative include container decontamination, building demolition, slurry wall construction, and capping the site (Appendix C). The annual operating and maintenance costs for Alternative 2 are estimated at $165,000. Operating and maintenance costs include utilities, cap maintenance, site inspections, and analytical monitoring. The cost present value for Alternative 2 is $8,350,000.

Alternative 3

The estimated capital cost of Alternative 3 is $8,086,000. Alternative 3 is identical to Alternative 2 with the exception that Alternative 3 incorporates a ground water withdrawal and treatment system which increases both the capital and the annual operating and maintenance costs. The annual operating and maintenance cost and cost present value for Alternative 3 are estimated at $261,000 and $9,320,000, respectively.

Alternative 4

The estimated capital cost of Alternative 4 is $60,096,000. Alternative 4 incorporates excavation and thermal treatment of all dioxin-contaminated waste and soil down to a dioxin concentration of 7 ppb. Thermal treatment of this large volume of soil on site significantly increases the alternative's overall capital cost and requires approximately six years for completion. The annual operating and maintenance cost and cost present value for Alternative 4 are estimated at $112,000 and $46,620,000, respectively.

Alternative 5

The capital costs for Alternative 5 are estimated at $16,879,000. Alternative 5 is the same as Alternative 4 except the soil is excavated, clean backfill is placed, and the excavated soil is placed into an above-grade vault rather than thermally treated. This will require approximately one less year for remediation when compared with Alternative 4. As can be seen, the resulting cost difference when compared to Alternative 4 is significant. The annual operating and maintenance costs and cost present value for Alternative 5 were estimated at $116,000 and $14,180,000, respectively.

Alternative 6

The costs associated with Alternative 6 are based on two options: landfilling or thermal treatment.

For the off-site landfilling option, the best estimate for the capital cost is $51,272,000. The unit cost for disposal for "the best estimate" was taken as 30 percent greater than current PCB landfilling costs. An additional 30 percent is included for the capital cost range. The actual unit cost is unknown. Off-site landfilling would require an annual operating and maintenance cost at the Lister Avenue site of $62,000. The cost present value is $39,460,000.

For the off-site thermal treatment option, the best estimate for capital cost is $247,808,000. In estimating the cost, the same percentage increases as for off-site landfilling were used. Off-site thermal treatment would require an annual operating and maintenance cost at the Lister Avenue site of $62,000. The cost present value is $188,460,000.

8.5 SELECTION OF REMEDIAL ACTION

The slurry wall, cap, pump, and treat system (Alternative 3) has been selected as the recommended remedial action. The rationale for this decision follows.

Alternative 1 has been excluded because:

- In the long-term, it is not responsive
- The waste source is not controlled
- No action results in further deterioration of the site which increases the risk for environmental and public exposure.

Alternative 2 is similar to Alternative 3; however, with the inclusion of the pumping and treatment system, Alternative 3 provides mitigation of the migration of ground water from the site. Therefore, Alternative 2 is not considered further.

At the present time, Alternative 6 is not a viable alternative because no facility can accept the materials. Therefore, it is not considered further.

The selection of the recommended remedial action is therefore between Alternatives 3, 4, and 5. The advantages and disadvantages of each of these alternatives are contained in Tables 8.5-1 through 8.5-3. Alternative 3 meets all the recommended goals of the risk assessment with a great deal of conservatism, without depending on the use of unproven technologies at a full scale (Alternative 4), the use of major excavation programs (Alternatives 4 and 5), or the construction of a vault (Alternative 5). Alternatives 4 and 5 have numerous associated potential problems.

In summary, Alternative 3 is the most technically viable and cost-effective method to meet the objectives of the ACO and, hence, is the recommended remedial action.

TABLES

TABLE 8.2-1

COMPARISON OF ALTERNATIVES IN REFERENCE TO THE OFF-SITE MIGRATION IN GROUND WATER SCENARIO OF SECTION 3.0

POTENTIAL CONCENTRATION AT CLOSEST RECEPTOR WELL
2,000 FEET SOUTHWEST OF THE SITE

ALTERNATIVE	DIOXIN CONCENTRATION ($\mu g/\ell$)	DDT CONCENTRATION ($\mu g/\ell$)
1	1.5×10^{-3}	1.49
2	2.4×10^{-4}	0.25
3	~0	~0
4	3.1×10^{-5} ~0(a)	4.6×10^{-4} ~0(a)
5	3.1×10^{-5} ~0(a)	4.6×10^{-4} ~0(a)
6	3.1×10^{-5} ~0(a)	4.6×10^{-4} ~0(a)
Recommended Goal Defined in Section 3.0	5.5×10^{-5}	0.23

(a)If a pump and treat system is included, the concentration off site will approach zero due to flow reversal.

NOTE: This table assumes no retardation.

TABLE 8.4-1

COST SUMMARY OF ALTERNATIVES

ALTERNATIVE	CAPITAL COST BEST ESTIMATE	CAPITAL COST RANGE	COST PRESENT VALUE	ANNUAL OPERATING AND MAINTENANCE COSTS
1	422,000	380,000-464,000	2,600,000	237,000
2	8,013,000	6,410,000-9,616,000	8,350,000	165,000
3	8,086,000	6,469,000-9,703,000	9,320,000	261,000
4	60,096,000	54,086,000-75,120,000	46,620,000	112,000
5	16,879,000	13,503,000-20,254,000	14,180,000	116,000
6 Landfill Option	51,272,000	46,145,000-66,653,000	39,460,000	62,000
6 Thermal Treatment Option	247,808,000	223,027,000-322,150,000	188,460,000	62,000

TABLE 8.5-1

ALTERNATIVE 3 - ADVANTAGES AND DISADVANTAGES

- Advantages
  - Could be implemented with proven technologies
  - No excavation results in less site disturbance and limited public exposure
  - Has short period of implementation (approximately 2.5 years)
  - Meets and exceeds all objectives of the remediation program, including isolation of the material from public exposure and protection of the ground and surface water
  - The construction of the slurry wall and cap can be reliably implemented and have long-term durability
  - The waste material will be stored in an accessible, yet secure containment area
  - Has fewer institutional constraints, thus minimizing the pre-implementation regulatory delay
  - Has the least cost of all alternatives that meet the recommended risk assessment goals
  - The site could be used in the future for light industrial purposes
- Disadvantages
  - There may be a perceived disadvantage in that the waste is not destroyed but instead is contained and treated
  - A water treatment system meeting stringent discharge criteria must be developed
  - A stabilization treatment for drummed wastes must be developed

TABLE 8.5-2

ALTERNATIVE 4 - ADVANTAGES AND DISADVANTAGES

- Advantages

  - Meets and exceeds all objectives of the remediation program by destruction of the hazardous material and thus eliminates long-term public exposure

  - Eliminates the majority of the on-site waste

  - The site could be used in the future for light industrial purposes

- Disadvantages

  - Thermal destruction of waste-containing dioxin is in the early stages of development and has not been commercially proven

  - Extensive materials handling requirements along with thermal treatment emissions will increase potential public exposure over a large populated area

  - Requires a long period of implementation (six years or more)

  - Deep excavation will require extensive dewatering and water treatment from within and outside the containment area

  - The outside dewatering resulting from deep excavation will require proper development of a contingency plan for high water level conditions; otherwise, disturbance of the silt layer might take place and affect the integrity of this unit, causing accelerated migration of chemicals to the sand formation

  - Because of the use of an on-site thermal destruction technology, extensive institutional constraints will develop

  - Public acceptance of thermal treatment of hazardous materials has been unfavorable in this area

TABLE 8.5-3

ALTERNATIVE 5 - ADVANTAGES AND DISADVANTAGES

- Advantages

  - Meets all objectives of the remediation program, including isolation of the material from public exposure and protection of the ground and surface water

  - The waste material will be stored in an accessible, yet secure containment area

  - The construction of the slurry wall and containment vault can be reliably implemented with proven technologies and durably maintained

  - The vault will be located above the 100-year flood level

- Disadvantages

  - Construction may not be feasible due to excavation, stockpiling, backfilling, and vault construction in a very limited area

  - High materials handling requirements will increase potential public exposure

  - Long period of implementation (approximately five years)

  - Deep excavation will require extensive dewatering and water treatment from within and outside the containment area with a subsequent discharge

  - The outside dewatering resulting from deep excavation will require proper development of a contingency plan for high water level conditions; otherwise, upheaving of the silty clay might take place and affect the integrity of this zone, causing rapid migration of chemicals to the sand formation

  - Maintaining the integrity of the above-grade vault through harsh weather extremes will be difficult

  - The containment of the site material in an above-grade waste isolation vault will result in extensive institutional constraints

  - Maintenance of the long-term security of the vault will be difficult

  - The site would have no other land use

9.0

APPENDIX
A

APPENDIX A

SUPPORTING INFORMATION FOR THE RISK ASSESSMENT

APPENDIX A

SUPPORTING INFORMATION FOR THE RISK ASSESSMENT

A.1.0 FAMILY GROUPING AND INDICATOR CHEMICAL SELECTION

A comparison of the chemical and physical properties which family members share, along with the criteria used to select the indicator chemicals, follows.

Chlorinated Benzenes--Chlorobenzene, three dichlorobenzene isomers, 1,2,4-trichlorobenzene, and hexachlorobenzene (HCB) were detected on site. HCB is the least soluble (0.11 mg/ℓ), and has the lowest vapor pressure (10^5 mm Hg). Its octanol water partition coefficient is high (log Kow=6.18) indicating a strong tendency of this compound to adsorb to soils and sediments. HCB is also expected to undergo bioconcentration, and is a very persistent compound in the environment (U.S. EPA, 1979). Due to its low solubility and vapor pressure, HCB is expected to have limited mobility via air and water routes except when carried on suspended particulate matter. HCB (No. 8) was selected to represent this group because it was found to be the only carcinogen.

Chlorinated Phenols--Chlorinated phenols reported in on-site soils include 2-chlorophenol, 2,4-dichlorophenol, and 2,4,5- and 2,4,6-trichlorophenols (TCP). As shown in Table 3.2-2, solubilities for these compounds are moderate, ranging from 800 mg/ℓ for 2,4,6-TCP to 28,500 mg/ℓ for 2-chlorophenol. Solubility decreases for increasing degrees of chlorination, and thus, increasing molecular weight. Vapor pressures for the chlorophenols are relatively low, ranging from less than 1mm Hg for TCPs to 5 mm Hg for 2-chlorophenol. Vapor pressures decrease with increasing molecular weight. The chemical 2,4,6-TCP is the least soluble of the group with a moderate solubility of 800 mg/ℓ, and it has a moderate octanol water partition coefficient (log Kow=3.38). These properties indicate some tendency to adsorb to soils and sediments. The chemical properties indicate that 2,4,6-TCP may be transported in water in dissolved form or may be adsorbed to suspended matter. The vapor phase mobility of 2,4,6-TCP in air is expected to be limited, although it may be transported via suspended particulates. Mobility of 2,4,6-TCP is expected to be representative of the chlorinated phenols observed on site.

Since 2,4,6-TCP (No. 1) is the only carcinogen in the family, it was chosen to represent this group.

Cyanides--Cyanide (No. 61) was reported as total cyanides and therefore this group is the indicator chemical.

Chlorinated dibenzo-p-dioxins (PCDD)--The chemical compound dioxin (2,3,7,8-TCDD) has extremely low solubility (0.0002 mg/ℓ) and vapor pressure (10^{-6} to 10^{-7} mm Hg). The log octanol water partition coefficient for dioxin is 7.14; therefore, dioxin is expected to have a strong tendency to adsorb to soils and sediments, and may bioconcentrate. The chemical properties of dioxin limit its mobility via water and air routes, except when carried on suspended particulates. Dioxin (No. 63) is a potent animal carcinogen and very acutely toxic; therefore, this compound was chosen to represent this group.

