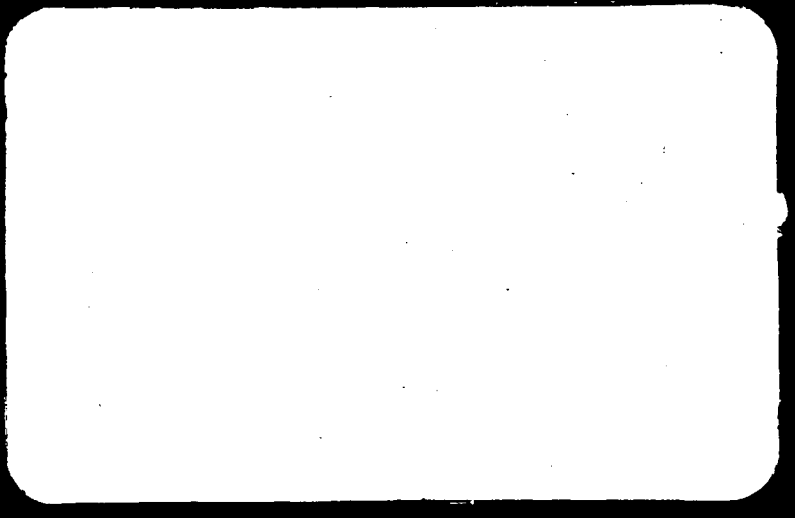
II-B. DRAFT FEASIBILITY STUDY

419789



JOHN CZAPOR

REMEDIAL RESPONSE ACTIVITIES zone 1 UNCONTROLLED HAZARDOUS WASTE DISPOSAL SITES



CAMP DRESSER & McKEE INC.
CH2M HILL
CONESTOGA-ROVERS & ASSOCIATES LIMITED
HALEY & ALDRICH, INC.

549

United States Environmental Protection Agency

New York, New York

VOLUME 1
DRAFT FEASIBILITY STUDY
EVALUATION OF
REMEDIAL ACTION ALTERNATIVES

Lone Pine Landfill, New Jersey
Work Assignment Z-1-17 Under
Contract No. 68-03-1612

June 1983

Camp Dresser & McKee Inc.

CONTENTS

VOLUME 1

1.0 INTRODUCTION..... 1

1.1 SITE BACKGROUND..... 1
1.2 NATURE AND EXTENT OF PROBLEM..... 5

2.0 REMEDIAL RESPONSE OBJECTIVES AND CRITERIA FOR EVALUATION OF ALTERNATIVES..... 8

2.1 REMEDIAL RESPONSE OBJECTIVES..... 8
2.2 REMEDIAL RESPONSE CRITERIA..... 9
2.3 CRITERIA FOR EVALUATION OF ALTERNATIVES..... 10

2.3.1 Cost..... 10
2.3.2 Reliability..... 12
2.3.3 Implementability..... 12
2.3.4 Operation and Maintenance Requirements..... 12
2.3.5 Environmental Considerations..... 13
2.3.6 Safety Requirements..... 13
2.3.7 Evaluation Summary..... 13

3.0 REMEDIAL ACTION ALTERNATIVES..... 14

3.1 IDENTIFICATION OF ALTERNATIVES..... 14

4.0 COMPUTER MODELING..... 43

4.1 GENERAL..... 43
4.2 DATA SOURCES/EXISTING INFORMATION..... 47
4.3 OVERVIEW OF THE LONE PINE SITE..... 49
4.4 SITE CONCEPTUALIZATION..... 53
4.5 MODEL FORMULATION..... 54
4.6 INITIAL PARAMETER VALUE ESTIMATES..... 60
4.7 FLOW MODEL CALIBRATION..... 67
4.8 CONTAMINANT TRANSPORT MODELING..... 82
4.9 SIMULATION OF ALTERNATIVES..... 95
4.10 SUMMARY OF ALTERNATIVE SIMULATION..... 117

5.0 SCREENING AND EVALUATION OF ALTERNATIVES..... 120

5.1 INTRODUCTION..... 120
5.2 ALTERNATIVES TO BE EVALUATED..... 120
5.3 SCREENING OF ALTERNATIVES..... 122

5.3.1 Costs..... 123
5.3.2 Environmental Impacts..... 129
5.3.3 Engineering Considerations..... 167

5.4 SUMMARY OF SCREENING RESULTS..... 169
5.5 ADDITIONAL CONSIDERATIONS..... 172

5.5.1 Manasquan Reservoir Effects..... 172
5.5.2 No Surface Seal Option..... 173
5.5.3 French Drain Option..... 176

5.6 EVALUATION OF REMAINING ALTERNATIVES..... 178

5.6.1 Costs..... 178
5.6.2 Reliability..... 178
5.6.3 Implementability..... 181
5.6.4 Operation and Maintenance Requirements..... 183
5.6.5 Environmental Impacts..... 183
5.6.6 Safety Requirements..... 186

5.7 RECHARGE AS AN OPTION TO TREATMENT AND DISCHARGE..... 187
5.8 RANKING BY COST AND NON-COST CRITERIA..... 187
5.9 CONCLUSIONS..... 189

VOLUME 2

APPENDIX A GROUNDWATER FLOW SIMULATION CODE--DYNFLO..... A-1

APPENDIX B CONTAMINANT TRANSPORT SIMULATION CODE--DYNTRA..... B-1

VOLUME 3

ENVIRONMENTAL INFORMATION DOCUMENT

FIGURES

1-1 Site Location Map..... 2

1-2 Site Map..... 3

3-1 Alternative 2--Deep Containment Wall with Plume Pumping..... 22

3-2 Treatment Facility Simplified Process Schematic..... 25

3-3 Schematic Treatment Facility Layout..... 27

3-4 Alternative 2A--Deep Containment Wall..... 35

3-5 Alternatives 3 and 3A--Shallow Containment Wall with Plume Pumping..... 36

3-6 Alternative 3B--Shallow Containment Wall..... 38

3-7 Alternative 4--Plume Interception..... 40

3-8 Alternative 4A--Surface Sealing Only (No Containment)..... 41

4-1 The Modeling Process..... 44

4-2 Lone Pine Landfill-Site Location Map..... 50

4-3 Cross Sectional Plot Illustrating Vertical Stratigraphy at Lone Pine Landfill..... 52

4-4 Horizontal Finite Element Grid Used in Simulations..... 55

4-5 Cross Sectional Plot of Simulated Vertical Stratigraphy..... 59

4-6 Level 1 (Lower Limit of Lower Red Bank Aquifer) Elevation Contours..... 61

4-7 Level 2 (Lower Limit of Upper Red Bank Aquifer) Elevation Contours..... 62

4-8 Level 3 (Lower Limit of Hornerstown Aquitard) Elevation Contours..... 63

4-9 Level 4 (Lower Limit of Vincentown Aquifer) Elevation Contours..... 64

4-10 Level 5 (Upper Limit of Vincentown Aquifer) Elevation Contours..... 65

4-11 Monitoring Well Location Map..... 70

4-12 Level 1 - Computed Piezometric Heads..... 75

4-13 Level 2 - Computed Piezometric Heads..... 76

4-14 Level 3 - Computed Piezometric Heads..... 77

4-15 Level 4 - Computed Piezometric Heads..... 78

4-16 Level 5 - Computed Piezometric Heads..... 79

4-17 Level 1 - Simulated Concentration Contours..... 89

4-18 Level 2 - Simulated Concentration Contours..... 90

4-19 Level 3 - Simulated Concentration Contours..... 91

4-20 Level 4 - Simulated Concentration Contours..... 92

4-21 Level 5 - Simulated Concentration Contours..... 93

4-22 Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 1..... 98

4-23 Simulated Extraction Well Locations..... 101

4-24 Computed Piezometric Heads for Levels 2 and 4 under Existing and Alternative 2 Conditions..... 102

4-25 Computed Piezometric Heads for Levels 2 and 4 for Alternative 2-A..... 104

4-26 Computed Piezometric Heads and Concentrations Contours in Levels 2 and 4 for Alternative 3..... 106

4-27 Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 3A..... 109

4-28 Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 3B..... 110

4-29 Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 4..... 112

4-30 Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 4A..... 114

4-31 Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 4B..... 115

4-32 Summary of Estimated Baseflow Concentrations in the Manasquan River at Burke Road..... 118

TABLES

3-1 Water and Air Monitoring Program..... 19

3-2 Basic Design Parameters of the Treatment Systems..... 31

4-1 Initial Element Property Estimates by Layer..... 66

4-2 Summary of Water Level Measurements..... 71

4-3 Well Construction Summary-Lone Pine Landfill..... 73

4-4 Final Element Property Values by Layer..... 80

4-5 Measured and Simulated Piezometric Heads at Monitoring Wells..... 81

4-6 Total Volatile Organic Concentrations Reported and Simulated at EPA Well Locations..... 94

4-7 Characteristics of Simulated Alternatives..... 96

5-1 Capital Costs of Components of the Alternatives..... 124

5-2 Capital Costs of the Alternatives..... 125

5-3 Total Annual O&M Costs of Components of Alternatives..... 126

5-4 Total Annual O&M Costs of Alternatives..... 127

5-5 Present Worth Costs Comparison of Alternatives..... 130

5-6 Environmental Matrix..... 131

5-7 Summary Present Worth Analysis..... 179

5-8 Non-Cost Evaluation Criteria Matrix..... 188

555

Section 1

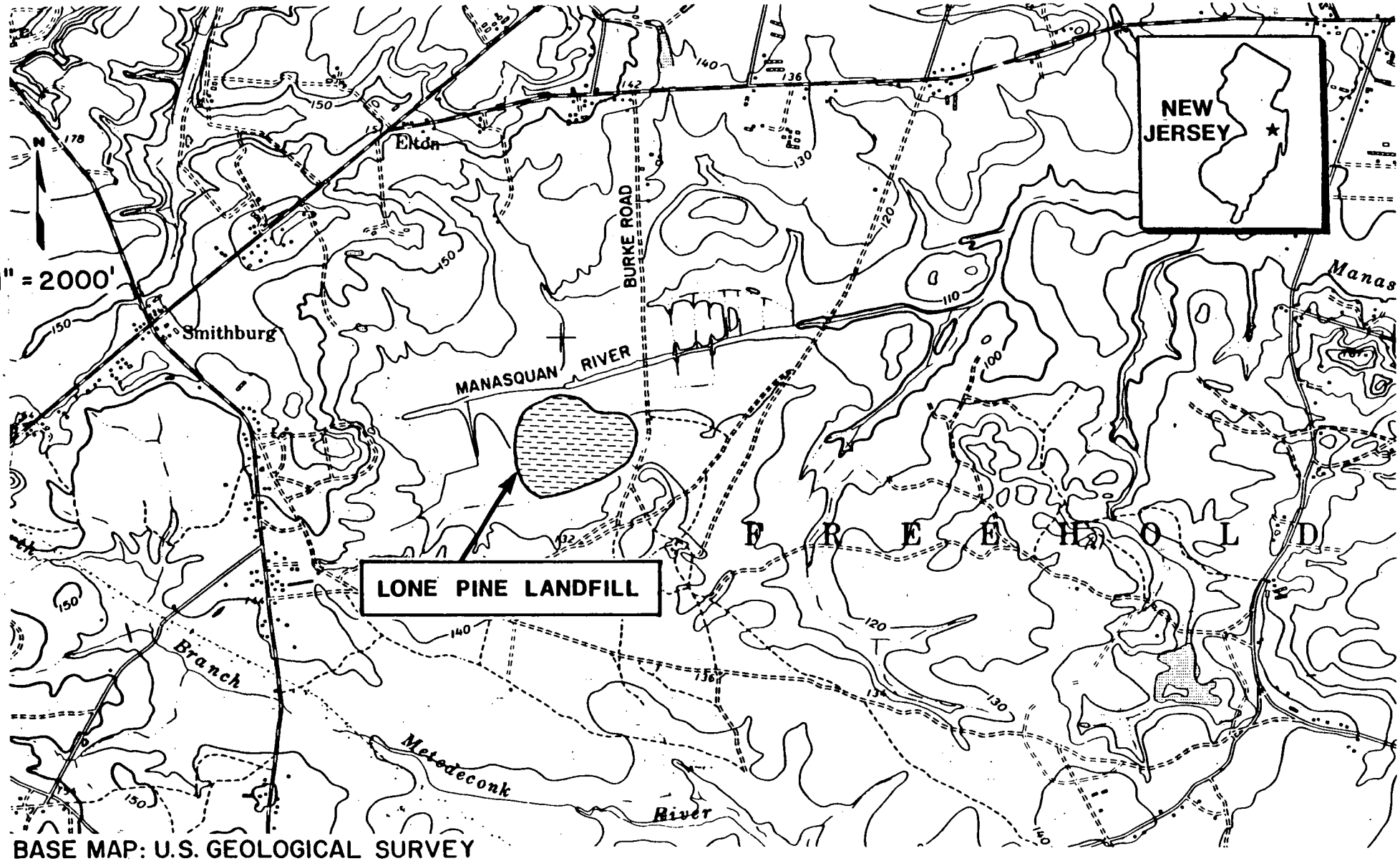
1.0 INTRODUCTION

1.1 SITE BACKGROUND

Lone Pine Landfill is a former municipal solid waste disposal site located on Burke Road in Freehold Township, Monmouth County, New Jersey (see Figure 1-1). The site is approximately 4 miles southwest of the Borough of Freehold, New Jersey. The approximately 45-acre landfill, situated on a 144-acre parcel, received municipal solid wastes for approximately 20 years. In the 1970's, both bulk and drummed hazardous wastes were disposed of at the site, while it continued to be used for the disposal of municipal solid wastes. The landfill generally consists of a large flat-topped mound, with an average height of 40 to 50 feet above the natural grade. The northern toe of the landfill slope lies approximately 600 feet south of the main headwaters stream of the Manasquan River. The site is only partially secured by fencing. A map of the site can be found on Figure 1-2.

The surrounding terrain is predominantly gently rolling Coastal Plains with small hills providing minor topographic relief. Site vegetation varies from non-existent at the top of the landfill through herbaceous materials on its side slopes to densely wooded areas at the northern, western and southern borders of the site. The soil type in the area is sandy in nature with high permeability.

The site lies within the 4-square-mile headwaters subbasin of the Manasquan River watershed. The site generally drains from the southwest to the northeast, towards the Manasquan River. The Metedeconk River watershed divide is immediately adjacent to the property on the south side.



ZONE 1
FEASIBILITY STUDY

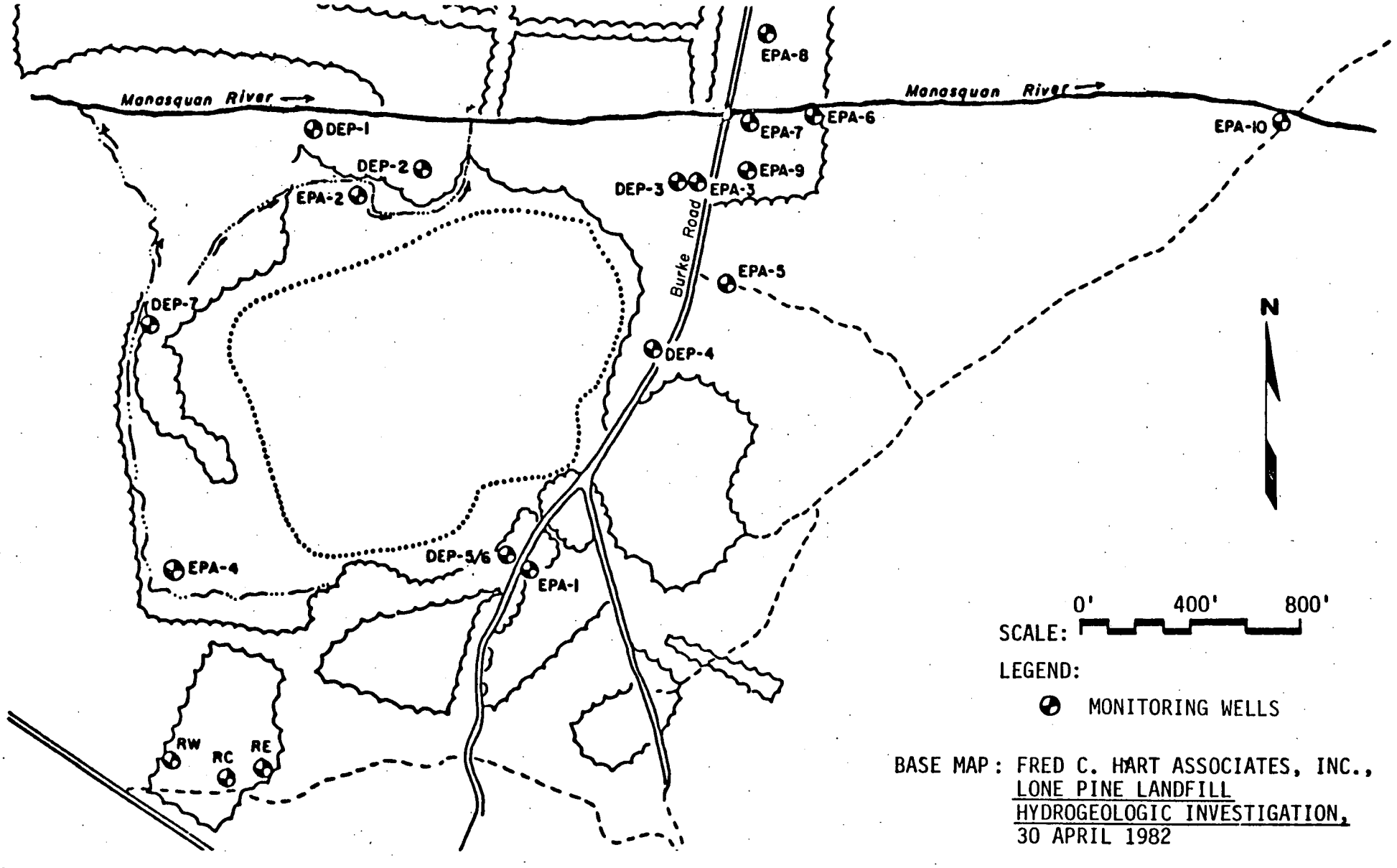
LONE PINE LANDFILL FREEHOLD N.J.

SITE LOCATION MAP

CAMP DRESSER & McKEE INC.

One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 1-1



BASE MAP: FRED C. HART ASSOCIATES, INC., LONE PINE LANDFILL HYDROGEOLOGIC INVESTIGATION, 30 APRIL 1982

ZONE 1
FEASIBILITY STUDY

LONE PINE LANDFILL FREEHOLD N.J.

SITE MAP

CAMP DRESSER & McKEE INC.

One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 1-2

Hydrogeologic studies in the study area reveal that the site, which is in the Atlantic Coastal Plain province, is underlain by unconsolidated gravel, sand and clay of the Quaternary, Tertiary and Cretaceous ages.

The landfill is located at the edge of the outcrop of Vincentown Sand, a water-bearing formation. Underlying the Vincentown Sand is the Hornerstown formation, a semi-confining bed. Below the Hornerstown is the Red Bank formation, a water-bearing formation which is composed of several distinct stratigraphic units. Below the Red Bank formation lies the Navesink Marl formation which is estimated to lie approximately 140 feet below the surface, according to geologic information in the area. Deep water-bearing formations below the site are the Englishtown and Raritan-Magothy aquifers.

The aquifers of concern in the feasibility study are the Vincentown and Red Bank formations. For study purposes a lower and an upper Red Bank aquifer have been designated with the base of the Tinton Sand layer serving as the boundary between the upper and lower Red Bank aquifer.[1]

The Lone Pine Landfill site began accepting municipal solid waste in 1959. Wastes were apparently deposited in the landfill after excavation as much as 10 feet down into the Vincentown formation. Quantities of septic tank liquid wastes and commercial liquid organic wastes were disposed of at the site in the 1970's. In 1978, a substantial number of 55-gallon drums of chemical wastes were buried at the site (it has been estimated that up to 50,000 drums may have been buried; the U.S. Justice Department has recently obtained convictions

---

[1]This description of the Red Bank aquifer is used for consistency purposes with previous USEPA studies, and may not agree with the New Jersey Geological Survey.

of one company in connnection with the illegal disposal of 17,000 drums). A limited drum excavation and sampling program has shown that a variety of organic priority pollutant substances and heavy metals are contained in the drums. Other information indicates that approximately 2 million gallons of spent toluene solvent along with several hundred thousand gallons or more of other bulk chemical wastes were placed in the landfill in the 1970's. In addition, soil that may have been contaminated by methylene chloride wastes was excavated from an area across Burke Road and deposited in the landfill.

In June, 1978, a chemical fire occurred at the landfill, during which exploding drums were observed. In response to the fire and follow-up investigation, the State of New Jersey issued an administrative order directed at mitigating potential environmental damage from the site. Failure by the owner to meet the requirements of the administrative order resulted in a state closure order in 1979. The site has been officially closed since December, 1979.

1.2 NATURE AND EXTENT OF PROBLEM

Field investigations, monitoring data and technical investigations performed by the USEPA and NJDEP have documented a number of environmental problems associated with the Lone Pine Landfill site. The major class of contaminated release occurring from bulk liquid wastes and drums disposed at the site is volatile organic priority pollutants. Other organic compounds, in particular, isophorone, phthalates, acetone, 2-butanone, 2-hexanone and 4-methylphenol are also being released. Elevated levels of heavy metals are also being released.

561

Limited data on radioactivity and air quality is available to document to what extent these types of releases are occurring. No evidence of radioactivity has been found; organic vapor analyzer readings up to 5 ppm (as isobutylene) above background levels have been detected on the landfill. Additional air quality monitoring is currently in progress. This air quality monitoring will help deter mine what specific remedial actions (if any) are necessary to control air emissions. The results of this air monitoring will included in the final version of this report.

The effects of the contaminant releases are being manifested in the following ways:

(1) Volatile organics (benzene, toluene, vinyl chloride, in particular) and heavy metals are migrating through the soil and into the Vincentown and Red Bank aquifers. Monitoring wells located north and northeast of the site, but south of the Manasquan River, show high levels of volatile organic contaminants.

(2) A contaminated plume emanates from the landfill and moves in a north-northeasterly direction to the Manasquan River. Low levels of organic compounds and heavy metals have been detected in the Manasquan River just downstream of the site. The contaminated plume has not apparently reached any existing drinking water supplies. The nearest private wells include a residential well approximately 600 feet south (upgradient) of the landfill, a non-residential well approximately 1000 feet east of the landfill and several residential wells 1/2 mile north of the site across the Manasquan River (groundwater data indicates that the plume does not migrate north of the river. See section 4). The nearest public water supply well is 4 miles from the site.

562

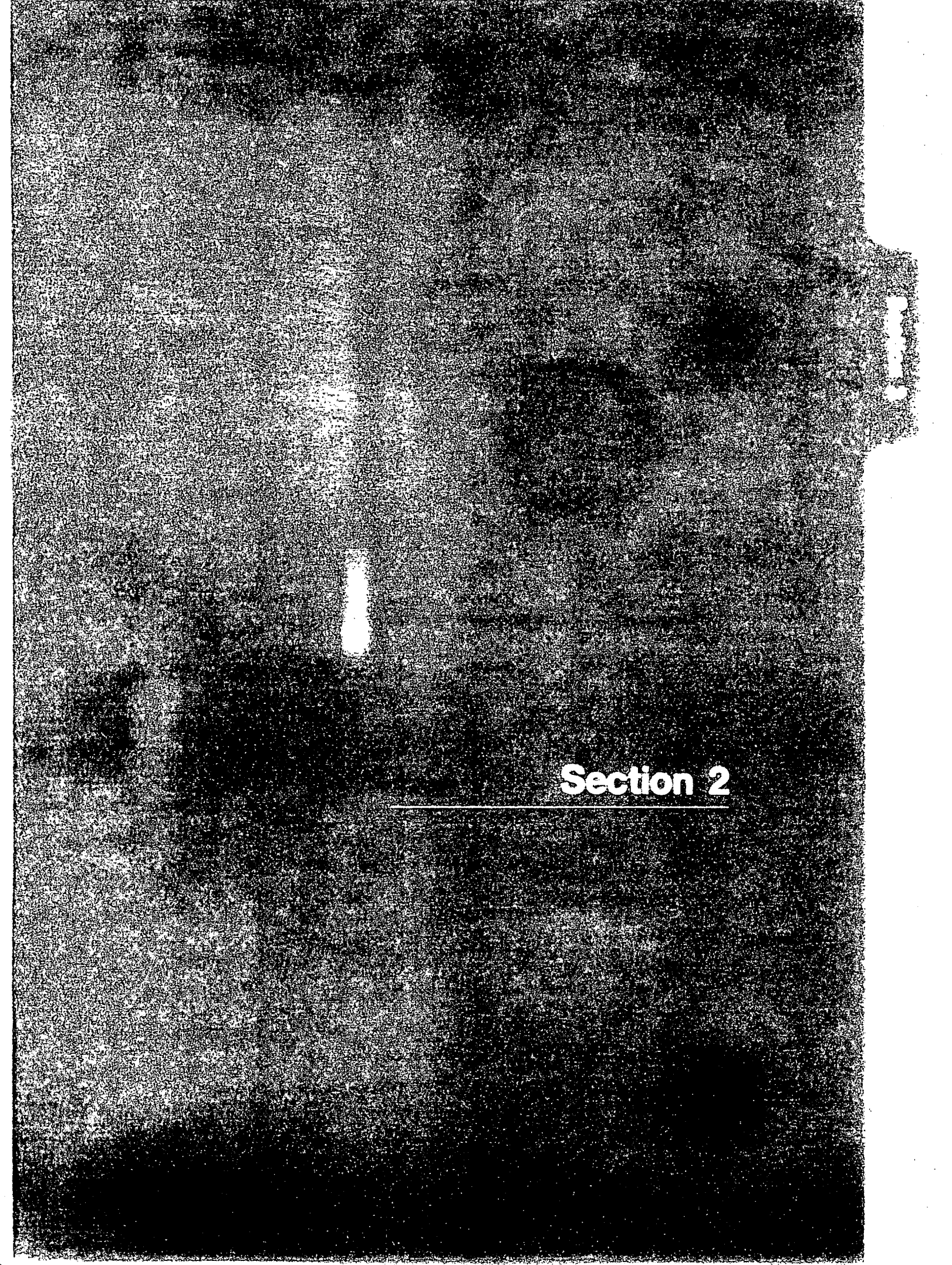
(3) Contaminated surface water runoff from the landfill flows into an adjoining wetlands area on the north and then into the Manasquan River. Substantial leachate seepage is occurring at the landfill. Priority pollutant organic contaminants have been detected in Manasquan River sediments near the site.

(4) There is considerable soil contamination on the landfill site itself and from contaminant-laden runoff to the areas north and northeast of the landfill.

(5) Terrestrial and aquatic plant and animal life near the site have been adversely affected by contaminated surface runoff and groundwater discharge to the river and by contaminated soils.

It must be recognized that the buried drums represent a hidden source of future contamination about which information is extremely limited. Thus the contaminants being released today, as evidenced in the existing data, may change in type (for example, volatile organics, non-volatile organics, heavy metals) and concentration as additional buried drums decay and liquid wastes are transported out of the landfill. Contaminants not present now in surface or groundwater may be present in the future as drums rupture.

Under a zone contract for remedial response activities at uncontrolled hazardous waste disposal sites, the USEPA has directed Camp Dresser & McKee Inc. (CDM) to perform a feasibility study to develop and evaluate remedial action alternatives aimed at preventing or mitigating the impacts of the migration of hazardous substances from the Lone Pine Landfill into the environment. This study was primarily based on existing information and data. During the period of the study additional sampling data was collected and used to corroborate earlier findings. Further data collection, particularly to acquire additional information on the landfill contents and leachate, will take place during the design stage.


Section 2

2.0 REMEDIAL RESPONSE OBJECTIVES AND CRITERIA FOR EVALUATION OF ALTERNATIVES

2.1 REMEDIAL RESPONSE OBJECTIVES

From the evaluation of existing data and information on the nature and extent of contaminant release from the Lone Pine Landfill site, three specific objectives were established:

(1) To maintain adequate safe drinking water supply for the population that could be affected by groundwater contaminant migration.

(2) To protect State-designated Manasquan River surface water uses (fishing, swimming and water supply with treatment) from contaminant release.

(3) To prevent local exposure to contaminated material (soil, sediments, leachate).

Regarding these objectives, the following points should be noted. The nearest public water supply well is approximately 4 miles from the site; the nearest private well is less than 1000 feet from the site. None of the existing wells has been found to be in violation of drinking water standards. However, a potable water reservoir has been proposed by the State for the Manasquan River approximately 16 miles downstream of the site. The potential water quality effects of the landfill on the proposed reservoir are a major concern of the State and USEPA Region II. Other major concerns include the 2000-acre Turkey Swamp Fish and Wildlife Management Area, a boundary of which is less than 1000 feet from the landfill, effects on aquatic biota and exposure to hazardous substances (downstream portions of the Manasquan River are stocked with trout which are subsequently consumed by humans).

565

2.2 REMEDIAL RESPONSE CRITERIA

To date, environmental standards to be used in the evaluation of remedial actions at uncontrolled hazardous waste disposal sites have not been specifically established by the USEPA. Also, individual drinking water standards have not been established for most of the hazardous contaminants in the Lone Pine area groundwaters. The USEPA and NJDEP developed response criteria to be used in evaluating the remedial action alternatives for the Price Landfill, New Jersey. In the absence of other specific standards, the following criteria have been adopted from the Price Landfill study and were used as an evaluation tool for comparison only of remedial action alternatives at Lone Pine Landfill; they are not a CDM recommendation:

(1) Treatment of the contaminated plume will be continued until the maximum concentration of total volatile organic compounds in the groundwater plume, as determined at the well pump, is 100 parts per billion (ppb), the concentration guideline established by the NJDEP for possible closure of a drinking water well (the companion concentration guideline for any individual volatile organic compound is 50 ppb.)

(2) Recharge to groundwater in a clean aquifer (one that meets drinking water standards) is to be at or below 100 ppb total volatile organics. During remedial action and prior to achieving cleanup of the aquifer, recharge for cleansing purposes can be at concentrations higher than 100 ppb, provided such recharge is part of an overall treatment system plan.

(3) Effluent discharged to the Manasquan River is not to exceed 100 ppb total volatile organics in combination with a 50 parts per million (ppm) total organic carbon limitation. In addition, New Jersey water quality heavy metal standards for FW-2 waters are to apply.

516

2.3 CRITERIA FOR EVALUATION OF ALTERNATIVES

Alternatives identified as having the potential to meet the remedial response objectives for Lone Pine were subjected to a two-step evaluation process. The first step consisted of an initial screening of the candidate alternatives (see sections 3, 4 and 5) based on relative present worth cost, environmental impacts and engineering considerations. Following the initial screening, the narrowed list of remedial alternatives was evaluated further in order to identify the most cost-effective alternative. This second evaluation step rated the alternatives according to six criteria: cost, reliability, implementability, operation and maintenance requirements, environmental impacts and safety requirements.

2.3.1 Cost

Evaluation of alternatives by cost utilized the present worth (life-cycle) method with a 50-year planning period and a 10 percent discount rate. Useful life projections for major components of the alternatives were designated as follows: structures (except slurry walls)--50 years; treatment units, wells and slurry walls--25 years and mechanical equipment--10 or 15 years. These projections are for costing purposes only.

Capital costs were estimated for the individual components of the alternatives. The estimated construction costs were based on March 1983 dollars, equivalent to an Engineering News Record (ENR) cost index of 4012. An allowance of 35 percent for engineering and contingencies was included in the total capital cost.

Annual operation and maintenance costs for the individual components included labor, power, chemicals, maintenance, supplies, carbon regeneration and sludge hauling. Labor costs were based on the estimated number of hours required for the operation of the facilities

and include allowances for fringe benefits, sick leave, and health insurance. Power costs included power for pumping, operating equipment and other purposes. Chemical costs were based on truck delivered rates, and include costs of soda ash for the chemical precipitation unit process step, polymer addition for mechanical dewatering of sludge and acid for pH adjustment. Costs for maintenance and supplies included routine equipment replacement parts and other miscellaneous items needed for the daily operation of the facility. Separate cost estimates for equipment and structural costs were obtained for the treatment facilities. For well systems, structural costs were assumed to be 60 percent of the construction costs, and structural maintenance was estimated as an annual cost of 0.5 percent of the structural costs. Equipment costs were assumed to be 40 percent of the construction costs and equipment maintenance was estimated as an annual cost of 1.0 percent of the equipment costs. Sludge hauling and disposal costs included both transportation and landfilling charges.

Replacement costs were included for replacing treatment facilities, wells and slurry walls once and mechanical equipment three times over the course of a 50-year period. In addition, an allowance for well cleaning was included in the replacement costs category. Well cleaning costs for internal wells (wells placed inside the landfill perimeter slurry wall) were estimated as $10,000 per well on an average of every 6 months. Well cleaning costs for external wells (wells placed between the landfill and the Manasquan River) were estimated as $200 per well every 4 months, on the average. Also allowed for in this category was one major surface seal repair event, such as substantial settlement over a portion of the landfill.

Major components were assumed to have no salvage value (100 percent depreciation) at the end of their useful lives.

2.3.2 Reliability

A comparison and ranking of the alternatives was performed based on the ability of the particular alternative to achieve long-term control of contaminant release and the potential for and consequences of failure of any component of the remedial plan. Factors influencing an alternative's reliability rating include time to achieve control, level of control to be expected, system complexity and degree of proven technology to be employed.

2.3.3 Implementability

For each alternative, substantial constraints to rapid implementation such as difficult permit requirements or complex construction phasing were identified. Also examined was whether options are available to segment the plan's implementation. Factors influencing the implementability ranking include offsite facility and pilot study requirements, institutional issues and public acceptability.

2.3.4 Operation and Maintenance Requirements

The alternatives were compared in terms of system flexibility, maintainability and operability. Factors examined included staffing levels and special operator training requirements, from both an operations standpoint and a handling and disposal of hazardous materials standpoint; plant and well monitoring frequency and levels and laboratory needs; increased system maintenance demands (due to the nature of the materials involved) and energy demands.

2.3.5 Environmental Considerations

Each alternative was evaluated for potential impacts on the physical, biological and socioeconomic environment. Within these three categories, the major environmental indicators of concern were surface water and groundwater quality, public health and terrestrial and aquatic plant and animal life.

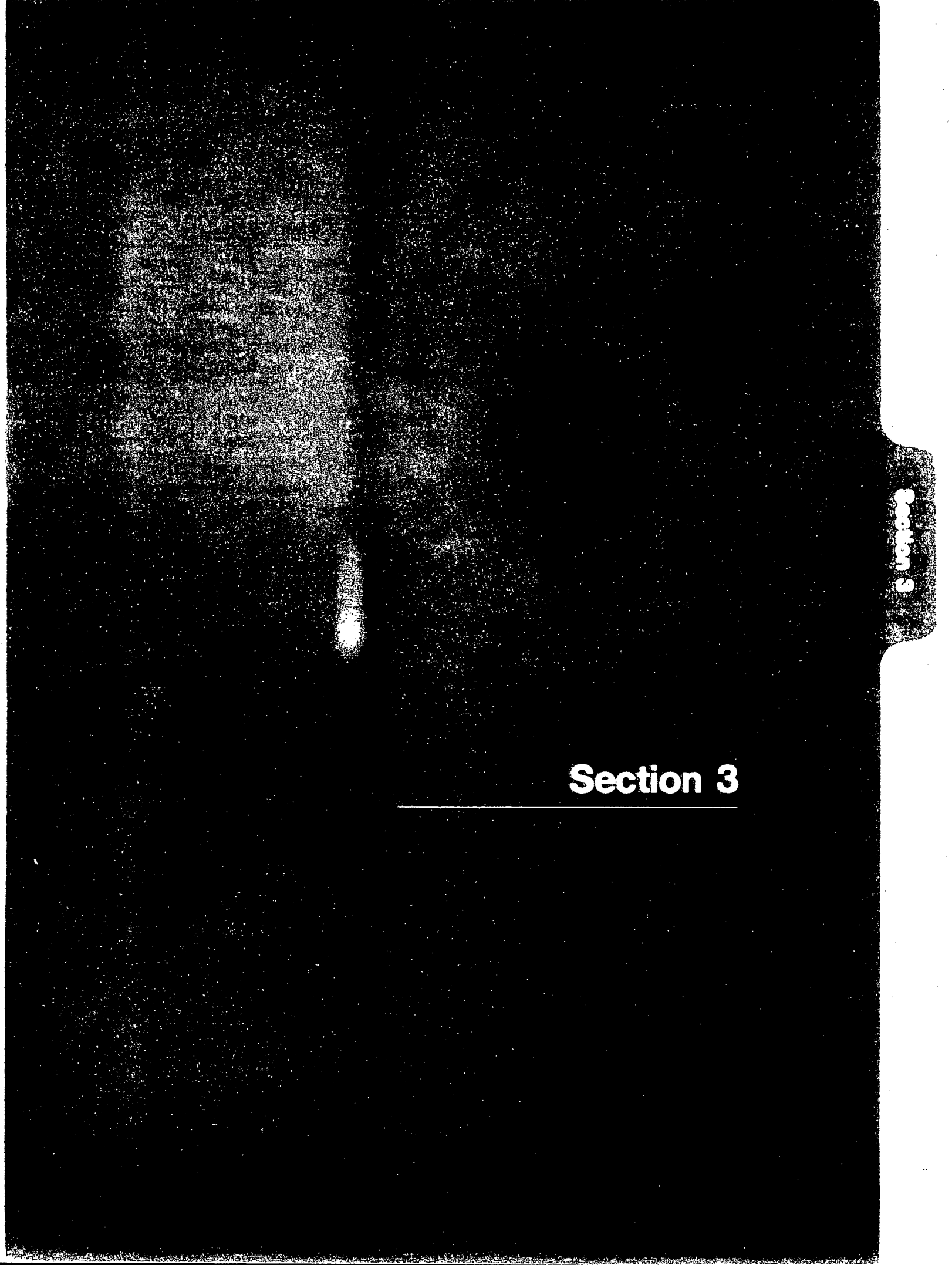
The evaluations were drawn from the Environmental Information Document (EID), which provides a comprehensive environmental analysis and ranking of the alternatives. The complete EID is in Volume 3.

2.3.6 Safety Requirements

Remedial action alternatives were evaluated with respect to the need for plant personnel to handle hazardous substances or contaminated materials, the production of explosive gases that could endanger on-site workers or the nearby community, the potential for generation of toxic airborne gases, fire hazards, and offsite transportation of hazardous materials.

2.3.7 Evaluation Summary

As a further aid to understanding the evaluation, a matrix was developed to summarize the results of the evaluation. For the non-cost criteria, the matrix displays the basic parameters involved in the analysis of each criterion and rates each alternative by these basic parameters, using a "+", "0" "-" scale. A "+" or "-" indicates a significant advantage or disadvantage, respectively, of an alternative compared to the other alternatives, while a "0" indicates no particular advantage or disadvantage.


Section 3

3.0 REMEDIAL ACTION ALTERNATIVES

3.1 IDENTIFICATION OF ALTERNATIVES

From a survey of available feasible remedial action technologies for uncontrolled hazardous waste sites and an analysis of known conditions, a total of nine alternatives were identified to satisfy the response objectives and cleanup criteria for the Lone Pine Landfill. The list of alternatives is presented below followed by a discussion of each alternative.

(1) No Action with monitoring program

(2) Deep containment wall with internal pumping and plume pumping, treatment and discharge

(2A) Deep containment wall with internal pumping, treatment and discharge

(3) Shallow containment wall with internal pumping and plume pumping, treatment and discharge

(3A) Shallow containment wall with internal pumping and high-rate plume pumping, treatment and discharge

(3B) Shallow containment wall with internal pumping, treatment and discharge

(4) Plume interception with treatment and discharge (no containment)

517

(4A) Surface sealing without containment wall or plume interception

(5) Drum excavation and removal with plume pumping, treatment and discharge.

Note also that Alternatives 2 through 5 each include surface sealing (capping) and sediment control components. Both of these components can be considered as options for the remedial action alternatives. The no-surface-sealing option would substitute a surface leachate collection and treatment system and final cover (without a clay layer) for the surface seal. The advantages and disadvantages of eliminating the surface seal are discussed in section 5.5.2. Sediment control may be excluded in the final remedial action plan, if the results of recent additional sediment sampling firmly establishes that such control is not necessary. All the alternatives include a water-and air-monitoring program.

No existing drinking water supplies are presently threatened with contamination from the Lone Pine Landfill site. Therefore, the alternative of replacement of existing water supplies is not applicable.

Alternative 1--No Action

With this alternative, no technologies are utilized; the site would remain in its present condition for an indefinite period. Current physical and biological processes now occurring on the site, such as leachate production and groundwater and surface water contamination, would continue unchecked. The potential for release of hazardous substances from the buried drums would likely increase in the future. As a result, contamination from the site could increase to more hazardous levels.

A water-and air-sampling program is included to monitor changes in contaminant releases from the landfill. The objective of the monitoring program is to observe trends in groundwater, surface water and air contaminant characteristics. The monitoring program may be used to defer remedial action until contaminant concentrations approach certain pre-established levels.

Groundwater sampling will consist of sampling from two pairs of nested monitoring wells installed by USEPA in 1981, EPA-3 and 3A ("A" signifies a deep well in the Red Bank formation) and EPA-8 and 8A (or a more appropriate location north of the river). See Figure 1-2. Both the Vincentown and Red Bank aquifers will be sampled. Surface water samples will be collected at two Manasquan River locations--at the Burke Road crossing and downstream of Burke Road at a location upstream of any other potential contamination sources. Ground and surface water samples will be analyzed for priority pollutants semiannually and volatile organics only the remaining two quarters for the first 3 years (EPA-8 and 8A, north of the river, will be analyzed for volatile organics only). If volatile organic concentration levels show an increasing trend, the analysis would be expanded to include full priority pollutant analysis). In addition, tentative identification of up to 10 volatile and 20 non-volatile organic non-priority pollutants will be made at the time of priority pollutant analysis. If contaminant levels show a decreasing trend, the frequency of priority pollutant analysis (and non-priority pollutant identification) will be reduced to annually and volatile organics only at the mid-year point after the initial 3-year period. However, should contaminant levels increase, more frequent monitoring can be instituted. For cost evaluation purposes, monitoring is assumed to include volatile organic-only analysis once a year and non-priority pollutant identification and priority pollutant analysis once a year (except for EPA-8 and 8A) after the initial 3-year period.

The first phase of the recommended air-monitoring program will be designed to establish baseline conditions to enable a determination of the nature and extent of air emissions and the potential effects of these emissions.

In order to collect additional data on ambient air quality over and above the initial air-monitoring survey in progress, a monitoring program of limited scope will be implemented to evaluate local conditions. The design of the preliminary monitoring effort is intended to determine the potential release rates of total hydrocarbons, methane and priority pollutants from the landfill. An analysis of background concentrations and concentrations downwind of the landfill will be part of the overall evaluation of data recorded during the preliminary monitoring effort. Recommendations on the extent and duration of future monitoring efforts cannot be made until some baseline information is accumulated.

The preliminary baseline study will consist of continuous monitoring of total hydrocarbons at the site for a period of 2 months. This monitoring is to be complemented by continuous monitoring of climatic data by a meteorological station. This data will provide a correlation between weather and hydrocarbon releases. In addition, at least six "grab" samples to be analyzed for priority pollutants are included in the baseline monitoring program.

Following the baseline study and assessment of conditions the second phase of the program would be implemented to serve as an ongoing warning system of changing conditions. Continuous monitoring of total hydrocarbons and meteorological data will continue and priority pollutant samples will be collected and analyzed semiannually. This phase assumes that a potential air emission problem is found to exist and is expected to continue.

Table 3-1 summarizes the elements of the recommended No Action monitoring program.

Alternative 2 -- Deep Containment Wall with Internal Pumping and Plume Pumping, Treatment and Discharge

Onsite containment of contamination is achieved by use of a slurry wall reaching an approximate average depth of 140 feet to the Navesink Marl formation, a relatively impermeable layer. This wall will ring the perimeter of the landfill a distance of about 6000 feet and enclose an area of approximately 45 acres (see Figure 3-1). This approach implies containment of the landfill contaminants by enclosing them in an impermeable box (entombment). However, because (1) slurry wall technology is not capable of producing a totally impermeable wall, (2) precipitation would penetrate a clay cap at reduced rates, and (3) the Navesink Marl would only severely retard the flow of contamination rather than completely stopping it, an internal pumping system is included to relieve hydraulic pressure within the slurry wall and thus prevent a forced hydraulic escape of contaminants. This is a maintenance pumping approach that is not intended to remove all of the contaminants in the landfill but instead immobilize them. This internal well system is to consist of a series of wells, located within the boundary of the slurry wall but outside the fill area and extending an average of 30 feet below grade (Figure 3-1). This depth places the well screen above the Hornerstown formation. The pumping rate, duration, and number of wells was determined from the analysis and evaluation of alternatives in sections 4 and 5. The final well field specifications will be determined after all field data are available. The contaminated pumped groundwater is to be treated and tested prior to discharge to the Manasquan River. The slurry wall, to be constructed by the slurry trenching method, will be 3 feet thick, with a permeability of not greater than 1×10^{-7} cm/sec.

TABLE 3-1

WATER AND AIR MONITORING PROGRAM

NO ACTION ALTERNATIVE

Groundwater and Surface Water Sampling

Sampling Locations:

Groundwater - Wells: EPA-3, 3A; 8, 8A

Surface water - Two Manasquan River locations downstream of landfill

Sampling Type and Frequency:

Priority and non-priority pollutants (except EPA-8 and 8A)	First 3 years: semiannually After 3 years*: annually
Volatile organics	First 3 years: quarterly After 3 years*: semiannually

*Assuming contaminant levels stabilize.

Air Sampling

Sampling Location:

Various onsite locations

TABLE 3-1 (continued)

Sampling Type and Frequency:

Total hydrocarbons - continuous

Priority pollutants - Initial baseline (2 months): 3 samples at each of 2 locations
After baseline: semiannually at 6 locations

ACTION ALTERNATIVES

Groundwater and Surface Water Sampling

Sampling Location:

Groundwater - Wells: EPA-3, 3A; 8, 8A
Surface water - Two Manasquan River locations downstream of landfill

Sampling Type and Frequency:

Priority and non-priority pollutants - First 2 years: semiannually
After 2 years*: annually

Effluent Sampling:

Total organic carbon (TOC) - Daily

Total organic Halides - Daily

Total volatile organics - Weekly

TABLE 3-1 (continued)

Air Sampling

Sampling Location:

Onsite and gas monitoring wells

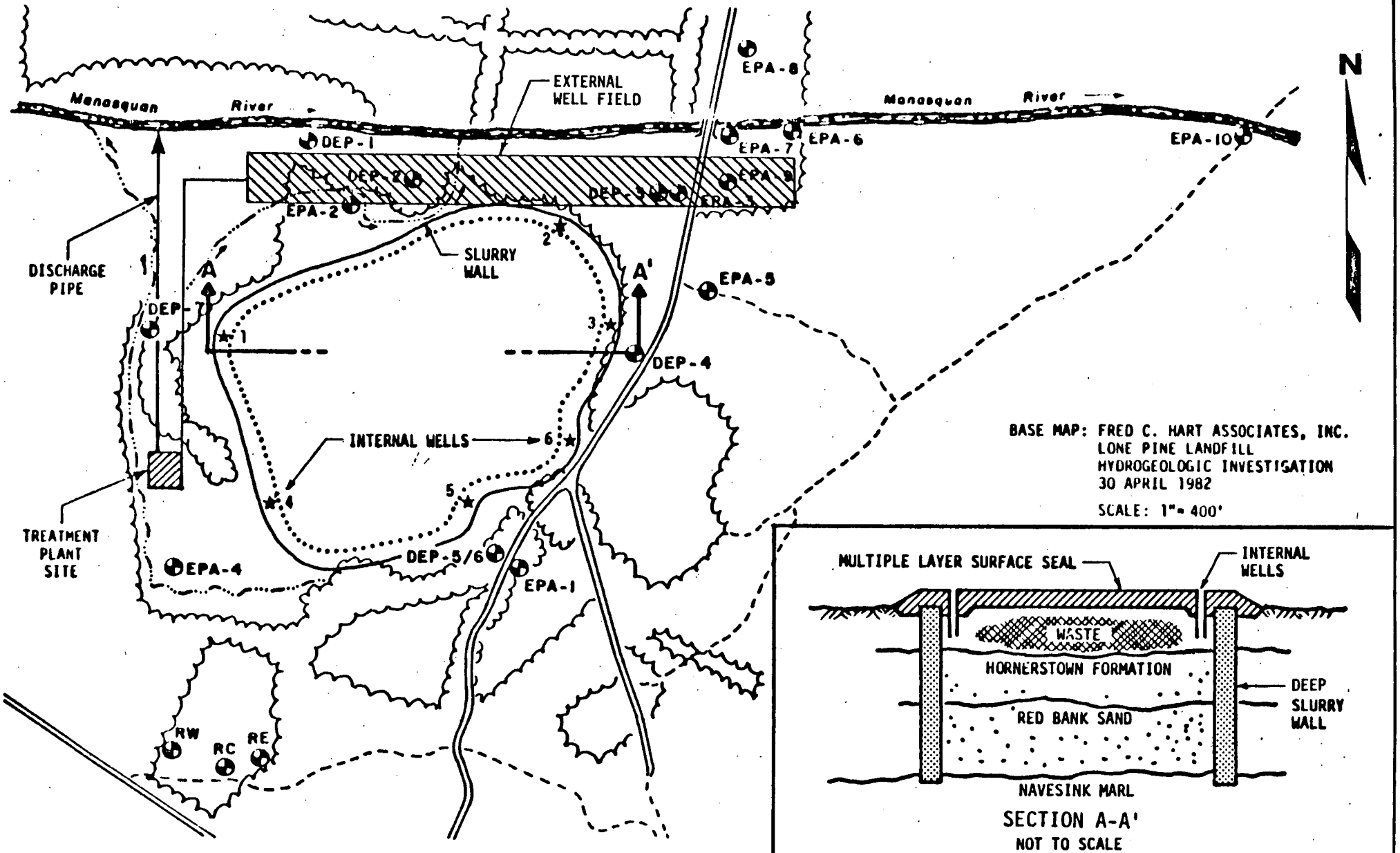
Sampling Type and Frequency:

Total hydrocarbons - Initial baseline: 2 months
(and meteorological data)
After surface seal installation: 2 months

Methane - First 5 years: quarterly
After 5 years: semiannually

Priority pollutants - First 3 years: semiannually
After 3 years*: annually

*Assuming contaminant levels stabilize or decrease.



ZONE 1
FEASIBILITY STUDY

LONE PINE LANDFILL FREEHOLD N.J.
ALTERNATIVE 2
DEEP CONTAINMENT WALL
WITH PLUME PUMPING

CAMP DRESSER & McKEE INC.
One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 3-1

External pumping is provided in Alternative 2 to intercept the existing contaminant plume extending from the landfill to the Manasquan River. This external pumping is to be achieved by means of a well field downgradient of the landfill, parallelling the river. The wells are to reach approximately 45 feet below ground into the Red Bank formation. The pumping rate, duration and number of wells was determined from the analysis and evaluation of alternatives in sections 4 and 5. The final well field specifications will be determined after all field data are available. This contaminated groundwater will be combined with that from the wells inside the slurry wall and be treated and tested prior to river discharge.

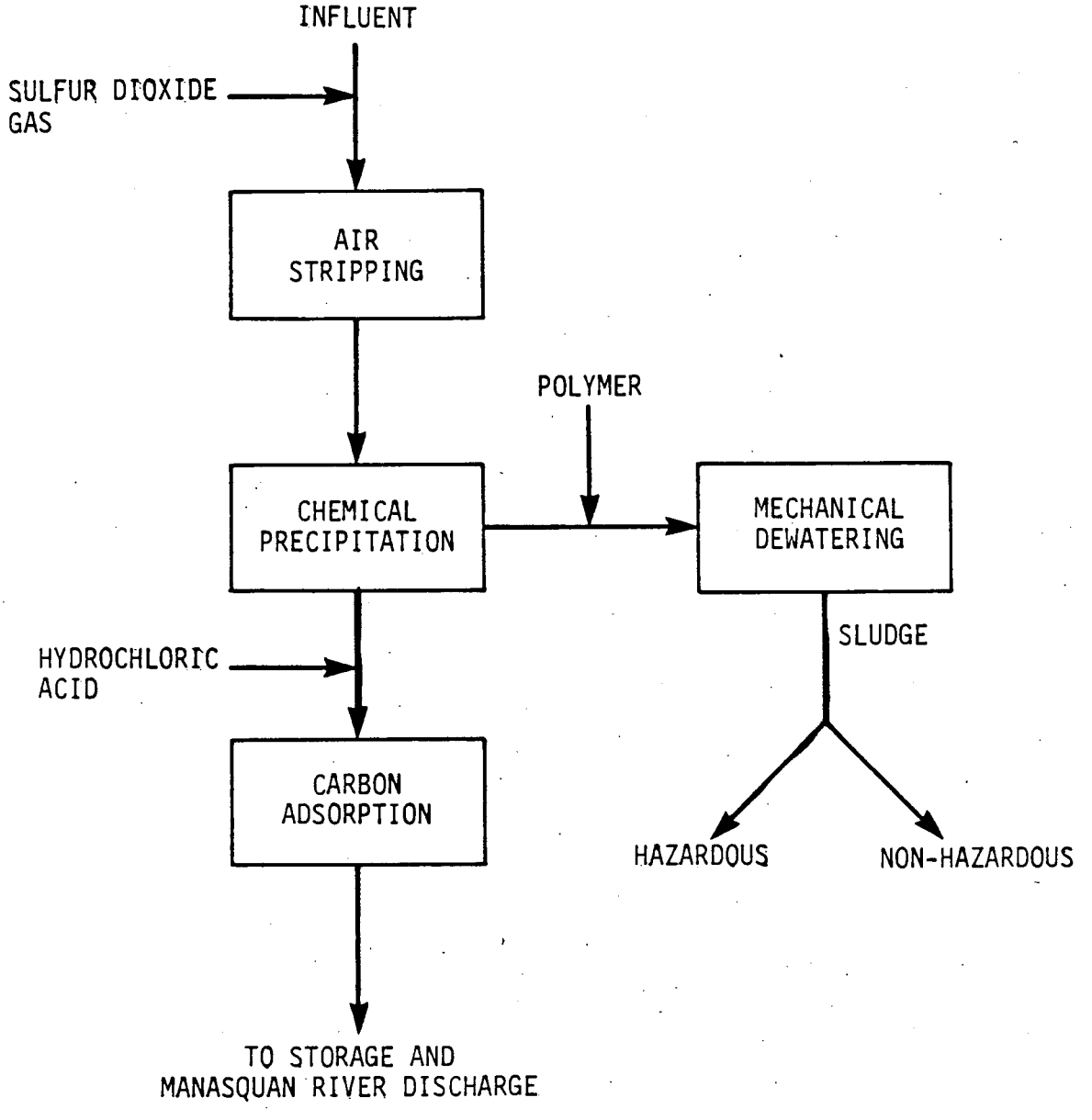
Because the precise nature of the contents of the landfill is unknown, it is not possible at this time to specify an exact treatment facility for treating the contaminated water from the landfill. Existing water quality data is that of groundwater downgradient and upgradient of the landfill and of surface water. As such, this data is a record of the effects of landfill contamination and not a record of the actual landfill contents. Sampling data of the actual contents of the landfill is limited to a sampling of 33 drums (and 8 groundwater samples) out of an estimated 30,000 to 50,000 drums. A treatment system comprised of several processes to treat the types of contaminants anticipated is proposed.

The contamination presently found in the groundwater plume consists of volatile organics, base neutral extractable and acid compounds and heavy metals. The contamination found in the 41 drum and groundwater samples also contained these contaminants and in addition several drums contained quantities (typically less than 5 ppm) of pesticides and one drum contained less than 1 ppm of PCBs. In light of the fact that there was both batch and drum dumping of chemical contamination, it is not possible to determine whether the contaminants in the groundwater plume are the result of the batch chemical dumping or the

rupturing of the drums. Furthermore, it is impossible to predict accurately the rate of contaminant release from the drums. A third source that must be considered is the contamination which results from the solid waste material in the landfill, a material which also varies widely in its constituents. It is thus apparent that even known constituents will vary greatly in concentration over time, and their treatment will be complicated by other competing contaminants.

The treatment system which is proposed, based on the existing data, is a physical/chemical treatment system which is to be viewed only as a representative treatment system to allow comparison of alternatives. This system will address the contamination as presently found in the groundwater plume and will also address the pesticide and PCB contamination as found in the sampling of drums. It must be emphasized that without in-depth sampling of the landfill contents themselves, any treatment system will always be addressing contamination as it is received rather than being designed for anticipated contamination. As these contaminants will vary in type and concentration over time, the treatment system and its operation will constantly have to be adjusted.

The physical/chemical treatment system is designed to provide removal of volatile organics, base neutral extractables, acid compounds, PCBs, pesticides, heavy metals, BOD and COD. This is accomplished by use of unit processes which each address specific contaminant groups. Pilot and treatability studies will be done during design. The preliminary selection of representative unit processes was based on the results of the pilot and treatability studies for the Price Landfill hazardous waste site. The unit processes that would be considered appropriate for conditions initially anticipated are air stripping, chemical precipitation and carbon adsorption (see Figure 3-2). In general, air stripping will remove volatile organic contaminants, chemical precipitation will remove heavy metals and carbon adsorption



CAMP DRESSER & McKEE INC.
One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 3-2

LONE PINE LANDFILL FREEHOLD N.J.

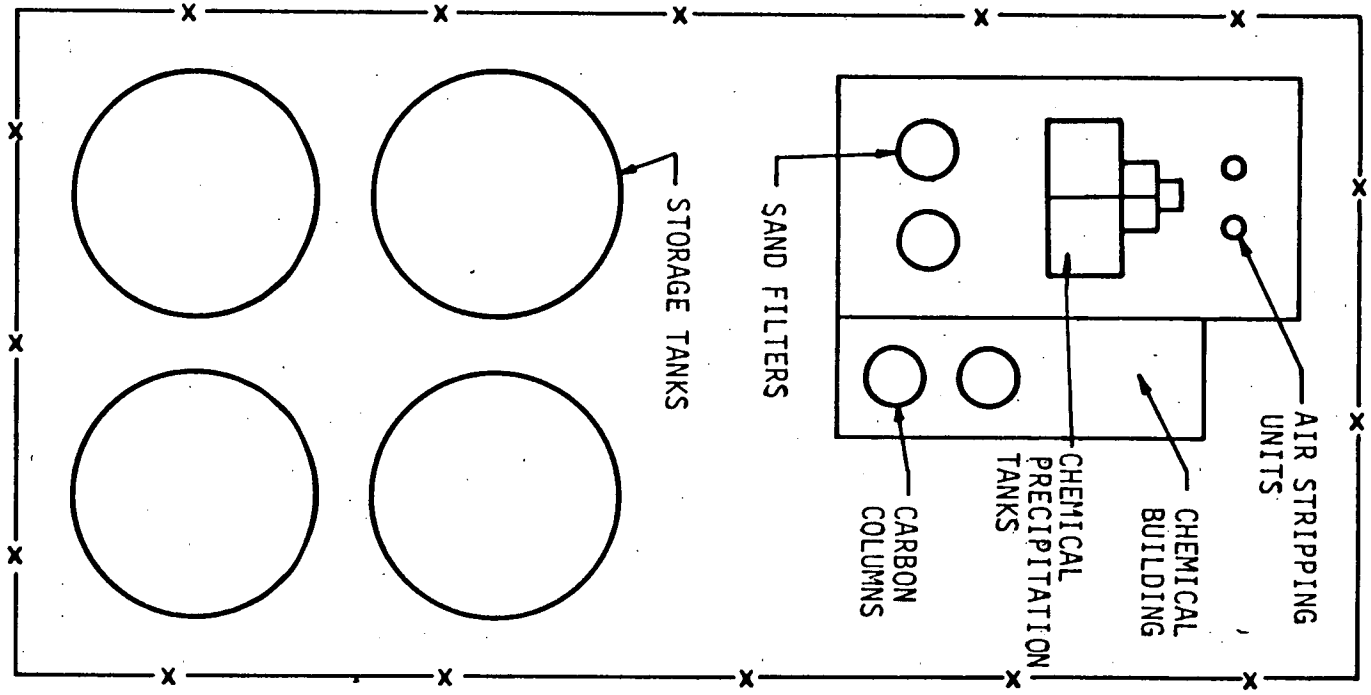
TREATMENT FACILITY SIMPLIFIED PROCESS SCHEMATIC

ZONE 1
FEASIBILITY STUDY

will remove both volatile and non-volatile organic contaminants. BOD and COD will be removed throughout the entire system. Auxiliary treatment processes such as filtration prior to carbon adsorption to remove fines and the addition of sulfur dioxide gas to keep up to 200 mg/l of iron in solution have been included in order to provide a flexible system. Also pH adjustment and mechanical dewatering are included. Preliminary sizing of these unit processes is accomplished by developing the worst case and average case scenarios for each contaminant based on the maximum and average levels of contamination reported in the most recent water quality sampling data and in the drum sampling data. This system should be capable of treating contamination of the type and concentration presently found at the landfill and can be used for alternative comparison purposes. However, this treatment system cannot be represented as being capable of treating all of the possible and as yet unspecified contamination present in the Lone Pine Landfill.

The treatment system will treat the groundwater from both the internal wells and external wells. At a future time, when treatment of the plume is no longer necessary (see section 4), the system will treat groundwater from the internal well system only. The plant effluent will be discharged to either of two storage tanks, each with a 1-day storage capacity, thus allowing the effluent to be sampled and tested prior to discharge to the river. See Figure 3-3 for an illustration of a schematic plant layout. Refer to Figure 3-2 for the treatment process schematic. The design of the system allows for recycling of the groundwater for additional treatment of higher concentration levels (if plant effluent is found not to meet discharge standards, this would entail a temporary shutdown of the groundwater

5304



ZONE 1 **FEASIBILITY STUDY**	LONE PINE LANDFILL FREEHOLD N.J. **SCHEMATIC TREATMENT FACILITY LAYOUT**	CAMP DRESSER & McKEE INC. One World Trade Center, Suite 2637 New York, New York 10048 **FIGURE: 3-3**

pumping system in order to allow additional treatment of the nonconforming effluent). Data from the monitoring program (described later) can be used to modify pumping and treatment rates as necessary. Based on the contaminants known to be present and the treatment process train proposed, sludge which results from the treatment facility is not anticipated to be a hazardous waste. The unknown nature of the contents of the buried drums, however, results in an uncertainty about the classification of future sludges.

The landfill mound would be covered by a multiple-layer surface sealing system which would also include provision for drainage swales to transport rainwater away from the landfill as rapidly as possible. The 45-acre landfill mound is currently covered with a layer of local fill, which would not be disturbed. An allowance of a 1-foot layer of new fill is included to permit grading of the site, with this layer being covered with a 1-foot thick layer of local clay (permeability not more than $1x10^{-7}$ cm/sec), a 1-foot thick layer of fine fill and a 6-inch thick layer of topsoil. The topsoil will then be seeded to stabilize the site. The alternative of using a synthetic membrane instead of clay for the impermeable layer was considered. Either material could achieve the desired degree of impermeability of $1x10^{-7}$ cm/sec. A synthetic membrane, though less costly than a clay layer, has several disadvantages for use at the Lone Pine site: 1) a 50-year design life for the synthetic membrane is questionable; 2) holding the membrane on side slopes would be difficult creating a potential for erosion control problems; and 3) concern for tearing of the continuous membrane would put a limitation on future site activity. At sites such as Lone Pine where the exact nature of the landfill contents is unknown, the predictability of long-term synthetic membrane performance is a concern. Thus, for the purposes of evaluation of alternatives at the Lone Pine site, a clay layer was determined to be the preferable approach to the surface sealing component of the remedial action alternatives. Final decisions on the barrier material will be reserved for the design stage.

556

A gas control system consisting of a series of gas monitoring wells will be provided. No major gas quantity or quality control problems requiring remedial action are anticipated, but periodic sampling from the gas monitoring wells will provide a continuous monitoring mechanism for gas production measurement and analysis. Air-stripping emissions will be controlled by an appropriate air cleaning system, to be determined as part of the forthcoming design step. If the need for removal of contaminated sediments from the Manasquan River and tributaries is determined by the recent additional sediment sampling, sediments would be removed by dredging the width of the stream and a 10-foot wide cut along the tributaries. The leachate ponds onsite are to be dredged after the contents of the pond have been drained and treated. The dredged areas will be filled with clean earth and reseeded for erosion control. The estimated quantity of dredged material is 75,000 to 100,000 cubic yards. It is assumed that the dredged material can be disposed of at the landfill. Should this assumption be found invalid, the dredged material will have to be disposed of at an offsite location, adding to the cost.

The groundwater-and surface water-monitoring program for this alternative would be similar to that of Alternative 1 except that priority and non-priority pollutants would be analyzed semiannually for the first 2 years, and annually thereafter, if the rate of contaminant releases decreases. In addition, treatment plant effluent would be sampled daily for total organic carbon and total organic halides and weekly for volatile organics. This sampling would continue as long as the treatment plant is in operation.

Prior to installation of the surface seal, baseline air monitoring would be the same as described in Alternative 1. Following installation of the surface seal, total hydrocarbon monitoring (and meteorological data collection) would be repeated for 2 months to verify the effectiveness of the surface seal. The four gas monitoring wells to be installed in this alternative would be sampled for methane quar-

terly for the first 5 years, and semiannually thereafter, if no methane problems are determined to exist. Sampling for priority pollutants would be conducted semiannually for the first 3 years and annually thereafter, if contaminant levels are acceptably low. If cover conditions warrant the use of methane vents for pressure relief, some air sampling at these locations could also be undertaken.

Table 3-1 preceding summarizes the elements of the monitoring program for this alternative.

Table 3-2 presents basic design parameters for the treatment system illustrated in Figures 3-2 and 3-3. These parameters are not based on a site-specific pilot plant study or sampling of the landfill contents and are not for final design.

Alternative 2A--Deep Containment Wall With Internal Pumping, Treatment and Discharge

Alternative 2A is identical to Alternative 2 with the exception that no external plume pumping is provided (see Figure 3-4). Thus, an internal well system treatment facility is provided for the life of the project.

Alternatives 3, 3A--Shallow Containment Wall with Internal and Plume Pumping, Treatment and Discharge

Onsite containment is achieved by use of a slurry wall having an average depth of 30 feet and keyed several feet into the Hornerstown formation, an aquitard. This wall will be of the same length, width and construction technique as the deeper wall in Alternative 2 (see Figure 3-5). Groundwater modeling results indicate that contamina-

503

TABLE 3-2

BASIC DESIGN PARAMETERS OF THE TREATMENT SYSTEMS

I. SULFUR DIOXIDE FEED SYSTEM	
Purpose:	Reduction of iron in leachate and maintain in solution until pH is raised for chemical precipitation.
System Type:	Gas
Point of Injection:	Prior to aeration
II. AIR STRIPPING	
Purpose:	Reduce volatile organics in water and reduce organic loadings on carbon adsorbers.
Type of unit:	Packed column
Air: Water Ratio:	Variable
Packing Type:	Polypropylene saddles
III. CHEMICAL PRECIPITATION	
Purpose:	Raise pH with soda ash, oxidize iron and metals, mix, flocculate and settle

559

TABLE 3-2 (continued)

A. Rapid Mixing

Number of Tanks :	1
Detention Time :	5 minutes
Mixing Equipment:	Rapid mixing

B. Slow Mixing/Flocculation

Numbers of Tanks:	2
Detention Time :	15 minutes
Mixing Equipment:	Slow speed flocculators

C. Detention Basin

Number of Tanks :	2
Overflow Rate :	600 gpd/sq ft
Detention Time :	1 hour minimum

D. Chemical Feed System - Soda Ash

Chemical Dosage:	To 300 mg/l

IV. PRE-FILTRATION

Purpose:	Reduce turbidity loading on carbon contactors and remove unreduced iron.

TABLE 3-2 (continued)

Chemical Addition:	Acid for cleaning
Surface loading rate:	1-4 gpm/sq ft
Media:	Sand
Media Depth:	3 ft
Backwash:	To chemical precipitation tank

V. pH ADJUSTMENT SYSTEM

Purpose:	Lower pH to optimal level for carbon adsorption
Chemical:	Hydrochloric acid
Chemical Dosage:	To 3 gpm

VI. GRANULAR ACTIVATED CARBON ADSORPTION

Purpose:	Adsorb non-volatile and remaining volatile organics
Contactor Configuration:	Two stage series
Minimum Carbon Onsite:	20,000 lbs

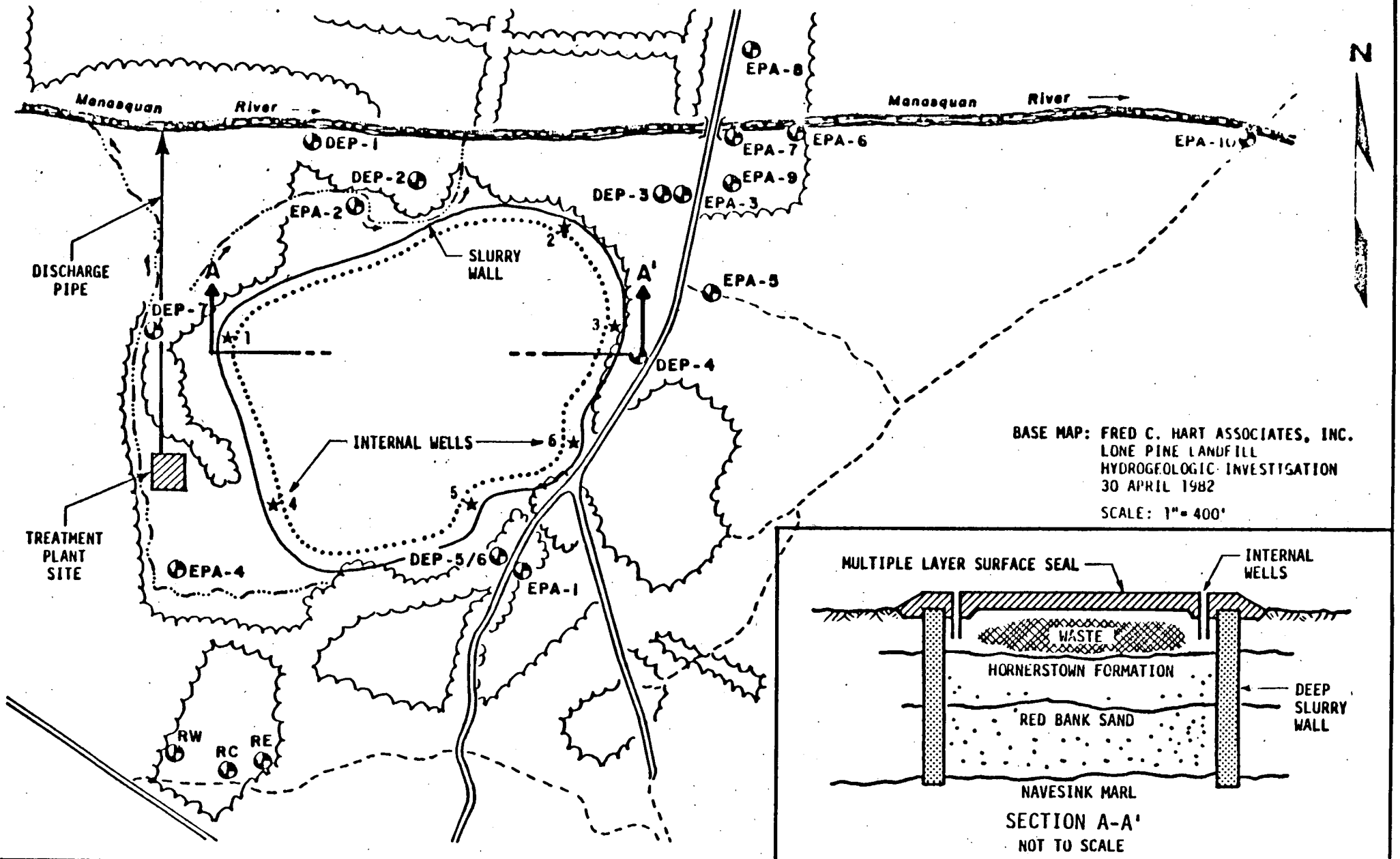
VII. SLUDGE DEWATERING AND REMOVAL

Purpose:	To dewater sludge and remove to a secure landfill

TABLE 3-2 (continued)

Equipment:

Dewatering:	Mechanical dewatering with dry polymer feed equipment
Removal:	One truck and a 30cu yd dump trailer



ZONE 1
FEASIBILITY STUDY

LONE PINE LANDFILL FREEHOLD N.J.

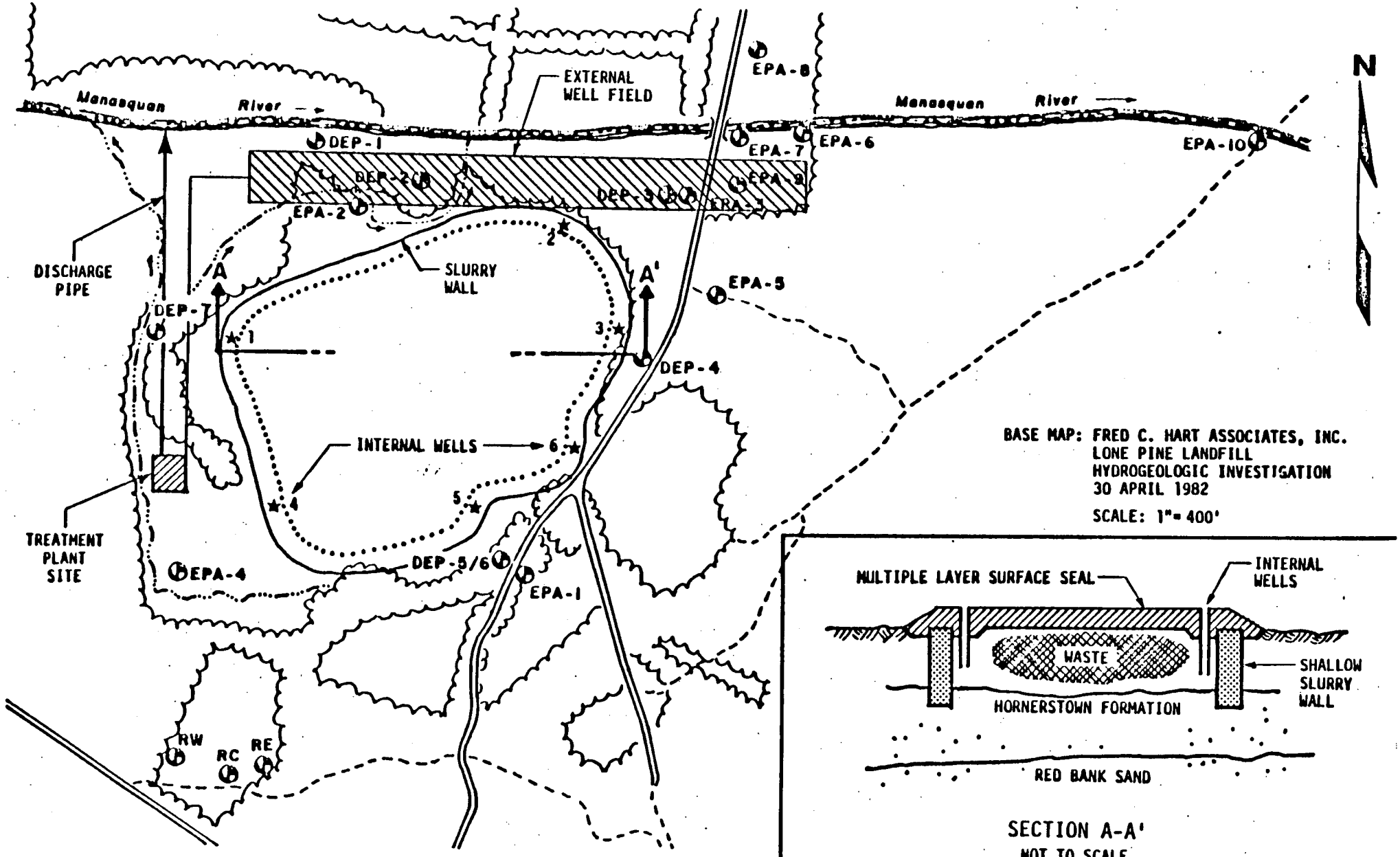
ALTERNATIVE 2A

DEEP CONTAINMENT WALL

CAMP DRESSER & McKEE INC.

One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 3-4



ZONE 1
FEASIBILITY STUDY

LONE PINE LANDFILL FREEHOLD N.J.
ALTERNATIVES 3 AND 3A
SHALLOW CONTAINMENT WALL
WITH PLUME PUMPING

CAMP DRESSER & McKEE INC.
One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 3-5

tion moves toward the river much faster than it moves through the Hornerstown formation into the Red Bank aquifer, and thus a shallow containment wall with internal pumping will provide an equivalent degree of containment of onsite contaminants as a deep containment wall with internal pumping. However, continued migration of contaminants already in the Red Bank formation directly under the landfill is not impeded. The internal pumping system is the same as discussed in Alternative 2. The contaminated groundwater is to be treated and tested as in Alternative 2, prior to river discharge. See Figure 3-5 for an illustration of the components of this alternative. The principal difference between Alternatives 2 and 3 is the depth of the slurry wall.

Alternative 3 features the same plume pumping, treatment and discharge concept as Alternative 2. Alternative 3A differs from Alternative 3 in that the external pumping rate is assumed to be double that of Alternative 3. Surface sealing and sediment control (if necessary) are also provided as described in Alternative 2. A monitoring program would be included as described in Alternative 2.

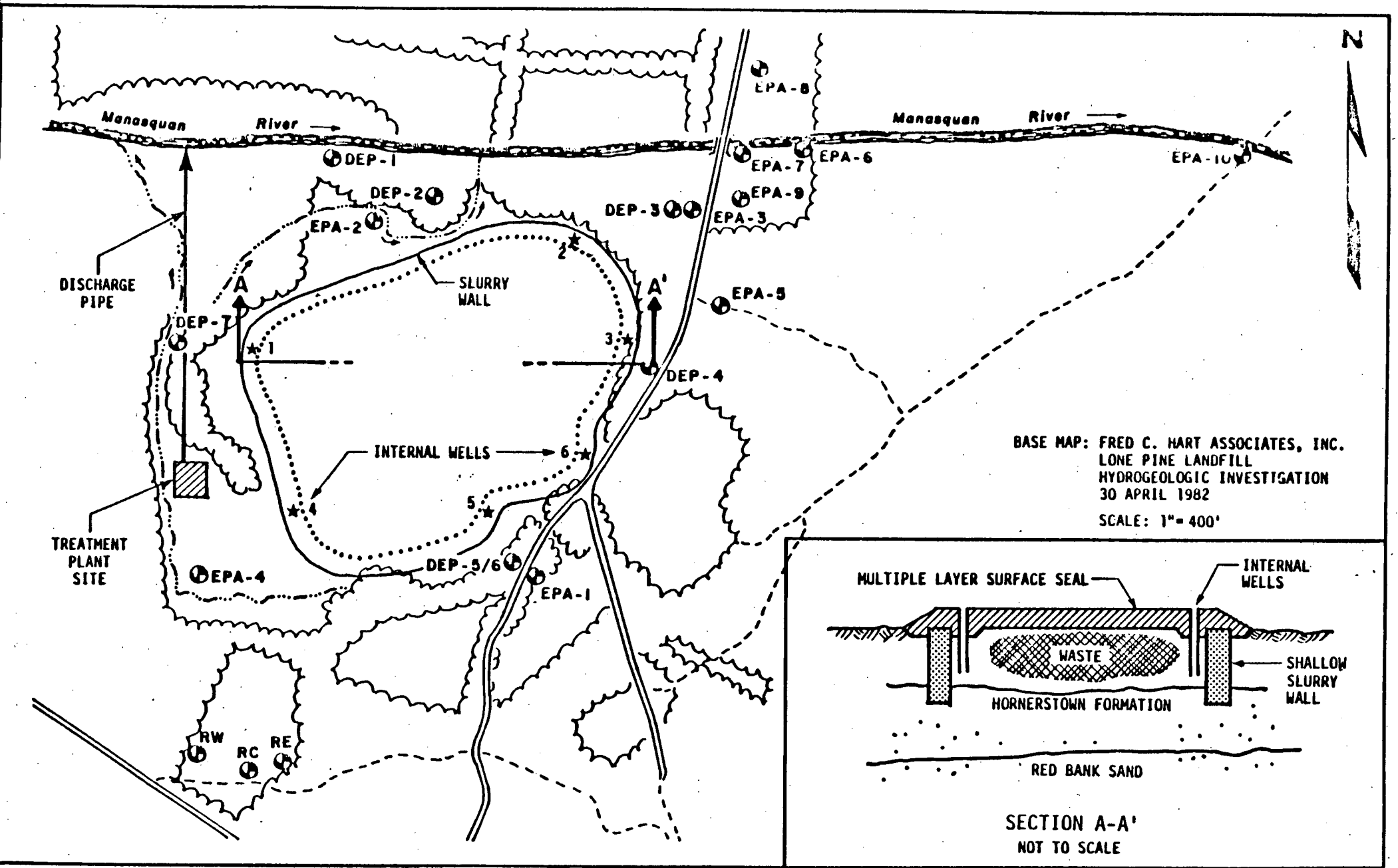
Alternative 3B--Shallow Containment Wall with Internal Pumping, Treatment and Discharge

Alternative 3B is identical to Alternative 3 with the exception that no external plume pumping is provided (see Figure 3-6). Thus, a treatment facility is provided for treatment of the internal well system water only.

Alternative 4--Plume Interception with Treatment and Discharge (No Containment)

This alternative differs from Alternatives 2 and 3 in that no physical onsite containment is provided, but rather a groundwater flow interception system is utilized to collect contaminated groundwater prior to its entering the river. As mentioned previously, the direc-

54



ZONE 1
FEASIBILITY STUDY

LONE PINE LANDFILL FREEHOLD N.J.
ALTERNATIVE 3B
SHALLOW CONTAINMENT WALL

CAMP DRESSER & McKEE INC.
One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 3-6

5-76

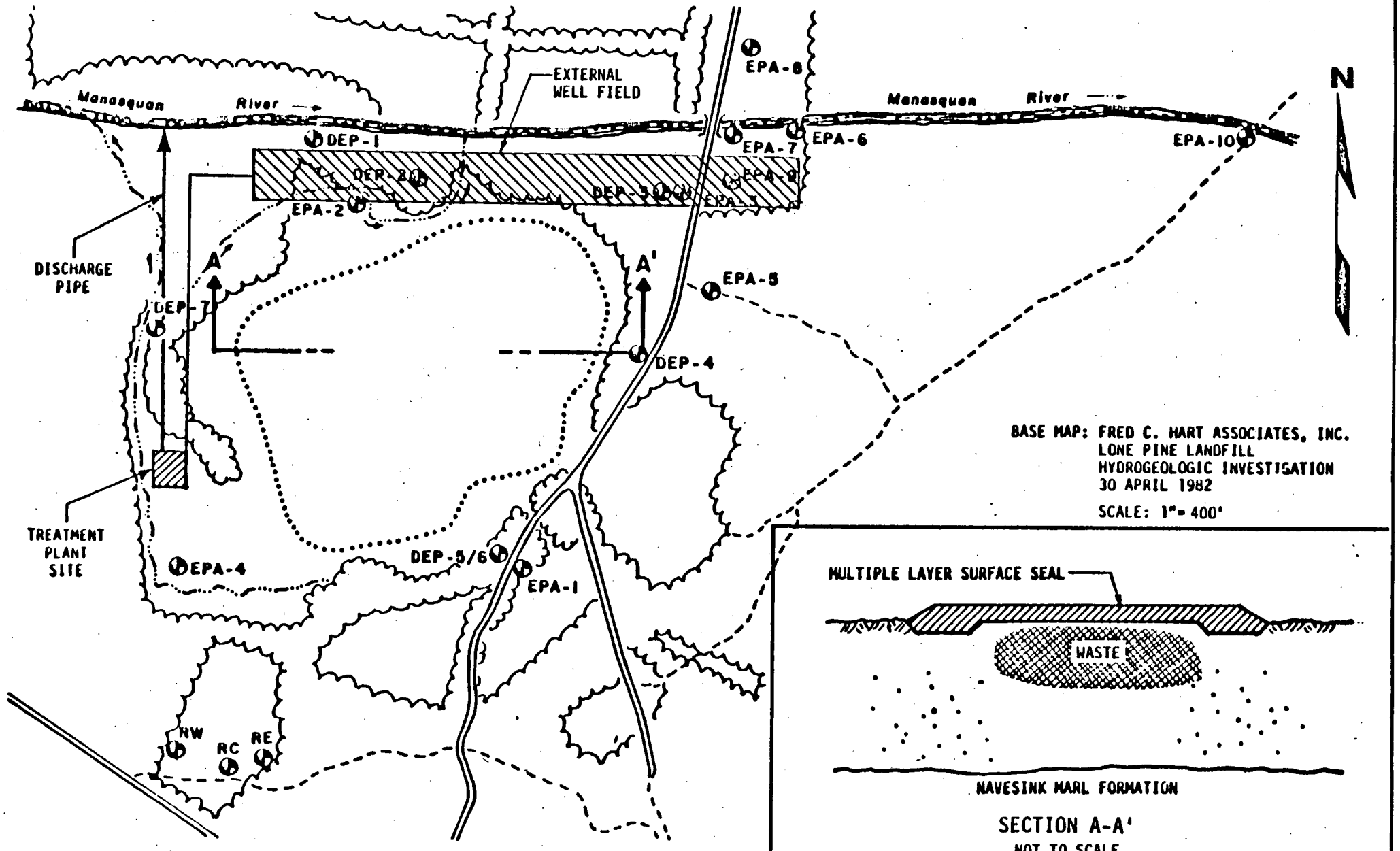
tion of groundwater flow is towards the river, and thus interception wells are only necessary in a zone between the landfill and the river (Figure 3-7). The wells would pump water from the Red Bank formation. Contaminated groundwater would be treated and discharged by the same type of treatment facility as proposed for Alternatives 2 and 3. Surface sealing and sediment control provisions are as described in Alternative 2. Monitoring program provisions are also as described in Alternative 2.

Alternative 4A--Surface Sealing without Interception

In Alternative 4A, the site surface is sealed as in Alternative 4, but there is no external groundwater interception (see Figure 3-8). This alternative examines the effect of simply sealing and closing the landfill.

Alternative 5--Drum Excavation and Removal with Plume Pumping, Treatment and Discharge

The alternative provides for removal by excavation of the buried drums on the site. Estimates of the number of drums at the site range between 30,000 and 50,000 drums. The contaminated earth and the other landfilled material would be left in the landfill, except for the earth removed during the excavation operation. Excavated drums and earth would be sampled and the drums, their contents and contaminated earth would be prepared for transportation off site. The final destination for disposal of the drums would depend on the material found in the drums. The three choices available for this final disposal are incineration, treatment, or disposal in a secure landfill. Because the final disposal of the drum contents depends on their composition, the costs of such an alternative are best estimated on a per drum basis. A contractor would purchase the drums and the contents and dispose of the contents in an approved manner which is most economical to the firm. The excavated earth would be disposed of in an approved secure landfill.

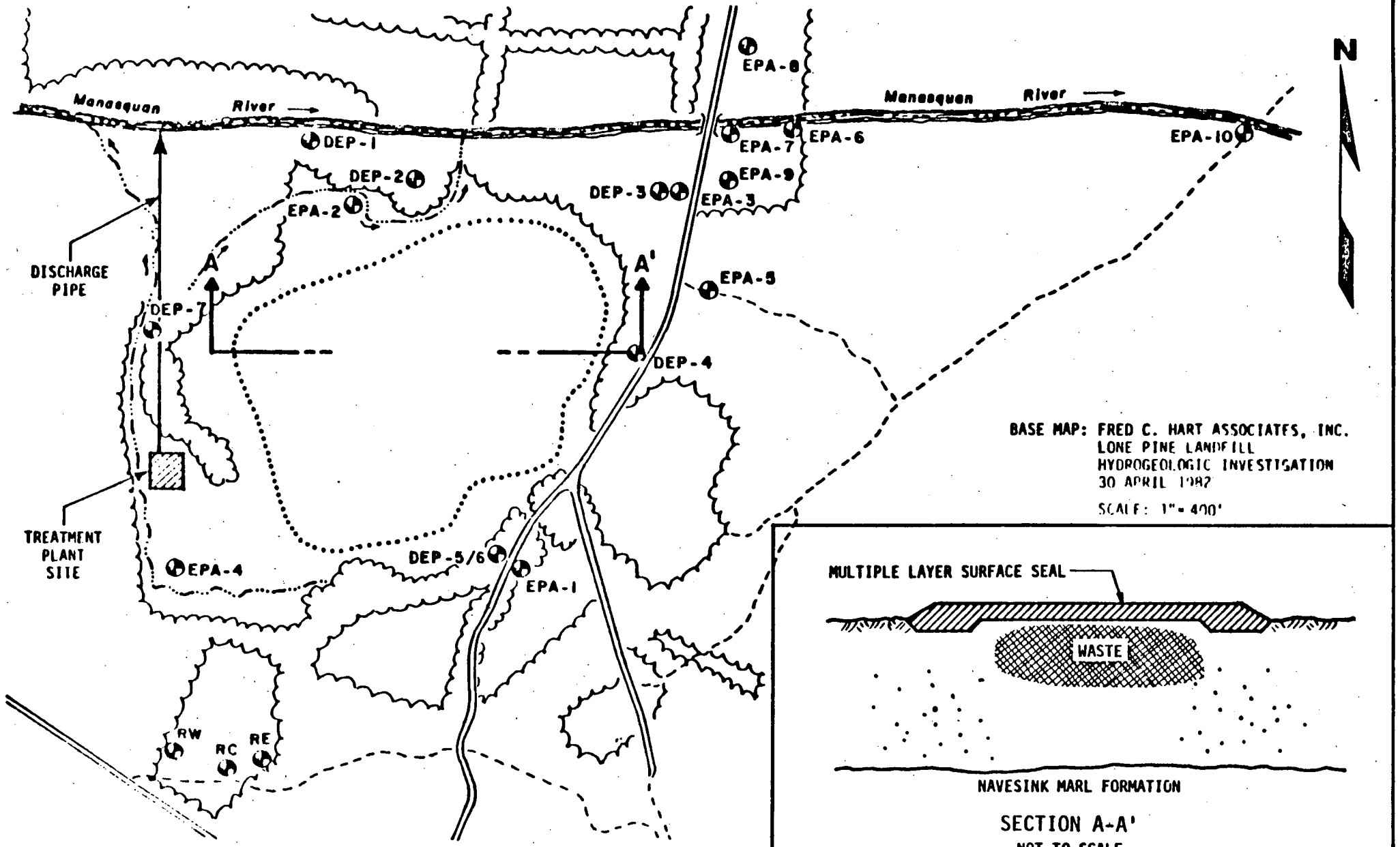


ZONE 1
FEASIBILITY STUDY

LONE PINE LANDFILL FREEHOLD N.J.
ALTERNATIVE 4
PLUME INTERCEPTION
(NO CONTAINMENT)

CAMP DRESSER & McKEE INC.
One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 3-7



ZONE 1
FEASIBILITY STUDY

LONE PINE LANDFILL FREEHOLD N.J.
ALTERNATIVE 4A
SURFACE SEALING ONLY
(NO CONTAINMENT)

CAMP DRESSER & McKEE INC.
One World Trade Center, Suite 2637
New York, New York 10048

FIGURE: 3-8

Although the contents of the drums and some of the surrounding contaminated earth are removed in this alternative, a large area of the landfill mound would still contain contaminated earth and the existing contaminant plume must still be considered. External plume pumping, treatment and discharge is thus included as in Alternatives 2, 3, 3A and 4. Surface sealing and sediment control provisions are as described in Alternative 2. Monitoring program provisions are also as described in Alternative 2. This alternative was not specifically simulated by the groundwater computer model (see section 4). However, in terms of the groundwater model, it is similar to Alternative 4, particularly in the short-term. After implementation, Alternative 5 would resemble the illustration for Alternative 4 (Figure 3-7).