Ketones--Three ketones were detected on site: acetone, 2-butanone, and 2-hexanone. All are quite soluble (35,000 mg/ℓ to miscible with water), and have correspondingly low octanol water partition coefficients. These compounds have relatively low affinity for soils and sediments, and are likely to be transported dissolved in the aqueous phase. Vapor pressures for acetone and 2-butanone are high (270 and 77.5 mm Hg, respectively) indicating a tendency to volatilize. The chemical compound 2-hexanone has a moderate vapor pressure of 2 mm Hg. The chemical compound 2-hexanone (No. 40) was selected to represent this group because it had the lowest threshold limit value (No. 40 = 2 ppm; No. 38 = 200 ppm; and No. 37 = 750 ppm) and the highest maximum level in the near-surface soil (No. 40 = 36,000 ppb; No. 38 = 9,200 ppb; No. 37 = 5,000 ppb).

Low?

Metals--The solubility and vapor pressure of metals are highly dependent on the chemical species. In general, adsorption to soils and sediments greatly retards the mobility of certain metals in ground and surface water, although in some cases soluble metals, ions or complexes may be present. In these cases, migration via water routes may be significant. With the exception of volatile metals, such as mercury and possibly arsenic, volatilization is not expected to represent a significant environmental transport mechanism. Metallic mercury, the most volatile metal, has a vapor pressure of only about

0.0012 mm Hg (U.S. EPA, 1979). Volatilization of mercury could be enhanced by microbial methylation under reducing conditions.

This group contained four human carcinogens (Nos. 50, 51, 52, 57). Arsenic (No. 50) was selected as the indicator chemical of choice because it was the most potent carcinogen, based on its having the lowest water quality criteria (No. 50 = 22 ng/ℓ; No. 51 = 37 ng/ℓ; No. 52 = 10,000 ng/ℓ; and No. 57 = 13,400 ng/ℓ), for 1 X 10^{-5} risk. The water quality criteria are derived from the potency slope for each respective chemical and are, therefore, highly correlated with this index of carcinogenic potential (Federal Register, 1980).

Polynuclear Aromatic Hydrocarbons (PAHs)--A variety of PAHs were detected on site. Properties for this class of compounds generally correlate with molecular weight, or number of rings in the compound structure. Solubilities range from 30 mg/ℓ for the two-ring naphthalene to less than 0.01 mg/ℓ for four- and five-ring compounds (such as chrysene and benzo(a)anthracene), and sediment water partition coefficients from about 100 for naphthalene to 10,000 to 100,000 for representatives of the four- and five-membered ring compounds, respectively. Vapor pressures are relatively low for PAH compounds. The largest reported vapor pressure is for naphthalene (0.05 mm Hg), decreasing to less than 10^{-6} mm Hg for four-membered ring and heavier compounds. With the possible exception of the relatively soluble naphthalene, the PAH compounds are strongly sorbed to soils and sediments, and are generally found in sediments and in the particulate phase of surface waters. This low solubility limits the aqueous mobility of the heavier PAH compounds.
Benzo(a)anthracene's solubility (0.04 mg/ℓ) and vapor pressure are low. The octanol water partition coefficient is relatively high (log Kow=5.61), indicating a strong tendency for this compound to adsorb to soils and sediments. Therefore, benzo(a)anthracene is expected to have limited mobility via air and water routes, except when transported on suspended particulate matter.

Four carcinogens were found in this family (Nos. 16, 17, 18, 25). The remaining screening criteria were either unavailable or unable to provide a basis for detecting meaningful intra-group variation. Benzo(a)anthracene (No. 16) was selected since it was the sole member detected in the ground water.

Phenolics (Nonchlorinated)--Chemical compound 2,4-dimethylphenol (No. 3) is the only member of this group and therefore was chosen as the indicator chemical.

Phthalate Esters--Bis(2-ethylhexyl)phthalate (No. 14) was the only carcinogen found in this family and therefore was selected as the indicator chemical.

Total Phenols--Phenol (No. 2) is the only member of this group and therefore was selected as the indicator chemical.

Volatile Aromatics--Volatile aromatics detected on site include benzene, toluene, xylenes, and ethylbenzene. These chemicals are moderately soluble, ranging from 152 mg/ℓ for ethylbenzene to 1,780 mg/ℓ for benzene. Based on octanol water partition coefficients, these compounds may exhibit some tendency to be adsorbed to soils and sediments and to bioconcentrate. As their name implies, this class of chemicals is relatively volatile, with vapor pressures ranging from 5 mm Hg for o-xylene to 76 mm Hg for benzene. Benzene represents the most mobile volatile aromatic compound via both air and water routes based on its solubility and vapor pressure. Benzene (No. 29) was the only carcinogen found in this family and therefore was chosen as the indicator chemical.

Volatile Chlorinated Organics--The four volatile chlorinated organics reported in on-site soils were chloroform, methylene chloride, 1,1,2,2-tetrachloroethane and trichloroethene. These compounds are relatively soluble, with solubilities ranging from 1,100 mg/ℓ for trichloroethene to 20,000 mg/ℓ for methylene chloride. Octanol water partition coefficients are correspondingly low, indicating relatively low tendency to bioconcentrate or adsorb to soils and sediments. Members with lower solubility (e.g., 1,1,2,2-tetrachloroethane and trichloroethene) may exhibit some tendency for bioconcentration and adsorption. Vapor pressures for these compounds are moderate to high, ranging from 5 mm Hg for tetrachloroethane to 349 mm Hg for methylene chloride. Chloroform (No. 31) and methylene chloride (No. 33) were noted to be carcinogens in this group. Chloroform was the most potent carcinogen and has the lowest vapor pressure and, therefore, was selected as the indicator chemical.

Chlorinated Phenoxy and Related Compounds--Chlorinated herbicides detected on site included chlorinated phenoxy herbicides (2,4-D, 2,4,5-T, 2,4-DB) and chlorinated benzoic acid (Dicamba). These compounds have low to moderate solubility, ranging from 46 mg/ℓ for 2,4-DB to 7,900 mg/ℓ for Dicamba. The low solubility members of the group (2,4-DB and 2,4,5-T) may exhibit some tendency to bioconcentrate and to adsorb to soils. The chemical 2,4-D is moderately soluble (890 mg/ℓ) and has a moderate octanol water partition coefficient (log Kow=2.81), indicating some tendency to adsorb to soils and sediments.

The national interim primary drinking water standard for 2,4,5-TP is used to represent the standard for 2,4,5-T since it is the lowest standard of this group. In addition, 2,4,5-T (No. 48) was selected as the indicator since it has the highest maximum detected concentration is the near-surface soil (No. 48 = 86,000 ppb; No. 47 = 85,000 ppb; and Nos. 65 and 66 = nondetectable).

DDT and Metabolites--Solubilities and vapor pressures for these compounds are generally low. DDT has a solubility of 0.003 mg/ℓ and a vapor pressure of about 10^{-7} mm Hg. Octanol water partition coefficients are high, indicating a tendency for these compounds to bioconcentrate and to adsorb to soils and sediments. The compound 4,4'-DDT (No. 42) was selected as the indicator chemical because it had the highest maximum detected concentration in the near-surface soil (No. 42 = 5,090 ppm; No. 44 = 164 ppm; No. 43 = 93 ppm).

Miscellaneous--Beta-BHC (No. 64) was the only known carcinogen found in this group and therefore was selected as the indicator chemical.

A.2.0 EXPOSURE ASSESSMENT

This section contains calculations and supporting information for results presented in Section 3.3. The analyses presented in this subsection were developed with the assistance of the staff of Woodward-Clyde Consultants and are further detailed in a report entitled "Exposure Assessment for 80 Lister Avenue, Newark, NJ, August 1985."

A.2.1 Surface Runoff

The amount of runoff from a given surface during a given precipitation event depends on the intensity and amount of rainfall, ground surface properties (infiltration capacities), and initial moisture conditions. Runoff from pervious surfaces (soil) will usually occur only in response to more intense precipitation events such as thunderstorms. A steady, low intensity rain extended over a longer period of time may result in more precipitation; however, due to the lower intensity, the infiltration capacity of the soil might not be exceeded at any time, and all precipitation may seep into the ground or evaporate. Hence, there would be recharge to the soil and, possibly, ground water, but no surface runoff. On the other hand, runoff from impervious (for example, paved) surfaces will occur during more intense as well as less intense precipitation events, but at different rates.

Based on a statistical analysis of rainfall characteristics for New York City (U.S. EPA, 1982), the mean volume of the average storm is 0.37 inches with an average duration of 6.7 hours. This results in an average intensity of 0.055 inches per hour. Two extreme cases that are likely to bound the problem will be considered.

[illegible]

In the first case, the site is assumed to contain only pervious surfaces (soil). Direct precipitation and runoff from building gutters and surfaces will drain onto pervious surfaces and, therefore, no surface runoff is generated during an average storm.

The second case is the opposite extreme, where all surfaces are paved and all of the precipitation during an average storm (except for a small amount lost to evaporation and detention storage in small depressions) remains on the surface in ponds, or leaves the site as surface runoff. Because there is no detailed topographic data for the site, all rainfall will be assumed to drain from the site as surface runoff. The total runoff from the site, as a result of the average storm, would then be 0.37 inches over the area of the site (3.4 acres) or about 4,500 cubic feet of water. This discharge would combine with drainage entering the site from adjacent areas and flow into storm sewers or directly into the river carrying along with it, in suspended and dissolved form, a chemical wash-off load containing constituents of common urban pollutant buildup, along with chemicals associated with the site. The fraction of runoff entering the river directly versus the portion entering storm sewers cannot be accurately determined without a detailed topographic survey, knowledge of the hydraulic condition of sewers and bedding materials, and information on the hydrologic characteristics of the ground surface. However, based on visual observations of the site topography, it appears that most of the surface runoff drains to the lowest portion of the site (the southern part of the site), and then into the river by way of storm sewers. Therefore, the major receptor of contaminants transported by surface water off the site is the Passaic River. Once the surface water reaches the river, it will mix with river water and be transported both downstream due to freshwater inflow, and also upstream due to mixing with saltwater inflow from the ocean during the incoming tide.

Estimation of potential exposure is determined for both extremes of rainfall-runoff. In the case where the entire site consists of paved or otherwise impervious surfaces, the average storm would result in total surface runoff from the site of about 4,500 cubic feet. Most of this runoff enters the Passaic River by way of storm sewers that discharge into the river with a smaller amount discharging directly and through the bulkheads. The average runoff from the average storm is, therefore, (4500 ft^3/6.7 hours) x (1 hour/3,600 seconds) = 0.19 cfs.

Discharge into the river will mix with river water both upstream and downstream depending on the tidal conditions. The mean concentration of compounds near the point of discharge in tidal rivers can be estimated using a simplified dilution analysis (Fischer, et al., 1979). The total flow available for diluting the runoff (Qd) is:

$$Q_d = (Q_e + Q_f)\ S_o/(S_o - S)$$

where:

Q_e = discharge into the river

Q_f = tributary discharge from all tributaries upstream of the point of discharge into the river

S_o = ocean salinity

S = salinity of the river.

The United States Geological Survey (Schopp, 1984) has developed equations using standard regression techniques for estimating mean annual flow in New Jersey streams. The equation for noncoastal drainages is:

$$\text{mean annual flow} = 1.534\ A^{1.0}$$

where A = drainage area in square miles

For the Passaic River at the site, the estimated mean annual flow is (1.534) $(920\ \text{miles}^2)^{1.0}$ = 1,411 cfs.

The average ocean salinity (S_o) is assumed to be 35 parts per thousand (ppth) (Riley and Chester, 1971). The salinity on the Passaic River at the Jackson Street bridge (about two miles upstream from the site) from February through September 1982 ranged from 0.45 to 20 ppth (Guttman, 1982). A reasonably conservative value of 10 ppth midway between the two extremes is assumed for river salinity (S). In the above equation, average runoff into the river Q_e = 0.19 cfs is insignificant when compared to the mean annual flow Q_f = 1,411 cfs and therefore can be disregarded. Therefore, the total flow available for diluting the stormwater runoff (Q_d) under average conditions is:

$$1{,}411\ \text{cfs} \times \frac{35\ \text{ppth}}{35\ \text{ppth} - 10\ \text{ppth}} = 1{,}976\ \text{cfs}$$

The dilution factor for runoff from an average storm into the river is:

$$0.19\ \text{cfs}/1{,}976\ \text{cfs} = 0.0001 = 1 \times 10^{-4}$$

In the opposite case where the entire site is pervious, the precipitation rate (0.37 inches over 6.7 hours, or 0.06 inches per hour) would not exceed the infiltration capacity of soils found at the site (0.24 inches per hour for soils with moderate infiltration rates) (U.S. Bureau of Reclamation, 1974). Instead of leaving the site as surface runoff, all of the precipitation from the average storm would, therefore, seep into the ground and would enter the unsaturated zone.

The average storm provides a means of analyzing conditions that may be expected to occur relatively frequently. However, larger and more intense but less frequent precipitation events must also be considered since most of the potential sediment transport from land surfaces occurs during these events. Since the site has been inactive for a number of years, and most of the soluble and volatile components (such as benzene, chloroform, 2,4-D, 2,4,6-TCP, 2-hexanone, and beta-BHC) in shallow soils (the top several inches) will already have been removed by natural processes, then off-site contaminant transport by way of solution in surface runoff during these larger, less-frequent events will most likely not be significant.

Occasional flooding of the site by tidal flooding of the Passaic River will occur. The elevation of the site ranges from seven to ten feet above mean sea level (MSL). According to the U.S. Army Corps of Engineers (COE) flood insurance study for the region, flood elevations for the 10-, 50-, 100-, and 500-year tides are 7.5, 9.3, 10.2, and 12.8 feet above MSL, respectively (COE, 1968). Therefore, over a long period of time, the site will be slightly inundated (to elevation 7.5) by flooding of the Passaic River once every ten years. The entire site will be flooded by the river (to elevation 10.2) once every 100 years. Many of the same processes discussed above during storm events, in which runoff and erosion are involved in transport of contaminants off site, will also be at work during flooding of the site by the Passaic River. Off-site migration of contaminants and exposure to potential receptors as a result of tidal flooding is, likewise, minimal.

Erosion of exposed soil surfaces will occur during larger, more intense but less frequent rainfall events and, consequently, cause transport of sediment off site due to the surface runoff and erosion. Contaminants adsorbed to the sediments will most likely be those with high octanol/water partition coefficients [such as benzo(a)anthracene, 4,4'-DDT, HCB, dioxin, and bis(2-ethylhexyl)phthalate]. The sediment from land surface erosion, along with the contaminants, will eventually find its way through the storm sewers to the river where it will be deposited.

A.2.2 Recharge From the Fill Area Into the Passaic River

The flow within the shallow ground water below the site is primarily horizontal. Boring logs from on-site borings suggest that the organic silt layer underlying the fill may be continuous across the site and thus provide a barrier to downward flow into deeper zones. Ground water levels indicate horizontal flow toward the river in the northern portion of the site and to the south in the southern portion (Figure 2.1-15).

The rate of horizontal ground water flow in the fill can be estimated using Darcy's equation (Freeze and Cherry, 1979):

$$Q = KiA$$

where

Q = fluid flow through a porous medium (cubic feet/day)
K = hydraulic conductivity of the porous medium (feet/day)
i = gradient of the water table (feet/feet)
A = cross-sectional area perpendicular to flow (square feet).

The following assumptions and parameter estimates were used to estimate a horizontal flow:

- Ground water in the northern half of the site drains to the north; the other half to the south (Figure 2.1-15).
- An east-west line of 350-foot length represents the cross section to major site flow vectors. This is the approximate width of the site.
- Contaminants are being transported off site in the saturated portion of the fill, an approximately six-foot-thick zone (Figure 2.1-11).
- The ground water gradient is approximately 0.02 both to the north and to the south (Figure 2.1-15; Table A-1).

- Mean hydraulic conductivity of 25 feet per day for the fill; a representative value based on slug tests conducted in the shallow monitoring wells.

Using the above assumptions and parameter values in Darcy's equation results in a calculated discharge to the north (and an equal amount to the south) of:

$$(25 \text{ ft/day}) (0.02) (350 \text{ ft}) (6 \text{ ft}) = 1050 \text{ cu ft/day} = 0.012 \text{ cu ft/sec}$$

for a maximum of 2,100 cubic feet per day leaving the site.

Following an analysis similar to the one for dilution by the Passaic River of surface water runoff, the dilution factor for ground water flow near the point of discharge to the river is approximately:

$$(0.012 \text{ cu ft/sec})/(1976 \text{ cu ft/sec}) = 6.1 \text{ X } 10^{-6}$$

If it is assumed that the discharge estimates represent average flow under steady-state conditions (outflow equals inflow with no change in storage with time), recharge from precipitation must replenish the shallow ground water lost to off-site flow. Therefore, the case in which all infiltration leaves the site as surface runoff with no recharge to the site cannot be true. The validity of the other case in which all the precipitation recharges the ground water, can be tested using a simplified water balance model in which inflow to the site equals outflow plus change in ground water storage. As mentioned before, the average storm precipitation for the site is 0.37 inches. The average time between storms for the site vicinity is 77 hours (U.S. EPA, 1982). If all the precipitation infiltrated into the ground, the amount of recharge to ground water would be an average of 1,470 cubic feet per day. Therefore, under average conditions precipitation recharge is approximately two-thirds that of the maximum ground water flow within the fill. This indicates that the calculated horizontal flow represents high flow and transient conditions. In other words, it represents a potential maximum.

This analysis shows that under average conditions, surface runoff is not an important migration pathway from the site. Rather, the major pathway/receptor combination for water at the site appears to be precipitation to the unsaturated zone, to ground water in the fill, and then to the Passaic River to the north. The fate of the flow off site to the south is much less clearly defined. On-site storm sewer lines as well as sanitary and storm sewer lines on Lister Avenue are known to exist. Their exact subsurface configuration and condition in the vicinity of the site are not known. For these reasons, a detailed assessment of the exposure risk by way of the sewers cannot be made at this time. However, it is reasonable to assume that ground water from the site would (1) flow into storm sewers draining into and mixing with the Passaic River, (2) flow into the sanitary sewers, eventually finding its way to the Passaic Valley Sewerage Treatment Plant and, (3) travel further off-site horizontally or move into deeper ground water zones.

Table 3.3-3 provides estimated off-site concentrations of indicator chemicals in surface water. In-stream concentrations for the Passaic River were estimated by using the mean and maximum values found in the shallow wells and diluting by 6×10^{-6}, the dilution factor for ground water to the river which was derived above. As shown in this table, DDT concentrations are relatively high, with a mean of 1.6 ppm and a maximum of 22 ppm. This maximum concentration occurred in Well 2-A, which is three to five feet from the bulkhead along the Passaic River. However, Wells 1-A and 3-A, also along the bulkhead, showed nondetectable DDT concentrations, indicating there is a "hot spot" around Well 2-A. Since we are interested in loading from the entire site and not from one area, an average concentration based on values found in the three shallow wells can be used for loading purposes. An average concentration of 7,333 ppb would yield an estimated river concentration value of 4.4×10^{-2} ppb DDT.

A.2.3 Ground Water Pathway

There are two primary concerns when evaluating the potential for chemical migration in ground water:

- The rate of migration of chemicals from the fill area to the glaciofluvial sands below
- The rate of migration of chemicals from the glaciofluvial sands to areas of potential receptors off site.

A.2.3.1 Vertical Migration Analysis

The well data from the fill area and glaciofluvial sands indicated that the highest chemical concentrations are found in the fill area. Relatively low concentrations of the indicator chemicals are found in the sands below, if detected at all, indicating that the rate of migration is slow or that the contaminants could be moving from an off-site source. This vertical rate of migration must be defined in order to evaluate various remedial actions, such as pumping, that can isolate the chemicals in the fill area, and prevent their migration to the sand aquifer system that has potential off-site receptors.

The organic silt layer may serve as the limiting factor in vertical flow because of its hydraulic conductivity. Water levels in the two off-site wells (10A and 10B) located within several feet of each other but screened in either the fill above the silt layer (well 10A) or in the sands below the silt (Well 10B), show a downward gradient of 0.59. This is based on an average difference of 5.4 feet between water levels in the two wells (measured on four dates in May/June 1985) over a distance of nine feet, which was determined to be the average thickness of the silt layer. Using Darcy's equation and an assumed hydraulic conductivity of 0.003 feet per day (or 10^{-6} cm/sec), the vertical leakage through the silt is estimated as:

$$(0.003 \text{ ft/day})\ (0.59)\ (148{,}104 \text{ feet}^2) = 262 \text{ feet}^3\text{/day (or 1.4 gpm)}$$

This analysis assumes that the entire site is pervious (Case 1). The value is approximately 20 percent of the total outflow of the site. Therefore, there is a potential for vertical migration of chemicals from the fill to the glaciofluvial sands below. However, this flow through the silt layer is relatively low at the rate of approximately one foot per year. Using an average thickness of nine feet, it would take a compound nine years to move through the silt and reach the top of the sands. For chemicals with high octanol/water coefficients and thus high retardation factors, the rate of movement will be drastically decreased.

As shown above, a hydraulic gradient exists between the ground water in the fill and the glaciofluvial sands below. A similar gradient exists between the top and bottom of the sands. Water levels in two off-site wells (10B and

10D), located within several feet of each other, but screened either at the top of the sands just below the organic silt (10B), or at the bottom of the sands just above the bedrock (10D) show a downward gradient of 0.037. This is based on an average difference of approximately 1.8 feet between water levels in the two wells (measured on three dates in May 1985) over a distance of 49 feet between the midpoints of the screens. However, this downward gradient will be affected by a clayey silt layer that seems to average 15 feet thickness at a depth of about 50 feet below the surface. This layer appears to be discontinuous across the site and constitutes yet another partial barrier to downward migration of contaminants from the site.

A.2.3.2 Ground Water Transport Off Site

The potential for contamination of the aquifers below exists even though the vertical migration of chemicals is low. Therefore, a ground water pathway and exposure analysis for the glaciofluvial sands and bedrock must be performed to determine the potential exposure, which in this case is ingestion of contaminated ground water that has moved off site. An overview of the geologic conditions of the glaciofluvial sands and bedrock aquifers is presented here to facilitate understanding.

A discontinuous dense till, above the glaciofluvial sand-bedrock interface, has been reported in borings in the area (Nichols, 1968). Recent borings advanced to bedrock near the site confirm the discontinuous nature of this and the other semipervious layers in the sands above. The combined effect of these layers is to force the ground water flow laterally before continuing downward, and would provide an obstacle to immediate downward migration. Therefore, the deeper the compounds migrate, the more likely they are to be displaced laterally from the site.

At the till-bedrock interface, migration of ground water is dependent on discontinuous nature of the porosity and permeability factors controlling flow. The flow through fractured rock occurs within a system of joints and fractures. Water can move vertically as well as horizontally within these interconnected zones of secondary porosity (Nichols, 1968). Pumping tests in the area show that aquifers in the sedimentary rocks of Triassic age of Northern New Jersey (such as the Brunswick shale bedrock below the site), are anisotropic; that is, they do not transmit water equally in all directions (Vecchioli, 1967). Water moves more readily along joints and fractures which strike parallel to the strike of the bedding (approximately N 30°E for most of Essex County), than along joints and fractures which strike in other directions.