Section 4

4.0 COMPUTER MODELING

4.1 GENERAL

The modeling of groundwater flow and contaminant transport is a multistage process as shown in Figure 4-1. Beginning with a review of existing field data and previous engineering analyses, an initial understanding of the system behavior is gained. This information forms the basis for a conceptual model of the aquifer flow regime and, where appropriate, contaminant plume configuration. The conceptual model describes in qualitative terms the boundary conditions, direction of flow, recharge, anisotropy, stratigraphy, current plume configuration and probable contaminant sources. As depicted by the return arrow in Figure 4-1, the conceptual model may be subject to revision as additional information is gathered and synthesized. From the conceptual model and the field data, the input to the numerical solution technique (computer model) is generated. The input consists of preliminary estimates of system parameters, hydrologic stresses, and boundary conditions. The results of the initial computer simulations are closely reviewed during calibration and verification--an iterative process in which numerical estimates of aquifer property values are balanced against the simulated hydrologic stresses to reproduce observed data, such as piezometric heads or contaminant concentrations. The final stage of the modeling effort consists of utilizing the calibrated model to predict the impacts of future activities near the landfill.

Two computer models were used in analyzing groundwater flow and contaminant transport in the Lone Pine Landfill: DYNFLO and DYNTRACK. DYNFLO (DYNamic FLOw simulation code) was constructed to simulate the

102

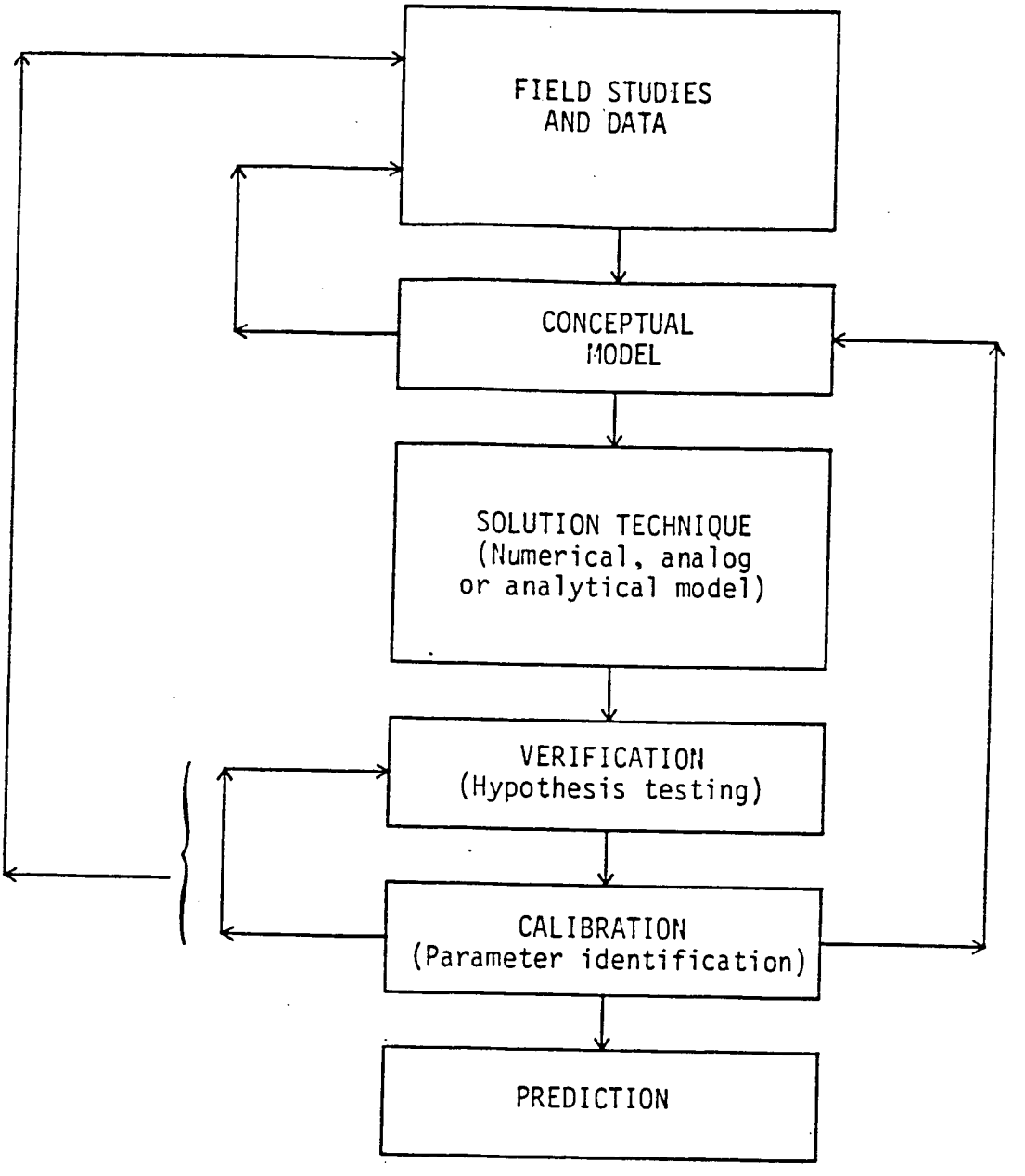


FIGURE 4-1: The Modeling Process

From: Wilson, J.L., Analytical Methods in Groundwater Hydrology, Boston Society of Civil Engineers Section of ASCE, Geotechnical Lecture Series for 1981, "Groundwater Hydrology," March 10, 1981, Cambridge, MA.

present and future groundwater flow regimes in the local aquifers. DYNTRACK (DYNamic particle TRACKing routine) was used to track the movement of contaminants from the landfill based on the flow fields generated by DYNFLO. A brief overview for each code is provided in sections to follow.

DYNFLO - Brief Description

DYNFLO is a three-dimensional groundwater flow simulation program that uses the Galerkin finite element formulation. This code was developed at CDM based on the earlier code AQUIFEM, which was developed at the Massachusetts Institute of Technology. The program can be used to represent fully three-dimensional groundwater flow, or it can simulate quasi-three-dimensional flow by assuming horizontal flow in the aquifer layers and essentially vertical flow in the semi-pervious (leaky) layers between aquifers. A fully three-dimensional flow representation was used in the Lone Pine simulations.

Based on the conventional equations of flow in porous media, DYNFLO can be used to simulate the transient response of groundwater flow systems to several types of natural and artificial stresses. The program employs linear finite elements, induced infiltration from streams, artificial and natural recharge or discharge, and non-homogeneous and anisotropic aquifer hydraulic properties. It solves both linear (confined) and non-linear (unconfined) aquifer flow equations, and includes special routines to handle a change in status from confined to unconfined conditions. The program has a "rising water" scheme to allow drainage to local streams if the piezometric head in a phreatic aquifer rises to the elevation of the streambed. DYNFLO also has special algorithms to treat the problem of multi-level pumping.

604

CDM has developed several data management and graphic display programs associated with DYNFLO. This associated software allows for input data and results processing, including tabular listings, time history plots, cross-sectional data displays, and contour plots.

Appendix A provides more details on groundwater flow theory, and how it is simulated by DYNFLO. Appendix A also demonstrates the validity of DYNFLO by comparing its results to theoretical, analytically derived solutions to selected groundwater flow systems.

DYNTRACK - Brief Description

DYNTRACK is the companion contaminant transport simulation program for DYNFLO. It is described in detail in Appendix B. DYNTRACK was developed at CDM, and uses DYNFLO-simulated flow fields as the basis for predicting the movement of pollutant particles within the groundwater system.

DYNTRACK can perform either simple, single-particle tracking or model three-dimensional mass transport for conservative and first order decay constituents. Single-particle tracking is used to follow the expected path of a conservative substance, to outline an expected volume of contamination, and to estimate time of pollutant travel. The single-particle tracking capability is used for "first-pass," screening-level approaches in analyzing the extent of aquifer contamination, identifying pollutant sources, and formulating conceptual mitigation strategies. The mass transport section of the code utilizes the "random walk" method for statistically significant numbers of particles, each particle having an associated mass and decay rate.

605

Pollutant concentrations are computed as the total particle weight divided by the finite element volume in which the particles reside during a time step. DYNTRACK can also simulate dispersion by imparting a random deflection (based on an underlying probability density function) to each particle in each time step. Thus, DYNTRACK can simulate the mass transport phenomena of convection, decay, and dispersion.

4.2 DATA SOURCES/EXISTING INFORMATION

Prior to application of mathematical modeling to simulate conditions at a site, a conceptual model of the physical system is formulated. The conceptual model is developed through a review of existing data, previous engineering analyses, and pertinent literature. Important factors to consider when modeling a groundwater flow system include:

- o the regional/site climatology
- o characterization of regional/site topography and drainage
- o characterization of regional/site geology
- o review of surface/subsurface flow field data.

In modeling contaminant transport an accurate and detailed source characterization proves invaluable. This should include the nature and origin of the contaminants; where, how, and when they were stored; and the existing and projected condition of the storage media. In addition, the existing state of the plume, potential modes of contaminant transport, decay, and adsorption characteristics of contaminants in the local area should be identified.

606

At the Lone Pine Landfill site several sources of information were identified and used in this formulation. These are listed below:

(1) Lone Pine Landfill Hydrogeologic Report, Fred C. Hart Associates, Inc., TDD #02-8105-05B/E, April, 1982.

(2) Geophysical Investigation for Buried Drums at the Lone Pine Landfill, Technos, Inc., TDD #F2-8105-05, August, 1981.

(3) Lone Pine Landfill Preliminary Aquifer Testing, Task Report to the Environmental Protection Agency, Contract No. 68-01-6056, TDD #02-8105-05G, June, 1982.

(4) Groundwater Resources of Monmouth County, New Jersey, Leo A. Jablonski, Special Report No. 23, State of New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply, 1968.

(5) Records of Wells and Groundwater Quality in Monmouth County, New Jersey, Water Resources Circular 2, State of New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply, 1959.

(6) Hydrogeologic Conditions in the Coastal Plain of New Jersey, Eric F. Vowinkel and W. Kendall Foster, U.S. Geologic Survey, Open File Report 81-405, 1981.

(7) Geology of Monmouth County in Brief, Paul B. Dahlgren, State of New Jersey, New Jersey Geological Survey, 1977.

(8) Water Resources Data for New Jersey, Part 1, Surface Water Records, U.S. Department of the Interior, Geological Survey, 1980.

607

(9) Groundwater Management Flow for Study Area I, Coastal Plain Formations, Camp Dresser and McKee, Inc. for Delaware River Basin Commission, March, 1982.

4.3 OVERVIEW OF THE LONE PINE SITE

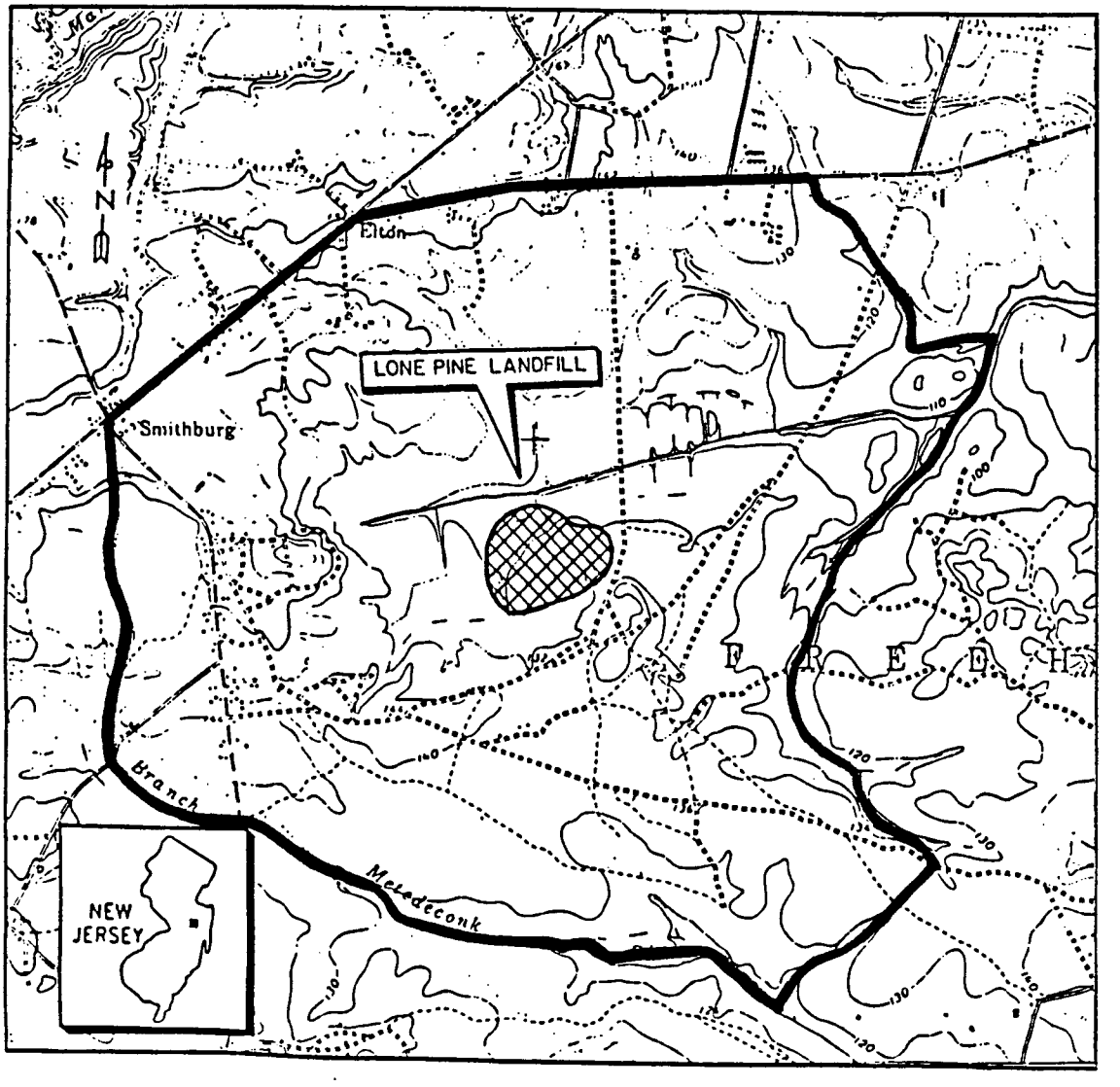
Lone Pine Landfill is situated at the headwaters of the Manasquan River Watershed in Monmouth County, New Jersey. The Manasquan River Basin lies within the Atlantic coastal plain physiographic province and ultimately discharges to the Atlantic Ocean. The basin is characterized as having low topographic relief and good drainage. The climate of the county is classified as moderate in terms of temperature, humidity and precipitation. Average annual precipitation totals 44.7 inches, and is relatively evenly distributed throughout the year. Mean annual temperature for the region generally ranges from 50°F to 55°F.

The site, shown in Figure 4-2, covers approximately 45 acres of a 144-acre parcel owned by the Lone Pine Corporation of Freehold, New Jersey. The northern edge of the landfill lies just south of the Manasquan River at a distance ranging from 500 to 1000 feet. It is bordered on the east and on the south by Burke Road. To the west of the landfill is an undeveloped swampy area, which drains northerly into the Manasquan River.

Site Geology

Geologic formations in the basin are comprised of marine and continental sedimentary rock, chiefly of late Cretaceous and Tertiary age. These rocks are composed of sands, silts, and clays with minor amounts of gravel. Locally, indurated sand and silt beds have also been identified. In general, formations in the basin dip gently to the southeast at a slope of approximately 50 feet per mile.

609



Scale 1"=2600'

Figure 4-2: Lone Pine Landfill - Site Location Map

The landfill is situated at the northern edge of an outcrop of Vincentown Sand. In Monmouth County, this formation is predominantly composed of a fine to medium grained quartz sand. The formation has also been described as micaceous, clayey, glauconitic, calcareous, and fossiliferous ((4)--see list of references in section 4.2). Vincentown Sand rests unconformably on the Hornerstown formation, which outcrops north of the landfill in a narrow band between the landfill and the Manasquan River.

The Hornerstown Sand, also referred to as the Hornerstown Marl, unconformably overlies the Red Bank Sand, and dips to the southeast at 50 to 60 feet per mile (4). In the vicinity of the site, the marl is composed of a clayey, glauconitic, very fine to fine sand with trace amounts of silt and mica. Throughout the county this formation has hydraulically been referred to as an aquiclude or confining bed. However, in the vicinity of the site, where it ranges in thickness from 10 to 12 feet, it is thought to function more as an aquitard or semi-confining bed between the Vincentown and Red Bank formations (1).

The Red Bank Sand lies conformably on the Navesink formation in Monmouth County. It consists of an upper layer composed of a clayey, glauconitic, indurated Tinton Sand and a lower layer composed of a medium to fine grained, very micaceous, clayey, glauconitic sand. The Tinton Sand layer is included with the upper Red Bank layer to be consistent with previous work at the site conducted by the USEPA Field Investigation Team (FIT).

A cross sectional plot illustrating the stratigraphy from well logs in the vicinity of the landfill is shown in Figure 4-3. In the Red Bank formation, several distinct stratigraphic beds were identified. These included, from top to bottom: a silt and fine sand zone; a zone of indurated Tinton Sand; a poorly sorted, coarse sand zone; and a second zone of silt and fine sands. None of the borings near the site penetrated a glauconitic clay member or the Navesink formation as described above.

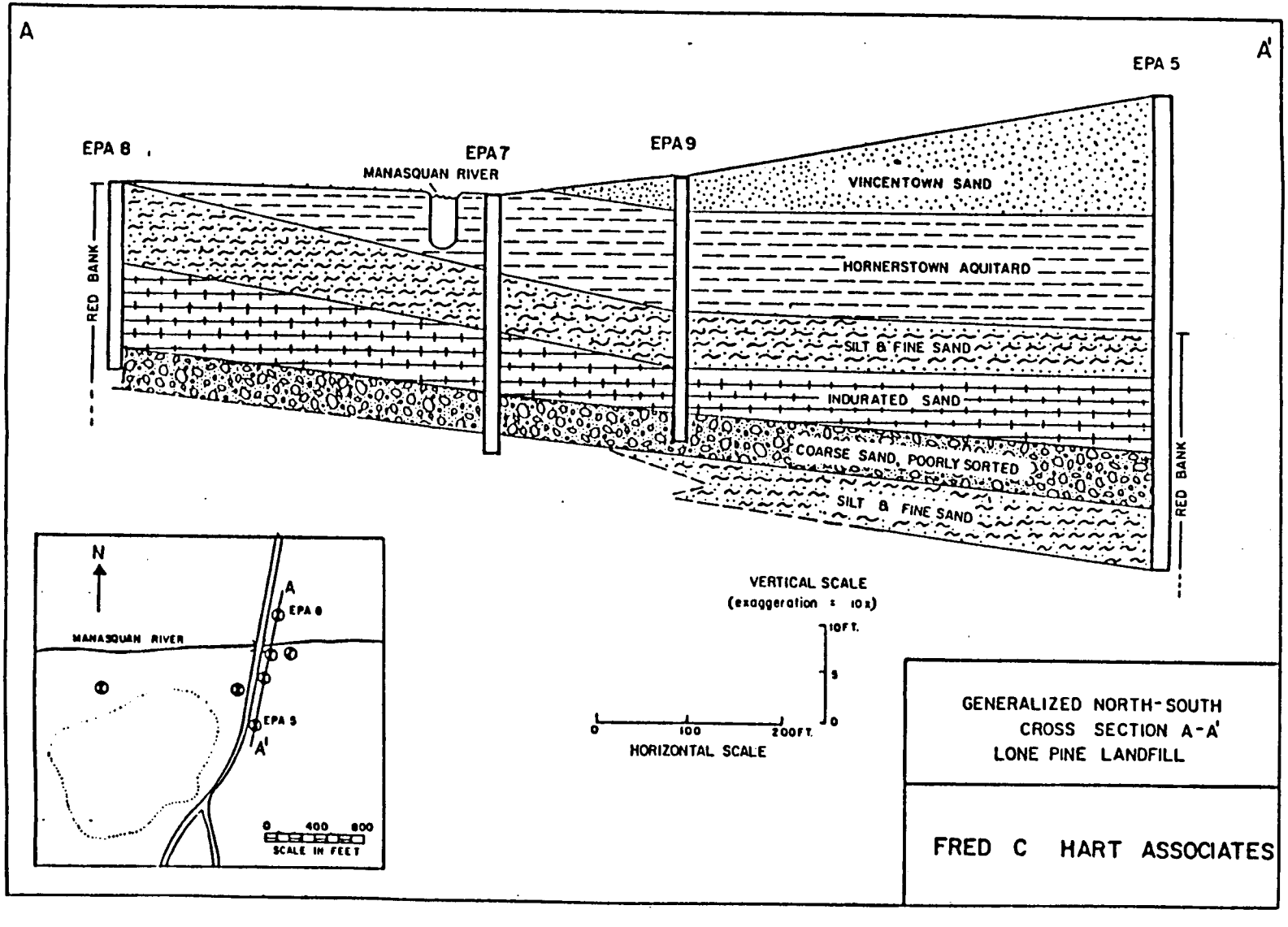


FIGURE 4-3: Cross Sectional Plot illustrating vertical stratigraphy at Lone Pine Landfill from Hart(1).

NOTE: This description was adopted from the cited report and may not agree with the New Jersey Geological Survey

4.4 SITE CONCEPTUALIZATION

Formulation of a conceptual model of the system began with the identification of hydrologic drainage divides for the headwaters subbasin of the Manasquan River Watershed (see Figure 4-2). North and west of the site, a surface water divide between the Manasquan River and Manalapan Brook extends roughly along New Jersey Rt. 537 from just south of Smithburg through West Freehold. The southwestern and southern boundary for the basin, separating overland flow to the Manasquan River from flow to the North Branch of the Metedeconk River, is best described as lying along the unimproved road from Smithburg to Georgia. East of the site, the Manasquan River Basin extends to the Atlantic Ocean; a reasonable eastern boundary of the conceptual model was assumed to extend from Georgia to West Freehold.

General observations with regard to groundwater flow characteristics for the area described above were then formulated. Judgment indicated the presence of a groundwater divide between the Manasquan River and the North Branch of the Metedeconk River south of the site. Although its exact location could not be pinpointed during preliminary formulation, it appeared to correspond roughly with the surface water divide between Smithburg and Georgia. Coupling this observation with water elevations reported at the 27 monitoring wells encircling the site, the north to northeasterly groundwater flow direction across the site was reasonably well established. In addition, a preliminary estimate for the area of groundwater recharge to surficial aquifers flowing beneath the site could be made.

North of the Manasquan River, similar reasoning indicated a south to southeasterly flow direction for the aquifers simulated. Furthermore, potentially high groundwater recharge areas for the lower stratigraphic formations were identified as lying north of this river where surface formations were found to pinch out.

Measured pollutant concentrations in close proximity to the landfill at the monitoring wells also assisted in the conceptual formulation of groundwater flow through the system, and preliminary assumptions concerning the degree to which the Hornerstown formation functioned as a confining bed were developed. Since volatile organics, as well as other constituents, were measured in high concentrations in lower layers it was apparent that a downward vertical gradient from the Vincentown to the Red Bank formation exists over the landfill and that the Hornerstown formation did not function as a confining layer. In addition, since upward vertical gradients between the landfill and the river were measured, it seemed likely that contaminants in lower layers would migrate upward and eventually discharge to the river itself.

The extent to which underlying groundwater aquifers contribute to flow in the headwaters reach of the Manasquan River was established from a more general descripton of aquifer hydraulic characteristics in Monmouth County. It was indicated that the Navesink formation underlying the Red Bank could be considered impermeable in conjunction with clay layers found in the lower Red Bank. This, therefore, was assumed to provide a lower boundary for simulating groundwater flow and contaminant migration at the site.

4.5 MODEL FORMULATION

The finite element grid constructed to model aquifer response at the Lone Pine Landfill site is shown in Figure 4-4. System boundaries, as illustrated, extend well beyond the limits of the landfill and represent the assumed lateral extent of the flow system simulated. The plan grid is composed of 219 node points, which define in plan view a total of 406 elemental plan areas. The increased density of nodes toward the center of the grid provides finer resolution within the area of greatest interest, and minimizes computer costs by not simulating in excessive detail at the edges of the grid.

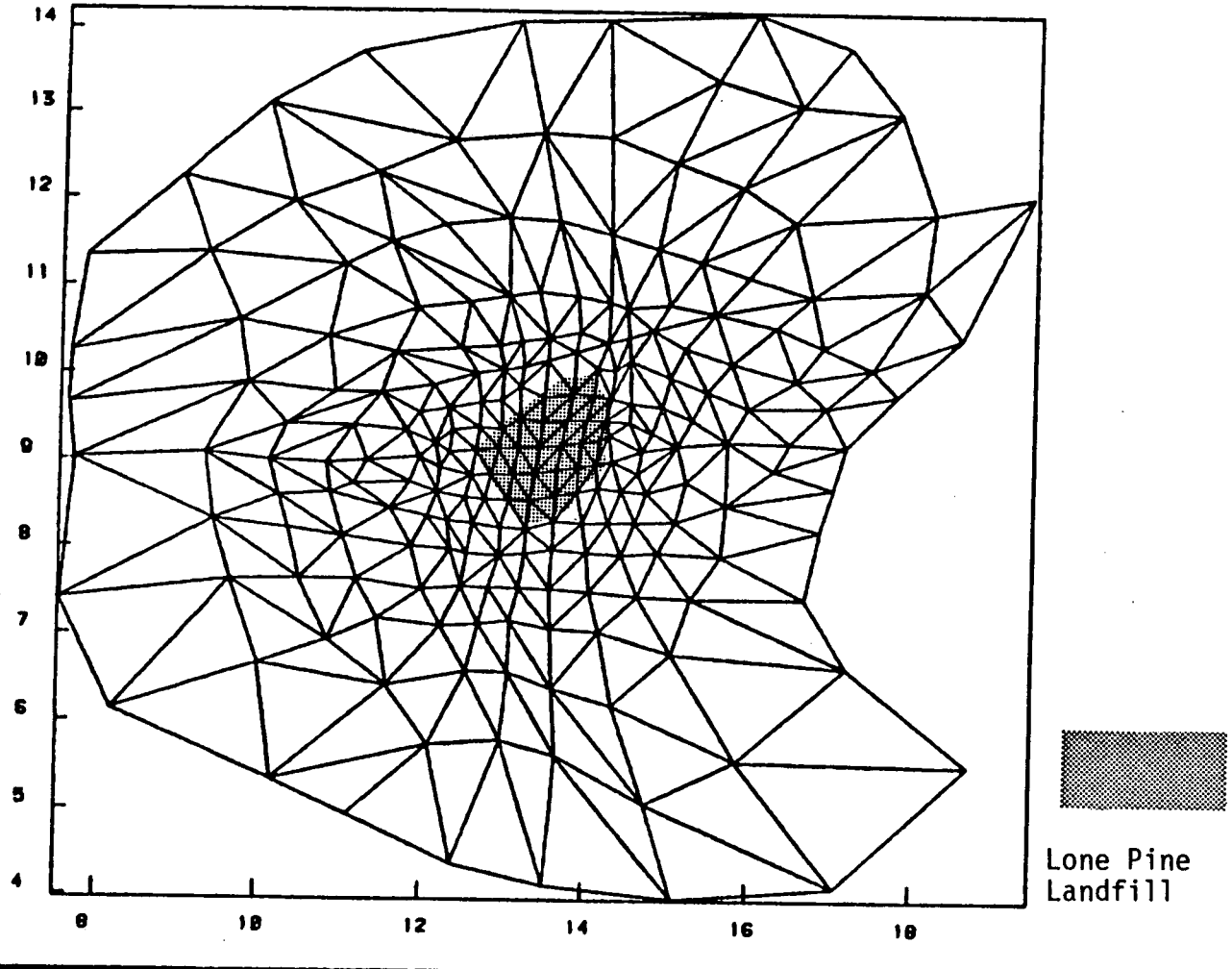


FIGURE 4-4: HORIZONTAL FINITE ELEMENT GRID USED IN SIMULATIONS

Project grid coordinates are based on the New Jersey Coordinate System. These have been simplified, however, for project purposes through the following transforms:

Project X Coordinate = East/West N.J. Coordinate - 2,080,000

Project Y Coordinate = North/South N.J. Coordinate - 490,000

In defining the horizontal limits of the model as outlined in Figure 4-2, a northern boundary was established extending from Smithburg along New Jersey Rt. 537 through Elton, then along New Jersey Rt. 524 approximately 1.1 miles to a small southerly flowing tributary to the Manasquan. This corresponds to the estimated divide location. The western boundary extended due south from Smithburg along a feeder stream to the North Branch of the Metedeconk River.

A no-flow boundary condition was assumed (see Appendix A for a detailed description of boundary conditions) along the western and northern limits of the simulation. This condition applied to all levels of the grid, as will be described later. Although the intermittent tributaries and highways along this boundary do not represent true groundwater divides for the aquifers simulated, the boundary conditions assigned are sufficiently removed from the area of interest such that all hydrologic stresses applied in the model will not be affected by this assumption. Therefore, they provide a sufficient starting point for simulation.

The southern boundary extended approximately 1.75 miles along the North Branch of the Metedeconk from its intersection with New Jersey Rt. 524 south of Smithburg.

615

Along the North Branch of the Metedeconk River a fixed-head boundary at all levels was assumed at an elevation equal to that of the stream bed. This assumption implies that all aquifers in the system are in direct hydraulic connection with the river along this reach. Although this assumption was not explicitly verified by field study, a true groundwater divide exists between the landfill and the North Branch which effectively nullifies any impact of this assumption on simulation at the site.

The eastern limit of the simulation extended along a northerly flowing tributary joining the Manasquan near the confluence of the southerly flowing intermittent tributary from New Jersey Rt. 524. The southeastern limit followed a southerly flowing tributary to the North Branch. Fixed-head boundary conditions for each node were specified. This condition, however, only applied to the surficial nodes, and a no-flow condition at lower nodes was simulated. This specifies a known fixed condition for simulation of the surficial aquifer without attempting to fix leakage characteristics for the remaining layers.

For surficial nodes along the Manasquan River and its tributaries, the "rising water" feature of DYNFLO was invoked. This permits water to leave the system at surficial nodes (i.e., permits groundwater discharge to streams), given that the computed phreatic water surface elevation exceeds ground surface or stream bed elevations at those nodes. In other words, water surface elevations were not externally fixed along the Manasquan River unless computed elevations indicated that water was flowing in the river. This condition also implies that the Manasquan River itself is not a source for induced infiltration to lower layers. This has been substantiated by field measurements, which indicate that an upward gradient exists from lower aquifers along this reach.

Aquifer response in the vicinity of the Lone Pine Landfill was simulated, as illustrated in cross section by Figure 4-5, with a 4 layer (5 level) vertical discretization in the DYNFLO groundwater flow simulation program. Layer 1, representing the lower limit of the system, was used to simulate the lower Red Bank aquifer, defined as the poorly sorted coarse sand zone. At the bottom of layer 1 (level 1) vertical leakage was assumed to be zero. Layer 2, the upper Red Bank aquifer, was defined as a composite layer composed of the indurated Tinton Sand and the silt and fine sand layer. Layer 3 represented the semi-confining Hornerstown aquitard, composed primarily of silt with some clay and fine to medium sand. Layer 4 defined the Vincentown formation, a medium sand with trace amounts of silts and clays. At the outer horizontal limits of simulation this layer was also assumed to include the Kirkwood formation, which is hydrogeologically similar to the Vincentown.

The vertical stratigraphy at each nodal point in the grid was assigned for each of the layers previously defined. Establishment of elevations for each of the five levels was based on depths reported in the boring logs compiled by the USEPA Field Investigation Team (FIT) contractor during monitoring well installation, well logs extracted from "Records of Wells and Groundwater Quality in Monmouth County, New Jersey," regional strike and dip characteristics for the formations present, and surface topographic mapping.

Elevations for level 1 were developed by contouring well log elevations within the study area and assuming that regional strike and dip prevailed at outlying nodes. For level 2 a relatively uniform thickness was reported at each of the EPA wells. Therefore, a mean thickness of 8 feet was added to level 1 elevations to define the upper limit of layer 1 (level 2).

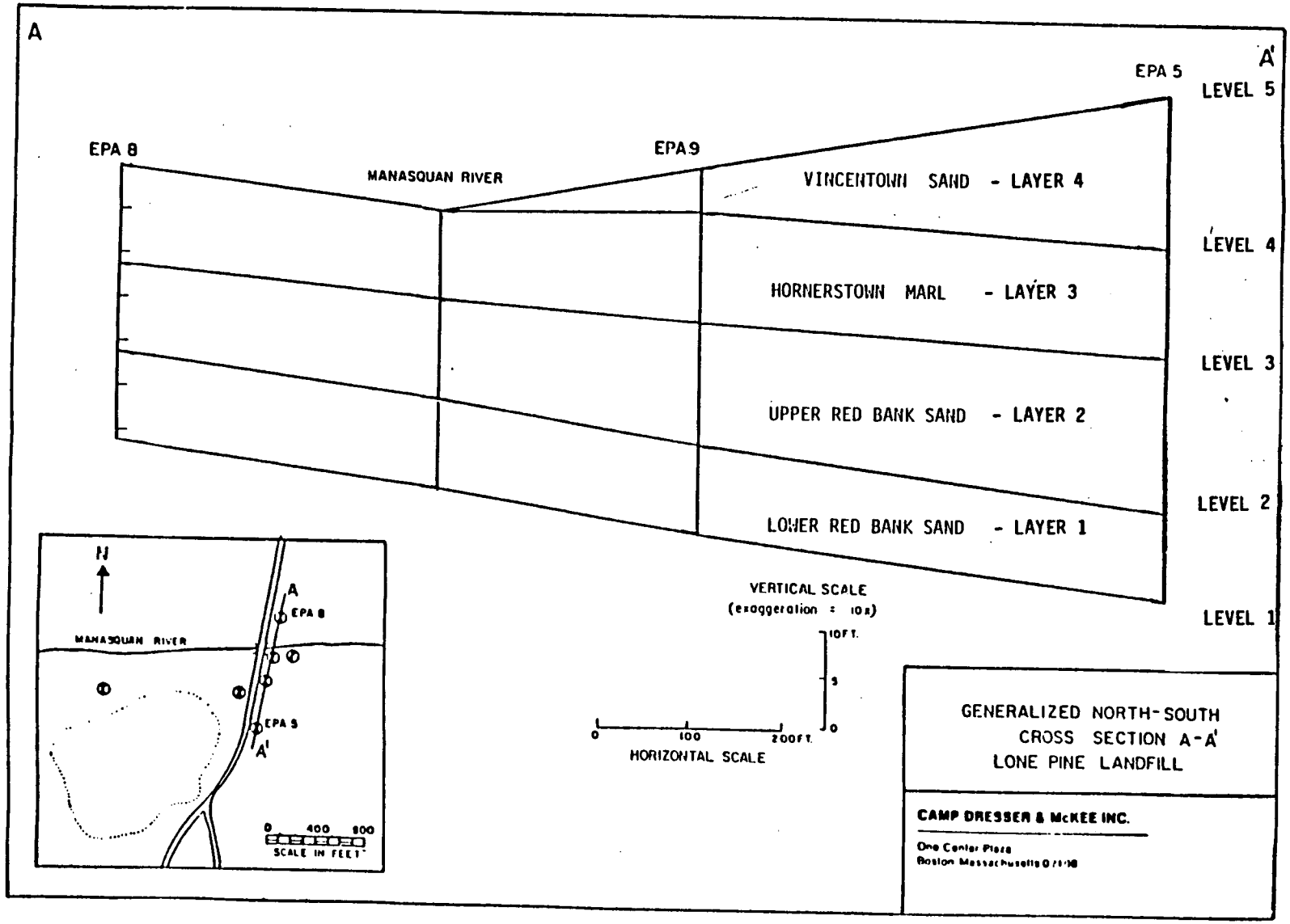


FIGURE 4-5: Cross Sectional Plot of Simulated Vertical Stratigraphy

619

Elevations for levels 3 and 4, defining the lower and upper limits of the Hornerstown formation and the thickness of the upper Red Bank aquifer were set in a similar fashion. Noting that reported elevations of the lower limit of the Hornerstown corresponded to reported regional strike and dip, EPA well logs were used as a reference point, and elevations were established at each node through extrapolation. For level 4, a mean layer thickness of 10 feet was used and adjusted, where appropriate, if the computed elevation exceeded ground surface elevations. Finally, elevations for the top layer were obtained directly from topographic mapping. Elevation contours for each level are shown in Figures 4-6 through 4-10.

Note that when a layer physically pinches out, as in the case of the Vincentown formation north of the landfill, the thickness of the modeled layer is set to zero. For example, elevations depicted in level 5 do not necessarily imply the existence of the Vincentown, but are intended to establish ground surface elevations over the grid.

4.6 INITIAL PARAMETER VALUE ESTIMATES

An initial set of aquifer properties had to be estimated and used in performing the first simulation. These initial estimates provided the starting point for the calibration process. The model results in connection with observed water surface elevations are then used to indicate how initial property estimates are adjusted or refined, as the calibration approaches observed conditions in the actual aquifer system.

Hydraulic and storage property parameters are specified for each model element. The initial model conceptualization identified four types of hydrologically similar strata. Their associated initial properties are listed in Table 4-1.

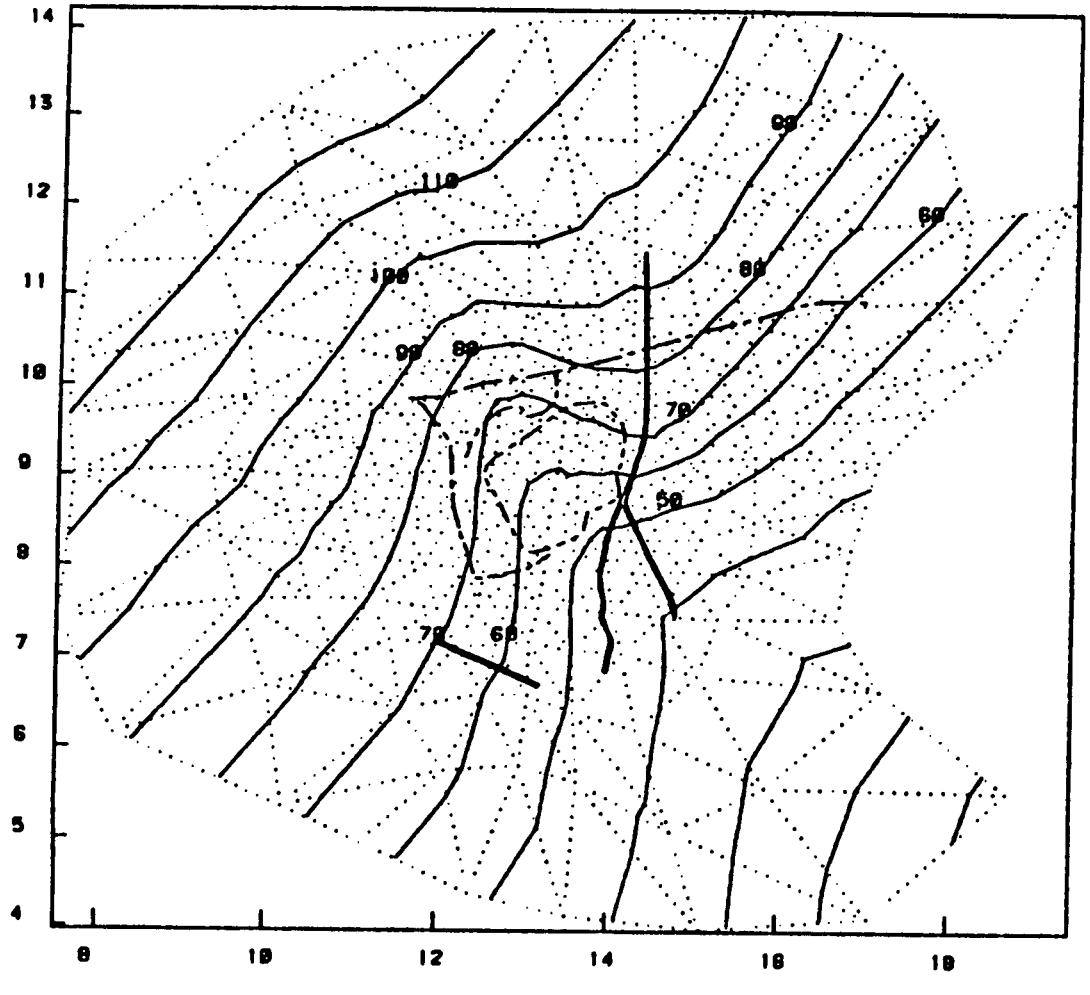


FIGURE 4-6: LEVEL 1 (LOWER LIMIT OF LOWER RED BANK AQUIFER) ELEVATION CONTOURS

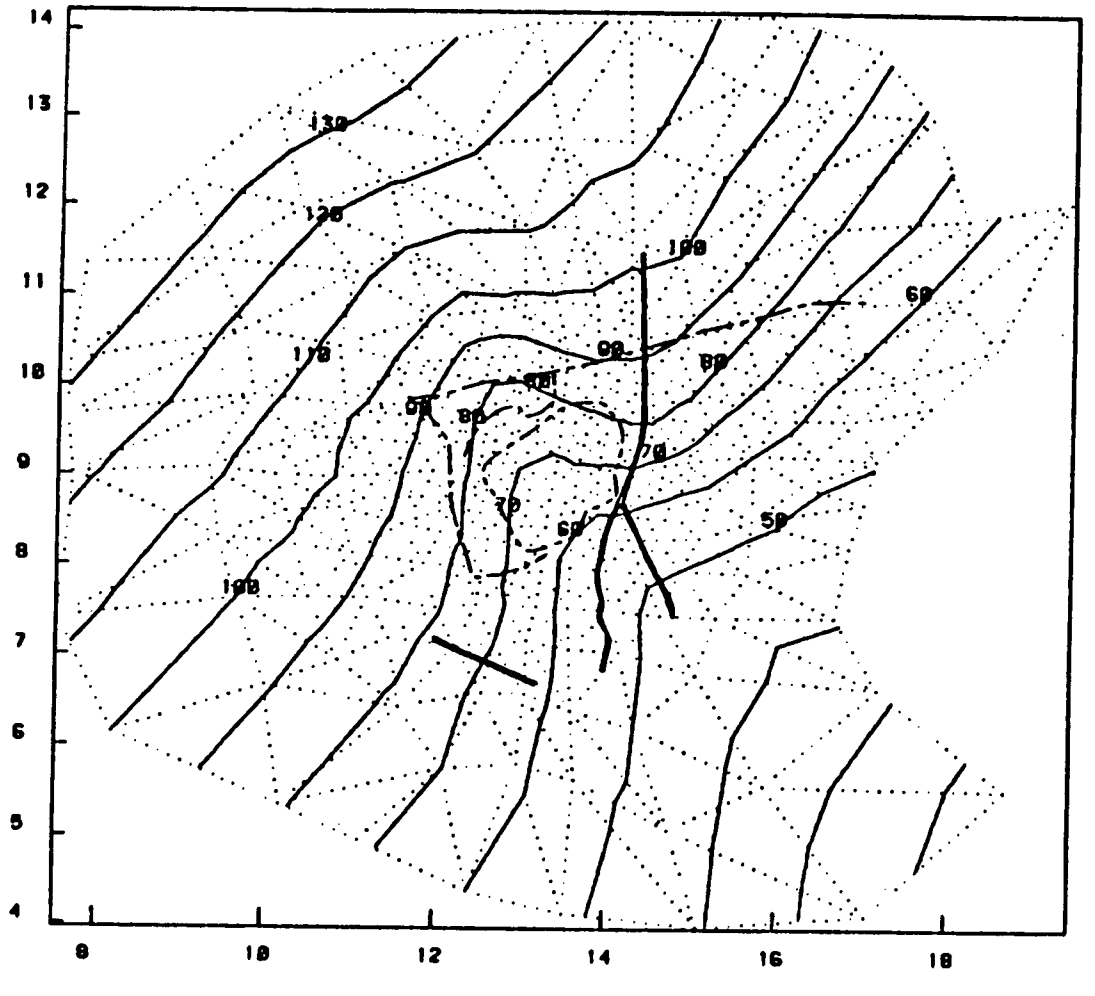


FIGURE 4-7: LEVEL 2 (LOWER LIMIT OF UPPER RED BANK AQUIFER) ELEVATION CONTOURS

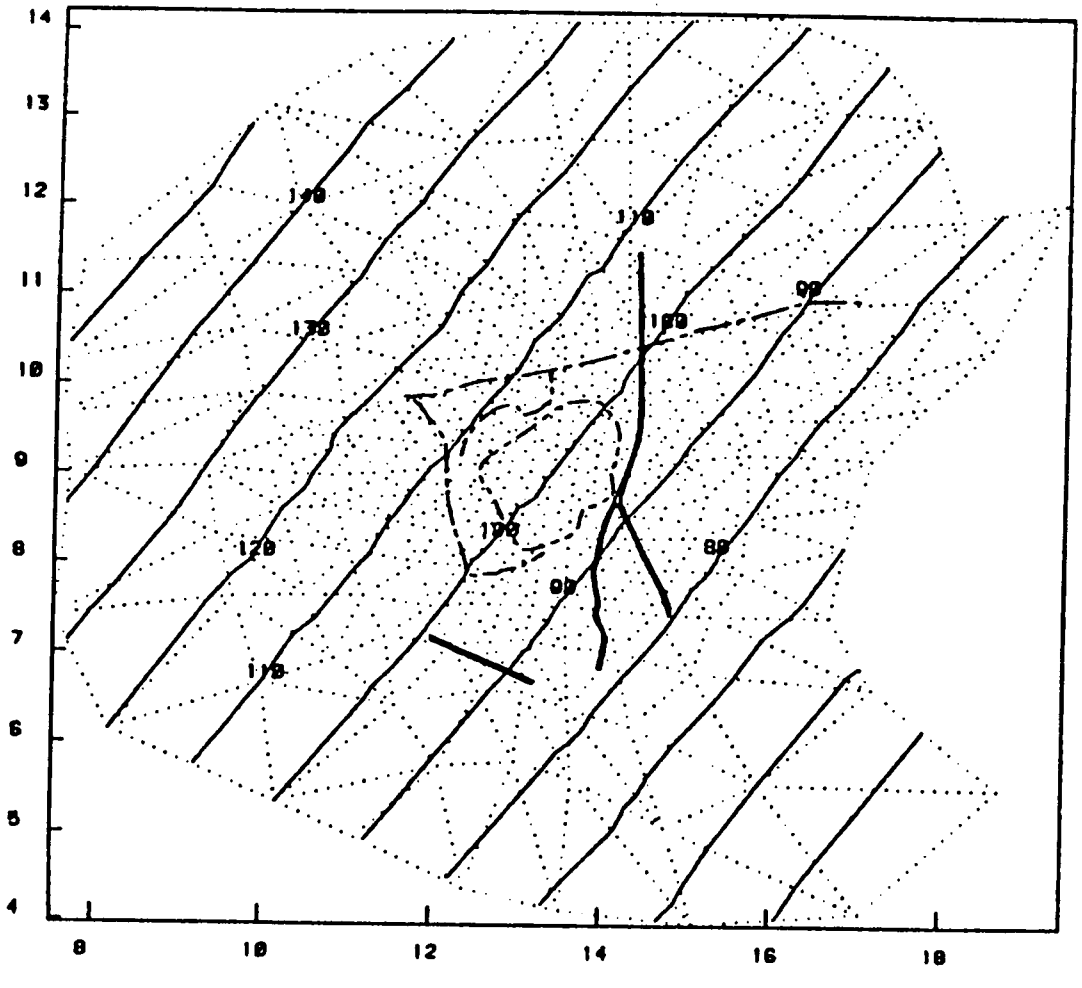


FIGURE 4-8: LEVEL 3 (LOWER LIMIT OF HORNERSTOWN AQUITARD) ELEVATION CONTOURS

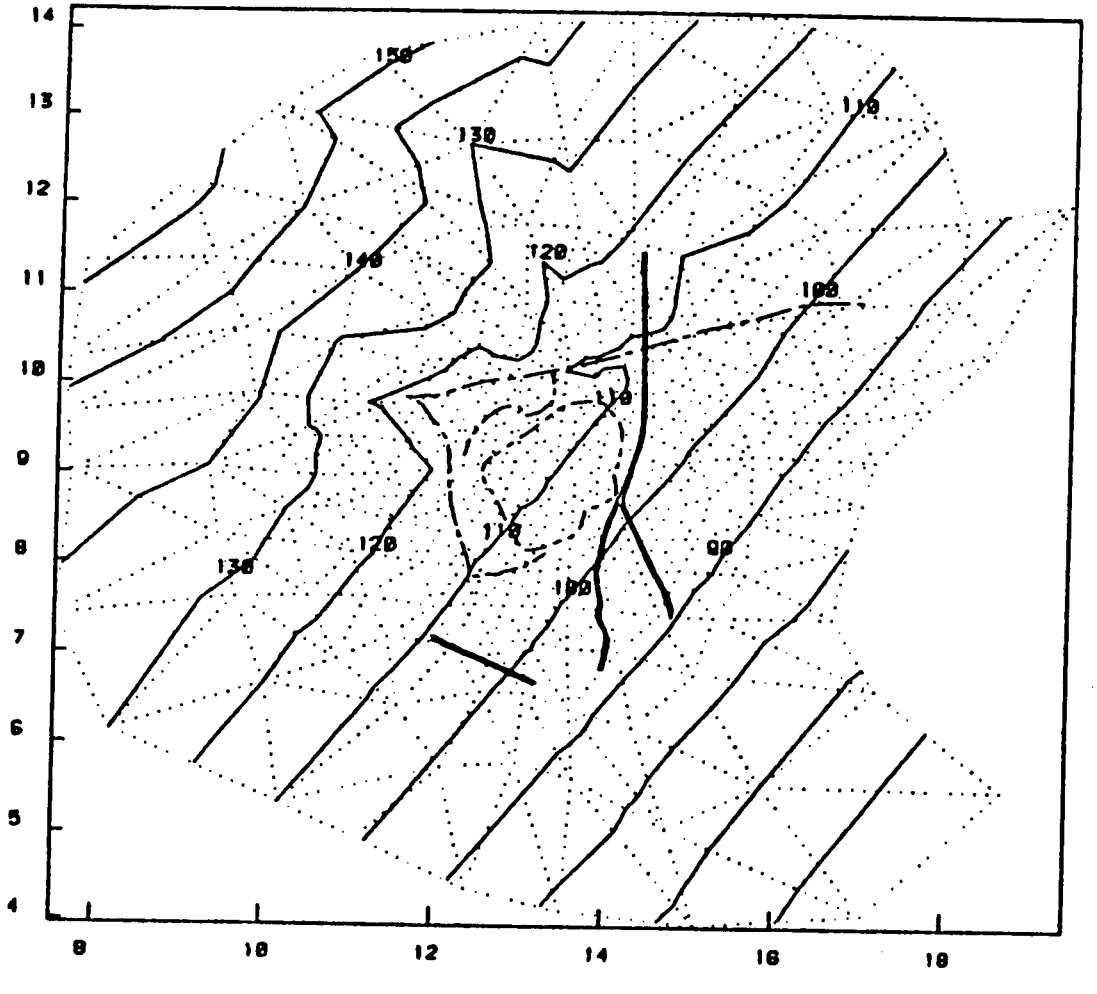


FIGURE 4-9: LEVEL 4 (LOWER LIMIT OF VINCENTOWN AQUIFER) ELEVATION CONTOURS

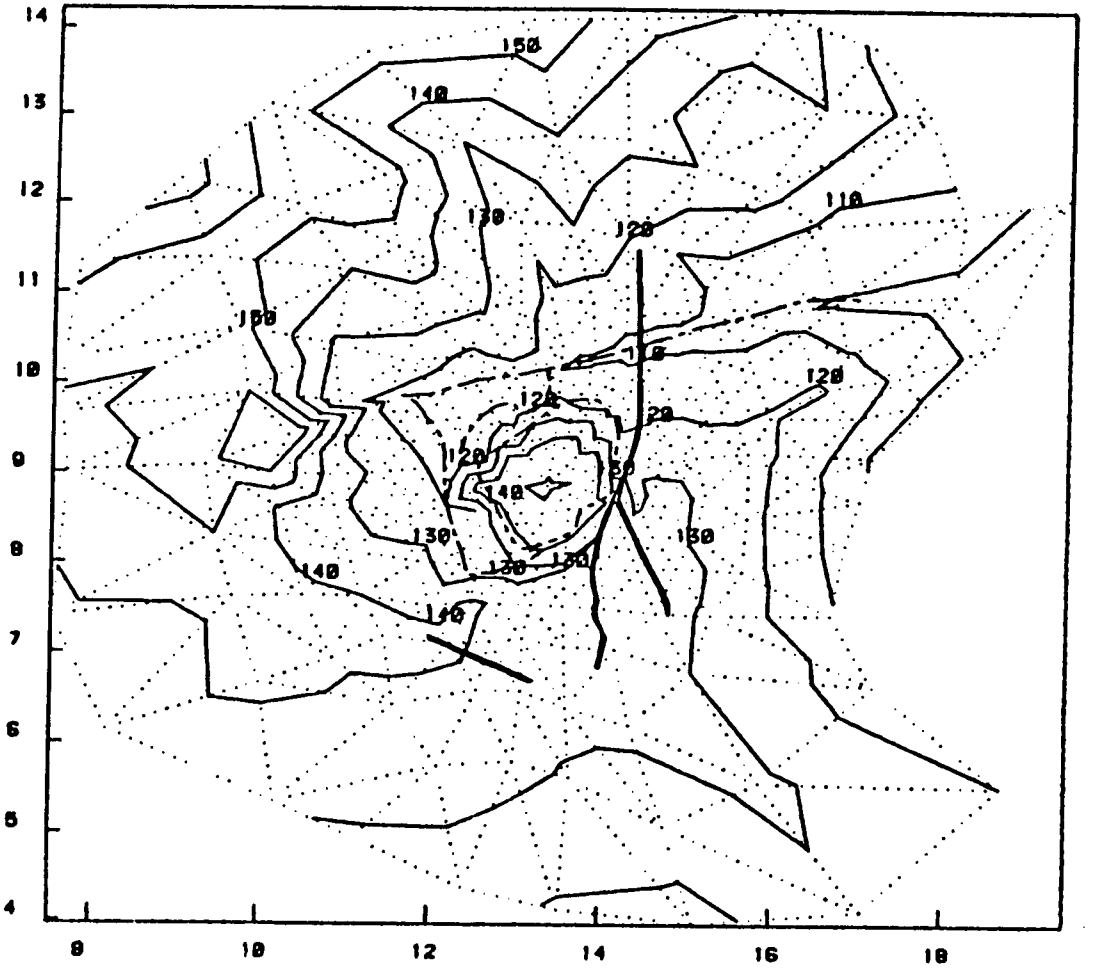


FIGURE 4-10: LEVEL 5 (UPPER LIMIT OF VINCENTOWN AQUIFER) ELEVATION CONTOURS

TABLE 4-1

INITIAL ELEMENT PROPERTY ESTIMATES BY LAYER

Parameter	Layer Number* 1	2	3	4
Horizontal Hydraulic Conductivity (feet/day)	60	4.0	1.0	40
Vertical Hydraulic Conductivity (feet/day)	6	0.4	0.1	4
Recharge Flux (feet/day)	0.0043	0.0021	0.0011	0.0043
Storativity	5×10^{-6}	5×10^{-6}	1×10^{-4}	5×10^{-6}
Specific Yield	0.2	0.2	0.3	0.2

*Note: Layer numbering scheme begins at the lowest formation and increases toward ground surface.

The values of the storage parameters, specific yield and storativity, were based on engineering judgement and previous experience with similar formations in coastal plain sediments. Values for these parameters could not be estimated directly from the step pump test results. Moreover, the storage coefficients typically vary over a narrow range of values, and aquifer response is significantly more sensitive to hydraulic conductivity estimates.

Initial horizontal and vertical hydraulic conductivities for each layer were estimated based upon review of the transmissivity and associated aquifer thickness values reported by Hart (1982). These were computed using a weighted average of the results obtained from wells screened at corresponding layers. These were, however, adjusted prior to simulation to reflect relative flow field characteristics observed during previous field investigations. Vertical hydraulic conductivity values were developed through the assumption that an anisotropy ratio of 0.10 exists for each layer. This value for the anisotropy ratio has been found to be appropriate in several previous investigations in similar formations.

The surface recharge flux value of 0.0043 feet per day adopted represents a flux or recharge value of 18.8 inches on an annual basis (approximately 42 percent of rainfall). Note, however, that values of recharge flux are applied only to "working" elements at the surface level of nodes as determined in the solution process.

4.7 FLOW MODEL CALIBRATION

The flow model was calibrated to steady-state or equilibrium conditions. The calibration process consisted of systematically adjusting DYNFLO element properties and boundary conditions until simulated

piezometric heads matched measured heads to within a reasonable tolerance limit. In addition, simulated flow fields were studied and compared with previously assumed flow fields from the conceptual model.

Interim Calibration Results

Twelve equilibrium (steady-state) calibration runs were made before computed heads were accepted as being representative of the observed heads. It would not be useful to the reader to have all of the interim parameter changes discussed herein. Instead, a brief discussion of changes made to depict each of the major hydrologic features of interest in the model is given below. Many of these changes occurred simultaneously, and consequently, the following description should not be construed as a chronological representation of the calibration efforts.

The important hydrologic features that were incorporated into the model are:

- the hydraulic connection between piezometric gradients measured within and directly north of the landfill
- the hydraulic connection between each aquifer simulated and the Manasquan River
- the presence of a "fractured zone" or zone of high hydraulic conductivity in the vicinity of the intersection of Burke Road and the Manasquan River.

The existing steady-state flow field in the vicinity of the landfill was evaluated based on groundwater elevations recorded during the period December, 1981 through August, 1982 coupled with surface water

characteristics of the surrounding area. Water surface elevations were reported at each of 10 deep and 10 shallow EPA monitoring wells installed by FIT; 7 wells installed by the owner to meet conditions required for a NJDEP landfill operating permit; and at 3 abandoned domestic wells designated RW, RC, and RE located south of the landfill. Well locations are shown on Figure 4-11. Water level measurements are listed in Table 4-2 and pertinent well installation data are summarized in Table 4-3. Note that no wells were installed within the landfill itself.

These data indicate that the direction of groundwater flow for the surficial or Vincentown aquifer is in a northerly direction across the landfill having an average gradient of 0.006 ft/ft. Directly west of the landfill the direction of groundwater movement is the same; however, the average gradient increases to 0.01 ft/ft as it approaches the Manasquan River. In general, field data for the surficial aquifer appear reasonable with respect to surface topographical features and stratigraphic characteristics.

Data collected in the Red Bank aquifer revealed that flow in the Red Bank Sand is in a northeasterly direction across the landfill to the Manasquan River, gradually turning eastward paralleling the direction of flow in the Manasquan. Although previous analysis has indicated the potential exists for flow in the Red Bank along a trough south of the stream bed, additional field study would be required to pinpoint the location of any trough. The data do, however, indicate the presence of a depression in the potentiometric surface centered around Burke Road and the Manasquan River. This coincides with drilling reports that indicate the indurated Tinton Sand layer in the vicinity may contain horizontal fractures capable of transmitting significant quantities of water. Estimated flow rates in this zone were reported to be 55 and 200 gpm during the installation of wells EPA-6 and EPA-7, respectively (1).

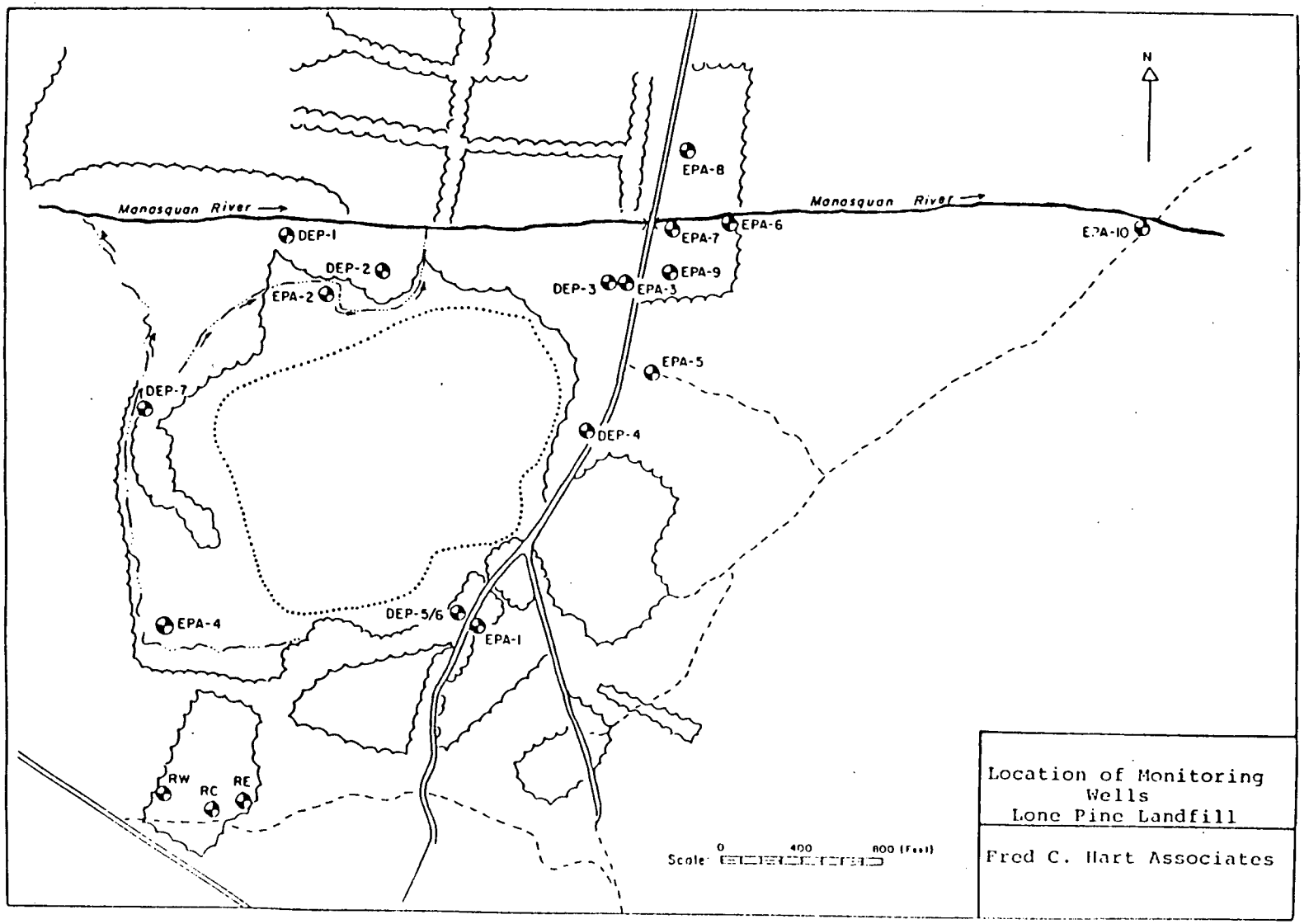


FIGURE 4-11: Monitoring Well Location Map (From Hart(1982))

TABLE 4-2

SUMMARY OF WATER LEVEL MEASUREMENTS
(from Hart(1982))

Well #	Top of Inner Casing Elevation (Feet)	Water Level Elevations in feet above Mean Sea Level					
		12-8-81	12-31-81	1-4-82	1-27-82	2-26-82	3-31-82
EPA-1	131.02	123.79	124.76	125.76	125.65	126.04	125.78
EPA-1A	130.27	122.08	122.66	123.08	123.28	123.48	123.51
EPA-2	120.29	115.56	115.65	116.22	115.74	115.72	115.76
EPA-2A	120.71	117.32	117.38	118.41	117.67	117.48	117.40
EPA-3	116.04	112.59	112.37	113.74	112.60	112.36	112.19
EPA-3A	114.77	112.59	112.63	113.78	112.91	112.75	112.61
EPA-4	125.24	122.84	-	-	121.74	121.78	121.76
EPA-4A	124.70	120.59	120.95	121.87	121.46	121.49	121.41
EPA-5	121.10	-	117.49	118.33	117.87	117.76	117.68
EPA-5A	119.67	-	112.57	113.67	112.90	112.77	112.66
EPA-6	112.27	-	107.61	109.51	107.34	107.74	107.57
EPA-6A	111.41	-	112.55	-	112.99	112.70	112.76
EPA-7	112.10	-	107.61	108.75	107.76	107.70	107.57
EPA-7A	110.17	-	-	-	112.90	112.69	112.66
EPA-8	113.27	-	110.52	111.67	110.64	110.47	110.46
EPA-8A	113.08	-	112.61	-	-	112.72	112.67
EPA-9	113.41	-	110.41	111.60	110.62	110.38	110.49
EPA-9A	112.46	-	113.27	113.88	113.06	113.11	113.17
EPA-10	108.60	-	-	-	105.84	105.60	105.37
EPA-10A	107.89	-	-	-	107.56	107.50	107.43
DEP-1	118.95	116.40	116.46	117.61	116.71	116.58	116.49
DEP-2	118.26	115.52	115.48	116.46	115.71	115.64	115.61
DEP-3	114.39	111.73	111.46	112.71	111.73	111.48	111.43
DEP-4	123.64	120.40	120.30	121.21	120.61	120.28	120.16
DEP-5	134.36	123.98	125.05	125.85	125.95	126.32	126.14
DEP-6	131.58	122.05	122.64	123.06	123.23	123.41	123.44
DEP-7	122.59	118.78	118.67	120.43	119.11	118.68	118.57
RE	138.01	-	128.01	128.12	129.51	130.27	130.20
RC	133.04	-	128.67	128.86	129.75	130.47	130.41
RW	139.25	-	-	-	130.22	130.97	130.95

TABLE 4-2 (Cont'd.)

SUMMARY OF WATER LEVEL MEASUREMENTS
LONE PINE LANDFILL

Well #	Top of Inner Casing Elevation (Feet)	Water Level Elevations in feet above Mean Sea Level					
		5-4-82	6-4-82	7-15-82	8-16-82		
EPA-1	131.02	127.09	126.68	125.54	124.48		
EPA-1A	130.27	124.15	123.79	123.16	122.45		
EPA-2	120.29	115.81	115.78	115.65	115.54		
EPA-2A	120.71	117.64	117.34	116.69	116.34		
EPA-3	116.04	112.49	112.15	110.76	110.03		
EPA-3A	114.77	112.92	112.69	111.92	111.51		
EPA-4	125.24	121.78	121.76	121.58	121.46		
EPA-4A	124.70	121.83	121.55	120.87	120.30		
EPA-5	121.10	117.93	117.60	116.77	115.39		
EPA-5A	119.67	112.94	112.70	111.96	111.52		
EPA-6	112.27	107.88	107.56	106.65	106.37		
EPA-6A	111.41	113.01	112.74	111.98	111.55		
EPA-7	112.10	107.70	107.46	106.67	106.50		
EPA-7A	110.17	112.88	112.62	111.90	111.42		
EPA-8	113.27	110.48	110.46	110.12	109.90		
EPA-8A	113.08	112.91	112.63	111.93	111.48		
EPA-9	113.41	110.48	110.30	109.31	109.04		
EPA-9A	112.46	114.11	113.24	112.32	111.88		
EPA-10	108.60	105.62	105.45	104.41	103.93		
EPA-10A	107.89	107.90	107.49	106.74	106.28		
DEP-1	118.95	116.69	116.51	115.93	NM		
DEP-2	118.26	115.76	115.62	115.01	114.73		
DEP-3	114.39	111.55	111.26	110.05	109.30		
DEP-4	123.64	120.62	120.47	119.46	118.93		
DEP-5	134.36	127.27	126.85	125.89	124.34		
DEP-6	131.58	124.05	123.69	123.08	122.34		
DEP-7	122.59	118.86	118.53	117.97	117.69		
RE	138.01	131.76	131.04	129.73	128.36		
RC	133.04	131.93	destroyed	-	-		
RW	139.25	132.46	131.71	130.68	destroyed		

Notes: NM - Not Measured

TABLE 4-3

WELL CONSTRUCTION SUMMARY
LONE PINE LANDFILL
(from Hart(1982))

Well Number	Top of Outer Casing Elevation above MSL[a] (feet)	Top of Inner Casing Elevation above MSL (feet)	Total Casing and Screen Length (feet)	Screen Setting (bgl)[b] (feet)	Date Completed
EPA-1	131.11	131.02	28.6	23.5 - 27.5	November 20, 1981
EPA-1A	130.75	130.27	85.9	81.0 - 85.0	November 23, 1981
EPA-2	121.55	120.29	11.1	5.0 - 9.0	November 25, 1981
EPA-2A	123.09	120.71	52.2	46.0 - 50.0	November 25, 1981
EPA-3	116.86	116.04	12.0	7.0 - 11.0	December 1, 1981
EPA-3A	115.02	114.77	34.7	30.5 - 34.5	December 2, 1981
EPA-4	125.35	125.24	17.2	11.5 - 15.5	December 3, 1981
EPA-4A	125.32	124.70	55.6	51.0 - 55.0	December 4, 1981
EPA-5	120.94	121.10	13.3	8.0 - 12.0	December 8, 1981
EPA-5A	119.87	119.67	42.4	38.0 - 42.0	December 9, 1981
EPA-6	112.92	112.27	16.2	10.0 - 14.0	December 14, 1981
EPA-6A	111.85	111.41	27.7	22.0 - 26.0	December 11, 1981
EPA-7	112.10	112.10	15.5	10.0 - 14.0	December 17, 1981
EPA-7A	110.91	110.17	24.5	20.0 - 24.0	December 16, 1981
EPA-8	113.33	113.27	11.0	5.0 - 9.0	December 21, 1981
EPA-8A	113.65	113.08	21.9	16.0 - 20.0	December 21, 1981
EPA-9	113.38	113.41	17.0	11.0 - 15.0	December 22, 1981
EPA-9A	113.17	112.46	28.8	23.5 - 27.5	December 22, 1981
EPA-10	109.51	108.60	8.0	3.5 - 7.5	January 8, 1982
EPA-10A	107.99	107.89	39.7	36.0 - 40.0	January 8, 1982
DEP-1	-	118.95	14.3	3.0 - 13.0	1976
DEP-2	-	118.26	15.7	3.5 - 13.5	1976
DEP-3	-	114.39	14.5	4.0 - 14.0	1976
DEP-4	-	123.64	17.9	6.0 - 16.0	1976
DEP-5	-	134.36	33.1	21.5 - 31.5	1976
DEP-6	-	131.58	91.2	81.0 - 91.0	1976
DEP-7	-	122.59	12.3	1.0 - 11.0	1976
RE	-	138.01	12.0		
RC	-	133.04	9.0		
RW	-	139.25	13.5		

NOTES:

a) MSL - Mean Sea Level
b) bgl - below ground level

In order to depict the observed depression in piezometric head values in the vicinity of Burke Road and the Manasquan River, element properties in layer two, the upper Red Bank, were adjusted. Recalling that the driller observed what appeared to be the existence of horizontal fracturing in the indurated sand layer, horizontal and vertical hydraulic conductivities for the layer in this area were increased. The final values selected for simulation were 200 feet per day and 20 feet per day for horizontal and vertical conductivities, respectively. These values preserved an anisotropy ratio of 0.10 for the system.

Finally, groundwater discharge to the Manasquan River was checked to insure that recharge flux values for each layer were reasonable. Given that simulated piezometric heads matched measured field data reasonably well, the model calibration was completed by checking the discharge to the Manasquan River. Assuming that all nodes having simulated discharge and surface drainage flow paths to the Manasquan River ultimately represented flow in the river, simulated flow in the Manasquan River was approximately 2.0 cfs. This value does appear reasonable with respect to average annual groundwater discharge values reported for the county.

Calibrated flow fields for each level are shown in Figures 4-12 through 4-16. Calibrated model parameter estimates are summarized in Table 4-4.

Table 4-5 presents a numerical comparison of the results of simulation at monitoring well locations. Field measurements recorded on March 31, 1982 are considered representative of conditions on other dates and are listed with corresponding simulation results.

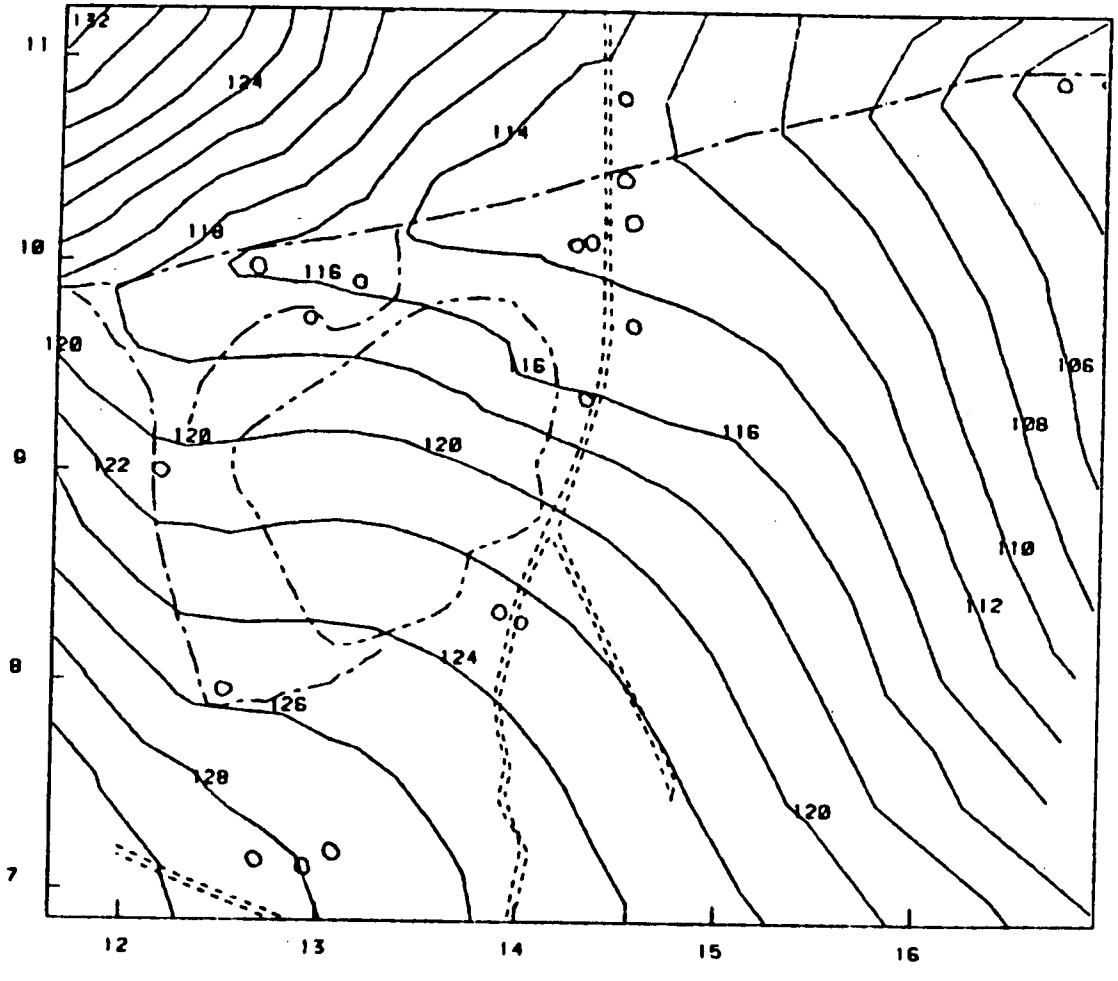


FIGURE 4-12: LEVEL 1 - COMPUTED PIEZOMETRIC HEADS

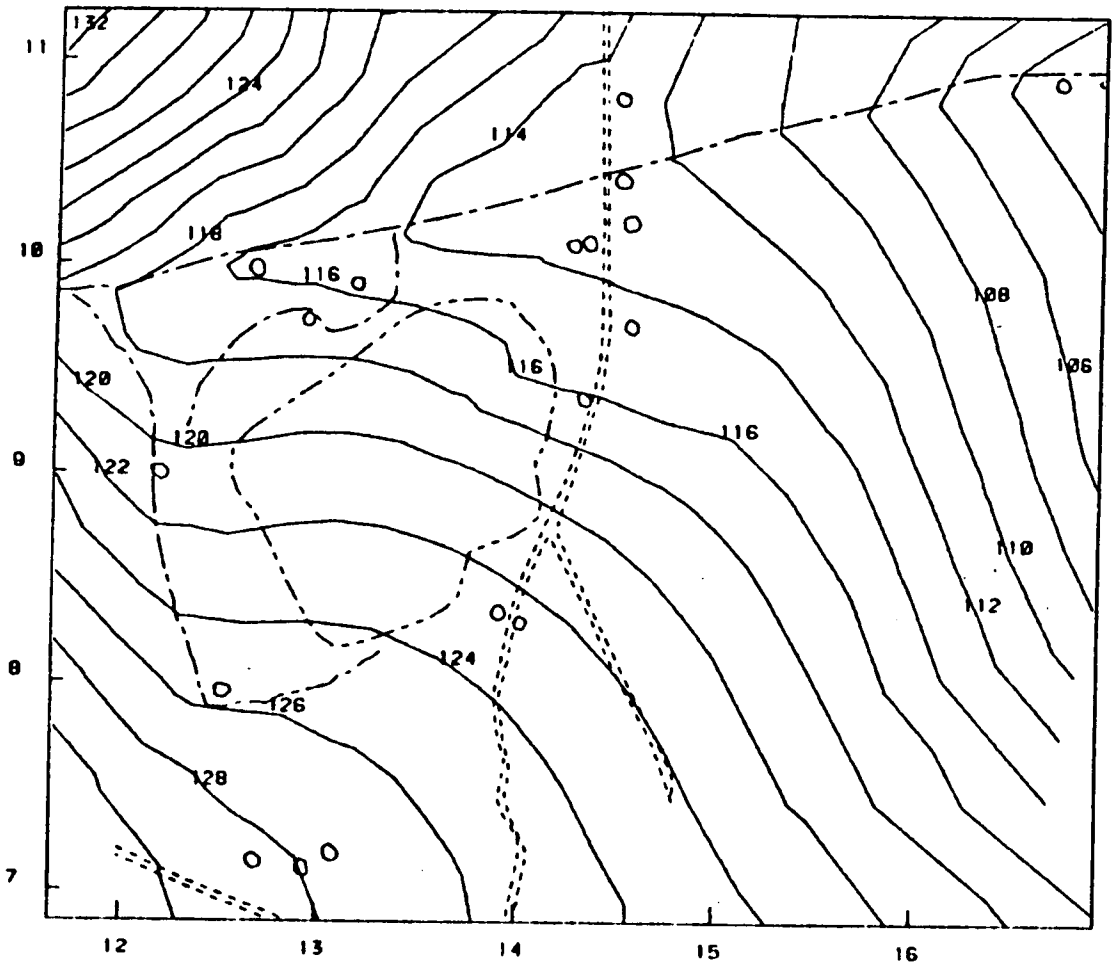


FIGURE 4-13: LEVEL 2 - COMPUTED PIEZOMETRIC HEADS

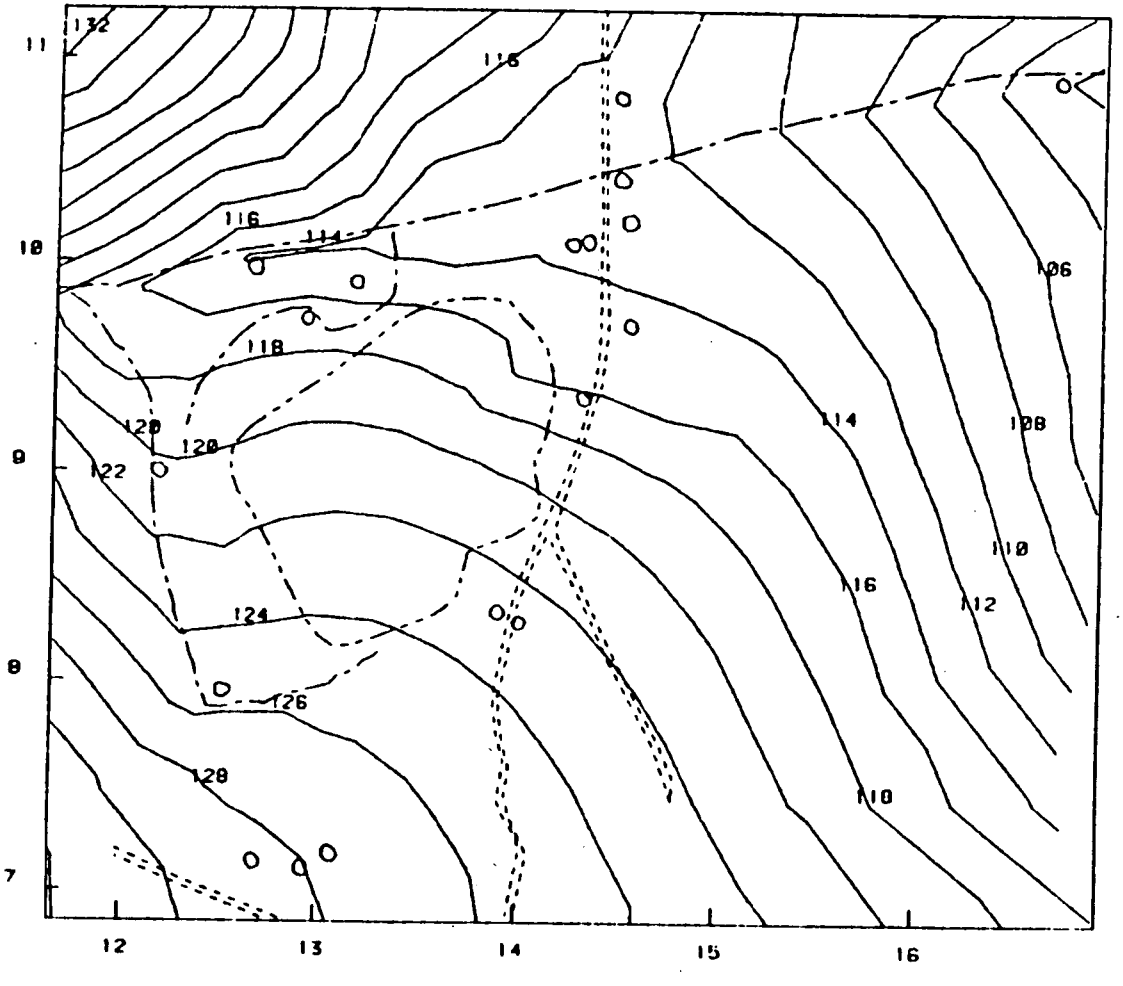


FIGURE 4-14: LEVEL 3 - COMPUTED PIEZOMETRIC HEADS

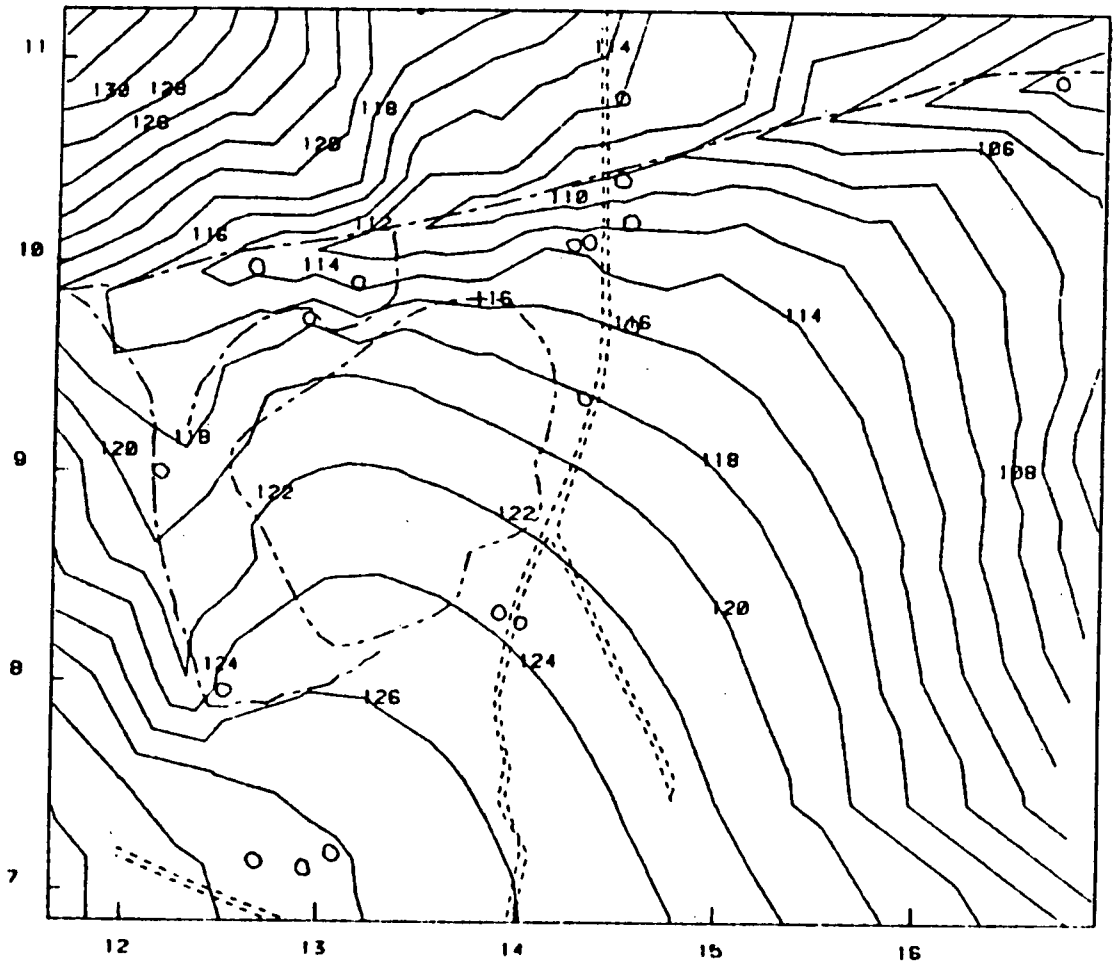


FIGURE 4-15: LEVEL 4 - COMPUTED PIEZOMETRIC HEADS

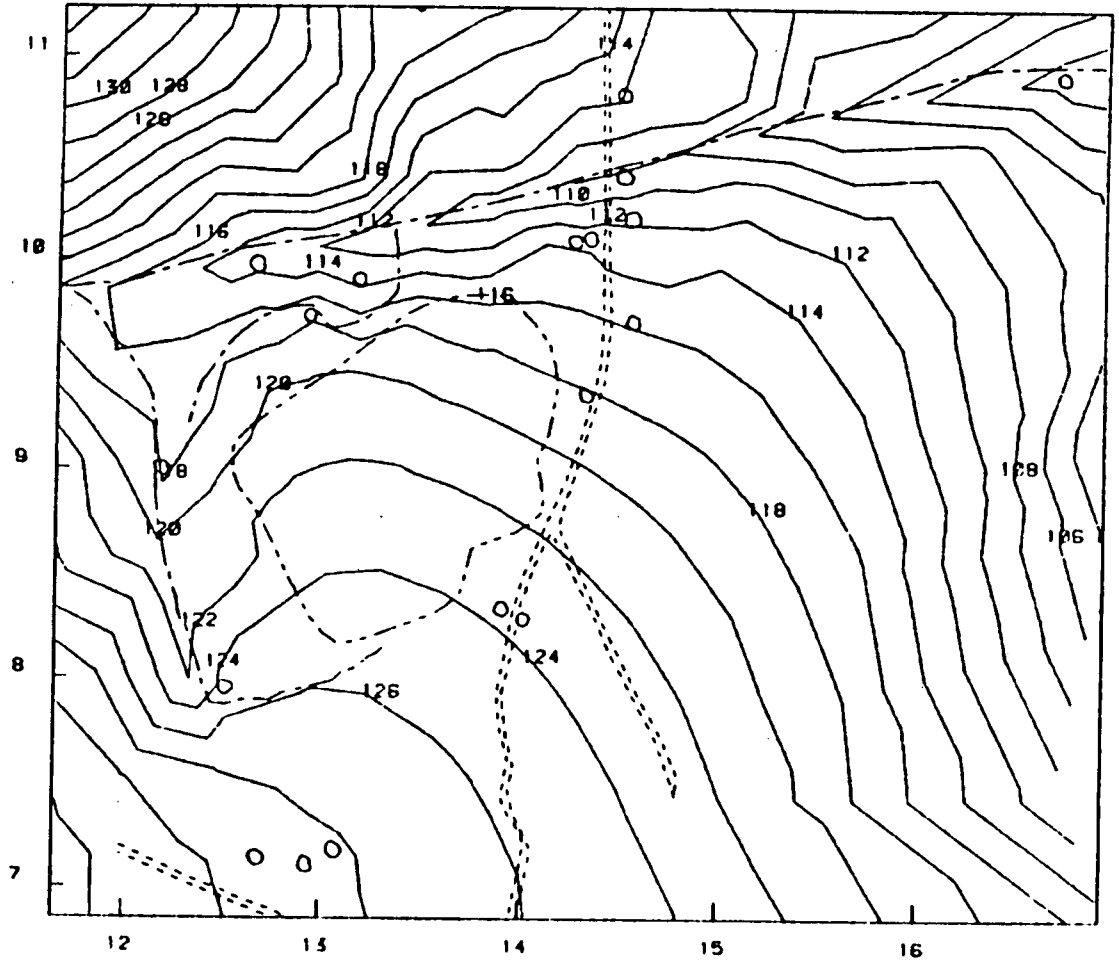


FIGURE 4-16: LEVEL 5 - COMPUTED PIEZOMETRIC HEADS

TABLE 4-4

FINAL ELEMENT PROPERTY VALUES BY LAYER

Parameter	Layer Number* 1	2	3	4
Horizontal Hydraulic Conductivity (feet/day)	60.0	4.0/200	0.3	30.0
Vertical Hydraulic Conductivity (feet/day)	6.0	0.4/20	0.03	3.0
Recharge Flux (feet/day)	0.0043	0.0021	0.0011	0.0043
Storativity	5×10^{-6}	5×10^{-6}	1×10^{-4}	5×10^{-6}
Specific Yield	0.2	0.2	0.3	0.2

*Note: Layer numbering scheme begins at the lowest formation and increases toward ground surface.

TABLE 4-5

MEASURED AND SIMULATED
PIEZOMETRIC HEADS AT MONITORING WELLS

Well #	Measured Piezometric Head feet (MSL)	Simulated Piezometric Head feet (MSL)
EPA-1	125.78	123.7
EPA-1A	123.51	122.7
EPA-2	115.76	117.2
EPA-2A	117.40	117.1
EPA-3	112.19	113.9
EPA-3A	112.61	113.7
EPA-4	121.76	124.9
EPA-4A	121.41	125.5
EPA-5	117.68	116.0
EPA-5A	112.66	114.6
EPA-6	107.57	108.0
EPA-6A	112.76	111.9
EPA-7	107.57	108.0
EPA-7A	112.66	112.4
EPA-8	110.46	112.0
EPA-8A	112.67	112.6
EPA-9	110.49	112.0
EPA-9A	113.17	113.2
EPA-10	105.37	99.0
EPA-10A	107.43	102.5
DEP-1	116.49	113.8
DEP-2	115.61	115.5
DEP-3	111.43	113.9
DEP-4	120.16	118.5
DEP-5	126.14	123.7
DEP-6	123.44	122.7
DEP-7	118.57	118.0
RE	130.20	128.2
RC	130.41	128.7
RW	130.95	129.1

4.8 CONTAMINANT TRANSPORT MODELING

Hazardous materials were disposed of at the Lone Pine Landfill during the 1970's. Operations terminated in October, 1979. The resulting development and migration of contaminant plumes from the site were evaluated utilizing DYNTRACK, CDM's groundwater contaminant transport simulation model. The objectives of this phase of the modeling effort were two-fold: to estimate the current extent of contaminant migration within the aquifers and to provide a starting point for the evaluation of aquifer restoration alternatives. The results of simulation using DYNTRACK are presented following a brief discussion of its method of application at the Lone Pine Landfill site.

Source Characterization

Following the termination of dumping at the site, several studies were initiated to augment the existing data collection and monitoring effort. These studies focused on quantitatively addressing the short and long-term environmental impacts of the landfill's operation. They also served as the basis for this phase of the modeling effort. The following subsections provide a brief synopsis of these investigations with an emphasis on how the results of these studies were incorporated into the modeling effort.

FIT Geologic Investigation. Utilizing continuous magnetometer recording equipment, a geophysical investigation was performed at the site by Technos, Inc. in conjunction with the FIT (2). Their objective was to determine the locations of buried drums within the landfill. Their results indicated that appreciable amounts of buried iron material were present. Furthermore, the observed magnetic

anomalies had characteristics similar to those of buried piles of drums. The spatial extent and size of the magnetic responses also suggested that the observed iron concentrations are equivalent to thousands and, possibly, tens of thousands of steel drums.

Drum Excavation and Sampling. A follow-up study was performed by the FIT to determine the nature of any drummed material buried on-site. Drums were excavated and sampled from four locations. A total of 69 drums were located which varied in condition from semi-crushed to intact. Faint markings found on six of the drums confirmed earlier suspicions that drums originated from a variety of sources. Samples of the contents of selected drums, along with groundwater in the excavations, were collected for laboratory analysis and showed that numerous organic priority pollutants were present in relatively high concentrations in all samples.

Hydrogeologic Investigation, Well Installation, Sampling. As previously indicated, the Field Investigation Team also supervised the installation and sampling of 20 nested groundwater monitoring wells at 10 locations. Well locations are shown in Figure 4-11. Following laboratory analysis of the samples extracted their conclusions were:

(1) Groundwater is severely contaminated with organic compounds in shallow wells EPA 2, 3, 6, 7, 9 and deep wells EPA 3A, 5A, and 9A

(2) Contaminants in the shallow aquifer migrate north from the landfill in the direction of groundwater flow and discharge into the Manasquan River

(3) Contaminants enter the deep semi-confined Red Bank aquifer in the recharge area beneath the landfill and migrate northeast toward the Manasquan River.

Overall, the conclusions drawn from these investigations with respect to source characterization were:

- Priority pollutants were identified in varying forms in all of the drums extracted and successfully sampled.

- The origin of most drums could not be determined, but numerous sources appeared likely. Leaking drums were found along with intact drums. Some leakage, however, could potentially be attributed to disturbances caused during excavation. Therefore, a precise estimate of the rate of leakage from any individual drum cannot be made.

- Groundwater samples taken from the excavations indicate the presence of contamination, but due to the highly disturbed nature of the sample source and the localized nature of the contaminants within the landfill, they are most likely not representative of levels over widespread areas of the landfill. A more precise means of measurement would be through the installation and sampling of wells within the landfill itself.

- Although contaminants identified in groundwater samples correlated well with contaminants found in excavated drums, the source of these contaminants cannot be assumed to be limited to the drums themselves. Previous dumping of bulk liquids, particularly near excavations where no drums were found, also represent a signficant source of contamination.

- The extent of contaminant migration is best represented by the samples from the EPA wells, but continued sampling is advisable.

In light of the above, several assumptions were made with respect to source simulation. These are as follows:

- Contaminant transport would be simulated as total priority pollutant volatile organics, rather than individual constituents, in an effort to best use the available data. This is not a limitation of the analysis, since water quality criteria have been stipulated in terms of total volatile organics.

- A uniform source distribution was assumed within the landfill. Although magnetic geophysical investigations indicated potential locations of drummed material, these could not detect areas in which bulk liquids were dumped.

- Contaminants were assumed to have been released from the landfill over the last 10 years. This coincides with the statement that dumping occurred in the 1970's and also corresponds with the slow "leaky" nature of drums deteriorating with time.

- The calibrated uniform source strength was determined by using the calibrated flow model with a set source value to match the observed plume concentrations. Thus, the source strength was a calibration parameter. The use of a calibrated uniform source strength was found to be a suitable means of dealing with the many variables and unknowns associated with the sources of contamination, i.e., the bulk solvents, the non-uniform disposal of drums with varying contents, and the time period over which disposal took place.

Contaminant Transport Parameter Value Selection

Contaminant transport in aquifers is primarily a function of groundwater transport; therefore, pollutant modeling is most sensitive to hydraulic and flow field parameter value estimates.

The total mass of contaminant simulated is dependent entirely on the representation of the source. The magnitude of simulated plume concentrations is strongly dependent on source strength (see above). The direction and extent of a plume are much less sensitive to source strength.

Convection and dispersion parameters, within a reasonable range, have a secondary effect on contaminant transport within the aquifer (see Appendix B for a discussion of these two factors). The extent over which a plume spreads is somewhat controlled by these parameters, but the direction of travel of a plume center line is not. The factors affecting convection are effective porosity, hydraulic conductivity and gradient. The factors affecting dispersion are mean velocity, longitudinal dispersivity (A_L), transverse dispersivity (A_T) and an empirical vertical anisotropy factor (S). From these factors the variance of the particle path from the mean is established.

The total mass of contaminant which enters an aquifer may be reduced in the simulation model by radioactive decay, chemical reactions, adsorption by soil particles, or other means. Given the method through which the source strength and characterization were developed, decay characteristics have been implicity considered. Due to the close proximity of the source relative to the Manasquan River and the lack of site-specific decay and adsorption data, use of an additional explicit decay algorithm is not justified for simulation at this site.

Effective Porosity. This parameter affects computed seepage velocities in the soil, and therefore, the rate at which contaminants are convected. For a given local flux, the seepage velocity is inversely proportional to the flow area, which is expressed by the effective porosity (see Appendix Section B.1).

Effective porosity values in soils are generally similar to or slightly greater than specific yield values. In this analysis they were assumed to be equivalent. For the more pervious sandy soils a value of 0.2 was used. For the more clayey, semi-pervious zone a value of 0.3 was used.

Dispersivity. The degree of dispersion with respect to convection is controlled by the longitudinal and transverse dispersivity constants, A_L and A_T. These parameters vary according to the aquifer materials. However, plume dispersion in aquifers is primarily a large scale phenomenon, so that generally a single set of dispersivity parameter values are specified for an entire aquifer system.

For the aquifers simulated, considering their size and the relatively high hydraulic conductivities of most of the soils in which transport occurs, a reasonable range of longitudinal dispersivity values is from 10 feet to 50 feet. Transverse dispersivity values are typically an order of magnitude lower than longitudinal dispersitivity. Values adopted for simulation were 25 feet and 2.5 feet for A_L and A_T, respectively. The empirical anisotropy factor S was assumed equal to 1.0, which assumes no vertical compression of the plume.

Particle Tracking/Time Step Determination

Preliminary pollutant simulation runs were made utilizing the particle-tracking option of DYNTRACK and the previously calibrated steady-state flow fields from the DYNFLO results. These runs were

used to determine an appropriate time step for pollutant transport modeling. The final time step for particle tracking was established as 30 days. This value produced reasonable results for each layer of the system given the gradients simulated by DYNFLO without unnecessarily increasing computer computational time.

The simulation results presented herein are a reliable indication of the direction, extent, and intensity of contaminant plumes, which have occurred as a result of prior disposal practices at the site. The simulation is based on a limited data base, which was used to the extent possible during the model development process.

Figures 4-17 through 4-21 graphically depict the simulated extent of contaminant migration at the site. Shown are contour plots of equal concentration superimposed on a base map at the site.

The general direction of plume migration from the site is, as expected, in a northerly direction for the surficial aquifer and in a northeasterly direction in lower layers. The leading edge of the plume, delineated by the 10 ppb contour, extends slightly beyond the intersection of Burke Road and the Manasquan River. Note, however, that contours shown north of the river do not indicate that contamination is migrating across the river. The contours north of the river are a byproduct of the interpolative scheme of model plotting. In level 5, however, the plume migration is considerably less. This is because the Vincentown formation is gradually pinched out north of the landfill. Simulated versus measured concentrations at the EPA wells are compiled in Table 4-6 for ready comparison. The table shows, overall, a good correlation between measured and simulated concentrations, particularly at the more contaminated locations. See Section 4.5--Model Formulation for explanation of the nodes and levels.

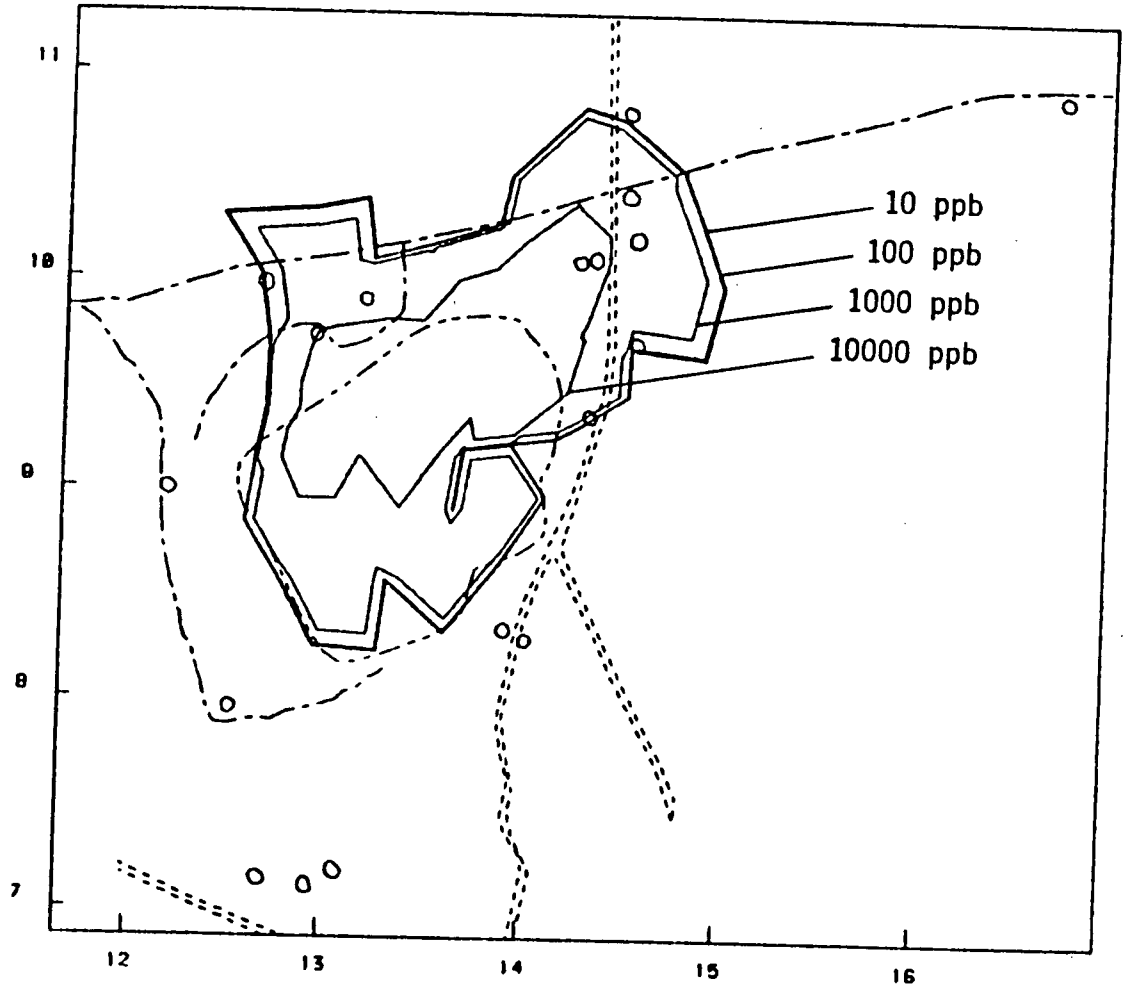


FIGURE 4-17: LEVEL 1 - SIMULATED CONCENTRATION CONTOURS

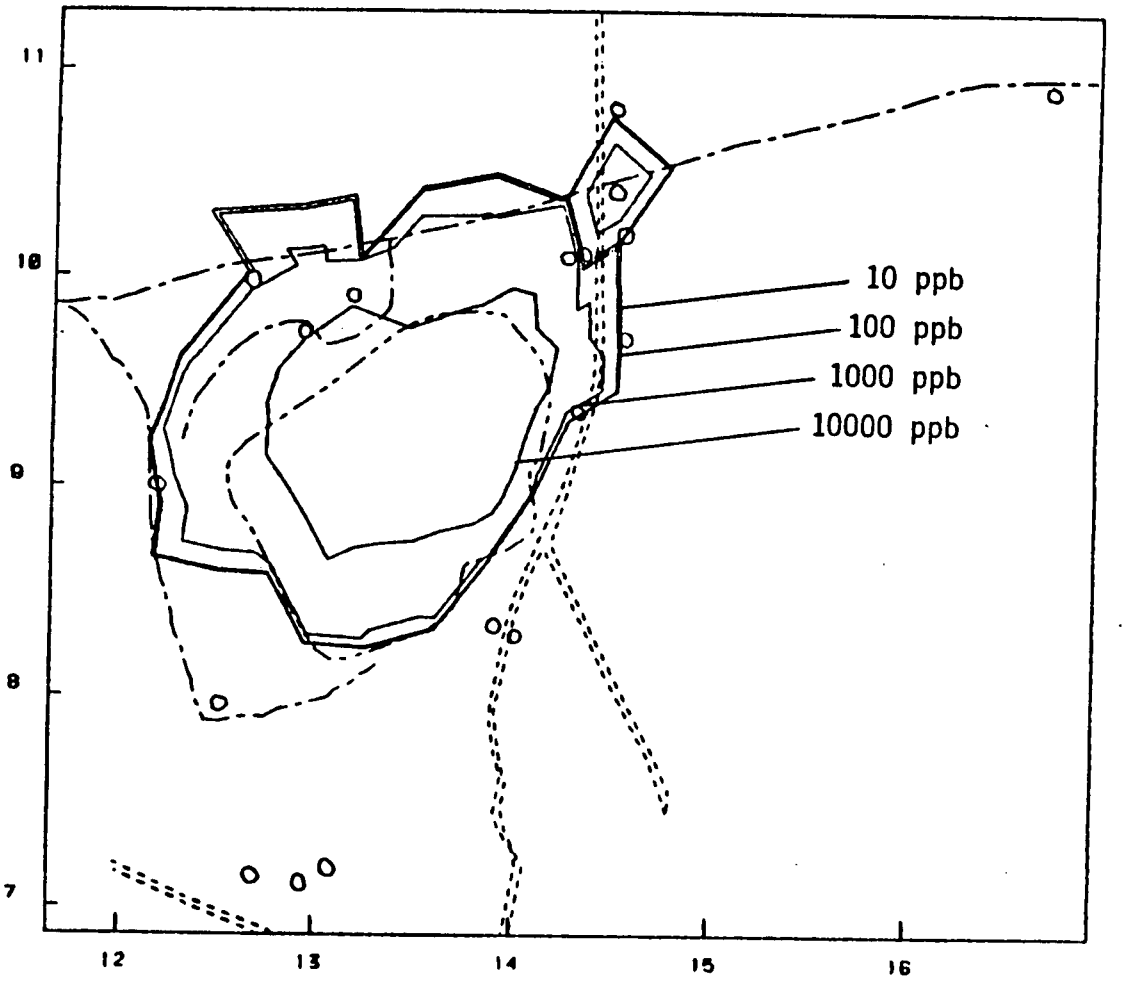


FIGURE 4-18: LEVEL 2 - SIMULATED CONCENTRATION CONTOURS

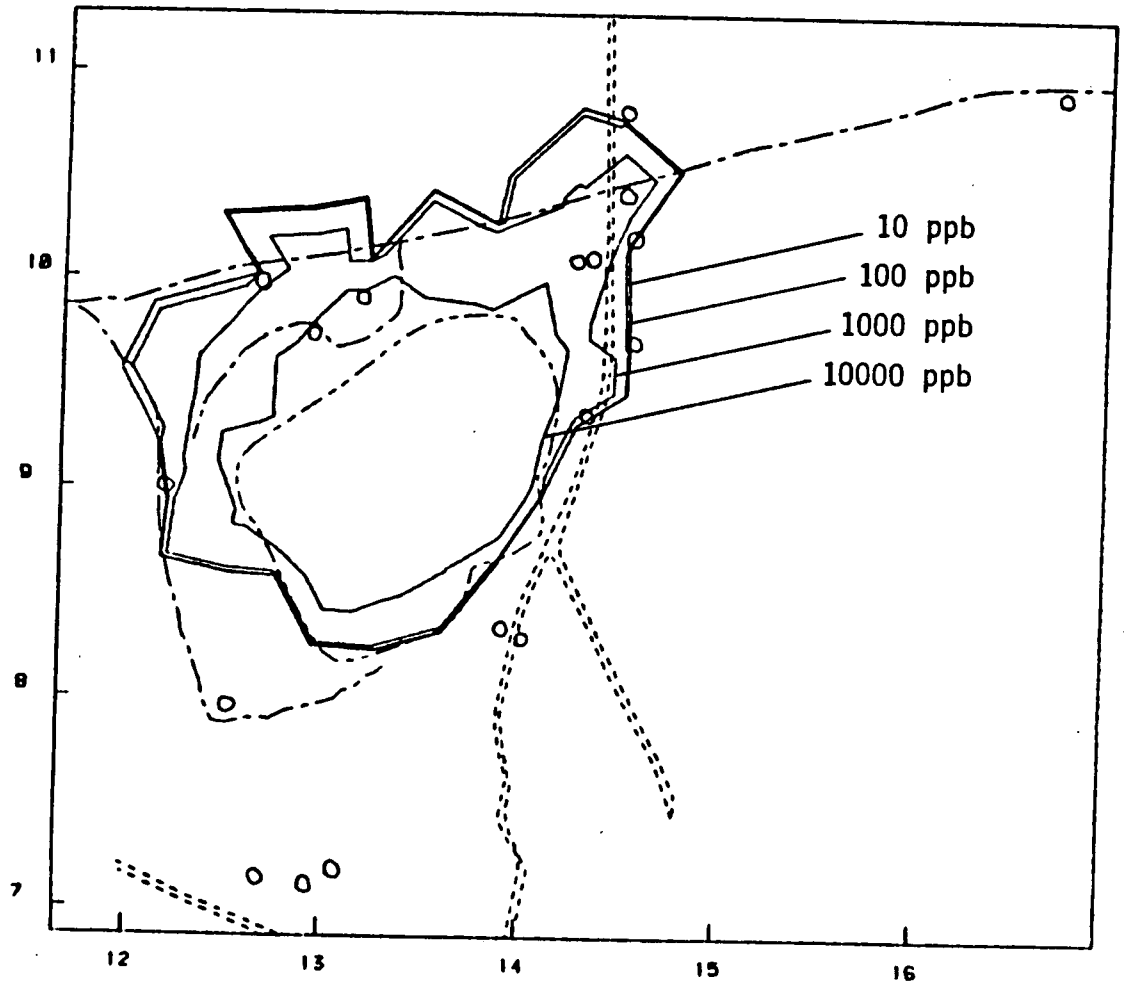


FIGURE 4-19: LEVEL 3 - SIMULATED CONCENTRATION CONTOURS

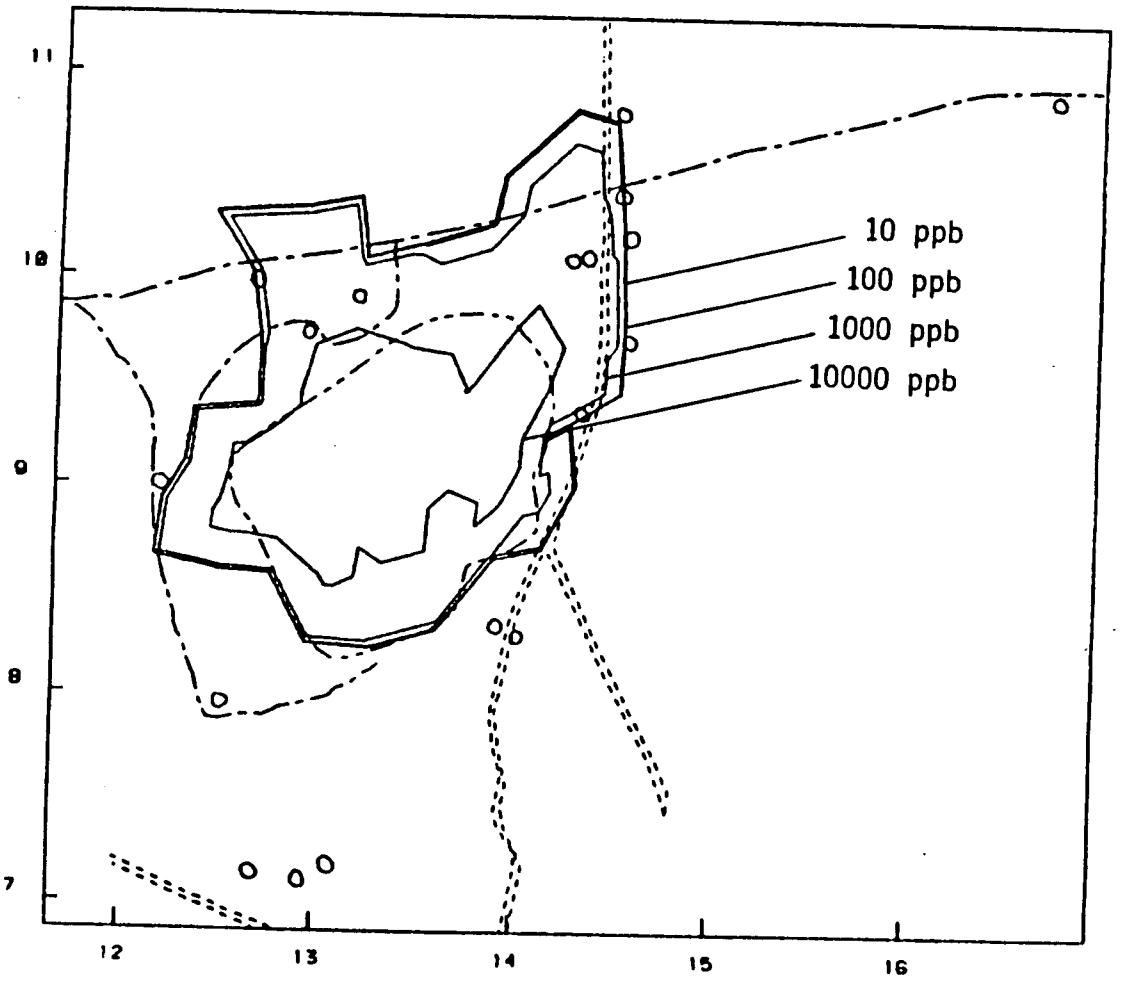


FIGURE 4-20: LEVEL 4 - SIMULATED CONCENTRATION CONTOURS

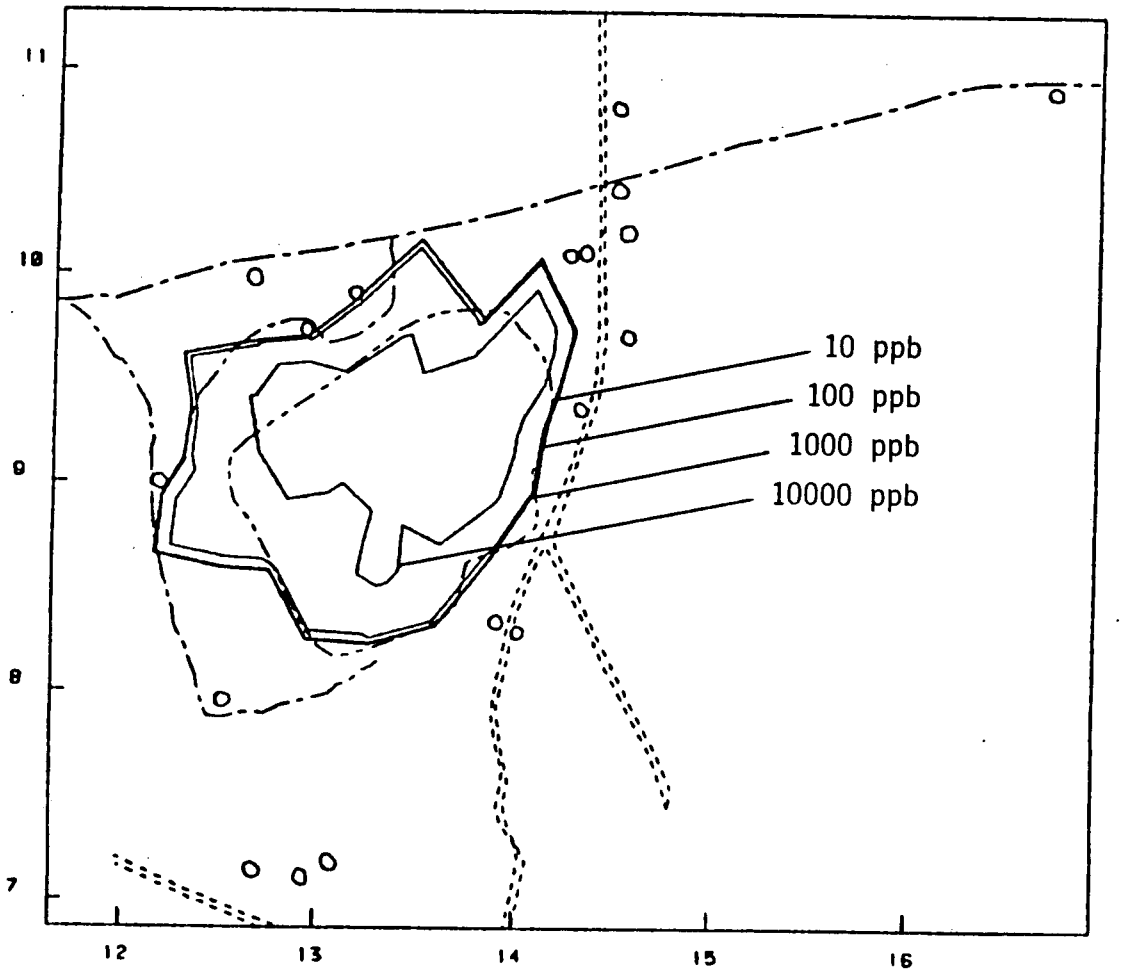


FIGURE 4-21: LEVEL 5 - SIMULATED CONCENTRATION CONTOURS

TABLE 4-6

TOTAL VOLATILE ORGANIC CONCENTRATIONS

REPORTED AND SIMULATED

AT EPA WELL LOCATIONS

Well	Measured Concentration (mg/l)	Node/Level	Simulated Concentration (mg/l)
EPA-1	ND	130/4	0
EPA-1A	ND	/1	0
EPA-2	ND	63/3,4	11.0
EPA-2A	10.4	/1,2	10.5
EPA-3	0.4	153/4	2.8
EPA-3A	16.5	/1	13.2
EPA-4	ND	57/4	0
EPA-4A	ND	/1	0
EPA-5	ND	169/4	0
EPA-5A	0.3	/1,2	0
EPA-6	9.3	171/3	0
EPA-6A	ND	/2	0
EPA-7	2.5	154/3	2.0
EPA-7A	ND	/2	2.5
EPA-8	ND	155/3	0
EPA-8A	ND	/2	0
EPA-9	2.7	170/3	0
EPA-9A	5.4	/1	5.0
EPA-10	ND	199/4	0
EPA-10A	ND	/1	0

4.9 SIMULATION OF ALTERNATIVES

The calibrated DYNFLO and DYNTRACK models were used to simulate nine alternative engineering cleanup strategies for the Lone Pine Landfill site. For alternative strategies which, if implemented, would have an impact on the existing steady-state flow field, revised estimates for the groundwater flow regime at the site were made using DYNFLO. Pollutant runs were then performed under transient conditions utilizing the calibrated plume configuration and revised steady-state flow field as the starting point for simulation. Although this assumes an instantaneous change in flow field from existing to future conditions, this is not considered significant given the formations present. Furthermore, steady-state conditions will be approached shortly after implementation of each alternative simulated.

Table 4-7 provides a ready reference indicating the components or characteristics associated with each alternative simulated. The identification code listed in column one will be used to address each alternative in the text. Columns two through five indicate their corresponding features. Pumping rates listed in column two represent total pumpage from all extraction wells used for aquifer cleanup. Internal control, listed in column five, specifies the pumping rate of intermittent pumping wells within the landfill to regulate groundwater elevations below the cap when a slurry wall is also specified.

In addition to the tabulated simulations, land application of extraction well effluent was also investigated utilizing the DYNFLO simulation code. Simulation results, however, indicated that this is not a hydrologically feasible alternative for further study. A discussion of this is presented at the end of this section.

TABLE 4-7

CHARACTERISTICS OF SIMULATED ALTERNATIVES

ALTERNATIVE NUMBER	EXTRACTION WELLS	SLURRY WALL	LANDFILL CAP	INTERNAL CONTROL
1	None	None	None	None
2	200 GPM	Deep	Yes	30 GPM
2A	None	Deep	Yes	30 GPM
3	200 GPM	Shallow	Yes	30 GPM
3A	400 GPM	Shallow	Yes	30 GPM
3B	None	Shallow	Yes	30 GPM
4	400 GPM	None	Yes	None
4A	None	None	Yes	None
4B	400 GPM	None	None	None

Alternative 1

Alternative 1 is the No Action alternative. Simulations were performed to investigate plume migration with time as an extension of the calibrated base case. Under the existing simulated flow field and source characterization, DYNTRAK simulation runs indicated that the spatial extent of aquifer contamination at the site has already been reached. In other words, pollutants leaching from the Vincentown Sand into lower aquifer layers are transported from beneath the landfill in a northeasterly direction and eventually discharged to the river in close proximity to the landfill itself. Pollutants are not transported beneath the river to the north side. The predicted configuration of the plume after 20 years is graphically illustrated with the corresponding flow field simulations for levels 2 and 4 in Figure 4-22.

Modeling results also predicted a gradual increase in total pollutant mass release to the Manasquan via base flow discharge. Utilizing an average annual base flow discharge of 2.0 cfs in the river at Burke Road, volatile organic concentrations were computed at 5-year increments using simulated mass release totals from DYNTRACK. This calculation yielded a concentration of 1000 ppb in the river at Burke Road under existing conditions, increasing to 1300 ppb over the 20-year period.

It should be noted, however, that these estimates are likely to represent only a lower limit to contaminant transport to the river on a total mass basis. This is due to the fact that "average annual conditions" are being simulated, which can only partially be assumed to indicate the effects of runoff and leachate breakout due to short-duration, high-intensity rainfall events. Although these events are

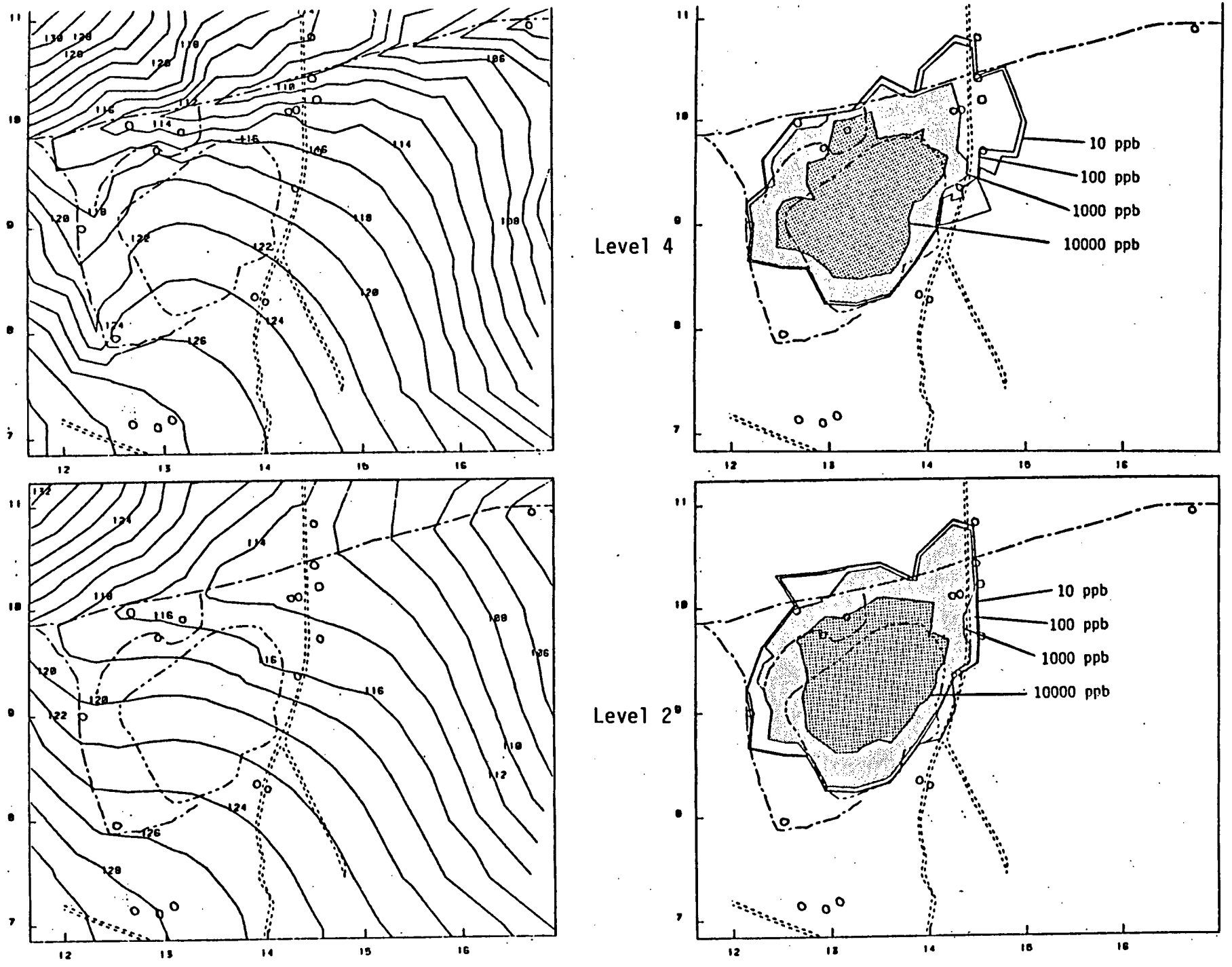


FIGURE 4-22: Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 1. (After 20 Years)

relatively infrequent, they may allow for a significant discharge of contaminants to the river. This is of particular importance at this site due to the steep slopes on the northern and western faces of the landfill and its relative proximity to either the Manasquan or the tributaries and drainage ditches encircling the site, which discharge directly to the river.

The No Action alternative would result in over 1000 ppb of total volatile organic discharge to the Manasquan River at Burke Road, and would do nothing to prevent the discharge of other, as yet unidentified contaminants, as a result of leachate breakouts and surface runoff.

Alternative 2

Alternative 2 calls for the installation of a deep slurry wall, keyed into the Navesink formation, a landfill cap with internal surficial aquifer piezometric head control, and external plume control via pumping from the Red Bank formation.

The deep slurry wall was simulated by altering the properties of elements encircling the landfill in each layer to approximate the hydraulic characteristics of a 3-foot thick clay wall. Net hydraulic conductivities for the wall were assumed to be 0.00028 feet per day horizontal and 0.000028 feet per day vertical. The horizontal conductivity value was arrived at through a process of calibration adjustment and refinement. The vertical conductivity value was set at 10 percent of the horizontal value, a ratio which has been confirmed through experience. Specific yield and storativity values were 0.35 and 0.0002, respectively. The landfill cap was simulated simply by removing the recharge flux from level 5 over the entire

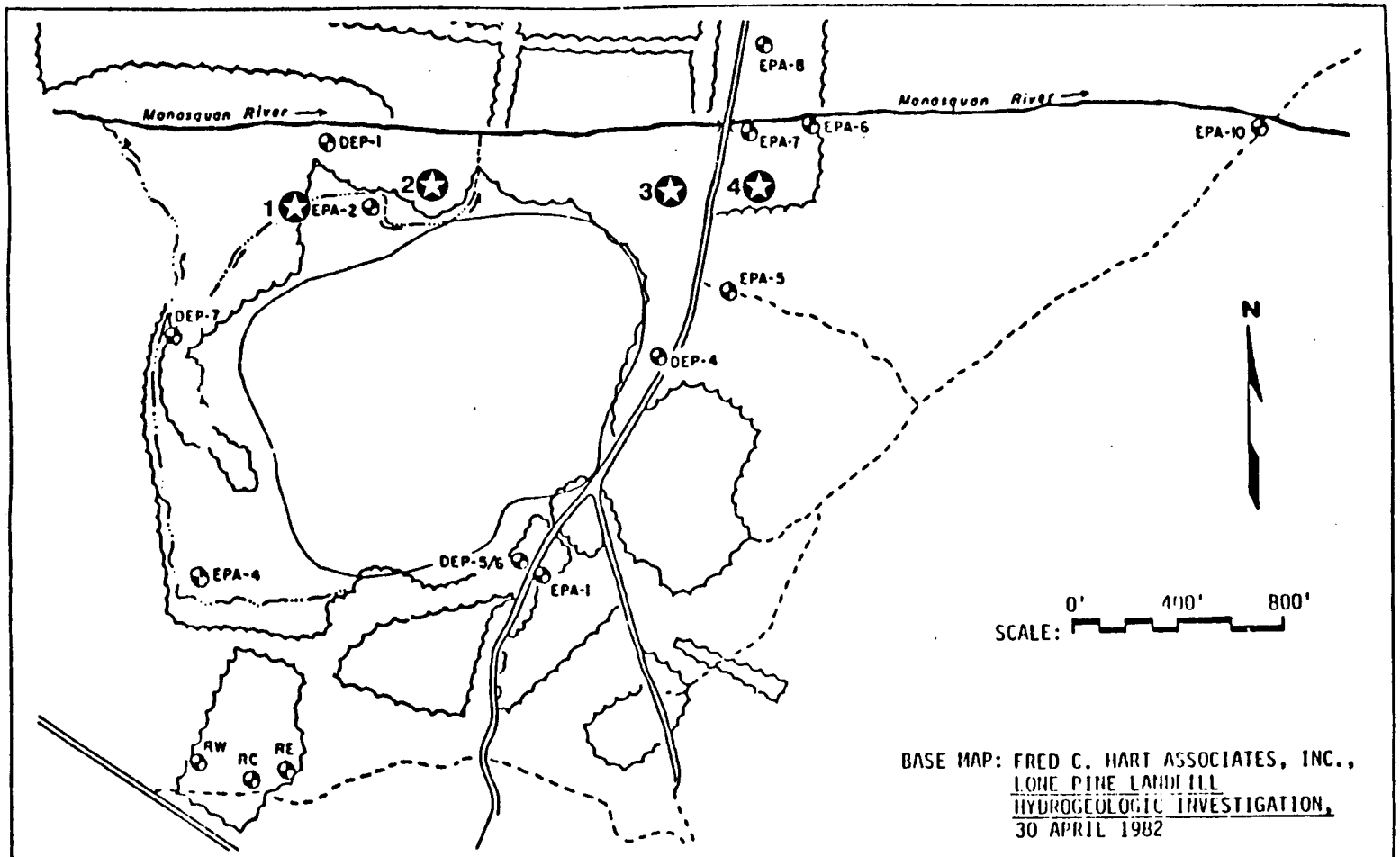
landfill area. The cap itself, however, will also function as a means to control erosion on site, thereby limiting the potential for pollutant transport via overland washoff. In addition, it will serve to eliminate the presence of leachate seeps found along the existing side slopes of the landfill mound.

Internal landfill pumping to control the phreatic water surface elevation within the landfill was simulated by fixing the elevations of landfill nodes at an elevation of 120 feet.

External pumpage was simulated from four locations north of the landfill, as shown in Figure 4-23. The first 50 gallons-per-minute (gpm) well was positioned approximately 200 feet due west of well EPA-2. The second (30 gpm well) was located near well DEP-2. The third and fourth (50 gpm each) were located northeast of the landfill near wells DEP-3 and EPA-9. For each well, pumping was simulated from layer 1, the lower Red Bank formation.

Figure 4-24 illustrates the hydrologic impact of the outlined control strategy for levels 2 and 4 as compared with the base case simulation. The steep hydraulic gradients observed north and south of the landfill result from the placement of an "impermeable" wall in the flow field. Note that the computed head differentials would actually exist through a 3-foot wall thickness. Contours in level 2 also illustrate the relatively small cone of depression produced by the extraction wells. In level 4 it can be seen that pumping at the specified rates has minimal influence on phreatic water surface elevations.

Pollutant plume migration at the site was simulated over a 15-year period utilizing the revised flow field and the additional assumption that installation of the slurry wall and cap would completely contain contaminants in the landfill. Therefore, the source was removed from the simulation and associated elements deleted from the solution.



ZONE 1 FEASIBILITY STUDY	LONE PINE LANDFILL FREEHOLD N.J. SIMULATED EXTRACTION WELL LOCATIONS	CAMP DRESSER & McKEE INC. One Center Plaza Boston Massachusetts 02108 FIGURE 4-23

660

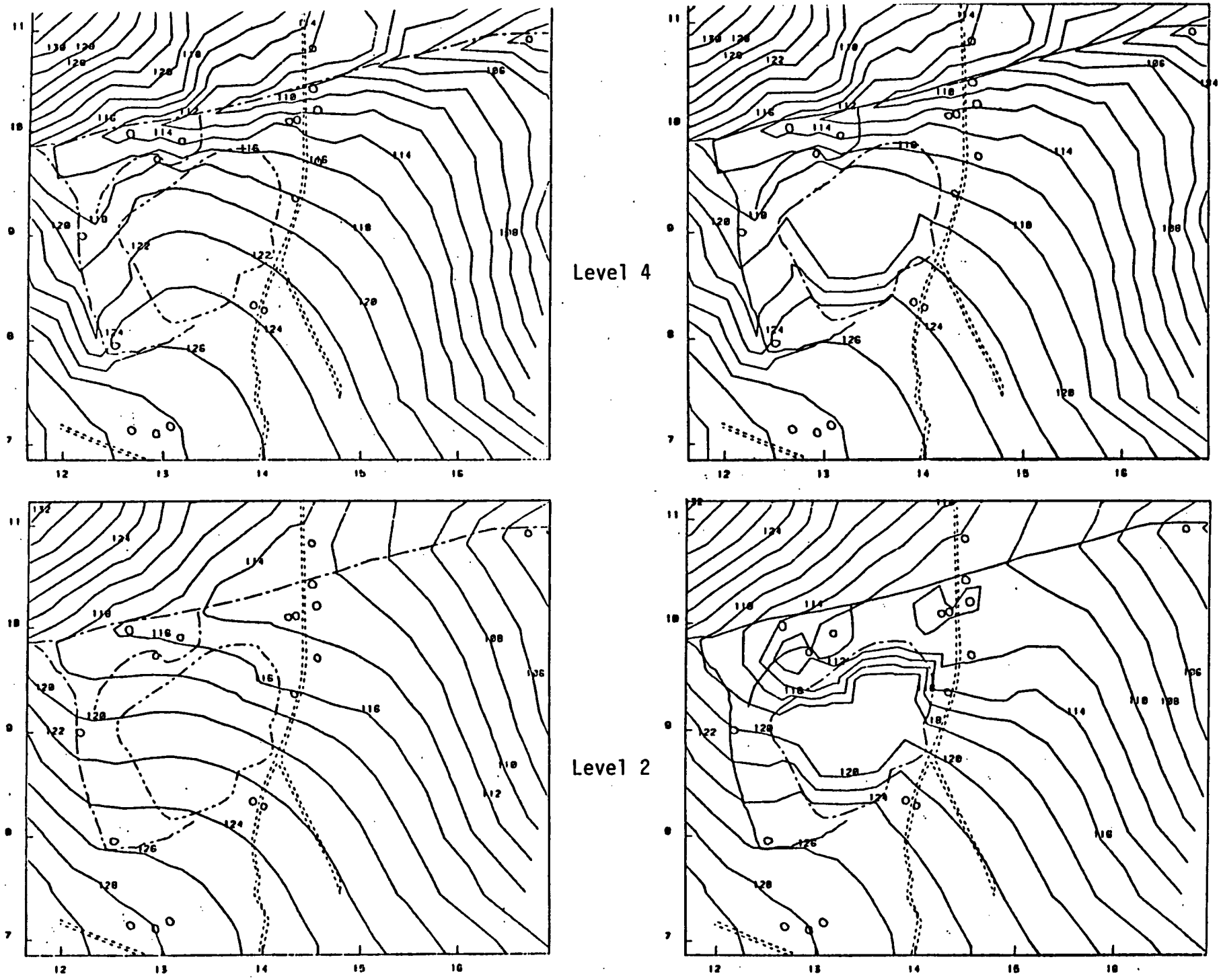


FIGURE 4-24: Computed Piezometric Heads for Levels 2 and 4 Under Existing and Alternative 2 Conditions.

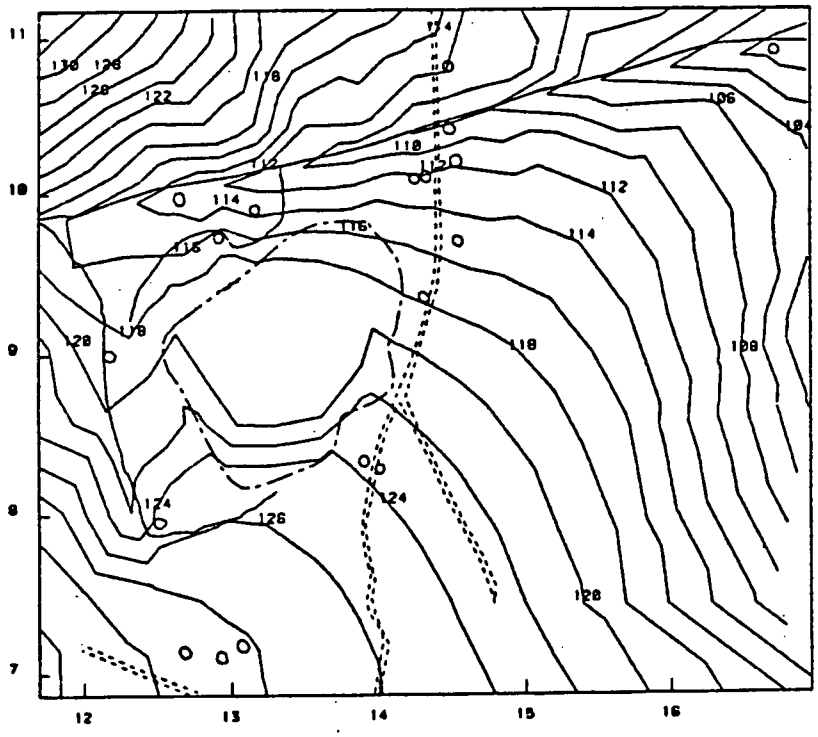
DYNTRACK simulation results following 5, 10, and 15 years revealed that, although upward vertical gradients through the Hornerstown Formation continued to transport contaminants already in this layer to the river, total mass release to the river was significantly reduced. Computed Burke Road concentrations at an average base flow of 2.0 cfs were approximately 150 ppb total volatile organics after 5 years and less than 15 ppb after 10 years. Simulation results following 15 years revealed that the aquifer is essentially restored in the region north of the site, and therefore pumping from the Red Bank may be discontinued. Results also indicate that extraction well 2 could be moved approximately 200 feet due east of its simulated location and pumped at 50 gpm to improve the overall effectiveness of this alternative.

As with all extraction well schemes, the pumped water will have to be sampled periodically to determine when the different sections of the aquifer are restored.

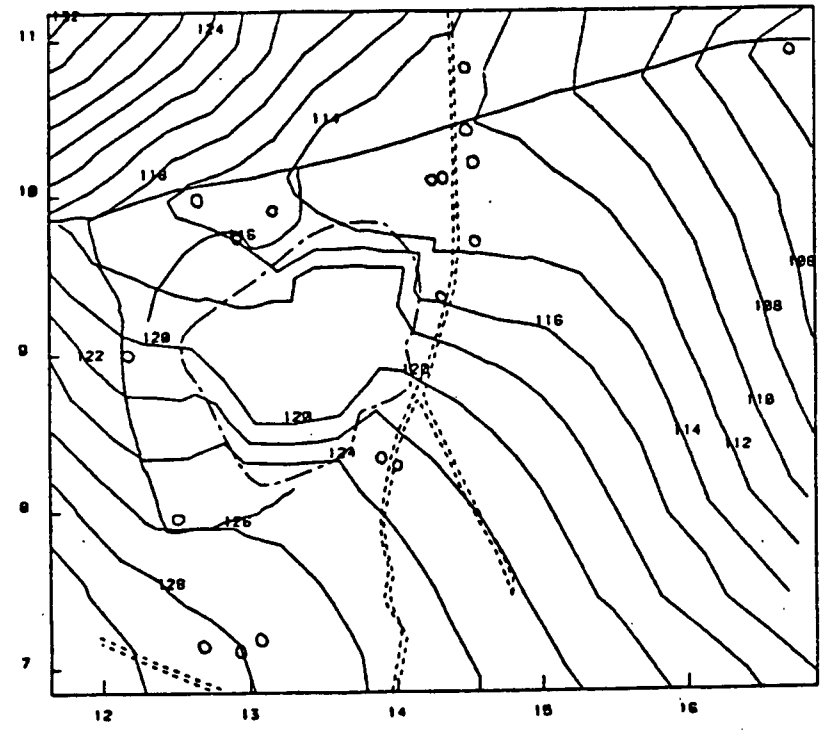
Alternative 2A

Given the favorable results provided by Alternative 2, the relative influence of the extraction well field in terms of the overall simulation was assessed. Noting that installation of a slurry wall to the depth of the Navesink formation effectively removed the bulk of aquifer contamination from the active flow field, Alternative 2A is a simulation without the use of extraction wells.

Figure 4-25 depicts the simulated flow field for this alternative. Simulated heads under this variation are essentially identical to those of Alternative 2 in the Hornerstown and Vincentown formations. In the Red Bank, the simulated flow field north of the landfill closely approximates that under existing conditions, preserving an upward gradient through all layers to the river. South of the landfill no discernible change is apparent from that of Alternative 2.



Level 4



Level 2

FIGURE 4-25: Computed Piezometric Heads for Levels 2 and 4 for Alternative 2-A.

Projected contaminant migration under this scheme was simulated for 15 years and results compared with those of the previous simulation. As would be expected, plume concentrations were slightly higher than those indicated by Alternative 2 at each increment and in each layer. However, the deep slurry wall without external pumping does approach comparable results with respect to aquifer restoration through natural flushing after 15 years. Computed concentrations in the Manasquan at Burke Road, as previously described, results in average concentrations of approximately 250 ppb, 75 ppb, and less than 15 ppb after 5, 10 and 15 years, respectively.

Alternative 3

Alternative 3 calls for the installation of a shallow slurry wall keyed into the Hornerstown formation, a landfill cap with internal surficial aquifer piezometric head control, and external plume control via pumping from the Red Bank formation.

The flow field simulated for this alternative is graphically illustrated for levels 2 and 4 in Figure 4-26. Simulation of external pumping, a slurry wall and capping was identical to that in Alternative 2, except for the depth of the wall. Internal head control in the landfill, however, was assumed to lower the heads within the landfill to 113 feet above Mean Sea Level (MSL). This represents a 7-foot decrease in the phreatic water surface elevation beneath the cap from the elevation sufficient for control under the complete containment scenario. This is intended to reverse the downward vertical gradient beneath the landfill to prevent further contaminant migration to lower layers and, to a limited extent, remove a fraction of the drums from submergence, a consideration not required for the fully penetrating wall.

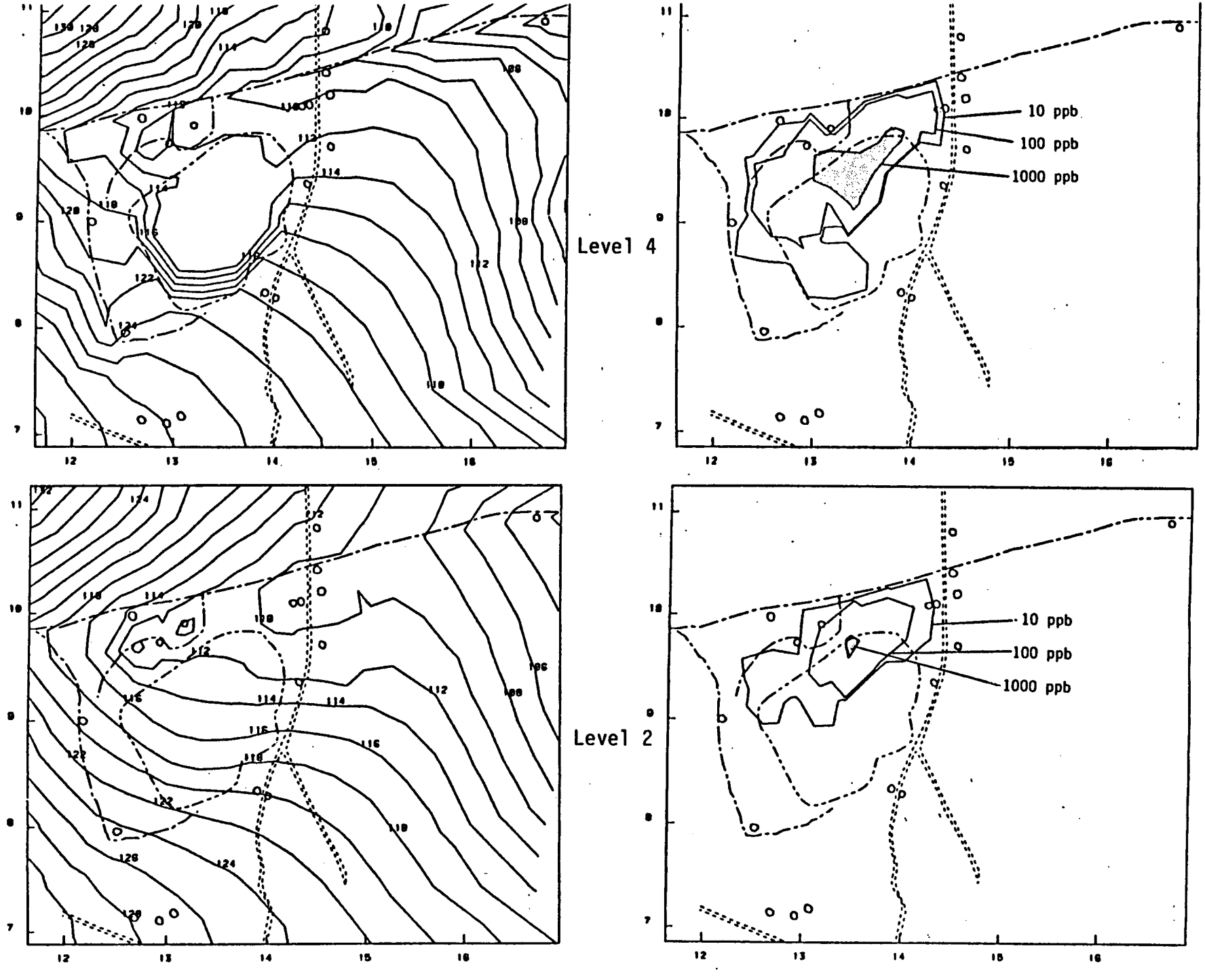


FIGURE 4-26: Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 3. (After 20 Years)

Simulation of plume migration, unlike that of the deep wall case, must consider the potential for continued migration of contaminants already in the Red Bank formation below the landfill. This preserves a significant mass of pollutants within the active flow field, pollutants previously isolated from the system by the deep confining wall of Alternatives 2 and 2A.

Due to the increase in mass outside the containment wall, plume concentrations following 15 years of simulation were higher than those found in Alternatives 2 or 2A. After 20 years of pumping however, as shown in Figure 4-26, simulation results indicate that the plume has been effectively controlled in the Red Bank formation. Although a residual plume still exists directly north of the landfill at level 2 in an area equidistant from pumps 2 and 3, this corresponds to the zone of least influence with respect to the simulated extraction well field. Furthermore, this indicates that well 2 should be located approximately 200 feet due east of well DEP 2 and pumped at 50 gpm to most effectively clean up the plume.

Pumping beyond 20 years at 50 gpm under this alternative is not advisable as a means to control concentrations within the Hornerstown formation (level 4). North of the landfill an upward vertical gradient through the Hornerstown is, in fact, the driving force for cleanup within this layer. This also implies eventual discharge to the river itself. In other words, cleanup within the Hornerstown is accomplished through natural aquifer flushing. Computed concentrations in the Manasquan River at Burke Road were approximately 160 ppb after 5 years, 60 ppb after 10 years and less than 20 ppb following 15 years of simulation.

399

Alternative 3A

Alternative 3A is similar to Alternative 3 except that pumping rates in extraction wells 1, 3, and 4 were increased to 100 gpm and pumping in well 2 was increased to 60 gpm. Simulated flow fields and residual concentration contour plots for layers 2 and 4 following 20 years of simulation are shown in Figure 4-27. Comparison of this flow field with that of Alternative 3 reveals that the simulated cones of depression for the extraction well field are greater, thereby allowing for improved capture of pollutants and a resultant decrease in contaminant release to the Manasquan River. Computed concentrations in the river were approximately 50 ppb following 5 years, 40 ppb after 10 years and less than 20 ppb following 15 years. With respect to aquifer restoration, however, the relative improvement of this scheme over that of Alternative 3 is considered marginal. By increasing extraction well drawdowns, vertical gradients through the Hornerstown formation approached zero in regions north and south of the wells which tended to trap portions of the plume at these locations. Although this in part may be an artifact of the simulation methodology, a relatively dilute residual plume located in the Hornerstown formation could be anticipated with this alternative.

Alternative 3B

Alternative 3B is a second variation of Alternative 3, which assumes no extraction pumping. Simulated flow fields and concentration contour plots after 20 years for levels 2 and 4 are shown in Figure 4-28. This figure illustrates that aquifer restoration without external pumping can be accomplished through shallow wall containment, but will proceed at a much slower rate than in Alternatives 3 or 3A. In addition, even though pollutant concentrations in the Manasquan River, as expected, are initially higher than those of Alternatives 3 or 3A, release following 15 years was considered acceptable. Com-

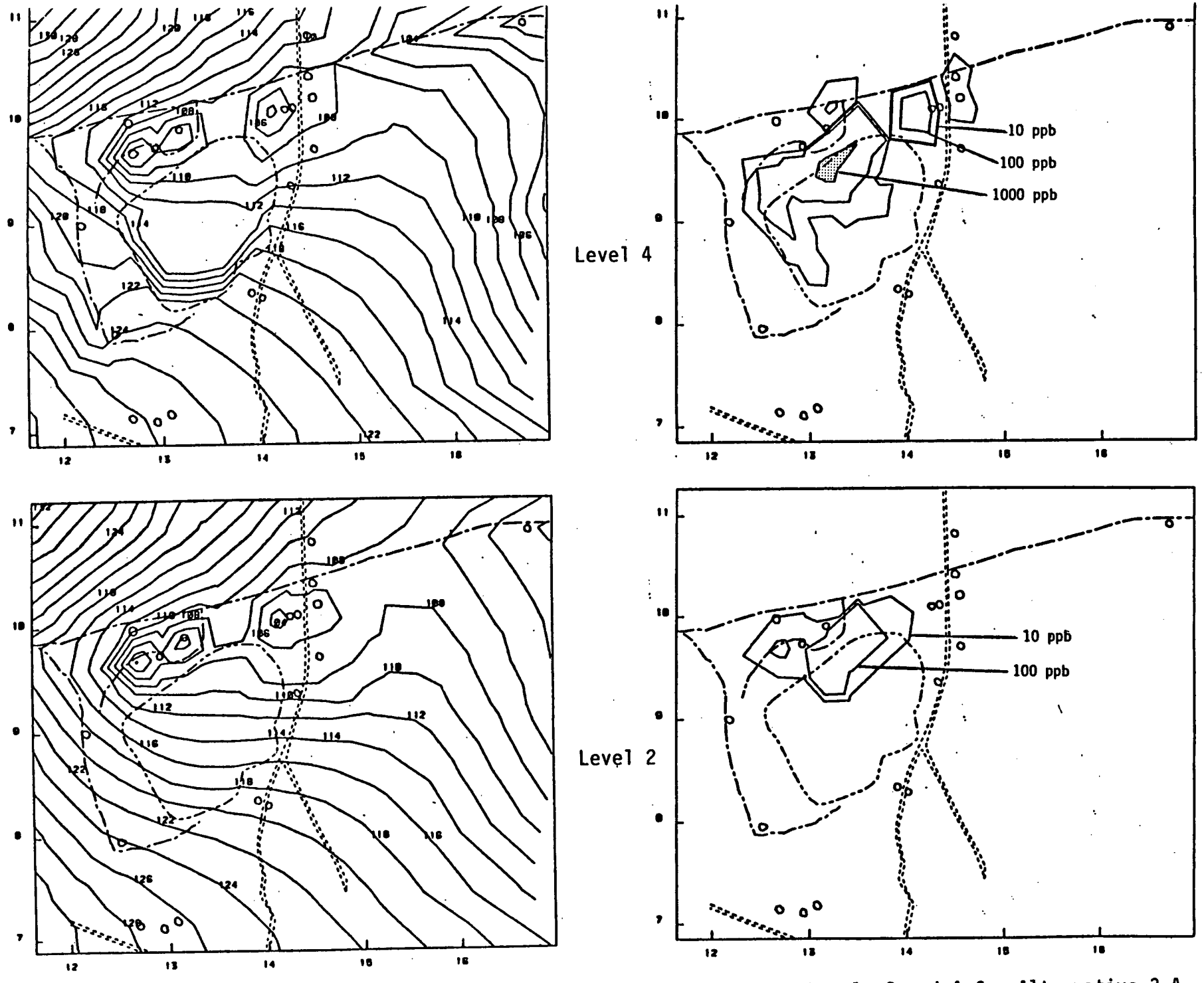


FIGURE 4-27: Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 3-A. (After 20 Years)

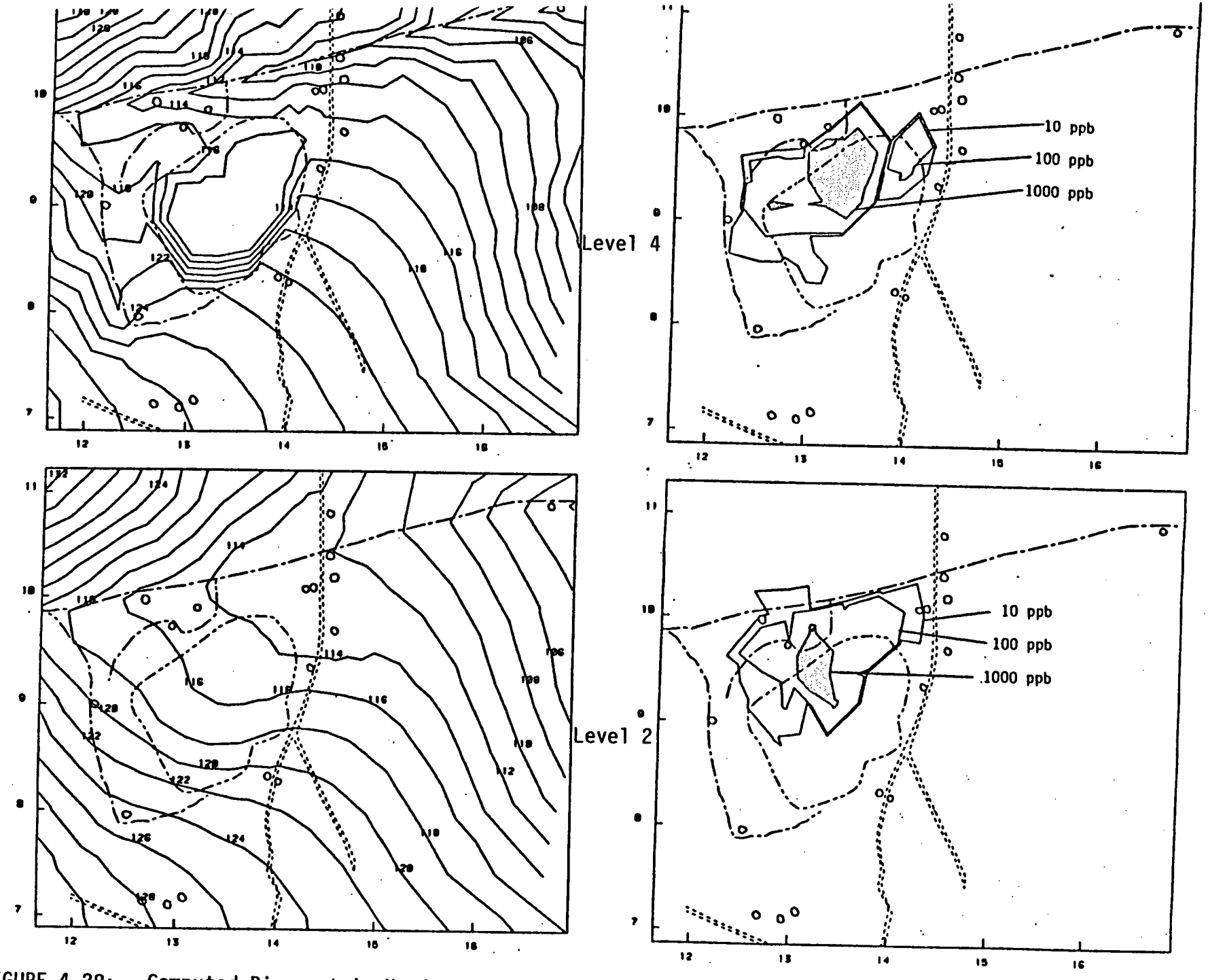


FIGURE 4-28: Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 3-B. (After 20 Years)

puted concentrations in the river at Burke Road following 5, 10, 15, and 20 year simulations were roughly 850 ppb, 250 ppb, 100 ppb and 40 ppb total volatile organics, respectively. Therefore, shallow wall containment at the site without extraction well pumping represents a feasible long-term cleanup strategy assuming that higher mass release is acceptable in the short term.

Alternative 4

Alternative 4 incorporated simulation of a landfill cap, coupled with external pumping from the Red Bank Sand layer. Pumping rates and locations were similar to those of Alternative 3A with the exception that pumping from wells 1 and 2 was increased to 120 gpm and 80 gpm, respectively.

The simulated flow field is illustrated in Figure 4-29 at levels 2 and 4. Since recharge to the surficial aquifer is eliminated over the landfill area, water table contours tend to flatten out indicating that mounding beneath the cap is eliminated. However, downward vertical gradients still exist through the Hornerstown formation in the southern half of the landfill. To reverse these gradients without the use of a slurry wall would require the placement of internal landfill pumps having rates significantly higher than those of Alternatives 2 or 3 within a highly contaminated zone. In addition, the horizontal gradient through the Vincentown Sand layer still prevails.

The projected plume configuration following 20 years of simulation is also shown for levels 2 and 4 in Figure 4-29. As can be seen, the plume configuration is essentially identical to existing conditions. This is primarily due to the fact that the source has not been removed from the active flow field. Slight improvement is observed in lower layers, but this is not considered significant with respect to the total system. The extraction wells do provide a mechanism for

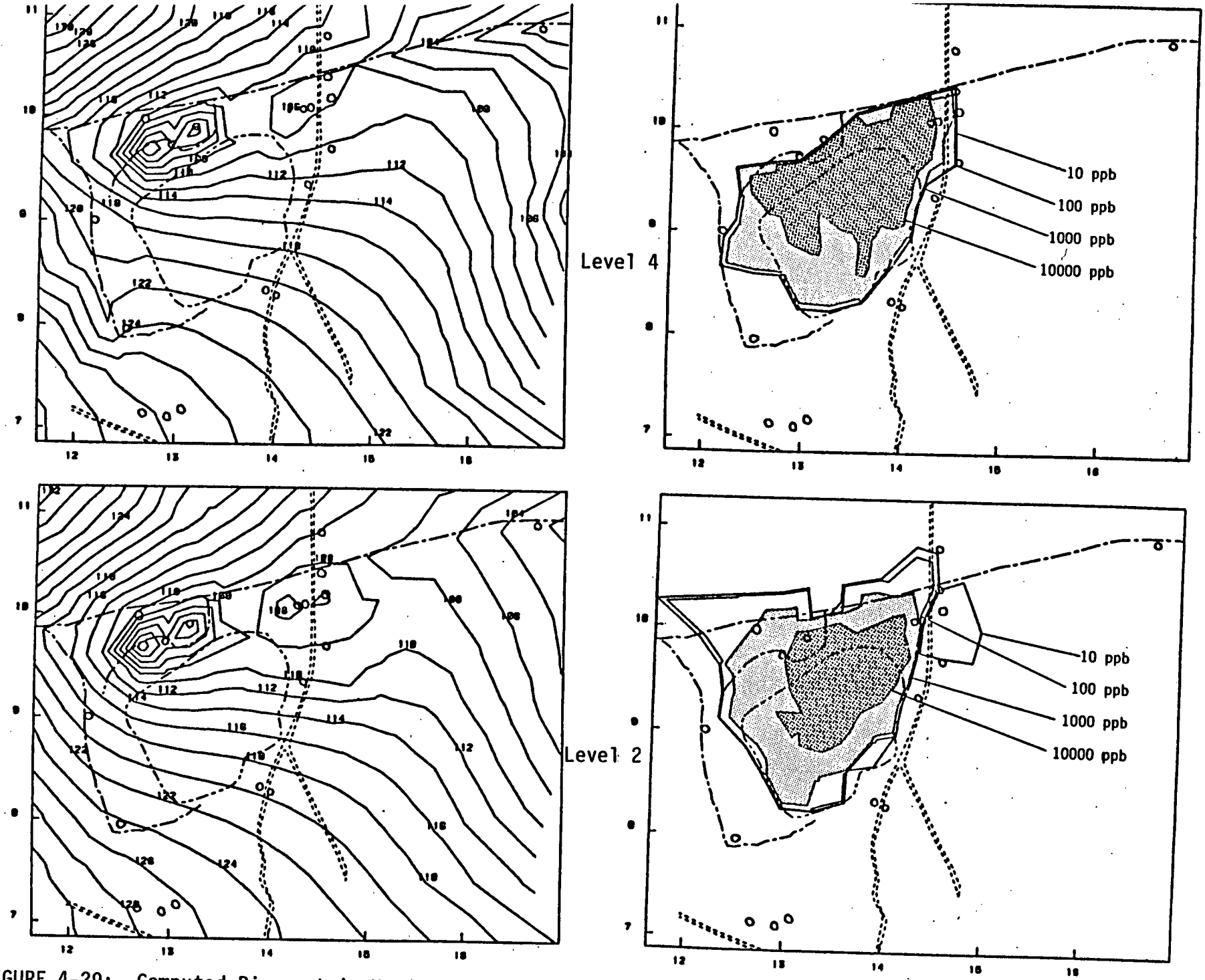


FIGURE 4-29: Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 4.

the capture of contaminants prior to reaching the Manasquan through depression of the phreatic water surface elevation between the landfill and river, but would require that pumping be continued until the source disappears. In other words, although this scheme allows for partial treatment of the existing plume it is not a means of achieving aquifer restoration until the source materials are out of the landfill. Computed concentrations in the Manasquan under this scheme ranged from 450 ppb to 100 ppb total volatile organics through the 20 year simulation.

Alternative 4A

Alternative 4A illustrates the effect of simply providing a landfill cap at the site. The simulated flow field and concentration contour plots are shown in Figure 4-30 for levels 2 and 4. In essence, simulation results indicate that the plume's configuration closely approximates that of Alternative 1, No Action. This is due to the fact that both horizontal and vertical flow field components are only minimally impacted by a reduction in recharge. Since contaminant migration is primarily a function of the flow field simulated, these results are considered reasonable. Therefore, merely installing a landfill cap will have minimal impact relative to preventing the release or migration of contaminants.

Alternative 4B

Alternative 4B considers the effectiveness of extraction well pumping without the use of physical barriers for source containment. Extraction wells were positioned at the 4 locations previously described and pumped at 120, 80, 100, and 100 gpm from the Red Bank Sand layer. The simulated flow fields together with contaminant plumes following 20 years of simulation are shown in Figure 4-31. Contaminant plume migration is seen as being similar to that in Alternative

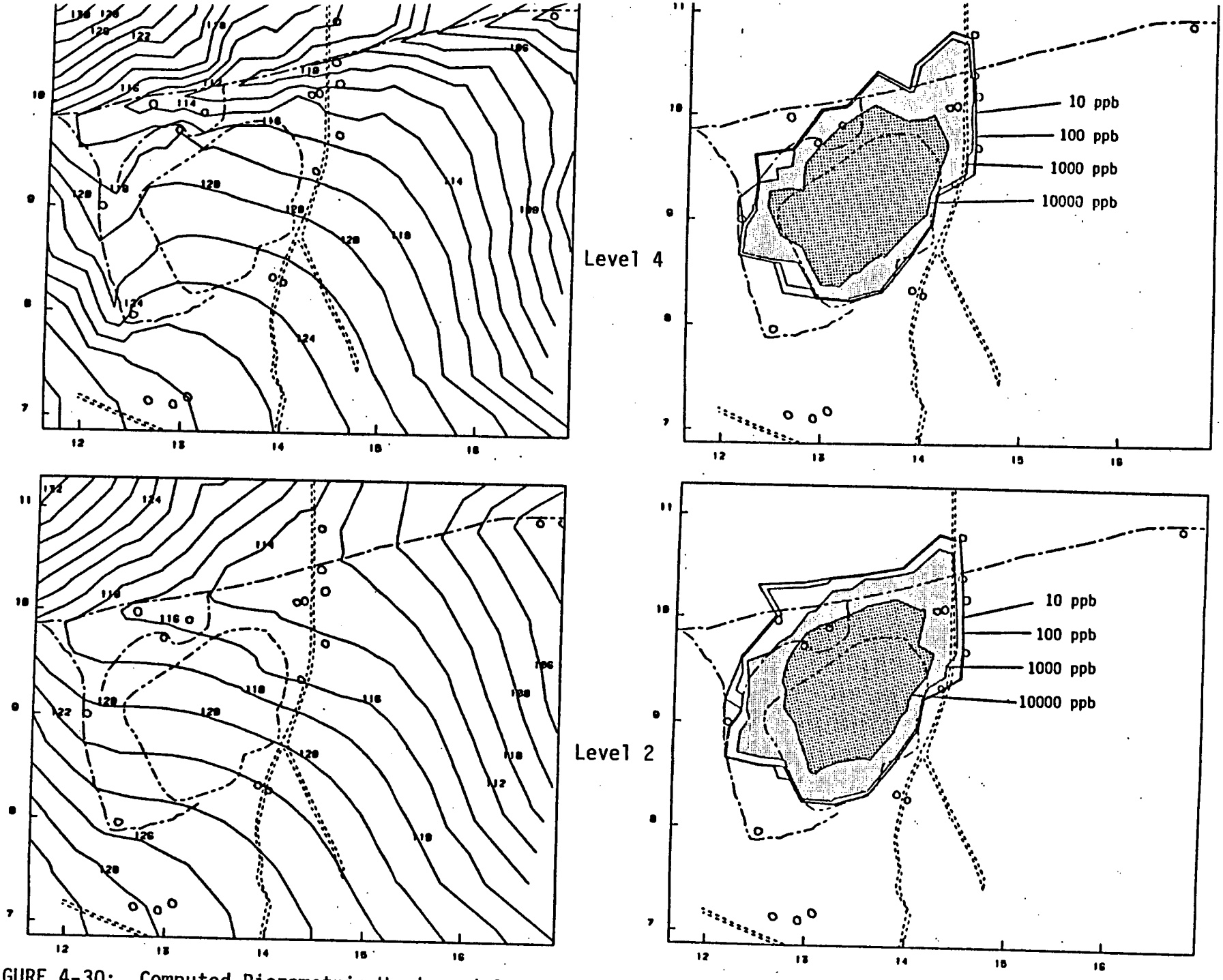


FIGURE 4-30: Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 4-A. (After 20 Years)

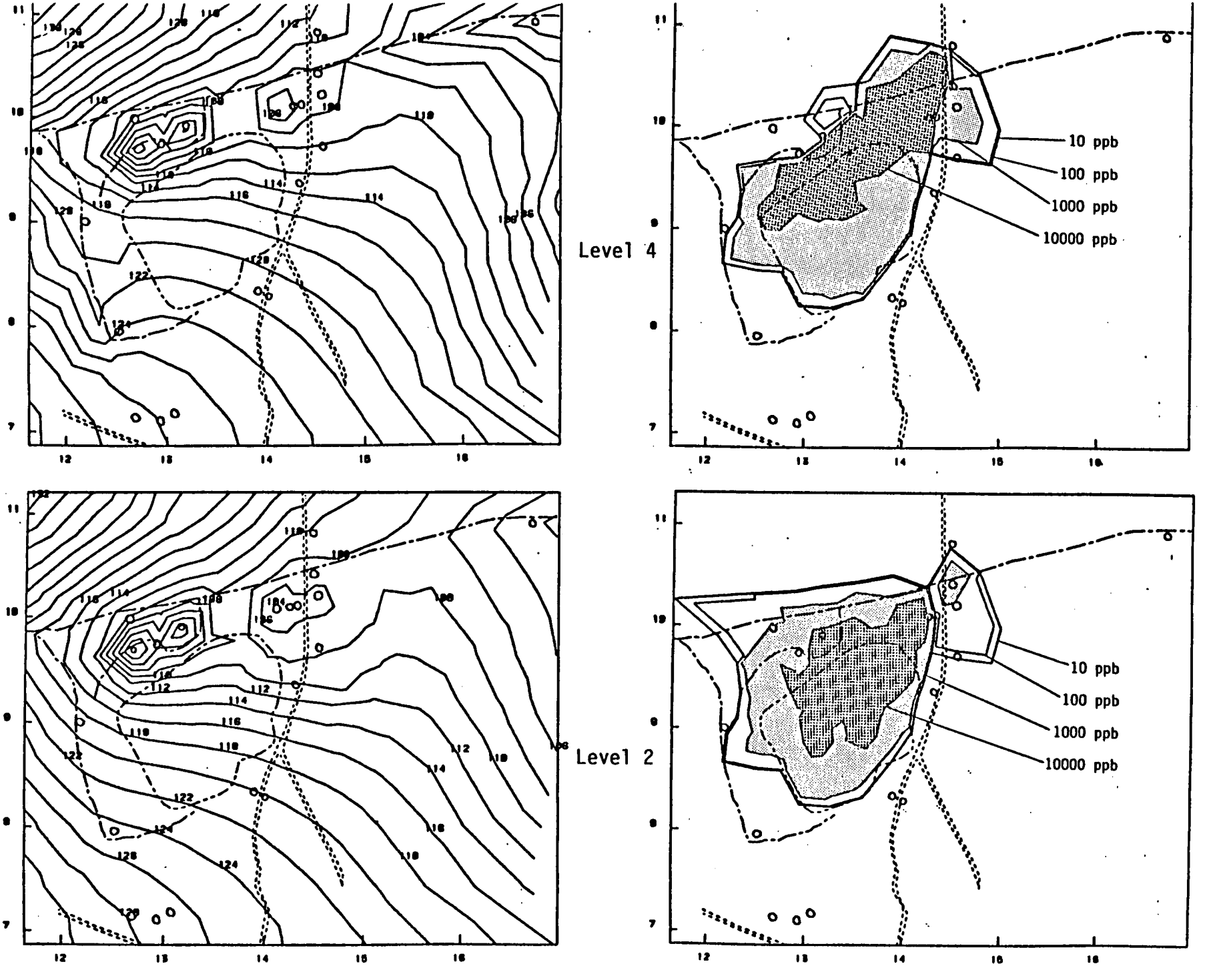


FIGURE 4-31: Computed Piezometric Heads and Concentration Contours in Levels 2 and 4 for Alternative 4-B.

4. Although a hydraulic barrier is created to capture contaminants from migrating to the river, aquifer restoration cannot be achieved until the source disappears. Computed concentrations in the Manasquan River were also similar to those reported for Alternative 4. However, as in the No Action case, overland washoff from surface runoff and leachate breakout, may also represent a significant mode of transport for pollutants to the river. Because Alternative 4B is essentially Alternative 4 without a clay landfill cap, it has not been treated in the report as a full alternative. As an option, however, no clay landfill cap is further discussed and evaluated in section 5.5.2.

Land Application of Extraction Well Effluent

Land application of extraction well effluent was considered as a means of reducing the costs for treatment in Alternatives 2, 3, 3A, 4 and 4B. Conceptually, this would incorporate the use of spray irrigation equipment or infiltration basins. Although these methods provide some means for the treatment of volatile organics, other known and unknown contaminants would preclude application of effluent over uncontaminated aquifer recharge zones. Therefore, it was concluded that the only acceptable location for land application was immediately south of the landfill in the recharge zone contributing to flow which passes beneath the landfill itself.

Spray irrigation in this zone was not considered feasible due to area limitations. At a recommended application rate of 2 inches per week, the required land area for treatment was determined to range between 37 and 75 acres for the pumping rates specified. Unfortunately the available land area south of the landfill is limited to approximately 15 acres without potential for contamination of the North Branch of the Metedeconk basin.

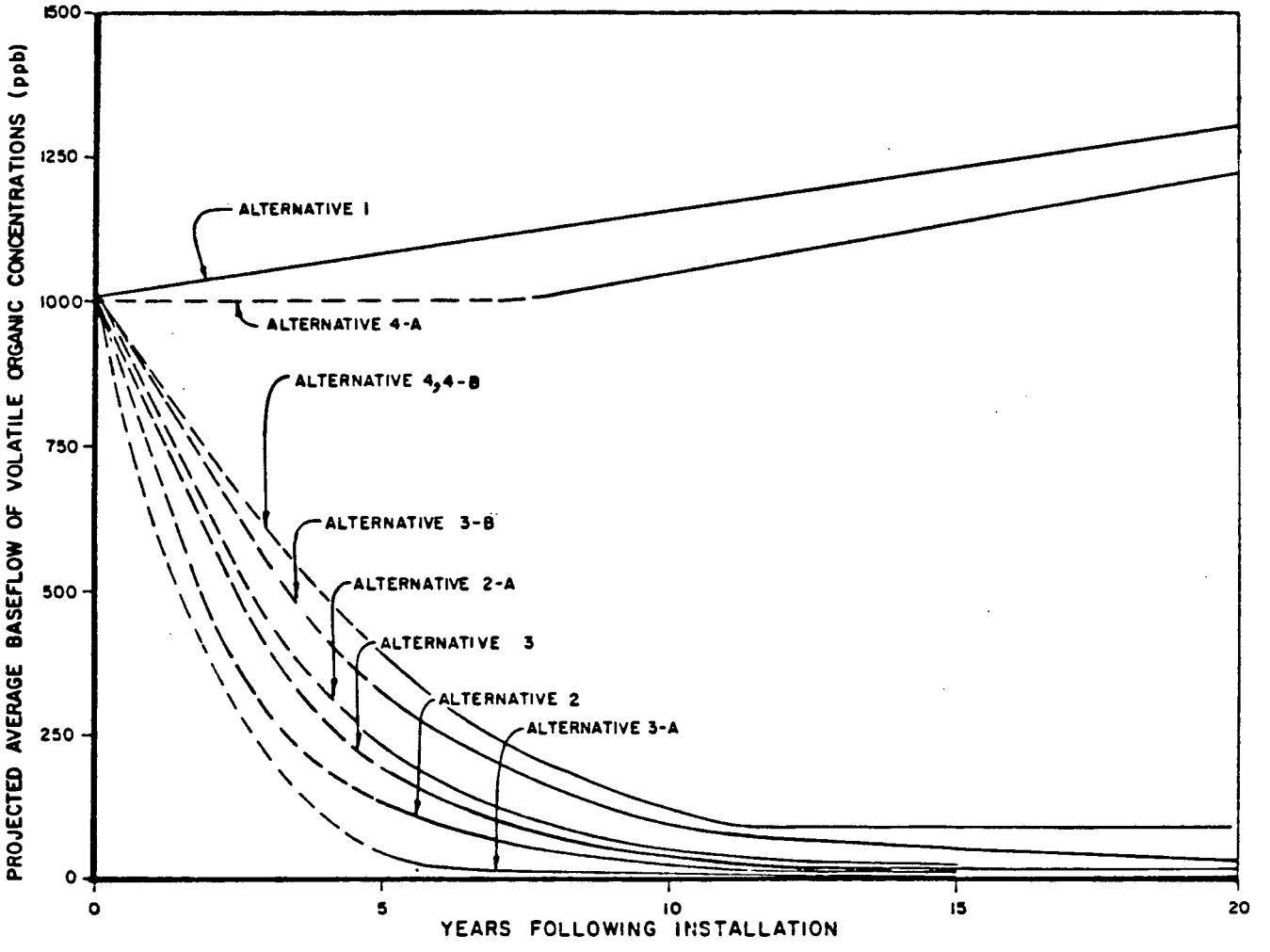
Utilizing preliminary design criteria for infiltration basins from EPA's Land Treatment of Municipal Wastewater Design Manual, it was concluded that rapid infiltration may be a feasible alternative. Noting that the stratigraphy south of the site is composed of approximately 30 feet of Vincentown Sand underlain by 10 feet of Hornerstown Marl, and that the water table is approximately 10 feet below ground surface, a basin area of 7 to 14 acres would be required assuming the vertical permeability of the Vincentown Sand remained in the range of 1.5 to 2.0 inches per hour. This was tested using DYNFLO by increasing the recharge flux in elements covering an area of 7 acres, assuming pumping equaled 200 gpm.

Simulation results revealed that even at the low end, i.e., extraction well pumping at 200 gpm, a significant potential exists for movement of the groundwater divide located south of the site to the recharge zone. Since this opens up the potential for a second contaminant plume to originate and migrate southward toward the North Branch of the Metedeconk River, it was not considered as a feasible treatment option.

4.10 SUMMARY OF ALTERNATIVE SIMULATION

Simulation results for each of the alternatives described above are summarized graphically in terms of projected pollutant release to the Manasquan River with time in Figure 4-32. This figure was developed for comparative purposes to illustrate the effectiveness of each of the alternatives in terms of estimated annual volatile organic concentrations resulting from base flow discharge to the river. For each of the curves, the flow rate in the Manasquan River was assumed

FIGURE 4-32



SUMMARY OF ESTIMATED BASEFLOW CONCENTRATIONS IN THE MANASQUAN RIVER AT BURKE ROAD

(BASED ON ESTIMATED AVERAGE BASEFLOW OF 2 c.f.s.)

to be equal to 2.0 cfs, a value representative of average base flow release over the grid without pumping. For alternatives incorporating pumping, this assumes that virtually complete removal is achieved through treatment and that the treated volume is then returned directly to the river with an insignificant concentration of total volatile organics.

Concentrations were computed at 5-year increments and represent average base flow release values for the period. Therefore, the curves plotted are somewhat conservative in terms of total effectiveness; however, relative differences are the important measure depicted.

Figure 4-32 illustrates that contaminant containment within the landfill, which also provides for aquifer restoration, allows for the greatest reduction in ultimate pollutant mass discharge to the Manasquan River with time. Utilization of a physical barrier in the form of a slurry wall and cap coupled with external pumping produces the best overall results as shown by the curves for Alternatives 2, 3 and 3A. Figure 4-32 also illustrates that as external pumping rates are increased, cleanup of the river proceeds at a faster rate. Note, however, that following 10 years of operation these differences become insignificant as shown by curves 2A and 3B. Although curves for Alternatives 4 and 4B also indicate that cleanup of the river can be accomplished through placement of a hydraulic barrier to contaminant transport from the landfill to the river, neither will provide for aquifer restoration until the source has been removed from the system. Simply capping the landfill, Alternative 4A, does not appear to be a feasible means for achieving a reduction in pollutant discharge to the river.

5.0 SCREENING AND EVALUATION OF ALTERNATIVES

5.1 INTRODUCTION

The remedial action alternatives described in sections 3 and 4 were subjected in this section to a two-step evaluation process. Sections 5.3 and 5.4 present the first step--an initial screening of the candidate alternatives based on cost, environmental impacts and engineering considerations. Sections 5.6 through 5.9 present the second step in the evaluation process, focusing on the alternatives that remain after the initial screening. Section 5.2 reviews the candidate alternatives, drawing from the results of section 4 and providing details on the internal and external well system specifications. Section 5.5 examines three additional considerations regarding the alternatives--Manasquan Reservoir effects, the no surface seal option and the French drain option.

5.2 ALTERNATIVES TO BE EVALUATED

Table 4-7 summarizes the major characteristics of remedial action alternatives 1 through 4B. External pumping in Alternative 5 is similar to Alternative 4 except that the external pumping rate is 200 gpm. As noted in section 4.9, Alternative 4B is essentially Alternative 4 without a clay landfill cap. It is evaluated in section 5.5.2.

The internal well system common to Alternatives 2, 2A, 3, 3A and 3B is to attain a total pumping rate of 30 gpm. This rate is achieved by providing a series of six wells around the landfill perimeter, each capable of extracting 10 gpm. At any given time half the

D49

wells would be in service. Internal pumping is necessary for an indefinite period because of the unknown source strength. For cost estimating purposes, a 50-year pumping duration is used.

The external well system common to Alternatives 2, 3, and 5 is to attain a total pumping rate of 200 gpm. In the groundwater model (section 4) this was simulated using four 50-gpm wells. In actual practice, however, a well field consisting of a large number of small capacity wells would be used rather than a small number of large capacity wells. The reasons for this are greater ease of operation and ease of well cleaning. Well cleaning becomes a major cost item on large diameter wells (see for example the well cleaning costs for the internal wells in section 2.3.1.) the 200-gpm pumping rate will be achieved with a well field of twenty-eight 10-gpm wells. The additional eight wells are required to provide for a certain number of wells being down for cleaning at any given time. For Alternatives 3A and 4 the total external pumping rate is 400 gpm. A well field of forty 10- to 15-gpm wells will provide this capability. Groundwater modeling results indicate that external pumping is necessary for 20 years, except for Alternative 2 which requires only 15 years and alternative 4 which requires pumping until the source disappears.

It is noted that the discharge-after-treatment component of Alternatives 2 through 5 refers to Manasquan River discharge. An option for groundwater recharge-after-treatment was considered. This option has been ruled out for the following reasons:

1) Groundwater modeling results (see section 4) indicate that the pumping rate required for plume containment is such that the amount of treated water to be discharged would not have a significant effect on stream flow, nor would the regional groundwater table be significantly lowered.

2) Stream discharge provides an opportunity for additional, post-treatment volatile organics removal (below the 100 ppb discharge standard) through natural aeration (see section 5.5.1--Manasquan Reservoir Effects).

3) Recharge to the aquifer between the landfill and river would be essentially the same as river discharge due to the proximity of the river. Recharge upgradient of the plume, as discussed in section 4.9, would require an area larger than is available at a 2-inch-per-week application rate (NJDEP guideline), and could cause localized flow of groundwater across the nearby groundwater divide into an "uncontaminated" aquifer if recharged at a 10-inch-per-week rapid infiltration system rate.

4) A groundwater recharge system would be more expensive than a surface water discharge system.

In view of the above considerations, there are no compelling reasons to choose groundwater recharge-after-treatment over surface water discharge-after-treatment. Therefore, the recharge-after-treatment option for the alternatives will not be evaluated further.

5.3 SCREENING OF ALTERNATIVES

Alternatives 1 through 5 were compared from the standpoints of cost, major short-term and long-term environmental impacts, and the engineering considerations, implementability and constructability. The screening provided an identification of those alternatives having excessive costs, significant adverse environmental impacts or major engineering problems. Those alternatives that are more cost intensive without providing commensurate benefits, have adverse environmental impacts that cannot be adequately mitigated, or are technically inappropriate for the site conditions were eliminated from further evaluation.