Unlike the upper fill zone where there are few, if any, pumping wells that affect flow, flow within the bedrock aquifer in the site vicinity may be controlled by pumping wells. These wells are normally cased a short distance into rock with an open rock hole extending up to more than 800 feet below the surface. At one time ground water pumping was much more extensive in the area than it is today. In 1879, the water levels in wells in eastern Newark ranged from a few feet above to 20 feet below the surface with 10 ppm to 25 ppm chloride content in the water. In 1947, water from wells in the same area ranged from 125 to 200 feet beneath the land surface with 250 ppm to 2,500 ppm chloride. Pumping levels ranged from 135 to 290 feet in 1947. During this time, the pumpage in the Ironbound district of Newark, in which the site is located, ranged from five to eight million gallons per day (Herpers and Barksdale, 1951). The greatly depressed aquifer water levels, likely aided by the piercing of the silt layer due to dredging of the Passaic River, induced salt water intrusion into the aquifers and forced ground water flow away from the river toward the largest pumping centers to the south.

Since that time, the ground water pumpage in the area has decreased significantly. The water level elevations in bedrock wells drilled after 1979 in the area range from -15 feet to 0 feet below sea level. Apparently, they have recovered from the severely depressed levels of the 1940's to 1960's and are now close to natural conditions.

A dramatic change in the ground water level has occurred in recent years in a monitoring well near P. Ballentine and Sons located within 2,500 feet of the site (see Figure A-1 and Table A-1 for location). P. Ballentine and Sons, the largest single ground water user in the area, stopped pumping in the early 1970's. The water level in the observation well has risen from almost 100 feet below the surface in 1972 to within 25 feet in 1979. A similar trend is seen in three wells installed at Ronson Metals, located within 4,000 feet to the south of the site. At this location, static water levels rose from 56 feet below the surface in 1965, to 35 feet in 1973, to 30 feet in 1981 (Table A-2).

A.2.3.2.1 Selection of Representative Ground Water Well

In general, the most important ground water migration pathways include those found between the ground surface and the upper zones of the glaciofluvial sands and gravels. This is due to the lateral flow gradients on site and the apparent lack of strong downward gradients.

In order to determine potential exposure from ingestion of contaminated water, a ground water well that potentially could be used for domestic purposes and whose radius of influence encompasses the ground water flow under the site must be identified.

Table A-2 lists and Figure A-1 displays all known bedrock water supply wells for which information is available within one mile of the 80 Lister Avenue site. The source of this information includes NJDEP Well Drilling, Water Allocation, Diversion, and Physical Connection Permits, and the City of Newark Water Department files. Wells in operation as well as those sealed are indicated. The status of all other wells is not known. For purposes of this assessment, wells drilled after 1965 are assumed to have a high probability of current use, while those installed before 1965 are assumed to have a low probability. Post-1965 and pre-1965 wells are distinguished in Table A-2 and Figure A-1.

The data upon which Table A-2 and Figure A-1 are based are not expected to be complete and locate every user of ground water. A permit to drill a well filed at NJDEP does not guarantee that the well was ever put in use. As the permit system originally operated, no further notification was required. Recently, a system in which users above 70 gpm are required to apply for a ground water diversion permit was initiated at NJDEP. To date, only one user in the area has applied. The NJDEP, in cooperation with the Newark Water Department, is continually updating their records in an attempt to gain information on ground water use in the area, as well as throughout the entire state. At present, the collective NJDEP-Newark Water Department data base represents the most extensive, publicly available information on ground water use in the site vicinity.

All wells listed in Table A-2 and shown in Figure A-1 are cased in bedrock, and all are used for industrial noncontact purposes. According to the Superintendent of the Newark Water Department (Crenshaw, 1985, personal communication), there are no known potable wells in the Ironbound section of Newark. No new domestic wells should be drilled in this area. There are, however, bedrock wells outside the Ironbound area that are used for drinking water. Domestic use is the indicated proposed use of water on several recent NJDEP permits to drill in the area (Nos. 7 and 26 in Table A-2). Number 7 on 196 Blanchard Street was investigated by the Newark Water Department on August 14, 1985 and was not in use at that time because the property on which it is situated has been vacant since January. Well No. 26 is over 8,000 feet to the southeast across the Passaic River in Kearny.

Well No. 28 is located about 9,500 feet southwest of the site and produced potable water when it was drilled and tested in 1980. According to the Newark Water Department, it has since been capped and is not being used. Another well, located about 12,000 feet west of the site at 105 Chestnut Street, also may have potable water but according to the Newark Water Department is used only for flushing toilets. According to the Newark Water Department (Crenshaw, 1985, personal communication), the only wells used for drinking water in Newark are at a restaurant on Bloomfield Avenue and Tiffany Jewelers, both in northern Newark. These wells are about 3.2 miles and 3.4 miles northwest of the site, respectively. The probability that compounds migrated to these wells is very low due to the relatively large distance between the site and the wells, the boundary effects of the Passaic River which lies between the site and the wells, and ground water flow in the glaciofluvial sands below the site being generally to the south.

Hydrogeologic data are available from the Ronson well (No. 5). According to the information gathered, however, this well is not the closest well to the site. The two wells closest to the site with the highest probability of being presently in operation are Nos. 9 and 11. The hydraulic parameters derived from the Ronson well pumping test were applied to wells Nos. 9 and 11 and these two wells were considered the wells most likely to intercept off-site contaminant migration in the ground water.

In order to determine if the ground water under the site may be intercepted by these wells, a radius of influence for each well was calculated. An empirical relationship was developed by Sichart for estimation of radius of influence (R_o) (Powers, 1981).

$$R_o = 3(H-H_w)\ (0.47K)^{1/2}$$

where

K = hydraulic conductivity (gpd/ft^2)
H = total head
H_w = head in well.

The permeability was estimated from the Ronson well pumping test where an average transmissivity (T) of 9,000 gpd/ft was used in the radius of influence computations (NJDEP, 1985). T is equivalent to (K)(b) where b = saturated thickness of the aquifer, here assumed to be about 200 feet (open portion of borehole). K is, therefore, equal to T/b = 9,000/200 = 45 gpd/ft^2.

Conservative values of R_o were estimated using maximum possible drawdown (drawdown to bottom of well). Well No. 9 is 275 feet deep and well No. 11 is 250 feet deep (Table A-2). Assuming a beginning water level of 20 feet below the surface, the maximum drawdown ($H-H_w$) for Well Nos. 9 and 11 are 255 feet and 235 feet, respectively. Therefore, R_o = 3 (255 feet) [(0.47) (45 gpd/ft)]$^{1/2}$ = 3,518 feet for Well No. 9, and 3 (235 feet) [(0.47) (45 gpd/ft)]$^{1/2}$ = 3,242 feet for No. 11. Therefore, based on prudent assumptions, the site is within the radius of influence of both these wells and the potential exists for ground water migration from the site to these wells.

Although ground water at the site can potentially be drawn into the two pumping wells, concentrations of compounds will be considerably lower in the well than in the site. Flow from the site will constitute only a small portion of the total discharge into the well because well discharge includes radial flow toward the well from all directions. An estimate of the concentration in the well discharge can be made using a simplified flow net analysis as follows.

As in the shallow ground water flow analysis, the contaminated portion of the site is assumed to be saturated thickness of the fill (six feet). Dilution and mixing of contaminated water at the site with water in a vertical column is assumed to be equal to the saturated thickness surrounding the well (distance from water table to bottom of well). The saturated thickness for well No. 9 will be assumed to be 271 feet (Table A-1). The dilution from mixing of the six feet of saturated fill zone in the vertical direction can be estimated at 271 feet per 6 feet = 45.2. There will also be dilution through mixing with water being drawn into the well from all directions. Because the horizontal angle subtended by the site from the well is about 15 degrees, the dilution from mixing in the horizontal-radial direction is 360 degrees/15 degrees = 24 for a total dilution of (45.2) (24) = 1,085. Similarly, for well No. 11, where the angle subtended is about 13 degrees, and the saturated thickness surrounding the well is about 246 feet, the dilution factor is (246 feet/6 feet) (360 degrees/13 degrees) = 1,135. The more conservative value (1,085 for Well No. 9) will be used in further analysis.

These dilution factors are also conservative in that they do not consider attenuation of compounds through biological and physical-chemical reactions with the soil or attenuation through dispersion. These factors should reduce concentrations during transport of contaminants from the on-site area to the surrounding environment. Furthermore, this analysis does not consider the effects of the subsurface stratigraphy. Discontinuous layers of silt and other low permeability layers within the glaciofluvial sands would be obstacles to the downward migration of compounds from the near-surface soils and their eventual migration to the primary potential ground water receptor, industrial water users. The potential for chemicals reaching domestic wells outside the Newark area is very small since any chemicals would most likely be intercepted by the industrial wells found in the vicinity of the site.

The mean and maximum concentrations of the indicator chemicals found within the shallow on-site wells are shown in Table 3.3-4. The maximum concentration of chemicals found in on-site monitoring wells was used because it provides a very conservative starting point for evaluating worst case concentrations off site. The mean concentrations provide a less cautious, but more reasonable, basis for estimating off-site concentrations. Together they provide a range of concentration estimates extending from the very conservative to a more probable value.

A.2.4 Air Pathway

This section describes the calculation of exposure potentials via the primary air pathways of particulates from buildings and volatile emission releases. These pathways are indicated in the pathway model shown in Figures 3.3-1 and 3.3-2, and also in Table 3.3-1.

A.2.4.1 Particulates from Buildings

The primary indicator chemical of concern for particulate release is dioxin, because of its low solubility and preference for sorption onto particulates which may be eroded and subsequently transported by the wind.

The maintenance of geofabric ground covering has eliminated surface soil wind erosion. However, the potential for particulate emissions from the buildings and structures still exists.

A comprehensive study of particulate-associated dioxin emission and transport was not conducted at the site. However, thirty-one 24-hour air samples were collected over a continuous 31-day period. Of these, the ten samples with the highest total Fe plus Mn concentrations (with two sample points subsequently shifted to other days by NJDEP) were analyzed for dioxin. Two of the air samples analyzed had detectable levels of dioxin which indicate the potential for dioxin becoming airborne from buildings on the site. These results may have been caused by disturbances of the site during the concurrent site investigation activities. Based on limited information on site activities and the lack of off-site air quality data, it is difficult to trace the origin of the dioxin collected on the air samples.

The results of the air sampling performed on site indicated two samples of the ten analyzed had detectable levels. There is no information available regarding an emission source of dioxin on site. It is unlikely that the measured airborne dioxin concentrations are from fugitive emissions of dioxin-containing soil since the site has been covered with geofabric continuously since 1983, as well as during the sampling. The source of the airborne dioxin measured could be from the buildings and structures on the site, or could have been a result of some of the site investigation activities.

The sampler was located on the roof of the office/laboratory building. The measured dioxin concentration at the roof parapet was 168 ng/m^2. The exhaust for the laboratory fume hood was also located on the roof. A sample taken from inside the laboratory fume hood showed a measured value of 14,000 ng/m^2 dioxin. There was potential for an air updraft, created by opening and closing doors in the building during site activities, to deposit particulates from the fume hood into the air above the roof. Site activities on the days of measured dioxin in the air included wipe and chip sampling in the office building, drum sampling, sediment sampling, tank sampling, tank cleaning, and work on the dike. Investigations are continuing to further evaluate the significance of these data.

A.2.4.2 Vapor Release

Surface soils on the site have the potential for releasing contaminants in the form of vapors even in the presence of geofabric covering the site. An evaluation was performed of the potential for volatilization of chemicals from the soil of the site. This evaluation was performed for benzene and chloroform which are the more volatile of the indicator chemicals.