5.3.1 Costs

An estimate of capital, annual operation and maintenance and present worth costs (50-year time period) was made for each alternative. Capital costs for the individual components of the alternatives are shown on Table 5-1. Capital costs by alternative are shown on Table 5-2. Capital costs for the surface seal component were calculated on a cost-per-cubic yard basis. Recognizing that each layer of the multiple-layer surface seal has specific material requirements such as stated permeability or sieve size distribution, it was assumed that a portion of the material requirements could be obtained from local sources but that the large total soil requirements dictate that imported material would be involved. The costs per cubic yard reflect this split between local and imported material. Other elements involved in the surface seal capital cost estimate were grading and gas monitoring wells. The elements involved in the capital cost estimates of the other components of the alternatives are described in section 3.1.

Annual operation and maintenance (O&M) costs for the individual components of the alternatives are presented on Table 5-3. Table 5-4 presents the annual O&M costs by alternative. These costs are presented for the categories of labor, power, chemicals, equipment maintenance, structural maintenance, carbon regeneration and sludge hauling. For labor costs, a minimum team of two for any activities at the site was assumed because of the hazardous nature of the site. Daily chemical batch preparation and effluent sampling will require 7-day per week staffing. These activities will probably not require a full 8-hour day. For the preliminary cost estimate, however, it was assumed that staff would be hired for the sole purpose of operating and maintaining the facility. Annual costs for the monitoring program include labor costs for equipment set-up and sample collection, laboratory analytical costs and monitoring well refurbishing and cleaning costs. Equipment and structural maintenance costs and replacement costs are also included.

637

TABLE 5-1

CAPITAL COSTS OF COMPONENTS OF THE ALTERNATIVES

1.	Surface Sealing with Drainage Swales and Gas Control - 45 acres		$5,690,000
2.	Slurry Walls		
	Shallow Design - 30 ft depth		882,000
	Deep Design - 140 ft depth		8,232,000
3.	Internal Wells and Piping	Q= 30 gpm-	210,000
4.	External Wells and Piping	Q=400 gpm-	524,000
		Q=200 gpm-	426,000
5.	Groundwater Treatment	Q=430 gpm-	2,189,000
		Q=400 gpm-	2,189,000
		Q=230 gpm-	1,415,000
		Q=200 gpm-	1,415,000
		Q= 30 gpm-	921,000
6.	Drum Excavation and Removal - 30,000 to 50,000 drums and associated earth		$22 to 50 million
7.	Sediment Control by Dredging - 75,000 cu yd		210,000
8.	Storage Prior to Discharge	Q=430 gpm-	1,350,000
		Q=400 gpm-	1,350,000
		Q=230 gpm-	900,000
		Q=200 gpm-	900,000
		Q= 30 gpm-	150,000
9.	Monitoring Program		30,000

TABLE 5-2

CAPITAL COSTS OF THE ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 2A	Alternative 3	Alternative 3A	Alternative 3B	Alternative 4	Alternative 4A	Alternative 5
Surface Sealing	----	$5,690,000	$5,690,000	$5,690,000	$5,690,000	$5,690,000	$5,690,000	$5,690,000	$5,690,000
Slurry Walls									
Shallow	---	---	---	882,000	882,000	882,000	---	---	---
Deep	---	8,232,000	8,232,000	---	---	---	---	---	---
Internal Wells	---	210,000	210,000	210,000	210,000	210,000	---	---	---
External Wells	---	426,000	---	426,000	524,000	---	524,000	---	426,000
Groundwater Treatment	---	1,415,000	921,000	1,415,000	2,189,000	921,000	2,189,000	---	1,415,000
Drum Excavation	---	---	---	---	---	---	---	---	22-50,000,000
Sediment Control*	---	210,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000
Storage	---	900,000	150,000	900,000	1,350,000	150,000	1,350,000	---	900,000
Monitoring Program	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Subtotal	30,000	17,113,000	15,443,000	9,763,000	11,085,000	8,093,000	9,993,000	5,930,000	30.7-58.7 million
Engineering and Contingencies (35%)	10,500	5,990,000	5,405,000	3,417,000	3,880,000	2,833,000	3,498,000	2,076,000	10.7-20.6 million
Total	40,500	23,103,000	20,848,000	13,180,000	14,965,000	10,926,000	13,491,000	8,006,000	41.4-79.3 million

*Total costs include sediment control costs. If sediment control is determined to be unnecessary, deletion of sediment control costs would not change the relative cost ranking, since all alternatives would be similarly affected.

6&5-

TABLE 5-3

TOTAL ANNUAL O&M COST OF COMPONENTS OF ALTERNATIVES

Internal Wells	
Power	$1,764
Structural Maintenance	630
Equipment Maintenance	840
Total	$3,234

External Wells	Q=400 gpm	Q=200 gpm
Power	$5,880	$2,940
Structural Maintenance	1,573	1,278
Equipment Maintenance	2,097	1,704
Total	$9,550	$5,922

	Flow (gpm)				
Groundwater Treatment	430	400	230	200	30
Labor	$70,000	$70,000	$70,000	$70,000	$70,000
Power	134,000	134,000	86,000	86,000	22,000
Chemicals	351,000	330,000	211,000	190,000	26,000
Equipment Maintenance	16,000	16,000	9,600	9,600	6,600
Structural Maintenance	3,200	3,200	2,300	2,300	1,300
Carbon Regeneration	100,000	100,000	100,000	100,000	100,000
Sludge Hauling	15,000	15,000	15,000	15,000	2,200
Total	$689,000	$668,000	$494,000	$473,000	$228,000
Storage	$ 6,750	$ 6,750	$ 4,500	$ 4,500	$ 750
Surface Seal	$ 5,000				

Monitoring Program	
Groundwater/Surface Water	
With Onsite Treatment	$ 58,900
Without Onsite Treatment	30,200
Air	
With Surface Seal	$ 29,000
Without Surface Seal	38,200

TABLE 5-4

ANNUAL O&M COSTS OF ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 2A	Alternative 3	Alternative 3A	Alternative 3B	Alternative 4	Alternative 4A	Alternative 5
Internal Wells	---	$ 3,234	$ 3,234	$ 3,234	$ 3,234	$ 3,234	---	---	---
External Wells	---	5,922	---	5,922	9,550	---	$ 9,550	---	$ 5,922
Groundwater Treatment	---	494,000	228,000	494,000	689,000	228,000	668,000	---	473,000
Surface Seal		5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Storage	---	4,500	750	4,500	6,750	750	6,750	---	4,500
Monitoring	68,380	87,850	87,850	87,850	87,850	87,850	87,850	59,200	87,850

NOTE: The specific external well, groundwater treatment, storage and monitoring annual O&M costs will not remain the same for any particular alternative for the entire 50-year period. Thus, these costs should not be totalled for comparison as total annual operation and maintenance costs.

The basis for power, chemical and equipment and structural maintenance costs are discussed in section 2. Carbon regeneration and sludge hauling costs are discussed here because of the possible variability in these costs. Carbon regeneration costs assume that the contaminated carbon can be regenerated. Contamination known at present to be at the landfill is almost completely of the type which can be removed when the carbon is regenerated. However, if the carbon beds become contaminated such that the carbon cannot be regenerated, they must be handled as a hazardous waste and be removed to a secure hazardous waste landfill and replaced by new carbon. The cost of replacing a contaminated carbon bed is more than double the cost of regenerating a bed.

Sludge hauling costs are also dependent on the nature of the sludge. The estimated costs shown are for a non-hazardous sludge being transported to an operating sanitary landfill 30 miles from the Lone Pine site and include costs for both transportation and landfilling charges. Should the sludge be classified as hazardous, it would have to be disposed of at a secure hazardous waste landfill and the costs would increase greatly.

It is not anticipated that the sludge will be hazardous because treatment process sequence changes can be made to remove the contamination prior to the chemical precipitation step. Nevertheless, changes in contaminant release from the landfill indicate that the possibility for future generation of a hazardous sludge does exist. Also to be considered is the possibility of containing resulting non-hazardous sludge at the Lone Pine site itself. This would greatly reduce transportation costs and also would not require extensive dewatering prior to transport. This sludge disposal option should be considered further in the conceptual design.

689

Present worth costs for each of the alternatives are presented on Table 5-5. As previously mentioned, a 50-year planning period has been employed to allow comparison of the alternatives on an equivalent basis. The selection of a 50-year period is a result of the assumed 50-year duration for pumping the internal wells. Replacement costs on Table 5-5 reflect the fact that the useful life for most of the components of the alternatives is less than 50 years.

5.3.2 Environmental Impacts

This section presents an evaluation of the environmental impacts associated with the nine remedial action alternatives. The major focus of this evaluation was directed at the magnitude of beneficial or adverse effects resulting from implementation of the various long-term remedial actions, relative to one another. This evaluation briefly addresses minor short-term adverse impacts associated with construction-related activities, since these impacts could be mitigated by appropriate control measures.

Table 5-6 presents these findings in an environmental matrix. Impacts have been evaluated with respect to duration and have been designated as short term or long term. Short-term impacts include those resulting from construction and implementation of the remedial action within a total period of 5 years. In other words, short-term impacts consider the effects of actual construction and the environmental impacts that result within the 3 to 4 years following installation. This allows a comparison between the immediate effects of each alternative on the environment. Long-term impacts are those which result from implementation of each alternative at the conclusion of the 5- year period to 20 years in the future. Twenty years was used as the cut-off point for long-term impacts, since this was the amount of time required to effectively clean up the surface and groundwater as indicated in the computer modeling.

689

TABLE 5-5

PRESENT WORTH COSTS COMPARISON OF ALTERNATIVES ($ MILLION)

	Alternative 1	Alternative 2	Alternative 2A	Alternative 3	Alternative 3A	Alternative 3B	Alternative 4	Alternative 4A	Alternative 5
Capital Costs	0.04	23.1	20.9	13.2	15.0	10.9	13.5	8.01	41.4-79.3
Present Worth of O&M Costs	---	5.76	3.54	6.03	7.80	3.54	7.07	0.05	4.31
Replacement Costs	---	1.39	1.21	0.71	0.95	0.53	1.02	0.03	0.47
Monitoring Costs	0.58	0.55	0.55	0.55	0.55	0.55	0.55	0.28	0.51
Total	0.62	30.8	26.2	20.5	24.3	15.5	22.1	8.37	$46.7-84.6

TABLE 6-6

ENVIRONMENTAL MATRIX

ALTERNATIVE		PHYSICAL ENVIRONMENT				BIOLOGICAL ENVIRONMENT		SOCIOECONOMIC ENVIRONMENT			
		GROUNDWATER	SURFACE WATER	AIR QUALITY		FLORA + FAUNA		LAND USE	POPULATION & ECONOMICS	TRANSPORTATION	ENERGY
No. 1 NO ACTION	SHORT TERM	--	--	*		--		--	--	0	++
	LONG TERM	--	--	*		--		--	--	0	++
No. 2 DEEP CONTAINMENT WALL WITH PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	+	+	*		+		+	+	--	--
	LONG TERM	++	++	*		++		+	+	0	-
No. 2A DEEP CONTAINMENT WALL WITHOUT EXTERNAL PUMPING	SHORT TERM	+	+	*		+		+	+	--	--
	LONG TERM	++	++	*		++		+	+	0	-
No. 3 SHALLOW CONTAINMENT WALL WITH PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	+	+	*		+		+	+	-	-
	LONG TERM	++	++	*		+		+	+	0	-
No. 3A SHALLOW CONTAINMENT WALL WITH HIGH-RATE PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	++	++	*		++		+	+	-	-
	LONG TERM	++	++	*		++		+	+	0	--
No. 3B SHALLOW CONTAINMENT WALL WITHOUT EXTERNAL PUMPING	SHORT TERM	+	+	*		+		+	+	-	-
	LONG TERM	++	++	*		++		+	+	0	-
No. 4 INTERCEPTION WITH TREATMENT AND DISCHARGE (NO CONTAINMENT)	SHORT TERM	+	+	*		+		+	0	-	+
	LONG TERM	+	+	*		+		+	0	0	--
No. 4A SURFACE SEALING WITHOUT INTERCEPTION, TREATMENT OR DISCHARGE (NO CONTAINMENT)	SHORT TERM	+	+	*		0		-	-	-	+
	LONG TERM	--	--	*		--		-	-	0	++
No. 5 DRUM EXCAVATION AND REMOVAL WITH PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	+	+	*		+		-	+	--	--
	LONG TERM	++	++	*		+		++	+	0	-

++ BENEFICIAL

+ MARGINALLY BENEFICIAL

0 INSIGNIFICANT

- MARGINALLY ADVERSE

-- ADVERSE

* AIR QUALITY MONITORING IN PROGRESS

The degree of impact has been evaluated and rated using the following designations:

++ Highly beneficial
+ Beneficial
o Insignificant
- Minor adverse
-- Adverse

The matrix consists of three categories: physical environment, biological environment and socioeconomic environment. The parameters listed under the physical environment and biological environment should be given the greatest consideration since these parameters directly, or indirectly, affect human health. When assessing the overall impacts of each alternative, it is important to recognize that impacts to the physical and biological environment are given more weight than those parameters constituting the socioeconomic environment.

The considerations given to each category of analysis were as follows.

Physical Environment

Groundwater and Surface Water. The impacts to surface and groundwater were evaluated on both a short-term and long-term basis. Consideration was given to contaminant migration, pollutant mass, aquifer restoration, surface runoff, potential seepage of landfill leachate and discharge to the Manasquan River.

The degree of impacts was based on the length of time required for improvement in surface and groundwater quality after installation of the remedial alternative. Those alternatives providing relatively fast cleanup of the surface and groundwater were rated as benefical on a short-term basis. Relative rating of long-term impacts on ground and surface water considered the effectiveness in containment and/or removing the source of contamination. The data base used in evaluating the impacts to surface and groundwater was obtained primarily from section 4.0.

Air Quality. Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts of each alternative could be made. Although additional air quality data is required to supplement the limited data presently available, some conclusions have been made primarily based on anticipated levels of exposure that could be expected under each alternative. Certain assumptions have been made regarding excavation and removal of the drums (Alternative 5) based on the limited data available on the character and quantity of contaminants found in the soil, surface water and groundwater, and on past excavation projects performed at hazardous waste sites, particularly with respect to the emission of volatile organic chemicals during excavation of the drums.

Biological Environment

Flora and Fauna. This category includes an assessment of impacts to aquatic plants and animals, wetlands and wildlife. The relative impacts of each alternative were based primarily on the length of time required for cleanup of the surface and groundwater and the effective containment of pollutants over a 20-year period. Remedial alternatives providing rapid cleanup of surface and groundwater were considered to have greater short-term and long-term beneficial impacts on plants and animals. This category also addressed potential impacts on human health.

Socioeconomic Environment

Land Use, Population and Economics. Impacts on land use, population and economics resulting from implementation of each alternative were based on the overall impacts to the physical and biological environmental categories. This assessment considered impacts on future potential growth and development in the study area and impacts to adjacent parklands. The migration of residents into and out of the study area resulting from implementation of each alternative was also considered.

Transportation. This environmental parameter included the impacts associated with short-term construction-related activities, transport of hazardous wastes off site, as well as long-term impacts associated with the transport of sludge generated by the groundwater treatment facility.

Energy. This environmental parameter included the impacts on energy resources associated with short-term construction-related activities such installation of a slurry wall, site grading and placement of a clay cap, implementation of internal and/or external extraction wells, and construction of the wastewater treatment facility. Long-term impacts on energy resources focused on the magnitude and duration proposed for abatement pumping of the contaminant plume under each of the alternatives.

The written discussion accompanying this matrix provides a descriptive evaluation of the degree of impact of each alternative on specific environmental parameters of concern. As with the matrix, the degree of impact of each alternative is relative to all other alternatives considered.

Alternative 1--No Action

Alternative 1 is the No Action alternative. Under this alternative, no technologies would be utilized to remedy the current situation and the site would remain in its present condition for an indefinite period of time. However, as part of this alternative a continuous air-monitoring program and a periodic sampling program for stream sediments and water quality would be implemented. The air-monitoring program would focus on monitoring hydrocarbon levels as indicators for potential volatile organic emissions.

Ground and Surface Water

Groundwater modeling results indicate that the spatial extent of aquifer contamination at the site will not increase over time. Pollutants leaching from the Vincentown Sand into the lower aquifer layers are transported from beneath the landfill in a northeasterly direction and eventually are discharged to the river in close proximity to the landfill.

Modeling results also indicate a gradual increase in total pollutant release to the Manasquan River. These results indicate that under existing conditions an average annual total volatile organic concentration of 1000 parts per billion (ppb) at Burke Road can be expected to increase to 1300 ppb over 20 years if no action is taken at the site. On a total mass basis, these values are likely to represent only a lower limit to contaminant transport to the river. This is due to the fact that "average annual conditions" at the site were simulated, which can only partially be assumed to indicate the effects of short-duration, high-intensity rainfall events. Although these events are relatively infrequent, they may allow for a significant release of contaminants to the river through overland flow.

This is of particular importance at this site since the landfill is in close proximity to the Manasquan River and its tributaries, and the drainage ditches encircling the site discharge directly to the river. Preliminary estimates indicate that volatilization should be virtually complete (i.e., volatile organic levels would be reduced to background levels) during the 16-mile passage from the landfill to the proposed reservoir intake. Water quality problems at the reservoir may occur if high concentration of nonvolatile contaminants are released from the source (as drums rupture over time or stemming from the bulk liquid wastes). Since the data available on such contaminants is positive in some cases, there is significant cause for concern regarding the potential for release of non-volatile compounds should the source not be controlled.

Under the No Action alternative, leachate would continue to seep from the surface of the landfill. This would contribute to further deterioration of surface water quality beyond that anticipated from base flow discharge.

Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with the No Action alternative can be made at this time.

Air monitoring, as currently being conducted and as proposed for the future, will provide data necessary for a complete air quality evaluation.

Flora and Fauna

Various site inspection reports have noted that the aquatic life within the Manasquan River has been adversely affected by the discharge of contaminated sediments and surface runoff. The headwaters

of the Manasquan has been described as a "total kill area" with no signs of biological life (Lester W. Jargowsky, Health Officer for Monmouth County). Most of the bottom of the river is coated with a black sludge and a dense growth of grey to red colored slime. Benthic organisms found consist primarily of Tubifex worms. These organisms indicate a highly organic environment and unhealthy conditions. No signs of green aquatic plant life are evident. In addition, wetlands adjacent to the river are severely stressed by the accumulation of contaminated sediment and runoff. Under the No Action alternative, the concentration of pollutants discharging into the Manasquan River from the landfill would continue to increase over time, adversely impacting areas further downstream.

Land Use

Under the No Action alternative, an adverse impact could occur to current property values and future growth and development in the study area due to the public's perception of adverse health effects resulting from air, water, soil and/or wildlife contamination. Development of new homes in those areas currently zoned for residential development north of the landfill could be discouraged due to the persistence of concern for the hazardous nature of the site and continued contamination. Parklands adjacent to the landfill that are currently unaffected could be adversely impacted due to the increased contaminant load carried downstream in the Manasquan River. That portion of the river located within the park would no longer be able to support waterfowl and other forms of wildlife. Contamination of all or portions of the parklands could be detrimental to public health and could result in restricted access to certain areas and/or closing of the parklands.

Population and Economics

The No Action alternative could have adverse impacts on the population within the study area resulting from the public's perception of adverse health effects mentioned previously. Allowing the existing condition to continue unabated could discourage development in the area and the subsequent in-migration of new residents. In fact, the No Action alternative could eventually result in the out-migration of local residents.

Minor adverse economic impacts could be closely tied to the impact on population and community growth potential. Halting the construction of new homes, coupled with the out-migration of area residents, could have marginally adverse impacts on local economics by eliminating the new jobs that would be generated during construction of new homes and could discourage local trade. These impacts would be minimal since future development plans within the study area call for low- to medium-density housing.

Transportation

Under Alternative 1 there would be no short-term or long-term impacts on transportation.

Energy

There would be no significant energy requirements under the No Action alternative. The only energy required would be as part of the stream sediment, water quality, and air-monitoring programs.

Alternative 2--Deep Containment Wall with Plume Pumping, Treatment and Discharge

Alternative 2 calls for the installation of a deep slurry wall around the full circumference of the landfill. An internal and external well system is proposed. Contaminated water from both well systems would be treated, stored and tested prior to discharging into the Manasquan River.

Groundwater and Surface Water

Construction of a deep slurry wall around the full circumference of the landfill would have similar short-term impacts as Alternatives 2A, 3 and 3B, which would have significantly more benefical impacts on the quality of both surface and groundwater than Alternative 1 but slightly fewer short-term beneficial impacts than Alternative 3A. Long-term beneficial impacts would be similar to those of Alternatives 2A, 3, 3A, and 3B. These impacts would be significantly more beneficial than those of Alternative 1, 4, 4A and 5. Sinking the wall to 140 feet will intercept the Navesink formation, a confining layer beneath the Red Bank Sand and the overlying formation. This procedure will severely retard the flow of contaminants rather than completely stop it. Internal pumping will create a negative pressure gradient within the confines of the wall and restrict the movement of contaminated groundwater away from the site. This procedure would allow a relatively rapid cleanup of the aquifer and surface water.

Groundwater modeling results indicate that, even with external pumping, contaminants would continue to be discharged to the Manasquan River for a 15- to 20-year period after the site is contained. Although an upward movement of groundwater through the Hornerstown formation will continue to transport contaminants in this layer to the river, total mass release to the river is significantly reduced.

The 100 ppb standard for discharge of volatile organics into surface and groundwater would be reached within 6 years after installation. Preliminary estimates of the dilution of contaminants within the Manasquan 6 years after installation indicate that the volatile organic concentration from the Lone Pine Landfill reaching the proposed reservoir would not exceed background levels at the intake.

Implementation of a multiple-layer surface seal would reduce leachate seeps above ground level. This would have a long-term beneficial impact on the quality of surface water by decreasing the contaminant load transported to adjacent water bodies and wetland areas.

Air Quality

As noted previously, monitoring of onsite air quality is in progress. Therefore, impacts on air quality resulting from implementation of this alternative cannot be completely assessed at this time. Air quality monitoring will provide data necessary for a complete air quality evaluation.

Available groundwater data indicates that some of the volatile organic compounds are already present in sufficient concentrations to be emitted at elevated levels when the groundwater is subjected to air stripping during the proposed treatment process. Based on findings from similar pilot plants and treatability studies, the volatile compounds of concern (vinyl chloride, benzene and toluene) could be completely removed from groundwater by the air-stripping process. This would result in certain volatile organic compounds emitted from the air-stripping process exceeding the 0.1 lb/hr emission rate limitation set by NJDEP. This, in turn, would require the air-stripping unit to be registered by the Department prior to construction. Exceeding this limit should not be misconstrued to represent a threat

to public health. This limit provides a point from which additional controls should be evaluated for inclusion in the design of the treatment facility.

While uncontrolled air stripping of the contaminated groundwater could potentially emit volatile organics above the 0.1 lb/hr threshold limit established by NJDEP, conventional air pollution control devices could be installed on the air-stripping units to prevent exceeding specific exposure limits. Exposure of water treatment plant operators to process emissions would be reduced through the use of protective equipment, such as encapsulated suits, chemical safety glasses, rubber boots, gloves and coveralls. It is not anticipated that air emissions from the treatment facility would have any negative impacts on residents in the area due to the distance of the landfill site from the residents and the dilution of the vapors in the air. Nevertheless, further evaluation of site-specific air quality data and modeling of plume dispersion from the air-stripping units are required before a final assessment can be determined.

This alternative also provides for the installation of a methane venting system if monitoring results indicate significant concentrations are being generated. Installation of this system would help to control the migration of methane off site and collection in clay pockets that could result in explosions and fires. In the event that methane vents are found necessary, air pollution control equipment, such as a carbon adsorption system, would be installed to prevent uncontrolled emissions of landfill gases.

Flora and Fauna

Implementation of Alternative 2 would have beneficial, long-term impacts on area plants and animals compared to the No Action alternative. Placement of a surface seal would allow revegetation of the site to occur and eventually provide habitats for many species of plants and animals (to the potential detriment of the surface seal integrity). Leachate seeps above ground level would be reduced by a surface seal, as would the transport of contaminated sediments and water to the Manasquan River. This technology, used in conjunction with a slurry wall and groundwater pumping and treatment, would allow a gradual restoration of the wetland areas and biological communities normally found in the headwaters of the Manasquan River. In addition, this alternative would provide safe drinking water to the wildlife located within the area. The gradual restoration of the wetland areas and adjacent surface waters would indicate an improvement in the environment and a beneficial long-term impact on public health, similar to those of Alternatives 2A, 3, 3A, and 3B.

Land Use

When compared to the No Action alternative, Alternative 2 would have a marginally beneficial impact on land use by improving the quality of the surface and groundwater. This alternative would protect the neighboring parklands and may encourage development of new homes in areas currently designated for such use. The impact would be marginal because most of the undeveloped land in the vicinity of the landfill is zoned 5-acre, rural residental. This classification allows for limited development of single-family detached housing units on 5-acre parcels. Therefore, under normal conditions, very little growth could occur.

Population and Economics

Alternative 2 would have marginally beneficial long-term impacts on the local population because this alternative would allow the area's continued growth under current rural residential zoning. In addition, marginally beneficial long-term impacts on economics could be anticipated because this alternative would allow for continued growth of the existing local economy.

Improvements in the quality of surface and groundwater under this alternative would not discourage new development in the area as may occur under the No Action alternative.

The movement of any new residents into the area would generally have a marginally beneficial impact on the local economy. Since only a few new residents could be expected to move into the community under normal growth, this could be translated into minor benefits to local trade.

Transportation

Construction under this alternative would have adverse short-term impacts on transportation due to the mobilization and demobilization of construction equipment, such as hydraulic backhoes, bulldozers, cranes, slurry mixers, etc., that would use local roadways to gain access to the site. There would be regular deliveries of construction materials and other equipment throughout the period of construction. This would include deliveries associated with the excavation and placement of the slurry wall, site grading and application of the clay cap, development of the extraction wells, and construction of the treatment facilities. These short-term impacts would be similar to Alternative 2A.

The sludge generated by the treatment facilities would require additional tank trucks for transporting the sludge off site. This would result in an estimated two truck trips per week. Therefore, this alternative would have no significant impact on transportation on a long-term basis.

Energy

Construction of a deep slurry wall to an estimated depth of 140 feet would expend substantially more energy than would construction of only a shallow slurry wall to an estimated depth of 30 feet proposed under Alternatives 3, 3A, and 3B. As a result, this alternative would have an adverse short-term impact to energy resources.

The energy required for pumping and treatment under this alternative would have a long-term adverse impact similar to those of Alternatives 2A, 3 and 3B, which all require the same level of pumping and treatment. The pumping period for the external wells would be at least 15 years. Internal pumping is necessary for approximately 50 years, during which time groundwater treatment would be performed. Both the pumping and groundwater treatment called for under this alternative would expend significantly more energy than those alternatives (such as 1 and 4A) which do not provide for these remedial actions.

Alternative 2A--Deep Containment Wall

Alternative 2A utilizes all of the same technologies as Alternative 2 without external plume pumping.

Groundwater and Surface Water

Alternative 2A would have short-term beneficial impacts on ground and surface water similar to those of Alternatives 2, 3, 3B, 4, 4A and 5. Groundwater modeling of this alternative indicates that the flow field north of the landfill closely approximates that under existing conditions, maintaining an upward gradient through all layers to the river. South of the landfill, no discernible change is apparent from that of Alternative 2.

Contaminant concentration in the Upper Red Bank Sand and Vincentown Sand after 15 years are higher than those indicated under Alternative 2. It is important to note, however, that aquifer restoration under Alternative 2A is achieved through natural aquifer flushing to the Manasquan River, whereas in Alternative 2, some of the pollutant mass outside the wall would be captured through pumping. Within 7.5 years after installation of this alternative, the concentration of volatile organic compounds discharging into the Manasquan River at Burke Road would be reduced to 100 ppb. It appears from the groundwater modeling results and data available that, after implementation of all the technologies provided for under this alternative, dilution and volatilization would reduce volatile organics released from the Lone Pine Landfill to background levels at the reservoir intake.

When compared to Alternative 2 this alternative would have similar long-term beneficial impacts on groundwater and surface water. These impacts would be relatively the same for 3, 3A and 3B as well.

Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with Alternative 2A can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air-stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lb/hr. Air quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment, which would need to be specified during the conceptual design.

Flora and Fauna

Implementation of Alternative 2A would have short-term beneficial impacts on plants and animals similar to those of Alternatives 2, 3, 3B, 4 and 5. Under Alternative 2A, however, the contaminated plume would continue to discharge at slightly higher levels than Alternatives 2, 3 and 3A into the Manasquan River for a 15-year period. The concentration of volatile organics in the Manasquan River would exceed the 100 ppb standard for approximately 7.5 years following installation of the slurry wall. On a long-term basis, cleanup of the surface and groundwater would have beneficial impacts on flora and fauna, as well as public health.

Land Use

The overall long-term beneficial impacts to land use described for Alternative 2, would also apply to this alternative.

Population and Economics

The long-term beneficial impacts to population and economics associated with Alternative 2, would also apply to this alternative.

206

Transportation

Construction of the 140-foot deep slurry wall, site grading and application of the clay cap, installation of internal extraction wells and construction of the wastewater treatment facilities would have adverse short-term impacts on transportation, similar to those of Alternative 2. There would be no long-term impacts on transportation resulting from the transport of sludge off site since the number of truck trips would be insignificant, as described in Alternative 2.

Energy

Short-term energy expenditures under this alternative would be similar to those of alternative 2, except that no energy would need to be expended for installation of an external extraction well field. This would result in short-term adverse impacts on energy resources similar to but marginally less than those of Alternative 2.

Alternative 2A would have fewer adverse long-term impacts on energy resources than those described under Alternative 2. Deletion of external extraction wells would reduce the energy requirements for pumping and reduce the quantities of groundwater that would require treatment under Alternatives 3A, 4 and 5.

Alternative 3--Shallow Containment Wall with Plume Pumping, Treatment and Discharge

Alternative 3 utilizes the same technology as Alternatives 2 and 2A. Onsite containment, however, is provided through the use of a shallow slurry wall penetrating to an average depth of approximately 30 feet.

Groundwater and Surface Water

Under Alternative 3, the short-term impacts to groundwater and surface water would be marginally less beneficial than those of Alternative 2. Long-term beneficial impacts on surface water and groundwater would be similar to those of Alternatives 2, 2A, 3A and 3B.

Unlike Alternatives 2 and 2A, which utilize a deep slurry wall, Alternative 3 allows a continuous migration of contaminants from the Red Bank formation under the landfill to occur, since contaminants have most likely already entered this level. External plume pumping would not effectively intercept all contaminants moving toward the Manasquan River in the deep Red Bank formation. This alternative leaves a significant mass of contamination within the active flow field, which would have a better chance of being removed from the system with the deep slurry wall. This mass of concentration remaining in the plume would be higher than that found with Alternatives 2 and 2A. Groundwater modeling results however, indicate that after 20 years of pumping, the plume would be effectively controlled in the Red Bank formation. Long-term beneficial impacts on surface water and groundwater would be similar to those of Alternatives 2, 2A, 3A and 3B.

Pumping beyond 20 years at 200 gpm under this alternative is not advisable as a means to control concentrations within the Hornerstown formation. Any residual contaminants remaining in the system after 20 years would be removed by natural aquifer flushing. This implies eventual direct discharge to the river itself.

Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with this alternative can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air-stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lb/hr. Air quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment, which would need to be specified during the conceptual design.

Flora and Fauna

The short-term impacts of this alternative on area flora and fauna would be similar to those of 2, 2A, 3B, 4 and 5, but slightly less beneficial than Alternative 3A since cleanup of the surface and groundwater would proceed at a slower rate. As stated previously, continued migration of contaminants from the Red Bank formation under the landfill to the Manasquan River would be likely. This migration would allow a portion of the plume to discharge into the Manasquan River for a longer period of time, resulting in an adverse impact on plant and animal life. In addition, this alternative calls for discontinuing external pumping after 20 years and provides for cleanup of the Hornerstown formation only through natural aquifer flushing.

The movement of contaminants from the surficial aquifer would then be discharged directly into the river. Long-term beneficial impacts of this alternative on flora and fauna, as well as public health, would be similar to those of Alternatives 2, 2A, 3A and 3B.

Land Use

The beneficial impacts on land use would be similar to those impacts discussed under Alternatives 2, 2A, 3A and 3B by improving the quality of surface and groundwater and thus allowing current land uses and development to occur as planned.

Population and Economics

Implementation of this alternative may have marginally beneficial long-term impacts on population and economics. These impacts would be equal in magnitude to those impacts associated with Alternatives 2, 2A, 3A and 3B, since growth and local economic development would not be inhibited.

Transportation

Construction of this alternative would have marginally adverse short-term impacts on transportation; however, these impacts would also be fewer than those described in Alternatives 2 and 2A because the magnitude and duration of construction of a shallow slurry wall would be substantially less. Long-term impacts on transportation resulting from the transport of sludge off site would be insignificant, as described in Alternatives 2, 2A, 3, 3A, 3B, 4, and 5.

Energy

Construction of this alternative would have fewer short-term impacts on energy resources than Alternatives 2 and 2A since substantially less energy would be expended for construction of a shallow slurry wall.

After 20 years of pumping, the contaminant plume should be effectively controlled in the Red Bank formation. The energy required for external pumping and groundwater treatment would have adverse impacts on energy resources, similar to Alternatives 2, 2A, and 3B. These impacts would be marginally less adverse than 3A and 4.

Alternative 3A--Shallow Containment Wall with High-Rate Plume Pumping, Treatment and Discharge

Alternative 3A utilizes the same technology as Alternative 3, except that the external pumping rate is doubled to a total of 400 gpm.

Groundwater and Surface Water

This alternative would have more beneficial short-term impacts on groundwater and surface water than Alternatives 1, 2A, 3, 3B, 4, 4A and 5. Long-term beneficial impacts would be similar to those of Alternatives 2, 2A, 3 and 3B.

Groundwater modeling results for Alternative 3A indicate that doubling the pumping rate within the external well field allows for improved capture of pollutants and a resultant decrease in contaminant release to the Manasquan River. The concentration of volatile organic compounds discharging into the Manasquan River at Burke Road would meet the current 100 ppb standard approximately 3.5 years after installation. These modeling results, however, indicate that the increased rate of plume pumping would not decrease the duration of pumping significantly below 20 years.

Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with Alternative 3A can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air-stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lb/hr. Air quality impacts associated with these emissions could be mitigated through installation of air pollution control equipment, which would need to be specified during the conceptual design of the treatment facility.

Flora and Fauna

Based upon modeling results, the short-term beneficial impacts to plant and animal life under this alternative would be greater than those of all other alternatives. This is because cleanup of both surface water and groundwater would proceed at a much faster rate and would achieve the current acceptable level for volatile organics under the State of New Jersey drinking water standards within 5 years. Long-term beneficial impacts on flora and fauna, as well as public health, would be similiar to the impacts achieved under Alternatives 2, 2A, 3 and 3B, because concentrations of volatile organics are projected to be well below State standards within the 20 year period.

Land Use

The marginal short-term and long-term beneficial impacts achievable under this alternative on land use would be attributed to improvements in ground and surface water quality and are similar to the impacts previously discussed in Alternatives 2, 2A, 3 and 3B.

Population and Economics

Implementation of this alternative would have marginal short-term and long-term beneficial impacts on population and economics because growth and local economic development would not be discouraged, as would be the case under the No Action alternative. These impacts would be similar to those described under Alternatives 2, 2A, 3 and 3B.

Transportation

Construction of this alternative would have marginally adverse short-term impacts on transportation and they would be fewer than those described in Alternatives 2 and 2A, because the magnitude and duration of construction of a shallow slurry wall would be substantially less. Long-term impacts on transportation resulting from the transport of sludge off site would be insignificant, as described in Alternatives 2, 2A, 3, 3B, 4 and 5. This is explained by the fact that although the quantity of groundwater treated would be greater, the groundwater would be more dilute. As a result, the quantity of sludge generated would be relatively the same as the other alternatives.

Energy

Construction of this alternative would have fewer short-term impacts on energy resources than Alternatives 2 and 2A since substantially less energy would be expended for construction of a shallow slurry wall. All other short-term construction-related energy impacts would be similar to those described under Alternatives 2, 2A and 3. On a long-term basis the increased rate of external pumping would create additional energy requirements beyond those of Alternatives 2, 2A, 3, 3B, 4A and 5. This alternative would have significant long-term adverse impacts to energy resources. Groundwater modeling results indicate that the duration of pumping could not be significantly reduced from 20 years.

Alternative 3B--Shallow Containment Wall

Alternative 3B is similar to Alternative 3 with the exception that no external wells are proposed.

Groundwater and Surface Water

The short-term impacts to surface and groundwater quality would be similar to those of Alternatives 2, 2A 3, 4, 4A and 5. When compared with simulation results for Alternatives 2, 2A, 3 and 3A, aquifer restoration without external pumping can be accomplished through shallow wall containment, but will proceed at a slower rate, particularly in the Red Bank formation. Also, as in Alternative 2A, restoration is achieved through natural aquifer flushing, with an increase in total pollutant mass release to the river. Under this alternative, the concentration of volatile organic compounds discharging to the Manasquan River at Burke Road will be reduced to 100 ppb approximately 10 years after installation. Long-term beneficial impacts of this alternative on groundwater and surface water would be similar to those of Alternatives 2 through 3A.

714

Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with Alternative 3B can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air-stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lb/hr. Air quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment, which would need to be specified during the conceptual design of the treatment facility.

Flora and Fauna

Beneficial short-term impacts on plants and animals, as discussed under Alternatives 2 through 3A, would apply to this alternative, although the degree of impact would be marginally less. Since this alternative does not provide for containment of contaminants in the Red Bank layer underneath the landfill, the concentration of contaminants found in the Red Bank layer of the plume would be higher. Without external wells this discharge would feed directly into the river. Although this alternative would have a long-term beneficial impact on plant and animal life, the short-term effectiveness of the system would be less than that of Alternatives 2 and 3A due to the length of time required to restore both the surface and groundwater quality. Wetlands are extremely sensitive areas reflecting subtle changes in the chemical, physical and biological parameters of the circulating water. It must be realized that continued release of contaminants to the Manasquan River, as would occur under this alternative, could adversely impact the wetlands areas.

Land Use

The short-term and long-term impacts associated with this alternative would be marginally beneficial and would be attributed to improvements in ground and surface water quality. These impacts are similar to those described under Alternatives 2, 2A, 3, and 3A.

Population and Economics

The marginal short-term and long-term beneficial impacts of this alternative would be similar to those discussed under Alternatives 2, 2A, 3, and 3A, since normal growth and local economic development would be unaffected.

Transportation

Construction of this alternative would have marginally adverse short-term impacts on transportation; these impacts would be fewer than those described in Alternatives 2 and 2A. The magnitude and duration of construction of a shallow slurry wall would be substantially less than a deep slurry wall because fewer truck deliveries of slurry would be required over a shorter construction period. Under this alternative no external extraction wells would be installed. All other construction-related impacts would be the same as those anticipated under Alternative 2.

The long-term impacts to transportation would be insignificant since less than two truck trips per week would be required for hauling of sludge off site.

Energy

Installation of a shallow slurry wall under this alternative would have significantly fewer short-term adverse impacts on energy resources than 2 and 2A, which utilize a deep slurry wall. In addition, short-term adverse impacts would be fewer since no energy would be expended in the development of external pumping wells. The long-term energy requirements of this alternative would cause a marginally adverse impact similar to that of Alternative 2A since no external pumping is employed.

Alternative 4--Interception with Treatment and Discharge (No Containment)

This alternative differs from Alternatives 2 and 3 in that no physical onsite containment is provided. Instead an external extraction well field with high-rate pumping is utilized to collect and treat contaminated groundwater prior to its entering the river.

Groundwater and Surface Water

The short-term impacts on surface and groundwater achievable under this alternative would be less beneficial than those of Alternatives 2 through 3B. The cleanup of the groundwater and surface water would proceed at a slower rate than under Alternatives 2 through 3B. Groundwater modeling results indicate that the total volatile organic concentration discharging into the Manasquan River at Burke Road would be reduced to 100 ppb approximately 11 years after installation. As with the other alternatives, placement of a surface seal would reduce recharge to the surficial aquifer from the entire landfill area, and the water table elevation contours would tend to

flatten out, indicating that mounding beneath the landfill is eliminated. However, the downward vertical gradient through the Hornerstown formation would still exist. In order to reverse this gradient without the use of a physical barrier, such as a slurry wall, significantly higher pumping rates than those proposed under Alternatives 2, 2A, 3, 3A and 3B would have to be employed under this alternative. In addition, a horizontal gradient through the Vincentown Sand layer would prevail. This would allow some contaminants to bypass the extraction wells and discharge into the Manasquan River.

Simulation results also indicate that this scheme will only allow for partial treatment of the existing plume. This is due primarily to the fact that the source has not been removed from the active flow field. The extraction wells provide a means of capture of contaminants prior to their reaching the Manasquan River, but continuous pumping would be required until the source is dissipated. Aquifer restoration would not be achieved until the source contaminants have migrated from the landfill, which is estimated to take more than 20 years. This is an important consideration in view of the fact that the exact nature of the contamination within the landfill has not been determined. It is not known to what degree present contamination results from bulk solvent wastes or drum contents. If the existing contaminant plumes result from bulk solvent wastes and do not reflect the drum contents, the constituents of the leachate could drastically change as more drums begin to leak. These constituents, as yet unidentified, could have significant short- and long-term adverse impacts on plants and animals, as well as human health, if allowed to enter the river at some future time. If external pumping is terminated, contaminants would discharge directly into the river since no onsite containment is provided.

Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with Alternative 4 can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air-stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lb/hr. Air quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment, which would need to be specified during the conceptual design of the treatment facility.

Flora and Fauna

The impacts of this alternative on plants and animals would be marginally beneficial even though cleanup would necessitate a longer period of time. Under Alternative 4, deterioration of both surface and groundwater is anticipated for a longer period of time than would be the case with Alternatives 2, 2A, 3, 3A and 3B. This deterioration could result in adverse impacts to wetland areas, decrease in surface water quality and loss of aquatic life. Wildlife utilizing the river for drinking water would continue to be threatened by volatile organics which find their way into the surface water over a longer period of time than projected for Alternatives 2, 2A, 3, 3A and 3B. Over the long term, continuous high-rate plume pumping will effectively control the migration of contaminants from the landfill to the river. The gradual restoration of the wetland areas and adjacent surface waters would indicate an improvement in the environment and beneficial impact to public health, similar to those under Alternatives 2 through 3B.

Land Use

The short-term and long-term impacts to land use under this alternative would be marginally beneficial even though groundwater and surface water cleanup would be effected over a longer period of time than projected under Alternatives 2, 2A, 3, 3A and 3B.

Population and Economics

This alternative would have the same marginally beneficial short-term and long-term impacts on population and economics as those described under Alternatives 2 through 3B, since normal population growth and economic development would not be adversely affected.

Transportation

Alternative 4 would have marginally adverse short-term impacts on transportation because construction and equipment mobilization and materials delivery to the site would be required for site grading and application of the clay cap, construction of the wastewater treatment facility and installation of the extraction wellfield. Transport of sludge off site would have insignificant long-term impacts on transportation, similar to all the other alternatives considered.

Energy

Alternative 4 would have fewer short-term adverse impacts on energy resources than Alternatives 2 through 3B since a containment wall would not be constructed. Long-term adverse impacts on energy required for pumping and treatment of groundwater would be similar to those of Alternative 3A.

Alternative 4A--Surface Sealing without Interception

In Alternative 4A, the site surface is sealed as in the other action alternatives, but there is no external extraction well field. This alternative examines the effect of simply sealing and closing the landfill.

Groundwater and Surface Water

Groundwater modeling results of this alternative indicate that the plume configuration closely approximates that of Alternative 1, No-Action. This is due to the fact that both horizontal and vertical components of the simulated flow field are only minimally impacted by the reduction in recharge caused by installation of the clay cap. Estimated volatile organic concentrations discharging into the Manasquan River at Burke Road would be approximately 1250 ppb 20 years after installation. The increased contaminant load to the river under this alternative over time would have more significant long-term adverse impacts than any of the other alternatives, except the No Action alternative, which would have the most serious adverse impacts with a discharge of 1300 ppb. Since this alternative does not offer onsite containment, the discharge of contaminants into the Manasquan River would not be inhibited. This is a major concern since the quantity and contents of the bulk liquid wastes and buried drums are not fully known.

Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with Alternative 4A can be made at this time.

Flora and Fauna

This alternative offers no solution to the long-term adverse impacts on plants and animals. As more pollutants from the landfill are released into the flow field, the levels of contaminants in the surface and groundwater would increase. The adverse impacts on wetlands, aquatic life and wildlife would eventually approach the degree of magnitude associated with the No Action alternative.

Land Use

The short-term and long-term marginally adverse impacts of this alternative on land use would be similar to those of the No Action alternative, since this alternative does not reduce the concentration of contaminants entering the flow field. This would adversely impact current property values and future growth and development in the study area due to the public's perception of adverse health effects resulting from air, water, soil and/or wildlife contamination.

Population and Economics

The short-term and long-term marginally adverse impacts of this alternative on population and economics would be similar to those impacts caused by the No-Action alternative since this alternative would not reduce the concentration of contaminants entering the flow field. This would tend to discourage development in the area and the subsequent in-migration of new residents resulting from the public's perception of adverse health effects. Marginally adverse impacts to local economics resulting from this alternative could be closely tied to the impact on population and community growth potential.

Transportation

Short-term marginally adverse impacts on transportation under Alternative 4A would be due to equipment mobilization, demobilization, daily deliveries for placement of a clay cap and site grading. The deletion of a groundwater treatment facility would eliminate sludge generation and the necessity for transport off site. The long-term impacts on transportation would be insignificant.

Energy

This alternative would have marginally beneficial short-term impacts on energy since there would be a limited amount of construction involved with site grading and placement of the clay cap. Since there is no pumping or groundwater treatment proposed under this alternative, no long-term energy expenditure is anticipated.

Alternative 5--Drum Excavation and Removal with Plume Pumping, Treatment and Discharge

This alternative provides for removal of the buried drums by excavation and transport off site. Contaminated earth and other landfilled material would be left in the landfill. External plume pumping, treatment and discharge is included, as in Alternatives 2, 3, 3A and 4.

Groundwater and Surface Water

This alternative was not computer-simulated due to uncertainties as to what proportion of the total contaminant source would remain after excavation of the drums. Therefore, its impacts on groundwater can only be estimated based upon the limited information about the drums

and their contents. Although this alternative will remove a major source of contamination, soil contaminated by bulk liquid wastes will remain and the existing contaminant plume would persist for many years. The short-term impacts on groundwater and surface water quality would be marginally beneficial because, although the existing contaminated plume would remain, the external plume pumping would effectively control the migration of contaminants from the landfill to the Manasquan River. It is estimated that the beneficial long-term impacts achievable under this alternative are relatively the same as those described for Alternatives 3 and 4. On a long-term basis, this alternative would achieve acceptable levels of volatile organics similar to those anticipated under Alternatives 3 and 4. This alternative would not be as effective in achieving cleanup as Alternative 2 because no containment or internal pumping is provided.

Air Quality

The potential short-term adverse impacts on air quality associated with this alternative would be greater than under any of the other alternatives. Excavation of the landfill could allow potential release of high levels of hazardous chemicals to the atmosphere. The actual extent of such a release is difficult to estimate. Because the drums containing the majority of the liquid wastes are relatively new, it is felt that they could be removed without substantial loss or spillage of the contents.

Exposure of onsite workers could be minimized by the use of protective clothing and breathing apparatus. The long-term impacts on air quality are similar to those anticipated under Alternatives 2 through 4B.

Flora and Fauna

The short-term and long-term marginally beneficial impacts on plant and animal life anticipated under this alternative would be similar to those achievable under Alternative 4. Some deterioration of both surface and groundwater may occur since no containment of the landfill contaminants is provided; however, the overall short-term improvements to surface and groundwater should have a positive impact on both plant and animal life in the area. Over the long-term, continuous pumping would effectively control the migration of contaminants from the landfill to the river, thus creating positive improvement to the water and aquatic habitats used by local plant and animal populations.

Land Use

The short-term impacts of this alternative on area land use would be adverse as a result of the excavation and removal of hazardous materials from the site. Excavation and transport of hazardous materials through the area could be perceived by the public as potential health risks resulting from air, water, soil and/or wildlife contamination. This would adversely impact current property values, growth and development on a short-term basis. In the long term, the impacts to land use would be beneficial as a result of the successful cleanup of the site and the elimination of the perceived threat to public health. This would allow for continued development in the area under current land use and zoning plans.

Population and Economics

The short-term and long-term impacts from this alternative on population and economics would be marginally beneficial. The removal of the bulk of the contaminant source could alleviate the public's perception of adverse health effects. This would allow for local population growth and economic development to occur at projected levels prior to the development of concerns about the site.

Transportation

Alternative 5 would have greater short-term impacts on the transportation than the other alternatives because of the large amount of excavation required for drum removal. Approximately 10-20 truck trips per day could be required for removal of the contaminants from the site during a 1-year excavation period. The daily transport of hazardous wastes over local roadways would be subject to stringent state regulation and could encounter serious public opposition. Long-term impacts on transportation from removal of sludge from the treatment facility could be insignificant.

Energy

The energy requirement for this alternative would have greater short-term adverse impacts than the No Action alternative and Alternatives 3, 3A, 3B, 4 and 4A due to the excavation operation involving the expenditure of gasoline, diesel fuel and other energy resources. Long-term energy requirements for groundwater pumping and treatment would be marginally adverse and similar to that required in Alternatives 2, 3 and 4.

5.3.3 Engineering Considerations

Alternative 1--No Action

Alternative 1 does not address the remedial response objectives for the Lone Pine Landfill. Essentially, the principal processes of environmental contamination such as leachate production and sediment transport remain uncontrolled.

Alternatives 2, 2A, 3, 3A and 3B--Deep or Shallow Containment Wall with or without Plume Control

Alternatives 2 and 3 and their variants address the major objectives at Lone Pine in a technically feasible manner. Both the deep and shallow slurry walls of Alternatives 2 and 3, respectively, meet the test of constructability and, with the inclusion of internal pumping, should achieve reliable containment of the source of contamination. However, potential construction problems such as dewatering and achieving uniform impermeability would be more likely to occur with the deep wall.

Alternatives 2, 3, and 3A require a treatment system for the contaminated groundwater pumped from the internal and external wells. The treatment system for Alternatives 2A and 3B must handle contaminated groundwater pumped from the internal wells only, resulting in a much smaller, but more contaminated (less dilute), volume.

All of the treatment alternatives require effluent monitoring and sufficient storage capacity to handle equipment downtime and temporary failures to meet discharge standards.

If sediment dredging is determined to be necessary based upon recent sediment sampling, it is assumed that the spoils would be disposed of at the site. No significant engineering problems are anticipated with the dredging operation.

Alternative 4--Plume Interception

Alternative 4 requires a treatment system similar to but larger in capacity than Alternatives 2 and 3. In this case, contaminated groundwater from the external wells only will go through the multi-step treatment system. The difference in volume between Alternative 4 and Alternative 2 or 3 is about 75 percent.

As seen in Figure 4-32, Alternative 4 is comparable to Alternatives 2 and 3 in achieving a reduction in river volatile organic concentrations after 10 years of pumping.

Alternative 4A--Surface Sealing

Alternative 4A involves no internal or external groundwater pumping. From Figures 4-30 and 4-32 it can be seen that sealing the surface of the site alone does not meet the site response objectives.

Alternative 5--Drum Excavation and Removal with Plume Control

Alternative 5, drum excavation, is the most complex of the alternatives and has a number of unique ramifications. The process of opening the landfill, excavating, testing and packing the drums and transporting them will be an arduous, difficult task. The excavation of drums below the water table, which is anticipated, would require dewatering and treatment of the highly contaminated water removed in the dewatering process. Although technically feasible, this alternative poses a greater potential than the other alternatives for adverse health and safety effects on onsite workers and the nearby population, as discussed in section 5.1.2.

5.4 SUMMARY OF SCREENING RESULTS

The results of the screening of the nine candidate alternatives are given as follows.

Alternative 1--No Action

The substantial adverse impacts on major environmental parameters such as groundwater quality, surface water quality and public health raise serious questions about the suitability of the No Action alternative for the Lone Pine site. The No Action alternative does not meet the study objective of reducing groundwater volatile organic concentration levels to a maximum of 100 ppb (Figure 4-22). As a result of the high degree of groundwater and surface water interconnection, base flow volatile organic concentration levels in the river at Burke Road would rise from 1000 ppb to 1300 ppb over 20 years (Figure 4-32). (See the discussion at the end of this section on the Manasquan Reservoir for predicted levels at the proposed reservoir intake.) Given the contamination presently being released from the site, and the additional contamination (both organic and inorganic compounds) that could leak from the buried drums, no action would pose a serious threat of harm to public health and safety and the physical and biological environment in the vicinity of the landfill. The No Action alternative will be retained for further analysis and comparison to action alternatives.

Alternatives 2 and 2A--Deep Containment Wall with or without Plume Control

The major consideration with these alternatives, which feature a deep slurry wall, is the substantially greater cost (see Table 5-5) compared to the shallow slurry wall alternatives (Alternative 3, 3A and 3B), with only slight groundwater cleanup advantages (Figures 4-24

through 4-28 and 4-32). Moreover, construction of the deep slurry wall would be considerably more difficult than the shallow slurry wall. In summary, there are no compelling reasons to prefer the deep slurry wall alternatives over the shallow slurry wall alternatives, and therefore, Alternatives 2 and 2A have been removed from further evaluation.

Alternatives 3, 3A and 3B--Shallow Containment Wall with or without Plume Control

As shown in Table 5-5, Alternative 3 is the fourth least expensive alternative, is technologically feasible, is capable of meeting the response objectives and ranks among the better alternatives from an environmental impact standpoint. With Alternative 3 the containment provided by the shallow slurry wall and internal pumping results in slightly longer duration than Alternative 2 for thorough cleanup of the contaminated plume outside the landfill. Alternative 3 will be retained for further evaluation.

Alternative 3A is the most effective alternative over the first 10 years but has higher cost and engineering complexity. After 10 years, the advantage of Alternative 3A over Alternatives 3 and 3B in achieving reduced volatile organic concentrations in the river becomes essentially insignificant. Another point to consider is that Alternative 3A would capture more non-volatile contaminants in the first 10 years. In spite of its greater cost, the environmental cleanup effectiveness of Alternative 3A over the first 10 years merits its further evaluation.

Alternative 3B would be considerably less expensive than Alternative 3, although it is not quite as fast in restoring the contaminated aquifers or reducing the release of pollutants to the Manasquan River. Alternative 3B merits further examination because of its cleanup effectiveness and positive environmental impacts at a relatively low cost.

Alternative 4--Interception

From Table 5-5, Alternative 4 is only slightly higher in cost than Alternative 3, and is successful in meeting the response objectives as long as external pumping is continued. However, it does not contain the source of contamination. It is technologically feasible and has net positive long-term environmental impacts. This non-slurry-wall concept alternative warrants further consideration because of its competitive cost and reasonable effectiveness.

Alternative 4A--Surface Sealing

Alternative 4A is eliminated for lack of responsiveness to the groundwater cleanup objective despite a present worth cost of over $8 million.

Alternative 5--Drum Excavation and Removal with Plume Control

This alternative is the most expensive of the alternatives considered. Furthermore, the environmental analysis points out a significant number of potential adverse short-term impacts in the areas of public health and safety, water quality and air quality. The hazards involved in excavation of drums up to 50 feet in depth are considerable. They include release of toxic gases, fire, explosion and worker injury.

These considerations outweigh the beneficial long-term impacts on water quality and public health in the study area that would result from removing the drums to a suitable final disposal location. It should be noted, however, that the state of the art of the technology is such that after excavation there would not be 100 percent certainty that all the drums had been located and removed. Also, soil con-

taminated by bulk liquid wastes would remain. This alternative also requires the offsite disposal of significant quantities of hazardous materials with the attendant problems, such as handling hazardous materials, transport over local roads and air emissions, associated with this. Therefore, this alternative has been eliminated from further evaluation.

5.5 ADDITIONAL CONSIDERATIONS

5.5.1 Manasquan Reservoir Effects

The exchange between the contaminated aquifers downgradient of the Lone Pine Landfill and the Manasquan River has been noted in Section 4. Figure 4-32 expresses the groundwater modeling results in terms of estimated base flow volatile organic concentration levels in the Manasquan River at Burke Road. The fate of these pollutants as they travel downstream to the vicinity of the proposed Manasquan Reservoir is a major concern, as previously stated. Two major processes serve to reduce the volatile organic concentration contribution from the Lone Pine Landfill: physical dilution and volatilization. The dilution factor between Burke Road and the reservoir intake is estimated to be 55:1, based on the ratio of drainage areas. (The estimated drainage area above the reservoir intake is 63.1 sq mi and above Burke Road is 1.14 sq mi.) Thus, assuming a diluting flow background volatile organic concentration of 50 ppb (a reasonable level for a semi-rural area), a contribution of 1300 ppb volatile organics from the landfill at the Burke Road crossing results, from dilution alone, in a 72 ppb volatile organic concentration at the proposed reservoir intake, approximately 16 miles downstream.

The degree of volatilization is a function of stream depth, velocity, distance traveled and other factors. A precise quantitative estimate of the degree of volatilization that would take place in the 16 miles between the landfill and the proposed Manasquan Reservoir intake was beyond the scope of this feasibility study. However, the nature of the river is such that over such a distance the extent of volatilization would be expected to be virtually complete. In other words, the combined, concurrent effect of dilution and volatilization would be expected to reduce the volatile organic concentration level to approximately background level. Further water quality concerns in the Manasquan River related to the Lone Pine Landfill are the concentrations of non-volatile contaminants and the impacts of the volatile organics immediately downstream from the landfill.

It must be emphasized that the estimated volatile organic levels are based on present levels of contamination. Because of the unknown contents of the source materials these volatile organic levels could increase or decrease in the future and non-volatile contaminants such as heavy metals and organic compounds could rise to higher, more hazardous levels than are presently found.

5.5.2 No Surface Seal Option

The option of deleting the clay cap as an element of the final cover for each of the alternatives has been examined. From an engineering point of view the following ramifications are of concern:

(1) Without the clay layer, leachate breakouts on the side slopes of the landfill would be more prone to occur, requiring surface leachate collection and storage and conveyance to a treatment system for treatment before discharge. This would

cause greater long-term operation and maintenance demands and treatment requirements. With a clay cap, surface runoff would not be contaminated by leachate, eliminating the need to collect and treat runoff.

(2) Infiltration into the landfill would decrease from approximately 37 gpm without a clay cap (based on a 50 percent recharge-to-rainfall ratio) to approximately 3 gpm with a clay cap. The effect of the extra infiltration on external plume pumping rates (Alternatives 2, 3, 3A, 4 and 5) would be minor (approximately a 10 percent increase), although the effect on internal pumping rates (Alternatives 2, 2A, 3, 3A and 3B) would be substantial (from 30 gpm to over 100 gpm), if a slurry wall were installed. This option was simulated with the groundwater model as applied to Alternative 4 (see section 4.9--Alternative 4B). The finding was that contaminant plume migration without the clay cap was substantially similar to that with a clay cap.

The cost implications of this option are as follows:

(1) Deletion of the clay layer from the final cover saves approximately $1.5 million in capital costs.

(2) The leachate collection system costs may be assumed to be contained in the $4.5-million capping costs. However, leachate storage before treatment is not included in these costs.

(3) The stormwater volume to be stored and treated is based on the expected runoff from the landfill site. For this purpose, a storm of 100-year frequency, 1-hour duration is used to conservatively estimate the stormwater runoff from the landfill site. For costing purposes, a storage volume of 1 million

gallons was estimated. If this flow is treated over a 3-day period, a flow of 210 gpm results. An increase of 200 gpm in treatment capacity results in a 50-year present worth cost in excess of $3 million. This breaks down as follows:

Capital Cost	- $775,000
Present Worth Operation and Maintenance Cost	- $1,933,000
Present Worth Replacement Cost	- $321,000

The savings in deleting the clay layer are outweighed by the above leachate treatment costs.

Furthermore, the $3-million cost is only for the additional treatment flow that would be expected due to stormwater flows. It does not include costs for the additional treatment flows that would result from infiltration into the uncapped landfill, for the required storage after treatment, or for the storage basin itself.

In addition, a number of environmental disadvantages are evident.

(1) The higher pumping rates would cause greater energy consumption.

(2) The increased quantities of groundwater requiring treatment would result in the generation of larger quantities of sludge for disposal. Also, this extra treatment would increase volatile organic air emissons.

(3) The migration of methane and volatile organic compounds through the surface of the landfill into the atmosphere would be greater. This is an important factor when using a methane venting system. Impeding the vertical movement of gas would force the gas to move in a horizontal direction and increase the overall efficiency of a venting system. In this way, emissions can be controlled at the point of release. At the present time, emissions from the landfill are not expected to pose a major problem, after surface sealing.

(4) Leachate breakouts, surface leachate drainage and increased volatile organic air emissions as a result of eliminating the clay cap increase the potential for direct human contact with hazardous substances. Surface runoff may transport a significant amount of pollutants to the river.

In summary, the environmental disadvantages of deleting the clay layer and the additional costs render the no-surface-seal option undesirable.

5.5.3 French Drain Option

The use of a French drain located subsurface along a portion of the landfill perimeter to capture contaminants instead of installation of a shallow slurry wall was evaluated. The French drain concept evaluated consists of an 8-inch diameter perforated pipe lying at the bottom of a crushed stone trench. The trench would penetrate down to the base of the Vincentown layer and extend approximately 3000 feet around the northern half of the landfill perimeter. Such a drain would be suitable for intercepting contaminant migration in the Vincentown aquifer within the landfill. But since contaminants would still be transported to the underlying Red Bank aquifer beneath the landfill, some control would be required in the Red Bank formation.

Thus, plume pumping similar to that developed for Alternative 4 would be needed to achieve a comparable degree of cleanup of the Red Bank aquifer.

Therefore, although the alternative is sound conceptually, it would have several disadvantages if applied at Lone Pine Landfill.

(1) The French drain alone would only clean up the Vincentown formation; the Red Bank formation would still require plume pumping.

(2) The total volume of contaminated water to be treated would increase substantially. It is estimated that 100-200 gpm would be captured by the French drain. Furthermore, the external plume pumping required would not decrease significantly from that of Alternative 4 (400 gpm) because external interception of a continuous plume with an active source and full regional flow is still essentially required.

(3) As a result, this option would be more costly than all of the five remaining alternatives. A preliminary estimate of the present worth cost of the French drain in conjunction with plume control and surface sealing is approximately $24.5 million which is approximately $2.5 million more than Alternative 4 and approximately $4 million more than Alternative 3.

In conclusion, it appears that there exist several technically feasible and effective alternatives that are less costly than the French drain with plume pumping alternative and, therefore, further consideration of the French drain option is not warranted at the Lone Pine site.

5.6 EVALUATION OF REMAINING ALTERNATIVES

The second step in the evaluation process focuses on the five alternatives that remain after the initial screening. The remaining alternatives are:

Alternative 1--No Action
Alternative 3--Shallow containment wall with internal and plume pumping, treatment and discharge
Alternative 3A--Shallow containment wall with internal and high rate plume pumping, treatment and discharge
Alternative 3B--Shallow containment wall with internal pumping, treatment and discharge
Alternative 4--Plume interception with treatment and discharge.

As described in section 2.3, the evaluation of the remaining alternatives focuses on six evaluation criteria: cost, reliability, implementability, environmental impacts, operation and maintenance requirements and safety requirements. The evaluations follow.

5.6.1 Costs

Present worth cost analyses for all the remedial action alternatives were developed in section 5.2.1. Table 5-7, which is drawn from Table 5-5, focuses on the five remaining alternatives.

5.6.2 Reliability

Alternative 3A captures more pollutant mass before it can enter the river and thereby achieves the fastest decrease in contaminant release to the river. However, with respect to aquifer restoration, the difference between Alternatives 3 and 3A is marginal.

TABLE 5-7
PRESENT WORTH ANALYSIS ($ MILLION)

	ALTERNATIVE 1	ALTERNATIVE 3	ALTERNATIVE 3A	ALTERNATIVE 3B	ALTERNATIVE 4
	No Action	Containment with Plume Control	Containment with High-rate Plume Control	Containment Only	Plume Control Only
Capital Costs	0.04	13.2	15.0	10.9	13.5
Present Worth of O&M Costs	-	6.03	7.80	3.54	7.07
Replacement Costs	-	0.71	0.95	0.53	1.02
Monitoring Costs	0.58	0.55	0.55	0.55	0.55
Present Worth	0.62	20.5	24.3	15.5	22.1

Alternative 3B is not quite as fast as Alternatives 3 and 3A in controlling the plume (manifested as approximately 3 more years to achieve a 100 ppb volatile organic concentration in the river) or in reducing pollutant mass release to the river. However, Alternative 3B requires a much smaller treatment facility and has no external well pumping, thus resulting in an advantage in terms of facility complexity.

Alternative 4 provides a comparable degree of long-term control of contaminant release to the river but does not restore the aquifer in the initial 20-year period and results in higher discharge concentrations in the short-term. Since Alternative 4 does not contain the source of the contamination, the external pumping rate must be double that of Alternative 3 to achieve similar long-term results. The lack of a containment wall in Alternative 4 implies greater adverse consequences to water quality if the pump and treatment system fails to perform as expected for a period of time. Furthermore, Alternative 4 contains more uncertainties about future contaminant level control because of the lack of source containment.

The basic components involved in all four action alternatives--the slurry wall, surface seal, extraction well and treatment system--are all applications of proven technology. The evaluations of the combinations of the individual components gives information on the reliability or effectiveness of each component.

The slurry wall in combination with maintenance pumping can reasonably be expected to provide years of reliable groundwater control with little maintenance, if it is properly designed and constructed. An essential aspect of proper design and construction is pre-construction testing, particularly with respect to achieving compatibility of the wall material with the leachate contaminants. This compatibility is necessary to avoid a gradual increase in permeability or creation of paths of contaminant movement through the wall.

The multiple layers of the surface seal provide improved infiltration resistance. If one layer fails, the other layers continue to provide cover. This makes the integrity of the seal system less susceptible to the effects of weather, tearing, cracking or peeling. Also, the use of vegetative covers helps to prevent drying and cracking.

The treatment system, as discussed before, would be subject to frequent adjustment as the influent changes over time. Reliability predictions are difficult to make with assurance until more is known about the landfill contents and until some operating data is available.

The effect of the shallow slurry wall can be seen in comparing the alternatives with or without external pumping (3 and 3B), the difference being a slightly longer time to achieve cleanup with Alternative 3B. Without the slurry wall (Alternative 4), reduction of volatile organic concentration levels in the Manasquan River to the 100 ppb level is achieved after 20 years but at the expense of a doubling in the pumping rate and without 20-year aquifer restoration or source control.

The No Action alternative provides neither control of contaminant release from the landfill nor active aquifer restoration. As previously shown, based on present levels, total volatile organic concentration levels at Burke Road will stay above 1000 ppb for at least 20 years.

5.6.3 Implementability

All four action alternatives include treatment and discharge components which will require a pilot plant study in order to specify the final design, effluent discharge limits, treatment monitoring and

sampling, and daily operation of a treatment facility for a long duration. The representative treatment system described herein should be capable of treating the contamination presently found at the landfill to meet discharge limits.

Because they contain both active internal and external measures, Alternatives 3 and 3A could be readily implemented in two phases. The containment wall could be installed initially and the plume control system could be phased to coincide with construction of the Manasquan Reservoir on the assumption that landfill contamination was determined, at that time, to threaten the reservoir water supply. None of the alternatives pose significant construction complexities.

Alternative 3B with greater potential for generating a hazardous sludge (see section 5.6.4) may have more difficult sludge disposal permit requirements.

Of the remaining five alternatives, Alternatives 3 and 3A with a combination of containment wall and external plume control are more likely to be perceived favorably by the public. Another advantage of Alternative 3A is that it has faster, more thorough control of contaminant release. The No Action alternative may have serious public acceptance problems. The need for continual long-term operation of a treatment system could be perceived as a negative feature by the public.

The most significant institutional issue is that of long-term operation and maintenance of a treatment system (included in each action alternative). As discussed previously, the technologies involved are in widespread use.

5.6.4 Operation and Maintenance Requirements

All four action alternatives involve treatment system operation. One significant difference is in the flow being treated: 30 gpm (Alternative 3B), 230 gpm (Alternative 3), 400 gpm (Alternative 4) and 430 gpm (Alternative 3A). A second significant difference is the more highly contaminated water to be treated under Alternative 3B.

Because of the hazardous nature of the contaminated water, some specialized operator training will be required with each of the alternatives. Each alternative will require staffing with two operators. The hazardous nature of the contaminated water also implies greater attention to operations, higher maintenance demands and shorter life expectancies for equipment and structures.

No significant differences in flexibility among the alternatives exist as all employ the unit process approach. Piping can be provided to permit flexible sequencing of unit process operations. The external wells in Alternative 4 would be easier to operate and maintain than the internal wells in Alternative 3B or the internal and external wells in Alternatives 3 and 3A.

5.6.5 Environmental Impacts

A comparison of environmental ratings of each alternative was presented in section 5.3.2. This section presents a relative comparison of the physical, biological and socioeconomic impacts associated with Alternatives 1, 3, 3A, 3B and 4.

Alternative 1--No Action

Alternative 1 has the greatest overall short-term and long-term impacts on the physical, biological and socioeconomic environment of all the alternatives considered. These impacts are associated with continued discharge of contaminants from the landfill into the groundwater and surface water resulting from surface and subsurface flow, further deterioration in the adjacent wetland areas, loss of both aquatic life and wildlife, and depreciation in current property values and future growth. Allowing the condition to continue unabated may discourage development and the movement of new residents into the area, which may adversely impact the population and community growth potential. There would be no short-term or long-term impacts to transportation under this alternative since no construction would be involved. This alternative, however, would require the least expenditure of energy when compared to all the other alternatives.

Alternatives 3 and 3B--Shallow Containment Wall with or without Plume Pumping, Treatment and Discharge

Alternatives 3 and 3B have marginally less beneficial short-term and long-term impacts on the physical and biological environment than Alternative 3A, which provides more rapid cleanup of the groundwater and surface water. The additional time required for cleanup under Alternatives 3 and 3B would have less beneficial impacts on area plants and animals. Long-term impacts of these alternatives on the socioeconomic environment would be relatively the same as Alternatives 3A and 4.

Alternative 3A--Shallow Containment Wall with High-Rate Plume Pumping, Treatment and Discharge

Alternative 3A has marginally beneficial short-term impacts on the physical and biological environment when compared to Alternatives 3 and 3B. These impacts are significantly more beneficial than those of Alternative 1. Long-term beneficial impacts on the physical, biological and socioeconomic environment are relatively the same as those of Alternatives 3 and 3B.

Alternative 4--Interception with Treatment and Discharge (No Containment)

Alternative 4 has short-term beneficial impacts on the biological, physical and socioeconomic environment that are relatively the same as those impacts anticipated under Alternatives 3 and 3B. However, cleanup of the groundwater and surface water would proceed at a slower rate than with Alternatives 3, 3A and 3B. This would allow some contaminants to bypass the extraction wells and discharge into the Manasquan River. Since this alternative only allows for partial treatment of the existing plume, deterioration of both surface and groundwater are anticipated for a longer period of time than would be the case with Alternatives 3, 3A and 3B. This deterioration could result in adverse impacts to wetland areas, decrease in surface water quality, and loss of aquatic life. The overall long-term impacts on the physical environment, would therefore be less beneficial than Alternatives 3, 3A and 3B.

5.6.6 Safety Requirements

With Alternatives 3, 3A, 3B and 4, plant operators will not have to directly handle any hazardous substances which will be removed in the treatment of the groundwater, nor will contact with contaminated groundwater occur. A minor advantage to Alternative 3B is the smaller quantities of contaminated groundwater going through the system. A disadvantage with Alternatives 3, 3A and 3B are the internal wells, which could be more hazardous to construct. With the No Action alternative, the potential for direct human contact with hazardous substances is greater, because of the site's accessibility to the public.

As explained previously, treatment sludges are anticipated to be classified as non-hazardous. An advantage to Alternative 3B in the event the sludges were classified as hazardous would be the smaller sludge quantities generated. On the other hand, a disadvantage to Alternative 3B is the greater potential for generating a hazardous sludge because of the more contaminated (less dilute) wastewater being treated. This disadvantage relates to both onsite worker safety and transportation off site, if required, over local roads in the community. For the activated carbon systems (air cleaning and carbon adsorption), the supplier would provide periodic regeneration. Thus, plant staff will not need to handle contaminated carbon.

No significant differences among the four action alternatives are seen with regard to fire and explosion hazards. All provide a surface cap and gas monitoring system to minimize this hazard. The No Action alternative poses a substantially greater fire and explosion hazard than Alternatives 3, 3A, 3B and 4, particularly if the site is not secured so as to restrict site access.

5.7 RECHARGE AS AN OPTION TO TREATMENT AND DISCHARGE

With Alternatives 3, 3A and 4, the pumped groundwater (230, 430 or 400 gpm) could be recharged upgradient of the landfill. This option was simulated using the groundwater model. The results of the evaluation, presented in section 4.9, were that the option is not feasible due to inadequate application area with a slow-rate system and proximity to a groundwater divide with a rapid infiltration system.

Alternative 3B, which involves internal pumping only, was not specifically evaluated in section 4.9. Based on local groundwater conditions this highly contaminated water, if recharged south of the landfill, would be expected to enter the Vincentown aquifer and migrate toward the river at a steeper gradient than currently exists. This would actually exacerbate contamination of the aquifer and river (compared to No Action). Thus, the recharge concept is unsuitable in conjunction with Alternative 3B.

Therefore, the option of recharging pumped groundwater, without treatment, has been concluded to be undesirable in connection with Alternatives 3, 3A, 3B or 4.

5.8 RANKING BY COST AND NON-COST CRITERIA

A matrix summarizing the results of the non-cost criteria evaluation is presented as Table 5-8. The matrix rates each alternative in terms of the basic parameters involved in the analysis. Also shown alongside the matrix, for comparison purposes, are the results of the cost evaluation. From the table it is seen that Alternative 3A ranks first based on non-cost criteria and Alternative 3B ranks first after No Action in lowest present worth cost.

TABLE 5-8

NON-COST EVALUATION CRITERIA MATRIX

	Reliability				Implementability			Operation & Maintenance			Environmental			Safety			Ranking	
	Time	Level	Complexity	Technology	Permits	Segmenting Option	Public Acceptability	Staffing	Maintenance	Monitoring	Physical	Biological	Socioeconomic	Hazardous Materials	Fire/ Explosion	Offsite Transportation	Non-Cost Ranking	Cost Ranking
Alternative 1 No Action	-	-	+	+	+	0	-	+	+	-	-	-	-	-	-	+	5th	1st
Alternative 3 Shallow Containment Wall with Plume Control	+	0	-	0	0	+	+	0	0	0	+	+	0	0	0	0	2nd	3rd
Alternative 3A Shallow Containment Wall with High-Rate Plume Control	+	+	-	0	0	+	+	0	0	0	+	+	0	0	0	0	1st	5th
Alternative 3B Shallow Containment Wall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	3rd	2nd
Alternative 4 Plume Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4th	4th

(SPH8/14)

Legend
+ Signifies a significant advantage over other alternatives
0 Signifies no significant advantages over other alternatives
- Signifies a significant disadvantage over other alternatives

5.9 CONCLUSIONS

Alternative 4 is noncompetitive in terms of cost and aquifer restoration. The environmental impact and reliability advantages of Alternatives 3 and 3A over 3B must be balanced against their 33 percent and 59 percent, respectively, greater costs. An important consideration in this balance is the effect on the Manasquan River. Computer simulation results indicate that the bulk of the effectiveness advantage of Alternatives 3 and 3A occurs in the first 10 years. Beyond that period, the discharge to the Manasquan River essentially meets the volatile organic cleanup criterion with Alternative 3, 3A or 3B. However, the gross amount of pollutant mass that reaches the river is greater under Alternative 3B than 3 or 3A. As previously discussed, under any of the alternatives the volatile organic contribution from the landfill at the proposed Manasquan Reservoir intake is estimated to be at background levels, based on present levels of contamination (which could increase as drums deteriorate or as contaminants from the bulk liquid wastes enter the groundwater). However, as previously noted, the future concentrations of non-volatile contaminants are also a concern.

The No Action alternative is noncompetitive in terms of the non-cost evaluation criteria, although it is the lowest in cost. No Action could only be an acceptable alternative, however, if the sole response objective were determined by USEPA and NJDEP to be protection of the future Manasquan Reservoir water supply, instead of cleanup of the contaminated groundwater plume and river environment in the area affected by the site, and if volatile organic priority pollutants continued to be the predominant contaminants being released from the landfill. However, since little is known about the contents of the drums, it should be assumed that the nature of the contamination released to the groundwater and the river will change over time, thereby posing a significant threat to the reservoir water supply. The monitoring program included in the No Action alternative would provide data over time to allow identification of contaminant types and concentrations being released from the landfill.

The fact that most of the hazardous wastes were deposited in the landfill in drums in the last 10 years makes it reasonable to assume that most of the contamination is still in the landfill and has yet to migrate from the site into the groundwater plume. Alternative 3B contains the landfill contamination equally as well as Alternatives 3 and 3A. Therefore, Alternative 3B will have an equal effect on future contaminant migration from the landfill and long-term aquifer restoration.

However, Alternative 3B relies on natural aquifer flushing to the Manasquan River for aquifer restoration. As discussed, the Manasquan River is planned to be a source of potable water in the future through construction of the Manasquan Reservoir. This suggests the advisability of external plume control in addition to onsite containment in order to effect faster cleanup of the contaminated plume and to reduce total pollutant mass release to the river. Alternatives 3 and 3A both provide this capability, but Alternative 3 is less costly.

The difference in present worth cost between Alternatives 3 and 3B is $2.5 million in Capital and Replacement costs and $2.5 million in Operation and Maintenance (O&M) costs. However, if after implementation of Alternative 3, sufficient decreases in contaminant concentration levels have been achieved, as indicated by the monitoring data, the external plume pumping could be suspended or reduced, decreasing treatment plant operation and maintenance requirements and attendant costs. Groundwater quality could continue to be monitored and if concentration levels begin rising, the external plume pumping could always be resumed. The necessary external wells and treatment facilities would be in place. The implication of this is that the $2.5 million in additional O&M costs represents a maximum difference which could conceivably be less in practice over the long term. Thus

the total 50-year present worth cost difference between Alternative 3 and 3B could range between $2.5 million and $5 million. Considering the added environmental benefits, particularly to surface water, of external plume pumping (see sections 4.9 and 5.3.2), the additional cost appears justifiable.

With regard to onsite treatment and discharge, which is included in all the action alternatives, a potential means of eliminating effluent from the onsite treatment facility is to transport and dispose of the pumped wastewater at a treatment plant. Depending on the quantities and characteristics of wastewater and the proximity to sewers and an accepting treatment facility, various methods of disposal could be evaluated as most appropriate or cost effective. The offsite disposal option with the greatest apparent potential would be to convey wastewater from the landfill to the Upper Manasquan Interceptor planned for installation in 1984 as part of a regional facilities plan to convey wastewater generated in the Manasquan River basin to the Ocean County sewerage service area for treatment at an Ocean County Utilities Authority regional wastewater treatment plant and discharge to the Atlantic Ocean. Two branches of the planned Upper Manasquan Interceptor will be 2 and 3 miles, respectively, from landfill. The existing treatment plants in the Freehold area are to be phased out. Initial examination shows that the cost of the landfill-to-interceptor connection facilities alone would be approximately $1 million. In addition to the connection costs, however, possible pretreatment prior to acceptance by the treatment facility and Ocean County user charges would have to be ascertained and added to the overall cost. This concept should be studied further during the design stage to select the most appropriate disposal method based on effluent characteristics and regional conditions.

As previously stated, the evaluation of remedial alternatives is based on use of existing data and documented environmental contamination. Therefore, a number of activities should be included in the next stage of the remediation program. A pilot plant study should be developed and conducted to establish specific design criteria for the selected treatment system. Also recommended is onsite sampling and testing for oil lenses. To obtain additional data on existing air quality, a baseline air monitoring program similar to that described for Alternative 1 in section 3 should be conducted.

DEC 21 198

U.S. Department of Justice

United States Attorney
District of New Jersey

970 Broad Street, Room 502
Newark, New Jersey 07102

201/645-2155
FTS/341-2155

December 18, 1984

The Honorable Dickinson R. Debevoise
United States District Judge
U.S. Post Office & Courthouse Building
Federal Square
Newark, New Jersey 07102

Re: Lone Pine Steering Committee, et al. v.
United States Environmental Protection Agency
Civil No. 84-4513

Dear Judge Debevoise:

Pursuant to your request made in the November 19, 1984 hearing on the defendant's Motion to Dismiss, the Government is transmitting documents which were a basis for the initial remedial decision made by EPA in September, 1984 for the Lone Pine Landfill in Freehold Township, New Jersey. The Government has included documents which appear to be pertinent to the arguments advanced by the plaintiffs to date.

The attached documentation does not include pages 1 to 435. These pages constitute the "Record of Decision" which was appended as Attachment 8 to EPA's Motion to Dismiss filed on November 14, 1984. Since these pages were produced and numbered previously, the Government has not submitted them again. The documents enclosed herewith are numbered p. 436 et seq.

To assist everyone in reviewing this documentation, an index is attached. Section I contains the Record of Decision which includes responses to all public comments submitted to EPA. Sections II and III contain the numerous technical studies which preceded EPA's decision. Section IV has depositions of principals of Lone Pine Corporation and of Freehold Cartage, a transporter which took hazardous substances to the Lone Pine site. Section V contains excerpts from the trial transcript of the Scientific Chemical Processing case. Both Sections IV and V are public information, and they underscore the extensive disposal of chemicals in the landfill. Sections VI and VII present background materials on the evaluation of the site under Superfund and the involvement of the State of New Jersey with the landfill. Sections VIII

and IX document the extensive effort of EPA to involve and inform the public, and to listen to and be responsive to the Lone Pine Steering Committee. Finally, Section X consists of the extensive EPA correspondence concerning the performance of the Remedial Investigation and Feasibility Study. Some of the recent documents in this section reinforce the agency's conclusion that a cap without a slurry wall is inadequate.

Notwithstanding its production of these documents, EPA does not waive any of its legal arguments, including any claims of privilege and work-product immunity and its position that the federal courts lack jurisdiction to review the EPA's Record of Decision at this time.

Respectfully submitted,

W. HUNT DUMONT
United States Attorney

By: ROGER J. BERNSTEIN
Assistant U.S. Attorney

Attachment
cc. Plaintiffs' Counsel

153Q

U.S. ENVIRONMENTAL PROTECTION AGENCY
INDEX TO DOCUMENTS PRODUCED ON DECEMBER 18, 1984
LONE PINE LANDFILL

I. Record of Decision, Lone Pine Landfill, 09/28/84:

A) Main text . . . . . p. 1

B) Comments Received by EPA . . . . . p. 74

C) EPA Responses to Comments . . . . . p. 369

II. Feasibility Study . . . . . p. 436

A) Final Work Plan, Feasibility Study, Camp, Dresser & McKee (November 30, 1982). . . . . p. 437

B) Draft Feasibility Study, Lone Pine Landfill, Camp, Dresser & McKee . . . . . p. 548

(B-1) Volume 1 - Evaluation of Remedial Action Alternatives . . . . p. 549

(B-2) Volume 2 - Evaluation of Remedial Action Alternatives . . . . p. 754

(B-3) Volume 3 - Environmental Information Document . . . . . p. 808

(B-4) Sampling and Analysis Protocol, December, 1982 . . . . . p. 987

(B-5) Quality Assurance Plan (January, 1983) . . . . . p. 1035

(B-6) Health and Safety Plan (January, 1983) . . . . . p. 1045

C) Supplemental Feasibility Study for the Lone Pine Landfill, Camp, Dresser & McKee (May, 1984). . . . . p. 1137 p 1135-1136 missing

III. Environmental Protection Agency Field Investigation and Sampling Reports. . . . . p. 1223

July 18, 1978 - Laboratory Results, Lone Pine Company Landfill; Memorandum, F. Brezenski to F. Rubel. . . . . p. 1224

November 15, 1979 - Hazardous Waste Site Dossier and Site Inspection Report . . . . . p. 1225A

December 4, 1979 - Investigation
of Lone Pine Landfill; Memorandum,
J. Alonso to F. Rubel . . . . . p. 1226

June 4, 1980 - Lone Pine Sampling Results;
Memorandum, R. Braun to R. Spear. . . . . p. 1233

May 1981 - Rating Forms for Waste Disposal
Sites . . . . . p. 1279A

June 3, 1981 - Laboratory Results -
Lone Pine Landfill; Memorandum,
F. Brezenski to B. Metzger . . . . . p. 1280

June 26, 1981 - Lone Pine Landfill;
Memorandum, J. Alonso to R. Spear . . . . . p. 1304

July 1, 1981 - Lone Pine Landfill;
Memorandum, R. Spear to J. Frisco . . . . . p. 1314

August, 1981 - Geophysical Investigation
for Buried Drums at the Lone Pine
Landfill - Technos, Inc.. . . . . p. 1334

January 15, 1982 - Lone Pine Landfill,
Drum Excavation and Sampling Project
Final Report; Fred C. Hart Associates . . . . . p. 1363

April 30, 1982 - Lone Pine
Landfill, Hydrogeologic Investigation
Fred C. Hart Associates . . . . . p. 1420

July 26, 1982 - Lone Pine Landfill,
Preliminary Aquifer Testing,
Fred C. Hart Associates . . . . . p. 1488

November 1, 1982 - Preliminary Work Plan
Property Boundary Survey and Topographic
Mapping, Camp, Dresser & McKee. . . . . p. 1514

February 15, 1983 - Analytical Results
for Samples Collected on September
13, 14, 15, and 16, 1982, Lone Pine
Landfill, Camp, Dresser & McKee . . . . . p. 1527

April 7, 1983 - Manasquan River Survey;
Memorandum, R. Braun to R. Spear. . . . . p. 1571

August 31, 1983 - April, 1983 Sampling
Results, Lone Pine Landfill; Memorandum
H. Boucher to J. Singerman. . . . . p. 1581

September 14, 1983 - Evaluation of Analytical Chemical Data from Lone Pine Landfill; NUS Corporation . . . . . p. 1586

February 3, 1984 - Evaluation of Analytical Chemical Data from Lone Pine Landfill; NUS Corporation . . . . . p. 1601

March, 1984 - Work Plan Feasibility Study, Lone Pine Landfill, NUS Corporation . . . . . p. 1619

March 20, 1984 - Presentation of Analytical Chemical Data and Ground Water Level Elevations from Lone Pine Landfill - NUS Corporation . . . . . p. 1631

May 11, 1984 - Addendum A - Presentation of Non-Volatile Organic and Inorganic Analytical Chemical Data from Lone Pine Landfill, NUS Corporation . . . . . p. 1654

May 29, 1984 - Summary of Camp, Dresser & McKee Field Investigation; Letter R. Hughto to J. Singerman . . . . . .p. 1681

June, 1984 - Project Operation Plan for Treatability Studies at the Lone Pine Landfill - Camp, Dresser & McKee. . . . . p. 1695

September 6, 1984 - Lone Pine Landfill Air Investigation Report; Camp, Dresser & McKee . . p. 1748

IV. Depositions from New Jersey v. Lone Pine Corporation. . . . . p. 1789

A) Depositions of Thomas and Sally Blauchet . . p. 1790

B) Deposition of Thelma Burke . . . . . p. 1900

C) Deposition of John O'Mara . . . . . p. 1977

V. Portions of Record from United States v. Case . . . . . p. 2051

A) Testimony of Carmine Trezza . . . . . p. 2052

B) Testimony of Henry Heflich . . . . . p. 2403

C) Testimony of William Miller . . . . . p. 2731

D) Testimony of George Smajda . . . . . p. 2744

p.2921-2990 Missing
E) Testimony of George Borden . . . . . p. 2820

F) Summations and Rebuttal . . . . . p. 2991

VI. CERCLA - Required Documents for Remedial Action . . . . . p. 3097

A) Hazard Ranking System Scoring Package (for inclusion of site on National Priorities List) . . . . . p. 3098

B) Superfund State Contract . . . . . p. 3141

VII. State of New Jersey - Inspection, Investigation, and Enforcement Activities . . . p. 3182

April 25, 1979 - Letter, Tylutki to O'Mara (transmitting Administrative Order closing Lone Pine Landfill. . . . . p. 3183

April 25, 1979 - Administrative Order closing Lone Pine Landfill. . . . . p. 3189

October 25, 1979 - State of New Jersey Department of Environmental Protection vs. Lone Pine Corp., et al. (Complaint with attachments) . . . . . p. 3196

June 2, 1981 - Chronology of Regulatory Events Regarding Lone Pine Corp. Landfill . . . p. 3269

September 4, 1981 - Memo, R. Dalton to P. Giardina re: Lone Pine Landfill. . . . . p. 3271

VIII. Community Relations, Public Meetings, Press Releases, etc. [thirty-three documents in chronological order] . . . . . p. 3312
p.3312-3346, 3402-3489, 3600-3602, 3604 } missing

IX. EPA/Lone Pine Steering Committee Correspondence, Notes, Meetings [fifty-six documents in chronological order] . . . . . p. 3402

X. Correspondence relating to Remedial Investigation/Feasibility Study - Contractor, Public, Congressional, Internal [two hundred seventy-five documents]. . . . . p. 3604
p.3622-3675, 3878-4048, 4152-4153 } missing

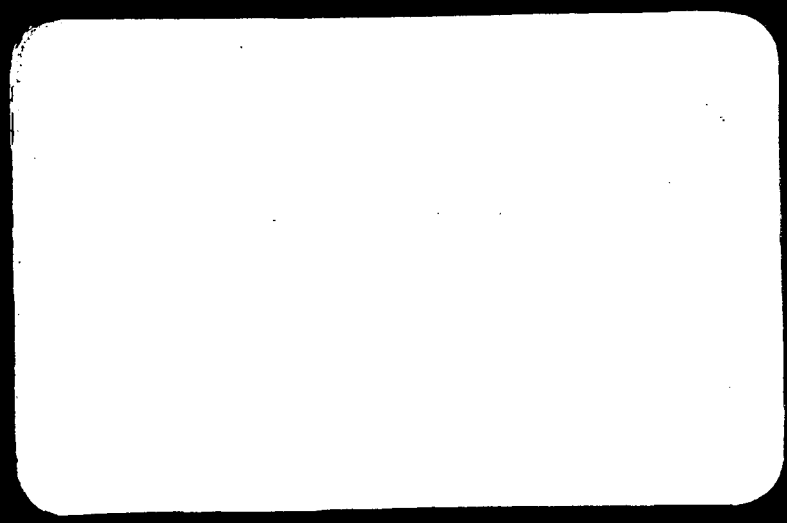
environmental engineers, scientists,
planners, & management consultants CDM®

753

JOHN CZAPOR

REMEDIAL RESPONSE ACTIVITIES

UNCONTROLLED HAZARDOUS WASTE DISPOSAL SITES



CAMP DRESSER & McKEE INC.
CH2M HILL
CONESTOGA-ROVERS & ASSOCIATES LIMITED
HALEY & ALDRICH, INC.

United States Environmental Protection Agency

New York, New York

VOLUME 2
DRAFT FEASIBILITY STUDY
EVALUATION OF
REMEDIAL ACTION ALTERNATIVES

Lone Pine Landfill, New Jersey
Work Assignment Z-1-17 Under
Contract No. 68-03-1612

June 1983

Camp Dresser & McKee Inc.