Volatilization or emission rates of volatile compounds (benzene and chloroform) from soils on site were estimated using a method presented by Shen (1980):

$$E_i = (D_i C_s A P_t)^{4/3} \left(\frac{1}{L} \cdot \frac{W_i}{W}\right)$$

where

E_i = emission rate (g/sec)
D_i = diffusion coefficient of component i (cm^2/sec)
A = exposed area (cm^2)
C_s = saturation vapor concentration of component i (g/cm^3)
P_t = soil porosity (dimensionless)
L = effective depth of soil cover (cm); and
W_i/w = weight percent of toxic component i in the waste (g/g).

The above equation is derived from Fick's Law and was originally developed by Farmer (Shen, 1980) for predicting volatilization of HCB through a dry soil cover on a landfill. Farmer's equation was modified by Shen by addition of the term W_i/w to express the concentration of the toxic component i in the soil.

The saturation vapor concentration, C_s in g/l, is an important variable and can be calculated by the following equation:

$$C_s = PM/RT$$

where

P = vapor pressure of the chemical (mm Hg)
M = mole weight (g/mole)
R = molar gas constant (62.3 mm Hg l/°K-mole); and
T = absolute temperature (°K).

This method was used with soil surface area of 1.74 acres to estimate the emission rates of benzene and chloroform based on maximum and midpoint of the range of concentrations in the soil. The following were used in the analyses:

- Surface area = 1.74 acres
- Soil porosity = 35 percent.

The emissions estimated were 1.97×10^{-4} g/sec (max) and 9.8×10^{-5} g/sec (midrange) for benzene and 1.004×10^{-3} g/sec (max) and 5.0×10^{-4} g/sec (midrange) for chloroform. The emission rates were used to estimate both on- and off-site concentrations in the air.

The PTDIS atmospheric dispersion model (Turner et al., 1973) was used to estimate concentrations of benzene and chloroform in the site area. The following were used in the analysis.

- Point source dispersion with PTDIS Model
- Atmospheric stability D; and
- Downwind frequency of 35 percent.

The on-site concentrations were estimated to be 8.3×10^{-5} g/m^3 (max) and 4.2×10^{-5} g/m^3 (midrange) for benzene, and 4.2×10^{-6} g/m^3 (max) and 2.1×10^{-6} g/m^3 (midrange) for chloroform.

Off-site concentrations associated with benzene and chloroform emissions were estimated with the PTDIS Model. The following were used in these estimations:

- Point source dispersion with PTDIS
- Atmospheric stability D; and
- Downwind frequency of 35 percent.

The concentrations at around 200 meters from the site were estimated to be 3.3×10^{-8} g/m^3 (max) and 1.6×10^{-8} g/m^3 (midrange) for benzene, and 1.7×10^{-7} g/m^3 (max) and 8.4×10^{-8} g/m^3 (midrange) for chloroform.

Exposure determinations for vapor releases were also made for a number of secondary pathways, including surface water, ground water, and the Passaic River for surface water. The first potential secondary air exposure pathway to be considered is via surface water. An analysis of the surface water is discussed in Section 3.3.2. Based on that analysis precipitation would not exceed infiltration; thus, precipitation from the average storm would seep into the ground and would enter the unsaturated zone, resulting in no surface runoff leaving the site. Under these circumstances chemicals may be washed off buildings and structures on site, but not be carried off site. Some ponding of water would occur in some of the impervious areas, and could contain chemicals of concern. This, however, would not be expected to result in significant emissions of chemicals to the air. Under average conditions, there will be no significant runoff from the site, and potential exposure via the air route associated with surface water runoff will be minimal. The concentrations that could result in the river due to runoff would be extremely low, and the potential for exposure is expected to be minimal.

Another potential secondary air exposure route is from ground water. This route considers chemicals migrating to off-site ground water wells that are used for various industrial or other purposes. In general, the exposures of concern (for the air route) would be vaporization of volatiles, which could occur depending on the chemical levels in the water and type of usage. Some activities that allow greater contact of the water with the air, would be expected to afford greater potential for volatilization and consequently exposure. A review of the estimated concentration levels of the indicator chemicals (Table 3.3-4) in off-site wells indicates low levels in the low ppb range for the more volatile indicator chemicals of benzene and chloroform. These low concentration estimates would result in relatively low volatilization rates and extremely low concentrations in the air. This pathway is not considered significant for the air route except possibly under some extremely specific situation.

The third potential exposure route is transport of chemicals from the river to the air. This is a secondary route which involves compounds migrating to the river and then potentially entering the air. The mechanisms of movement to the air would be due to volatilization from the water surface or fugitive dust from deposits of material on shorelines. A review of the estimated concentrations of the indicator chemicals in the river (Table 3.3-3) indicates extremely low concentrations of these substances in the river water. Benzene and chloroform would be of greatest concern of the indicator chemicals due to their higher vapor pressures. However, these concentrations are quite low (3×10^{-2} ppb to 9.6×10^{-4} ppb) and also would be subject to additional mixing and dilution due to movement of river waters. These low concentrations in the water would result in very low rates of emission to the air, and after atmospheric dispersion would result in extremely low concentrations in the air. Deposition of contaminants along the river shoreline would also result in negligible impacts on air quality concentrations. Many of the indicator chemicals would be expected to be suspended in the water column or settle out in sediments before becoming available for deposition along the shorelines. Any chemicals deposited along the shoreline would be subject to the variable conditions of wind erosion and dispersion.

A.3.0 CALCULATIONS USED IN HEALTH RISK ESTIMATES

A.3.1 Ground Water Recommended Exposure Criteria

The assumptions listed in Section 3.4 were used to calculate the recommended exposure criteria for the ground water off-site pathway. These assumptions are based on the occupational scenario. The occupational lifetime exposure was assigned a value of 38.5 years, as defined by U.S. OSHA. Assuming an individual works 240 days per year, the exposure duration is 9,240 days per lifetime. The ingestion rate of one liter per day is based on the guidance of two liters total drinking water consumed per day as defined by U.S. EPA. It is assumed that half the daily total of water is consumed at work.

A sample calculation follows along with appropriate data for the other chemicals of concern. The allowable daily intake was first calculated using the cancer potency slope (U.S. EPA, 1984). The cancer potency slope for DDT is $q = 8.42\ (\mathrm{mg/kg/day})^{-1}$. The daily dose was calculated by the formula:

$$\text{Approximate Risk} = qD$$

where D = daily dose.

For DDT at 10^{-5} risk:

$$D = \frac{10^{-5}}{8.42}\ (\mathrm{mg/kg/day})^{-1}$$

or 83 μg/day for a 70 Kg person.

This daily dose represents the allowable dose for a residential exposure. To correct this value to an occupational exposure, the daily dose is multiplied by 2.77, which adjusts for the difference represented by a 70-year lifetime and a 38.5 year, 240-day per year occupational lifetime.

For DDT, the industrial exposure = 8.3×10^{-2} μg/day x 2.77 = 0.23 μg/day.

For an industrial well consumption of one liter per day, this is equivalent to 0.23 μg/L. The cancer potency slopes and calculated 10^{-5} risk exposure concentrations are presented in Table A-3.

A.3.2 Excess Cancer Risk Estimates for Ground Water

Excess cancer risk estimates for indicator chemicals in ground water (Table 3.3-4) were calculated using the following formula:

$$\text{Excess Cancer Risk} = \frac{\text{Estimated Concentration at Receptor}}{\text{Acceptable Exposure Criteria}} \times \text{Acceptable Risk Level}$$

Estimated concentrations for the nearest well, both mean and maximum, were taken from Table 3.3-4. Acceptable exposure criteria for the indicator chemicals detected in ground water are presented in Table 3.4-1.

Using DDT as an example, the following analysis is used to calculate the excess cancer risk from DDT in ground water.

Estimated concentrations in nearest well (from Table 3.3-4) = 1.49 μg/L (mean), 20.3 μg/L (maximum).

Acceptable exposure criteria of DDT in ground water = 0.23 μλ/L (Table 3.4-1).

Assuming an acceptable risk level of 10^{-5}:

$$\text{Excess Cancer Risk}_{\text{low}} = \frac{1.49}{0.23}\,(10^{-5}) = 6.5 \times 10^{-5}$$

$$\text{Excess Cancer Risk}_{\text{high}} = \frac{20.3}{0.23}\,(10^{-5}) = 8.8 \times 10^{-4}$$

A.3.3 Air Recommended Exposure Criteria

Exposure criteria were derived for both on-site (occupational) and off-site (residential) exposure. Occupational exposure parameters were derived the same way as those for ground water ingestion in Section A.3.1. For residential exposure, different parameter values were used. Assuming a lifetime duration of 70 years, and continual exposure over the course of the year (i.e., 365 days), the exposure duration is calculated to be 25,550 days. The absorption fraction parameter for vapor was assigned a value of 1.0, which means that the total mass of contaminants inhaled (or 100 percent) is retained in the lungs and absorbed into the body. The inhalation rate of 23 m^3/day from Schaum (1984) reflects normal household activities.

A.3.4 Excess Cancer Risk Estimates for Air

Excess cancer risk estimates for indicator chemicals in air were calculated in the same manner as those for ground water in Section A.3.2. Estimates for the two indicator chemicals for air (inhalation) exposure, benzene, and chloroform, are presented in Table 3.4-4.

APPENDIX A

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TABLES

TABLE A-1

SUMMARY OF SHALLOW MONITORING WELL DATA

WELL NUMBER	DEPTH TO STATIC WATER LEVEL(a) (ft)	GROUND SURFACE ELEVATION(b) (ft)	DEPTH TO TOP OF SCREEN(c) (ft)	DEPTH TO BOTTOM OF SCREEN(c) (ft)	ESTIMATED SATURATED THICKNESS OPPOSITE WELL SCREEN (ft)	DEPTH INTERVAL OF SATURATED FILL (ft)
MW-1	6.6	98.7	3.5	14.2	7.9	6.6 to 14.5
MW-2	4.6	98.9	3.5	15.2	10.6	4.6 to 15.2
MW-3	4.7	97.3	3.0	8.5	3.8	4.7 to 8.5
MW-4	0.7	97.6	2.0	7.0	6.0	0.7 to 6.7
MW-5	4.2	98.9	3.0	8.5	3.8	4.2 to 8.0
MW-6	4.1	98.9	1.9	7.9	3.7	4.1 to 7.8
MW-7	1.6	98.4	2.0	8.2	6.6	1.6 to 8.2
MW-8	0.4	99.7	2.0	7.0	6.1	0.4 to 7.0

(a)Depths to static water level from ground surface at the time of slug tests (obtained from field log notebook).

(b)Elevations are with respect to site datum.

(c)Depths are with respect to ground surface.

TABLE A-2

BEDROCK WATER SUPPLY WELLS WITHIN ONE MILE OF 80 LISTER AVENUE(a)

REFERENCE NUMBER	REPORTED ADDRESS	OWNER	YEAR DRILLED	TOTAL DEPTH BELOW SURFACE ELEVATION (ft)	DEPTH OF CASING (ft)	YIELD (gpm)	STATIC WATER DEPTH AT TIME DRILLING (ft)	IN USE AS OF MAY 1985(a)	REMARKS
1	185 Foundry St. Newark	Arkansas Co.	1965	400	73	65	20	?Y	
2	84 Foundry St. Newark	Pffuffy Kendall	1965	200	30	100	30	?Y	Somerville Well Drilling Co.
3	Foot of Brill St. Newark	Standard Bithulitic Co.	1964	406	90	360	103	?N	Wm. Stothoff Co.
4	325 Raymond Blvd. Newark	Hildeman Indus.	1981	400	95	38	20	Y	Somerville Well Drilling Co.
5	45 Manufacturer Newark	Ronson Metals	1965 1973 1981	300 300 165	80 88 90	220 150 150	56 35 30	?Y	NJDEP Division Permit No. 2015-P max. rate total-.350 gpm
6	1215 Harrison Ave. Kearny	Theobald Industries	1973	584	110	350	50	?Y	Wm. Stothoff Co.
7	196 Blanchard St. Newark	International Metallurgical	1980	300	86	150	5	?Y	Somerville Well Drilling Use
8	12 Lister Ave. Newark	ACME Refinery	1960	500	144	150	91	N	Garden State Well and Pump Co.