CONTENTS

VOLUME 2

APPENDIX A GROUNDWATER FLOW SIMULATION CODE--DYNFLO..... A-1

A.1 THEORY..... A-1
A.2 COMPARISONS WITH ANALYTIC SOLUTIONS..... A-7

A.2.1 Linear Confined Flow..... A-8
A.2.2 Non-Linear Unconfined Flow..... A-9
A.2.3 Tank Drainage..... A-12
A.2.4 Theis Curves..... A-12
A.2.5 Hantush Solution..... A-13
A.2.6 One-Dimensional Consolidation..... A-13
A.2.7 Pond Elements..... A-20

A.3 APPLICATION PROCEDURES..... A-20

APPENDIX B CONTAMINANT TRANSPORT SIMULATION CODE--DYNTRA..... B-1

B.1 THEORY..... B-1

B.1.1 Groundwater Flow Field..... B-1
B.1.2 Single Particle Tracking... B-2
B.1.3 Dispersion Algorithms..... B-3
B.1.4 Decay..... B-5
B.1.5 Plume Modeling..... B-5

B.2 COMPARISONS WITH ANALYTIC SOLUTIONS..... B-7

B.2.1 Convection and Dispersion in One Dimension..... B-7
B.2.2 Convection and Dispersion in Two Dimensions..... B-8
B.2.3 Convection and Dispersion in Three Dimensions..... B-12
B.2.4 Simulation Precision..... B-18

FIGURES

A.1 Discretization of Schematic Aquifer System..... A-4

A.2 DYNFLO Working Finite Element and Components..... A-5

A.3 Comparison of DYNFLO Results with Analytic Solutions for Theis Test Case..... A-17

A.4 Comparison of DYNFLO Results with Analytic Solutions for Hantush Test Case..... A-18

B.1 One Dimensional Dispersion Test..... B-9

B.2 2-D Dispersion from Plug Source--T=4..... B-10

B.3 2-D Dispersion from Plug Source--T=8..... B-11

B.4 2-D Dispersion from Constant Source--T=20..... B-13

B.5 3-D Dispersion Section with Z=2, T=8..... B-14

B.6 3-D Dispersion, Vertical Section with Y=5, T=8..... B-15

B.7 2-D Dispersion from Plug Source--5000 Particles..... B-16

B.8 2-D Dispersion from Plug Source--1000 Particles..... B-17

B.9 DYNTRA Simulation Precision--2-D Dispersion of a Plug Source..... B-20

TABLES

A.1	Comparison of DYNFLO Results with Analytic Solution for Linear Confined Flow Case.....	A-10
A.2	Comparison of DYNFLO Results with Analytic Solution for Dupuit-Type Flow Test Case.....	A-14
A.3	Comparison of DYNFLO Results with Analytic Solution for Tank Drainage Case.....	A-15
A.4	Comparison of DYNFLO Results with Analytic Solution to One-Dimensional Consolidation Case.....	A-19
A.5	Comparison of DYNFLO Results with Analytic Solution for Pond Test Case.....	A-21
A.6	Brief Descriptions of DYNFLO Major Commands.....	A-24

Appendix A

APPENDIX A

GROUNDWATER FLOW SIMULATION CODE - DYNFLO

This appendix provides a brief description of groundwater flow theory and how it is implemented in and used by the DYNFLO program to simulate groundwater flow fields. Also included are demonstrations of its validity through simulation of groundwater flow problems having independently derived, "simple", analytical solution algorithms.

A.1 Theory

Groundwater flow theory is based on the combination of two relationships; Darcy's Law, and the conservation of Mass Law. Darcy's Law states that the rate of groundwater flow through a given cross-sectional area is directly proportional to of the hydraulic gradient, which is a measure of energy dissipation. Mathematically, Darcy's Law can be stated as:

$$q = -k \nabla h \qquad (A.1)$$

where:

q = specific discharge, or flow rate through a unit area L/T

k = hydraulic conductivity, the proportionality constant L/T

∇ = gradient operator 1/L

h = piezometric head L

L = length units (e.g., "feet")

T = time units (e.g., "days")

Expanding the gradient operator and assuming that anisotropy in the hydraulic conductivity is orthogonal, as is usually the case, Darcy's Law can be expressed as:

$$q = -k_i \frac{\partial h}{\partial x_i} \quad (i=1,2,3) \qquad (A.2)$$

where x take on values for each of the three orthogonal axis directions.

The Conservation of Mass Law requires that:

INFLOW RATE	-	OUTFLOW RATE	=	RATE OF CHANGE IN STORAGE	(A.3)

By combining Darcy's Law with the above stated relationsip, the following equation results (see, for example, Bear, 1979):

$$S_0 \frac{\partial h}{\partial t} = \frac{\partial}{\partial x_i} \left(k_{x_i} \frac{\partial h}{\partial x_i} \right) + Q \delta \qquad (A.4)$$

$$(i=1,2,3)$$

where:

S_0 = specific storativity 1/L

t = time T

Q = flux at a point L^3/T

δ = Dirac delta function

Equation A.4 is the governing equation in DYNFLO for three-dimensional flow in an aquifer system.

FINITE ELEMENT SOLUTION TECHNIQUE

Several difficulties are encountered when attempting to derive a mathematical technique for the solution of problems in continuous domains. To completely describe the flow in aquifers, for example, requires that values of piezometric head be determined at each of an infinite number of locations in a spatially-varying system. To do this mathematically would require that an infinite number of equations, with a corresponding infinite number of unknowns, be written and solved simultaneously. This problem, however, may be simplified by subdividing the system into a finite number of cells or elements. Mathematically, piezometric head values within the system may then be defined at a finite number of intersections between adjoining elements, termed nodes. Between nodes, at remaining points within the elements, values of piezometric head are then expressed in terms of an assumed shape function of interpolation function. Therefore, following the establishment of piezometric heads at nodal locations and development of suitable shape function, system transport characteristics may be simulated over the entire domain. The degree of accuracy of this technique, termed the finite element method, depends on the size and shape of the elements, and on the selection of an appropriate interpolation function.

The DYNFLO program utilizes this finite element technique for simulating groundwater flow fields. DYNFLO uses triangular elements, in plan view for two reasons: 1) geometric simplicity, particularly in a two dimensional representation, and; 2) they are flexible enough to approximate most boundary conditions encountered in groundwater flow systems. Linear interpolation functions were adopted based on a similar line of reasoning. That is, they are simple yet capable of accurately representing the spatial distribution of piezometric head over discrete intervals.

A schematic of a portion of a DYNFLO finite element grid is shown in Figure A.1. The horizontal grid remains constant, in plan view, throughout all modeled stratigraphy levels. These levels are used to represent points in the vertical direction, z, at which geologic formations change or at intermediate points in the same formation where significant changes in head over the vertical occur. In the example of Figure A.1, two geologic formations with different hydraulic properties might be assumed, and stratigraphy level number 2 is at the elevation where they meet.

Each aquifer system layer is comprised of a set of vertical prisms which are called DYNFLO three-dimensional working elements. Each working element is formed by six nodes. The six nodes are three from the stratigraphy level above and three from stratigraphy level below (see Figure A.2). Each working element is divided, during DYNFLO computations, into three tetrahedra (Figure A.2) for the code to perform its finite element computations. Within each tetrahedra, also called a computational element, the piezometric head is assumed to vary in a linear fashion across the element, and concurrently the

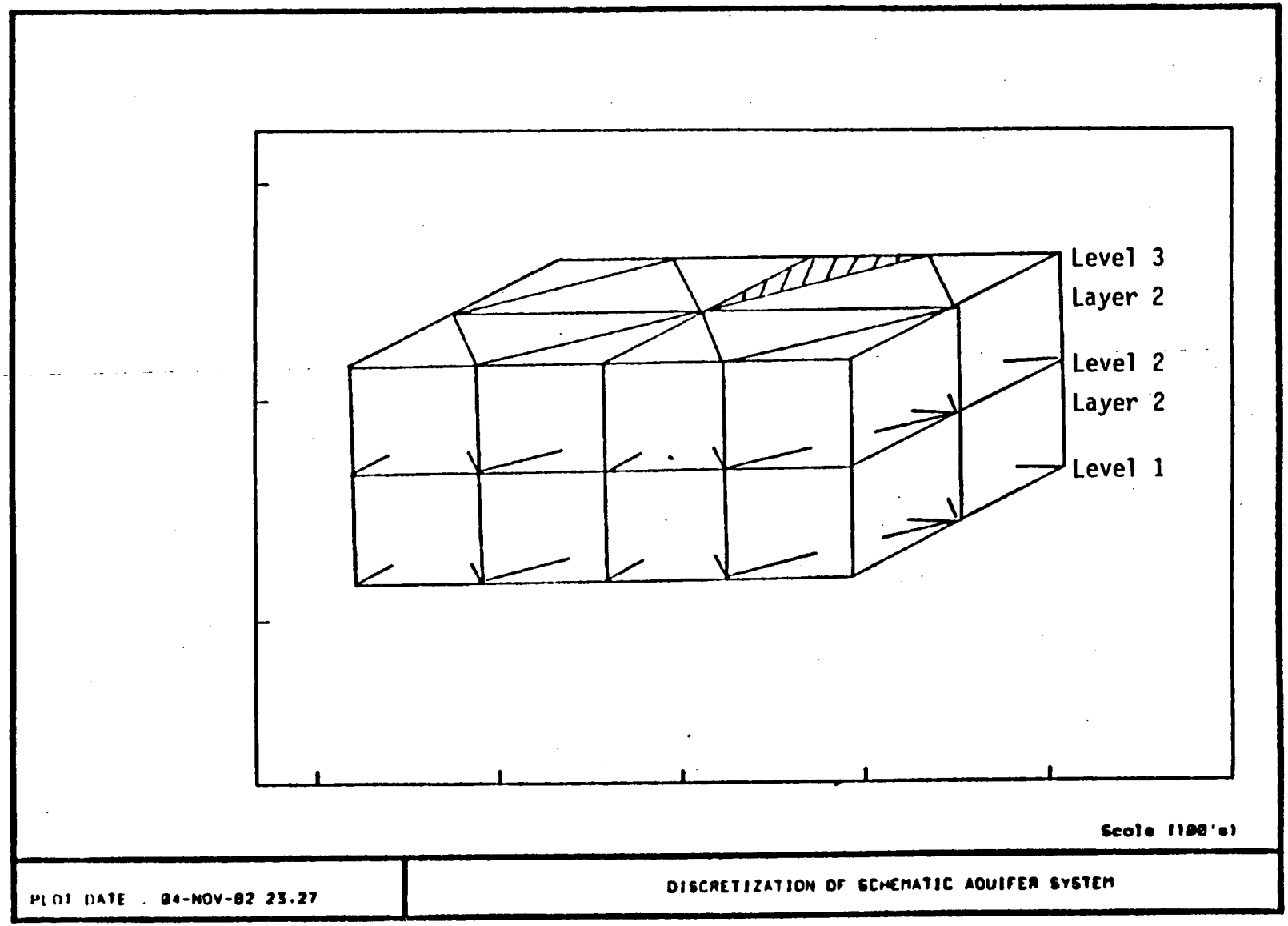

Level 3
Layer 2
Level 2
Layer 2
Level 1
Scale (100's)
PLOT DATE : 04-NOV-82 23.27
DISCRETIZATION OF SCHEMATIC AQUIFER SYSTEM

FIGURE A.1

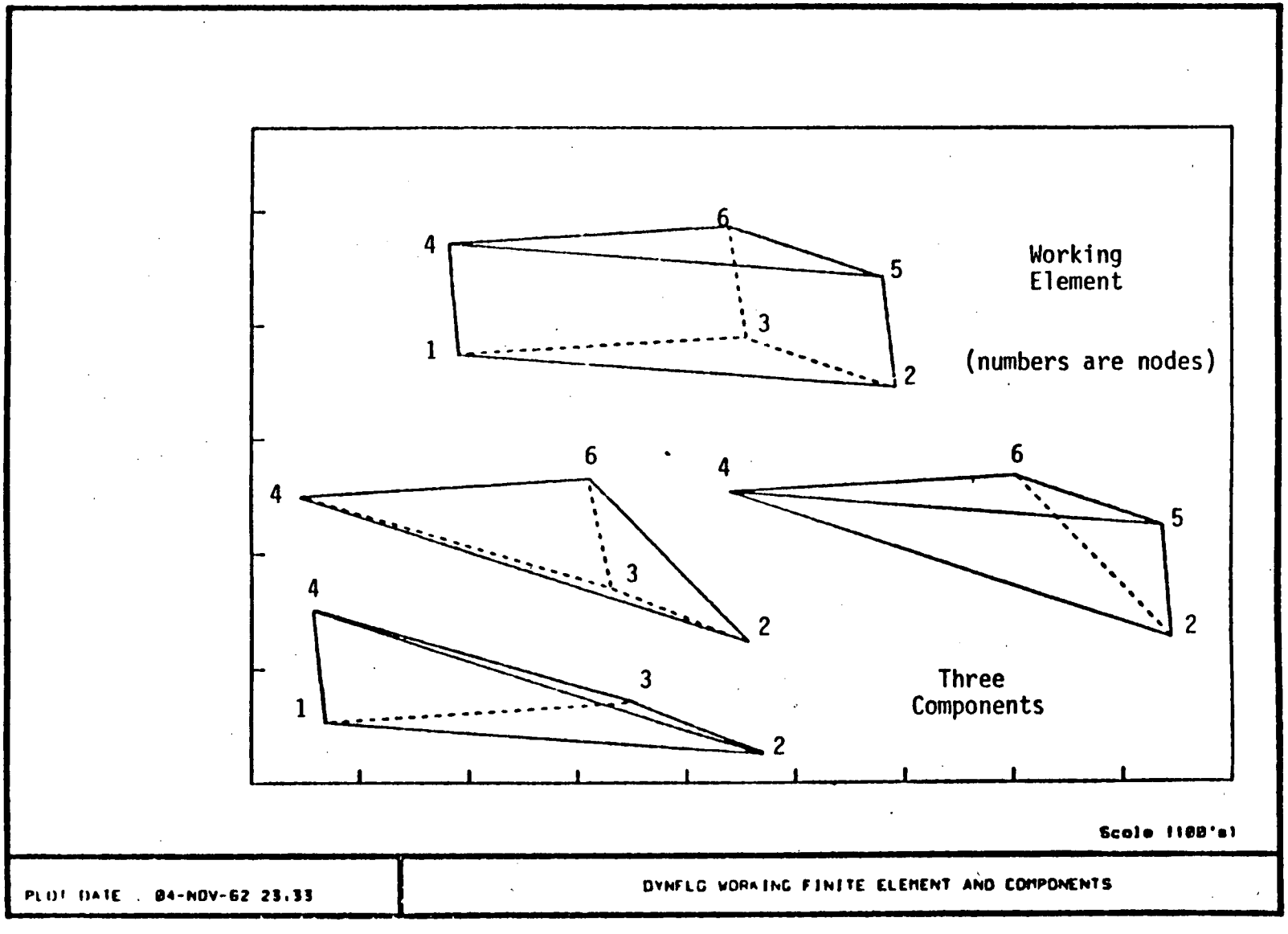


FIGURE A.2

764

gradient in the element is constant. For a complete discussion of the solution algorithms and programming techniques for this type of finite element solution, see, for example, Segerlind (1976). Non-homogeneous aquifer properties are permitted in DYNFLO, as well as anisotropic permeability along the principal axes. Any aquifer layer may be phreatic, confined, or a combination of the two.

With the above structural configuration, the governing set of system equations is reduced to a single equation at each node through specification of a suitable boundary condition. This equation relates nodal point flux to head at a given node relative to the flux and head values at all adjacent nodes in the system. Therefore, one of the following must be specified for each node:

Specified Head - Type 1 Boundary Condition

Specified Flux - Type 2 Boundary Condition

DYNFLO includes algorithms for determining which type of boundary condition to apply, including:

- Direct specification by the program user of type 1 (head) or type 2 (flux).
- "Rising Water," for which DYNFLO will set a type 1 (specified head) boundary condition with the head set to ground surface if the head in a phreatic aquifer rises to ground surface.
- "Dry," for which DYNFLO will set at type 1 (specified head) boundary condition if the head in an aquifer layer drops to the bottom of the aquifer. This is currently implemented for only the lowest (in elevation) layer.

Values of specified flux can be designated in several ways. Any layer of the aquifer system can experience artificial or natural recharge; at points to model wells, or, over areas, to simulate precipitation recharge. Streams or lakes can be treated as specified head boundaries or as sources of induced infiltration. Certain streams can also be intermittent receivers of baseflow, as accommodated by the "rising water" feature of the code. DYNFLO assumes that boundaries along which no explicit boundary conditions have been specified are to be simulated as no-flow boundaries.

DYNFLO treats wells that penetrate multiple aquifer layers with a special algorithm, based on one-dimensional finite elements of high conductance. These elements are used to connect two nodes directly so that, in the case of a multi-aquifer well, piezometric head at the nodes comprising the well will be approximately equal.

DYNFLO can also simulate surface water bodies, such as lakes, lagoons, and ponds with a special type of element, called a "pond" element. At the end of each simulation time step, DYNFLO computes the

net inflow to each and determines net change in storage for each element or group of elements. The program then enters the head-area-volume curve for each "pond", given the new stored volume, and computes the new head level and surface area. These latter two values (head and area) are utilized in the next time step to compute leakage into or from the aquifer and evaporation off of the "pond" surface.

DYNFLO can simulate both steady-state (equilibrium) and time-varying (transient) aquifer responses. For transient simulations, the program steps through time in discrete, pre-determined intervals. DYNFLO applies an average storage change as a semi-implicit flux to represent unsteady flow at the end of each time step. This numerical method, called forward differencing, is unconditionally stable.

A.2 Comparisons with Analytic Solutions

CDM has tested DYNFLO against several analytic solutions and has tabulated the comparison, all of which demonstrate the validity of the code and its component algorithms. The test cases include steady-state and transient situations, with confined and phreatic aquifer conditions, and horizontal and vertical flow. All of the cases are one or two-dimensional idealizations. The solutions tested with DYNFLO are:

NO.	NAME	DESCRIPTION/PURPOSES
1.	LINEAR	Steady-state, confined, one-dimensional horizontal flow. Tests horizontal flow and nodal point flux computation.
2.	DUPUIT	Steady-state, phreatic, one-dimensional horizontal flow. Tests phreatic surface algorithm.
3.	TANK	Transient, phreatic, one-dimensional vertical flow. Tests vertical flow computations and phreatic surface computations.
4.	THEIS	Transient, phreatic or confined, two-dimensional radial (horizontal) flow. Tests horizontal two-dimensional flow and specified fluxes.
5.	HANTU	Hantush analytic solution to transient, confined, two-dimensional radial (horizontal) flow, with leakage. Tests two-dimensional flow with a vertical flow component. Note that the DYNFLO formulation, because it is a full three-dimensional representation and thus more complete, violates some of the Hantush idealized two-dimensional boundary conditions, including leaky layer storage and horizontal flow.

796

6. CONSO — Terzaghi's one-dimensional consolidation solution: transient, confined, one-dimensional vertical flow. Tests transient vertical flow.

7. POND — Same as TANK case, but simulates situation with "pond" elements. Tests the "pond" element computations.

So that you may review the bases for these analytic solutions, the following table lists commonly available references:

SOLUTION NAME	REFERENCE
LINEAR	Not necessary - see the description of this simple case below.
DUPUIT	Freeze and Cherry, Groundwater, pages 188-189.
TANK, POND	See the description of this simple case below.
HANTU	Freeze and Cherry, Groundwater, page 321; and Lohman, Ground-Water Hydraulics, USGS Professional Paper 708, 1979, pages 30-32.
THEIS	Freeze and Cherry, Groundwater, pages 321-322; and Lohman, Ground-Water Hydraulics, USGS Professional Paper 708, 1979, page 8.
CONSO	Lambe and Whitman, Soil Mechanics, pages 406-410.

The following pages contain short descriptions of each test case and the plots of DYNFLO results versus the analytic solutions.

A.2.1 Linear Confined Flow

This case tested horizontal steady-state flow computations for a confined aquifer. It was based on Darcy's Law, which states that:

$$Q = -k\ i\ A = -k\ \frac{H_d}{L}\ BW \qquad (A.5)$$

where:

Q = flow rate (cu. ft./day)

k = hydraulic conductivity (ft/day)

i = hydraulic gradient

A = cross-sectional area of flow (sq. ft.)

H_d = head drop across aquifer (ft)

L = length of aquifer (ft)

B = thickness of aquifer (ft)

W = width of aquifer (ft)

A long "one-dimensional" grid was used with one layer and two levels. The parameters were assumed to be:

$$k = 1.0 \text{ ft/day} \qquad (A.6)$$

H_d = 50 ft

L = 100 ft

B = 20 ft

W = 10 ft

The head variation from one end to the other is linear, and the flow at the downstream end is given by:

$$Q = -(1.0)\frac{(100 - 50)}{100}(20)(10) = -100 \text{ cu. ft./day} \qquad (A.7)$$

Flow at the opposite end is the same but opposite in sign, positive meaning flow into the system.

Table A.1 shows the comparison of DYNFLO with the analytic solution.

A.2.2 Non-Linear Unconfined Flow

This case tested horizontal steady-state flow computations for an unconfined aquifer, and specifically, it tested the phreatic surface algorithm in DYNFLO. Using the Dupuit-Forcheimer Theory, the one-dimensional solution for the phreatic surface configuration between a point of specified head and a discharge point is:

$$h^2 = h_0^2 - \frac{x}{L}(h_0^2 - h_L^2) \qquad (A.8)$$

TABLE A.1

COMPARISON OF DYNFLO RESULTS WITH ANALYTIC SOLUTION
FOR LINEAR CONFINED FLOW CASE

Distance from Downstream End (ft.)	Piezometric Head (ft.)	
	Analytic	DYNFLO
10.	55.0	55.0
20.	60.0	60.0
30.	65.0	65.0
40.	70.0	70.0
50.	75.0	75.0
60.	80.0	80.0
70.	85.0	85.0
80.	90.0	90.0
90.	95.0	95.0

FLOW RATES

	Downstream	Upstream
Analytic	-100.0	+100.0
DYNFLO	-100.0	+100.0

where:

h_0 = fixed head at discharge point

x = distance from the discharge point to the point at which the head h is being computed

L = distance between the specific head location and the discharge point

h_L = fixed head at the specific head location

The flow through the aquifer is:

$$Q = \frac{k}{2L} (h_0^2 - h_L^2) \qquad (A.9)$$

For the test case, a long "one-dimensional" grid was utilized, with one layer and two levels, and these values used:

h_0 = 50 ft (A.10)

h_L = 100 ft

L = 100 ft

k = 1.0 ft/day

The analytic solutions for the head distribution and flow are:

h^2 = (2500 + 75x) sq. ft. (A.11)

Q = 37.5 cu. ft/day

The comparison of DYNFLO results with those solutions is shown in Table A.2. It should be recognized that the analytical solution, based on the Dupuit approximation, neglects vertical hydraulic gradients whereas, the DYNFLO code includes the effect of vertical gradients.

A.2.3 Tank Drainage

This case tested the vertical flow computations and phreatic surface algorithm, as well as transient computations. In this situation, a vertical tank was simulated which was initially full and drained over time. The analytic solution is:

$$h(t) = h_0 \exp(-(k/b)t) \qquad (A.12)$$

where:

$h(t)$ = head variation over time (ft)

t = time (days)

k = vertical hydraulic conductivity of tank outlet (ft/day)

b = thickness of tank outlet (ft)

A simple two-element horizontal grid was employed, with ten levels and nine layers. The bottom layer was given the vertical hydraulic conductivity from Equation A.12, while the remaining layers were given a high conductivity and storage coefficient equal to unity to simulate a hydrostatic tank. The values of the parameters were selected as:

$$h_0 = 80 \text{ ft} \qquad (A.13)$$

$k = 0.1$ ft/day

$b = 10.0$ ft

The comparison of the analytic solution to DYNFLO is shown in Table A.3.

A.2.4 Theis Curves

This case tested the horizontal two-dimensional flow and specified flux computations, as well as transient confined and phreatic calculations. The analytical solution is termed the Theis Curve. A single quadrant radial grid with two levels and one layer was used to test DYNFLO. The following parameters were utilized:

k_h = horizontal hydraulic conductivity = 500 ft/day (A.14)

k_v = vertical hydraulic conductivity = k_h

b = aquifer thickness = 20 ft

S_s = storativity = .00005

S_y = specific yield = 0.10

Q = well pumping rate = 160,000 cu. ft/day

Comparisons of the analytic solutions to those from DYNFLO at three points, 200, 650, and 1000 feet from the pumping well, are shown in Figure A.3.

A.2.5 Hantush Solution

This case tested horizontal two-dimensional flow (with a vertical leaky flow component) and specified flux computations, as well as transient calculations. A single quadrant radial grid with three levels and two layers was used to test DYNFLO. The following parameters were utilized:

k_h = kv = hydraulic conductivity of aquifer = 500 ft/day

k_v = vertical hydraulic conductivity of leaky layer = 1.0

b = aquifer thickness = 10 ft (A.15)

S_s = storativity = .00005

S_y = specific yield = 0.10

Q = well pumping rate = 160,000 cu.ft/day

Direct comparison of the results at 200, 650, and 1000 feet from the pumping well are shown in Figure A.4.

A.2.6 One-Dimensional Consolidation

This case tested the transient vertical flow computations in DYNFLO. The analytical solution was originally derived by Terzaghi, and is presented in the reference cited previously. To simulate it using DYNFLO, a simple two-element grid with ten levels and nine layers was employed. The parameters selected were:

k = hydraulic conductivity = 1.0 ft/day (A.16)

S_s = specific storativity = 1.0 ft

S_y = specific yield = 1.0

h_0 = initial head = 200 ft

TABLE A.2

COMPARISON OF DYNFLO RESULTS WITH ANALYTIC SOLUTION

FOR DUPUIT-TYPE FLOW TEST CASE

Distance x (ft.)	Head, h (ft.)	
	Analytic	DYNFLO
10.	57.01	57.06
20.	63.25	63.33
30.	68.92	68.99
40.	74.16	74.21
50.	79.06	79.10
60.	83.67	83.73
70.	88.03	88.09
80.	92.20	92.24
90.	96.18	96.21

And the flow computation comparison is:

Analytic.....37.50 cu. ft./day

DYNFLO.....37.51 cu. ft./day

TABLE A.3

COMPARISON OF DYNFLO RESULTS WITH ANALYTIC SOLUTION

FOR TANK DRAINAGE CASE

Time (days)	Head, h(t) in feet	
	Analytic	DYNFLO
10	72.387	72.75
20	65.498	66.23
30	59.265	59.94
40	53.626	54.62
50	48.522	49.92
60	43.905	44.52
70	39.727	40.16
80	35.946	36.44
90	32.526	32.92
100	29.430	29.93

h_d = head drop = 50 ft

The comparison of the analytic solution to the DYNFLO results is shown in Table A.4.

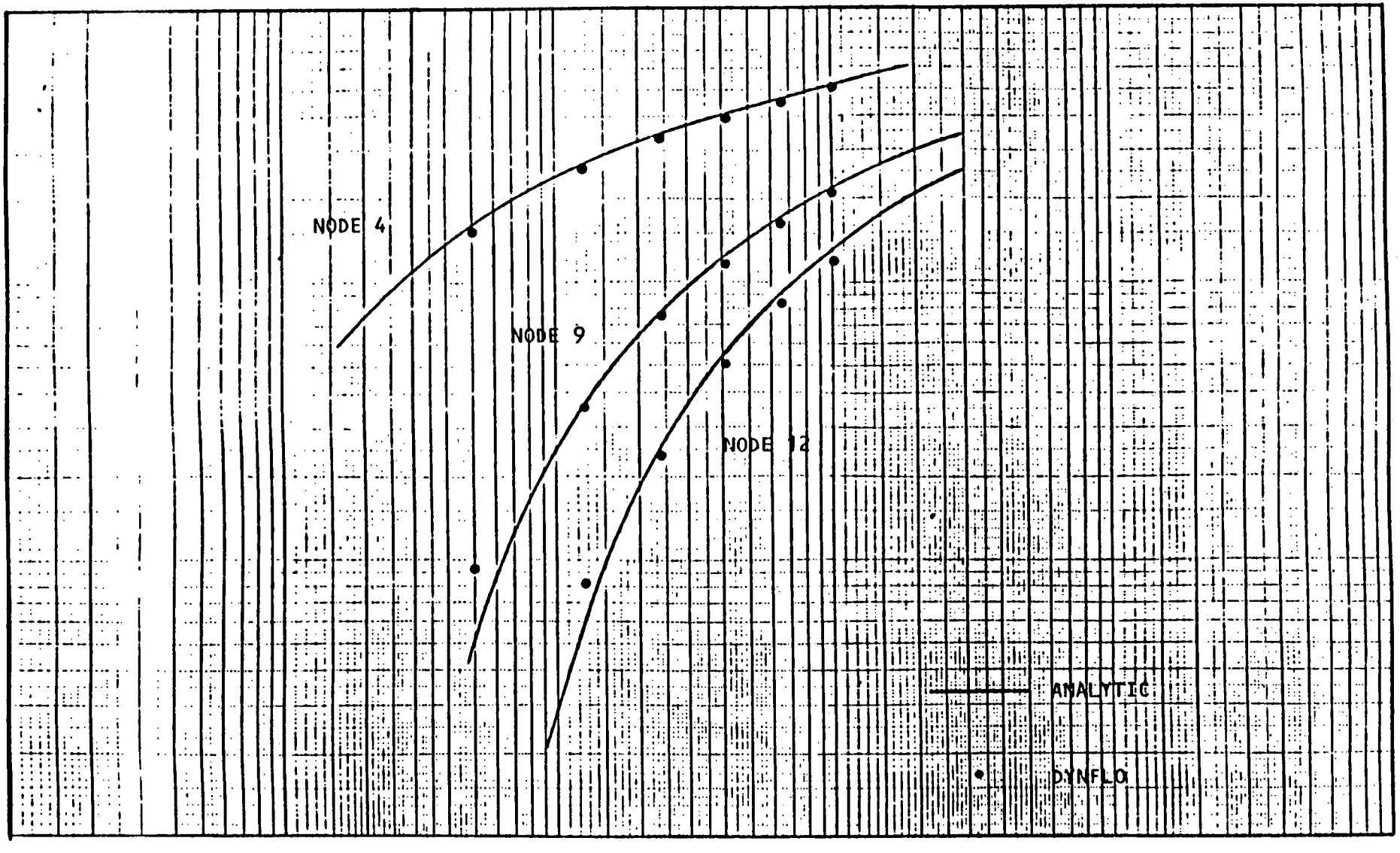


FIGURE A.3 -- Comparison of DYNFLO Results with Analytic Solutions for Theis Test Case

$$\nu = \frac{r}{2}\sqrt{\frac{K'}{b'T}} \quad ,$$

where: K' = the vertical hydraulic conductivity of the confining bed. [L/T]

b' = the thickness of the confining bed. [L]

T = aquifer transmissivity. [L^2/T]

r = radius.

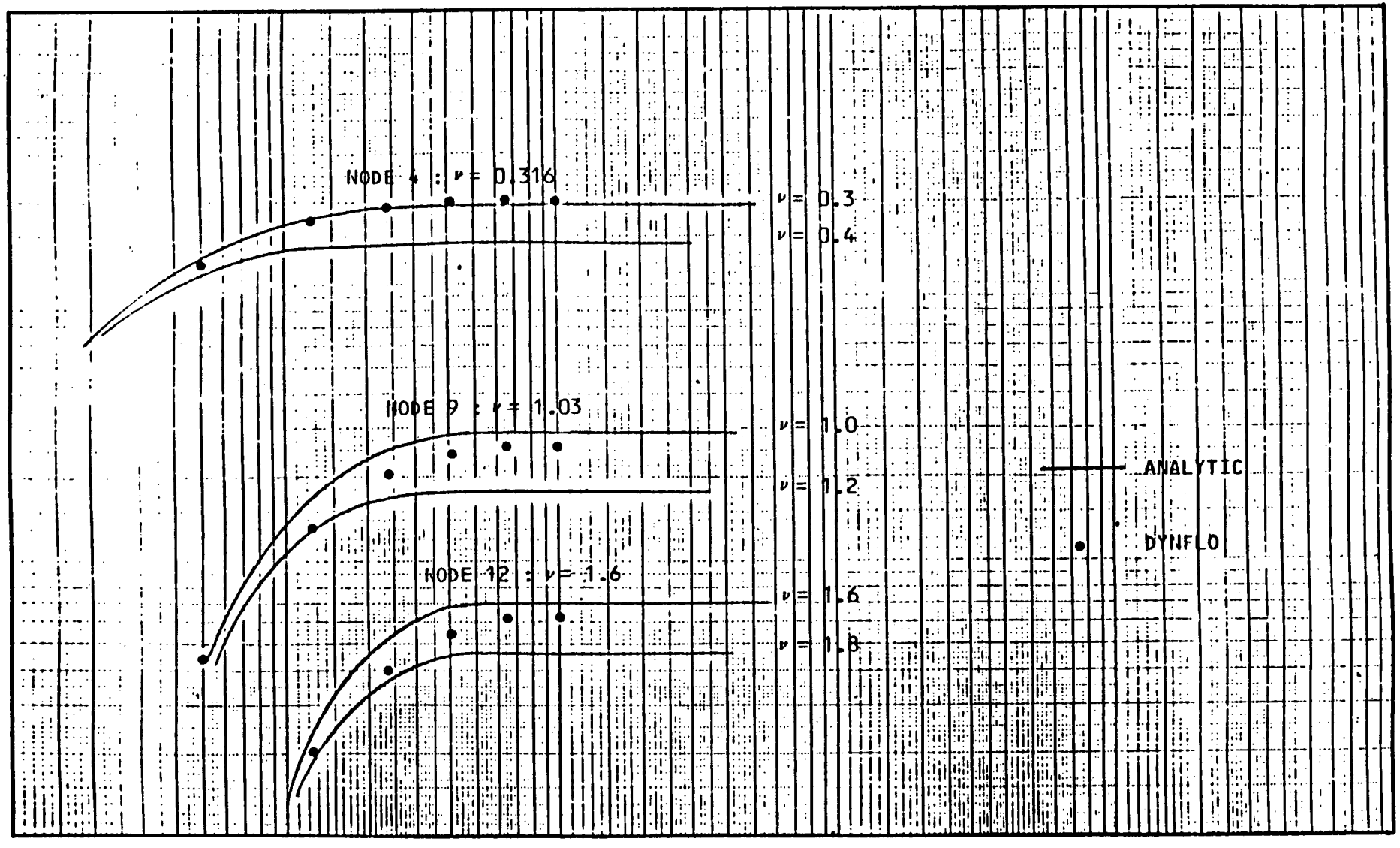


FIGURE A.4 -- Comparison of DYNFLO Results with Analytic Solutions for Hantush Test Case

TABLE A.4

COMPARISON OF DYNFLO RESULTS WITH ANALYTIC SOLUTION

TO ONE-DIMENSIONAL CONSOLIDATION CASE

Time (days)	Head (ft.)			
	1/4 or 3/4 Point In Aquitard		Mid-Point In Aquitard	
	Analytic Solution	DYNFLO	Analytic Solution	DYNFLO
1,000	187.0	187.5	197.2	196.4
2,000	177.5	177.9	188.5	187.8
3,000	170.3	171.5	180.0	179.6
4,000	166.7	166.7	173.7	173.1
5,000	162.8	162.9	168.5	167.9
6,000	160.0	160.0	164.3	163.9
7,000	157.7	157.8	161.2	160.8
8,000	155.8	156.0	158.8	158.4
9,000	154.6	154.7	156.8	156.5

A.2.7 Pond Elements

This case tested the pond algorithm computations, as well as vertical flow calculations. In this situation, a vertical tank was simulated by assigning a head-area-volume curve to the pond in which the surface area was always 1.0 and the volume equaled the pond head at all points on the curve. The analytic solution is given by Equation A.12 in Section A.2.3, the Tank Drainage case. The results of the computations are presented in Table A.5.

A.3 Application Procedures

The application of DYNFLO involves five major steps, these steps being viewed in conjunction with the overall modeling process previously described. These steps are:

1. Drawing and digitizing of the finite element grid. This provides the appropriate level of horizontal discretization for each level of nodes.

2. Contouring and digitizing of the stratigraphy of the formations to be modeled. This provides the appropriate level of vertical discretization.

3. Assignment and digitizing of the boundary conditions.

4. Coding of the simulation controls.

5. Execution of the model and interpretation of the simulation results.

The drawing and digitizing of the model grid comprises several sub-tasks. They are:

1.1 Transformation of conceptual model ideas into the setting of horizontal grid limits/boundaries.

1.2 Selection of node point densities, based on simulation needs; i.e., higher densities in the areas of interest, and at locations of field data measurements.

1.3 Drawing of node "bandwidth lines", for preserving minimum bandwidth in the coefficient matrix; this improves computational efficiency.

1.4 Placement of node points along the "bandwidth lines".

1.5 Drawing of the element sides, based on minimum bandwidth criteria (i.e., do not cross the "bandwidth lines," and follow boundary conditions and other conditions, such as topographic/stratigraphic features).

TABLE A.5

COMPARISON OF DYNFLO RESULTS WITH ANALYTIC SOLUTION

FOR POND TEST CASE

Time (days)	Head, h(t) in feet	
	Analytic	DYNFLO
10	72.387	72.00
20	65.498	64.80
30	59.265	58.32
40	53.626	52.49
50	48.522	47.24
60	43.905	42.51
70	39.727	38.26
80	35.946	34.44
90	32.526	30.99
100	29.430	27.89

1.6 Digitizing of node X,Y coordinates, using a digitizing tablet.

1.7 Digitizing of element connectivities (i.e., three nodes comprising each element).

1.8 Assembly of the node and element information into a single grid computer file.

1.9 Checking and plotting of the grid to insure that the aspect ratio (a measure of element stretching, which affects numerical stability) criteria are met and that no mistakes were made during the digitizing and assembly process.

1.10 Plotting of the grid for report and data take-off purposes.

The digitizing of stratigraphy information relies on the conceptual model formulation and on plots of actual, field-measured data. The sub-steps are:

2.1 Plotting of data cross-sections, showing the actual logs taken at boreholes and showing any water level measurements.

2.2 Plotting of data in plan view, with a first-pass plot of individual data points followed by contouring.

2.3 Digitizing of the elevations of each model "level," which are defined as the break points between different aquifer/aquitard/aquiclude formations. Note that this digitizing process is currently not automated because of the judgment involved in data interpretation and the difficulty of reliably translating such judgment into digitizing software.

2.4 Plotting and checking of the elevations for report and further data set-up purposes.

2.5 Selection of properties: hydraulic conductivities (in the X,Y, and Z directions) and storage coefficients.

Once the horizontal and vertical discretization have been set, the boundary conditions and simulation controls can be assigned. The boundary condition choices are specified head (type 1), specified flux (type 2), rising, or dry. The last two are computer program "flags" to set type 1 or 2 boundaries depending on preconditions. Note that a first-type boundary takes priority and will override any specification of flux at a node. One such condition must be selected for each node for all simulation times. By default, DYNFLO assigns a zero flux boundary condition at each node, an assignment which the user can change. DYNFLO currently accepts the specification of flux at elements, to simulate recharge - this recharge will only be applied to the uppermost layer if it is phreatic. And, DYNFLO will simulate drainage of a phreatic layer to the surface. In the event that the

water table rises to the surface DYNFLO will, through the rising water boundary condition option, hold the water table at the surface elevation, thereby, (a) creating a specified head (type 1) boundary condition and (b) computing a flux out of the aquifer at that point. Nodes at which the head tends to be less than the node elevation can be fixed at the node elevation through the "dry" option. This command is implemented currently for only the lowermost node level.

The simulation controls are all incorporated in a file called the DYNFLO run control file. This file contains all of the commands which control the execution of DYNFLO. In general, the control file performs these functions:

4.1 Specification of the file from which DYNFLO should read the finite element grid information.

4.2 Specification of the number of levels in the model.

4.3 Selection of in-core or out-of-core solution procedure.

4.4 Assignment of stratigraphy and/or specification of files on which the stratigraphy information resides.

4.5 Same, boundary conditions.

4.6 Same, properties.

4.7 Specification of solution convergence parameters: maximum number of iterations per time step and the convergence acceptance tolerance.

4.8 Selection of time-stepping parameters.

4.9 Specification of information storage and display parameters.

4.10 Directing DYNFLO to perform its simulation computations.

DYNFLO allows the user to run in an interactive or batch mode, the latter being the preferable mode when long computer times or the need for re-running simulations are encountered. Commands are specified as major keywords with qualifiers for the levels and grid nodes or elements to which the command should apply. Sub-commands include the means for specifying file names and file processing modes, as well as data transformation methods (add, multiply, etc.). In brief, the major commands are described in Table A.6.

Execution of a simulation run and interpretation of the results include the following sub-steps:

5.1 Submitting the simulation control file.

5.2 Printing and review of the results.

5.3 Post-processing of the results:

TABLE A.6

BRIEF DESCRIPTIONS OF DYNFLO MAJOR COMMANDS

COMMAND	MEANING
GRID	Process grid info.
LEVE	Specify number of levels.
BLOC/XBLO	Select in-core (block) or out-of-core (non-block) solution procedure.
ELEV	Assign stratigraphic elevations.
PROP	Tabulate an element property set (K's, S, SY, recharge).
ELEM or MATN	Assign element property set to elements. Note: the type of element activated is based on the hundreds digit of the data value field; e.g., value 307 will activate the 3D DYNFLO and will assign property set number 7. The element types are as follows:

SERIES	TYPE
100-199	1D
200-299	2D
300-399	3D
400-499	Planar

INIT	Assign initial heads.
HEAD	Assign/process heads following the first simulation time step.
FIX	Specify nodes in the system at which heads are to be held fixed (type 1).

TABLE A.6 (CONT.)

BRIEF DESCRIPTIONS OF DYNFLO MAJOR COMMANDS

COMMAND	MEANING
FREE	Remove the fixed head specification, and return the boundary condition to specified flux (type 2).
FLUX	Assign the amount of flux to be simulated at selected nodes.
ITER	Specify maximum number of iterations.
TOL	Assign convergence tolerance.
DT	Assign simulation time step. Note: DT = Ø means that a steady-state solution will be computed.
ACCE	Specify time step acceleration factor.
TIME	Assign simulation time.
PRIN	Print the current state of the system.
PRAL	Print the state of the system at all time steps during simulation.
MBPR	Print the current mass balance of the system (i.e., fluxes).
MBAL	Print mass balance at all time steps during simulation.
POND	Activates POND processing routines in DYNFLO.
GOTIL	Perform simulation (GO) until (TIL) the specified simulation ending time. Note: A subsequent GOTIL command can re-start simulation.
FILE	Store simulation results (heads and node point fluxes) on a binary file, for later post-processing.

- o Time history plotting
- o Contour plotting, in plan view and cross-section
- o Mass balance calculations, including computation of fluxes such as baseflow to rivers and leakage through aquitard (leaky) layers.

5.4 Marking and filing of the documents and graphics produced.

Appendix B

APPENDIX B

CONTAMINANT TRANSPORT SIMULATION CODE - DYNTRA*

B.1 Theory

The contaminant transport model, DYNTRA, simulates the convective and dispersive processes by which pollutant plumes develop and travel through aquifers. A particle tracking technique is used, whereby a pollutant mass is represented as a cloud of several thousand discrete particles.

Because contaminant transport in an aquifer is primarily a function of groundwater flow, detailed flow field determination is a prerequisite to transport modeling. DYNTRA was designed to be compatible with DYNFLO, CDM's groundwater flow simulation code. The results of DYNFLO simulation, in the form of flow fields, are input directly to DYNTRA.

This appendix:

(1) introduces the theory on which DYNTRA is based, and;
(2) presents test simulations used to demonstrate agreement between theoretical and simulated results.

DYNTRA utilizes the same three-dimensional finite element grid representation of aquifer geometry and geological stratigraphy described previously for the DYNFLO model. Nodal point heads, separately calculated by hydraulic simulation, are input to DYNTRA along with the same element material properties and system boundary conditions input to DYNFLO. An additional material property, effective porosity, is required for DYNTRA flow field computations as described below.

B.1.1 Groundwater Flow Field

The first task of transport modeling is to determine mean flow velocity for each component direction for each element. This is computed from element geometry, material properties, and nodal point heads at the element vertices using Darcy's Law, which expresses flow rate as a function of hydraulic gradient. In the x-direction:

$$q_x = -k_x \frac{\partial h}{\partial x} \qquad (B.1)$$

where:

q = mean specific discharge or volumetric flow rate per unit area

k = hydraulic conductivity

*Alternative name for DYNTRACK

h = piezometric head

The hydraulic conductivity, k, of element materials is determined in the flow model calibration process.

Since groundwater flow is limited to connected pore spaces, the actual mean seepage velocity is greater than the specific discharge by the ratio of total element volume to effective pore volume.

$$v_x = q_x / n_{eff} \tag{B.2}$$

where:

v = mean seepage velocity

$n_{eff} = V_{void}/V_{tot}$ = effective porosity

V_{void} = volume of hydraulically connected voids

V_{tot} = total volume

The value of effective porosity, is similar to specific yield, which is the proportion of drainable volume in soil. Effective porosity may be somewhat greater than specific yield but will always be less than the total porosity. Since computed convective velocities are directly related to the value of this parameter, the values selected can materially affect modeling results.

B.1.2 Single Particle Tracking

In the simplest analysis, pollutants are assumed to be convected in groundwater at the rate of the local mean seepage velocity. If a tracer particle is injected in a flow field at point x, y, z and time t, after a period of time Δt its new location will be:

$$x_{t+\Delta t} = x_t + v_x \Delta t \tag{B.3}$$

$$x_{t+\Delta t} = x_t + v_y \Delta t \tag{B.4}$$

$$z_{t+\Delta t} = z_t + v_z \Delta t \tag{B.5}$$

where the seepage velocities, are those computed for the element in which it was injected. If the new location is in a different element, the seepage velocities computed for the new element will be applied to compute particle displacement for the next time step.

Single particle tracking is a means of forecasting the mean path and velocity of transport from a particular point in an aquifer under given hydraulic conditions. By computing negative displacements, it can sometimes be used in a "hindcasting" mode, whereby possible source

areas of contaminants reaching a particular point in an aquifer are suggested. However, single particle tracking does not account for the dispersion of contaminant plumes observed in nature.

B.1.3 Dispersion Algorithms

Dispersion phenomena in flow through porous media occur at three scales of observation. The smallest scale is molecular diffusion due to random collisions and displacements of individual molecules. At laboratory scale, dispersion is observed in a uniform medium due to the many different tortuous flow paths followed by discrete portions of a tracer, each with somewhat different velocity and direction. In the field, due to limited sampling and the variable, "interbedded" nature of aquifer materials, soils which are considered uniform for analytical purposes will be more or less variable in their ability to transport contaminants. Dispersion occurs in all three cases because different fractions of a tracer mass are transported in different directions at different velocities.

Dispersion observed at field scale is much greater than that observed at laboratory or molecular scale. It is most relevant to contaminant transport studies in real aquifers. It makes sense that the magnitude of field dispersion is a function not only of soil types and flow velocities, but also of the scale and precision of study. Other things equal, mass transport in a large aquifer system approximately represented will appear to be governed more by random dispersion than transport in a small aquifer very precisely represented.

Fick's Law, which is used to represent molecular diffusion as well as many other transport processes, is usually applied to field dispersion in groundwater studies. The dispersion equation, without convection, is written:

$$\frac{\partial C}{\partial t} = D_x \frac{\partial^2 C}{\partial x^2} + D_y \frac{\partial^2 C}{\partial y^2} + D_z \frac{\partial^2 C}{\partial z^2} \qquad (B.6)$$

where:

C = concentration

D = dispersion coefficient (units of L^2/T)

Various studies (Bear, 1972) have shown that dispersion in the direction of mean flow tends to be greater, usually by an order of magnitude, than dispersion transverse to the mean direction of flow. Therefore, when simulating dispersion in any element, DYNTRA assumes a natural coordinate system with the principal axes aligned parallel (x) and perpendicular (y,z) to the velocity vector. Separate coefficients are applied to longitudinal and transverse dispersion. It is also been shown that dispersion coefficients are proportional to the magnitude of the resultant seepage velocity. In any element, the

coefficients are computed:

$$D_{x'} = A_L \ |v| \tag{B.7}$$

$$D_{y'} = A_T \ |v| \tag{B.8}$$

$$D_{z'} = A_T \ |v| \tag{B.9}$$

where A = dispersivity (units of length) and the subscripts L and T refer to directions longitudinal and transverse to the mean flow direction. These parameters are assumed constant through time. Dispersivity values are additional element material properties which must be input to DYNTRA.

In DYNTRA a contaminant mass is represented by many particles. The dispersion process is simulated by adding to each particle random dispersive displacements in addition to the convective displacements described for single particle tracking. It can be shown that equation (B.6), applied to a given mass injected at a point, will lead to a normal distribution of mass in any of the principal directions (see Model Verification). The standard deviation of the distribution, or the average displacement, will be:

$$\sigma = \sqrt{2D \Delta t} \tag{B.10}$$

The central limit theorem of statistics insures that the summation of random displacments of many particles will lead to a normal distribution. The magnitude of the random displacements is computed as follows in order to preserve the correct standard deviations in the particle distribution.

$$\Delta x' = \sqrt{2D_L \Delta t} \quad (\sqrt{12}) \quad [R]_{-.5}^{+.5} \tag{B.11}$$

$$\Delta y' = \sqrt{2D_T \Delta t} \quad (\sqrt{12}) \quad [R]_{-.5}^{+.5} \tag{B.12}$$

$$z' = \sqrt{2D_T \Delta t} \quad (\sqrt{12}) \quad [R]_{-.5}^{+.5} \tag{B.13}$$

where:

$R_{-.5}^{+.5}$ = uniformly distributed random number between -0.5 and 0.5.

$1/\sqrt{12}$ = standard deviation of the uniform random number distribution.

and the x direction is aligned with the direction of flow.

Where the bedded nature of soil deposits results in significantly reduced vertical flow conductance compared to horizontal conductance, observed vertical dispersion may be considerably suppressed. DYNTRA allows for the specification of an anistropy ratio by which vertical dispersion is suppressed with respect to horizontal dispersion in a given element.

B.1.4 Decay

The total mass of a contaminant which enters an aquifer may be reduced by radioactive decay, chemical reactions, adsorption by the soil particles, or other means. Reduction of mass can be simulated in DYNTRA as a simple first order decay process. The mass assigned to each particle would be adjusted at each time step according to the formula.

$$W_{t+\Delta t} = W_t \exp(-\lambda \Delta t) \qquad (B.14)$$

where:

W = particle weight

λ = first order decay coefficient

exp = natural logarithmic base

B.1.5 Plume Modeling

To model the passage of a contaminant plume through an aquifer, thousands of individual particles are tracked. Convective and dispersive displacements are computed repeatedly for each particle at small time intervals. The particles represent contaminant mass, with a small discrete portion of that mass assigned to each particle.

Based on the distribution and weight of particles at a given time, the model computes contaminant concentrations. It does this by dividing the total space being modeled into sub-regions, one for each node of the 3-dimensional grid. The total mass of particles located in the region around a node, divided by the pore volume of that region, determines the concentration assigned to that node.

791

Note that there may be some inaccuracy in reporting concentrations this way, arising from the fact that particle mass may not be evenly distributed within a node region. This problem is of minor concern where node spacing is not excessive and a sufficient number of particles is used, but it tends to make interpolated concentration contour lines "ragged" looking rather than smooth. This effect is not cumulative, so that the error does not grow as simulation computations proceed.

Finally, note that the transport model assumes that concentrations are small enough to have no significant effect on the density of groundwater; i.e., flow velocities are independent of concentration.

B.2 Comparisons with Analytic Solutions

The ability of DYNTRA to simulate mass transport correctly according to theory was tested by simulating simple cases for which analytical solutions are readily available, and comparing simulated with analytical results. Agreement was found to be generally satisfactory.

The test cases selected all utilize a uniform flow field in which the mean seepage velocity is constant throughout. Either a single slug of mass is inserted at a given point and allowed to convect and disperse, or a continuous source is assumed which injects mass at a constant rate.

B.2.1 Convection and Dispersion in One Dimension

A slug of mass is injected at a point, x , in a uniform flow field with seepage velocity, v, in the x-direction. Neglecting dispersion, in time t the mass will be convected to a point.

$$x'(t) = x_0 + v \cdot t \tag{B.15}$$

When one-dimensional dispersion in the x-direction is included, the mass will be distributed with x'(t) at the center. The theoretical shape of this distribution is determined by the dispersion equation (B.6). Assuming that the initial slug of mass, M, at x has dimensions of unity in the y and z directions, the solution of the differential equation can be expressed (Bear, 1972).

$$C(x_j t) = \frac{M/n}{\sqrt{4\pi D_x t}} \exp \frac{-(x - x'(t))^2}{4D_x t} \tag{B.16}$$

where:

C = concentration

M = mass injected

n = effective porosity

D_x = dispersion coefficient

Note that equation (B.16) is the equation for a normal distribution centered about x' with standard deviation:

$$\sigma = \sqrt{2D_x t} \tag{B.17}$$

This is the basis for the computation of particle dispersive

displacements described in Section B.1.3.

A DYNTRA simulation of simple one-dimensional convection and dispersion was performed using the following parameters (any consistent set of units can be assumed):

$$\begin{aligned} v &= 1.0 \\ M &= 25 \\ n &= 0.25 \\ A_L &= 0.3 \\ D_X &= A_L\ V = 0.3 \\ X_o &= 2 \end{aligned} \qquad \text{(B.18)}$$

The results at times 4 and 8 are plotted in Figure B.1, along with theoretical results computed using equation (B.16). The trend of the simulated results is entirely faithful to theory. Slight deviationss are the result of the statistical nature of the simulation algorithm. The simulated results represent the theoretical distribution with a limited random sample (2000 particles). Even greater simulation precision can be achieved by increasing the size of the sample (i.e., the number of particles).

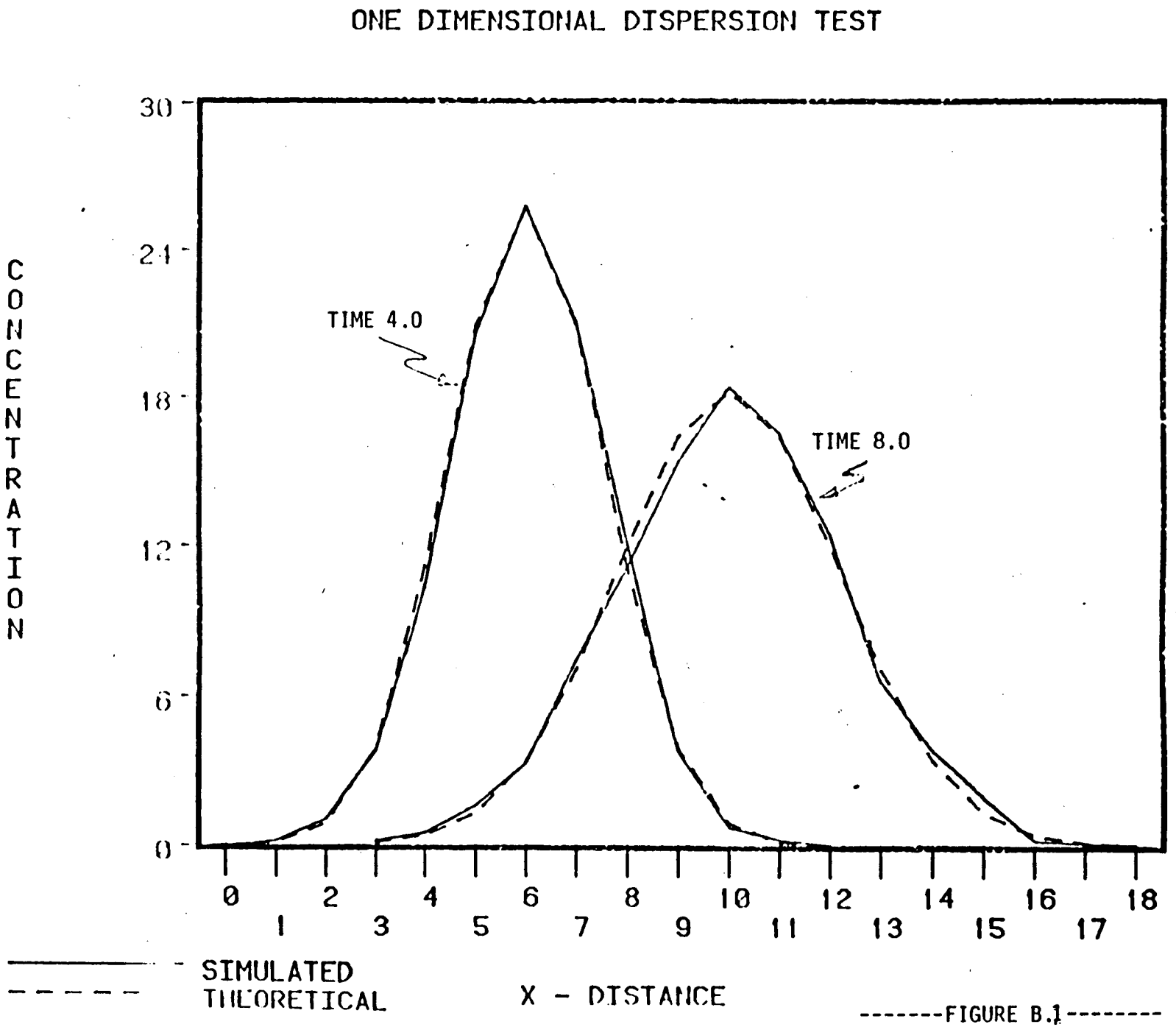
B.2.2 Convection and Dispersion in Two Dimensions

In two dimensions, it is possible to compute dispersion both longitudinal and transverse to the direction of mean flow. Convection, assuming mean flow in the x-direction, is still represented by equation (B.15). For a slug of mass, M, inserted in a uniform flow field at a point x , y with thickness of unity, the dispersion equation can be expressed (Miller, 1975):

$$C = \frac{M/n}{4\pi\sqrt{D_x D_y}\ t} \quad \exp - \frac{(x-x')^2}{4D_x t} + \frac{(y-y_o)^2}{4D_y t} \qquad \text{(B.19)}$$

Simulated results of two-dimensional convection and dispersion of a plug source are shown in Figures B.2 and B.3, in which contour lines of equal concentration are plotted. The following parameter values were used:

$$\begin{aligned} v &= 1.0 \\ M &= 25 \\ n &= 0.25 \\ A_L &= 0.3 \\ A_T &= 0.1 \\ D_X &= A_L \times V = 0.3 \\ D_Y &= A_T \times V = 0.1 \\ X_O &= 2.0 \\ Y_O &= 5.0 \end{aligned} \qquad \text{(B.20)}$$


ONE DIMENSIONAL DISPERSION TEST
CONCENTRATION
30
24
18
12
6
0
TIME 4.0
TIME 8.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
SIMULATED
THEORETICAL
X - DISTANCE

-------FIGURE B.1--------

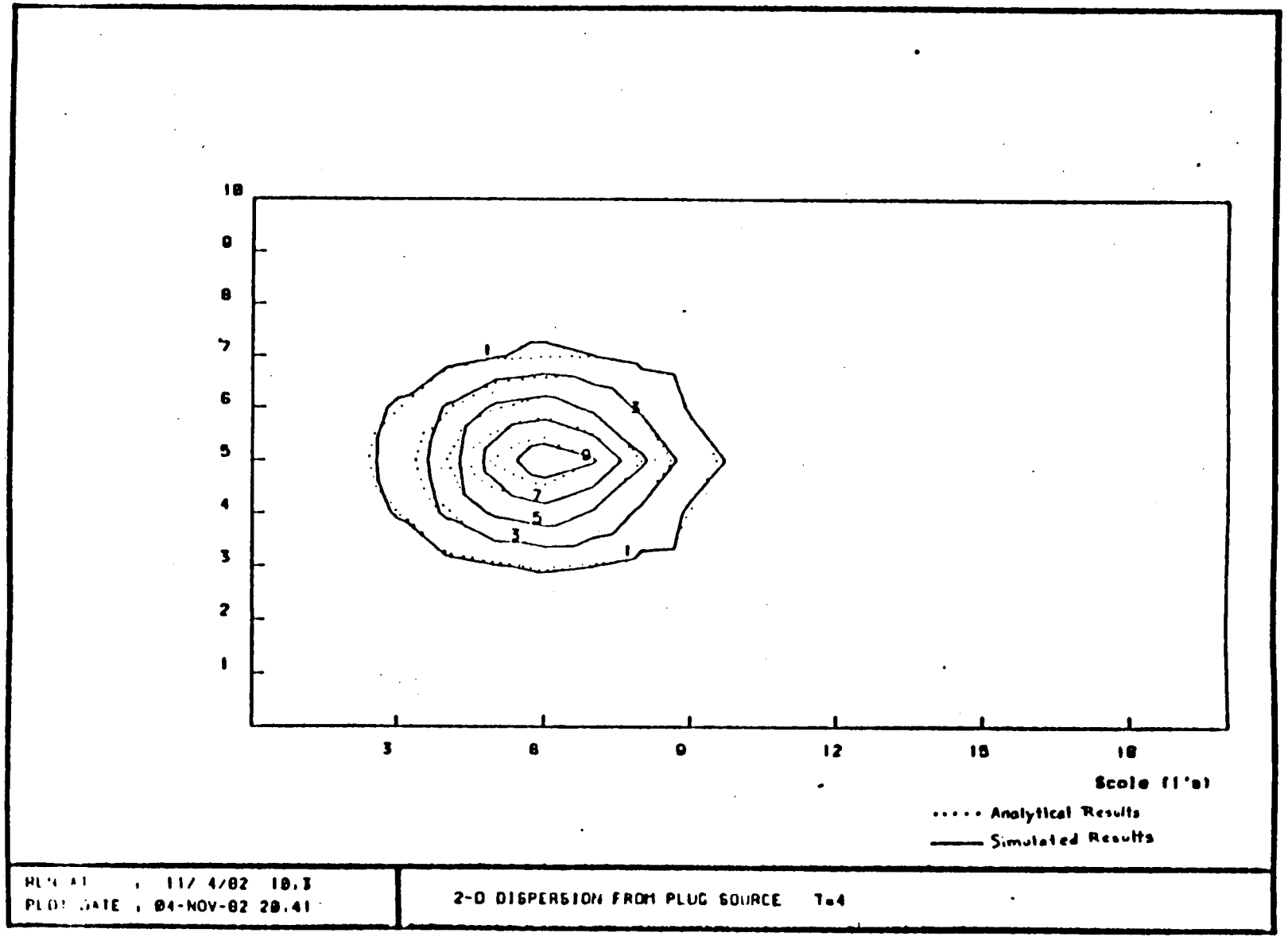

10
9
8
7
6
5
4
3
2
1
1
3
5
7
9
3
6
9
12
15
18
Scale ft'al
..... Analytical Results
——— Simulated Results
PLOT DATE : 04-NOV-82 20.41
2-D DISPERSION FROM PLUG SOURCE T=4

FIGURE B,2

96

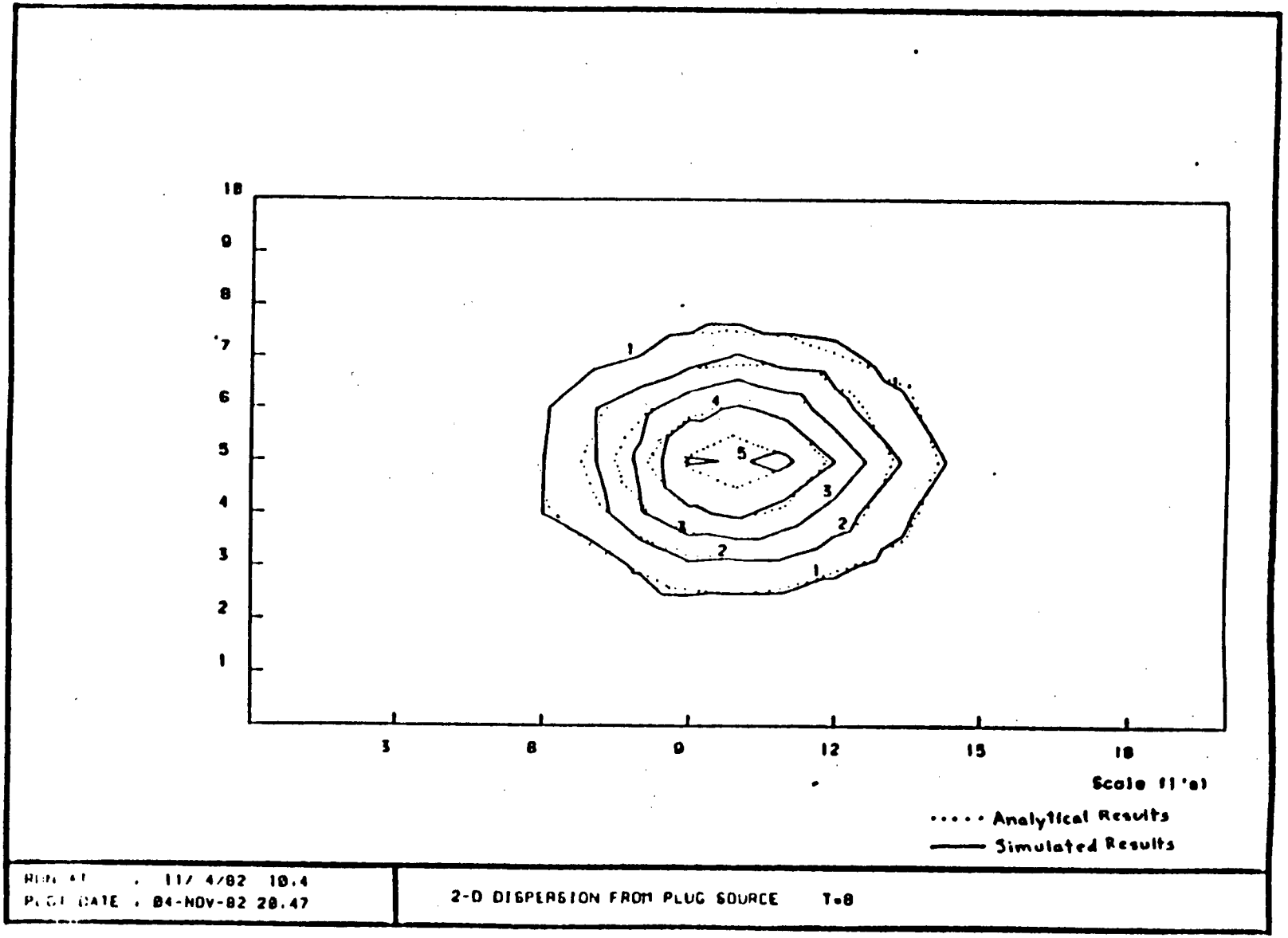

18
9
8
7
6
5
4
3
2
1
3
8
9
12
15
18
Scale ft'a)
..... Analytical Results
—— Simulated Results
RUN 41 . 11/ 4/82 10.4
PLOT DATE . 04-NOV-82 20.47
2-D DISPERSION FROM PLUG SOURCE T=8

FIGURE B.3

As with the one-dimensional test, the simulation agrees with theory except for minor random deviations. Note that the machine generated contours are not smooth ellipses. This is a result of the way contour lines are interpolated from a grid of point concentration values.

Another example of two-dimensional dispersion for which an analytical solution is available is when a source continuously injects mass into a uniform flow field at point x , y at a rate q (M/T). A close approximation of the theoretical solution, from (Miller, 1975), can be written.

$$C = C^* \left(\frac{\pi}{2B}\right)^{\frac{1}{2}} \exp\left(\frac{(x-x_o)}{2A} - B\right) \operatorname{erfc}\left(\frac{B-2U}{2\sqrt{U}}\right) \tag{B.21}$$

in which

$$C^* = \frac{q_m}{4\pi n v (A_L A_T)^{\frac{1}{2}}} \tag{B.22}$$

$$U = \frac{v t}{4 A_L} \tag{B.23}$$

$$B = \frac{((x-x_o)^2 + (A_L/A_T)(y-y_o)^2)^{\frac{1}{2}}}{2 A_L} \tag{B.24}$$

Results of a test simulation with a constant source are plotted in Figure B.4. All parameters are unchanged from the previous simulation except that a mass flux:

$$q_m = 2.5 \tag{B.25}$$

is specified in place of an initial mass. The simulated results agree substantially with theoretical results. There is less precision than the previous tests because fewer particles are spread over a greater region.

B.2.3 Convection and Dispersion in Three Dimensions

The DYNTRA program uses the same algorithms and the same programming code for three-dimensional dispersion as for two-dimensional dispersion. Therefore, new model capabilities are not tested by three-dimensional simulations except for the ability to suppress vertical dispersion with respect to horizontal dispersion.

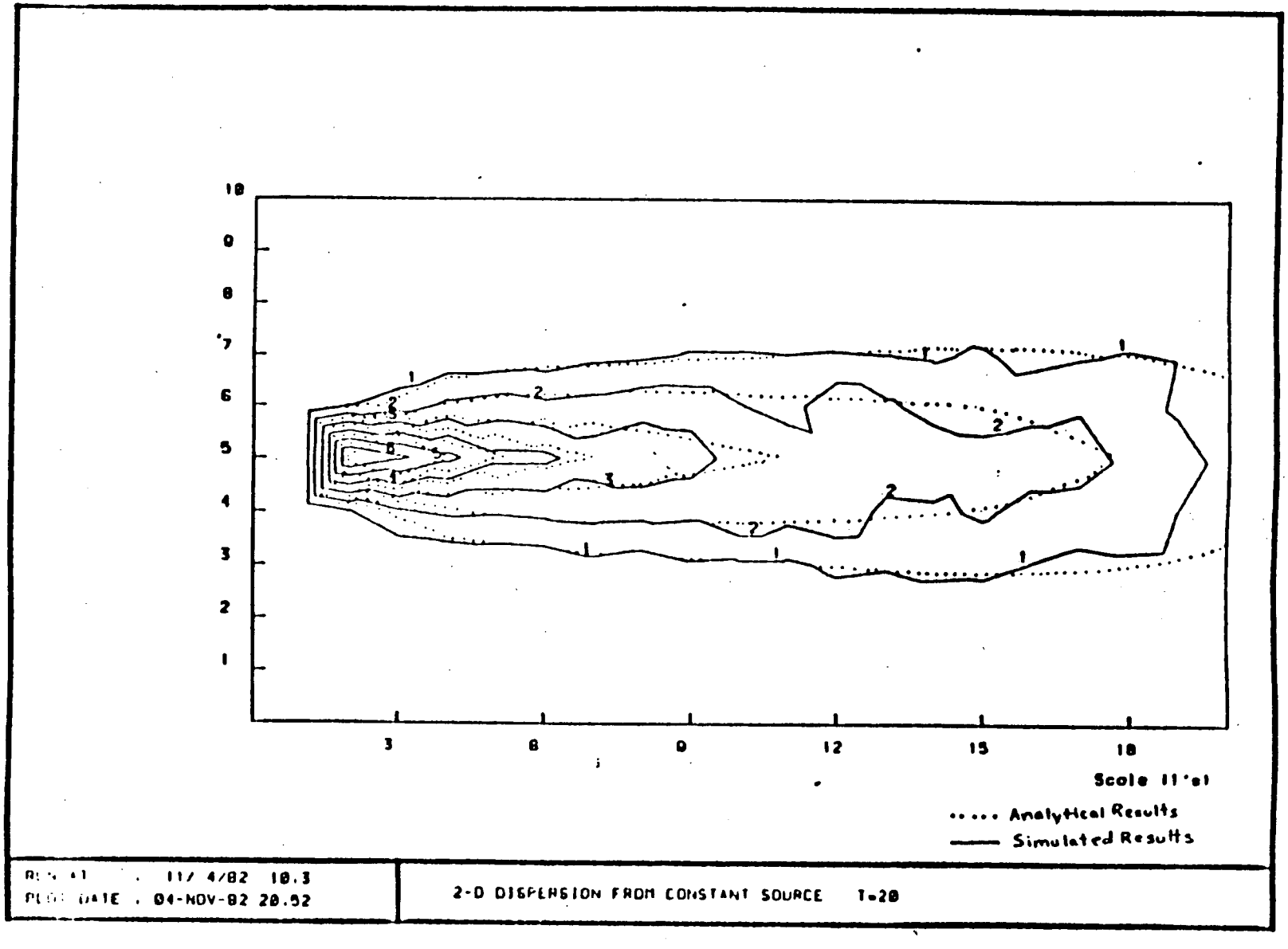


FIGURE B.4

799

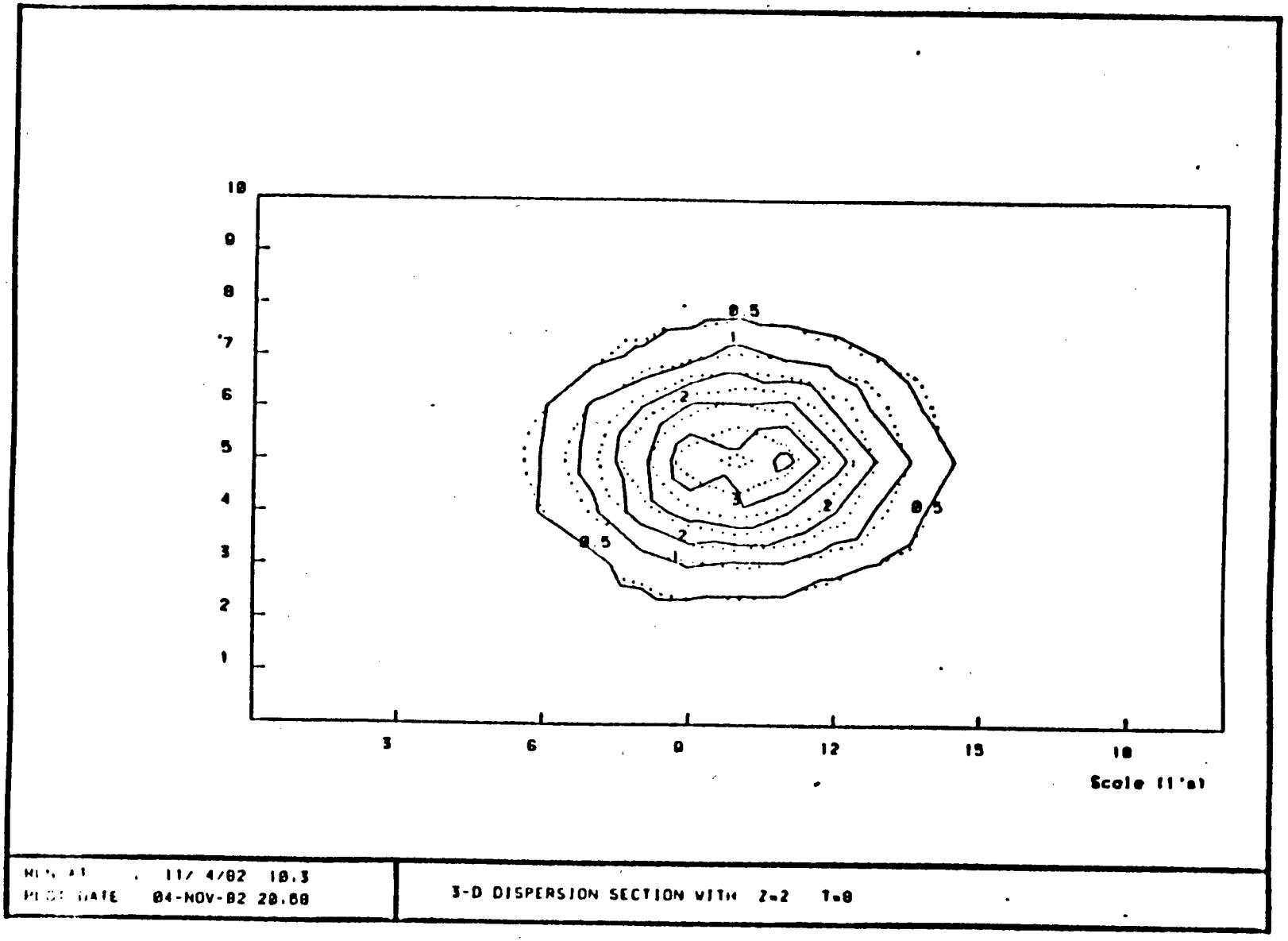

10
9
8
7
6
5
4
3
2
1
0.5
1
2
3
2
1
2
0.5
0.5
3
6
9
12
15
18
Scale (1"=
11/ 4/82 10.3
PLOT DATE 04-NOV-82 20.68
3-D DISPERSION SECTION WITH Z=2 T=0

FIGURE B.5

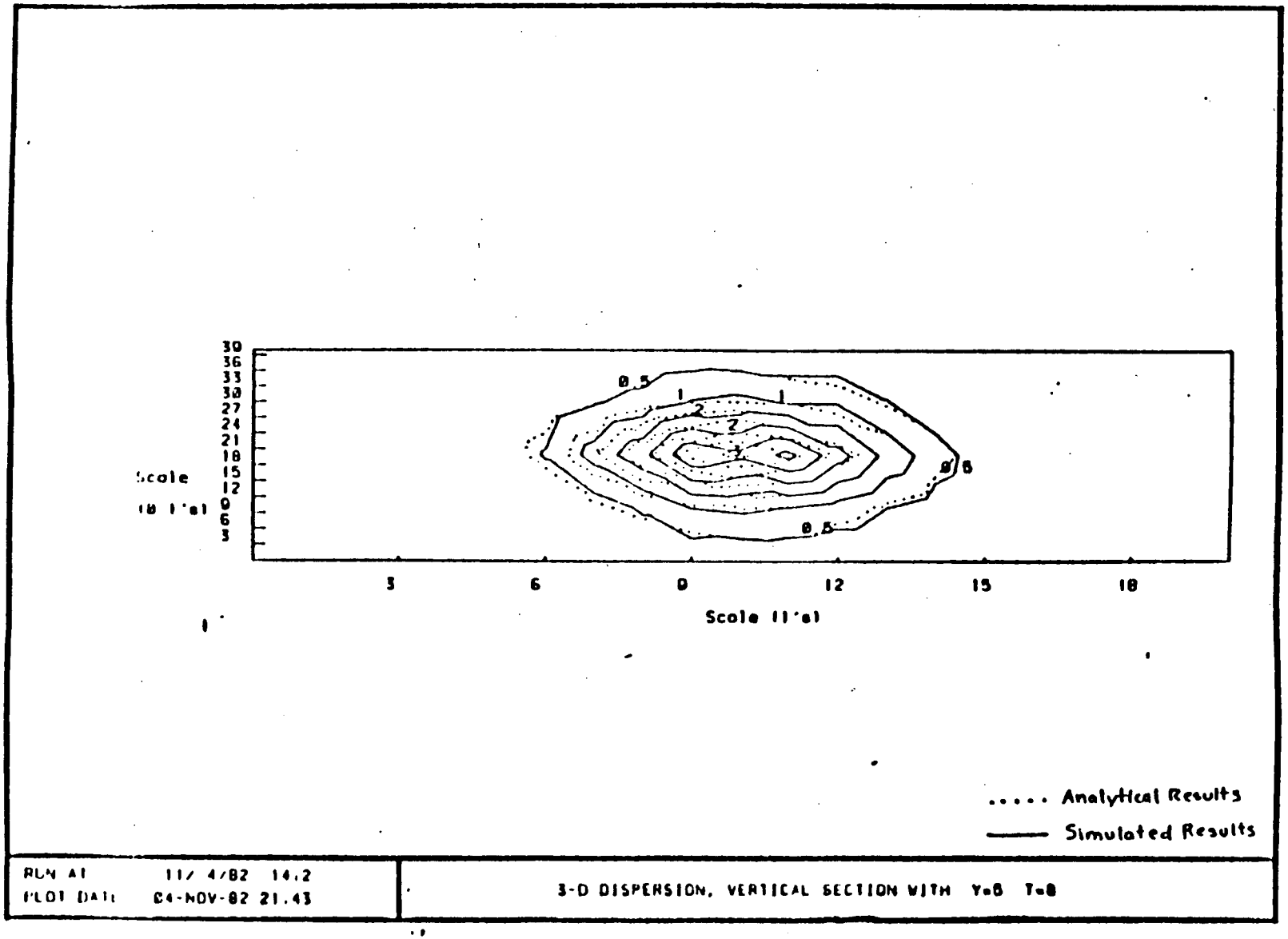

30
36
33
30
27
24
21
18
15
12
9
6
3
Scale
18 Feet
0.5
1
2
3
0.5
3
6
9
12
15
18
Scale Feet
..... Analytical Results
—— Simulated Results
RUN AT 11/ 4/82 14.2
PLOT DATE 04-NOV-82 21.43
3-D DISPERSION, VERTICAL SECTION WITH Y=0 T=0

FIGURE B.6

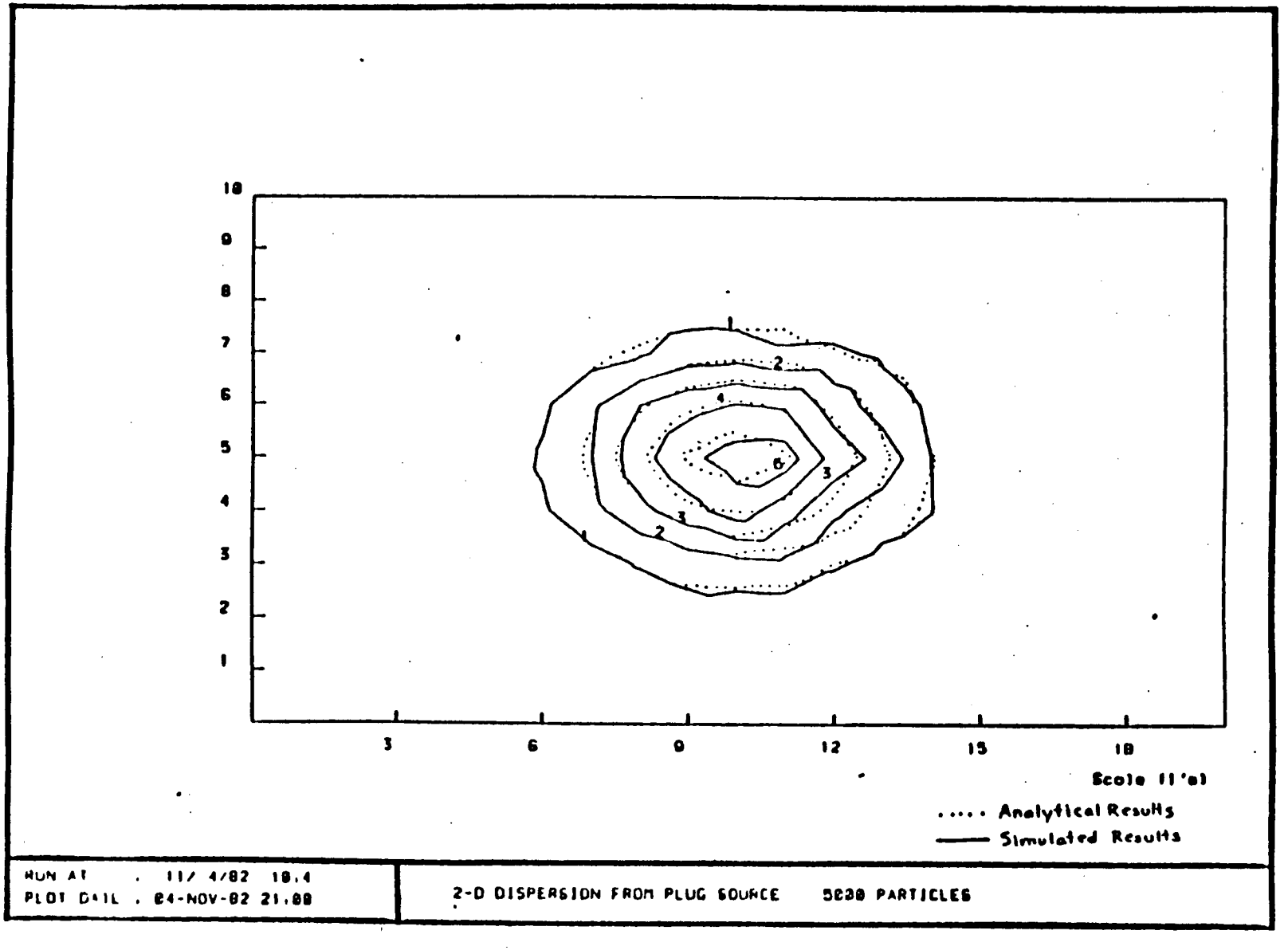

10
9
8
7
6
5
4
3
2
1
3
6
9
12
15
18
Scale 1"=1
..... Analytical Results
—— Simulated Results
RUN AT . 11/ 4/82 18.4
PLOT DATE . 04-NOV-82 21.08
2-D DISPERSION FROM PLUG SOURCE 5000 PARTICLES

FIGURE B.7

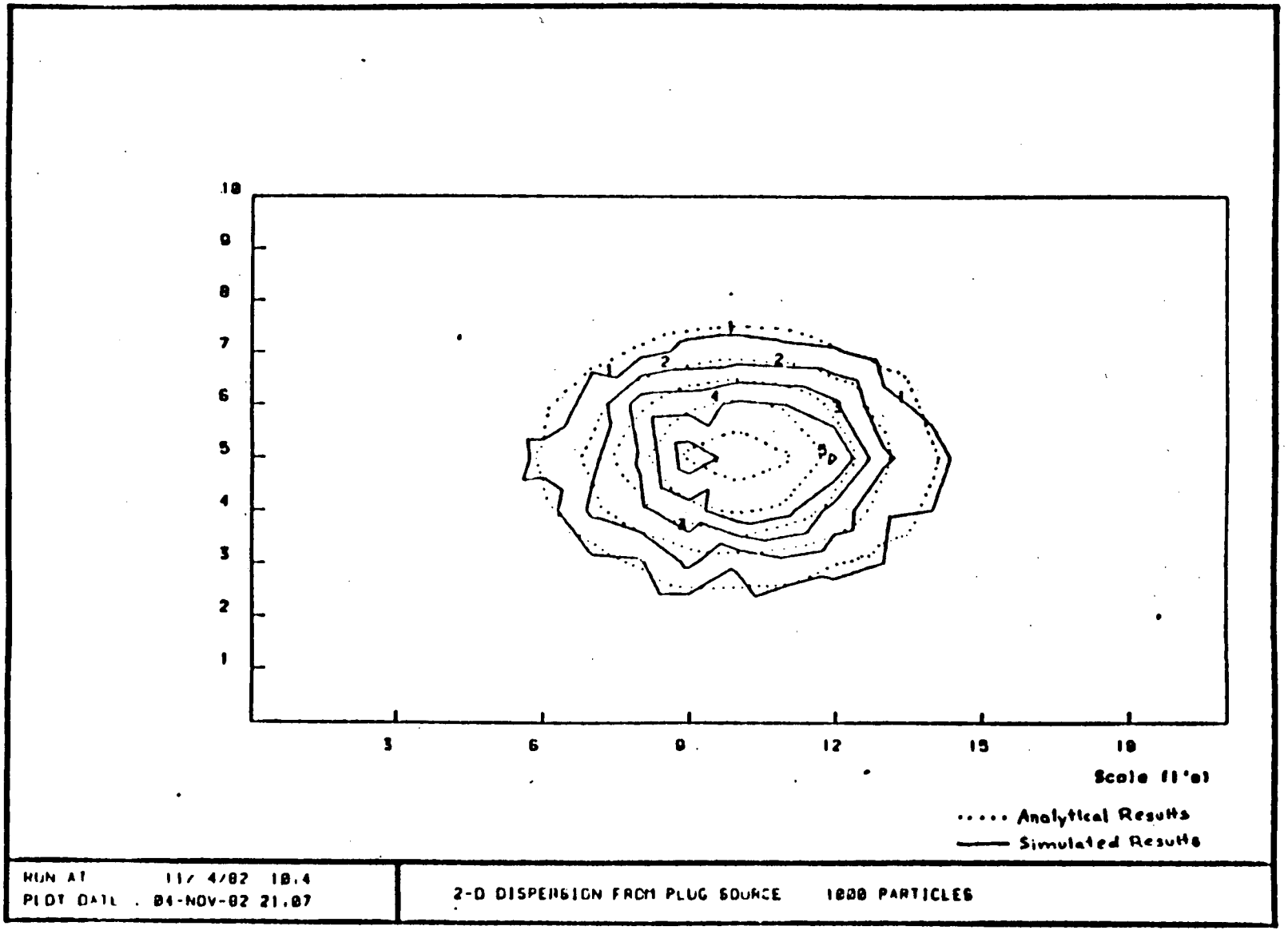

10
9
8
7
6
5
4
3
2
1
3
6
9
12
15
18
Scale ft*e1
..... Analytical Results
—— Simulated Results
RUN AT 11/ 4/82 18.4
PLOT DATE . 04-NOV-82 21.07
2-D DISPERSION FROM PLUG SOURCE 1000 PARTICLES

FIGURE B.8

A single three-dimensional dispersion test is presented for completeness. The three-dimensional equation for a single plug of mass inserted in a uniform flow field is:

$$C = \frac{M/n}{(4\pi t)^{3/2}(D_x D_y D_z)^{1/2}} \exp - \left\{ \frac{(x - x')^2}{4D_x t} + \frac{(y - y_o)^2}{4 D_y t} + \frac{(z - z_o)^2}{4D_z t} \right\} \quad (B.26)$$

The two-dimensional simulation for a single plug of mass was reproduced in three-dimensions. The additional parameters are:

$$z_o = 2.0 \quad (B.27)$$

$s = 0.25$ (vertical to horizontal dispersion suppression ratio)

$D_z = A_T \times V \times s = 0.025$

Figure B.5 shows simulated and theoretical contours for a horizontal cross-section taken at $z = z_o$. Figure B.6 is a vertical cross-section taken at $y = y_o$. Note that precision decreases somewhat as the same number of particles are spread over a greater region by the addition of the third dimension.

B.2.4 Simulation Precision

In the preceding sub-sections, it was noted that while simulation results are reliable in their agreement with theory, there is more or less random statistical error, or "noise". The degree of noise depends on the number of particles used to represent a plume and the extent over which they are spread. Simply, greater density of particles gives greater precision.

As an example, note that with the same number of particles (10,000), the two-dimensional test results at time 4 are more precise than the three-dimensional results at time 8, because the particles are more spread out in the latter case. For further illustration, compare Figure B.3 with Figures B.7 and B.8. These three figures represent the same simulation, with 10,000, 5,000 and 1,000 particles respectively. Simulation precision decreases corresponding to the number of particles used. This relation is illustrated in Figure B.9, in which mean squared error (theoretical versus simulated) is plotted as a function of the number of particles.

It is very difficult to generalize the relationship of precision to the number of particles. The curve in Figure B.9 applies only to the results of a particular simulation at a particular time. Also, the engineering significance of mean squared error values is unclear. Note, however, that while the 1,000 particle simulation is a fairly

crude representation of the theoretical distribution, for most engineering applications it is probably as valid as the 10,000 particle simulation. It should be emphasized that DYNTRA determines only the most probable path and distribution of a contaminant plume based on available geologic and hydrologic data. It does not purport to predict exact plume configurations because detailed aquifer data is necessarily limited.

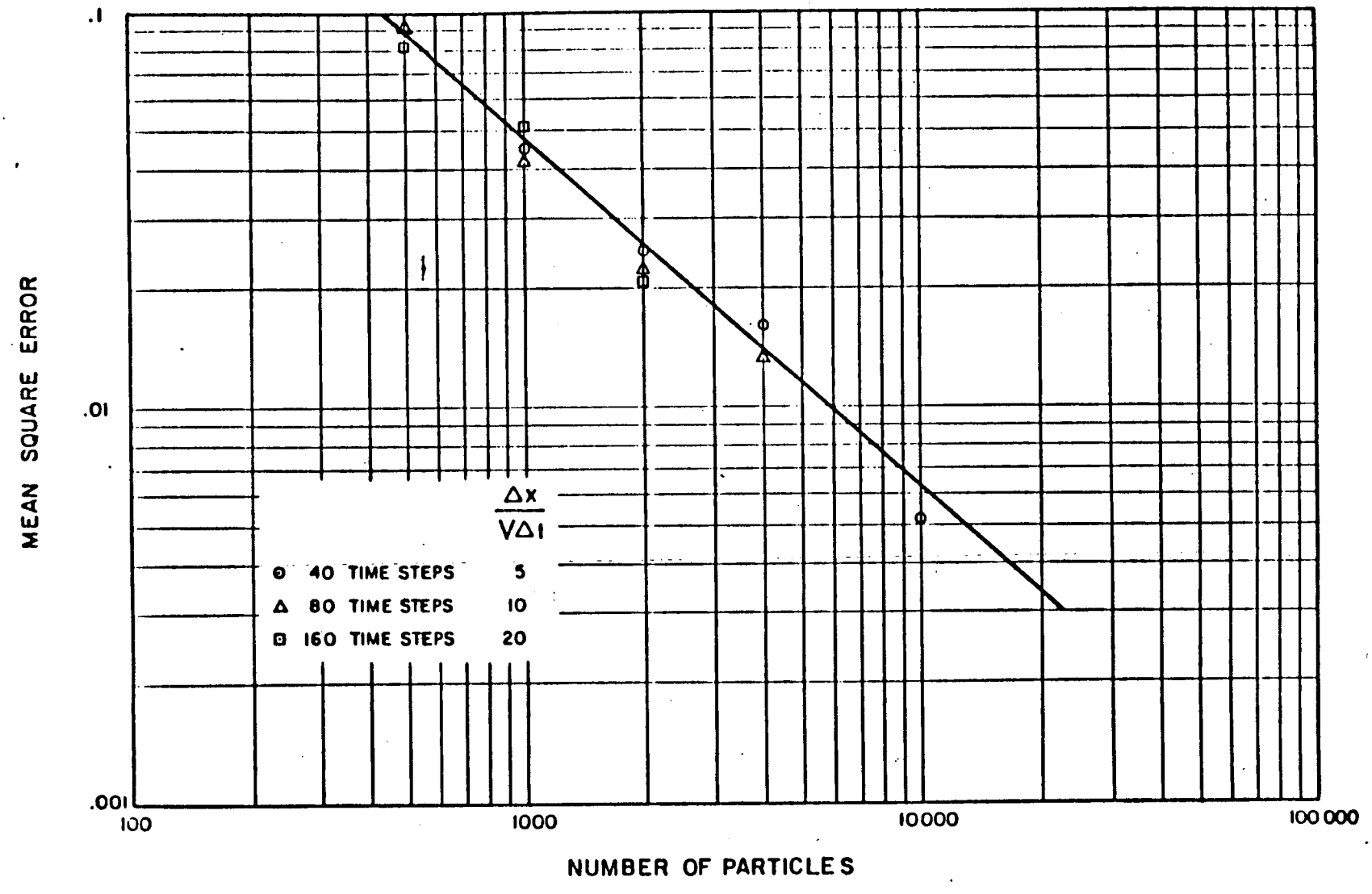


FIG. B.9 DYNTRA SIMULATION PRECISION
2-D Dispersion of a Plug Source

806

environmental engineers, scientists,
planners, & management consultants CDM®

807

JOHN CZAPOR

REMEDIAL RESPONSE ACTIVITIES zone 1 UNCONTROLLED HAZARDOUS WASTE DISPOSAL SITES

CAMP DRESSER & McKEE INC.
CH2M HILL
CONESTOGA-ROVERS & ASSOCIATES LIMITED
HALEY & ALDRICH, INC.

808

United States Environmental Protection Agency

New York, New York

VOLUME 3
DRAFT ENVIRONMENTAL INFORMATION DOCUMENT
EVALUATION OF
REMEDIAL ACTION ALTERNATIVES

Lone Pine Landfill, New Jersey
Work Assignment Z-1-17 Under
Contract No. 68-03-1612

June 1983

Camp Dresser & McKee Inc.

809

ENVIRONMENTAL INFORMATION DOCUMENT

Table of Contents..... i
List of Figures..... iv
List of Tables..... vi
Summary..... viii
Glossary..... x

1.0 Purpose and Need..... 1

1.1 Introduction..... 1
1.2 Statement of Problem..... 2
1.3 Study Area..... 4

2.0 Existing Conditions..... 7

2.1 Introduction..... 7
2.2 Physical Environment.....
2.2.1 Geology and Soils..... 8
2.2.1.1 Geology..... 8
2.2.1.2 Soils..... 8
2.2.1.3 Topography..... 11
2.2.1.4 Drainage..... 16
2.2.2 Groundwater:..... 17
2.2.2.1 Drinking Water Supply..... 17
2.2.3 Surface Water..... 23
2.2.4 Climate and Air Quality..... 28
2.2.4.1 Climate..... 38
2.2.4.2 Air Quality..... 41

2.3 Biological Environment..... 44
2.3.1 Flora and Fauna..... 44
2.3.1.1 Flora..... 44
2.3.1.2 Fauna..... 44

2.4 Socioeconomic Environment..... 45
2.4.1 Zoning and Land Use..... 45
2.4.1.1 Zoning..... 45
2.4.1.2 Land Use..... 48
2.4.2 Population..... 49
2.4.3 Economics..... 53
2.4.4 Transportation..... 54
2.4.5 Energy..... 59
2.4.6 Noise..... 60

2.5 Environmentally Sensitive Areas..... 60
2.5.1 Floodplains..... 60
2.5.2 Rare and Endangered Species..... 62
2.5.3 Wetlands..... 64
2.5.4 Historic/Archaeological Resources..... 66
2.5.5 Sole Source Aquifer..... 68
2.5.6 Pinelands..... 68
2.5.7 Wild and Scenic Rivers..... 69
2.5.8 Environmentally Significant Agricultural Land..... 69

2.6 Institutional/Regulatory Review..... 70

3.0 Description of Alternatives..... 71

3.1 Introduction..... 71
3.2 Overview of Proposed Remedial Alternatives..... 71

4.0 Evaluation of Alternatives..... 83

4.1 Introduction..... 83
4.2 Environmental Impact Methodology..... 85
4.2.1 Physical Environment..... 85
4.2.1.1 Groundwater and Surface Water.... 85
4.2.2.2 Air Quality..... 86
4.2.2 Biological Environment..... 86
4.2.2.1 Flora and Fauna..... 86
4.2.3 Socioeconomic Environment..... 87
4.2.3.1 Land Use, Population and Economics. 87
4.2.3.2 Transportation..... 87
4.2.3.3 Energy..... 87

4.3 Environmental Impacts of Remedial Alternatives... 88
4.3.1 Alternative 1-No Action..... 88
4.3.2 Alternative 2-Deep Containment Wall with Plume Pumping, Treatment and Discharge.... 92
4.3.3 Alternative 2A-Deep Containment Wall..... 98
4.3.4 Alternative 3-Shallow Containment Wall With Plume Pumping, Treatment and Discharge..... 101
4.3.5 Alternative 3A-Shallow Containment With High-Rate Plume Pumping, Treatment and Discharge..... 104
4.3.6 Alternative 3B-Shallow Containment Wall... 108
4.3.7 Alternative 4-Interception With Treatment and Discharge (No Containment).. 111
4.3.8 Alternative 4A-Surface Sealing Without Interception..... 114

811

4.3.9 Alternative 5-Drum Excavation and Removal With Plume Pumping, Treatment and Discharge..... 117
4.4 Screening and Evaluation of Alternatives..... 120

4.5 Environmental Impacts of Remedial Alternatives Remaining After Initial Screening..... 121

5.0 Recommended Plan and Mitigative Measures..... 124
5.1 Introduction..... 124

References

Appendix A Geologic Formations and Their Water Bearing Properties Within the Study Area
Appendix B Water Quality Criteria for FW-2 Waters in New Jersey
Appendix C Air Quality Within the Vicinity of the Lone Pine Landfill Site
Appendix D Fauna and Flora of the Study Area
Appendix E A Review of Permits and Review Requirements

8/12

List of Figures

Section	Title	Page
Figure 1-1	Site Location Map.....	5
Figure 1-2	Study Area.....	6
Figure 2-1	Generalized Geologic Cross Section Monmouth County.....	10
Figure 2-2	Cross Section of the Stratigraphy In Vicinity of Lone Pine Landfill.....	12
Figure 2-3	Soil Types and Slopes.....	13
Figure 2-4	Generalized Geo-Hydrologic Cross Section In Vicinity of Lone Pine Landfill.....	18
Figure 2-5	Location of Monitoring Wells and Manasquan River Sampling Locations.....	20
Figure 2-6	Location of Existing and Proposed Drinking Water Wells.....	24
Figure 2-7	Location of Private Drinking Water Wells.....	26
Figure 2-8	The Manasquan River.....	29
Figure 2-9	Sewage Treatment Plants in the Vicinity of Lone Pine Landfill.....	33

Figure 2-10	Location of Weather Stations.....	39
Figure 2-11	Zoning Map of Lone Pine Landfill Study Area....	46
Figure 2-12	Transportation Map.....	58
Figure 2-13	Flood Boundary and Floodway Map.....	61
Figure 2-14	Wetland Map.....	65
Figure 2-15	Archaeological and Historical Sites Within the Study Area.....	67
Figure 3-1	Deep Containment Wall with Plume Pumping, Treatment and Discharge.....	73
Figure 3-2	Deep Containment Wall.....	75
Figure 3-3	Shallow Containment Wall with Plume Pumping, Treatment and Discharge.....	76
Figure 3-4	Shallow Containment Wall.....	78
Figure 3-5	Interception with Treatment and Discharge (No Containment).....	80
Figure 3-6	Surface Sealing without Interception (No Containment).....	81

814

List of Tables

Section	Title	Page
Table 2-1	Soil Characteristics in the Vicinity of Lone Pine Landfill.....	15
Table 2-2	Summary of Organic Priority Pollutants Found in EPA Groundwater Monitoring Wells and Manasquan River, February 1982.....	21
Table 2-3	Summary of Organic Priority Pollutants Found in Groundwater Monitoring Wells and Manasquan River, September 1982.....	22
Table 2-4	Freehold Township Water System--Existing Wells: 1982.....	27
Table 2-5	Analytical Results of Drinking Water.....	28
Table 2-6	Sampling Results of Manasquan River Water.....	31
Table 2-7	Chemical Analysis of On-site Sludge.....	36
Table 2-8	Stream Sample Analysis Downstream of Landfill.....	36
Table 2-9	Manasquan River Water Sampling Before and After a Storm Event.....	37

Table 2-10	Climatological Data from Weather Stations in the Vicinity of Lone Pine Landfill.....	40
Table 2-11	Air Quality Data from Various Monitoring Stations Nearest Lone Pine Landfill.....	43
Table 2-12	Land Use: 1962-1980, Freehold Township.....	50
Table 2-13	Nature of Population Growth: 1960-1980, Township of Freehold.....	52
Table 2-14	Employment by Industry Group: 1950-1970 (Monmouth County).....	55
Table 2-15	Resident Unemployment Rates: 1970-1981.....	56
Table 4-1	Environmental Matrix.....	84

8/16

SUMMARY

The Lone Pine Landfill, situated on Burke Road, off Elton-Adelphia Road in Freehold, Monmouth County, New Jersey, is an abandoned hazardous waste site covering an area of approximately 45 acres. Field investigations, monitoring data and technical investigations performed by the USEPA and NJDEP have documented a number of environmental problems associated with the Lone Pine Landfill site.

The major class of contaminant release occurring at the site consists of volatile organic pollutants, such as benzene, chlorobenzene, methyl chloride and vinyl chloride. A second class of compounds, base neutral extractables, in particular, isophorone and phthalates, are being released. Isophorone is commonly used as a solvent for lacquers and is an irritant to the eyes, skin and throat. Phthalates are a group of chemical compounds that are commonly used as a plasticizers in plastics and may cause damage to the liver and kidney. Heavy metals are also being released in elevated levels.

The major environmental concern currently associated with this site is contamination of the Manasquan River which lies approximately 500' north of the site. A potable water reservoir is proposed by the State for the Manasquan River approximately 16 miles downstream of the site.

An environmental analysis of the long-term remedial alternatives indicate that Alternatives 2, 2A, 3, 3A and 5 would have the most beneficial long-term environmental impacts and would probably facilitate better clean-up than all other alternatives considered. The No Action alternative utilizes no technologies and allows the site to remain in its present condition. Air and water monitoring would be

employed in the No Action alternative, as in all the other alternatives proposed. The long-term effectiveness of the shallow slurry wall, as proposed under Alternatives 3, 3A and 3B, assumes that the integrity of the shallow and deep slurry wall would be maintained until the source of contamination has dissipated. Potential environmental impacts of each alternative are also an important consideration when assessing the effectiveness of each alternative. The most beneficial long-term impacts from an environmental standpoint would result from those alternatives offering onsite containment, coupled with external plume pumping, treatment and discharge of treated wastewater.

818

GLOSSARY

Ambient - surrounding environment; usually pertains to air and water

Aquiclude - a porous formation that absorbs water slowly but does not transmit water fast enough to supply a well or spring.

Aquifer - permeable rock or soil unit capable of yielding significant amounts of groundwater.

Aquitard - a semi-permeable formation which severely retards the vertical movement of groundwater.

Attainment Pollutants - those pollutants whose background concentrations are within standards set for a given time period.

Base flow - the flow of water entering a stream channel from groundwater sources.

Benthic - of, or pertaining to, living at the bottom of a body of water.

Biochemical Oxygen Demand (BOD) - The quantity of oxygen used in the aerobic decomposition of organic matter, usually expressed in parts per million.

Calcareous - soil containing sufficient calcium carbonate, often with magnesium carbonate, to effervesce visibly when treated with cold, 0.1 normal hydrochloric acid.

Classified pollutants - Pollutants for which no standards exist but are monitored for determination of background levels.

Criteria pollutants - Pollutants for which ambient air quality standards have been established. These include Total Suspended Particulates (TSP's), Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Ozone (O_3) and Lead (Pb).

Cretaceous - the latest system of rocks or period of the Mesozoic Era (between 136 to 65 million years ago).

Dip - the downard slope of a stratum or vein relative to the horizontal.

Downdip - pertaining to a position which is parallel to, or in the direction of, a dip in the stratum.

Fauna - animal life.

819

Fecal Streptococci - is a bacteria that normally inhabits the intestines of man and animals and are used to indicate fecal pollution. (i.e., septic wastes)

Flora - plant life.

Fossiliferous - containing the organic remains or imprints of an organism preserved in the earth's crust during a previous geologic period.

Glauconitic - consisting of a clay mineral.

Hydraulic - effected or operated by the action of water or other material with similar viscosity.

Hydraulic Head - the elevation of the water surface.

Hydrogeologic - the interrelationship between surface and groundwater and its effects on erosion and regional geology.

Indurated - the hardening of a rock through application of heat and low pressure, or by a cementing material.

Leachate - liquid that is produced from landfills due to organic decomposition and percolation of rainwater.

Micaceous - consisting of a group of minerals with sheet-like structures.

Non-Attainment Pollutant - a pollutant whose background concentration is in violation of established standards for a given time period.

Outcrop - exposed stratum or body of natural mineral compound at the surface of the earth.

Peat - a dark brown or black material produced by the decomposition of organic matter.

Permeability - the property of a material that permits appreciable movement of water through it when it is saturated.

Physiographic province - a region having a pattern of relief features or landforms that are significantly different from adjacent regions.

Pleistocene - also referred to as the Ice Age. A period of geologic time of the Quaternary period following the Tertiary and before the Holocene.

Quaternary - the second period of the Cenozoic geologic area, following the Tertiary, and spans the last 2-3 million years.

Phytoplankton - passively floating plant life carried by the movement of tides, waves and or currents.

Primary standards - maximum concentration level set for a specific pollutant for a specified time frame. Set to protect the physical health and well-being of man.

Secondary Standards - concentration level set for a specific pollutant for a specified time frame (levels are less than that for primary standards). Set to protect the aesthetic qualities of the environment allowing no degradation of parklands, vegetation, monuments and the like.

Stratigraphic Unit - a stratum of rock or a body of strata that is classified as a unit based on characterstics and property.

Strike - the trace of a rock bed, fault, or vein on the horizontal.

Surficial - of, or occurring on or near the surface of the earth.

Tertiary - the older major period of the Cenozoic era which spans the end of the Cretaceous to the beginning of the Quaternary. (70,000,000 to 2,000,000 years ago).

Tubifex worms - sludge worms; normally found in highly enriched waters with low dissolved oxygen concentrations.

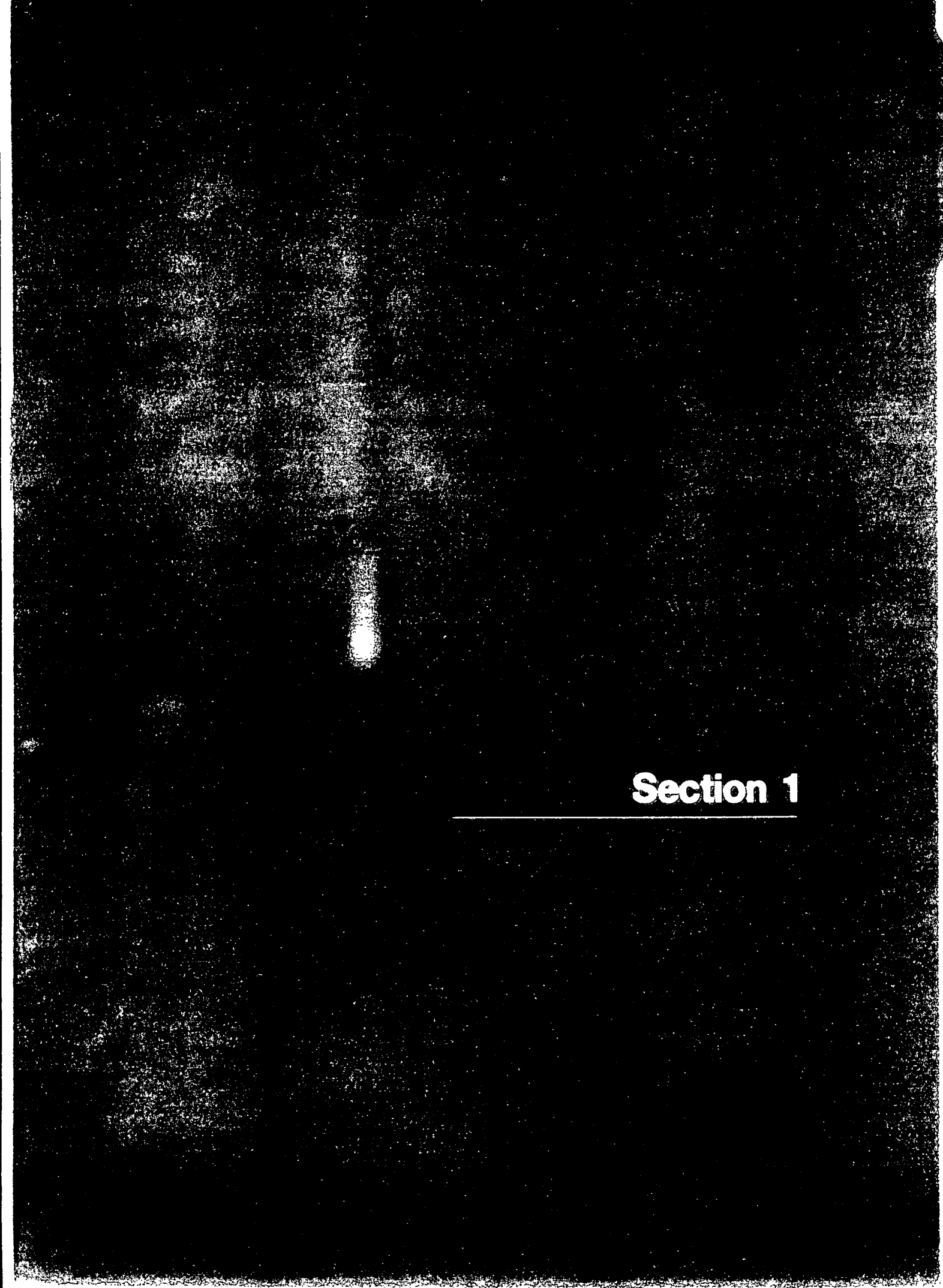
Unconformably - strata that differ in position, dip or strike from older underlying formations.

Unconsolidated - loosely arranged sediments whose particles are not cemented together.

Volatile organics - a group of chemical compounds with high vapor pressure at ordinary temperatures. These compounds are most often considered toxic or carcinogenic and can be readily inhaled or absorbed through the skin.

Volatilization - the conversion of a chemical substance to a gaseous or vapor state by exposure to ambient air or applying heat, and/or reducing pressure.

821



Section 1

1.0 PURPOSE AND NEED

1.1 INTRODUCTION

The National Environmental Policy Act (NEPA) of 1969 requires that all federal agencies incorporate into the decision-making process "appropriate and careful consideration of all environmental effects of proposed actions." This environmental information document (EID) provides a written analysis describing the environmental impacts of the remedial action alternatives developed as part of the feasibility study for the Lone Pine Landfill, located in the Township of Freehold, Monmouth County, New Jersey. The EID also provides a discussion of the impacts associated with the recommended plan and outlines mitigative measures to offset the plan's adverse environmental impacts.

The objective of the proposed remedial actions is to control the migration of contamination from the site within levels that protect (1) the public health and welfare, with particular emphasis on maintaining safe drinking water supplies, and (2) the natural environment affected by the site. Regarding public health and welfare, a principal concern is the existing local public and private drinking water supply. The nearest public water supply well is approximately 4 miles from the site; the nearest private well is less than 1,000 feet upgradient of the landfill. None of these wells, however, are presently threatened with contamination from the Lone Pine Landfill. A potable water reservoir is proposed by the State for the Manasquan River approximately 16 miles downstream of the site. The potential effect of the landfill on the proposed reservoir is also of concern. With regard to the natural environment, major concerns include the 2,000-acre Turkey Swamp Fish and Wildlife Management Area, a boundary

of which is less than 1,000 feet from the landfill, and effects on aquatic biota and exposure to toxic compounds (downstream portions of the Manasquan river are stocked with trout which are subsequently consumed by humans).

1.2 STATEMENT OF PROBLEM

The Lone Pine Landfill site began accepting municipal solid waste in 1959. Wastes were apparently deposited in the landfill after excavation as much as 10 feet down into the Vincentown formation. Quantities of septic tank liquid wastes and commercial liquid organic wastes were disposed of at the site in the 1970's. In 1978, a substantial number of 55-gallon drums of chemical wastes were buried at the site (up to 50,000 drums may have been buried; the U.S. Justice Department has indicted one company in connection with the illegal disposal of 17,000 drums). A limited drum excavation and sampling program has shown that a variety of toxic organic substances and heavy metals are contained in the drums. Other information indicates that approximately 2 million gallons of spent toluene solvent along with several hundred thousand gallons or more of other bulk chemical wastes were placed in the landfill in the 1970's. In addition, soil which may have been contaminated by methylene chloride wastes was excavated from an area across Burke Road and deposited in the landfill.

In June 1978, a chemical fire occurred at the landfill, during which exploding drums were observed. In response to the fire and follow-up investigation, the State of New Jersey issued an administrative order directed at mitigating potential environmental damage from the site. Failure by the owner to meet the requirements of the administrative order resulted in a State closure order in 1979. The site has been officially closed since December 1979.

Field investigations, monitoring data and technical investigations performed by the U.S. Environmental Protection Agency (USEPA) and New Jersey Department of Environmental Protection (NJDEP) have documented a number of environmental problems associated with the Lone Pine Landfill site. The major class of contaminated release occurring consists of volatile organic priority pollutants. A second class of compounds, base neutral extractables, in particular, isophorone and phthalates, is also being released. Heavy metals are also being released in elevated levels.

The effects of the contaminant releases are being manifested in the following ways:

(1) Volatile organics (benzene, toluene, vinyl chloride, in particular) and heavy metals are leaching through the soil and into the Vincentown and Red Bank aquifers. Wells located north and northeast of the site, but south of the Manasquan River, show high levels of volatile organic contaminants.

(2) A contaminated plume emanates from the landfill and moves in a north-northeasterly direction to the Manasquan River. Low levels of toxic organic compounds and heavy metals have been detected in the Manasquan River just downstream of the site. The contaminated plume apparently has not reached any existing drinking water supplies.

(3) Contaminated surface water runoff flows into an adjoining wetland area on the north and then into the Manasquan River. Toxic organic contaminants have been detected in Manasquan River sediments near the site.

(4) Considerable soil contamination has occurred at the site.

425

(5) Terrestrial and aquatic plant and animal life near the site have been adversely affected.

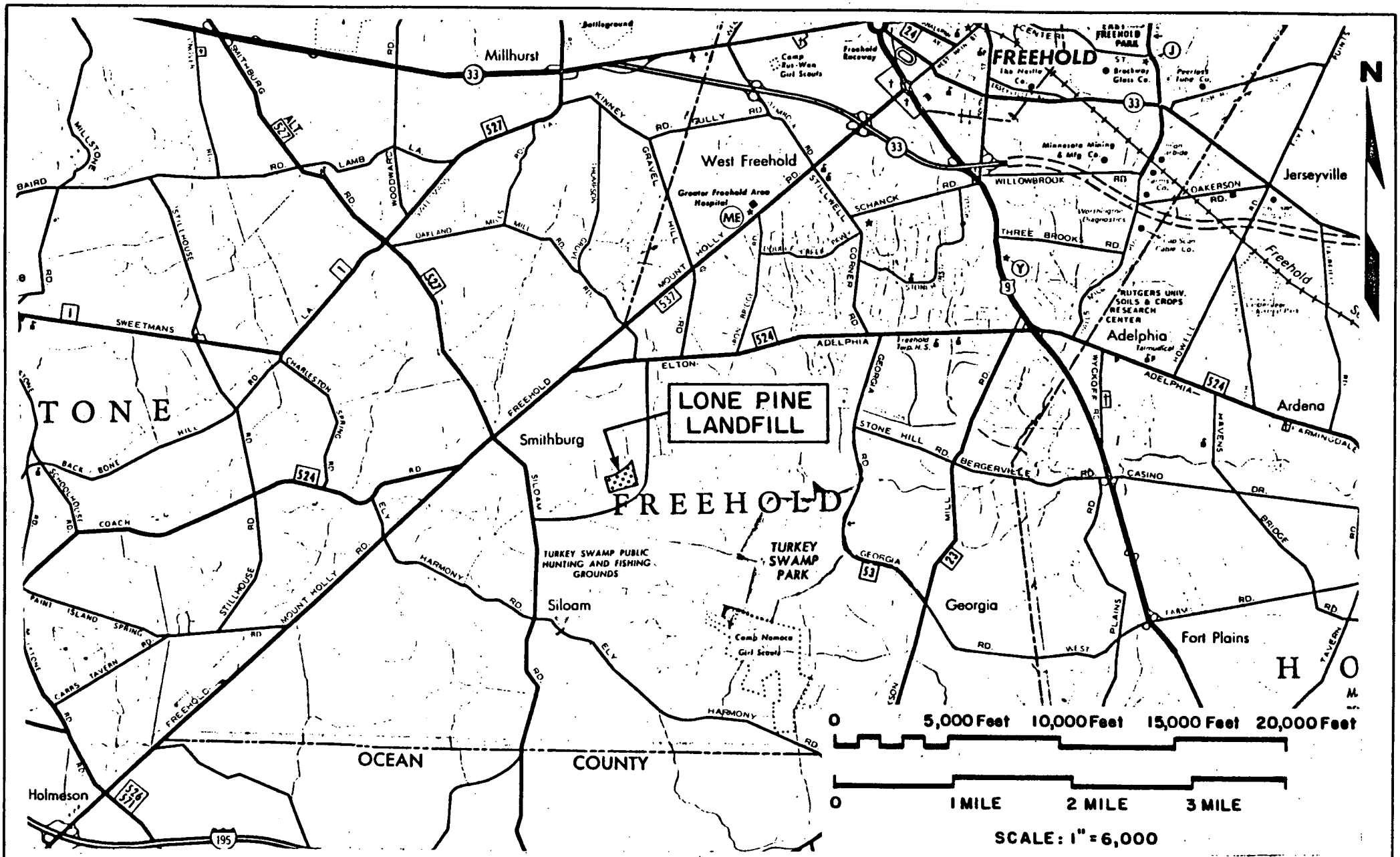
Under a zone contract for remedial response activities at uncontrolled hazardous waste disposal sites, the USEPA has directed Camp Dresser & McKee Inc. (CDM) to perform a feasbility study to develop and evaluate remedial action alternatives aimed at preventing or mitigating the migration of hazardous substances from the Lone Pine Landfill into the environment. This EID addresses the environmental issues associated with the remedial action alternatives developed.

1.3 STUDY AREA

The Lone Pine Landfill is located on Burke Road, off Elton-Adelphia Road, in Freehold Township, Monmouth County, New Jersey (figure 1-1). The landfill site covers an area of approximately 45 acres. The site is situated on a 144-acre parcel owned by Lone Pine Corporation.

The evaluation of impacts presented in this EID has been directed at those specific areas in which remedial actions would take place and those areas affected by such actions. The general area addressed in this EID, hereafter referred to as the study area, is depicted in figure 1-2. The entire study area covers approximately 3,419 acres (5.3 square miles) and is situated south of Elton-Adelphia Road and north of the Metedeconk River. The eastern and westernmost boundaries are formed by Georgia Road and Siloam Road, respectively. Approximately 25 percent of the study area, or 818 acres, comprises the New Jersey Fish and Wildlife Management Area. Turkey Swamp County Park occupies an additional 468 acres of the total study area.

426



CDM

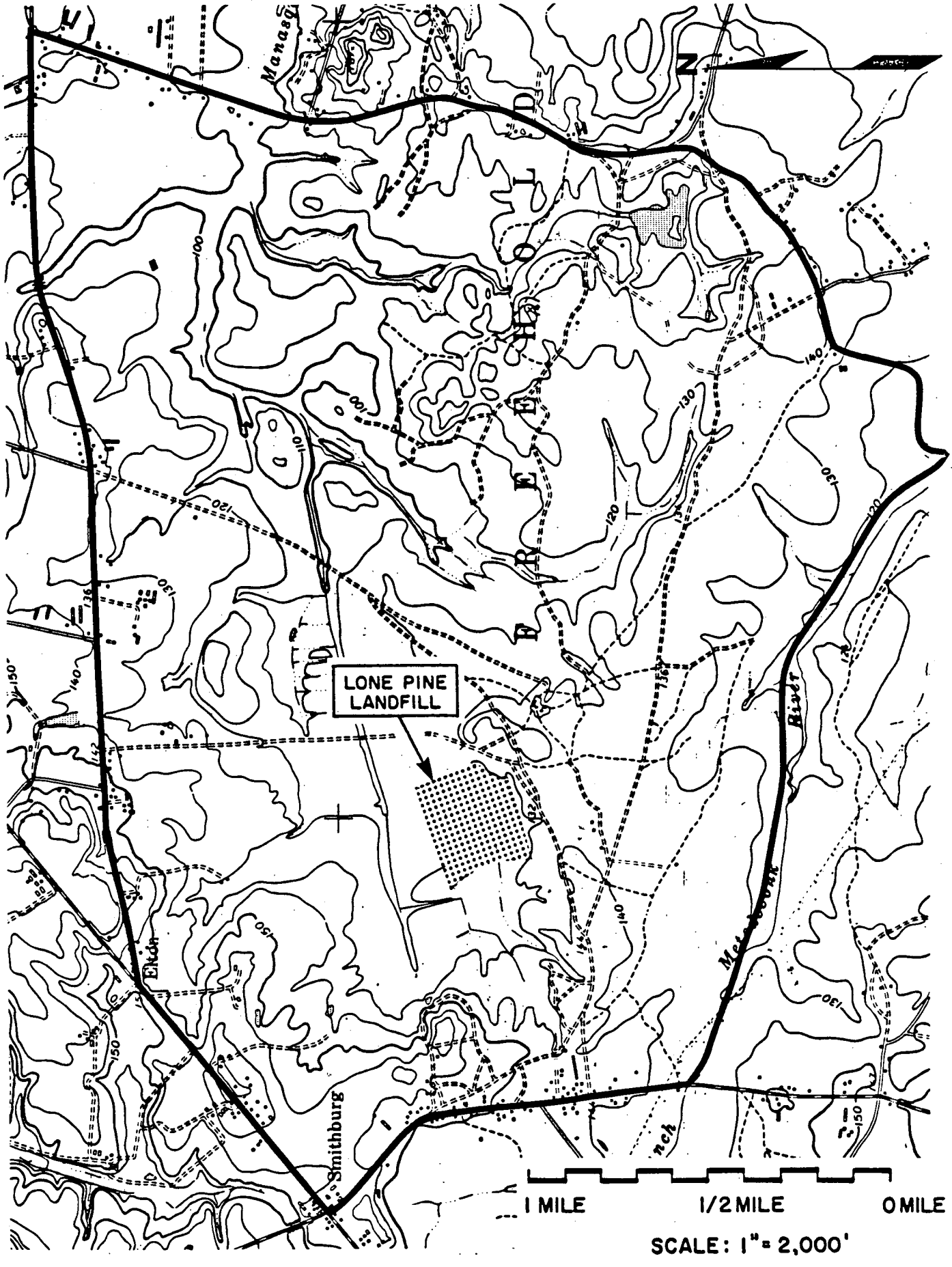
environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

SITE LOCATION MAP

FIGURE 1-1



CDM

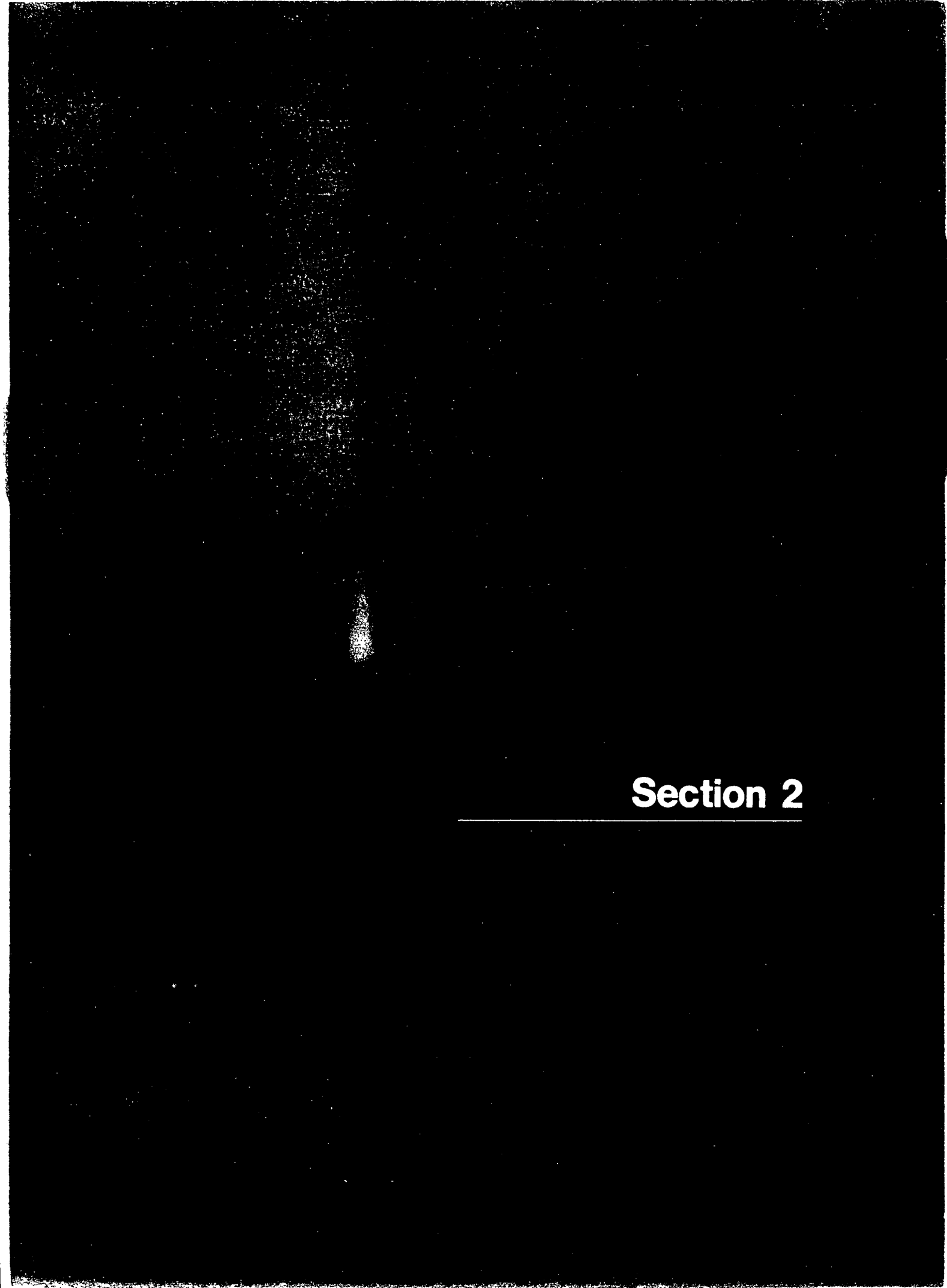
environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

STUDY AREA

FIGURE 1-2



Section 2

2.0 EXISTING CONDITIONS

2.1 INTRODUCTION

The information presented in the following section has two major purposes: to assess the existing environmental quality in the vicinity of the Lone Pine Landfill and to identify environmentally significant factors or areas that may be affected by implementation of a given mitigative alternative. Only those environmental factors that are pertinent to the project are considered. The environmental factors used in describing the existing conditions within the study area include the following:

PHYSICAL ENVIRONMENT

- Geology and soils
- Groundwater
- Surface water
- Climate and air quality

BIOLOGICAL ENVIRONMENT

- Flora and fauna

830

SOCIO-ECONOMIC ENVIRONMENT

Land use/zoning
Population
Economics
Transportation
Energy

ENVIRONMENTALLY SENSITIVE AREAS

Floodplains
Rare and endangered species
Wetlands
Historic/archeological resources
Sole source aquifer
Pinelands
Wild and scenic rivers
Environmentally significant agricultural lands

INSTITUTIONAL/REGULATORY REVIEW

Federal-level requirements
State-level requirements
Local requirements

2.2 PHYSICAL ENVIRONMENT

2.2.1 Geology and Soils

2.2.1.1 Geology. Lone Pine Landfill is situated in the Coastal Plain physiographic province. The site is underlain by unconsolidated gravel, sand and clay of Quaternary, Tertiary and Cretaceous

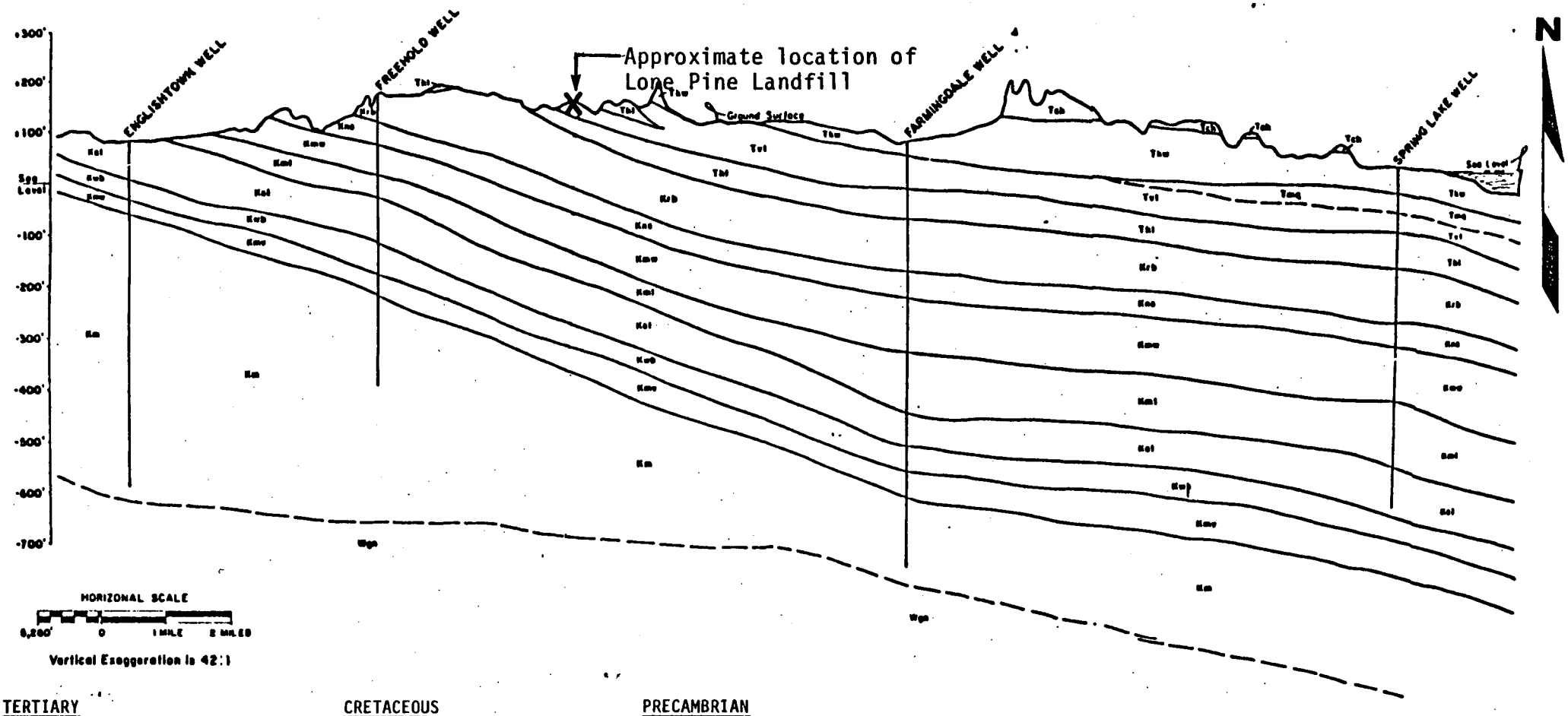
age. These formations dip slightly to the southeast, with older formations exposed in the northwest and progressively younger formations outcropping in the southeast (Fred C. Hart, 1982). Figure 2-1 presents a generalized geologic cross section in the vicinity of Lone Pine Landfill.

Lone Pine Landfill is located at the edge of the outcrop of the Vincentown Sand. The Red Bank Sand is exposed in outcrops north of the Manasquan River. Parallel to the river, the Hornerstown Marl outcrops in a thin band.

Test pits in and around the landfill indicate that in the easternmost portion of the site, the Vincentown Sand is situated near the surface and thickens in a wedge towards the southeast. In the southwestern portion of the site, a recent deposition of black organic topsoil is found at the surface. The Vincentown lies directly beneath the topsoil, underlain by the Hornerstown Marl.

The Vincentown Sand, the youngest Pleistocene formation in the vicinity of the landfill, consists of two members: the upper member ranges from a fine-to-medium-grained quartz sand to a sandy, clayey, limestone character (Owens and Minard, 1960). The sand of this member is micaceous, clayey, glauconitic, calcareous and fossiliferous. The lower member is a greenish-gray micaceous, clayey, glauconitic fine-to-medium-grained sand (Jablonski, 1968).

The Vincentown Sand is conformably underlain by the Hornerstown formation, a deep green, silty, glauconitic, fine sand with varying amounts of clay. In Monmouth County, this formation is generally considered to function as an aquiclude or confining bed in restricting the vertical movement of groundwater. In the vicinity of the site, however, where the formation ranges in thickness from 10 to 12 feet, it is believed to function as more of an aquitard or semi-confining bed between the Vincentown and Red Bank formations (Fred C. Hart, 1982).



TERTIARY

Tch-Cohansey Formation (Fm)
Tkw-Kirkwood Fm
Tmq-Manasquan- Shark River Marl
Tvt-Vincentown Sand
Tht-Hornerstown Marl

CRETACEOUS

Krb-Red Bank, Tinton Sands
Kns-Navesink Marl
Kmw-Wenonah, Mt Laurel Sands
Kmt-Marshalltown Fm
Ket-Englishtown Sand
Kwb-Woodbury Clay
Kmv-Merchantville Clay
Km-Magothy Fm, Inc. some Raritan Fm at the base.

PRECAMBRIAN

Wgn-Wissahickon Gneiss (metamorphic)

Source: NJDEP Well Records
Prepared by the Monmouth County Planning Bd., Dec. 1980

33

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

GENERALIZED GEOLOGIC
CROSS SECTION MONMOUTH COUNTY

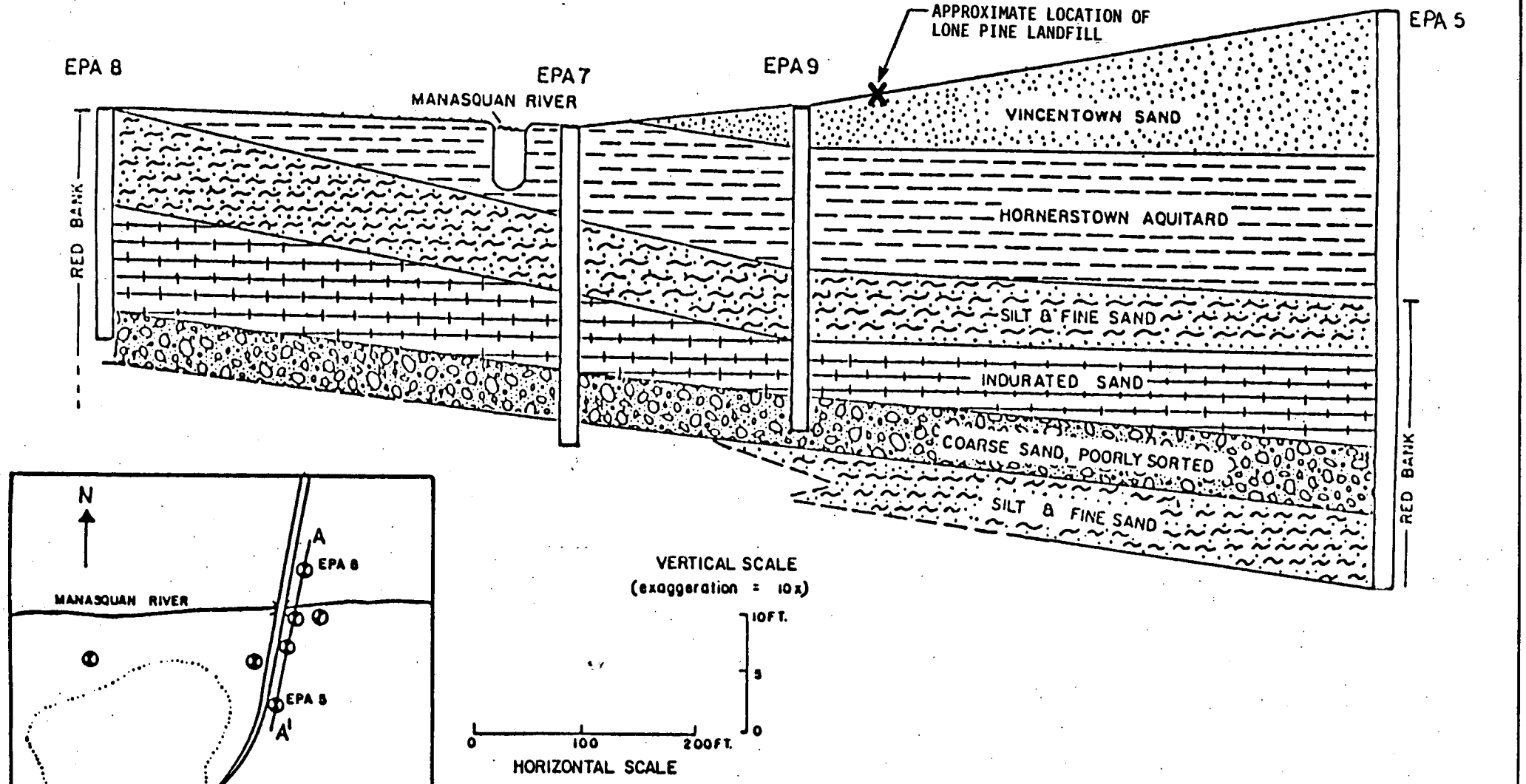
FIGURE 2-1

The Cretaceous Red Bank Sand underlies the Hornerstown formation. This formation consists of an olive green sand and dark gray micaceous silt. Test borings indicate the presence of several distinct stratigraphic units within the Red Bank Sand. The upper portion of the formation is partially indurated, glauconitic, silty, fine sand. This is underlain by the Tinton Sand which ranges from 5 to 8-feet thick and is heavily indurated with siderite, a finely crystalline ferric carbonate ($FeCO_3$). The Tinton Sand exhibits moderate permeability depending on the degree of cementation (Fred C. Hart, 1982).

A cross section of the stratigraphy from well logs in the vicinity of the landfill is presented in figure 2-2. As can be seen, several distinct stratigraphic beds have been identified. From top to bottom, these include a silt and fine sand zone; a coarse sand, poorly sorted zone; a zone of indurated Tinton Sand; and another band of silt and fine sand. A glauconitic clay member of the Navesink formation underlies the Red Bank Sand. (Fred C. Hart, 1982).

2.2.1.2 Soils. Soils conditions at Lone Pine Landfill site are an important consideration since they directly affect the vertical movement of leachate into the underlying aquifer. In addition, the ability to attenuate various contaminants is also dependent, in part, on soil characteristics.

The U.S. Department of Agriculture (USDA), Soil Conservation Service, has identified three major soil series in the immediate vicinity of the landfill; these are the Atsion, Lakehurst and Lakewood series. The soils generally consist of gravelly sands, silty-gravelly sands and clayey-gravelly sands, with high permeability rates, generally increasing with depth (figure 2-3).



SOURCE: FRED C. HART ASSOCIATES, INC., 1982

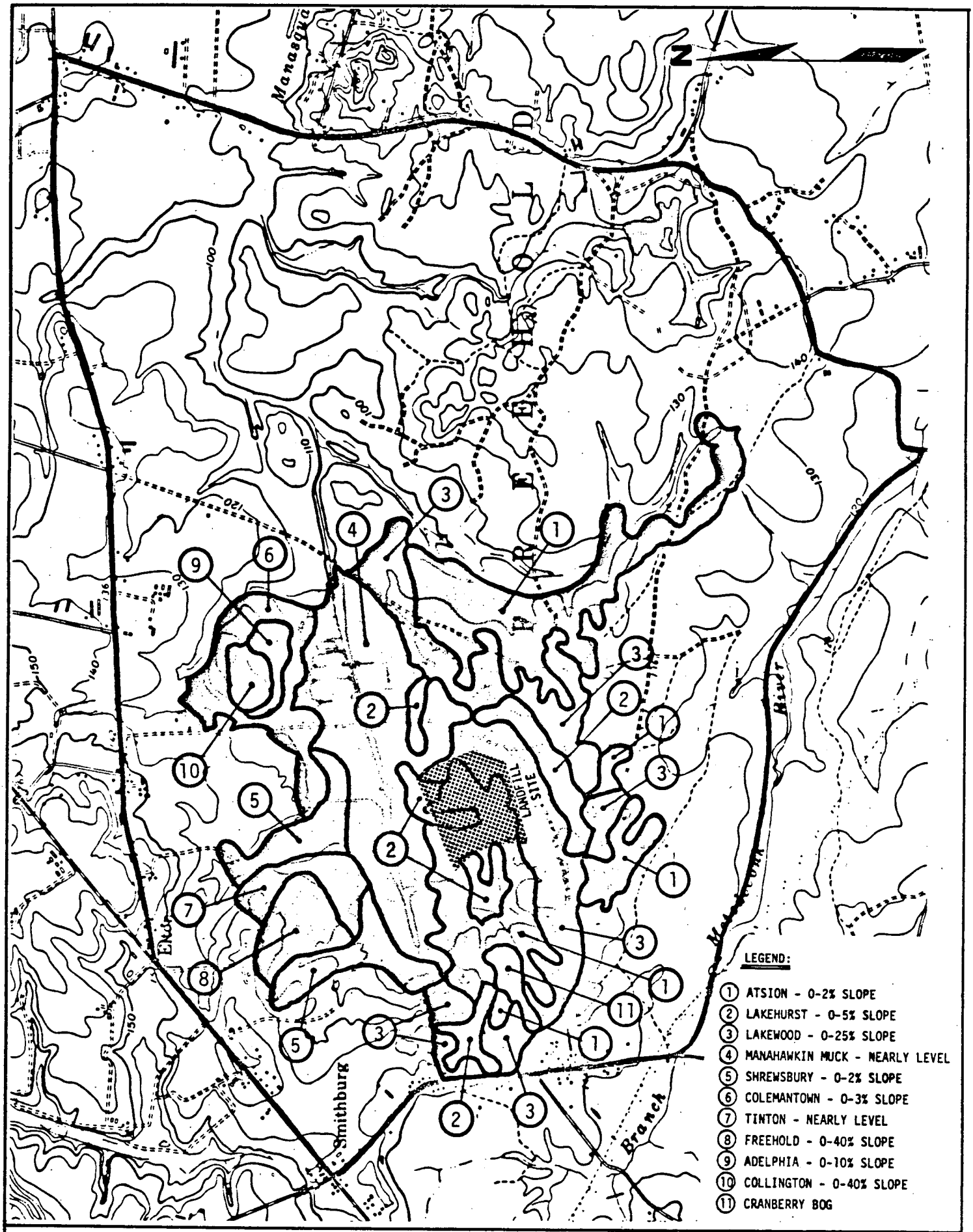
CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

CROSS SECTION OF THE STRATIGRAPHY IN VICINITY OF LONE PINE LANDFILL

FIGURE 2-2



SCALE: 1"=2000'

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

SOIL TYPES AND SLOPES

FIGURE 2-3

Drainage properties vary considerably between the different types of soils. The Lakewood series are deep, excessively drained soils on uplands and are typically found in woodland areas. The Lakehurst series consist of deep, moderately well or somewhat poorly drained soils and, like the Lakewood series, are commonly found in woodland areas. Deep, poorly drained soils on uplands characterize the Atsion series. Both the Atsion and the Lakehurst series have elevated seasonal high water tables ranging from 0 to 1.0 feet in November through June and 1.5 to 3.5 feet in January through April. The seasonal high water table for the Lakewood series exceeds 6 feet in depth. Soil reaction is strongly acidic throughout all three soil types. Erosion potential is generally low, except for the Atsion series, which has low erosion potential at the surface and subsurface and increases with depth (table 2-1).

The types of soils found on site are representative of those soils found immediately to the south, east and west of the landfill. These soils consist primarily of sand-gravel and some clay with low-to-moderate erodibility, and permeability increasing with depth.

Immediately north of the site, a deep, mucky material is found. This material comprises the Manahawken series and prevails on both sides of the Manasquan River. The soil consists of a sandy or clayey peat and gravelly-silty sands. The water table is at the surface in the winter and does not drop much in summer, except in extremely dry periods. Slopes are nearly level. The material is extremely acidic with a high organic content.

The original soil types found on-site have been disturbed by past excavation and filling operations. A typical vertical profile of the site has the following characteristics: the upper layer of material from ground level to 2 feet below grade primarily consists of black organic silt and little medium to fine sand. Mottled brown, yellow,

TABLE 2-1

SOIL CHARACTERISTICS IN THE VICINITY OF LONE PINE LANDFILL

SOIL SERIES & SYMBOL	DEPTH TO SEASONAL HIGH WATER TABLE (ft.)	TYPICAL VERTICAL PROFILE (inches)	TEXTURE OF SUBSOIL	PERMEABILITY (in/hr)	NATURAL DRAINAGE CLASS	REACTION (pH)	ERODIBILITY	SUITABILITY FOR LANDFILL AND KIND OF LIMITATION
Atsion (At)	1-1.0 (apparent Nov.-June)	0-40	Sand or Loamy sand subsoil	6.0-20	Poorly drained	3.6-5.0	Low-moderate	Severe seasonal high water table at depth of 0-12 inches.
Lakehurst (La)	1.5-3.5 (apparent Jan.-April)	0-60	Sand or Loamy sand subsoil	6.0-20	Moderately well drained	3.6-5.0	Low	Severe: seasonal high water table at depths of 1.5-3.5 hazard of ground-water pollution because of rapid permeability.
Lakewood (Le)	6.0	0-60	Sand or Loamy sand subsoil	6.0-20	Excessively drained	3.6-5.0	Very low-low	Severe: Low amount of filter material; hazard of ground water pollution because of rapid permeability.
Shrewsbury (Sn)	0-1.0 (apparent Oct.-June)	0-60	Sandy clay loam subsoil, sandy surface layer lacking or > 20 inches	0.6-20	Poorly drained	3.6-5.0	Mod-low	Severe
Colemantown (Cm)	0-1.0 (perched Oct.-June)	0-60	Clayey subsoil, high glauconite	0.2-0.6	Poorly drained	3.6-5.5	-	Severe
Tinton (To)	5.0+	0-60	Sandy clay loam, low glauconite,	2.0-6.0	Well drained	3.6-5.0	Subject to wind erosion if left bare	Low amounts of filter material rapid permeability in substratum permits groundwater pollution.
Freehold (Fr)	76.0	0-60	Sandy clay loam, subsoil, low glauconite	0.2-6.0	Well drained	3.6-5.0	Mod-High	Severe: slope
Adelphia (Ae)	15-4.0 (apparent Jan.-April,	0-60	Sandy clay loam subsoil, moderate glauconite	0.2-6.0	Moderately well drained	3.6-5.0	Mod-High	Severe: wetness
Collington (Cn)	6.0	0-60	Sandy clay loam subsoil, moderate glauconite	0.6-6.0	Well drained	3.6-5.5	Mod-Low	Severe: slope
Manahawk in Muck (Ma) at surface		0-60	Organic material-much sand, gravelly sand	>6.0	Very poorly	3.6-5.0	-	Severe: High water table, low bearing capacity; hazard of flooding.

Source: USDA Soil Conservation Service, 1982.

green, medium-to-fine sand and some silty clay may be encountered at depths ranging from 1 foot to 10 feet below grade. This material may be replaced or underlain by green medium to fine sand and some silty clay throughout these depths. Green silty clay and traces of medium-to-fine sands are typically found at depths exceeding 6 feet (Technical Testing Inc., 1970).

2.2.1.3 Topography. Topography of the landfill site and vicinity is important in evaluating the environmental impacts of erosion and run-off resulting from construction at the site. Steep slopes, generally defined as slopes in excess of fifteen percent, are environmentally sensitive areas in that they may induce severe erosional effects such as soil loss and sedimentation into surface waters.

The study area is characterized by broad lowlands and gently rolling hills formed on unconsolidated and semi-consolidated marine and terrestrial deposits. These sediments consist of sands, silts, clays and small quantities of gravel.

Topographic relief within the area ranges from approximately 250 feet in the southwestern portion of the Township to elevations of less than 100 feet in the eastern portions. Local topographic highs are associated with remnants of Quaternary deposits. Turkey Swamp Park, located in the southeastern portion of the study area, is characterized by extensive freshwater marshes (Dames and Moore, 1974).

The landfill consists of a large, flat-topped mound, averaging 40 to 50 feet above grade. The mound occupies approximately 40 acres. The northern toe of the landfill slope is situated about 500 feet south of the Manasquan River.

Immediately surrounding the landfill, the terrain south of the Manasquan River is predominately gently rolling, with small hills providing minor topographic relief.

639

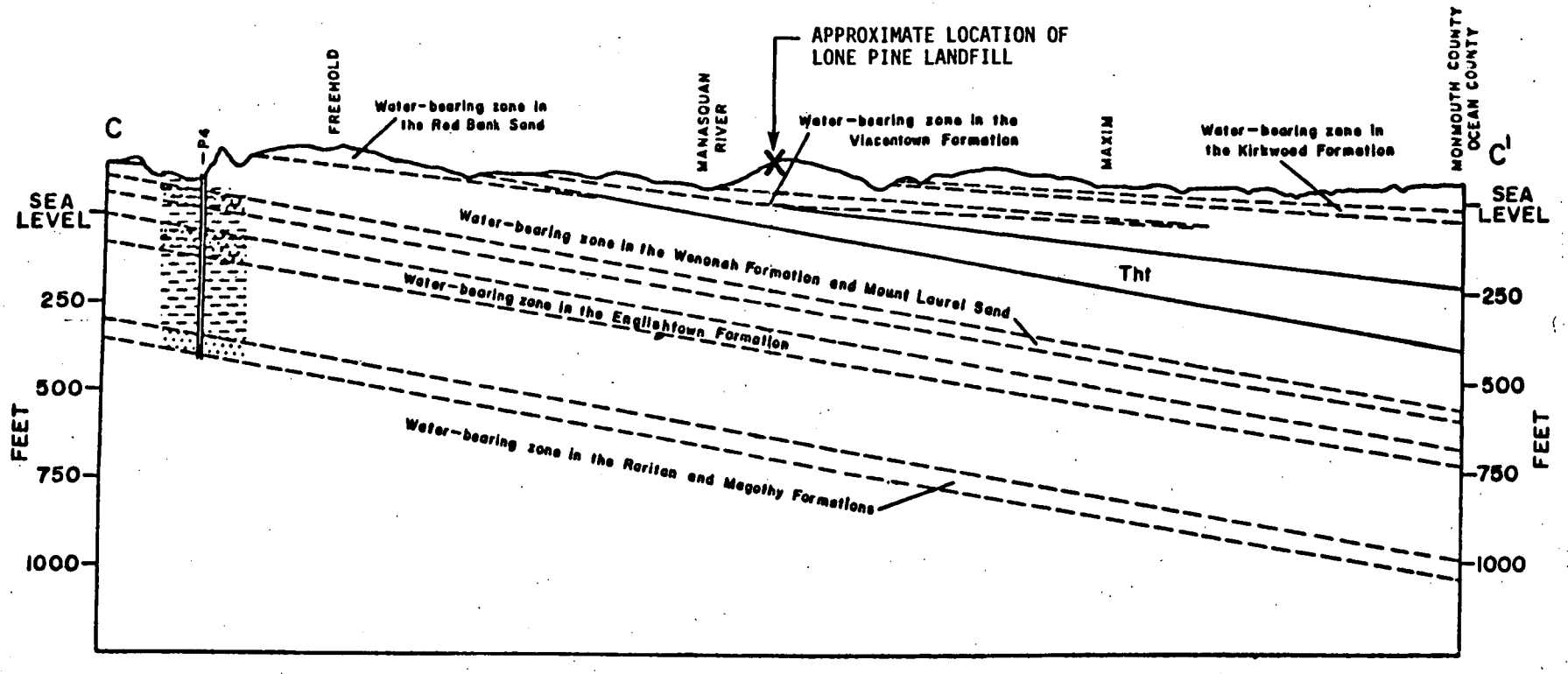
2.2.1.4 Drainage. Drainage characteristics of the site are important because they affect both the potential for rainwater runoff, surface water ponding and erosion. A landfill site providing adequate drainage facilitates surface water flow and discourages the downward percolation of surface water. Overland flow to surface waters is of concern since it may serve as a vehicle in transporting contaminated sediments.

The landfill site is situated within the headwaters subbasin of the larger regional Manasquan River watershed. The subbasin covers an area of approximately 2.4 square miles. Surface waters within this subbasin empty into tributaries which flow into the Manasquan River. Surface waters outside of the subbasin enter the Manasquan through tributaries downstream of the site, except for those waters to the southwest and south sides of the subbasin, which border the Metedeconk River basin (Fred C. Hart, 1982).

2.2.2 Groundwater

No existing drinking water supplies are presently threatened with contamination from the Lone Pine Landfill site. Groundwater in the immediate vicinity of the landfill provides a major source of water for the Manasquan River. This is a major environmental concern since a potable water reservoir is proposed approximately 16 miles downstream of the site.

There are several hydrogeologic deposits with water-bearing properties that underlie the study area. These formations can be described from the botton to the top (northwest to southeast) as follows: The Raritan formation, which is commonly associated with the overlying Magothy formation, Englishtown formation, Mount Laurel Sand and Wenonah formation, Navesink, Red Bank, Hornerstown and Vincentown formation. A generalized hydrogeologic cross section in the vicinity of the landfill is presented in figure 2-4. Appendix A provides a detailed description of the geologic formations and their water bearing properties within the study area.



FROM FREEHOLD TO OCEAN COUNTY LINE

LEGEND:

CLAY

THT-HORNERSTOWN SAND

SCALE: 1"=2 MILES

VERTICAL SCALE IS 21 TIMES THE HORIZONTAL

ENVIRONMENTAL INFORMATION DOCUMENT

SY

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

GENERALIZED GEO-HYDROLOGIC CROSS-SECTION IN VICINITY OF LONE PINE LANDFILL

FIGURE 2-4

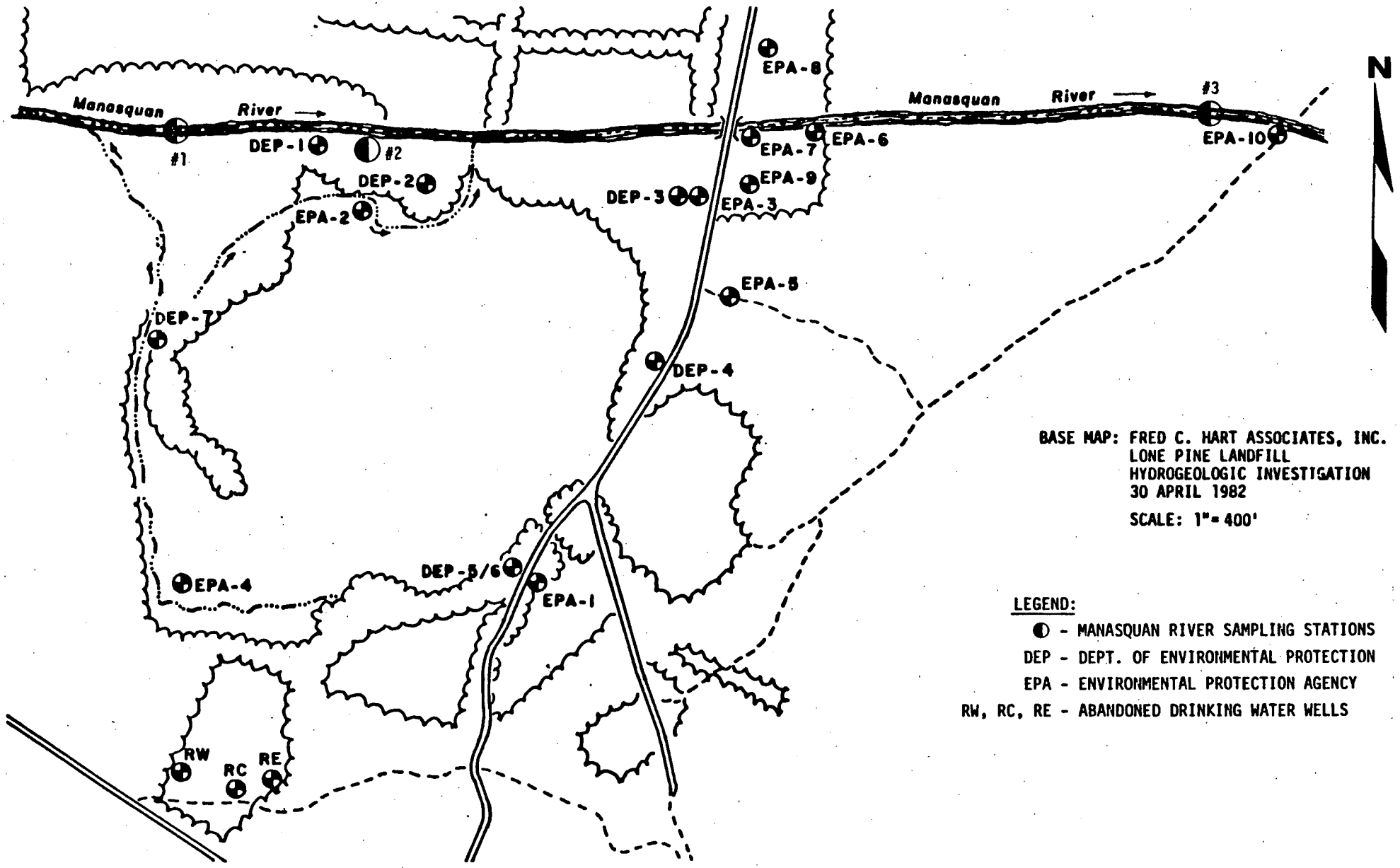
In February 1982 the EPA Field Investigation Team (FIT) performed a hydrogeologic study of the Lone Pine Landfill to determine the level of groundwater contamination and direction of groundwater flow. A total of twenty wells were installed, ten deep and ten shallow. Figure 2-5 indicates the approximate location of each well. Wells designated "A" are deep and extend into the Red Bank aquifer. All remaining wells are shallow and penetrate the surficial Vincentown aquifer. A summary of organic priority pollutants detected in the EPA wells are presented in Table 2-2.

The results of this survey indicated that groundwater is severely contaminated with organic compounds in shallow wells EPA 2, 3, 6, 7, and 9 and deep wells EPA 3A, 5A and 9A.

In September 1982, additional groundwater monitoring was conducted of both the DEP and EPA wells. The results of this investigation indicated the presence of several organic priority pollutants, as indicated in Table 2-3.

Water surface elevations in the wells indicated that groundwater in the surficial aquifer or Vincentown aquifer generally moves north, turning eastward to parallel the direction of flow in the Manasquan River. Groundwater in the Red Bank aquifer moves north and east across the landfill in a roughly defined trough (Fred C. Hart, 1982). Contaminants enter the deep semiconfined Red Bank aquifer from the recharge area beneath the landfill and migrate toward the Manasquan River. Leakage from the Red Bank aquifer to the upper aquifer may occur in the discharge area located northeast of the site.

Since volatile organics, as well as other constituents, were found in high concentrations in the lower layers beneath the landfill, it is apparent that there is a downward vertical movement of pollutants from the Vincentown to the Red Bank formation. This further indi-



CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

LOCATION OF MONITORING WELLS + MANASQUAN RIVER SAMPLING LOCATIONS

FIGURE 2-5

fig 2

TABLE 2-2

SUMMARY OF ORGANIC PRIORITY POLLUTANTS FOUND IN EPA GROUNDWATER MONITORING WELLS AND MANASQUAN RIVER

February 1982

Parameter	Sample Location																						
	Well 1	Well 1A	Well 2	Well 2A	Well 3	Well 3A	Well 4	Well 4A	Well 5	Well 5A	Well 6	Well 6A	Well 7	Well 7A	Well 8	Well 8A	Well 9	Well 9A	Well 10	Well 10A	River Upstream	River Midstream	River Downstream
BASE NEUTRAL EXTRACTABLES																							
Bis (2-ethylhexyl) phthalate						*			523							*					*		
Di-n-octyl phtalate									57														
Diethylphthalate						*			*														
ACID COMPOUNDS																							
Pentachlorophenol						12																	
Phenol			42		37	625					321		35				22a	54					
VOLATILES																							
Benzene			560		134	1939				54	1557		512				381	628				25	14
Chlorobenzene			*a			97				*	67		20				21	41				*	
1,2-Dichloroethane			*a		242	1655					26						*	746				*a	
1,1-Dichloroethane			*a		35	208				*	110		48				38	90					
1,1-Dichlorethylene						61																	
1,2-trans-Dichloroethylene			389		12	2128				15	530		39				*	1532				*	
Ethylbenzene			12			3325				52	3635	*	1112		*		960	1456				12	*
Methylene Chloride (Dichloromethane)	*	*		*	*	527	*	161		*		*	23					17		*		22	
Methyl Chloride (Chloromethane)	NO	NO																					
Trichlorofluoromethane																						15	
Tetrachloroethylene			*			76					*							12					
Toluene			21			4708				73	2543		724				1280	856				26	18
Trichloroethylene			*			1423					*							40					
Vinyl Chloride			53			334				123	814												

Source: (Fred C. Hart, 1982)

Note: * - Trace amounts

TABLE 2-3

SUMMARY OF ORGANIC PRIORITY POLLUTANTS FOUND IN GROUNDWATER MONITORING WELLS AND MANASQUAN RIVER
September 1982

Parameter	Sample Location																		
	DEP 2	DEP 4	EPA 1	EPA 1A	EPA 2	EPA 3	EPA 3A	EPA 5	EPA 5A	EPA 6	EPA 6A	EPA 7	EPA 8	EPA 8A	EPA 9	EPA 9A	EPA 10A	River Midstream	River Upstream
BASE NEUTRAL EXTRACTABLES																			
Di-n-butyl Phthalate										40			LT				27		
1, 2-Dichlorobenzene	33																		
Naphthalene																		170	
Diethylphalate																		24	
ACID COMPOUNDS																			
Pentachlorophenol		22	LT	70					LT						130				
Phenol		LT				LT	260			310					27				
2, 4-Dimethyl phenol									25										
2, 4, 6-Trichlorophenol		LT																	
VOLATILES																			
Chloroform		15																	
Benzene	5700	10				110	1100		13	1300Q		130			350Q	1600D		2200D	
Chlorobenzene	120						55			65		6.1			16	500D		100	
1, 2-Dichloroethane		180				220	530Q		26						21	1900D		120	
1, 1-Dichloro ethane		5.2					110			100		11				170D		220	
1, 1-Dichloroethene		5.9					21									31		23	
1, 2 trans-Dichloroethene	LT	35					980			1100								1700D	29
Ethylbenzene	150				LT	18	2300Q		15	3600Q		290			720	4200D		5000D	280
Methyl Chloride	LT	22				330	1200Q	190	53	100	15	8.9	190	9.4		3000D			35
1, 1, 2, 2-Tetrachloroethane		6.1																	
1, 2-Dichloropropane																5.5		LT	
Chloromethane																			13
Tetrachloroethene							24									59		32	
Chloroethane	11																		
1, 1, 1-Trichbroethane		6.8																	
Trichloroethene		200					370		8.7	8.9						800D		28	
Toluene	1210Q	9.1			LT	LT	3300Q		20	2100Q		120	LT		880Q	2800Q		4800D	370Q
Vinyl Chloride	LT				15		95		LT	120					13	60		440	36
Methylene Chloride	LT	22																	35

Q- Quantitated from secondary ion

Source: Fred C. Hart Assoc., 1983

LT- Less than the specified detection limit but greater than one half of the detection limit.

D- Sample analysis using a dilution.

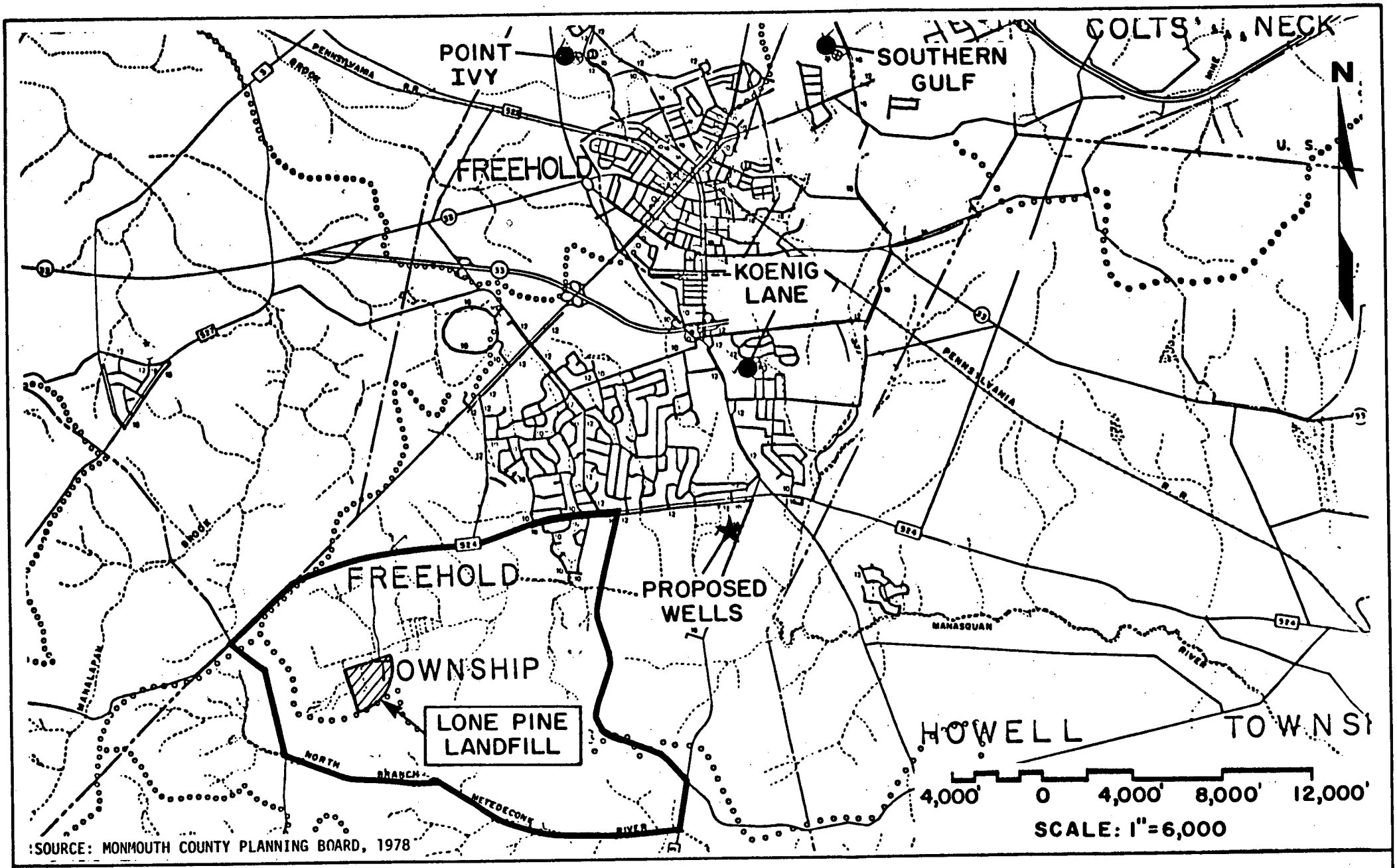
cates that the Hornerstown formation does not function as a confining layer. Since upward vertical gradients between the landfill and the river were found, it seems probable that contaminants in lower layers may migrate upward and eventually discharge into the river.

The distribution of volatile organics in a potential discharge area increases the likelihood that contaminants may be entering the Manasquan River from the Red Bank and surficial aquifers. Such components were found midstream and downstream of the Manasquan River sampling station (Fred C. Hart, 1982).

2.2.2.1 Drinking Water Supply. Major developments throughout the central and northern portions of Freehold Township are served by a municipal water system, which is owned and operated by the Township. Most of the developed system is north of Elton-Adelphia Road. Approximately 85 percent of the township residents are served by the township system.

In 1967 the municipal system was established by the aquisition of the Freehold Water Company, which served the central and north-central portions of the township. Five years later the township acquired the Southern Gulf Water Company, which extended the service to the northeastern portion of the township. Since this time, the township has expanded its distribution system to provide service to major residential, industrial and commercial establishments.

The present water system consists of six wells located at three sites (see figure 2-6): Koenig Lane in the Wynefield area, east of Route 9 in the east-central part of the township; Point Ivy in the northwestern portion of the township; and the Southern Gulf well site located on East Freehold Road, north of Dutch Lane Road in the north central portion of the township (Townplan Associates, 1982).



:SOURCE: MONMOUTH COUNTY PLANNING BOARD, 1978

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

LOCATION OF EXISTING & PROPOSED DRINKING WATER WELLS

FIGURE 2-6

Two additional wells are under design and are expected to be constructed in early 1985 adjacent to the Public Works Yard on Jackson Mill Road.

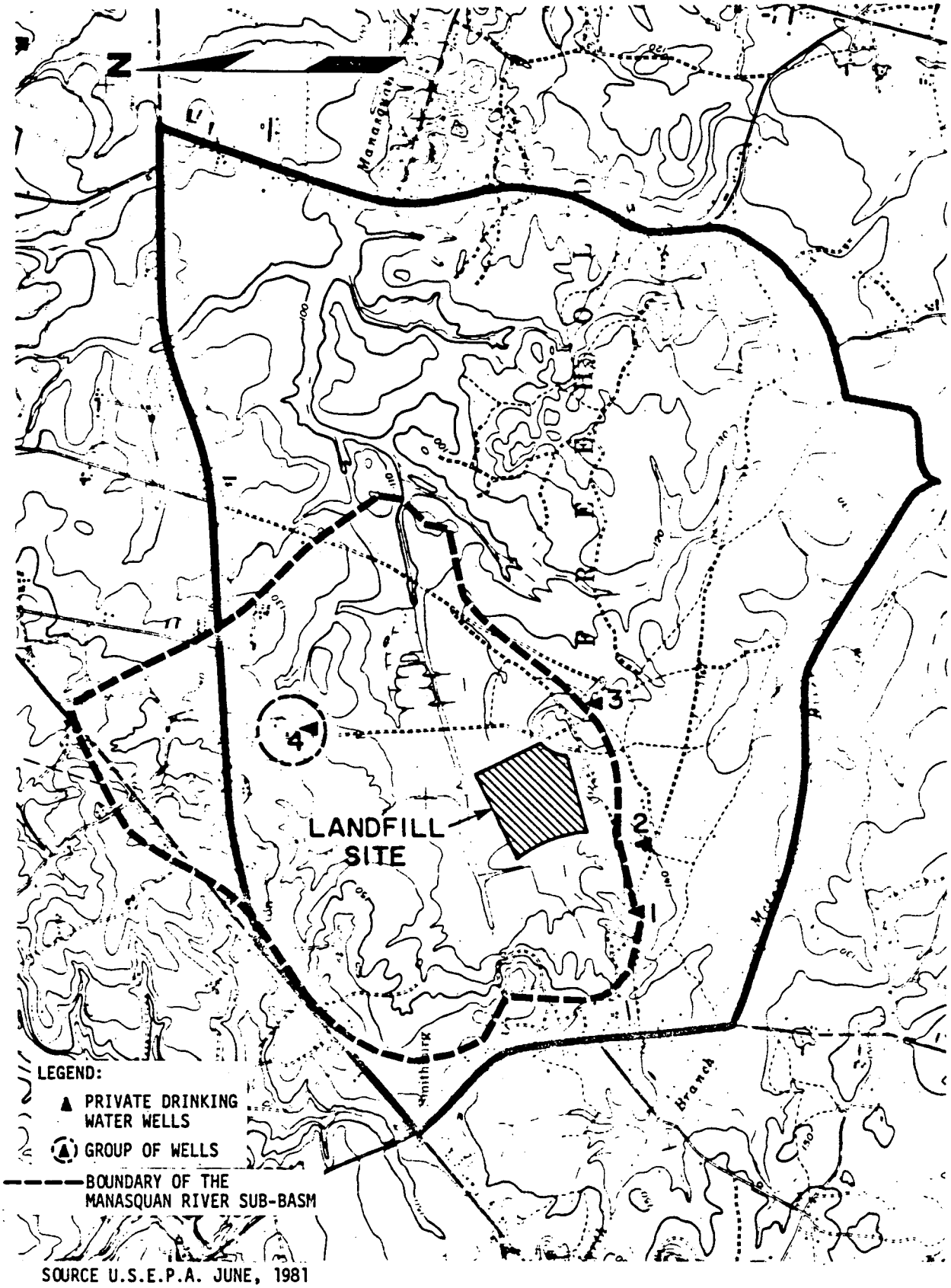
Characteristics of the six wells are presented in table 2-4. Water in Freehold Township is treated for iron removal, pH adjustment, fluoridation and chlorination (Townplan Associates, 1982).

There are several privately owned, operating drinking water wells within the study area. Three of these wells (no. 1, 2 and 3) are located south of the site (figure 2-7). The closest well, No. 3, is less than 1/4 mile from the southernmost boundary of the landfill. Wells No. 1 and 2 are constructed 15-feet to 25-feet deep and penetrate the Vincentown Aquifer. Well No. 3 located east of the site, is approximately 200-feet deep into the Englishtown aquifer.

North of the site, across the Manasquan River, along Burke Road are a cluster of approximately five wells. Well no. 4, located within this cluster, is approximately 1/2 mile from the northernmost boundary of the landfill. This well and the next three wells are approximately 200-feet deep extending into the Englishtown aquifer. The remaining well, closest to Elton-Adelphia Road, is a shallow well which extends approximately 25-feet deep to the top of the Vincentown aquifer.

In May 1981 water samples were taken in wells No. 1, 2, 3 and 4. The results indicated that there were no violation of drinking water standards in the wells sampled. The results of these tests are presented in table 2-5 (USEPA, 1981).

848



SOURCE U.S.E.P.A. JUNE, 1981

FRED C. HART, 1982

SCALE: 1" ≅ 2700'

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

LOCATION OF PRIVATE DRINKING WATER WELLS

FIGURE 2-7

TABLE 2-4

FREEHOLD TOWNSHIP WATER SYSTEM-EXISTING WELLS: 1982

Well No.	Location	Depth	Pump Capacity (gpm)*	Formation
1.	Koenig Lane	670 feet	200	Raritan
2.	Koenig Lane	Abandoned		
3.	Point Ivy	200 feet	500	Englishtown
4.	Koenig Lane	670 feet	1080	Raritan
5.	Southern Gulf	600 feet	80	Englishtown
6.	Southern Gulf	700 feet	200	Raritan
7.	Point Ivy	650 feet	880	Raritan-Magothy

* Gallons per minute

Source: William B. Dickerson, Township Engineer as reported by Townplan Assoc.

TABLE 2-5

ANALYTICAL RESULTS OF DRINKING WATER

Constituent	OWNER Siversen (well #1)	Hunt (well #2)	Club (well #3)	Kojac (well #4)
Zinc	20(e)	170	660	92
Lead	---	20(e)	---	30(e)
Benzene	---	---	---	---
Toluene	---	---	---	---

Sampling date: 31 May 1981.

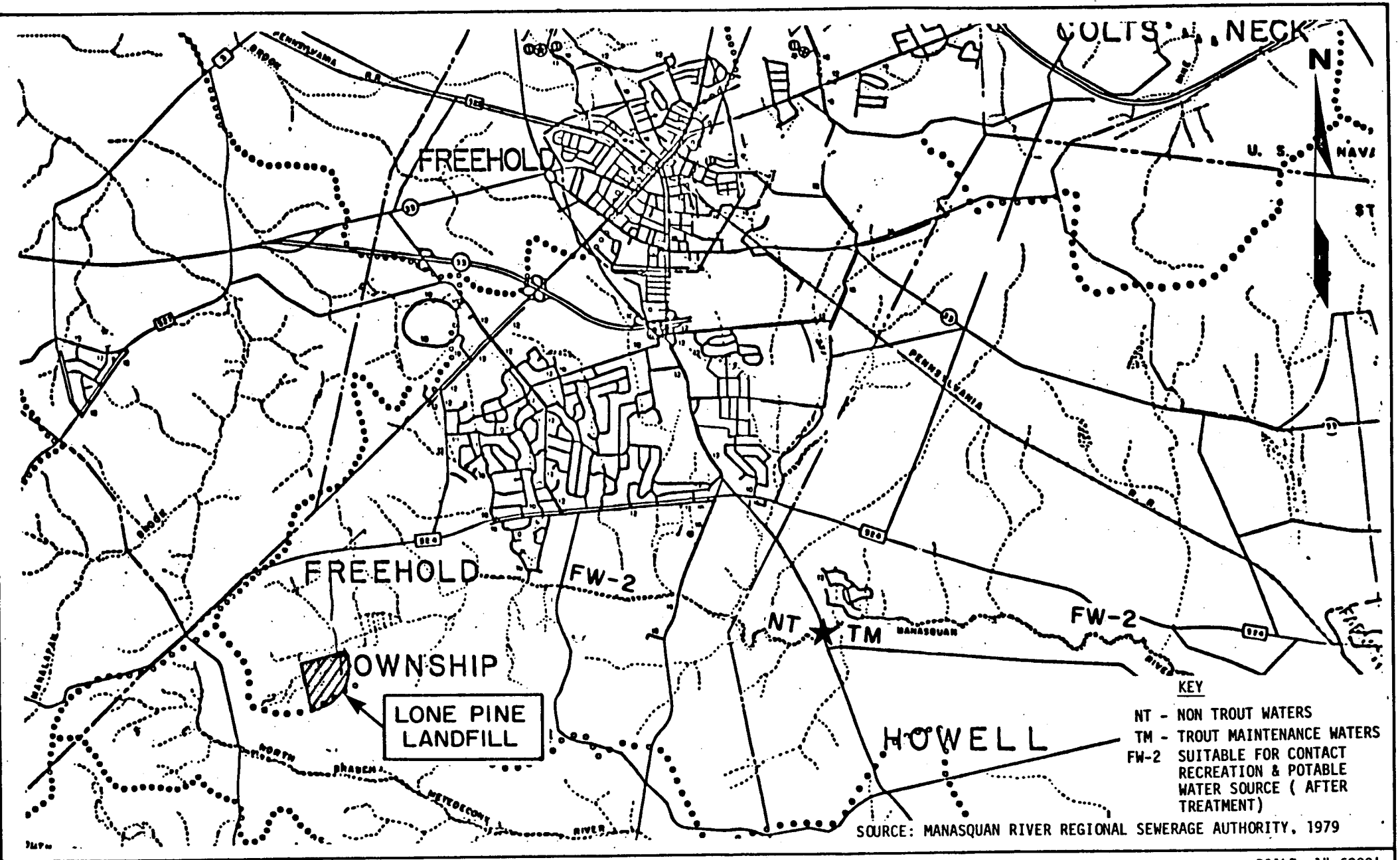
(e) = estimated

Source: (USEPA, 1981).

2.2.3 Surface Water

Surface water within the study area, in particular, the Manasquan River, is a major environmental concern since it provides drinking water to wildlife and supports a variety of aquatic biota further downstream. In addition, a potable water reservoir is proposed by the State for the Manasquan River approximately 16 miles downstream of the site.

The headwaters of the Manasquan River originate from a cranberry bog near Siloam Road. The main stream flows to the north and then east to Burke Road, forming the northern boundary of the site. There are three intermittent feeder streams that lead into the river from the north, northwest and south. The north and northwest streams originate in the woodlands surrounded by open space. The south streams wind through the northeast section of the landfill property and directly receive landfill runoff. The main stream is a relatively narrow gully ranging from 6 to 8 feet in width (figure 2-8).



SOURCE: MANASQUAN RIVER REGIONAL SEWERAGE AUTHORITY, 1979

SCALE: 1"=6000'

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

MANASQUAN RIVER

FIGURE 2-8

The river winds some 21.0 miles downstream from its headwaters to the Manasquan Inlet, which divides Ocean and Monmouth counties. Upstream near Allaire State Park, it supports a population of freshwater trout, and further toward the inlet it is an estuarine system supporting numerous species of saltwater fish (Carney, 1981). The limit of saltwater enroachment is 1.1 miles downstream of the Garden State Parkway (USEPA, 1979).

The headwaters of the Manasquan River are highly acidic (pH from 2.8 to 4.2). This condition is attributed to underlying acid sand formations (Kirkwood and Cohansey formations) that were exposed during a channelization project conducted in the 1940's (Tectonic, 1976).

Water quality sampling at four sites within the river in 1971 indicated excessive concentrations of the following chemicals: ammonia-nitrogen (NH_3-N); total nitrogen (TN); organic nitrogen; total solids (TS); total phosphates and iron. These high concentrations were attributed to runoff from the Lone Pine Landfill. The results also indicated an excessive biochemical oxygen demand (BOD_5), on the order of 34 milligrams per liter (mg/l) and a decrease in the dissolved oxygen (DO) concentration to 1.0 mg/l. A high fecal coliform to fecal streptococci ratio indicated pollution from septic wastes (Takacs, 1971). Table 2-6 summarizes the parameters of the landfill runoff and its effects upon the main stream of the Manasquan River. The high biological oxygen demand and low dissolved oxygen indicate the waters are unsuitable for fish survival.