TABLE A-2
(Continued)

REFERENCE NUMBER	REPORTED ADDRESS	OWNER	YEAR DRILLED	TOTAL DEPTH BELOW SURFACE ELEVATION (ft)	DEPTH OF CASING (ft)	YIELD (gpm)	STATIC WATER DEPTH AT TIME DRILLING (ft)	IN USE AS OF MAY 1985(a)	REMARKS
9	140 Chapel St. Newark	Stanley Tool	-	275	150	0	0	Y	NJDEP Physical Connection Permit
10	290 Ferry St. Newark	Courtaulds CPD Inc.	-	-	-	-	-	Y	NJDEP Physical Connection Permit
11	117 Blanchard St. Newark	Fairmount Chem.	1968	250	74	200	70	Y	NJDEP Physical Connection Permit
12	70 Blanchard St. Newark	Newark Parrafin Co.	1968	603	70	100	26	N	
13	Freeman St. Newark	P. Ballentine & Sons	Various 1937	Various 875	-	Various 375	-	N	Major user in are before early 1970
14	80 Lister Ave. Newark	Kolker Chemical Works	1949 1951	359 802	-	300 600	-	N	Well deepened-on-site well
15	574 E. Ferry St. Newark	Technical Plastic Extruders, Inc.	1981	300	98	422	22	N	Sealed 3/27/81
16	17 Blanchard St. Newark	Newark Box Board Co.	1981	400	90	105	21	N	Sealed 1/10/83
17	722 Cross St. Newark	Reynolds Metal Co.	1941	467	95	350	60	N	C.W. Lauman & Co.
18	171 Blanchard St. Newark	Eureka Construction Co.	1959	50	90	75	25	N	Rinbrand Well Drilling Co.
19	4th & Passaic Ave. Newark	PSE&G	1932	804	207	406	37	N	A. V. Connolly

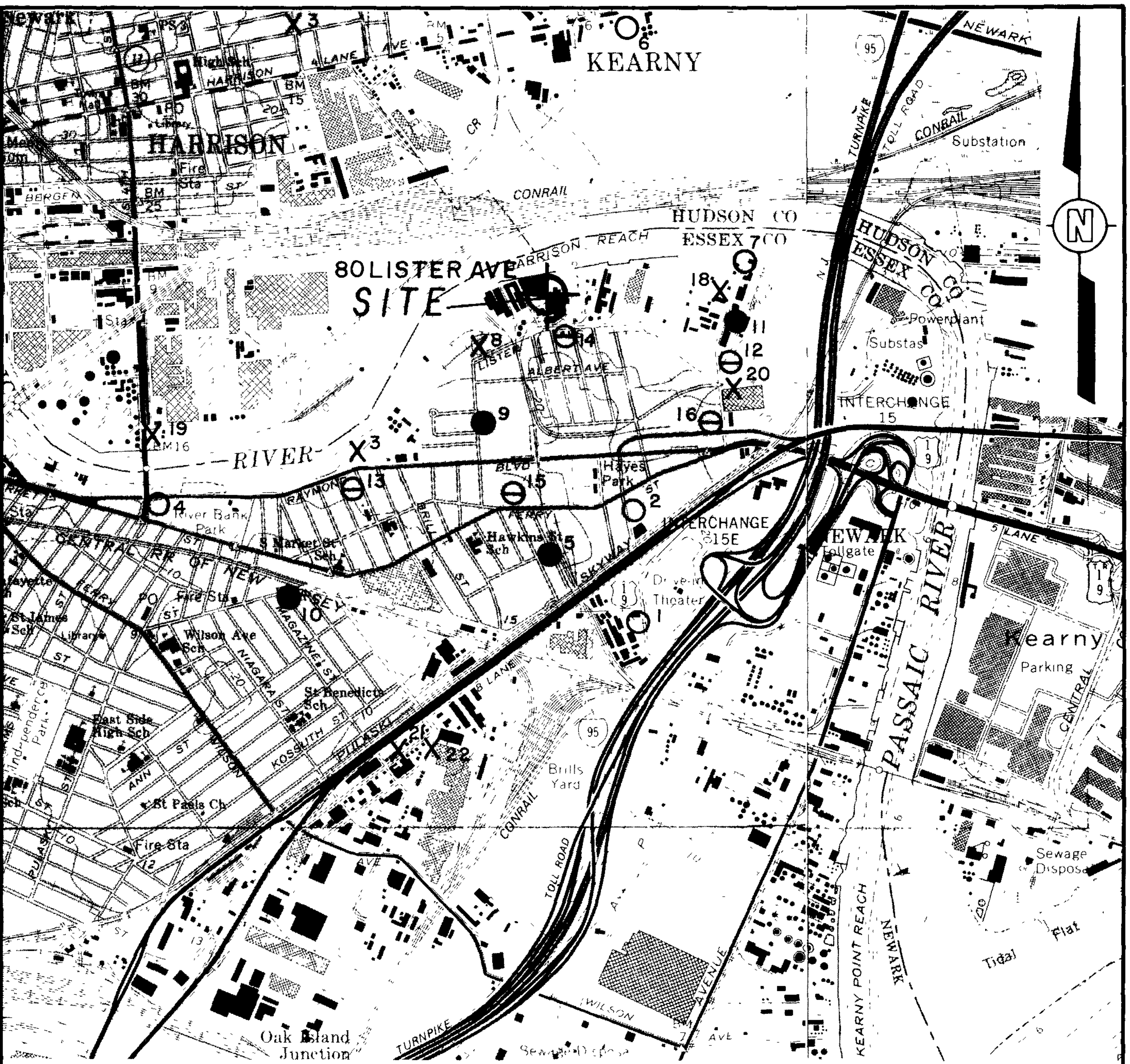
TABLE A-2
(Continued)

REFERENCE NUMBER	REPORTED ADDRESS	OWNER	YEAR DRILLED	TOTAL DEPTH BELOW SURFACE ELEVATION (ft)	DEPTH OF CASING (ft)	YIELD (gpm)	STATIC WATER DEPTH AT TIME DRILLING (ft)	IN USE AS OF MAY 1985(a)	REMARKS
20	60 Blanchard St. Newark	Ardin Chemical	1952	400	70	100	26	N	Garden State Artesian Well
21	50 Paris St. Newark	Federal Pacific Electric	1955	500	120	250	95	N	Garden State Well & Pump Co.
22	18 Avenue L Newark	John Egelhon & Sons	1952	500	122	450	-	?N	A. J. Connolly, Inc.
23	Near intersection of Raymond Blvd. and Richard St.	U.S. Geological Survey; BalCo	1949	875	95	-	-	-	Monitoring Well
24	Adjacent to 80 Lister Ave.	Diamond Shamrock	1985	-	-	-	10	-	Monitoring Well
25	354 Doremus Ave. Newark	Celanese Chemical Co.	1981	700	650	100	20	Y	Use-domestic Somerville Well Drill Co.
26	Lincoln Hwy. and Hackensack Ave. Newark	Coca-Cola Co.	1981	650	100	20	25	Y	Use-domestic Somerville Well Drilling Co.
27	37-34 Backus St. Newark	Northern Feather	1980	300	102	120	25	Y	NJDEP Physical Connection Permit
28	411 Wilson St. Newark	Scientific Chemical Co.	1980	170	51	70	12	Y	Ernest R. Richardson Driller

(a)Locations shown in Figure A-1.

FIGURES

DRAWN BY RW/mel 8-26-85 | CHECKED BY JAD 9-17-85 | APPROVED BY DT 10-3-85 | DRAWING NUMBER 850032-A10



LEGEND:

○ WELLS INSTALLED SINCE 1965 FOR WHICH PERMITS TO DRILL EXIST. NO SUBSEQUENT INFORMATION ON USE IS AVAILABLE. THE PROBABILITY IS HIGH THAT THE WELL IS BEING USED.

● WELLS IN USE TODAY WITH EITHER DIVERSION OR PHYSICAL CONNECTION NJDEP PERMITS.

⊖ WELLS WHICH ARE KNOWN TO HAVE BEEN SEALED OR OTHERWISE NOT IN USE.

X WELLS INSTALLED BEFORE 1965 FOR WHICH PERMITS TO DRILL EXIST BUT FOR WHICH NO SUBSEQUENT INFORMATION ON USE IS AVAILABLE. THE PROBABILITY IS LOW THAT THE WELL IS BEING USED.

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7.5 MINUTE USGS TOPOGRAPHIC QUADRANGLE MAPS OF: ELIZABETH AND JERSEY CITY, N.J.-N.Y., DATED: 1967, PHOTOREVISED: 1981, SCALE: 1" = 2000'.

SCALE

0 2000 4000 FEET

FIGURE A-1

WATER SUPPLY WELLS WITHIN ONE MILE OF 80 LISTER AVE. SITE

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APPENDIX B

HYDROGEOLOGIC ASSESSMENT OF THE ALTERNATIVES

APPENDIX B

HYDROGEOLOGIC ASSESSMENT OF THE ALTERNATIVES

B.1.0 INTRODUCTION

The purpose of this section of the feasibility study is to evaluate how the components of the various alternatives will reduce the ground water migration of chemical constituents, especially dioxin and DDT.

The present hydrologic and geologic conditions occurring at the site will be summarized as they pertain to material transport. A brief summary of the geochemistry of dioxin and DDT, the compounds that are presumed to pose potential elevated risks at off-site wells, will be presented. Finally, the major components of various alternatives (slurry wall, capping, pumping, and excavation) will be evaluated for their ability to prevent or diminish future adverse impacts to the underlying sand unit.

B.2.0 PRESENT CONDITIONS

The site was constructed on fill material composed of a fairly homogeneous mixture of loose to medium dense dark sands and gravels. The mixture also contains bricks, wood fragments, glass, porcelain, ashes, and cinders. The fill ranges in thickness from 8 to over 15 feet with an average thickness of approximately 10 feet. The average saturated thickness of the fill is 6 feet and ranges from about 2 to 8 feet.

Ground water in the fill flows to the north and south from a high located near the center of the site (Figure 2.1-15). The average hydraulic conductivity in the fill is 25 feet per day (8.8×10^{-3} centimeter per second). Computed ground water velocities range from 6 to 4 feet per day from the center of the site north toward the Passaic River. Computed velocities from the center of the site toward the south range from 0.5 to 1.3 feet per day (Section 2.1.6).

Underlying the fill is a continuous organic rich silt layer which ranges in thickness from 2 to 15.5 feet. It is significantly less permeable than the fill material. Based upon comparison with values for similar materials in the literature (Freeze and Cherry, 1979), an intermediate value of 0.003 foot per day (1.0 x 10^{-6} centimeter per second) was chosen as a reasonable value for the average vertical conductivity of the silt. The average vertical gradient was determined to be approximately 0.59. The computed ground water velocity from the fill through the silt is 2 x 10^{-3} foot per day (Section 2.1.6).

Beneath the silt layer are approximately 80 feet of sands and discontinuous layers of silt and clay. The sand aquifer is under confined conditions. Piezometric levels from the monitoring wells indicate the head is approximately five feet less than in the fill. The flow of ground water in the glaciofluvial sand is generally in a southerly direction with an average gradient of 0.002 in the upper portion of the aquifer. Because of the nonhomogeneity of the sand unit, it is expected that hydraulic conductivities will vary. For average conductivities in the range of 0.1 to 0.6 foot per day, the corresponding ground water velocities range from 0.002 to 0.0012 foot per day.