TABLE 2-6

SAMPLING RESULTS OF MANASQUAN RIVER WATER

Samping Sta. No.	Intermittent Clean Stream #4	Manasquan R. Headwaters #3	Stream Adjacent to Landfill #2	Main Stream at Burke Rd. #1
Ammonia N	neg	neg	43	7
Total Nitrogen	2	2	51	10
Organic Nitrogen	2	2	8	3
Total Solids	130	126	670	356
Total Phosphate	0.04	0.12	7.0	0.34
Fe	1.0	7.3	20.0	12.0
DO	9.5	10.3	0.3	1.0
BOD	<1	<7	65	34

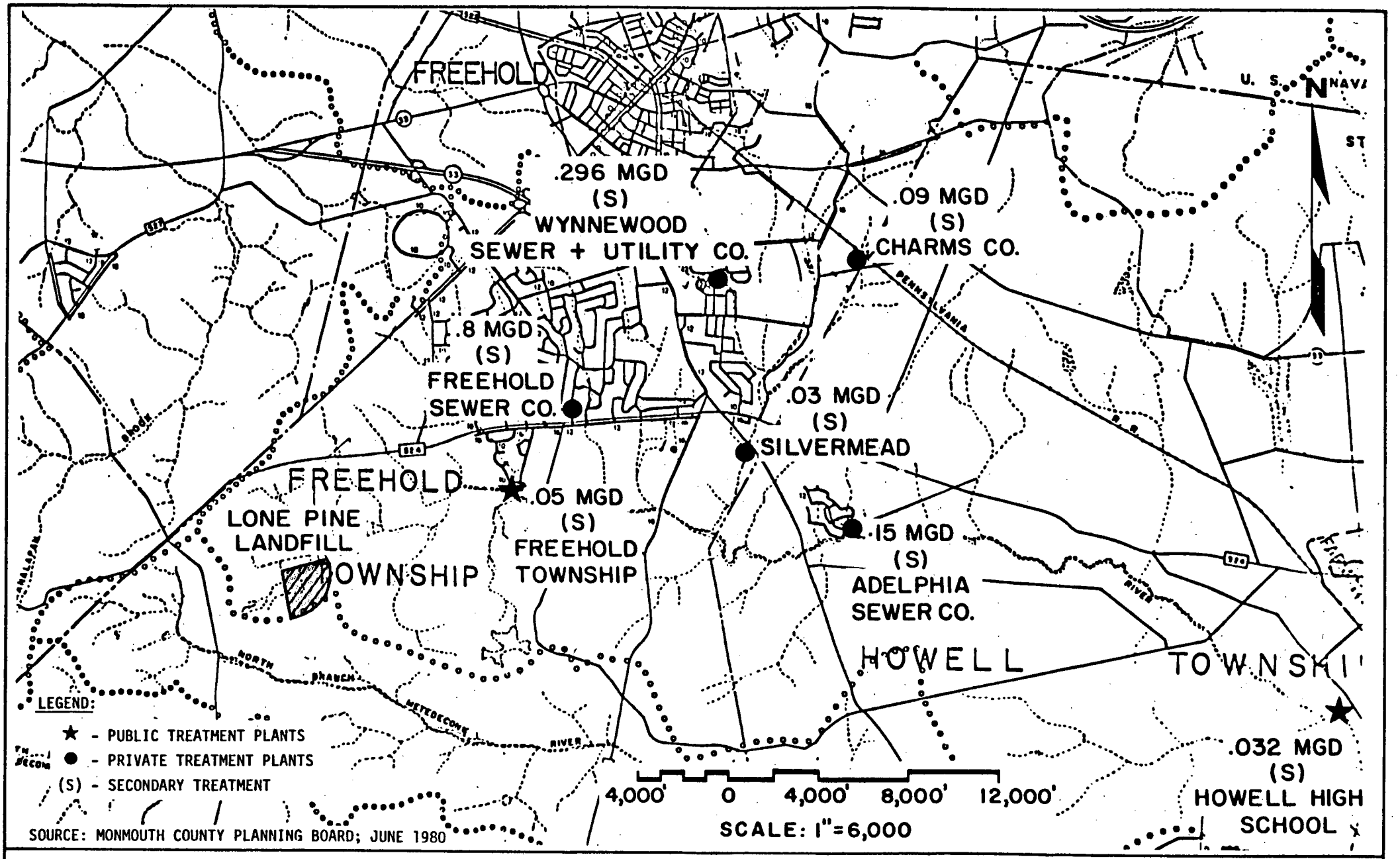
Source: Takacs, 1971

In 1971 the NJDEP noted that from the main stream at Burke Road up to station no. 3 strong odors were emitted. The composition of benthic organisms consisted of Tubifex worms. Soft black sludge blanketed most of the river bottom with a dense growth of grey to red colored slime. The composition of organisms found is indicative of an organically enriched, unhealthy environment. No signs of green aquatic plant life were evident. Dislodged whitish slime filaments were found floating downstream. The stream at station no. 3 was odor-free and only slime growth was noted along the banks. Above the stream the slime growth decreased. Station no. 2 emitted a pungent odor. Observation of the benthic community was impaired by the dark brown colored water. At station no. 4 a clean stream with green aquatic vegetation was observed (Takacs, 1971).

That portion of the Manasquan River within the study area is designated as FW-2, Non-Trout Waters (Ruggero, 1977). Appendix B presents NJDEP water quality standards for the FW-2 classification. Downstream of the study area several species of fish use the river as spawning habitats. (Zich, 1977). Prior to 1920 shad, blueback herring, white perch, and alewives were abundant; soft-shelled crabs and shellfish, particularly oysters, were fished commercially. By the late 1950's only the crab fishery and limited alewife-menhadin fisheries were still operating commercially. Fish surveys of the Manasquan River and its tributaries east of the study area (figure 2-8) indicated the presence of those fish species listed in table D-5, of appendix D. Sea lamprey, redear sunfish, mud sunfish and chain pickerel have been found in the Manasquan Basin (Tectonic, 1976). It is reasonable to assume that the shortnose sturgeon (an endangered species in New Jersey) may frequent the lower portions of the river. The shortnose sturgeon ranges throughout the Atlantic seaboard rivers from New Brunswick to Florida. The Hudson, Delaware and Connecticut River also support populations of sturgeon specimen have been recorded in New Jersey from the Maurice River and Dividing Creek and from Little Creek, Delaware.

Downstream of the site the Manasquan River is currently used for canoeing, sport fishing, limited irrigation supply and nature walks along its banks (Killam/Dames and Moore, 1974).

Point-source discharges in the Manasquan River are substantial. These discharges have caused low dissolved oxygen concentrations and occasional fish kills of substantial magnitude (Zich, 1973). Several wastewater treatment facilities discharge secondary treated sewage effluent into surface water systems within the vicinity of Lone Pine Landfill (figure 2-9). The overall effect of this effluent on the quality of water within the Manasquan River is unknown but could contribute to deterioration of the river water.



CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

SEWAGE TREATMENT PLANTS
IN THE VICINITY OF
LONE PINE LANDFILL

FIGURE 2-9

Non-point sources of pollutants may also contribute to a deterioration in the water quality of the Manasquan River. Stormwater runoff from highways, and commercial/industrial areas may contribute to major pollutant loadings. The major contaminants in the runoff from these areas are coliform bacteria, organic chemicals, sediment, heavy metals and nitrogen. Cesspools and septic systems also contribute nitrogen, and to a lesser degree organic chemicals. Fertilizers and pesticides applied to crops, lawns and landscaping may contribute nitrogen and organic compounds. Overfertilization commonly occurs in residential and recreational areas.

The headwaters of the Manasquan River have been reported as being devoid of fish life because of the poor water quality and dredging and channelization projects which have produced an unstable, and nearly sterile, bottom (NJDEP, 1983). The Manasquan River has also been described as virtually devoid of the habitat required by invertebrate fauna (NJDEP, 1983). Since the 1950's and early 1960's an increasing number of fish kills have been reported which have been attributed to sewage and other point-source discharges (Zich, 1973). Lester W. Jargowsky, Health Officer for Monmouth County, has called the headwaters a "total kill area" in which there have been no signs of aquatic life for sometime (Carney, 1981).

A recent 1980 biological study of the Manasquan River indicated that immediately downstream of Burke Road the bottom is blanketed by Tubifex worms, as mentioned previously. At Turkey Swamp Road there appeared to be biological recovery with the presence of caters flies (family of hydropsycidae) and snails, although no fish were observed.

As of February 1973 leachate has been observed flowing from the diversion ditch at the toe of the landfill through the woods and directly into the Manasquan River. It also appears that leachate has passed through the downslope wall of the ditch to be discharged into

the marsh area adjoining the river (Walker, 1973). Significant leachate seeps into the Manasquan River from the shallow water zone above the Hornerstown formation. These seeps are 200 to 300 feet from the toe of the landfill (Dalton, 1980). The USEPA found leachate oozing from the bank into the river at the rate of 2 to 5 gpm. At that rate, approximately 2,880 to 7,200 gallons per day (gpd) were flowing into the river (Carney, 1981).

Leachate emanating from the landfill site contains not only the normal expected pollutants, but more importantly, contains hazardous chemical wastes. In particular, exceedingly high concentrations of chloroform, benzene, chlorobenzene, and trichloroethylene have been identified as constituents of the leachate (Buchanan 1979). In June 1978 USEPA took several samples of liquids at the landfill; one sample was of on-site sludge; another was from the Manasquan River downstream of the site. The results of their chemical analysis are presented in table 2-7 and table 2-8 (Faille, 1978).

Since the natural topography of the landfill slopes downward toward the Manasquan River, most rainwater is carried directly into the main stream, with liquid wastes flowing toward the stream (Takacs, 1971). A study conducted by Rutgers University, under the direction of the NJDEP Office of Cancer and Toxic Substances Research in July 1978, confirmed the presence of various toxics in the Manasquan River at Burke Road during and after a rainstorm. The results of this study are summarized in table 2-9.

From 1977 to 1981 the Office of Cancer and Toxic Substances Research (OCTSR) collected additional water quality data in both the landfill leachate and headwaters of the Manasquan River. Samples collected from the landfill leachate and headwaters of the Manasquan indicate the presence of several volatile organic compounds. The concentrations of volatiles in the leachate are high but are reduced at Burke Road because of aeration and subsequent volatilization.

TABLE 2-7

CHEMICAL ANALYSIS OF ON-SITE SLUDGE
(June 1978)

Methyl Chloride	170 ppb
1,1 Dichloroethylene	6 ppb
Chloroform	95 ppb
1,2 Chloroethane	260 ppb
1,1,1 Trichloroethane	1,600 ppb
Benezene	2,900 ppb
Trichloroethylene	24,000 ppb
1,1,2 Trichloroethane	34 ppb
Toluene	80,000 ppb
Tetrachloroethylene	12,000 ppb
1,1,2,2 Tetrachloroethane	1,040 ppb
Ethyl Benzene	25,000 ppb
Chlorobenzene	4,100 ppb

TABLE 2-8

STREAM SAMPLE ANALYSIS DOWNSTREAM OF THE LANDFILL
(June 1978)

Benzene	121 ppb
Chlorobenzene	7.77 ppb
Methylene	9.00 ppb
1,2 dichloroethylene	124 ppb
Toluene	533 ppb
Ethylbenzene	43 ppb
1,2 dichlorethane	13 ppb

ppb = parts per billion
Source: (Faille, 1978)

TABLE 2-9

MANASQUAN RIVER WATER SAMPLING BEFORE AND AFTER A STORM EVENT

Compound	Day Sampled After Storm				
	Rain Day	Day 1	Day 4	Day 8	Day 12
Methyl Chloride	ND	ND	ND	31.2	ND
Chloroform	ND	ND	1.2	1.3	ND
1,1,2 Trichloroethane	3.6	5.1	6.0	4.4	6.6
Trifluoromethane	ND	ND	ND	16.3	ND
1,2 Dichloroethane	6.0	31.3	8.4	14.5	17.4
Vinyl Chloride	11.1	ND	6.1	1.9	4.3

ND - not detected; all values are expressed as ug/l.

Source: Burke and Garie, 1982

Despite the analytical data available for the Manasquan River, there are many unanswered questions regarding the fate of toxics in the river. Conflicting results from the studies do not provide information on the extent of downstream transport in the water column or the effects of storm events on leachate characteristics and the transport of contaminated sediments (Burke and Garie, 1982).

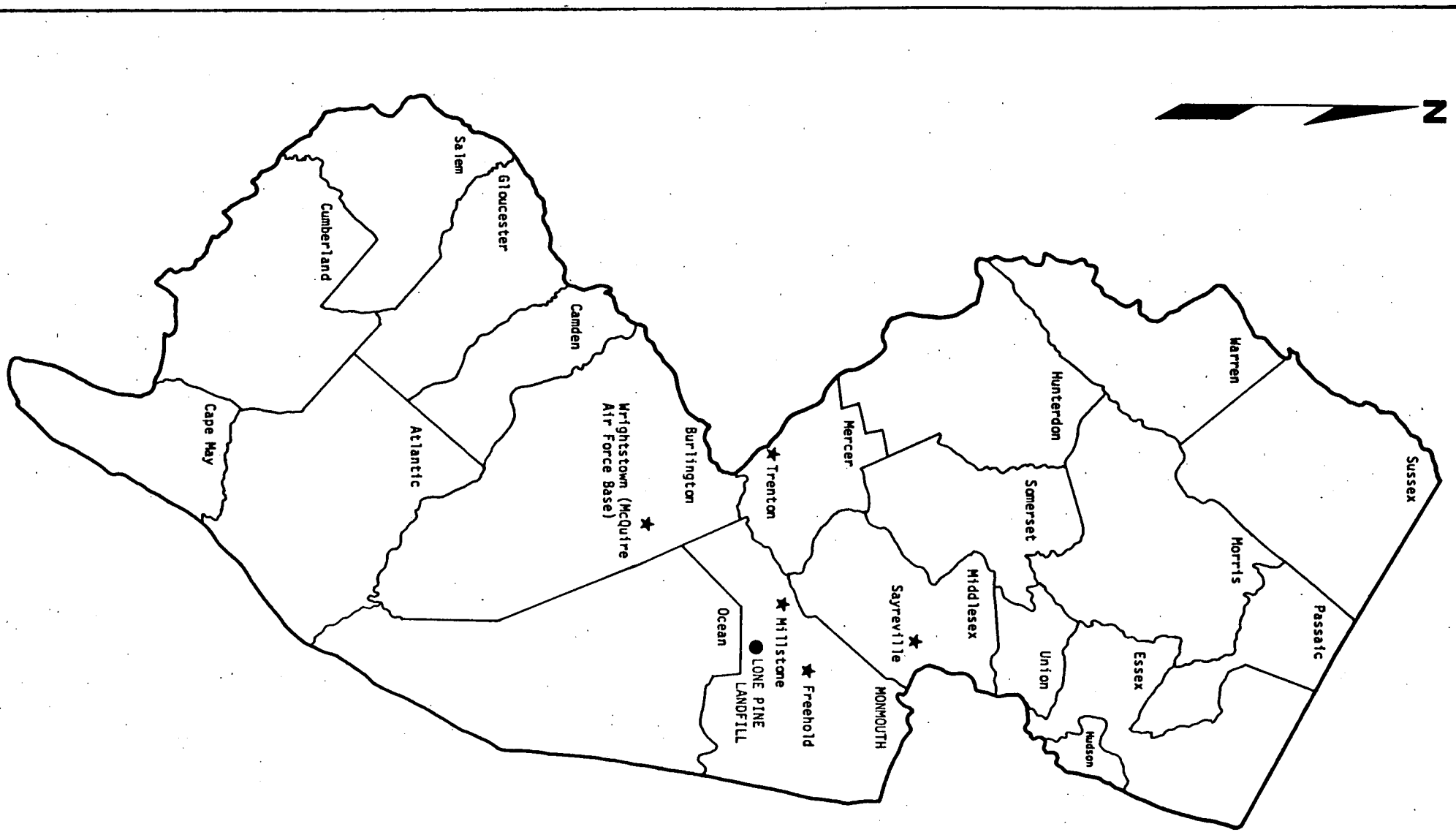
Bog Creek Farm, a hazardous waste site located on Squankum Brook, a tributary to the Manasquan River, is approximately 12 miles downstream of the Lone Pine site. Bog Creek Farm contributes volatile organics to the river but sediment concentrations have not been addressed. High concentrations of aluminum (10,000 ppb) have been detected in bog runoff. This condition has been implicated in fish kills that have occurred in the area (Burke and Garie, 1982).

2.2.4 Climate and Air Quality

2.2.4.1 Climate. The prevailing climate in the vicinity of the Lone Pine Landfill, such as, precipitation, temperature, and wind speed and direction, influence environmental conditions at the landfill. Precipitation increases leachate production; temperature and wind conditions infulence volatilization and dispersion of organic compounds that may be emitted to the atmosphere.

The closest weather stations to Lone Pine Landfill are located in Freehold and Wrightstown, New Jersey (figure 2-10). Temperature and precipitation readings taken at the Freehold station from the period 1941 to 1970 and wind speed and direction recorded at McQuire Air Force Base in Wrightstown from 1948 to 1977 are presented in table 2-10.

The climate of Freehold is classified as continental, with only minor influence from the Atlantic Ocean. Normal average temperature for the year is about 53^{o}F (NOAA, 1982).



NOT TO SCALE

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

LOCATION OF WEATHER STATIONS

FIGURE 2-10

TABLE 2-10

CLIMATOLOGICAL DATA FROM WEATHER
STATIONS IN THE VICINITY OF LONE PINE LANDFILL

Month	Temperature[1] (^{o}F)	Precipitation[1] (in.)	Speed(KL)	Direction
January	31.4	3.17	7	W
February	32.7	3.09	8	W
March	40.2	4.23	8	WNW
April	51.0	3.45	7	W
May	61.0	3.93	5	S
June	70.0	3.40	5	S
July	74.6	4.69	4	S
August	72.8	4.39	4	S
September	66.5	3.47	4	SSW
October	56.3	3.14	5	W
November	45.6	4.11	6	W
December	34.2	3.65	7	W
Annual Average	53.0	4.47	6	W

Source: (NOAA, 1982)

[1]Station: Freehold, N.J. Recorded From 1941-1970.
[2]Station: McQuire Air Force Base (Wrightstown). Recorded From Aug. 1948-Nov. 1977.

Precipitation in Freehold averages about 46 inches a year. Heaviest rainfalls generally occur during the summer growing season (NOAA 1982). Snowfall averages about 26 inches a season.

Destructive storms are rare in Freehold. Occasional summer thunderstorms combine high winds and heavy rainfall. Heavy rains have occurred in connection with hurricanes and tropical storms, which pass along the New Jersey coast and contribute a portion of the rainfall occurring in the summer and autumn (NOAA, 1982).

Winds in the general vicinity of the Lone Pine Landfill average approximately 6 knots, with maximum wind speeds occurring in the winter and early spring. Winds generally blow from a westerly direction throughout most of the year, except in the summer months when the wind direction is predominantly from the south (NOAA, 1982).

2.2.4.2 Air Quality. National ambient air quality standards (NAAQS) for the criteria pollutants which include sulfur dioxide, total suspended particulates, carbon monoxide, photochemical oxidants, hydrocarbons and nitrogen dioxide were promulgated by the USEPA on 30 April 1971. (Lead was later added to this list.) Within 9 months thereafter, the Clean Air Act required each state to adopt and submit a plan that would implement, maintain and enforce the standards within the state. The major objective of the plan was to bring the levels of nonattainment pollutants within the standards set by both the USEPA and State of New Jersey by the year 1987. In New Jersey, this plan, referred to as the State Implementation Plan (SIP), was accepted by the USEPA in 1977. The State was subsequently granted an extension to achieve pollutant standards by the year 1987.

The NJDEP Bureau of Air Quality Surveillance maintains both continuous and manual air-monitoring systems in various locations throughout the State. Representative air quality data from monitoring sites nearest the Lone Pine site are presented in table 2-11. More detailed information on air quality from stations within the vicinity of the landfill can be found in appendix C.

Air quality control regions have been established by the State for planning purposes and are divided into one of three categories, a) attainment, (b) classified, or (c) nonattainment.

The Lone Pine Landfill site is located within the New Jersey-New York Interstate Air Quality Control Region (AQCR). This region is designated attainment for sulfur dioxide, total suspended particulates, and nitrogen dioxide.

Since limited site-specific baseline air monitoring data for Lone Pine Landfill exists, an air sampling program has been included in each remedial alternative to monitor changes in contaminant releases from the landfill. The first phase of the recommended air monitoring program would be designed to establish baseline conditions to enable a determination of the nature and extent of air emissions and the potential effects of these emissions. Following the initial baseline study and assessment of conditions the second phase of the program would be implemented to serve as an ongoing warning system of changing conditions. Details of the air monitoring program are provided in the Draft Preliminary Report Feasibility Study (CDM, 1983).

TABLE 2-11

AIR QUALITY DATA FROM VARIOUS MONITORING STATIONS
TO LONE PINE LANDFILL (1979-1981)

Contaminant	Year	Station	Averaging Period	Concentration	Units	Primary Standard	Secondary Standard
Photo Chemical Oxidants (ozone)	1981	McQuire A.F.B	1-hr-avg max	0.162	ppm	0.12^{1}_{2}	0.12^{1}_{2}
	1980	McQuire A.F.B		0.228		0.08^{2}	0.08^{2}
	1979	Trenton		0.133			
Lead	1981	Trenton	1st quarter mean	0.59	ug/m^3	Quarterly mean 1.5	Quarterly mean 1.5
	1980	Trenton		0.86			
	1979	Sayreville		0.35			
			2nd quarter	0.42			
				0.54			
				0.49			
			3rd quarter	0.48			
				0.81			
				0.48			
			4th quarter	0.35			
				0.71			
				0.12			
Nitrogen Dioxide	1981	McQuire A.F.B	12-mo avg	0.018	ppm	0.05	0.05
	1980	McQuire A.F.B		0.018			
	1979	Not available		—			
Sulfur Dioxide	1981	McQuire A.F.B[3]	12 mo. avg	--		0.03	0.02
	1980	Freehold		.007	ppm		
	1979	Freehold		.008			
			24 hr avg max	.059		0.14	0.10
				.049			
				.060			
			3 hr avg max	.069		--	0.5
				.075			
				.092			
Total Suspended Particulates	1981	Millstone	12 mo	42.5	ug/m^3	75.0	60.0
	1980	Millstone		42.9			
	1979	Millstone		36.7			
			24 hr avg max	93.0		260	150
				76.0			
				86.0			
Carbon Monoxide	1981	Freehold	8 hr avg max	10.1	ppm	9.0	9.0
	1980	Freehold		10.8			
	1979	Freehold		12.6			
			1 hr avg max	16.7		35	35
				13.9			
				21.3			

(1) NAAQS - National Ambient Air Standard
(2) NJAAQS - New Jersey Ambient Air Quality Standard

ppm = parts per million
ug/m^3 = microgram per cubic meter
p = violation of primary standard
s = violation of secondary standards

(SPH12/23)

2.3 BIOLOGICAL ENVIRONMENT

2.3.1 Flora and Fauna

An ecological inventory of the existing plant and animal life in the vicinity of the Lone Pine Landfill aids in the identification of key species, their distribution and relative abundance of each. This investigation is necessary for preserving natural habitats and breeding grounds, safeguarding threatened or endangered species, and preventing interference with the movement of any resident or migratory fish or wildlife species.

2.3.1.1 Flora. An inventory of the flora and fauna that may occur in the study area has been categorized into terrestrial, semi-aquatic and aquatic habitats. The forests, grasslands and farmlands comprise the terrestrial habitats of the study area. The wooded areas exhibit a transition from the Appalachian Oak forest type to the Pine Barrens environment of the Northeastern Oak Pine forest type (Dames and Moore, 1974). The major forest species are oaks, maples, American beech and tulip or yellow poplar. Pitch pine, scrub oak, white and red oak, sweet gum, sour gum and Atlantic white cedar are the predominant species found in the sandier soils. Principal vegetation that may be found within the study area are listed in table D-1 of appendix D.

2.3.1.2 Fauna. A variety of fauna utilize the terrestrial habitats. Common land animals (birds and mamals) that may be found in the study area are listed in tables D-2 and D-3 of appendix D.

Semiaquatic habitats are provided by swamps and bogs adjacent to rivers and their tributaries. Sphagnum logs, swamp-oak, and tulip tree forests predominate in these low-lying areas. The fauna (amphibians and reptiles) that are likely to be found within the study area are presented in table D-4 of appendix D.

The aquatic habitats within the study area are associated with the Manasquan River and its tributaries. These aquatic habitats support a number of plants and animals. Vegetation consists primarily of rooted aquatic plants and phytoplankton. A list of fish species that may be found in the river is presented in table D-5 of appendix D.

Soils formerly found at the Lone Pine Landfill site have been disturbed from past excavation and filling. The habitats required by area plants and animals have been destroyed and it is highly unlikely that species normally found in the study area would be present on the site.

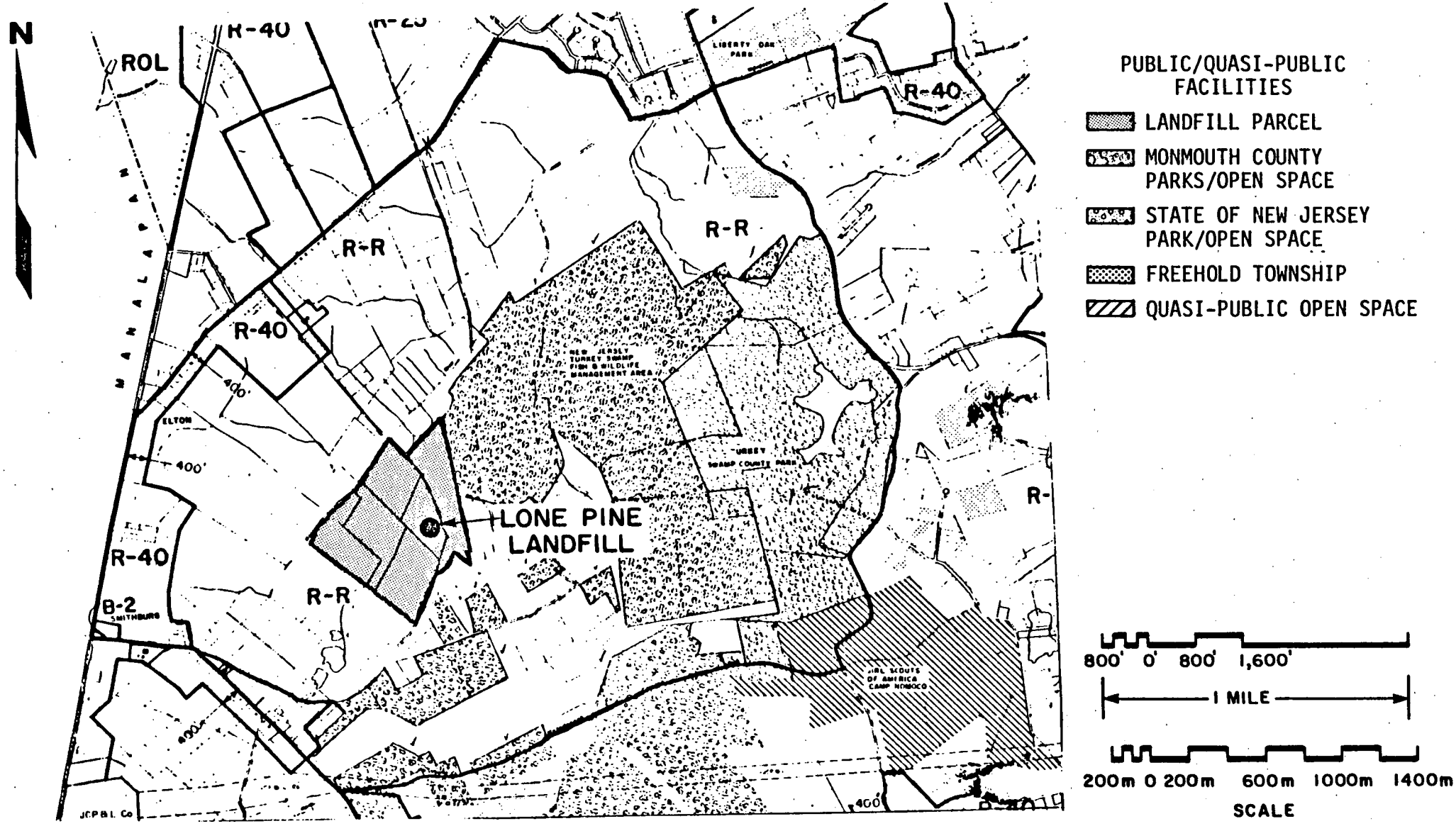
2.4 SOCIOECONOMIC ENVIRONMENT

2.4.1 Zoning and Land Use

Existing and planned area land use, zoning, aesthetic features and local recreation assets, are all affected by the existing condition at the landfill site.

2.4.1.1 Zoning. A major portion of the area south of Elton-Adelphia Road in the Township of Freehold is zoned 5-Acre rural-residential (R-R) (see figure 2-11). This classification allows for development of single-family, detached housing units on 5-acre parcels. This area is not served by public sewers.

Historically, this area developed with scattered large lot rural residental developments along roadways. In general, the rural-residential area is prone to flooding in the areas of stream and tributaries forming the Metedeconk and Manasquan river systems.



SOURCE: TOWN PLAN ASSOC.

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ZONING MAP OF
LONE PINE LANDFILL
STUDY AREA

FIGURE 2-11

There are various locations throughout this area that are not prone to flooding and are suitable for development on less than 5-acre parcels. These areas are mostly found along existing historic roadways, such as Jackson Road, Eli Harmony Road and Siloam Road.

The second largest residential area is zoned R-40, single-family residential area. These areas are varied in size depending upon their location in the township. In the study area, R-40 designated areas generally lie in a linear strip along existing roadways which have developed historically and have higher elevations than the surrounding land. These areas are not expected to exhibit significant development in the future because of their dependence on onsite septic systems and well water. Areas designated as R-40 in this portion of the township are areas which have developed, in part, as 1-acre lots and are generally not served by public sewers (Townplan Assoc., 1982). Another category of R-40 lands is existing agricultural areas which are planned to be retained for agricultural use.

The B-2, service and supply designation is intended to provide for general business activities such as retail space, offices, personal service and small commercial establishments on lots of approximately 20,000 to 25,000 square feet with a frontage of 100 feet. Within the study area, B-2 designated areas are restricted to a small parcel of land situated in the Town of Smithburg.

Quasi-public land uses in the study area represent a relatively small proportion of the total land area. This classification has been categorized as any building or land devoted to public administration, health, safety or welfare, including municipal buildings, schools, fire houses, open space and conservation areas. Quasi-public uses are buildings and/or properties owned by an organization or institution which are generally open to the public, but usually require some form of membership or affiliation. Within the study area, public/

quasi-public designated areas are restricted to the southeastern portion and are designated for use by the Girl Scouts of America, Camp Nomoco.

In 1981 the Township of Freehold instituted the Water Resources Protection ordinance to restrict construction and development in certain areas of the township that could result in substantial impairment to water resources. The objective of the ordinance was to regulate development and construction upon lands with delicate hydrology and to limit mound systems with ejector pumps as a means of septic disposal upon such lands. The ordinance sets forth specific standards that require the applicant to submit an application with hydrologic data for every fifth lot proposed for development. If such development violates the standards of the ordinance, the applicant must revise the development plot to show no development on those lots or in those areas affected.

The New Jersey State Turkey Swamp Fish and Wildlife Management Area occupies approximately 25 percent of the study area, or 818 acres. This facility provides opportunities for hiking, hunting and nature studies. Monmouth County Turkey Swamp Park, comprising 468 acres, or approximately 13 percent of the study area, provides opportunities for camping, hiking and boating (see figure 2-11).

2.4.1.2 Land Use. A variety of land uses exists in Freehold Township. Historically, the township was a rural, agricultural area with scattered farms, small settlements and commercial establishments. For almost 200 years this pattern of development persisted (Townplan Associates, 1982).

Between 1962 and 1980 the township experienced substantial changes in land uses. The rapid expansion of residential, commercial, and public and quasi-public land uses can be seen in table 2-12. In 1962 developed lands accounted for only 17.1 percent of the township. By 1980 developed lands amounted to 39.9 percent of the township, a 133-percent increase in two decades. Residential development accounted for the bulk of the change from 1962 to 1980, which increased 2,670 acres during this period; public/quasi-public development increased 1,459 acres during this same period. In 1980 the total developed land was 5,575 acres. Agricultural lands decreased by 3,787 acres from 1962 to 1980, while vacant/woodlands areas decreased by 1,788 acres. Most of the large-scale developments during the past two decades have occurred on large, open field farmlands in the northern portion of the township (Townplan Associates, 1982).

2.4.2 Population

The trends of population within the Township of Freehold will provide an indication of potential population growth that may occur within the vicinity of Lone Pine Landfill. This information provides insight into the number of people who may be affected by existing conditions at the site.

Between 1960 and 1980 the Township of Freehold experienced a rapid population growth, with more growth expected to occur through the year 2000. From 1960 to 1970 the Township experienced more population growth than it had in the previous 170 years, with a population increase from 4,779 to 13,185. The Garden State Parkway and other regional highway improvements during this period contributed to the influx of new residents (Townplan Assoc., 1982).

TABLE 2-12

LAND USE: 1962-1980,
FREEHOLD TOWNSHIP

Land Use	Acres		Change (1962-1980)	
	1962	1980	Acres	Percent
DEVELOPED				
Residential	1,250	3,920	2,670	213.6
Commercial	89	310	221	248.3
Industrial	160	295	135	84.4
Public & quasi-public	2,699	4,158	1,459	54.1
Total developed	4,198	9,773*	5,575	132.8
Percent developed	17.1%			
UNDEVELOPED				
Agriculture	10,957	7170	(3,787)	(34.6)
Vacant/woodland	9,357	7569	(1,788)	(19.1)
Total undeveloped	20,314	14,739	(5,575)	(28.4)
Percent undeveloped	72.3%	60.1%		

Notes: Total township area - 24,512 acres (39 square miles)
( ) Represents a decrease from 1962 to 1980
* Total includes railroads (35 acres) and streets and highways (1055 acres)

Sources: 1962 - Master Plan prepared by O. Wayne Noble.
1980 - Land Use Survey: Townplan Associates.

Prepared by: Townplan Associates.

473

The rapid growth of the 1960's was carried over into the early 1970's as large-scale subdivisions, garden apartments, mobile homes and modular housing developments were constructed. In the late 1970's, despite the lack of sewage treatment facilities and high interest rates, there was a total increase in population of 6,017.

Population growth from the years 1960 to 1980 resulted from natural causes; that is to say, the number of births outnumbered the number of deaths.

During the past two decades the township has experienced a net natural increase in population, reaching a peak in 1974. In the early 1960's the average annual increase was 75 persons, increasing to an average of 89 people between 1965 and 1969. From 1970 to 1974 the average annual increase was 160 persons, increasing to 115 persons during the period from 1975 through 1979 (Townplan Assoc., 1982).

Approximately 10 percent (819) of the total increase in population occurred in the 1960's. A net in-migration of 7,587 new residents resulted from rapid residential development. In the 1970's net in-migration accounted for 3,760 residents and a natural increase in population of 1,373 (Townplan Assoc., 1982).

With a declining birth rate within the township, it is expected that the natural growth in population will not increase significantly in the future. If the 1975 to 1980 trend continues, the 1980's would produce only about 1,200 additional residents. A major population growth would be expected only if there was a significant in-migration of new residents. Table 2-13 presents the natural population increase and net in-migration of residents into the township from 1960 to 1980.

TABLE 2-13

NATURE OF POPULATION GROWTH: 1960-1980,
TOWNSHIP OF FREEHOLD

		1960-1969	1970-1980
I	BASE POPULATION	4,779 (1960)[1]	13,185 (1970)[1]
II	NATURAL INCREASE		
	Total Births[2]	1,392	2,243
	Total Deaths[2]	-573	-870
	Natural Increase	819	1,373
III	NET MIGRATION		
	Total Population Increase	8,406 (1960-1970)	6,017 (1970-1980)
	Natural Increase	-819	+1,373
	Net In-Migration	7,587	4,644
IV	NET POPULATION INCREASE		
	Base Population	4,779	13,185
	Natural Increase	+819	+1,373
	(Plus) In-Migration	7,587	4,644
	Total Population	13,185 (1970)[1]	19,202 (1980)[3]

Sources:

1 U.S. Census of Population: 1960 and 1970.

2 New Jersey Department of Health, Public Health Statistics: 1960-1979.

3 New Jersey Provisional Census Counts of Population and Housing: 1 April 1980 (March 1981).

Compiled by Townplan Associates.

2.4.3 Economics

Local economic development within the study area is related to the area's population growth. Community-related economic features are affected by the migration of residents into and out of the study area and its resultant effect on local trade.

Monmouth County is ranked among the nation's top 100 counties in dollar value of agricultural products sold per acre farmed. It leads the State in horse breeding, the production of wheat and potatoes and nursery acreage. Although agriculture is still important to the county's economy, it has declined relative to the importance of other industries (Monmouth Co. Planning Board, 1982).

Following the introduction of the railroad in the 1850's, summer resorts began to develop along the shore fronts. This event was the beginning of the tourist industry, which now accounts for 25 percent of the county's employment and approximately 10 percent of the county's total income (Monmouth Co. Planning Board, 1982).

In the older urban centers of Monmouth County the manufacturing industry began with glass, apparel and electrical machinery businesses. With expansion of the highway network and proximity to markets in New York and Philadelphia, suburbanization and commercial expansion began. Currently there are over 400 firms representing a variety of industries in the County, employing approximately 33,000 workers. Among the major employers in the County are: Bell Telephone Laboratories; Jersey Central Power and Light; Prudential Property and Casualty Insurance; Perkin-Elmer Computer Systems Division; Midland Glass; International Flavours and Fragrances; Bendix; Insco Systems; Brockway Glass; and Electronics Associates. Approximately 25 percent of the workforce have been working outside the county since 1950 (Monmouth Co. Planning Board, 1982).

Census data indicate the following trends (see table 2-14) in employment from 1950 to 1970: significant increases in educational services, retail trade and professional and related services, slight increases in wholesale trade and other industries, and significant decreases in agriculture and mining (Monmouth Co. Planning Board, 1982).

The average annual resident unemployment rate (see table 2-15) in Monmouth County from 1970 to 1981 was greater than the nation's rate of 6.4 percent, but less than New Jersey's rate of 7.2 percent (Monmouth Co. Planning Board, 1982).

According to the 1980 Census figures, the county's per capita income rose 141.4 percent from 1970, compared to a statewide increase of 130.8 percent, and a 0.5 increase of 141.1 percent (Monmouth Co. Planning Board, 1982).

Family incomes within the Township of Freehold exceed those of both the county and State. In 1970 42.7 percent of Freehold Township residents earned over $15,000 compared to 31.7 percent and 31.6 percent of county and State residents, respectively. In 1970, the average family income in Freehold Township was $15,176, compared to the county and State average family incomes of $13,397 and $13,025, respectively (Townplan Assoc., 1982).

2.4.4 Transportation

The existing roads within the vicinity of the site must be analyzed for accessibility and carrying capacity since heavy volumes of traffic will be generated should construction occur. In addition, potential long-term use of these roadways for transport of sludge and/or other waste material, which may be determined as hazardous, is a major environmental concern.

TABLE 2-14

EMPLOYMENT BY INDUSTRY GROUP: 1950-1970
(Monmouth County)

	1950	%	1960	%	1970	%
Agriculture and mining	5,345	6.5	3,375	3.0	2,654	1.6
Construction	7,567	9.3	9,068	7.9	10,588	6.5
Manufacturing	16,976	20.8	26,506	23.2	36,661	22.5
Transportation, Communication and utilities	6,304	7.7	8,448	7.4	13,715	8.4
Wholesale trade	2,500	3.1	3,436	3.0	5,327	3.3
Retail trade	13,578	16.6	18,095	15.9	27,834	17.1
Services	13,344	15.1	15,691	13.8	22,437	13.8
Educational services	2,352	2.9	4,979	4.4	11,827	7.3
Other professional and related Services (including Eng. and Legal)	1,551	1.9	3,924	3.4	5,281	3.2
Public administration	8,149	10.0	10,776	9.4	13,998	8.6
Other industries and industries not reported (Forestry now in Agriculture)	5,014	6.1	9,807	8.6	12,439	7.6
TOTAL	81,689	100.0	114,104	100.0	162,761	100.0

SOURCE: U.S. Census of Population, 1950-1970, as reported in Growth Management Guide, 1982.

TABLE 2-15

RESIDENT UNEMPLOYMENT RATES: 1970-1981
(Monmouth County, New Jersey, and United States)

Year	Monmouth Co.[1]	New Jersey[2]	United States[2]
1970	4.3	4.6	4.9
1971	5.0	5.7	5.9
1972	5.3	5.8	5.6
1973	5.2	5.6	4.9
1974	6.0	6.3	5.6
1975	9.4	10.2	8.5
1976	9.6	10.4	7.7
1977	9.2	9.4	7.0
1978	7.3	7.2	6.0
1979	7.2	6.9	5.8
1980	7.2	7.2	7.1
1981*	7.0	7.3	7.6

*Preliminary Figures

SOURCE: [1] New Jersey Department of Labor and Industry, as of February 26, 1982.

[2] United States Bureau of Labor Statistics, as of 26 February 1982.

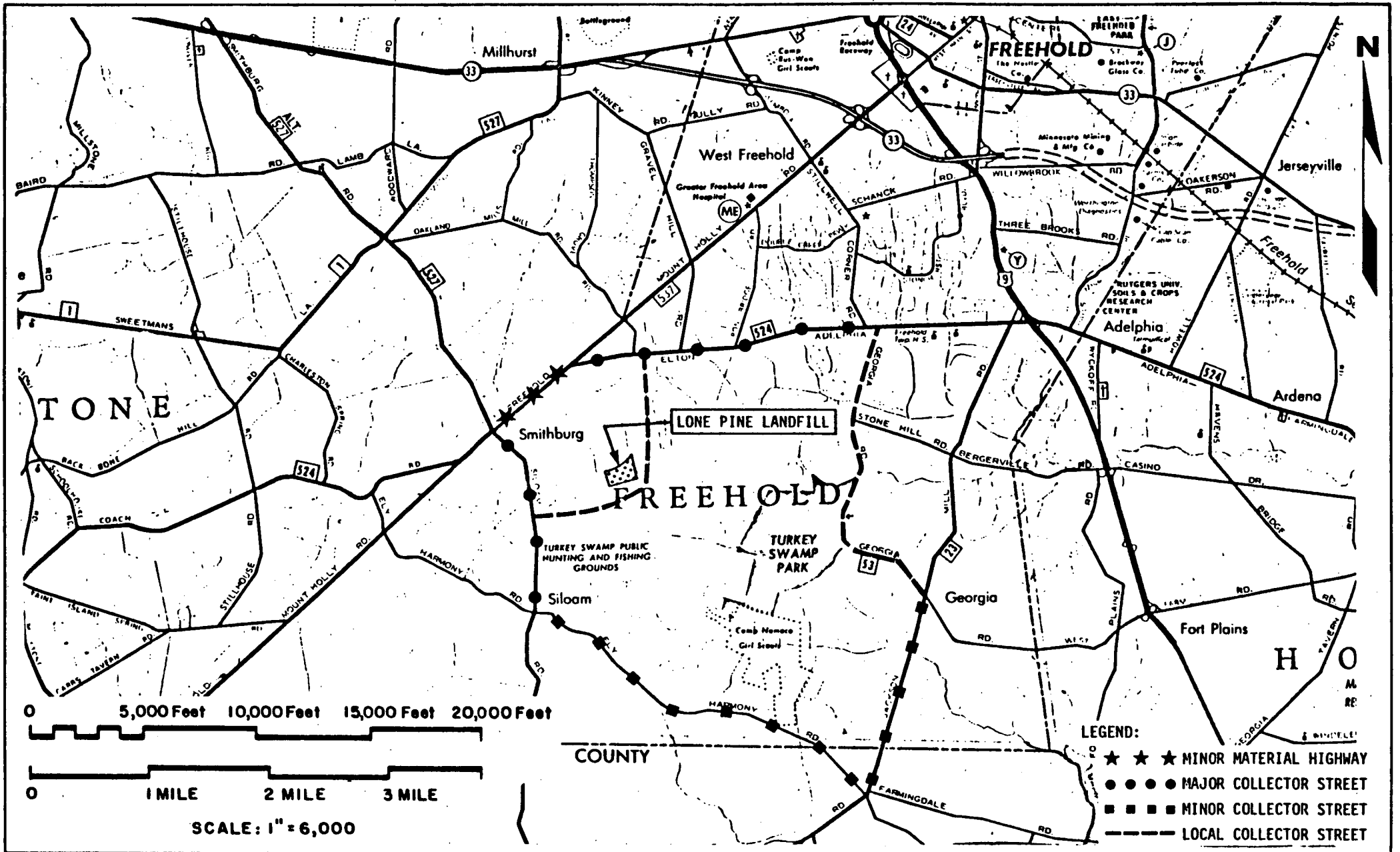
Excerpt from Growth Management Guide, 1982.

The U.S. Department of Transportation, Federal Highway Administration has established a classification system for roadways for the purposes of allocating Federal funds for highway improvements. The study area lies in the Rural Area category which generally includes four types of roads: Principal Arterial Highways, Minor Arterial Highways, Major Collector Roads, and Minor Collector Roads. Of these four classifications, roadways in and around the study area can be classified in the last three categories (figure 2-12).

There is only one minor arterial highway in the study area. This road type collects "traffic from one or more local, minor or major collector street and leads it to a system of other minor arterial highways or principal arterial highways." (Townplan Assoc., 1982). These roadways typically have one lane of traffic in each direction. Monmouth County Route 537 (Freehold-Smithburg Road), located on the northwest boundary of the site falls under this classification. (Townplan Assoc., 1982.)

The second classification in the rural areas is major collector streets. These roads "collect traffic from minor and local collector streets, as well as local streets, and channel it into the system of minor arterial or major arterial highways." (Townplan Assoc., 1982). They typically carry traffic volumes in excess of 2,500 vehicles per day. Monmouth County Route 524 (Elton-Adelphia Road), the northern boundary of the study area; and Monmouth County Route 527 (Siloam Road), the western border of the study area, are considered major collector streets. (Townplan Assoc., 1982).

The remainder of the roads in the study area fall under the classification of local collector streets. These roadways "serve the principal function or collection traffic from residential neighborhoods and feeding it to roads of higher classifications." (Townplan Assoc., 1982). The following roads fall under this classification:



CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

TRANSPORTATION MAP

FIGURE 2-12

Georgia Road, the eastern boundary of the study area; Iron Bridge Road and Turkey Swamp Road, bisectors of the study area; and Nomoco Road, the southeastern boundary of the study area (Townplan Assoc., 1982).

Roadway capacities are not specifically mentioned under these classifications. However, for the purposes of proposed construction travel and traffic to the landfill site, those roads with higher classifications (such as minor arterial highways and major collector streets) should allow a higher capacity for truck travel since they generally handle larger volumes of traffic.

Since the area is primarily rural, volumes of traffic should not be interfered with should construction occur at the landfill site. Proper scheduling can avoid peak travel times along all adjacent roadways.

2.4.5 Energy

The Township of Freehold is within the service area of the Jersey Central Power and Light Compant. A major transmission line extends 4.2 miles through the southern portion of the township. The right-of-way is 260 feet wide from Howell Township north of Ely Harmony Road to Siloam Road and extends 520 feet wide from Siloam Road to Freehold Smithburg Road. (Townplan Assoc., 1982). A major transmission substation is located on Freehold Smithburg Road. Jersey Central Power and Light has been able to supply services for both residential and commercial development throughout the township and there are no forseen problems of providing services in the future. (Townplan Assoc., 1982)

2.4.6 Noise

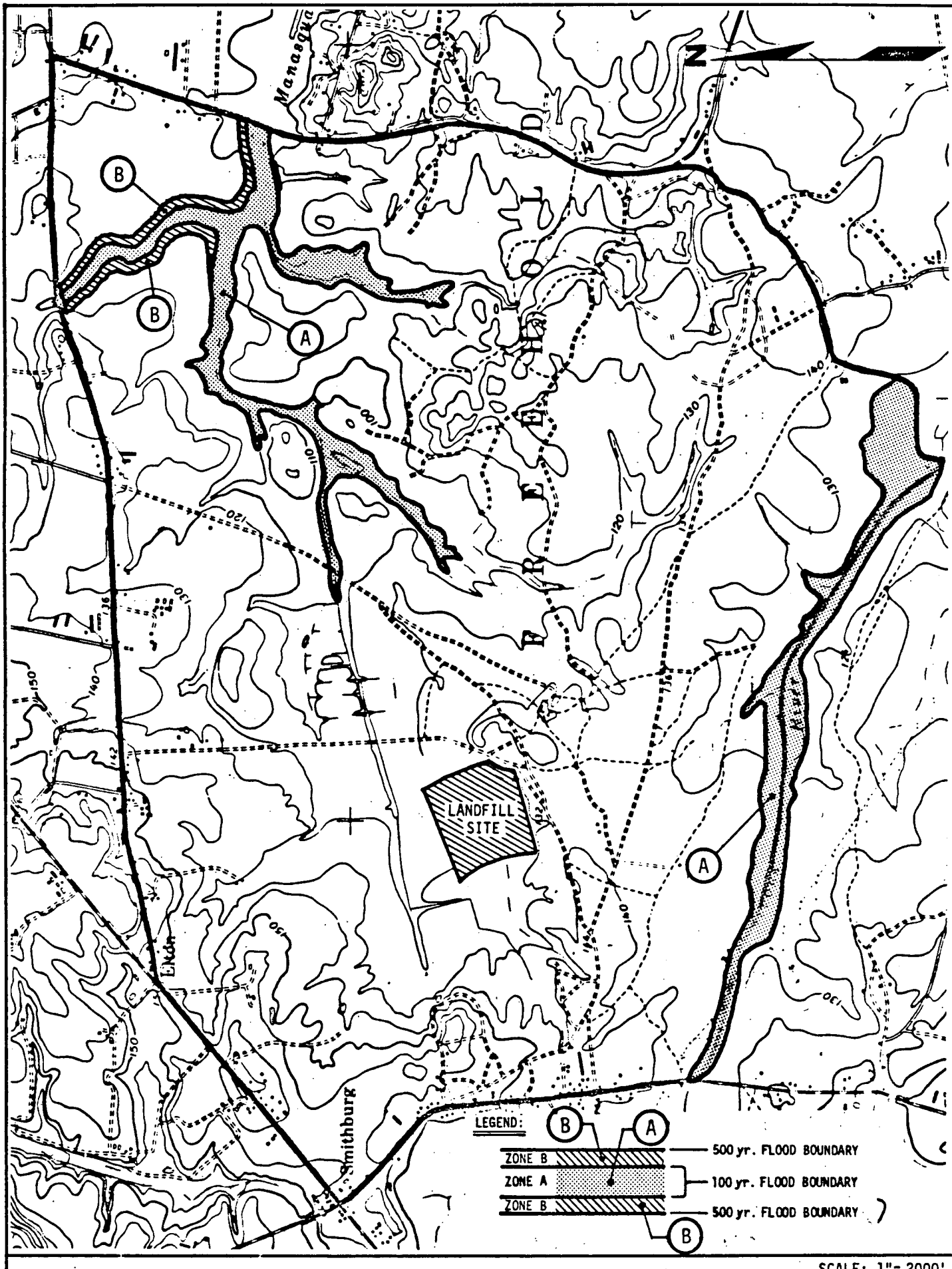
Existing noise levels within the study area will not be addressed in this document for two reasons: firstly any increase in noise generated during the construction period will be of short duration and can be mitigated. Second, the landfill site is located in a relatively remote area with buffering provided by natural vegetation. The increase in noise levels generated during the construction phase would be minimal and temporary and would have no impacts on local residents.

2.5 ENVIRONMENTALLY SENSITIVE AREAS

2.5.1 Floodplains

Encroachment on floodplains, such as artificial fill, reduces the flood-carrying capacity of streams, increases the flood heights of streams, and increases the frequency of flooding in areas upland of the obstruction.

In order to provide a national standard without regional discrimination, floodplain management measures have been developed by the Federal Emergency Management Agency (FEMA) using the 100-year flood as the base flood. The 100-year flood is defined as an event which has a 1-percent chance of being equaled or exceeded in any given year. The 500-year flood (0.2 percent chance of annual occurrence) is employed to indicate additional flood-risk areas in the community. In cases where the 100-year and 500-year flood boundaries are relatively close, only the 100-year boundary is indicated. Boundaries of the 100-year and 500-year floods within the study area are depicted on the flood boundary and floodway map (figure 2-13). No floodplains have been designated within the limits of the site.



SCALE: 1"= 2000'

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

FLOOD BOUNDARY AND FLOODWAY MAP

FIGURE 2-13

The area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is a channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order to accomodate the 100-year flood without producing a substantial increase in flood heights. The area immediately adjacent to the floodway is termed the floodway fringe. This area includes a portion of the floodplain that could be completely obstructed without increasing the flood heights above State standards. (The FEMA limits the flood heights to 1 foot, providing hazardous velocities are not reached. The State of New Jersey, however, has established criteria limiting the flood height to 0.2 feet.)

The NJDEP has delineated Flood Hazard Areas around portions of the Metedeconk and Manasquan rivers within the study area, as authorized under the Flood Hazard Area Control Act (N.J.S.A. 58: 16A-50 et. seq.), and by FEMA. Where Flood Hazard Areas have not been delineated by NJDEP or FEMA, the 10-foot contour line is used as the inland boundary of the floodplain (NJDEP, 1982).

2.5.2 Rare and Endangered Species

Section 4(c) of The Endangered Species Act of 1973 requires the Secretary of the Interior to publish in the Federal Register, and from time to time revise, if necessary, a list of all species determined by him or the Secretary of Commerce to be threatened and/or endangered species. A list of these species are found in the Endangered and Threatened Wildlife and Plants, 50 CFR 17.11 and 17.12., Dept. of the Interior, U.S. Fish and Wildlife Service.

The term "threatened species" means any species which is likely to become an endangered species within the forseeable future throughout all, or a portion of, its range. An "endangered species" is any

species which is in danger of extinction through all, or a portion of, its range excluding species of the Class Insecta (Public Law 93-205, 1978).

The New Jersey State Endangered Species legislation was adopted by the State to assist in protecting species or subspecies of wildlife which are deemed to be endangered, including those on any federal endangered species list. According to the NJDEP, an endangered species is one whose prospects for survival within the State are in immediate danger due to one or many factors: a loss of, or change in, habitat, over-exploration, predation, competition, or disease.

The NJDEP Division of Fish, Game and Wildlife has published a list of threatened and endangered species in New Jersey. A list of species from this list that may occur in the study area based on feeding and breeding range and habitat requirements is provided in Table D-6 of appendix D. Of these species, the following have been sighted in the study area: bog turtle, timber rattlesnake and pine snake.

The State of New Jersey does not have an official listing of threatened or endangered plant species. However, a report entitled, Rare or Endangered Vascular Plants of New Jersey, March 1975, lists those species that should be given primary consideration for preservation, conservation and protection (Fairbrothers, D. and M. Hough). A rare species as defined here is not currently threatened with extinction, but it occurs in such small numbers in New Jersey that it may become endangered if its environment deteriorates further or other limiting factors are altered. A list of plant species that may occur in the study area is included in table D-7 of appendix D.

Due to past excavation and filling operations, there are no endangered species on the site and no habitate exists that is conducive to their migration onto the site.

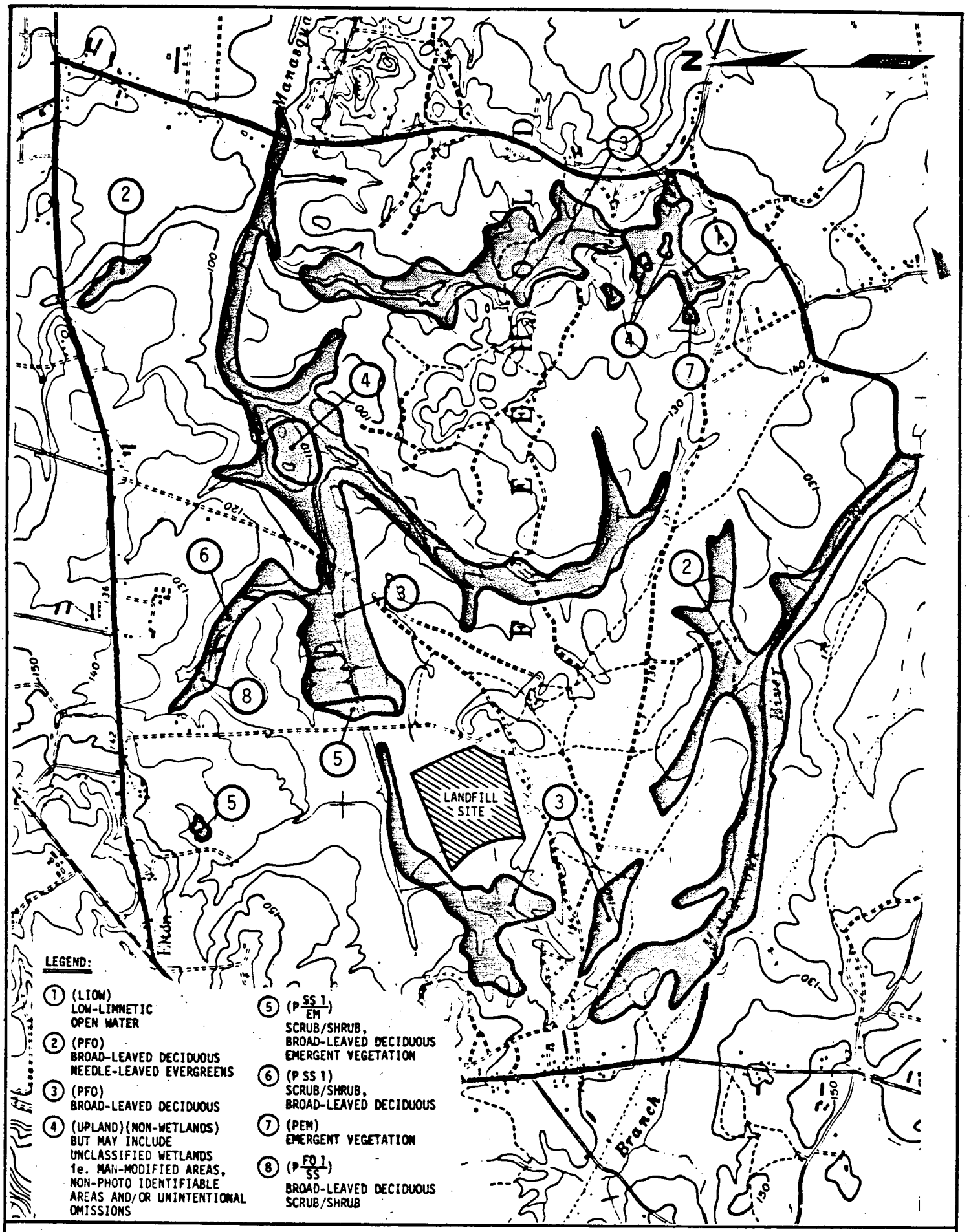
2.5.3 Wetlands

Wetlands are those areas that are frequently inundated by surface or groundwater and normally support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. The soil tends to be saturated with water, salt or fresh, and numerous channels or ponds of shallow or open water may be found. Because of a number of ecological factors, they generally comprise a rigorous (highly stressed) habitat, occupied by relatively small, relatively specialized indigenous fauna and flora. Wetlands comprise the marshes, swamps and bogs. They are vital resources in that they provide natural flood control, stabilize stream flow and may act as sediment and pollutant traps. They are essential to aquatic life of all types and as habitats for many wildlife species.

There are several wetland types that have been mapped by the U.S. Fish and Wildlife Service (FWS) in the study area. The distribution of these wetlands is depicted in figure 2-14. Wetland classifications are based on types of vegetation and visible hydrology and geology, as interpreted from high altitude aerial photographs.

The most common types of wetlands found in the study area are swamps, marshes and bogs, with broad-leaved deciduous vegetation. These wetlands are situated primarily to the north-northeast of the site, and comprise approximately 50 percent of the total wetland area.

A simular type of wetland is found along the entire southern boundary of the study area, north of the Metedeconk River. This system includes a mixture of both broad-leaved deciduous and needle-leaved evergreens; the remaining wetlands within the study area support mainly shrubs and/or broad-leaved deciducous vegetation, characteristic of marshes and bogs (National Wetlands Inventory, Fish and Wildlife Service.)



SCLAE: 1"= 2000'

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT

LONE PINE LANDFILL

WETLAND MAP

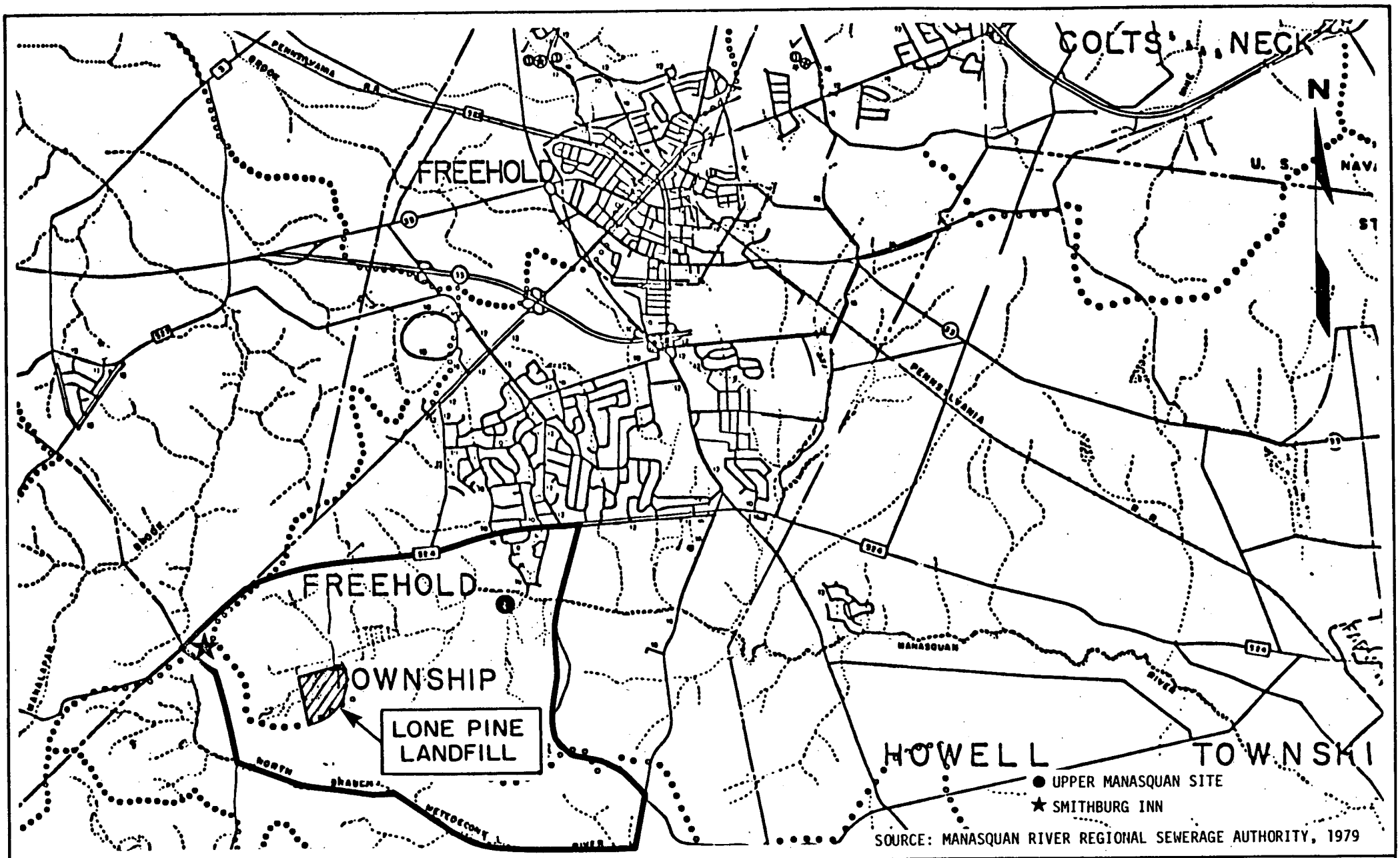
FIGURE 2-14

There are no federally-designated wetlands on the Lone Pine Landfill site.

2.5.4 Historic/Archaeological Resources

Historic and archaeological resources refer to objects, structures, neighborhoods and man-made or man-modified features of the landscape, including archaeological sites, which may or may not be included on the State or National Register of Historic Places but may be considered for inclusion (National Preservation Act 1966, as amended 1980, Section 106). Criteria used for a determination of eligibility are defined in N.J.A.C 7:4-4.2.

There are no sites within the study area that are listed on, or under consideration for inclusion in, either the State or Federal Register of Historic Places (Terry Karshner, Office of Historic Preservation, 1982). However, the Monmouth County Parks Department has designated one site within the study area as being architecturally and historically significant. The structure is a house located in the small village of Smithburg located at the crossroads of County Highway 537 and Siloam Road (see figure 2-15). The house is the most prominent (though not the oldest) remaining structure in the village. William M. Smith, son of Asher Smith, after whom Smithburg is named, originally owned the house. Asher Smith kept an inn across the road until 1856, at which time he was succeeded by his son, who sold it in 1863 (Gail Hunton, Monmouth County Park System/Monmouth County Historical Association, 1982). The structure faces northwest on a 3-acre parcel. Southeast of the house is a frame rectangular barn with wood shingles and a gable roof.



SCALE: 1"=6000'

CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ARCHAEOLOGICAL AND HISTORICAL SITES WITHIN THE STUDY AREA

FIGURE 2-15

F2r1

As part of cultural resource survey for the Manasquan River Sewerage Authority, an unnamed site was identified northeast of the study area as having archaeological and historical significance (figure 2-15). The site reportedly had kaolin pipe fragments as well as undescribed aboriginal material and was plow-disturbed. The site was not investigated on this survey but was considered of some importance.

An archaeologist for Monmouth County has found the remains of Indian artifacts in Turkey Swamp Park (Personal Communication, John Cavallo, 1982).

There are no architectural, archaeological or historical resources on the Lone Pine site.

2.5.5 Sole Source Aquifer

A sole source aquifer provides the principal source of drinking water for the overlying areas and that, "if the aquifer system were contaminated, it would create a significant hazard to public health." To date, the aquifers, underlying the landfill site have not been designated sole source, although a petition has been submitted to the USEPA (Federal Register, Vol. 44, No. 56, 21 March 1979).

2.5.6. Pinelands

Properties within the municipality of Freehold, including the Lone Pine Landfill site, are outside the legislative boundaries of the Pinelands and are not under the jurisdiction of the Pinelands Commission (Written Correspondence, Terrence Moore, 1982).

891

2.5.7 Wild and Scenic Rivers

The Wild and Scenic Rivers Act protects in their 'free flowing' condition, "designated rivers or river segments with exceptional natural, scenic, recreational or other qualities that are worthy of preservation." The Act is administered jointly by the Department of Agriculture and Interior. A river is added to the system by Federal legislation or by State legislation with the approval by the Secretary of the Interior." (USEPA, 1979).

The Manasquan River, located within the study area, has not been designated, and is not under consideration for inclusion in the State or federal Wild and Scenic River system (Jack Haubert, Wild and Scenic River Division, Dept. of Interior, 1982). The Nationwide Rivers Inventory, developed by the Department of Interior, lists those rivers which would qualify as wild and scenic if ever authorized by Congress for study. To date, the Manasquan River is not included on this list (Jack Haubert, and Dalton Dulac, Wild and Scenic River Division, Dept. of Interior, 1982).

2.5.8 Environmentally Significant Agricultural Land

It is the Soil Conservation's Service's (SCS) policy to keep a current inventory of prime farmlands and unique farmlands of the country pursuant to 7 CFR 657. This inventory is performed in cooperation with all levels of government. The objective of the inventory is to identify the extent and location of the important rural lands needed to produce food, feed, fiber, forage and oilseed crops.

As of February 1982 no such designation has been made for either the site or the study area (Carl Eby, USDA, 1982).

892

2.6 INSTITUTIONAL/REGULATORY REVIEW

A regulatory review was conducted concurrent with the development of initial remedial strategies for the Lone Pine site in order to compile information which could be used in an analysis of regulations and statutes incurred by various alternatives. These are detailed in appendix E. Those permits and review requirements that may be applicable to the proposed remedial actions at the Lone Pine Landfill site are listed below.

1. Resource Recovery and Conservation Act Permits
2. Federally Administered Wetlands/Waterway Permits
3. Permit to Generate or Transport Hazardous Wastes
4. National Pollutant Discharge Elimination System Permit
5. Water Diversion Permit
6. Approval to Disrupt a Landfill
7. Permit to Build, Modify or Operate an Air Pollution Control Device
8. Approval of a Soil Erosion and Sediment Control Plan
9. Construction Easement Approval

Section 3

3.0 DESCRIPTION OF ALTERNATIVES

3.1 INTRODUCTION

Long-term remedial action alternatives identifying methodologies to mitigate the contamination of surface water and groundwater resources in the vicinity of Lone Pine Landfill were identified in the Preliminary Report, Feasibility Study, Evaluation of Remedial Action Alternatives (CDM, 1983). The initial nine alternatives were developed based upon an evaluation of existing data, the nature and extent of the contamination identified in the vicinity of the landfill, physical limits of the landfill and on local and regional geohydrogeoloic characteristics. A general discussion of the technologies involved in each alternative is provided in the following section. More detailed information on the alternatives can be found in the Draft Report: Feasibility Study-Evaluation of Remedial Action Alternatives (CDM, 1983).

3.2 OVERVIEW OF PROPOSED REMEDIAL ALTERNATIVES

Alternative 1--No Action

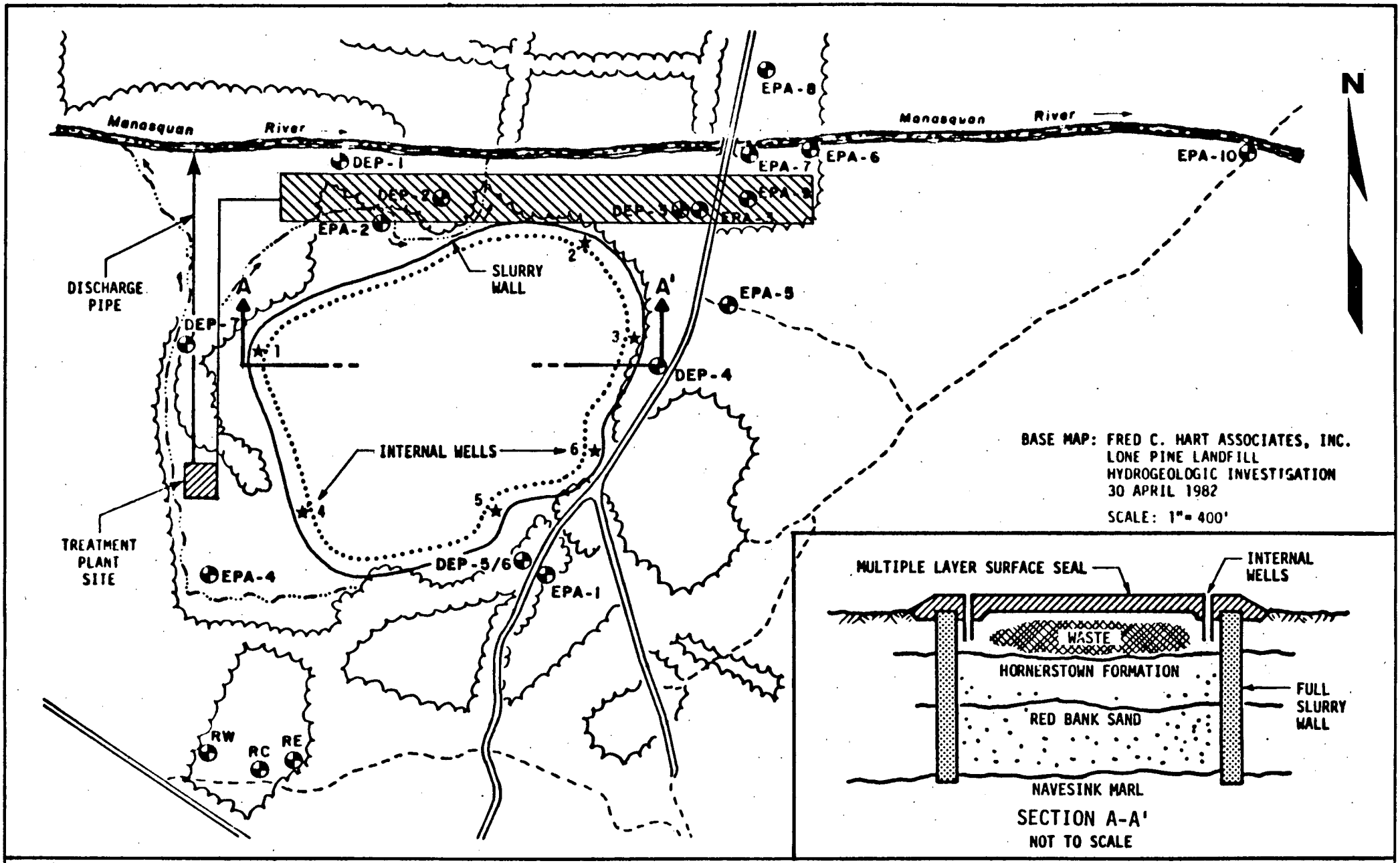
Alternative 1 is the no-action alternative. Under this alternative, no technologies would be utilized and the site would remain in its present condition for an indefinite period of time. A water and air sampling program is included to monitor changes in contaminant releases from the landfill. The objective of the monitoring program is to observe trends in groundwater, surface water, and air contaminant

characteristics. The monitoring program may be used to defer remedial action until contaminant concentrations approach certain preestablished levels. (Details of the water and air monitoring program can be found in the Draft Report Feasibility Study Report).

Current physical and biological processes now occurring on the site, such as leachate production and groundwater and surface water contamination, would continue unchecked. The potential for release of hazardous substances from the buried drums would likely increase in the future. Bulk liquids may also provide a significant source of contamination to both the groundwater and surface water. As a result, contamination from the site could increase to more hazardous levels.

Alternative 2--Deep Containment Wall with Plume Pumping, Treatment and Discharge

Alternative 2 calls for the installation of a slurry wall around the full circumference of the landfill, reaching an average depth of 140 feet to the Navesink Marl formation (figure 3-1). An internal well system is proposed to consist of six wells, each capable of extracting 10 gallons per minute (gpm). The wells would be located within the wall and would extend an average of 30 feet below ground level. At any given time, half the wells would be in service. Internal pumping is necessary for an indefinite period. In addition, external pumping would be employed outside the wall, between the Manasquan River and the northern boundary of the landfill. This wellfield would consist of 28 10-gpm wells, each reaching approximately 45 feet into the Red Bank formation. External pumping would be conducted for a period of 15 years. Contaminated water would be combined with that from the internal wells and be treated, stored and tested prior to discharging to the river. Monitoring would be performed to determine



CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ALTERNATIVE 2
DEEP CONTAINMENT WALL WITH
PLUME PUMPING, TREATMENT & DISCHARGE

FIGURE 3-1

when pumping has achieved cleanup of the surface water and groundwater. (Treated groundwater is not to exceed 50 ppm (mg/l) total organic carbon). The design of the treatment plant allows for recycling of the groundwater for additional treatment if necessary. As part of this alternative, the landfill mound would be covered by a multiple-layer surface seal. A gas-control system consisting of a series of gas monitoring wells would be provided. Initially, baseline air monitoring would be the same as described in Alternative 1. Following installation of the surface seal, total hydrocarbon monitoring (and meteorological data collection) would be repeated for 2 months to verify the effectivness of the surface seal. (See the Draft Feasiblity Study Report for details of the air monitoring program). If the need for removal of contaminated sediments from the Manasquan River and landfill tributaries is indicated by additional sediment sampling, contaminated sediments would be removed by dredging.

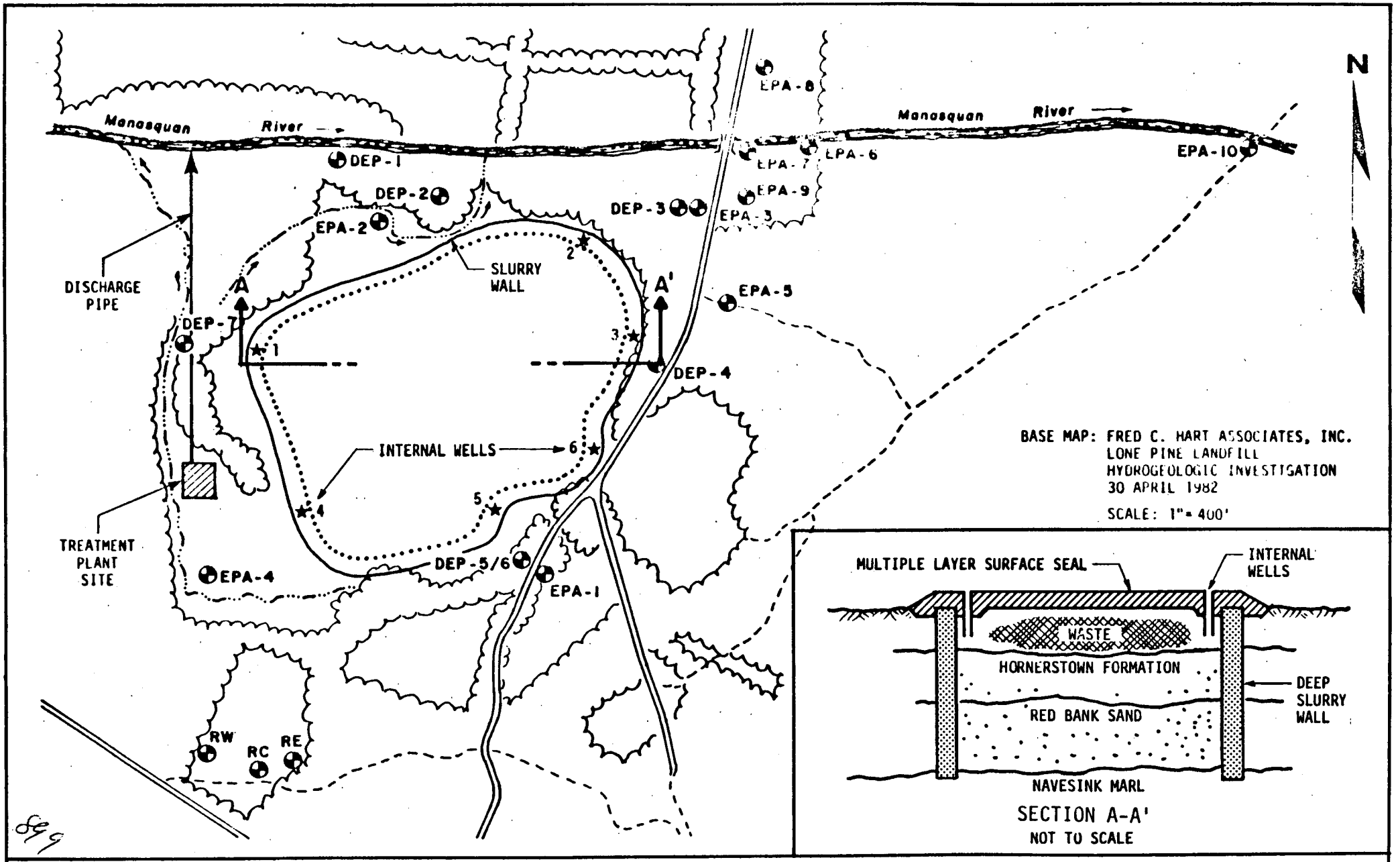
Alternative 2A--Deep Containment Wall

Alternative 2A is identical to Alternative 2, with the exception that no external plume pumping is provided (figure 3-2).

Alternative 3--Shallow Containment Wall with Plume Pumping, Treatment and Discharge

Under Alternative 3, shallow onsite containment is achieved through the use of a shallow slurry wall reaching an average depth of 30 feet into the Hornerstown formation (figure 3-3). The internal pumping system would consist of the same six wells as proposed in Alternative 2, and the wells would be pumped at the same flow rate (30 gpm total) for a period of 50 years. Alternative 3 features the same plume

598



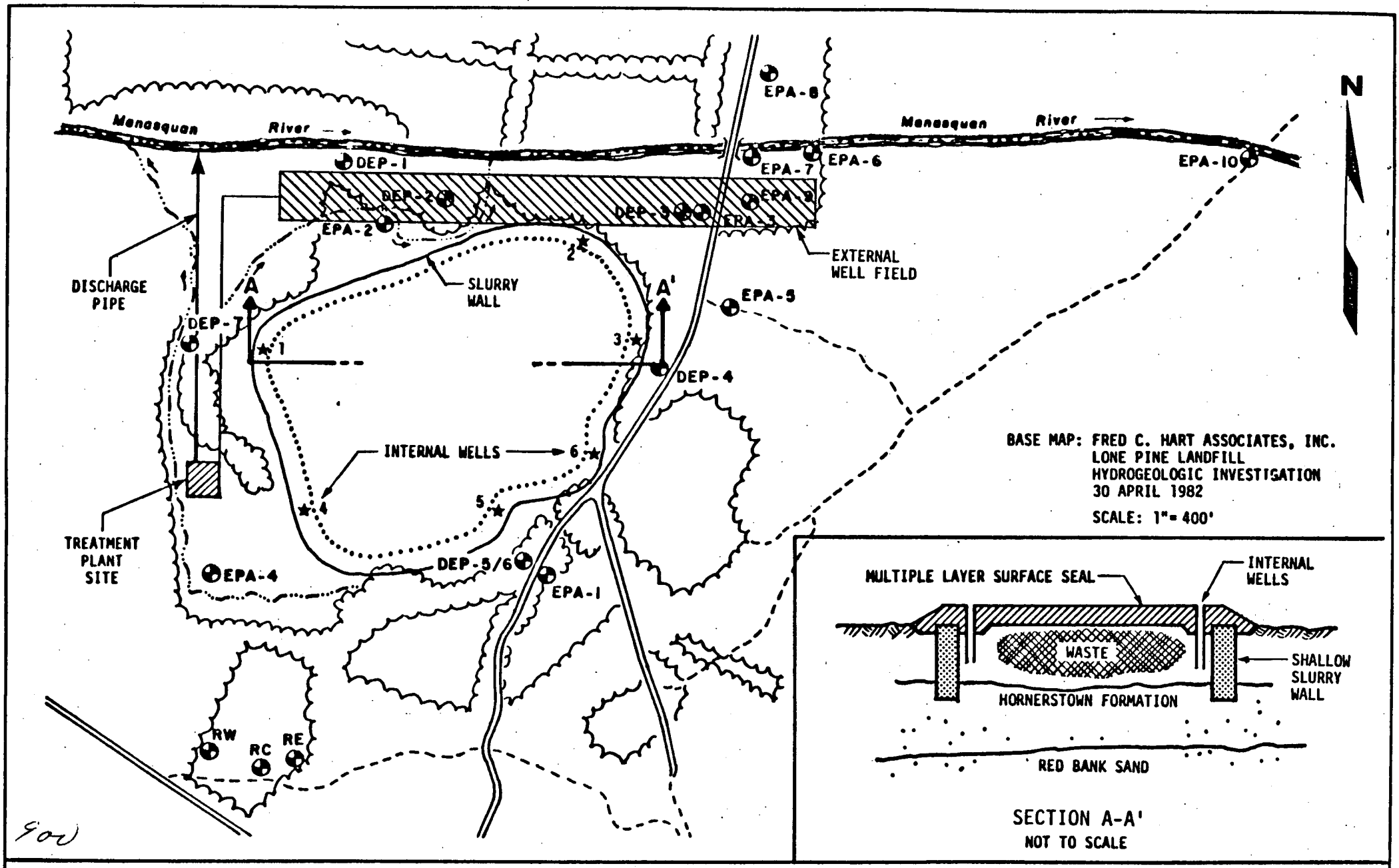
CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ALTERNATIVE 2A
DEEP CONTAINMENT WALL

FIGURE 3-2



CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ALTERNATIVE 3+3A
SHALLOW CONTAINMENT WALL WITH
PLUME PUMPING, TREATMENT & DISCHARGE

FIGURE 3-3

pumping, treatment and discharge plan as Alternative 2, except that plume pumping duration is 20 instead of 15 years. A wellfield of 28 10-gpm wells is provided, for a total pumping rate of 200 gpm. Contaminated groundwater is to be treated, stored and tested prior to river discharge. This alternative includes the placement of a multiple-layer surface seal, with provision for a methane-monitoring system. Air monitoring would be included as in Alternative 2. Dredging of the river sediments and leachate lagoons is conditional, depending upon the results of sediment sampling recently completed.

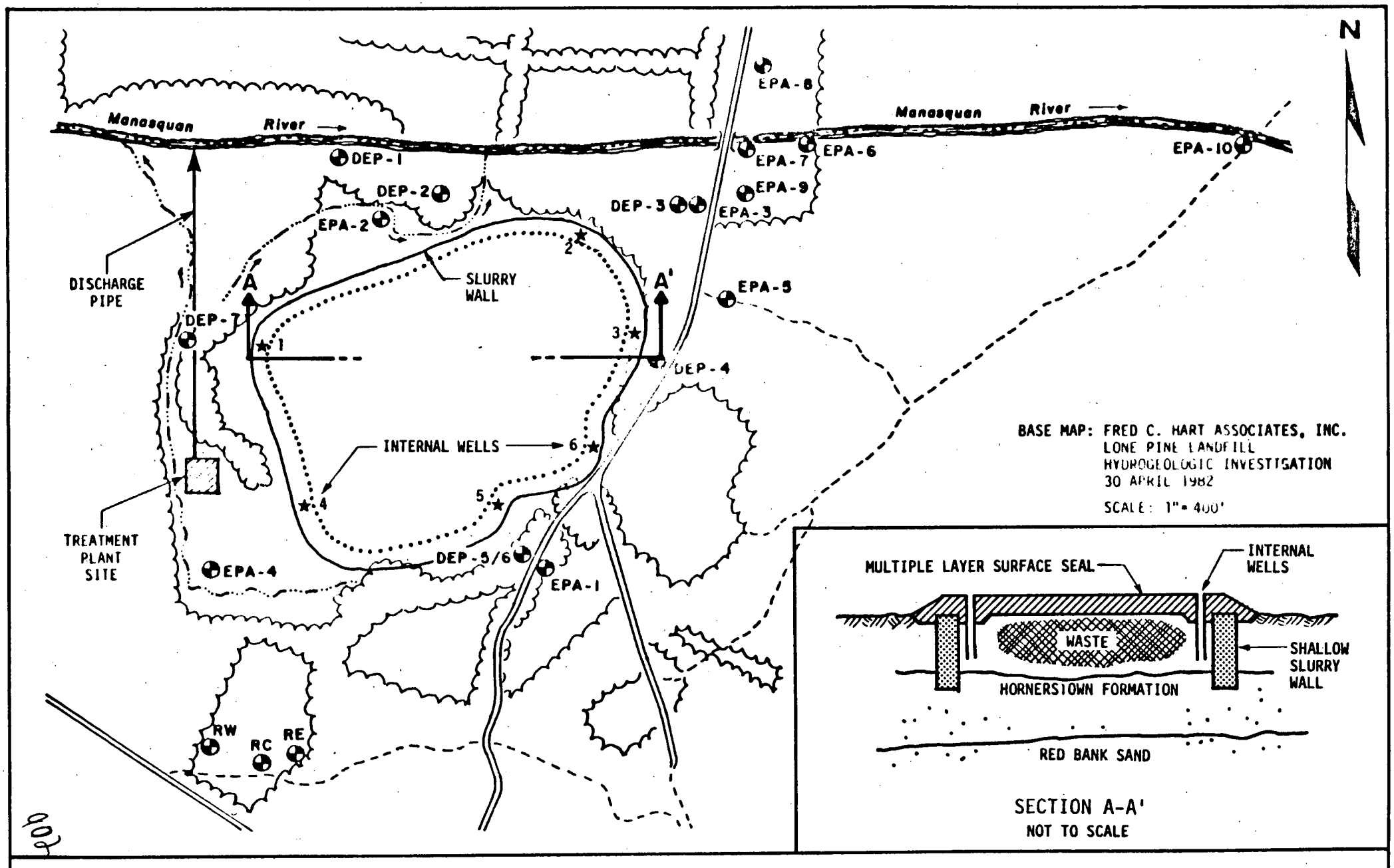
Alternative 3A--Shallow Containment Wall with High-Rate Plume Pumping, Treatment and Discharge

Alternative 3A utilizes the same technology as Alternative 3, except that the external pumping rate is doubled to a total of 400 gpm. A wellfield of 40 10 to 15-gpm wells is provided for achieving this pumping rate (figure 3-3). Contaminated groundwater would be treated and discharged by the same type of treatment facility as proposed for Alternatives 2 and 3. Surface sealing, methane-monitoring wells and sediment-control provisions are included in this Alternative and are all identical to Alternatives 2 and 3. Monitoring program provision are also as described in Alternative 2.

Alternative 3B--Shallow Containment Wall

Alternative 3B is similar to Alternative 3, with the exception that no external wells are provided (figure 3-4).

901



CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ALTERNATIVE 3B
SHALLOW CONTAINMENT WALL

FIGURE 3-4

Alternative 4--Plume Interception with Treatment and Discharge (No Containment)

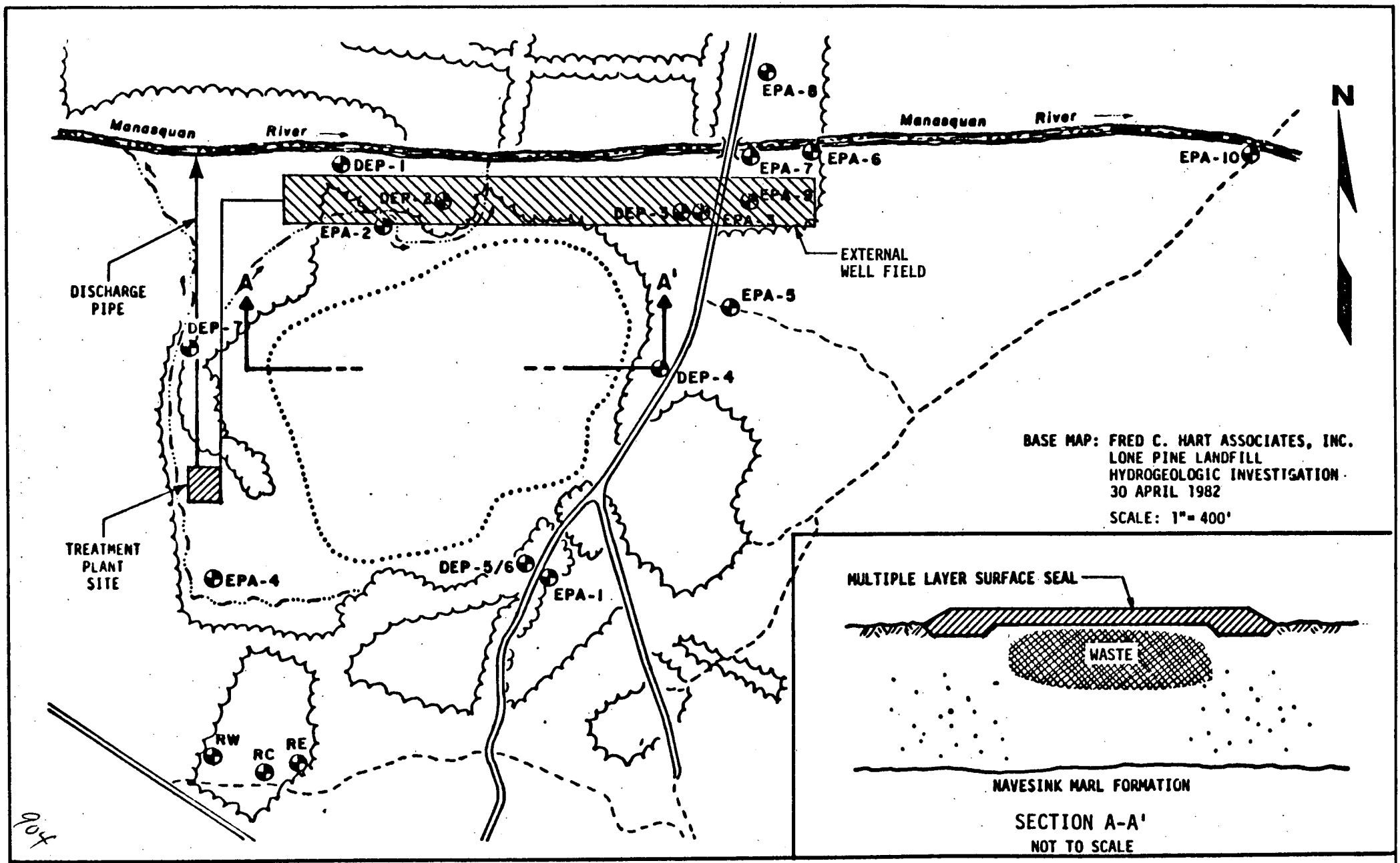
This alternative differs from Alternatives 2 and 3 in that no physical onsite containment is provided, but rather a groundwater-flow interception system is utilized to collect contaminated groundwater prior to its entering the river (figure 3-5). This groundwater interception system is composed of the same series of external wells but with a higher pumping rate than Alternatives 2 and 3. Existing data indicates that the direction of groundwater flow is towards the river, and thus interception wells are only necessary in a zone between the landfill and the river. Contaminated groundwater would be treated and discharged by the same treatment facility as proposed for Alternative 3A; the flow would be 400 gpm for 20 years. Surface sealing and sediment control provisions are described in Alternative 2, as is the proposed air and water quality monitoring program.