The risk assessment (Section 3.0) has projected the potential for an elevated risk at the closest off-site well at some point in the future. The projection is based upon seepage through the silt layer of affected ground water from the fill. This water mixes with, and is diluted by, ground water in the sand unit. Present concentrations of dioxin in ground water from the fill range from nondetectable to 10.4 ppb. DDT concentrations vary from nondetectable to 22,000 ppb. Recent analysis of three ground water samples from the sand unit shows dioxin concentrations ranging from nondetectable to 0.0043 ppb (Table 2.2-5). DDT was detected at 17 ppb in Monitoring Well MW-10B. This compound was later nondetectable at the same well and at three other monitoring wells sampling the sand aquifer (Table 2.2-6).

B.3.0 GEOCHEMISTRY OF DDT AND DIOXIN

The analytical protocols for organic priority pollutants and dioxin specify the analysis of a total sample with its associated particulate matter. It is, therefore, reasonable to assume that the detected concentrations of DDT and dioxin in the ground water which far exceed their aqueous solubilities of 3 and 0.2 ppb, respectively, may be attributable to compounds sorbed on mineral and organic particulates.

The ratio of relative rate of migration of ground water to the velocity of the chemical constituents is represented by the retardation factor (R_f). The retardation factor is equal to one when both ground water and chemical constituents such as chloride travel with the same velocity. As the retardation factor increases, the rate of migration of chemical constituents decreases. The retardation factor for organic material is a function of octanol-water partition coefficient (K_{ow}) and the fraction of organic carbon present in the media, porous media porosity, and the bulk density. The following equation defines the retardation factor (Freeze and Cherry, 1979).

$$R_f = 1 + \frac{\rho}{n} K_d$$

where

R_f = retardation factor,
ρ = bulk density of porous media,
n = porosity, and
K_d = distribution coefficient.

The relationship between K_d and K_{ow} is as follows (Karickhoff, et al., 1979):

$$K_d = K_{oc} \times \text{fraction of organic carbon}$$

where

K_{oc} = organic carbon partition coefficient.

From the relationship:

$$\log K_{oc} = 1.00 \log K_{ow} - 0.21 \text{ (Karickhoff, et al., 1979)}$$

the organic carbon partition coefficient (K_{oc}) may be calculated.

The sorption of DDT from aqueous solutions by soil particulate matter has been well established over the years (Peterson, et al., 1971; Shin, et al., 1970; Weidhaas, et al., 1961; Wiese, 1964). Because of its low solubility in water

(3 ppb) and high octanol-water partition coefficient (log K_{ow} = 6.19), the compound is relatively immobile in soil systems containing expanding-type clay minerals (Swoboda, et al., 1971) and humic material. Guenzi and Beard (1967) stated that due to its low solubility, DDT might precipitate out on the adsorbent surfaces as crystals or be complexed with lipid portions of soil organic matter.

Many studies addressing the mobility of dioxins have found that dioxins are tightly bound to soils containing a high organic content. Kearney, et al. (1973), observed that the mobility of dioxin decreased with increasing organic content of soil. Similar conclusions were reached by Matsumura and Benezet (1973) who showed that the mobility of dioxin is much slower than that of DDT. This may be due to its lower water solubility (0.2 ppb) and higher octanol-water partition coefficient (log K_{ow} = 7.14). Ward and Matsumura (1976) observed that the concentrations of dioxin in waters separated from a contaminated lake bottom sediment exceeded its water solubility (0.2 ppb). The report suggests this may be due to the binding or adsorption of dioxin onto organic matter or suspended sediment particles.

Jackson, et al. (1985), examined the leaching potential of dioxin-contaminated soils from various sites, including fill samples from 80 Lister Avenue. Soil partition coefficients were large (the mean log K_d for two samples was 5.9 and 6.02), indicating that dioxin is only very slightly soluble and that only very small amounts of dioxin will be released into water. The effects of cocontaminants, i.e., semivolatile halogenated hydrocarbons, were also studied. The authors concluded that, although dioxin dissolution appears to be regulated by these cocontaminants, the rates of dioxin movement in these soils are so slow that other transport mechanisms such as wind and water erosion are likely to be more significant.

Retardation factors can be estimated for DDT and dioxin based upon the octanol-water coefficient (K_{ow}) of the two compounds. The log K_{ow} for DDT is 6.19 and the log K_{ow} for dioxin is 7.14 (Table 3.2-2).

Assuming that all adsorption of these compounds will occur on the organic matter in the aquifer, the distribution coefficient (K_d) for dioxin and DDT is calculated. The organic carbon content of glacially derived sediments varies approximately from 1 to 3 percent. Using a conservative estimate of 1 percent organic carbon, the K_ds (log K_d) for dioxin and DDT are calculated to be 85,000 (4.9) and 9,500 (4.0), respectively.

Calculation of the retardation factor requires a knowledge of certain aquifer parameters. They are porosity and bulk density. Using an average porosity of 0.4 and a bulk density of 1.6 grams per cubic centimeter (Freeze and Cherry, 1979), the retardation factor may be calculated from the above equation as follows:

$$R_f = 1 + \frac{1.6}{0.4} K_d$$

The calculated retardation factor for dioxin and DDT is thus 340,000 and 38,000, respectively. These are very high retardation factors and indicate that the compounds will be adsorbed by the media and be essentially immobile in the sand aquifer. In addition, the organic silty clay unit and meadowmat, which contain high organic carbon content, will significantly retard the migration of the dioxin and DDT.

It should be noted that the retardation factor for dioxin in the fill unit, calculated from a measured log K_d of 5.9 and bulk density of 1.27 grams per cubic centimeter (Jackson, et al., 1985), is 2,522,000. The fill contains solvents that are thought to increase the solubility of dioxin. In this environment, it still has been shown that dioxin will be immobile.

B.4.0 NO-ACTION ALTERNATIVE

The no-action alternative consists of the transfer of shipping containers of dioxin-containing material to 80 Lister Avenue from the adjacent 120 Lister Avenue. Maintenance of the secured condition of the site, air monitoring, and ground water monitoring will continue.

The present seepage rate of ground water from the fill to the glaciofluvial sand unit has been estimated to be a maximum of 262 cubic feet per day over the 3.4 acres of the site (Section 2.0):

$$Q = KiA$$

where

K = 0.003 foot per day,
i = 0.59, and
A = 148,104 square feet.

A dilution factor of 1,085 was calculated in Appendix A for Receptor Well No. 9. Using average concentrations of 1.57 µg/ℓ for dioxin and 1,620 µg/ℓ for DDT in the fill ground water, the concentrations of dioxin and DDT in the receptor well could reach 1.4×10^{-3} and 1.49 µg/ℓ, respectively. (Acceptable concentration levels for dioxin and DDT are 5×10^{-5} µg/ℓ and 0.23 µg/ℓ.) These numbers assume no geochemical retardation; that is, the sand and silt units are geochemically isotropic and the compounds are nonreactive during migration from the fill to the receptor well. This is an extremely conservative assumption. As previously indicated, the distribution coefficient of dioxin is very high and the solubility is 0.2 ppb. This implies that 100 pounds of dioxin could be adsorbed by approximately 2 million cubic feet of soil containing 1 percent organic carbon. Additionally, the organic carbon content of the silt layer is probably higher than 1 percent and its ability to adsorb dioxin will be greater. Therefore, dioxin will not migrate significantly in the sand unit.

The current discharge to the Passaic River from the site has been estimated to be 1,036 cubic feet per day. A dilution factor, based upon the estimated mean annual flow of the river, was calculated to be 6.1×10^{6}. Average concentrations of dioxin and DDT in the three monitoring wells adjacent to the river bulkhead were used for the mass loading calculation. The results indicate estimated river concentrations of 1.0×10^{-6} µg/ℓ for dioxin and 0.03 µg/ℓ for DDT.

B.5.0 SLURRY WALL AND CAPPING

A slurry wall will be constructed to contain the entire site and will be keyed into the silt layer. The hydraulic conductivity of the composite soil-bentonite wall is 0.00028 foot per day (1×10^{-7} centimeter per second).

A sealed cap and a sand flow zone underlain by a liner will cover the entire site. The hydraulic conductivity of the cap is 0.00028 foot per day.

If it is assumed that infiltration through the concrete portion of the cap is continuous over the entire area, the maximum seepage rate is 41.5 cubic feet per day.

$$Q = KiA$$

where

$K = 2.8 \times 10^{-4}$ feet per day = hydraulic conductivity of the cap,

$i = 1$ foot per feet = conservative estimate of gradient across cap, and

$A = 148{,}104$ square feet = estimate of cap area.

However, the presence of the flow zone and liner will significantly reduce this flow. A conservative estimate for actual seepage to the fill is 4.1 cubic feet per day. Seepage to the river will be reduced to approximately 0.6 cubic foot per day, assuming that the head difference between the fill and river is 6 feet.

$$Q = KiA$$

where

$K = 2.8 \times 10^{-4}$ cubic feet per day = hydraulic conductivity of the slurry wall,

$i = 1$ foot per foot = conservative estimate of gradient across wall, and

$A = 2{,}100$ square feet = estimate of area of slurry wall at river.

Because the hydraulic conductivity of the silt is greater than that of the cap or slurry wall, the rate of seepage to the sand unit exceeds the total flow of water into the enclosed volume. Assuming a gradient of one across the area of the slurry wall (7,050 square feet), the maximum seepage will be approximately two cubic feet per day. In addition, as the water level within the enclosed volume declines, it is expected that inflow to the containment area through the silt beneath the slurry wall will increase in proportion to the increasing head difference on either side of the slurry wall.

If it is assumed that this inflow is negligible, the steady-state seepage rate is estimated to be approximately 6 cubic feet per day. The time required to attain this rate is in excess of 70 years and approximately 890,000 cubic feet of water will have seeped into the sand aquifer. Assuming that the concentration of dioxin and DDT will be equal to their average concentrations in the fill ground water and no retardation occurs, the mass loading of these compounds into the aquifer will be 39.5 and 40,820 grams, respectively, over a 70-year period. The high retardation factors of dioxin and DDT will significantly reduce the rates of migration of these compounds. Most of them will be adsorbed by the organic silty clay unit.

When steady state is achieved, the yearly mass loading of dioxin and DDT will be 1.7×10^{-3} and 100 grams per year, respectively. Again, this assumes that the concentrations in the fill ground water will remain at their present average values and no attenuation occurs.

If the barriers are not constructed, the volume of water seeping into the sand aquifer over 70 years will be approximately 67 million cubic feet with a mass loading of dioxin and DDT (assuming no retardation) of 2,980 and 3,000,000 grams, respectively. This assumes the seepage rate will remain at its present calculated rate of 262 cubic feet per day and the concentrations of dioxin and DDT in the fill ground water remain at present-day levels.

B.6.0 SLURRY WALL - CAPPING - GROUND WATER PUMPING

A slurry wall and cap will be constructed having the same properties as those described in the previous subsection. In addition, a well point system consisting of four to six well points extending to the bottom of the fill will be installed beneath the cap at appropriate locations. Water pumped from the enclosed volume will be treated with a small, permanent, on-site, activated carbon filtration unit. The treated water will be discharged either to the Passaic River or a POTW.

The benefits of this system are twofold. First, the seepage rate of water containing dioxin into the sand unit will quickly decline. If the pumping rate is 3,850 cubic feet per day (20 gpm), the time required to essentially eliminate seepage to the sand unit will be approximately eight months. The average saturated fill thickness is six feet and the average head difference between the sand and fill aquifers is five feet. When the water level in the fill declines more than five feet, flow reversal will occur. The second benefit, upward seepage from the sand unit, will begin and future effects on the sand aquifer will be virtually eliminated.

The estimated seepage rates into the contained volume will be:

- Sand - Upward flow of 49 cubic feet per day
- Cap - 4.1 cubic feet per day
- Slurry wall - 2 cubic feet per day.

The total seepage into the volume will be about 55.1 cubic feet per day (0.3 gpm).

In order to maintain the reversed flow, the well points will have water level switches to automatically initiate pumping when the water level exceeds a predetermined height. Therefore, continuous pumping will not be necessary.

As was previously stated, future effects on the sand aquifer will be virtually eliminated. In addition, partial remediation of the silt and fill units will result. The maximum concentration of dissolved dioxin and DDT in waters seeping upward through the silt will be limited by their solubility. Furthermore, solvents and particulate matter containing sorbed compounds will also be extracted from the fill and silt units.

B.7.0 EXCAVATION AND TREATMENT OF FILL

Excavation of fill material to the 7 ppb level will require virtually complete excavation of the site. In addition, all buildings and sewers will have to be demolished. All demolition and excavation material except structural steel will be treated and returned as fill. Excavation will require construction of a slurry wall, dewatering of the site, pressure relief wells in the sand unit to prevent heaving of the silt unit, and treatment of the water before discharge into the Passaic River or a POTW.

Although ground water will be removed and all fill, wastes, and structures decontaminated, adverse effects on the sand unit may still occur. The silt unit contains dioxin at levels ranging from nondetectable to 11.8 micrograms per kilogram (μg/kg). If an average concentration of 6.15 μg/kg is assumed for the silt layer, the total mass of dioxin remaining in the silt is 409 grams.

Upon completion of the site remediation, the cleaned fill unit will again become saturated and seepage of fill ground waters will begin. At some time in the future, the seepage rate may be assumed to reach approximately 6 cubic feet per day. Dioxin, and if it is present DDT, will again seep into the sand aquifer. Assuming the solubility of dioxin is 0.2 μg/ℓ and the rate of seepage is 6.1 cubic feet per day, the daily mass loading will be 3.4×10^{-5} gram per day.

Excavation of fill material will reduce overburden pressure on the silty clay unit. Since the sand unit has an artesian head and portions of the site are adjacent to the river, proper precautionary measures should be taken to prevent upheaving of the low-permeability silty clay unit. Otherwise, the integrity of the unit might be affected and downward migration of the chemical constituents might increase. This might require dewatering of the sand unit below to decrease the head to the top of the silty clay unit by installing several wells and continuing the slurry wall to bedrock adjacent to the river. The final design should consider both the location of pumping wells and possible treatment of the water.

B.8.0 SUMMARY

The hydrogeologic analyses of various components of the alternatives are summarized as follows:

- No-Action Alternative - Continued potential long-term unacceptable effects to the sand unit will result. Concentrations of dioxin and DDT might exceed acceptable concentration levels in this unit.

- Slurry Wall-Cap - Decreasing impact of the sand unit will result. Concentrations of dioxin and DDT in the sand aquifer will be in the range of acceptable concentration levels.

- Slurry Wall-Cap-Pumping - Immediate reduction of chemical mass loading to sand unit. Long-term near elimination of seepage to aquifer. Partial remediation of silt and fill zones.
- Excavation of Fill - Immediate reduction of chemical mass loading to sand unit upon completion of excavation. Long-term increase in seepage to aquifer due to renewed infiltration of ground water through affected silt zone. If slurry wall and cap are installed, virtual elimination of seepage to the sand unit.

APPENDIX B

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APPENDIX
C

APPENDIX C

AVERAGE COST SUMMARY OF ALTERNATIVES

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AVERAGE COST SUMMARY OF ALTERNATIVES

This appendix itemizes in detail the average capital and operation and maintenance costs for each of the six remedial alternatives described in Section 7.0. A summary of these costs with a cost range and cost present value is provided in Table 8.4-1.

Many assumptions have been used to develop these initial alternative cost estimates. Final design parameters will be developed during the detailed engineering and design prior to implementation of the project.

In conformance with EPA Guidelines for Feasibility Studies, the cost estimates are expected to provide an accuracy of -30 to +50 percent. The estimated uncertainty in the cost estimates for the alternatives in this study is as follows:

ALTERNATIVE	PERCENTAGES USED FOR COST RANGE
1	-10, + 10
2	-20, + 20
3	-20, + 20
4	-10, + 25
5	-20, + 20
6	-10, + 30

The high uncertainty in Alternative 4 reflects the high costs which would be incurred should a major problem develop in the thermal treatment facility. The high uncertainty in Alternative 6 reflects the uncertainty associated with the estimated unit costs for the landfilling or thermal treatment of waste containing dioxin.

ALTERNATIVE 1

CAPITAL COSTS

ITEM	COST ($)
Security (Site Lighting)	20,000
Excavation, and Transportation of Contaminated Material (120 Lister Avenue)	363,000
Backfill Excavation	16,000
Repair Fencing	23,000
TOTAL	422,000

ANNUAL O&M COSTS

Security Guard	88,000
Utilities	4,000
Minor Maintenance	2,000
Inspections (Structural)	20,000
Monitoring (Analytical)	96,000
Administrative, General Engineering	5,000
Miscellaneous Expenses	22,000
TOTAL	237,000

APPENDIX C
(Continued)

ALTERNATIVE 2

CAPITAL COSTS

ITEM	COST ($)
Security	262,000
Bulkhead Replacement	460,000
Disassemble and Decontaminate Salvageable Vessels	693,000
Locate and Plug Underground Conduit	211,000
Building Demolition, Haul, Spread, and Compact	607,000
Transportation and Handling of Waste Containers	1,143,000
Slurry Wall Construction	350,000
Stabilization of 570 Drums of Process Waste	50,000
Construct Containment Cap	2,183,000
Additional Equipment Decontamination	29,000
Water Treatment	75,000
Additional Cost Items (mob-demob, per diem, lodging, trailer rental, site vehicles, supervisor, clerk, engineering, health and safety)	1,950,000
TOTAL	8,013,000

ANNUAL O&M COSTS

Utilities	4,000
Cap Maintenance	46,000
Monitoring	95,000
Administration, General Engineering	5,000
Additional Expenses	15,000
TOTAL	165,000

APPENDIX C
(Continued)

ALTERNATIVE 3

CAPITAL COSTS

ITEM	COST ($)
Security (Lighting, Guard, Fence)	262,000
Bulkhead Replacement	460,000
Disassemble and Decontaminate Salvageable Vessels	693,000
Locate and Plug Underground Conduit	211,000
Building Demolition, Haul, Spread, and Compact Waste Over Site	607,000
Transportation and Handling of Shipping Containers	1,143,000
Slurry Wall Construction	350,000
Stabilization of 570 Drums of Process Waste	50,000
Construct Containment Cap	2,183,000
Ground Water Pumping Network	66,000
Additional Equipment Decontamination	29,000
Water Treatment	75,000
Additional Cost Items (mob-demob, per diem, lodging, trailer rental, site vehicles, supervisor, clerk, engineering, health and safety)	1,957,000
TOTAL	8,086,000

ANNUAL O&M COSTS

Utilities	4,000
Cap Maintenance	46,000
Ground Water Treatment and Maintenance	61,000
Monitoring	120,000
Administration, General Engineering	6,000
Additional Expenses	24,000
TOTAL	261,000

APPENDIX C
(Continued)

ALTERNATIVE 4

CAPITAL COSTS

ITEM	COST ($)
Security (Lighting, Guard, Fence)	481,000
Bulkhead Replacement	460,000
Disassemble and Decontaminate Salvageable Vessels	693,000
Locate and Plug Underground Conduit	181,000
Building Demolition, Haul, Spread, and Compact Waste Over Site	588,000
Transportation and Handling of Shipping Containers	1,013,000
Handling and Transportation of All Waste to Thermal Treatment	1,320,000
Slurry Wall Construction	1,565,000
Excavation of Contaminated Soil to 7 ppb	600,000
Sand/Soil Dewatering and Water Treatment	648,000
Construct Containment Cap	2,183,000
Thermal Treatment	42,250,000
Sampling and Analyses	425,000
Spread and Compact Waste Over Site	138,000
Additional Equipment Decontamination and Water Treatment	54,000
Additional Cost Items (mob-demob, per diem, lodging, trailer rental, site vehicles, supervisor, clerk, engineering, health and safety)	7,497,000
TOTAL	60,096,000

ANNUAL O&M COSTS

Utilities	4,000
Cap Maintenance	46,000
Monitoring	47,000
Administration, General Engineering	5,000
Additional Expenses	10,000
TOTAL	112,000

APPENDIX C
(Continued)

ALTERNATIVE 5

CAPITAL COSTS

ITEM	COST ($)
Security	437,000
Bulkhead Replacement	460,000
Disassemble and Decontaminate Salvageable Vessels	693,000
Locate and Plug Underground Conduit	181,000
Building Demolition, Haul, Spread, and Compact Waste Over Site	588,000
Slurry Wall Construction	1,565,000
Excavation of Contaminated Soil to 7 ppb	600,000
Sand/Soil Dewatering and Water Treatment	648,000
Purchase Fill and Compact Clean Soil Into Excavation Site	1,250,000
Sampling and Analyses	425,000
Construct Vault	3,052,000
Construct Cap	1,997,000
Transportation and Placement of Waste Container Material	1,510,000
Stabilization of 570 Drums of Process Waste	54,000
Additional Equipment Decontamination and Water Treatment	30,000
Additional Cost Items (mob-demob, per diem, lodging, trailer rental, site vehicles, supervisor, clerk, engineering, health and safety)	3,389,000
TOTAL	16,879,000

ANNUAL O&M COSTS

Utilities	4,000
Cap Maintenance	46,000
Monitoring	50,000
Administration, General Engineering	5,000
Additional Expenses	11,000
TOTAL	116,000

APPENDIX C
(Continued)

ALTERNATIVE 6 (OFF-SITE LANDFILL)

CAPITAL COSTS

ITEM	COST ($)
Security (Lighting, Guard, Fence)	481,000
Bulkhead Replacement	460,000
Disassemble and Decontaminate Salvageable Vessels	693,000
Locate and Plug Underground Conduit	181,000
Building Demolition	588,000
Slurry Wall Construction	1,565,000
Excavation of Contaminated Soil to 7 ppb	600,000
Sand/Soil Dewatering and Water Treatment	648,000
Purchase, Fill, and Compact Clean Fill in the Excavated Pit ·	1,250,000
Sampling and Analyses	425,000
Load and Haul Waste to Off-Site Landfill and Unload Into Landfill	17,356,000
Landfill Disposal Charge	20,475,000
Additional Equipment Decontamination and Water Treatment	54,000
Additional Cost Items (mob-demob, per diem, lodging, trailer rental, site vehicles, supervisor, clerk, engineering, health and safety)	6,496,000
TOTAL	51,272,000

ANNUAL O&M COSTS

Utilities	4,000
Monitoring	47,000
Administration, General Engineering	5,000
Additional Expenses	6,000
TOTAL	62,000

APPENDIX C
(Continued)

ALTERNATIVE 6 (OFF-SITE THERMAL TREATMENT)

CAPITAL COSTS

ITEM	COST ($)
Security (Lighting, Guard, Fence)	481,000
Bulkhead Replacement	460,000
Disassemble and Decontaminate Salvageable Vessels	693,000
Locate and Plug Underground Conduit	181,000
Building Demolition	588,000
Slurry Wall Construction	1,565,000
Excavation of Contaminated Soil to 7 ppb	600,000
Sand/Soil Dewatering and Water Treatment	648,000
Purchase, Fill, and Compact Clean Fill in the Excavated Pit	1,250,000
Sampling and Analysis	425,000
Load and Haul Waste to Off-Site Landfill and Unload Into Landfill	25,400,000
Thermal Treatment Charge	191,100,000
Additional Equipment Decontamination and Water Treatment	54,000
Additional Cost Items (mob-demob, per diem, lodging, trailer rental, site vehicles, supervisor, clerk, engineering, health and safety)	24,363,000
TOTAL	247,808,000

ANNUAL O&M COSTS

Utilities	4,000
Monitoring	47,000
Administration, General Engineering	5,000
Additional Expenses	6,000
TOTAL	62,000