Alternative 4A--Surface Sealing Without Interception

In Alternative 4A the site is sealed, as in Alternative 4, but there is no external groundwater interception. This alternative examines the effect of simply sealing and closing the landfill (figure 3-6).

Alternative 5--Drum Excavation and Removal with Plume Pumping, Treatment and Discharge

This alternative provides for excavation of the buried drums on the site and removal of the contents of the drums. Estimates of the number of drums at the site range between 30,000 and 50,000. The contaminated earth and the other landfilled material would be left in the landfill except for contaminated earth removed during the drum



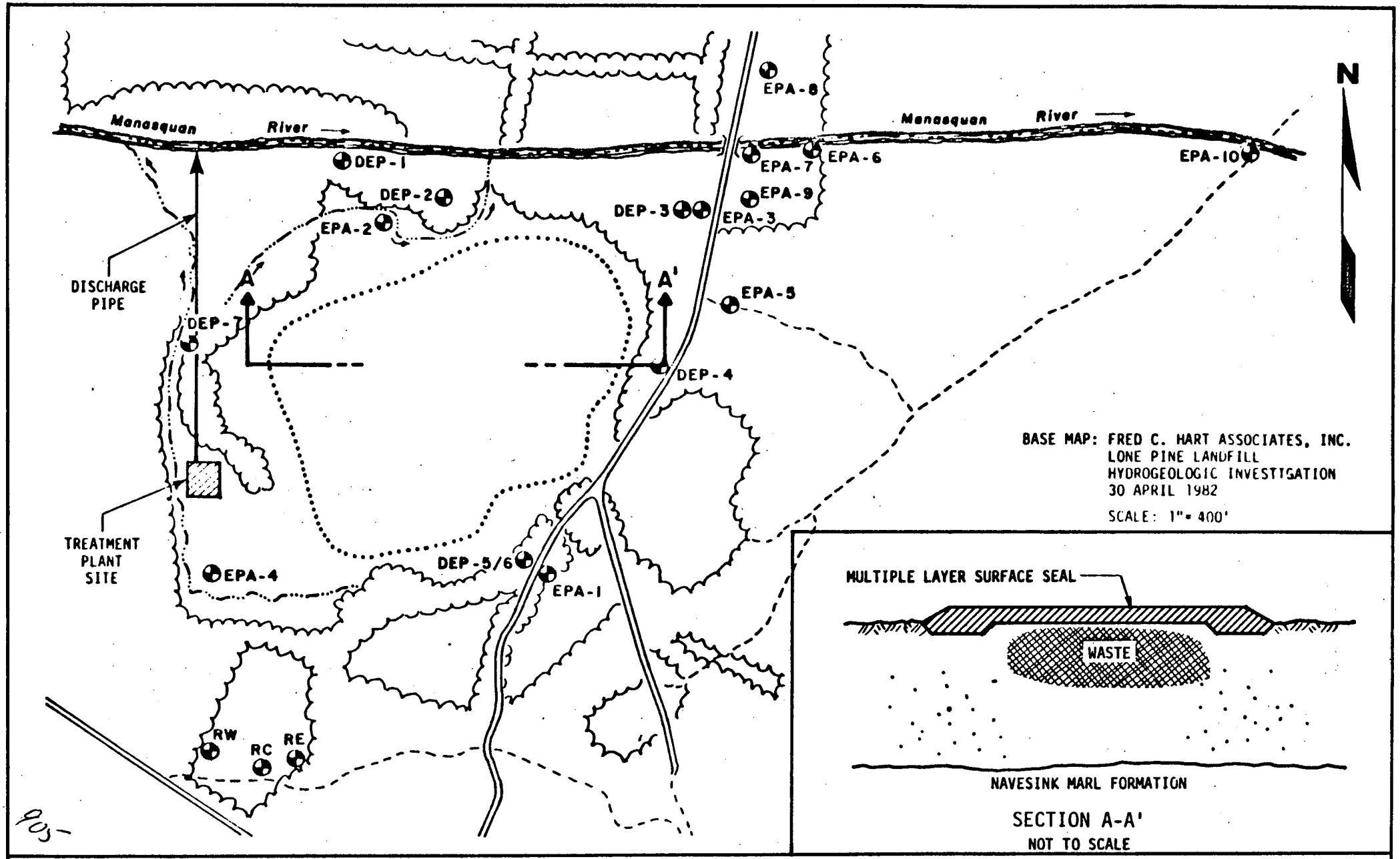
CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ALTERNATIVE 4
INTERCEPTION WITH TREATMENT & DISCHARGE
(NO CONTAINMENT)

FIGURE 3-5



CDM

environmental engineers, scientists, planners & management consultants

ENVIRONMENTAL INFORMATION DOCUMENT
LONE PINE LANDFILL

ALTERNATIVE 4A
SURFACE SEALING WITHOUT INTERCEPTION
(NO CONTAINMENT)

FIGURE 3-6

excavation operation. Excavated drums would be sampled and drums and contents prepared for transport off site. The final destination for disposal of the drums would depend on the material found in the drums. The three choices available for this final disposal are incineration, treatment or disposal in a secure landfill. The contaminated earth would be disposed of in a secure landfill.

Although the contents of the drums are removed in this alternative, the landfill mound would still contain contaminated earth and the existing contaminant plume must still be considered. External plume pumping is thus included as in Alternative 2, 3 and 4 for a 20-year period. This contaminated groundwater will be treated and discharged from the same type of treatment facility as in Alternatives 2, 3 and 4, at the flow rate of 200 gpm for a period of 20 years. Surface sealing and sediment-control provisions are also included in this alternative. Monitoring program provisions are as described in Alternative 2.

906

Section 4

4.0 EVALUATION OF ALTERNATIVES

4.1 INTRODUCTION

This section presents an evaluation of the environmental impacts associated with the nine remedial action alternatives and the five alternatives remaining after the initial screening. The major focus of this evaluation was directed at the magnitude of beneficial or adverse effects resulting from implementation of the various long-term remedial actions, relative to one another. This evaluation briefly addresses minor short-term adverse impacts associated with construction-related activities, since these impacts could be mitigated by appropriate control measures.

Table 4-1 presents these finding in an environmental matrix. Impacts have been evaluated with respect to duration and have been designated as short-term or long-term. Short-term impacts include those resulting from construction and implementation of the remedial action within a total period of 5 years. In other words, short-term impacts consider the effects of actual construction and the environmental impacts that result within the 3 to 4 years following installation. This allows a comparison between the immediate effect of each alternative on the environment. Long-term impacts are those which result from implementation of each alternative at the conclusion of the 5-year period to 20 years in the future. Twenty years was used as the cut-off point for long-term impacts, since this was the amount of time required to effectively cleanup the surface and groundwater as indicated in the computer modeling.

908

TABLE 4-1

ENVIRONMENTAL MATRIX

		PHYSICAL ENVIRONMENT				BIOLOGICAL ENVIRONMENT		SOCIOECONOMIC ENVIRONMENT			
ALTERNATIVE		GROUNDWATER	SURFACE WATER	AIR QUALITY		FLORA + FAUNA		LAND USE	POPULATION & ECONOMICS	TRANSPORTATION	ENERGY
No. 1 NO ACTION	SHORT TERM	--	--	*		--		--	--	0	++
	LONG TERM	--	--	*		--		--	--	0	++
No. 2 DEEP CONTAINMENT WALL WITH PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	+	+	*		+		+	+	--	--
	LONG TERM	++	++	*		++		+	+	0	-
No. 2A DEEP CONTAINMENT WALL WITHOUT EXTERNAL PUMPING	SHORT TERM	+	+	*		+		+	+	--	--
	LONG TERM	++	++	*		++		+	+	0	-
No. 3 SHALLOW CONTAINMENT WALL WITH PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	+	+	*		+		+	+	-	-
	LONG TERM	++	++	*		+		+	+	0	-
No. 3A SHALLOW CONTAINMENT WALL WITH HIGH-RATE PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	++	++	*		++		+	+	-	-
	LONG TERM	++	++	*		++		+	+	0	--
No. 3B SHALLOW CONTAINMENT WALL WITHOUT EXTERNAL PUMPING	SHORT TERM	+	+	*		+		+	+	-	-
	LONG TERM	++	++	*		++		+	+	0	-
No. 4 INTERCEPTION WITH TREATMENT AND DISCHARGE (NO CONTAINMENT)	SHORT TERM	+	+	*		+		+	0	-	+
	LONG TERM	+	+	*		+		+	0	0	--
No. 4A SURFACE SEALING WITHOUT INTERCEPTION, TREATMENT OR DISCHARGE (NO CONTAINMENT)	SHORT TERM	+	+	*		0		-	-	-	+
	LONG TERM	--	--	*		--		-	-	0	++
No. 5 DRUM EXCAVATION AND REMOVAL WITH PLUME PUMPING, TREATMENT AND DISCHARGE	SHORT TERM	+	+	*		+		-	+	--	--
	LONG TERM	++	++	*		+		++	+	0	-

++ BENEFICIAL

+ MARGINALLY BENEFICIAL

0 INSIGNIFICANT

- MARGINALLY ADVERSE

-- ADVERSE

* AIR QUALITY MONITORING IN PROGRESS

The degree of impact has been evaluated and rated using the following designations:

- ++ Highly beneficial
- + Beneficial
- o Insignificant
- - Minor adverse
- -- Adverse

The matrix consists of three categories: physical environment, biological environment and socioeconomic environment. The parameters listed under the physical environment and biological environment should be given the greatest consideration since these parameters directly, or indirectly, affect human health. When assessing the overall impacts of each alternative, it is important to recognize that impacts to the physical and biological environment be given more weight than those parameters constituting the socioeconomic environment.

The considerations given to each category of analysis were as follows:

4.2 ENVIRONMENTAL IMPACT METHODOLOGY

4.2.1 Physical Environment

4.2.1.1 Groundwater and Surface Water - The impacts to surface and groundwater were evaluated on both a short-term and long-term basis. Consideration was given to contaminant migration, pollutant mass, aquifer restoration, surface runoff, potential seepage of landfill leachate and discharge to the Manasquan River.

The degree of impacts was based on the length of time required for improvement in surface and groundwater quality after installation of the remedial alternative. Those alternatives providing relatively fast clean up of the surface and groundwater were rated as benefical on a short-term basis. Relative rating of long-term impacts on ground and surface water considered the effectiveness in containment and/or removing the source of contamination. The data base used in evaluating the impacts to surface and groundwater was obtained primarily from section 4.0 of the Draft Feasibility Study Report.

4.2.1.2 Air Quality - Because monitoring of on-site air quality is in progress, no definitive analysis of the air quality impacts of each alternative could be made. Although air quality data is required to supplement the limited data presently available, some conclusions have been made primarily based on anticipated levels of exposure that could be expected under each alternative. Certain assumptions have been made regarding excavation and removal of the drums, Alternative 5, based on the limited data available on the character and quantity of contaminants found in the soil, surface water and groundwater; and past excavation projects performed at hazardous waste sites; particularly in respect to the emission of volatile organic chemicals during excavation of the drums.

4.2.2 Biological Environment

4.2.2.1 Flora and Fauna - This category includes an assessment of impacts to aquatic plants and animals, wetlands and wildlife. The relative impacts of each alternative was based primarily on the length of time required for cleanup of the surface and groundwater and the effective containment of pollutants over a 20-year period. Remedial alternatives providing rapid cleanup of surface and groundwater were considered to have greater short-term and long-term beneficial impacts on plants and animals. This category also addressed potential impacts on human health.

911

4.2.3 Socioeconomic Environment

4.2.3.1 Land Use, Population and Economics - Impacts on land use, population and economics resulting from implementation of each alternative were based on the overall impacts to the physical and biological environmental categories. This assessment considered impacts on future potential growth and development in the study area and impacts to adjacent parklands. The migration of residents into and out of the study area resulting from implementation of each alternative was also considered.

4.2.3.2 Transportation - This environmental parameter included the impacts associated with short-term construction-related activities, off-site transport of hazardous wastes, as well as long-term impacts associated with the transport of sludge generated by the groundwater treatment facility.

4.2.3.3 Energy. This environmental parameter included the impacts on energy resources associated with short-term construction-related activities such installation of a slurry wall, site grading and placement of a clay cap, implementation of internal and/or external extraction wells, and construction of the wastewater treatment facility. Long-term impacts on energy resources focused on the magnitude and duration proposed for abatement pumping of the contaminant plume under each of the alternatives.

The written discussion accompanying this matrix provides a descriptive evaluation of the degree of impact of each alternative on specific environmental parameters of concern. As with the matrix, the degree of impact of each alternative is relative to all other alternatives considered.

4.3 ENVIRONMENTAL IMPACTS OF REMEDIAL ALTERNATIVES

4.3.1 Alternative 1-No Action

Alternative 1 is the No Action alternative. Under this alternative, no technologies would be utilized to remedy the current situation, and the site would remain in its present condition for an indefinite period of time. However, as part of this alternative a continuous air monitoring program and a periodic sampling program for stream sediments and water quality would be implemented. Since limited site-specific baseline air monitoring data for Lone Pine Landfill exists, the first phase of the recommended air monitoring program would be designed to establish baseline conditions to enable a determination of the nature and extent of air emissions and the potential effects of these emissions. Recommendations on the extent and duration of future monitoring efforts would then be made based on the information accumulated. At this time a program would be developed to serve as an ongoing warning system of changing conditions.

4.3.1.1 Ground and Surface Water

Groundwater modeling results indicate that the spatial extent of aquifer contamination at the site will not increase over time. Pollutants leaching from the Vincentown sand into the lower aquifer layers are transported from beneath the landfill in a northeasterly direction and eventually are discharged to the river in close proximity to the landfill.

Modeling results also indicate that a gradual increase in total pollutant release to the Manasquan River. These results indicate that under existing conditions an average annual total volatile organic concentration of 1000 parts per billion (ppb) at Burke Road

can be expected to increase to 1300 ppb over 20 years if no action is taken at the site. On a total mass basis, these values are likely to represent only a lower limit to contaminant transport to the river. This is due to the fact that "average annual conditions" at the site were simulated, which can only partially be assumed to indicate the effects of short duration, high intensity rainfall events. Although these events are relatively infrequent, they may allow for a significant release of contaminants to the river through overland flow.

This is of particular importance at this site since the landfill is in close proximity to the Manasquan River and its tributaries, and the drainage ditches encircling the site discharge directly to the river. Preliminary estimates indicate that volatilization should be virtually complete (i.e., volatile organic levels would be reduced to background levels) during the sixteen mile passage from the landfill to the proposed reservoir intake. Water quality problems at the reservoir may occur if high concentration of nonvolatile contaminants are released from the drums and bulk liquid wastes. Since the data available on such contaminants is positive in some cases, there is cause for significant concern should the source not be controlled.

Under the No Action alternative, leachate would continue to seep from the surface of the landfill. This would contribute to further deterioration of surface water quality beyond that anticipated from base flow discharge.

4.3.1.2 Air Quality

Because monitoring of on-site air quality is in progress, no definitive analysis of the air quality impacts associated with the No Action alternative can be made at this time.

The current air monitoring program and the continuing program proposed under this alternative will provide data necessary for a complete air quality evaluation.

4.3.1.3 Flora and Fauna

Various site inspection reports have noted that the aquatic life within the Manasquan River has been adversely affected by the discharge of contaminated sediments and surface runoff. The headwaters of the Manasquan has been described as a "total kill area" with no signs of biological life (Lester W. Jargowsky, Health Officer for Monmouth County). Most of the bottom of the river is coated with a soft, black sludge and a dense growth of grey to red colored slime. Benthic organisms consisted primarily of Tubifex worms. These organisms indicate a highly organic environment and unhealthy conditions. No signs of green aquatic plant life are evident. In addition, wetlands adjacent to the river are severely stressed by the accumulation of contaminated sediment and runoff. Under the No Action alternative, the concentration of pollutants discharging into the Manasquan River from the landfill would continue to increase over time, adversely impacting areas further downstream.

4.3.1.4 Land Use

Under the No Action alternative, an adverse impact could occur to current property values and future growth and development in the study area due to the public's perception of adverse health effects resulting from air, water, soil and/or wildlife contamination. Development of new homes in those areas currently zoned for residential development north of the landfill could be discouraged due to the persistence in concern of the hazardous nature of the site and

continued contamination. Parklands adjacent to the landfill that are currently unaffected, could be adversely impacted due to the increased contaminant load carried downstream in the Manasquan River. That portion of the river located within the park would no longer be able to support waterfowl and other forms of wildlife. Contamination of all or portions of the parklands could be detrimental to public health and could result in restricted access to certain areas and/or closing of the park.

4.3.1.5 Population and Economics

The No Action alternative could have adverse impacts on the population within the study area resulting from the public's perception of adverse health effects mentioned previously. Allowing the existing condition to continue unabated could discourage development in the area and the subsequent in-migration of new residents. In fact, the No Action alternative could eventually result in the out-migration of local residents.

Minor adverse economic impacts could be closely tied to the impact on population and community growth potential. Halting the construction of new homes, coupled with the out-migration of area residents, could have marginally adverse impacts on local economics by eliminating the new jobs that would be generated during construction of new homes and could discourage local trade. These impacts would be minimal since future development plans within the study area call for low to medium density housing.

4.3.1.6 Transportation

Under Alternative 1 there would be no short-term or long-term impacts on transportation.

4.3.1.7 Energy

There would be no significant energy requirements under the no action alternative. The only energy required would be as part of the stream sediment, water quality, and air monitoring programs.

4.3.2 Alternative 2--Deep Containment Wall With Plume Pumping, Treatment and Discharge

Alternative 2 calls for the installation of a deep slurry wall around the full circumference of the landfill. An internal and external well system is proposed. Contaminated water from both well systems would be treated, stored and tested prior to discharging into the Manasquan River. Initially, baseline air monitoring would be the same as described in Alternative 1. Following installation of the landfill surface seal, total hydrocarbon monitoring would be repeated for 2 months to verify the effectiveness of the surface seal. (Details of the air monitoring program can be found in the Draft Feasibility Study Report.)

4.3.2.1 Groundwater and Surface Water

Construction of a deep slurry wall around the full circumference of the landfill would have similar short-term impacts as Alternatives 2A, 3 and 3B. These impacts would be significantly more benefical on the quality of both surface and groundwater than Alternative 1 but would be slightly less beneficial than Alternative 3A. Long-term impacts would be significantly more beneficial than Alternative 1, 4, 4A and 5. Sinking the wall to 140' will intercept the Navesink formation, a confining layer beneath the Red Bank Sand and the overlying formation. This procedure will severely retard the flow of contami-

nants rather than completely stopping it. Internal pumping will create a negative pressure gradient within the confines of the wall and restrict the movement of contaminated groundwater away from the site. This procedure would allow a relatively rapid cleanup of the aquifer and surface water.

Groundwater modeling results indicate that contaminants would continue to be discharged to the Manasquan River for a 15-20 year period after the site is contained. Although an upward movement of groundwater through the Hornerstown formation will continue to transport contaminants in this layer to the river, total mass release to the river is significantly reduced. The 100 ppb standard for discharge of volatile organics into surface and groundwater would be reached within six years after installation. Preliminary estimates of the dilution of contaminants within the Manasquan six years after installation indicate that the volatile organic concentration from the Lone Pine Landfill reaching the proposed reservoir would not exceed background levels at the intake.

Implementation of a multiple layer surface seal would reduce leachate seeps above ground level. This would have a long-term beneficial impact on the quality of surface water by decreasing the contaminant load transported to adjacent water bodies and wetland areas.

4.3.2.2 Air Quality

As noted previously, monitoring of onsite air quality is in progress and, therefore, impacts on air quality resulting from implementation of this alternative cannot be completely assessed at this time. Air quality monitoring will provide data necessary for a complete air quality evaluation.

Available groundwater data indicates that some of the volatile organic compounds are already present in sufficient concentrations to be emitted at elevated levels during the proposed air stripping process. Based on findings from similar pilot plants and treatability studies, the volatile compounds of concern (vinyl chloride, benzene and toluene) could be completely removed from groundwater by the air stripping process. This would result in certain volatile organic compounds emitted from the air stripping process exceeding the 0.1 lb/hour emission rate limitation set by NJDEP. This, in turn, would require the air stripping unit to be registered by the Department prior to construction. Exceeding this limit should not be misconstrued to represent a threat to public health. This limit provides a point from which additional controls should be evaluated for inclusion in the design of the treatment facility.

While uncontrolled air-stripping of the contaminated groundwater could potentially emit volatile organics above the 0.1 lb/hr. threshold limit established by NJDEP, conventional air pollution control devices could be installed on the air stripping units to prevent exceeding specific exposure limits. Exposure of water treatment plant operators to process emissions would be reduced through the use of protective equipment, such as encapsulated suits, chemical safety glasses, rubber boots, gloves and coveralls (Generic Site Investigation Protocol for Uncontrolled Hazardous Wastes Sites, CDM, 1982). It is not anticipated that air emissions from the treatment facility would have any negative impacts on residents in the area due to the distance of the landfill site from the residents and the dilution of the vapors in the air. Nevertheless, further evaluation of site-specific air quality data and modeling of plume dispersion from the air stripping units are required before a final assessment can be determined.

This alternative also provides for the installation of a methane venting system if monitoring results indicate significant concentrations are being generated. Installation of this system would help to control the migration of methane off-site and collection in clay pockets that could result in explosions and fires. In the event that methane vents are found necessary, air pollution control equipment, such as a carbon adsorption system, would be installed to prevent uncontrolled emissions of landfill gases.

4.3.2.3 Flora and Fauna

Implementation of Alternative 2 would have beneficial, long-term impacts on area plants and animals compared to the No Action alternative. Placement of a surface seal would allow revegetation of the site to occur and eventually provide habitats for many species of plants and animals. (However, burrowing animals would be detrimental to the integrity of the surface seal). Leachate seeps above ground level would be reduced by a surface seal, as would the transport of contaminated sediments and water to the Manasquan River. This technology, used in conjunction with a slurry wall and groundwater pumping and treatment, would allow a gradual restoration of the wetland areas and biological communities normally found in the headwaters of the Manasquan River. In addition, this alternative would provide safe drinking water to the wildlife located within the area. The gradual restoration of the wetland areas and adjacent surface waters would indicate an improvement in the environment and a beneficial long-term impact on public health, similar to Alternatives 2A, 3, 3A, and 3B.

920

4.3.2.4 Land Use

When compared to the no-action alternative, Alternative 2 would have a marginally beneficial impact on land use by improving the quality of the surface and groundwater. This alternative would protect the neighboring parklands from potential adverse impacts and would allow continuing development of new homes in areas currently designated for such use, the impact would be marginal because most of the undeveloped land in the vicinity of the landfill is zoned 5-acre, rural residental. This classification allows for limited development of single family detached housing units on 5 acre parcels. Therefore, under normal conditions, very little growth could occur.

4.3.2.5 Population and Economics

Alternative 2 would have marginally beneficial long-term impacts on the local population because this alternative would allow the areas continued growth under current rural residential zoning. In addition, marginally beneficial long-term impacts on economics could be anticipated because this alternative would allow for continued growth of the existing local economy.

Improvements in the quality of surface and groundwater under this alternative would not discourage new development in the area that may be anticipated with the No-Action alternative.

The movement of any new residents into the area would generally have a marginally beneficial impact on the local economy. Since only a few new residents could be expected to move into the community under normal growth, this could be translated into minor benefits to local trade.

4.3.2.6 Transportation

Construction under this alternative would have adverse short-term impacts on transportation, due to the mobilization and demobilization of construction equipment, such as hydraulic backhoes, bull dozers, slurry mixers, etc., that would utilize local roadways to gain access to the site. These short-term impacts would be similar to Alternative 2A. There would be regular deliveries of construction materials and other equipment throughout the period of construction. This would include deliveries associated with the excavation and placement of the slurry wall, site grading and application of the clay cap, development of the extraction wells, and construction of the treatment facilities.

Although the sludge generated by the treatment facilities would require additional tank trucks for transporting the sludge off-site, this would result in an estimated two trucks per week. Therefore this would have no significant impact on transportation on a long-term basis.

4.3.2.7 Energy

Construction of a deep slurry wall to an estimated depth of 140 feet would expend substantially more energy than would construction of only a shallow slurry wall to an estimated depth of 60 feet proposed under Alternatives 3, 3A, and 3B. As a result, this alternative would have an adverse short-term impact to energy resources.

The energy required for pumping and treatment under this alternative would have a long-term adverse impact similar to Alternatives 2A, 3 and 3B which all require the same level of pumping and treatment. The pumping period for the external wells would be at least 15 years.

Internal pumping is necessary for approximately 50 years, during which time groundwater treatment would be performed. Both the pumping and groundwater treatment called for under this alternative would expend significantly more energy than those alternatives (such as 1 and 4A) which do not provide for these remedial actions.

4.3.3 Alternative 2A--Deep Containment Wall

Alternative 2A utilizes all of the same technology as Alternative 2 without external plume pumping.

4.3.3.1 Groundwater and Surface Water

Alternative 2A would have similar short-term beneficial impacts on ground and surface water to Alternatives 2, 3, 3B, 4, 4A and 5. Groundwater modeling of this alternative indicates that the flow field north of the landfill closely approximates that under existing conditions, maintaining an upward gradient through all layers to the river. South of the landfill, no discernible change is apparent from that of Alternative 2.

Contaminant concentration in the Upper Red Bank Sand and Vincentown Sand after 15 years are higher than those indicated under Alternative 2. It is important to note, however, that aquifer restoration under Alternative 2A is achieved through natural aquifer flushing to the Manasquan River, whereas in Alternative 2, some of the pollutant mass outside the wall was captured through pumping. Within 7.5 years after installation of this alternative, the concentration of volatile organic compounds discharging into the Manasquan River at Burke Road would be reduced to 100 ppb. It appears from the groundwater model-

ing results and data available that after implementation of all the technologies provided for under this alternative that dilution and volatilization would reduce volatile organics generated by the Lone Pine Landfill to background levels at the reservoir intake.

When compared to Alternative 2 this alternative would have similar long-term beneficial impacts on groundwater and surface water. These impacts would be relatively the same for 3, 3A and 3B as well.

4.3.3.2 Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with Alternative 2A can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lbs/hr. Air quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment which would need to be specified during the conceptual design.

4.3.3.3 Flora and Fauna

Implementation of Alternative 2A would have similar short-term beneficial impacts on plants and animals as Alternatives 2, 3, 3B, 4 and 5. Under Alternative 2A, however, the contaminated plume would continue to discharge at slightly higher levels than Alternatives 2, 3 and 3A into the Manasquan River for a fifteen year period. The concentration of volatile organics in the Manasquan River would exceed

the 100 ppb standard for approximately 7.5 years following installation of the slurry wall. On a long-term basis, cleanup of the surface and groundwater would have beneficial impacts on flora and fauna, as well as public health.

4.3.3.4 Land Use

The overall long-term beneficial impacts to land use described for Alternative 2, would also apply to this alternative.

4.3.3.5 Population and Economics

The long-term beneficial impacts to population and economics associated with Alternative 2, would also apply to this alternative.

4.3.3.6 Transportation

Construction of the 140-foot deep slurry wall site grading and application of the clay cap, installation of internal extraction wells and construction of the wastewater treatment facilities would have adverse short-term impacts on transportation, similar to Alternative 2. There would be no long-term impacts on transportation resulting from the transport of sludge off-site since the number of truck trips would be insignificant as described in Alternative 2.

4.3.3.7 Energy

Short-term energy expenditures under this alternative would be similar to Alternative 2 except that no energy would need to be expended for external extraction well field. This would result in short-term adverse impacts on energy resources similar to but marginally less than Alternative 2.

Alternative 2A would have less adverse long-term impacts on energy resources than those described under Alternative 2. Deletion of external extraction wells would reduce the energy requirements for pumping and reduce the quantities of groundwater that would require treatment under Alternatives 3A, 4 and 5.

4.3.4 Alternative 3 - Shallow Containment Wall With Plume Pumping, Treatment and Discharge

Alternative 3 utilizes the same technology as Alternatives 2 and 2A. Onsite containment, however, is provided through the use of a shallow slurry wall penetrating to an average depth of approximately 30 feet. Surface sealing and sediment control (if necessary) are also provided as described in Alternative 2. A monitoring program would be included as described in Alternative 2.

4.3.4.1 Groundwater and Surface Water

Under Alternative 3, the short-term impacts to groundwater and surface water would be marginally less beneficial than Alternative 2. Long-term beneficial impacts on surface water and groundwater would be similar to Alternatives 2, 2A, 3A and 3B.

Unlike Alternatives 2 and 2A, which utilize a deep slurry wall, Alternative 3 allows a continuous migration of contaminants from the Red Bank Formation under the landfill to occur since contaminants have most likely already entered this level. External plume pumping would not effectively intercept all contaminants that have already entered the Red Bank formation and are moving toward the Manasquan River. This alternative leaves a significant mass of contamination within the active flow field, which would have a better chance of being removed from the system with the deep wall. This mass of concentration remaining in the plume would be higher than that found with Alternatives 2 and 2A. Groundwater modeling results however, indicate that after 20 years of pumping, the plume would be effectively controlled in the Red Bank formation. Long-term beneficial impacts on surface water and groundwater would be similar to Alternatives 2, 2A, 3A and 3B.

Pumping beyond 20 years at 200 gpm under this alternative is not advisable as a means to control concentrations within the Hornerstown formation. Any residual contaminants remaining in the system after 20 years would be removed by natural aquifer flushing. This implies eventual direct discharge to the river itself.

4.3.4.2 Air Quality

Because monitoring of onsite air quality is currently in progress, no definitive analysis of the air quality impacts associated with this alternative can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lbs/hr. Air quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment which would need to be specified during the conceptual design.

4.3.4.3 Flora and Fauna

The short-term impact of this alternative on area flora and fauna would be similar to 2, 2A, 3B, 4 and 5, but slightly less beneficial than Alternatives 3A since cleanup of the surface and groundwater would proceed at a slower rate. As stated previously, continued migration of contaminants from the Red Bank formation under the landfill to the Manasquan River would be likely. This migration would allow a portion of the plume to discharge into the Manasquan River for a longer period of time, resulting in an adverse impact on plant and animal life. In addition, this alternative calls for discontinuing external pumping after 20 years and provides for cleanup of the Hornerstown formation only through natural aquifer flushing. The movement of contaminants from the surficial aquifer would then be discharged directly into the river. Long-term beneficial impacts of this alternative on flora and fauna, as well as public health, would be similar to Alternatives 2, 2A, 3A and 3B.

4.3.4.4 Land Use

The beneficial impacts on land use would be similar to those impacts discussed under Alternatives 2, 2A and 3A and 3B by improving the quality of surface and groundwater and thus allowing current land uses and development to occur as planned.

4.3.4.5 Population and Economics

Implementation of this alternative may have marginally beneficial long-term impacts on population and economics. These impacts would be equal in magnitude to those impacts associated with Alternatives 2, 2A, 3A and 3B, since growth and local economic development would not be inhibited.

428

4.3.4.6 Transportation

Construction of this alternative would have marginally adverse short-term impacts on transportation and would be less than those described in Alternatives 2 and 2A because the magnitude and duration of construction of a shallow slurry wall would be substantially less. Long-term impacts on transportation resulting from the transport of sludge off-site would be insignificant as described in Alternatives 2, 2A, 3, 3A, 3B, 4, and 5.

4.3.4.7 Energy

The construction of this alternative would have less short-term impacts on energy resources than Alternatives 2 and 2A since substantially less energy would be expended for construction of a shallow slurry wall.

After 20 years of pumping, the contaminant plume should be effectively controlled in the Red Bank Formation. The energy required for external pumping and groundwater treatment would have an adverse impacts on energy resources, similar to Alternatives 2, 2A, and 3B. These impacts would be marginally less adverse resources than 3A and 4.

4.3.5 Alternative 3A--Shallow Containment Wall With High-Rate Plume Pumping, Treatment and Discharge

Alternative 3A utilizes the same technology as Alternative 3, except that the external pumping rate is doubled to a total of 400 gpm.

4.3.5.1 Groundwater and Surface Water

This alternative would have more beneficial short-term impacts on groundwater and surface water than Alternatives 1, 2A, 3, 3B, 4, 4A and 5. Long-term beneficial impacts would be similar to Alternatives 2, 2A, 3 and 3B.

Groundwater modeling results of Alternative 3A indicate that doubling the pumping rate within the external well field allows for improved capture of pollutants and a resultant decrease in contaminant release to the Manasquan River. The concentration of volatile organic compounds discharging into the Manasquan River at Burke Road would meet the current 100 ppb standard approximately 3.5 years after installation. These modeling results, however, indicate that the increased rate of plume pumping would not significantly decreased the duration of pumping significantly below 20 years.

4.3.5.2 Air Quality

Because monitoring of onsite air quality data is in progress, no definitive analysis of the air quality impacts associated with Alternative 3A can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lbs/hr. Air quality impacts associated with these emissions could be mitigated through installation of air pollution control equipment which would need to be specified during the conceptual design of the treatment facility.

4.3.5.3 Flora and Fauna

Based upon modeling results, the short-term beneficial impacts to plant and animal life under this alternative would be greater than those of all other Alternatives. This is because cleanup of both surface water and groundwater would proceed at a much faster rate and would achieve the current acceptable level for volatile organics under the State of New Jersey drinking water standards within 5 years. Long-term beneficial impacts on flora and fauna, as well as public health, would be similiar to the impacts achieved under Alternatives 2, 2A, 3 and 3B, because concentrations of volatile organics are projected to be well below state standards within the 20 year period.

4.3.5.4 Land Use

The marginal short-term and long-term benefical impacts achievable under this alternative on land use would be attributed to improvements in ground and surface water quality and are similar to the impacts previously discussed in Alternatives 2, 2A, 3 and 3B.

4.3.5.5 Population and Economics

Implementation of this alternative would have marginal short-term and long-term beneficial impacts on population and economics because growth and local economic development would not be discouraged as it would be under this no-action alternative. These impacts would be similar to those described under Alternatives 2, 2A, 3 and 3B.

931

4.3.5.6 Transportation

Construction of this alternative would have marginally adverse short-term impacts on transportation and would be less than those described in Alternatives 2 and 2A because the magnitude and duration of construction of a shallow slurry wall would be substantially less. Long-term impacts on transportation resulting from the transport of sludge off-site would be insignificant as described in Alternatives 2, 2A, 3, 3A, 3B, 4 and 5. The increased rate of external plume pumping will increase the quantity of groundwater to be treated. This water will effectively dilute the relatively high concentration of contaminants extracted from the internal wells when both systems are combined. As a result, the quantity of sludge generated would be relatively the same as those alternatives utilizing a slower rate of pumping.

4.3.5.7 Energy

The construction of this alternative would have less short-term impacts on energy resources than Alternatives 2 and 2A since substantially less energy would be expended for construction of a shallow slurry wall. All other short-term construction related energy impacts would be similar to those described under Alternatives 2, 2A and 3. On a long-term basis the increased rate of external pumping would have additional energy requirements beyond those of Alternatives 2, 2A, 3, 3B, 4A and 5. This alternative would have significant long-term adverse impacts to energy resources. Groundwater modeling results indicate that the duration of pumping could not be significantly reduced from 20 years.

4.3.6 Alternative 3B - Shallow Containment Wall

Alternative 3B is similar to Alternative 3 with the exception that no external wells are proposed.

4.3.6.1 Groundwater and Surface Water

The short-term impacts to surface and groundwater quality would be similar to Alternatives 2, 2A 3, 4, 4A and 5. When compared with simulation results for Alternatives 2, 2A, 3 and 3A, aquifer restoration without external pumping can be accomplished through shallow wall containment, but will proceed at a slower rate, particularly in the Red Bank formation. Also, as in Alternative 2-A, restoration is achieved through natural aquifer flushing with an increase in total pollutant mass release to the river. Under this alternative, the concentration of volatile organic compounds discharging to the Manasquan River at Burke Road will be reduced to 100 ppb approximately 10 years after installation. Long-term beneficial impacts of this alternative on groundwater and surface water would be similar to Alternatives 2 through 3A.

4.3.6.2 Air Quality

Because monitoring of onsite air quality data is in progress, no definitive analysis of the air quality impacts associated with Alternative 3B can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lbs/hr. Air

quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment which would need to be specified during the conceptual design of the treatment facility.

4.3.6.3 Flora and Fauna

Beneficial short-term impacts on plants and animals, as discussed under Alternatives 2 through 3A would apply to this alternative, although the degree of impact would be marginally less. Since this alternative does not provide for complete containment of landfill contaminants, the concentration of contaminants found in the Red Bank layer of the plume would be higher. Without external wells this discharge would feed directly into the river. Although this alternative would have a long-term beneficial impact on plant and animal life, the short-term effectiveness of the system would be less than Alternatives 2 and 3A due to the length of time required in restoring both the surface and groundwater quality. Wetlands are extremely sensitive areas reflecting subtle changes in the chemical, physical and biological parameters of the circulating water. It must be realized, that continued release of contaminants to the Manasquan River, as would occur under this alternative, could adversely impact the wetlands areas.

4.3.6.4 Land Use

The short-term and long-term impacts associated with this alternative would be marginally beneficial and would be attributed to improvements in ground and surface water quality. These impacts are similar to those described under Alternatives 2, 2A, 3, and 3A.

4.3.6.5 Population and Economics

The marginal short-term and long-term beneficial impacts of this alternative would be similar to those discussed under Alternatives 2, 2A, 3, and 3A. Since normal growth and local economic development would be unaffected.

4.3.6.6 Transportation

Construction of this alternative would have marginally adverse short-term impacts on transportation and would be less than those described in Alternatives 2 and 2A. The magnitude and duration of construction of a shallow slurry wall would be substantially less than a deep slurry wall because fewer truck deliveries of slurry would be required over a shorter construction period. Under this alternative no external extraction wells would be installed. All other construction-related impacts would be the same as those anticipated under Alternative 2.

The long-term impacts to transportation would be insignificant since less than two truck trips per week would be required for off-site hauling of sludge.

4.3.6.7 Energy

Installation of a shallow slurry wall under this alternative would have significantly fewer short-term adverse impacts on energy resources than 2 and 2A which utilize a deep slurry wall. In addition, short-term adverse impacts would be less since no energy would be expended in the development of external pumping wells. The long-term energy requirements of this alternative would cause a marginally adverse impact similar to that of Alternative 2A since no external pumping is employed.

4.3.7 Alternative 4 - Interception With Treatment and Discharge (No Containment)

This alternative differs from Alternatives 2 and 3 in that no physical onsite containment is provided. Instead, a external extraction well field with high-rate pumping is utilized to collect and treat contaminated groundwater prior to its entering the river. Surface sealing and sediment control provisions are as described in Alternative 2. Monitoring program provisions are also as described in Alternative 2.

4.3.7.1 Groundwater and Surface Water

The short-term impacts on surface and groundwater achievable under this alternative would be less beneficial than Alternatives 2 through 3B. The cleanup of the groundwater and surface water would proceed at a slower rate than Alternatives 2 through 3B. Groundwater modeling results indicate that the total volatile organic concentration discharging into the Manasquan River at Burke Road would be reduced to 100 ppb approximately eleven years after installation. As with the other alternatives, placement of a surface seal would reduce recharge to the surficial aquifer from the entire landfill area and the water table elevation contours would tend to flatten out indicating that mounding beneath the landfill is eliminated. However, the downward vertical gradient through the Hornerstown formation would still exist. In order to reverse this gradient without the use of a physical barrier, such as a slurry wall, significantly higher pumping rates than those proposed under Alternatives 2, 2A, 3, 3A and 3B would be employed under this alternative. In addition, a horizontal gradient through the Vincentown Sand layer would prevail. This would allow some contaminants to bypass the extraction wells and discharge into the Manasquan River.

Simulation results also indicate that this scheme will only allow for partial treatment of the existing plume. This is due primarily to the fact that the source has not been removed from the active flow field. The extraction wells provide a means of capture of contaminants prior to their reaching the Manasquan River, but continuous pumping would be required until the source is dissipated. Aquifer restoration would not be achieved until the source contaminants have migrated from the landfill, which is estimated to take more than 20 years. This is an important consideration in view of the fact that the exact nature of the contamination within the landfill has not been determined. It is not known to what degree present contamination results from bulk solvent wastes or drum contents. If the existing contaminant plumes result from bulk solvent wastes and does not reflect the drum contents, the constituents of the leachate could drastically change as more drums begin to leak. These constituents, as yet unidentified, could have significant short and long-term adverse impacts on plants and animals, as well as human health, if allowed to enter the river at some future time. If external pumping is terminated, contaminants would discharge directly into the river since no onsite containment is provided.

4.3.7.2 Air Quality

Because monitoring of onsite air quality data is in progress, no definitive analysis of the air quality impacts associated with Alternative 4 can be made at this time.

Preliminary estimates do indicate, however, that emission rates from the air stripping units of the proposed treatment facilities would most likely exceed the current NJDEP standard of 0.1 lbs/hr. Air quality impacts associated with these emissions would be mitigated through installation of air pollution control equipment which would need to be specified during the conceptual design of the treatment facility.

4.3.7.3 Flora and Fauna

The impacts of this alternative on plants and animals would be marginally beneficial even though cleanup would necessitate a longer period of time. Under Alternative 4, deterioration of both surface and groundwater are anticipated for a longer period of time than would be the case with Alternatives 2, 2A, 3, 3A and 3B. This deterioration could result in adverse impacts to wetland areas, decrease in surface water quality and loss of aquatic life. Wildlife utilizing the river for drinking water would continue to be threatened by volatile organics which find their way into the surface water over a longer period of time than projected for Alternatives 2, 2A, 3, 3A and 3B. Over the long-term continuous high-rate plume pumping will effectively control the migration of contaminants from the landfill to the river. The gradual restoration of the wetland areas and adjacent surface waters would indicate an improvement in the environment and beneficial impact to public health, similar to Alternatives 2 through 3B.

4.3.7.4 Land Use

The short-term and long-term impacts to land use under this alternative would be marginally beneficial even through groundwater and surface water cleanup would be effected over a longer period of time than projected under Alternatives 2, 2A, 3, 3A and 3B.

4.3.7.5 Population and Economics

This alternative would have the same marginally beneficial short-term and long-term impacts on population and economics, as those described under Alternatives 2 through 3B, since normal population growth and economic development would not be adversely affected.

4.3.7.6 Transportation

Alternative 4 would have marginally adverse short-term impacts on transportation because construction and equipment mobilization, and materials delivery to the site would be required for site grading and application of the clay cap, construction of the wastewater treatment facility and installation of the extraction well field. Transport of sludge off site would have insignificant long-term impacts on transportation similar to all the other alternatives considered.

4.3.7.7 Energy

Alternative 4 would have fewer short-term adverse impacts on energy resources than Alternatives 2 through 3B since a containment wall would not be constructed. However, some energy would be required for installation of the groundwater extraction wells. Long-term adverse impacts on energy required for pumping and treatment of groundwater would be similar to Alternative 3A.

4.3.8 Alternative 4A - Surface Sealing Without Interception

In Alternative 4A, the site surface is sealed as in the other alternatives but there is no external extraction well field. This alternative examines the effect of simply sealing and closing the landfill.

4.3.8.1 Groundwater and Surface Water

Groundwater modeling results of this alternative indicate that the plume configuration closely approximates that of Alternative 1, No-Action. This is due to the fact that both horizontal and vertical

components of the simulated flow field are only minimally impacted by the reduction in recharge accomplished by installation of the clay cap. Estimated volatile organic concentrations discharging into the Manasquan River at Burke Road would be approximately 1250 ppb 20 years after installation. The increased contaminant load to the river under this alternative over time would have more significant long-term adverse impacts than any of the other alternatives, except the No Action alternative which would have the most serious adverse impacts with a discharge of 1300 ppb. Since this alternative does not offer onsite containment, the discharge of contaminants into the Manasquan River would not be inhibited. This is a major concern since the contents of the buried drums and bulk liquid wastes are not fully known.

4.3.8.2 Air Quality

Because monitoring of onsite air quality is in progress, no definitive analysis of the air quality impacts associated with Alternative 4A can be made at this time.

4.3.8.3 Flora and Fauna

This alternative offers no solution to the long-term adverse impacts on plants and animals. As more pollutants from the landfill are released into the flow field, the levels of contaminants in the surface and groundwater would increase. The adverse impacts on wetlands, aquatic life and wildlife would eventually approach the degree of magnitude associated with the No Action alternative.

4.3.8.4 Land Use

The short-term and long-term marginally adverse impacts of this alternative on land use would be similar to those of the No Action alternative since this alternative does not reduce the concentration of contaminants entering the flow field. This would adversely impact current property values and future growth and development in the study area due to the public's perception of adverse health effects resulting from air, water, soil and/or wildlife contamination.

4.3.8.5 Population and Economics

The short-term and long-term marginally adverse impacts of this alternative on population and economics would be similar to those impacts caused by the No-Action alternative since this alternative would not reduce the concentration of contaminants entering the flow field. This would tend to discourage development in the area and the subsequent in-migration of new residents resulting from the public's perception of adverse health effects. Marginally adverse impacts to local economics resulting from this alternative could be closely tied to the impact on population and community growth potential.

4.3.8.6 Transportation

Short-term marginally adverse impacts on transportation under Alternative 4A would be due to equipment mobilization, demobolization, daily deliveries for placement of a clay cap and site grading. The deletion of a groundwater treatment facility would eliminate sludge generation and the necessity for off site transport. The long-term impacts on transportation would be insignificant.

941

4.3.8.7. Energy

This alternative would have marginally beneficial short-term impacts on energy since there would be a limited amount of construction involved with site grading and placement of the clay cap. Since there is no pumping or groundwater treatment proposed under this alternative, no long-term energy expenditure is anticipated.

4.3.9 Alternative 5 - Drum Excavation And Removal With Plume Pumping, Treatment and Discharge

This alternative provides for removal of the buried drums by excavation and off site transport. Contaminated earth and other landfilled material would be left in the landfill except for contaminated earth removed during the drum excavation operation. External plume pumping, treatment and discharge is included as in Alternatives 2, 3, 3A and 4. Surface sealing and sediment control provisions are as described in Alternative 2. Monitoring program provisions are as described in Alternative 2.

4.3.9.1 Groundwater and Surface Water

This alternative was not computer-simulated due to uncertainties as to what proportion of the total contaminated source would remain after excavation of the drums. Therefore, its impacts on groundwater can only be estimated based upon the limited information about the drums and their contents. Although this alternative will remove a source of contamination, bulk liquid wastes will remain and the existing contaminant plume would persist for many years. The short-term impacts on groundwater and surface water quality would be marginally beneficial because, although the existing contaminated plume

would remain, the external plume pumping would effectively control the migration of contaminants from the landfill to the Manasquan River. It is estimated that the beneficial long-term impacts achievable under this alternative are relatively the same as those described for Alternatives 3 and 4. On a long-term basis, this alternative would achieve acceptable levels of volatile organics similar to those anticipated under Alternatives 3 and 4. This alternative would not be as effective in achieving cleanup as Alternative 2 because no containment or internal plume pumping is provided.

4.3.9.2 Air Quality

The potential short-term adverse impacts on air quality associated with this alternative would be greater than under any of the other alternatives. Excavation of the landfill could allow potential release of high levels of hazardous chemicals to the atmosphere. The actual extent of such a release is difficult to estimate. Because the drums containing the majority of the liquid wastes are relatively new, it is felt that they could be removed without substantial loss or spillage of the contents.

Exposure of onsite workers could be minimized by the use of protective clothing and breathing apparatus. The long-term impacts on air quality are similar to those anticipated under Alternatives 2 through 4B.

4.3.9.3 Flora and Fauna

The short-term and long-term marginally beneficial impacts on plant and animal life anticipated under this alternative would be similar to those achievable under Alternative 4. Some deterioration of both

943

surface and groundwater may occur since no containment of the contaminated plume is provided; however, the overall short term improvements to surface and groundwater should have a positive impact on both plant and animal life in the area. Over the long-term, continuous pumping would effectively control the migration of contaminants from the landfill to the river, thus creating positive improvement to the water and aquatic habitats used by local plant and animal populations.

4.3.9.4 Land Use

The short-term impacts of this alternative on area land use would be adverse as a result of the excavation and removal of hazardous materials from the site. Excavation and transport of hazardous materials through the area would be perceived by the public as potential health risks resulting from air, water, soil and/or wildlife contamination. This could adversely impact current property values, growth and development on a short-term basis. In the long-term, the impacts to land use would be beneficial as a result of the successful cleanup of the site and the elimination of the perceived threat to public health. This would allow for continued development in the area under current land use and zoning plans.

4.3.9.5 Population and Economics

The short-term and long-term impacts from this alternative on population and economics could be marginally beneficial. The removal of the bulk of the contaminant source would alleviate the public's perception of adverse health effects. This would allow for local population growth and economic development to occur at projected levels prior to the development of concerns about the site.

4.3.9.6 Transportation

Alternative 5 would have adverse short-term impacts on transportation greater in magnitude than the other alternatives because of the large amount of excavation required for drum removal. Depending on the amount of contaminated soil removed during drum excavation, between ten and twenty truck trips per day would be required for removal of the contaminants from the site during a one year excavation period. Moreover, the daily transport of hazardous wastes over local roadways would be subject to stringent state regulation and could encounter serious public opposition. Long-term impacts on transportation from removal of sludge from the treatment facility could be insignificant.

4.3.9.7 Energy

The energy requirement for this alternative would have greater short-term adverse impacts than the No Action alternative and Alternatives 3, 3A, 3B, 4 and 4A due to the excavation operation involving the expenditure of gasoline, diesel fuel and other energy resources. Long-term energy requirements for groundwater pumping and treatment would be marginally adverse and similar to Alternatives 2, 3, 3A and 4.

4.4 SCREENING AND EVALUATION OF ALTERNATIVES

Alternatives 1 through 5 were compared from the standpoints of cost, major short-term and long-term environmental impacts, and the engineering considerations, implementability and constructability (Draft Feasibility Study, 1983). The screening provided an identification of those alternatives having excessive costs, significant adverse environemntal impacts or major engineering problems.

Those alternatives that were more cost intensive without providing commensurate benefits had adverse environmental impacts that could not be adequately mitigated, or were technically inappropriate for the site conditions were eliminated from further evaluation.

Following the initial screening, the narrowed list of remedial alternatives was evaluated further in order to identify the most cost-effective alternative. This second evaluation step rates the alternatives according to six criteria: cost, reliability, implementability, operation and maintenance requirements, environmental impacts and safety requirements. This second step in the evaluation process focused on the five alternatives that remain after the initial screening. The remaining alternatives are:

Alternative 1--No Action
Alternative 3--Shallow containment wall with internal and plume pumping, treatment and discharge
Alternative 3A--Shallow containment wall with a high rate plume pumping, treatment and discharge
Alternative 3B--Shallow containment wall with internal pumping, treatment and discharge
Alternative 4--Plume interception with treatment and discharge.

Section 4.5 presents a comparative summary of the environmental impacts associated with each of the five remaining alternatives.

4.5 ENVIRONMENTAL IMPACTS OF REMEDIAL ALTERNATIVES REMAINING AFTER INITIAL SCREENING

4.5.1 Alternative 1 - No Action

Alternative 1 has the greatest overall short-term and long-term impacts on the physical, biological and socioeconomic environment than all other alternatives considered. These impacts are associated

with continued discharge of contaminants from the landfill into the groundwater and surface water resulting from surface and subsurface flow, further deterioration in the adjacent wetland areas, loss of both aquatic life and wildlife, and depreciation in current property values and future growth. Allowing the condition to continue unabated may discourage development and the movement of new residents into the area which may adversely impact the population and community growth potential. There would be no short-term or long-term impacts to transportation under this alternative since no construction would be involved. This alternative, however, would require the least expenditure of energy when compared to all the other alternatives.

4.5.2 Alternatives 3 and 3B Shallow Containment Wall

Alternatives 3 and 3B have marginally less beneficial short-term and long-term impacts on the physical and biological environmental than Alternative 3A, which provides more rapid cleanup of the groundwater and surface water. The additional time required for cleanup under Alternatives 3 and 3B would have less beneficial impacts on area plants and animals. Long-term impacts of this alternative on the socioeconomic environment would be relatively the same as Alternative 3A.

4.5.3 Alternative 3A - Shallow Containment Wall with High-Rate Plume Pumping, Treatment and Discharge

Alternative 3A has marginally beneficial short-term impacts on the physical and biological environment when compared to Alternatives 3 and 3B. These impacts are significantly more beneficial than Alternative 1. Long-term beneficial impacts on the physical, biological and socioeconomic environment are relatively the same as Alternatives 3 and 3B.

4.5.4 Alternative 4 - Interception with Treatment and Discharge (no containment)

Alternative 4 has short-term beneficial impacts on the biological, physical and socioeconomic environment relatively the same as those impacts anticipated under Alternatives 3 and 3B. However, cleanup of the groundwater and surface water would proceed at a slower rate than Alternatives 3, 3A and 3B. This would allow some contaminants to by-pass the extraction wells and discharge into the Manasquan River. Since this alternatives only allows for partial treatment of the existing plume, deterioration of both surface and groundwater are anticipated for a longer period of time than would be the case with Alternatives 3, 3A and 3B. This deterioration could result in adverse impacts to wetland areas, decrease in surface water quality, and loss of aquatic life. The overall long-term impacts on the physical environment, would be therefore be less beneficial than Alternative 3, 3A and 3B.

Section 5

5.0 RECOMMENDED PLAN AND MITIGATIVE MEASURES

5.1 INTRODUCTION

This section will provide a description of the recommended long-term remedial action plan for the Lone Pine Landfill. Public input will be incorporated into the decision-making process to ensure all public concerns have been considered. This section will also provide a discussion of mitigative measures which should be implemented as part of the recommended plan to offset any potential adverse impacts and to ensure optimum protection of the environment.

References

Buchanan, Ronald J. 1979. Affadavit. State of New Jersey, County of Mercer.

Burke, Thomas A. and Hank Garie. 1982. Memo to Arnold Schiffman, Director of Water Resources, NJDEP, from the Office of Cancer and Toxic Substances Research.

Camp, Dresser and McKee. 1983. Generic Site Investigation Protocol for Uncontrolled Hazardous Wastes Sites.

Camp, Dresser and McKee. 1983. Essex County Resource Recovery Environmental Impact Assessment Air Quality Related Issues. Prepared for the Port Authority of New York and New Jersey.

Carney. 1981. The New York Times.

Cavallo, J. 1982. (Telephone Communication) Conversation between John Cavallo, archaeologist for Monmouth County and Lee Guterman, CDM.

Dalton, R. 1979. Affadavit. State of New Jersey, County of Mercer.

Dalton, R. 1980. NJDEP. Memo to Walter Burshtin, Solid Waste Administration, from Richard Dalton. Lone Pine Corporation Sanitary Landfill.

Dames and Moore. 1974. Natural Resources Inventory for Freehold Township, Monmouth County, New Jersey. Prepared by Freehold Township Environmental Commission.

Dickerson, William B. 1982., as cited in the Draft Master Plan, Township of Freehold, Monmouth County, New Jersey.

Eby, C. 1982. (Telephone Communication) Conversation between C. Eby, USDA, Soil Conservation Service, and Lee Guterman, CDM.

Faille, E. 1978. NJDEP. Spill File Prosecution. Chemical Spill at Lone Pine Landfill.

Fairbrothers, D. and M. Hough. 1973. Rare or Endangered Vascular Plants of New Jersey. Science Notes No. 14.

Federal Register. Vol. 44, No.46, 3/79.

Fred C. Hart Assoc. 1982. Draft Final Report, Lone Pine Landfill Hydrogeologic Investigation. Contract No. 68-01-6056.

Fred C. Hart Assoc. 1982. Draft Final Report, Lone Pine Landfill Hydrogeologic Investigation. TDD #02-8105-05 B/E.

Garie, H. 1982. Interpretation of Toxic Data in the Manasquan River Basin. Office of Cancer and Toxic Substances Research (Unpublished).

Garie, H. 1982. (Telephone Communication) Conversation with H. Garie, Biologist at the Office of Cancer and Toxic Substances Research and Lee Guterman, CDM.

Greer, B. 1983. (Telephone Communication) Conversation between Barbara Greer, NJDEP, Division of Water Resources, and Lee Guterman, CDM.

Harden, E. 1983. (Telephone Communication) Conversation between E. Harden, NJDEP, Division of Water Resources, and Lee Guterman, CDM.

Haubert, J. 1982. (Telephone Communication) Conversation between John Haubert, Wild and Scenic River Division, Dept. of Interior, and Lee Guterman, CDM.

Haubert J. and D. Dulec. 1982. (Telephone Communication) Conversation between John Hubert/Dalton Dulac, Wild and Scenic River Division, Dept. of Interior, and Lee Guterman, CDM.

Hunton, G. 1982. (Telephone Communication) Conversation between

Gail Hunton, Monmouth County Parks System/ Monmouth County Historic Association, and Lee Guterman, CDM.

Jablonski, L. 1968. Groundwater Resources of Monmouth County, New Jersey. Special Report No. 23.

Karshner, T. 1982. (Telephone Communication) Conversation between Terrence Karshner, Office of Historic Preservation, and Lee Guterman, CDM.

Killam/Dames and Moore. 1974. Wastewater Management Study of the Manasquan Basin and the Metedeconk Basin in Monmouth County, as cited in Natural Resources Inventory, 1974.

Kuchler, A.W. 1964. Potential Natural Vegetation of the Conterminous United States. American Geographic Society. Special publication No. 36, as cited in Natural Resources Inventory, 1974.

Monmouth County Environmental Commission. 1975. Natural Features Study for Monmouth County.

Monmouth County Parks System. 1975., as cited in Natural Features Study for Monmouth County. Prepared by the Monmouth County Environmental Council.

Monmouth County Planning Board. 1982. Growth Management Guide (Summary)

Moore, T. 1982. (Written Correspondence) Letter from Terrence Moore, Pinelands Commission, to Lee Guterman, CDM.

National Oceanic and Atmospheric Administration. Climatological Data, 1982.

N.J. Department of Conservation and Economic Development, Division of Resource Development, Bureau of Parks and Recreation, Natural Areas Section, Nature at Allaire., as cited in Natural Resources Inventory, 1974.

NJDEP. Undated. Wildlife Species in New Jersey. State of New Jersey Dept. of Environmental Protection. Division of Fish, Game and Wildlife. Prepared by the Endangered and Nongame Species Project.

NJDEP. 1979. Lone Pine Landfill Area-Private Wells. Memo #955.

NJDEP. 1982. National Flood Insurance Program: Flood Insurance Rate Map/ Floof Boundary and Floodway Maps, Township of Freehold, New Jersey, Monmouth County.

Owens, J.P. and Minard. 1960. The Geology of the North-Central Part of the New Jersey Coastal Plain; John Hopkins University Studies in Geology, No. 18, as cited in Groundwater Resources of Monmouth County,1968.

Ruggero, A. 1977. (Telephone Communication) Conversation between A. Ruggero, NJDEP, and J. Burkholder, EcolSciences, as cited in the USEPA publication Environmental Impact Statement for the Manasquan River Regional Sewerage Authority, 1979.

Rutgers University. 1978. Summary of Toxics Detected in the Manasquan River Below Lone Pine Landfill During and After a Rainstorm. Performed under the direction of NJDEP-Office of Cancer and Toxic Substances Research.

Takacs, F. 1972. Inspection Report-Lone Pine Landfill (Burke's) Landfill. NJDEP, Bureau of Water Pollution Control, Trenton, N.J.

Technical Testing. 1970. Engineering Report Lone Pine Sanitary Landfill, Freehold Township, Monmouth County, New Jersey. Prepared by Wehran Engineering Corporation.

Tectonic. 1976. Howell Township. Natural Resource Inventory, Somerville, New Jersey, as cited in Environmental Impact Statement for the Manasquan River Regional Sewerage Authority, 1979.

Townplan Assoc. 1982. Draft Master Plan, Township of Freehold, Monmouth

mouth County, New Jersey.

USDA, Soil Conservation Service. Undated Soil Interpretation Records.

USDA, Soil Conservation Service. 1980. Endangered and Threatened Species of New Jersey.

USDA, Soil Conservation Service. 1982. Important Farmlands of New Jersey.

US Dept. of Commerce, Bureau of the Census. U.S. Census of Population, as cited in Townplan Assoc., 1982.

USEPA. 1979. Environmental Impact Statement for the Manasquan River Regional Sewerage Authority Wastewater Facilities Plan, Monmouth County, New Jersey.

USEPA. 1981. Memo from John C. Alonso to Richard Spear. EPA Lone Pine Landfill Sampling Results.

US Fish and Wildlife Service, Dept. of Interior. 1978. The Endangered Species Act of 1973.

US Fish and Wildlife Service, Dept. of Interior. 1982. Endangered and Threatened Wildlife and Plants, 50 CFR 17.11 et. 17.12.

Walker, Ian R. 1973. An Analysis of Sanitary Landfills at Smithburg, Monmouth County and Mount Holly, Burlington County.

Warner, B. 1982. (Telephone Communication) Conversation between Bruce Warner, Turkey Swamp Park, and Lee Guterman, CDM.

Zich, H. 1973. Memorandum to A. Pyle/W. Marawski; Fisheries Evaluation of the Proposed Lower Manasquan River Reservoir, Wall Township, Monmouth County, as cited in the Environmental Impact Statement for the Manasquan River Regional Sewerage Authority, 1979.

Geologic Formations and Their Water Bearing Properties Within the Study Area

APPENDIX A

The aquifers and other formations of the Coastal Plain can be described from the bottom to the top (northwest to southeast) as follows: The deepest formation is the Raritan formation, which is commonly associated with the overlying Mathogy formation. The average thickness of the aquifer is about 50 feet. In most locales the Raritan and Magothy are indistinguishable, except in the outcrop areas where they are separated by a layer of clay. (Federal Register, Vol. 44, No. 46, March 1979).

The Raritan-Magothy formation constitutes the most important water supply aquifer in the Coastal Plain. In Monmouth County, the aquifer supplied approximately 12.3 million gallons per day, or 57 percent of all the groundwater used, in 1958 (Jablonski, 1968). The quality is generally good, except for the presence of iron and manganese (table A-1). Isolated problems have occurred with nitrates and some heavy metals, e.g; cadmium and chromium. The U.S. Army Corps of Engineers has estimated that approximately 43 percent of recharge to the Raritan-Magothy is from the Delaware River (Jablonski, 1968). Water in this formation generally moves from the northwestern part of the County to discharge areas in the eastern and northern parts of the County (figure 2-4).

The Merchantville formations and Woodbury Clay overlie the Raritan-Magothy formations, which form a major confining zone with a combined thickness of approximately 100 feet. Normally this layer would protect the Raritan-Magothy from contamination; however, excessive pumpage from the Raritan-Magothy has resulted in the confining bed transmitting considerable quantities of water from the overlying aquifers (Federal Register, Vol. 44, No. 56, March 1979).

TABLE A-1

Water-Bearing Properties and Quality of
Geologic Formations In the Vicinity of Lone Pine Landfill

Geologic formation	Water-bearing properties	Water Quality
Vincentown Formation	Numerous domestic wells tap this sand; yields 10-50 gpm to domestic wells	Excellent Incidence of low pH and high iron content.
Hornerstown Sand	A poor aquifer; yields up to 5 gpm to domestic wells.	
Red Bank	Yields range from 3-30 gpm to domestic wells.	Acidic may require treatment for removal of iron.
Navesink Formation	Important to domestic consumers. Wells yield 10 gpm or less.	Excellent
Mount Laurel Sand Wenonah Formation	A single aquifer. Average yield 10 gpm. Maximum yield reported was 335 gpm.	Generally good, except for iron Moderately high hardness in some areas.
Marshalltown Formation	Not considered water-bearing in the county.	
Englishtown Formation	Average yield 25 gpm. Maximum yield reported 640 gpm. Average yield to large-capacity wells 410 gpm.	Excellent except for high iron content.
Woodbury Clay Merchantville Formation	Both formations act as a single aquiclude. Not water-bearing.	
Magothy Formation	Sands are discontinuous, and thickness variable. Maximum yield reported 250 gpm.	Generally good, except for iron and magnesium. Isolated problems have occurred with nitrates and some heavy metals, e.g., cadmium and chromium.
Raritan Formation	Contains most important aquifers. Yields range 100-1,400 gpm to large-diameter wells.	
Wissahickon Formation	No wells in this formation.	

Source: New Jersey Department of Conservation & Economic Development 1968

The Englishtown formation rests conformably on the Woodbury Clay, overlain by the Marshalltown formation. It is so thin in some areas that development is limited. Northeast to southwest along the outcrop, the formation changes from a sand 150-feet thick to a series of silt or clay and sand layers 50-feet thick. The Englishtown formation has a lower ability to transmit water than the Raritan-Magothy formations, but yields sufficient quantities of water to be considered an important aquifer. In 1958 this aquifer contributed 20 percent of all groundwater used. Water-level data indicates that throughout most of the outcrop area, recharge from precipitation is discharged to streams (Jablonski, 1968). The water quality of this aquifer is excellent except for generally high iron content (Federal Register, Vol. 44, No. 46, March 1979). Water moves toward the outcrop area and downdip toward the coastal part of the County (Jablonski, 1968).

The Marshalltown formation overlies the Englishtown formation, ranging about 30-feet in average thickness. Consisting primarily of clay, this formation acts as an aquiclude or confining layer between the Englishtown and overlying formations. In some locales, the formation serves in conjunction with part of the overlying Wenonah formation as an aquiclude. This formation is not considered water-bearing in the County (Jablonski, 1968).

The Wenonah formation and Mount Laurel Sand comprise the next important aquifer. Although distinct formations, they are considered as one, since they are hydraulically connected and function as a single aquifer. In most places the aquifer is between 30- and 50-feet thick and has a relatively low capacity for transmitting water. Nevertheless, the good quality of the water makes it an important aquifer. In 1958, this aquifer contributed 3 percent of the total groundwater withdrawals in Monmouth County. Water quality is generally good except for iron, particularly in the outcrop area. Moderately high

hardness is found in areas where heavy pumpage has induced leakage from overlying zones (Jablonski, 1968). Water-level measurements taken in 1958 suggest that the precipitation that recharged the aquifer in the outcrop area south of a point about 5 miles southwest of Morganville in Monmouth County does not flow downdip in the aquifer. In this area, the hydraulic head is toward the outcrop. The precipitation that recharged the aquifer in the outcrop in the remaining northern parts of the County flowed eastward (Jablonski, 1968).

Overlying the Mount Laurel Sand is the Navesink formation, which has a fairly uniform thickness of 25 feet. The shell zone at the base of this formation is in hydraulic continuity with the underlying Mount Laurel Sand and may be considered as part of the aquifer in the Wenonah formation and Mt. Laurel Sand. The Navesink formation, in conjunction with the basal clay member of the overlying Red Bank Sand, forms a confining layer between the Mount Laurel Sand and the overlying formation. A few domestic wells tap the shell zone and yield up to 15 gallons per minute (gpm) of water of excellent quality (Jablonski, 1968).

The Red Bank Sand lies conformably over the Navesink formation. In outcrop areas there are two distinct members: an upper sand member and a lower clayey sand member. The upper sand layer functions as an aquifer and ranges in thickness from 0 to 70 feet (Jablonski, 1968). The aquifer in the Red Bank Sand supplies many domestic wells with water but only relatively small quantities are withdrawn. Most of the recharge is probably discharged as base flow to nearby streams. The yields of wells drilled in this aquifer range from 2 to 25 gpm. Some well owners report the water is acidic and requires treatment to remove excess iron (Jablonski, 1968).

The Hornerstown Sand unconformably overlies the Red Bank Sand. It ranges in thickness from 25 feet to about 100 feet toward the southeast. Comprised primarily of clay, this formation functions primarily as an aquitard in the vicinity of the landfill. The Hornerstown Sand may yield enough water in some areas of the outcrop to satisfy domestic needs (Jablonski, 1968).

Unconformably overlying the Hornerstown formation is the Vincentown formation, although in some parts of the County the outcrop is overlain by the Kirkwood formation. In 1958, less than 1 percent of the groundwater used in Monmouth County was withdrawn from this aquifer. The part of the aquifer that is less than 10-feet thick can be considered the downdip useable limit of the aquifer. Southeast of this limit the aquifer is quite thin, discontinuous, and yields insignificant quantities of water to individual wells (Jablonski, 1968).

Available water quality data indicates that the aquifer provides an excellent quality of water with occasionally high iron concentrations and low pH. East of Freehold the general direction of water movement in this aquifer is from the outcrop toward the coast (Jablonski, 1968).

Appendix B

Water Quality Criteria for FW-2 Waters in New Jersey

APPENDIX B

Parameter	FW-2 Waters	FW-3 Waters
Floating, suspended colloidal and settleable solids; oil, grease, color turbidity	None noticeable; and none which would preclude designated uses. Maximum 30-day average of 20 JTU*, and a maximum of 110 JTU except under natural conditions.	Same as for FW-2 waters.
Toxic or deleterious substances	None which would adversely affect humans or aquatic biota.	Same
Taste and odor producing substances	None offensive, or which would preclude designated uses.	Same
pH	6.5 to 8.5	6.5 to 8.5
Dissolved oxygen (mg/l)	$\geq$ 7.0 in trout production waters; 24 hour average $\geq$ 6.0, and never < 5.0 in trout maintenance waters; 24 hour average $\geq$ 5.0, and never < 4.0 in trout waters. For stratified eutrophic lakes, > 4.0 in or above the thermocline where water temperature is < 22.2 C (72 F) where temperature is $\leq$ 22.2 C, 24 hour average > 6.0, and never $\leq$ 5.0.	
Coliforms (MPN/ 100 ml	Geometric average not to exceed 200 as fecal	Same as for FW-2 waters

Source: NJDEP, Division of Water Resources, 1974

Parameter	FW-2 Waters	FW-3 Waters
Totals Dissolved Solids (mg/l)	Not to exceed 500, or 133% of background	Not to exceed 133% of background
Total Phosphorus (mg/l)	Not to exceed 0.05 at inlet to lotic waters, unless phosphorus is shown not be a limiting factor to productivity	Same as for FW-2 waters.
Temperature	Treated effluent discharge cannot increase stream temperature more than 0.6°C (1°F) above ambient in trout production waters, nor more than 1.1°C (2°F) in trout maintenance waters. In trout maintenance waters, temperature can be reduced where trout will benefit without detriment to other designated uses; and temperature cannot be increased to more than 20°C (68°F). In trout maintenance lakes, no alterations except where designated uses will be benefited. In non-trout waters, temperatures as measured outside the heat dissipation areas (not more than ½ of the cross-sectional area and/or volume of stream flow and leaving at least 1/3 of the surface area) cannot be altered by more than 2.8°C (5°F). Also, temperature cannot exceed 27.8°C for smallmouth bass or yellow perch, nor 30°C (86°F) for other waters. No thermal alterations of more than 1.7 C (3 F) in the epilimnion of (non-trout) lakes and other lentic waters. No discharge of thermal effluent to (non-trout) lake hypolimnia unless designated water uses will be benefited. In all waters, rate of temperature change cannot cause fish mortality.	

*JTU = Jackson Turbidity Units

Note: Proposed standards for TW-1 and CW-1 waters are that fecal coliforms cannot exceed 15 MPN/100 ml, and that not more than 10% of the samples can exceed 49 MPN/100 ml (Vernan, 1977).

Appendix C

Air Quality Within the Vicinity of
the Lone Pine Landfill Site

APPENDIX C

The annual average sulfur dioxide concentrations at the Freehold stations from 1980 to 1981 were 0.007 ppm and 0.008 ppm, respectively. These concentrations are well below both the primary and secondary standards of 0.03 and 0.02 ppm respectively. From 1979-1981, twenty-four hour average maximum concentrations at the McQuire Air Force Base and Freehold stations ranged from 0.049 to .060 ppm, substantially less than the primary and secondary standards of 0.14 and 0.10 ppm, respectively. The highest 3-hr. average maximum concentration of .092 ppm reported at the Freehold station did not exceed the .5 ppm secondary standard.

The annual geometric mean of suspended particulates reported at the Millstone station from 1979-1981 ranged from 36.7 to 42.9 ug/m^3, compared to primary and secondary standards of 15 to 60 ug/m^3, respectively. The 24-hr average maximum was also below the primary and secondary standards of 260 and 150 ug/m^3, ranging from 76 to 93 ug/m^3. Average annual concentrations of nitrogen dioxide reported at McQuire Air Force Base from 1980-1981 were 0.018 ppm, substantially less than 0.05 ppm primary and secondary standards. Lead concentrations at the Trenton and Sayreville stations were also well below both the quarterly mean primary and secondary standards of 1.5 ug/m^3.

Contraventions of carbon monoxide (CO) were reported at the Freehold stations from 1979-1981. Average CO 8-hr maximum concentrations ranged from 10.1 to 12.6 ppm. These concentrations were higher than the 9.0 ppm primary and secondary standards. In 1979, the 9 ppm standard was exceeded 13 times at the Freehold station which is located within a non attainment area for CO. One-hour average maximum concentrations do not exceed the 35 ppm standards.

The 1980 reported values for ozone at the McQuire Air Force Base was nearly twice the National Air Quality Standards (NAAQS of 0.12 ppm). This monitor reported 23 contraventions of the NAAQS and 474 contraventions of the 0.08 ppm state standards. This area is currently designated non-attainment for ozone.

Contraventions of photochemical oxidants (ozone) pervade the site. These pollutants are produced in the atmosphere by a series of chemical reactions occurring between sunlight, warm air temperatures and certain precursor pollutants, including nitrogen oxides and volatile organic compounds. The latter are commonly generated by the combustion of fossil fuels, chemical refining and petrochemical processing. Wind direction and velocity directly affect the dispersion of these compounds. Thus, the concentration of ozone at any particular location will necessarily vary with wind conditions. Ozone is transported for many miles and much of New Jersey's ozone originates from pollutants in the highly industrialized northeast corridor from Boston, Massachusetts, to Washington, D.C. It is very difficult for New Jersey alone to control ozone because of this long-range transport phenomenon. Nevertheless, strategies for volatile organic compound emission reductions for the SIP attainment year of 1987 were evaluated in the New Jersey State Implementation Plan, November 1981.

Appendix D

APPENDIX D

Fauna and Flora of the Study Area

TABLE D-1

PRINCIPAL VEGETATION THAT MAY BE FOUND IN STUDY AREA

Common Name

Red maple[1]	Sugar maple[1]	Black birch[1]
Ironwood[1]	American beech[1]	Ash[1]
Spicebush[1]	Sweet gum[1]	Pitch pine[1]
Bigtooth aspen[1]	White oak[1]	Scarlet oak[1]
Northern red oak[1]	Black oak[1]	Swamp white oak[1]
Swamp chestnut oak[1]	Tulip tree[1]	Scrub oak[1]
Sour gum[1]	Atlantic white cedar[1]	Gray birch[1]
Quaking aspen[1]	Wild red cherry[1]	Wild black cherry[1]
Blueberry[2]	Mountain laurel[2]	Cinnamon[2]
Blackberry[2]	White pine[2]	Teeberry[2]
Black spruce[3]	Tree-of-Heaven[3]	Black walnut[3]
Crack willow[3]	Green Ash[3]	Basswood[3]
Black gum[3]	Flowering dogwood[3]	American elm[3]
Pignut hickory[3]	Norway maple[3]	American holly[3]
Black locust[3]	Silver maple[3]	White mulberry[3]
Willow oak[3]	Red pine[3]	Sassafras[3]
Norway spruce[3]	Water tupelo[3]	Black willow[3]
Weeping willow[3]	White ash[3]	Box elder[3]
American chestnut[3]	Eastern red-cedar[3]	Eastern hemlock[3]
Shagbark hickory	Honey locust[3]	Red mulberry[3]
Chestnut oak[3]	Pine oak[3]	Pink azalia[3]
Wild azalia[3]	Choke cherry[3]	Coralberry[3]
Red osier dogwood[3]	Common elderberry[3]	Hawthorn[3]
Inkberry[3]	Sweet pepperbush[3]	Shadbush[3]
Staghorn sumac[3]	Winged sumac[3]	Winterberry[3]
Swamp azalia[3]	Southern bayberry[3]	Blackhaw[3]
Common buttonbush[3]	Sand cherry[3]	Large cranberry[3]
Swamp dogwood[3]	Fetter-bush[3]	Huckleberry[3]
Raspberry[3]	Spicebush[3]	Poison sumac[3]
Arrow-wood viburnum[3]	Witch-hazel[3]	

Sources:

Kuchler, 1964

[1]Freehold Township Environmental Commission, 1974

[2]Bruce Warner, Turkey Swamp Park, 1982

[3]Monmouth County Parks System, 1975.

TABLE D-2

SOME COMMON BIRDS THAT MAY FREQUENT THE STUDY AREA

Common Name	Common Name
Red-wing blackbird	Common grackle
Red-tailed hawk	Cardinal
Chimney swift	American goldfinch
Common flicker	Starling
Common crows	Robin
Blue jay	Mourning dove
Yellow warbler	Mallard duck
Downy woodpecker	American woodcock
Barn swallow	Screech owl
Wood thrush	Belted kingfisher
Mockingbird	Canada goose
Black and White warbler	Ruffed grouse
House sparrow	Ring-necked pheasant
Black-capped chickadee	Baltimore oriole
Evening grosbeak	Bob-white
Pine siskin	Tufted titmouse
White-throated sparrow	Cranes
North Limenan birds	

Sources: N.J. Dept of Conservation and Economic Development, 1969.
Bruce Warner, Turkey Swamp Park, 1982.

TABLE D-3

SOME COMMON MAMMALS THAT COULD BE FOUND IN THE STUDY AREA

Common Name	Common Name
Opposum[1]	Short-tail shrew[3]
Woodchuck[1]	Eastern mole[3]
Striped skunk[1]	Keen's myotis[3]
Deer mouse[1]	Small-footed myotis[3]
Raccoon[1]	Silver-haired bat[3]
Gray squirrel[1]	Eastern pipestrel[3]
Eastern cottontail[1]	Big brown bat[3]
Eastern chipmunk[1]	Hoary bat[3]
Mink[1]	River otter[3]
Muskrat[1]	Beaver[3]
White-tailed deer[1]	White-footed mouse[3]
Red fox[1]	House mouse[3]
Gray fox[1]	Norway rat[3]
Weasel[1]	Southern bog lemming[3]
Red squirrel[1]	Boreal redback vole[3]
Southern flying squirrel[1]	Meadow vole[3]
Starnose mole[1]	Pine vole[3]
Red bat	Meadow jumping mouse[3]
Groundhog[2]	Eastern cottontail rabbit[3]
Smokey shrew[3]	New England cotton-tail[3]
Least shrew[3]	European hare[3]

Sources: [1] N.J. Dept. of Conservation and Economic Development, 1969
Monmouth County Park System, 1971
[2] Bruce Warner, Turkey Swamp Park, 1982
[3] Monmouth Co. Parks System, 1975

TABLE D-4

COMMON AMPHIBIANS AND REPTILES
THAT MAY OCCUR IN STUDY AREA

Amphibians

Fowlers[3]
Cricket[3]
Pickerel[3]
Carpenter frog[3]
Wood frog[3]
Common toad[1]
Red-spotted newt[1]
Bullfrog[1]
Green frog[1]
Leopard frog[1]
Northern spring peeper[1]
Eastern spadefoot[3]
Pine Barrens treefrog[3]
Gray treefrogs[3]
New Jersey chorus frog[3]

Reptiles

Northern pine snake[3]
Corn snake[3]
Eastern milk snake[3]
Timber rattler[3]
Common snapping turtle[1]
Spotted turtle[1]
Mud turtle[1]
Northern water snake[1]
Eastern box turtle[1]
Eastern garter snake[1]
Eastern painted turtle[1]
Northern black racer[1]
Eastern hognose snake[2]

Reptiles

Diamond-backed Terrapin[3]
Bog turtle[3]
Red-earred turtle[3]
Eastern smooth-earth snake[3]

Northern brown[1]
Northern ringneck[3]
Black rat snake[3]
Scarlet snake[3]
Eastern king snake[3]
Red bellied snake[3]
Eastern ribbon snake[3]
Eastern worm snake[3]
Rough green snake[3]
Riding turtle[2]
Northern fence lizard[3]
Wood turtle[3]
5-Line skunk[3]
Musk turtle[3]

Sources: [1] Monmouth County Park System, 1971
Freehold Township Environmental Commission, 1974

[2] Bruce Warner, Turkey Swamp Park, 1982

[3] Monmouth County Parks System, 1975

TABLE D-5

FISH TAKEN IN THE MANASQUAN RIVER (TROUT-MAINTENANCE SECTION) MINGAMAHONE, SQUANKUM, UNNAMED TRIBUTARY (ELTON-ADELPHIA), MARSH BOG, BEAR SWAMP, DEEP, MANASA, BOG AND MILL RUN BROOKS

Brown trout
Grass pickerel
Pumpkinseed sunfish
White (common) sucker
Creek chubsucker
Golden shiner
Johnny darter
Brook lamprey
American eel
Largemouth bass
Brown bullhead
Mudminnow
Redfin pickerel
Mud sunfish
White catfish
Yellow perch
Carp
Bluegill sunfish
Pirate perch
Blacknose dace

---

* Dates: One or more dates during August-September 1971, August 1972 (Deep Brook only) and May 1974 (Mingamahone, Mill Run and Bog Brooks).

Source: USEPA, 1979
Bruce Warner, Turkey Swamp Park, 1982.

TABLE D-6

RARE, THREATENED AND ENDANGERED SPECIES WHICH MAY OCCUR IN THE STUDY AREA

Common Name	Scientific Name	Status
Pine Barrens Treefrog	Hyla andersoni	$E^{1,2}$
Bog Turtle	Clemmys muhlenbergi	E^{1}
Wood Turtle	Clemmys insculpta	T^{1}
Northern Pine Snake	Pituophis melanoleucus melanoleucus	T^{1}
Timber Rattlesnake	Crotalus horridus	E^{1}
Short-Billed Marsh Wren	Cistothorus platensis	T^{1}
Eastern Mud Salamander	Pseudotriton montanus montanus	T^{1}
Corn Snake	Elaphe guttata	T^{1}
Tremblay's Salamander	Ambystoma tremblayi	E^{1}
Eastern Tiger Salamander	Ambystoma tigrinum tigrinum	E^{1}
Blue-Spotted Salamander	Ambystoma laterale	E^{1}
Long-tailed Salamander	Eurycea longicauda longicauda	T^{1}
Pied-Billed Grebe	Podilymbus podiceps	T^{1}
Great Blue Heron	Ardea herodias	T^{1}
Red Shouldered Hawk	Buteo lineatus	T^{1}
Bald Eagle	Haliaectus leucocephalus	$E^{1,2}$
Osprey	Pandion Haliaetus	E^{1}
Upland Sandpiper (Plover)	Bartramia longicauda	T^{1}
Roseate Tern	Sterna dougalli	T^{1}
Barred Owl	Strix varia	T^{1}
Red-Headed Woodpecker	Melanerpes erythro cephalus	T^{1}
Short-Eared Owl	Asio flammeus	T^{1} - breeding pop.
Bobolink	Dolichonyx oryzivorus	T^{1} - breeding pop.
Savannah Sparrow	Passerculus sandwich-ensis	T^{1} - breeding pop.
Grasshopper Sparrow	Passercherbulus hen-slouri	T^{1} - breeding pop.
Vesper Sparrow	Pooecetes gramineus	T^{1} - breeding pop.
Marsh Hawk	Circus cyaneus	T^{1} - breeding pop.
Merlin	Falco columbarius	T^{1}
American Shad	Alosa sapidissima	T^{1}
Brook Trout	Salvelinus fontinalis	T^{1}
Atlantic Tomcod	Microgadus tomcod	T^{1}

T^{1} - Threatened (State)
E^{1} - Endangered (State)
E^{2} - Endangered (Federal)

1 The Endangered and Nongame Species Project, State of New Jersey Dept. of Environmental Protection, Division of Fish, Game and Wildlife, Wildlife Species in New Jersey.

2 Endangered and Threatened Species, NJDEP, Div. of Fish, Game and Wildlife, Endangered and Nongame Species Project and USDA Soil Conservation Service, 1980.

TABLE D-7

RARE OR ENDANGERED VASCULAR PLANTS OF NEW JERSEY[1]

Common Name	Scientific Name	Status
Yellow Water Butter	Ranunculus Flabellaris	E
Mist Flower, Blue Boneset	Eupatorium Coelestinum	R
Star Duckweed	Lemna trisulca L.	R
Small Cranberry	Vaccinium Oxycoccos L.	R
Early or Pale or Northern Coral Root	Corallorhiza trifida Chatelain	R
Little Five-Leaves	Small Whorled Pagonia Isotria Medeoloides	R
Parker's Pipewort	Eriocaulon parkeri	R
Mudwort	Limosella Subulata	E
Waterwort	Elatine minima	R
Loesel's Twayblade	Liparis loeselii	R
Little or Beck's Ladies' Tresses	Spiranthes tuberosa	R
Crane-fly orchid	Tipularia discolor	R

---

1 This list has been developed for planning purposes only, and does not represent an official federal or state listing.

3 Endangered And Threatened Wildlife and Plants, 50 CFR 17.11 and 17.12. Dept. of the Interior, U.S. Fish and Wildlife Service, 1 Jan. 1982.

R: Rare.
E: Endangered.

Appendix E

A Review of Permits and Review Requirements

APPENDIX E

Federal-level Requirements

The federal permit programs that could regulate actions at the Lone Pine site are presented below.

Resource Recovery and Conservation Act (RCRA) Permits. The exact applicability of RCRA permits for onsite processing and storage activities at Superfund sites has not been resolved. USEPA, in the final National Contingency Plan, indicates that this question will be addressed on a program-by-program basis. RCRA requirements for treatment, storage and disposal of hazardous wastes and materials have not been applied to other Superfund sites that CDM has worked on.

RCRA regulations apply to transportation of hazardous wastes off site. This requires that someone must be designated as the generator. A USEPA identification number is needed by the generator; manifest forms must be completed by the generator, transporter, and disposer; hazardous waste transport regulations must be followed; and the waste must be disposed of at a RCRA-permitted facility.

Federally Administered Wetland/Waterway Permits. There are two legislative acts that authorize federal jurisdiction in, and adjacent to, wetlands. Section 404 of the Clean Water Act (1972) regulates discharges of dredged or fill material into waters of the U.S. This law is no longer restricted to navigable waterways and places tributaries under federal jurisdiction. Section 10 of the Rivers and Harbors Act (1899) limits federal jurisdiction to the mean high water line.

The National Wetlands Inventory Maps developed by the U.S. Fish and Wildlife Service is utilized by the Corps of Engineers as a guide to locating the general vicinity of wetland areas. It is common practice for the Corps of Engineers to inspect the site and delineate wetlands on a case-by-case basis to determine if a wetland is within their jurisdiction.

Dredging of the sediments within the Manasquan River, as proposed, may require a Section 404 permit under 33 U.S.C. 1344. The Harbors Act of 1899 (33 U.S.C., Section 403) will not be invoked since federal jurisdiction is restricted to the high water line of navigable waters.

National Pollutant Discharge Elimination System (NPDES) Permit. Discharges from a point source to surface waters of the State requires a NJPDES permit which grants approval for such discharge. Those persons planning to discharge must first receive a discharge allocation certificate. This certificate allocates effluent limits which a new facility must meet initially.

Two of the three federal permit programs which regulate actions at the Lone Pine site will be administered by agencies of the State of New Jersey. The NJDEP currently handles the permitting of hazardous waste operations under the Resource Conservation and Recovery Act and the National Pollution Discharge Elimination System, pursuant to the Federal Water Pollution Control Act (PL 92-500, Section 402, effective 18 October 1972). Both of these are discussed in the section on State permits.

State-level Requirements

New Jersey Coastal Area Facility Review Act. Under Chapter 185, Laws of 1973, N.J.S.A. 13: 19-1 et seq., the Coastal Area Facility Review Act (CAFRA) authorizes NJDEP to regulate and approve the location, design and construction of major facilities along designated coastal regions of New Jersey. Included under CAFRA are all riparian, tideland and wetland areas. CAFRA areas extend from the confluence of the Chesapeake Creek with the Raritan Bay in Middlesex County, southward along the Coast to Cape May and then northward along the Delaware Bay to Pennsville in Salem County. The Lone Pine Landfill is not within the designated coastal zone and is, therefore, not under the jurisdiction of NJDEP insofar as CAFRA is concerned.

Wetlands Act of 1970. Under Chapter 272, Laws of 1970, N.J.S.A. 13:9A-1 et seq., the Wetlands Act of 1970 authorizes NJDEP to regulate activities in tidal wetlands within the State. The act, which is administered by the Division of Coastal Resources, gives the State broad discretion in regulating virtually any form of development or disturbance on mapped coastal wetlands. Here, coastal wetlands are defined as those wetlands subject to tidal action along specified water bodies. Neither the site nor the study area are included on this map and are, therefore, not subject to this law.

Waterfront Development Act. Under the Waterfront Development Law, N.J.S.A. 12:5-3, the NJDEP is authorized to regulate the construction or alteration of various projects on or adjacent to navigable waterways and streams throughout the State. Originally the administrative practice under the law was restricted to tide-flowed lands in or below the mean high water line, but NJDEP has now adopted regulations to broaden their jurisdiction. The waterfront area (N.J.A.C. 7:7-2.4) is defined as including all tidal waterways and adjacent

lands up to the first property line, public road or railroad right-of-way, generally parallel to the waterway. This rule applies to upland areas beyond the mean high water line only outside the CAFRA area and Hackensack Meadowlands District. Since that portion of the Manasquan River within the study area is not a tidal waterway, the NJDEP is not authorized to regulate actions under this act.

Permit to Generate or Transport Hazardous Wastes. A permit is needed to generate or transport hazardous solids, liquids or sludges. Lone Pine Landfill is technically considered a "generator" because it is the source of hazardous wastes or materials which may be transported off site for disposal. Generator requirements are found under 49 CFR 172, 40 CFR 263, and N.J.A.C. 7:26-7.1, et seq.

NJDEP administers these USEPA Resource Recovery and Conservation Act and U.S. Department of Transportation regulations. Wastes transported out of State must be handled by a licensed hauler/transporter, who will need a NJDEP permit for in-state movements and federal or state permits for out-of-state transport to secure landfills or incineration depots. The hauler/transporter must operate in compliance with State and federal regulations on driver training; waste identification; marking, labelling, and placarding; and shipping papers.

National Pollutant Discharge Elimination System (NPDES) Permit N.J.A.C. 7:14A-1 et seq.). The NJDEP Division of Water Resources administers the National Pollution Discharge Elimination System (Federal Water Pollution Control Act Amendments of 1972, Public Law) This permit (New Jersey Pollutant Discharge Elimination System) will be required for recharging or discharging treated groundwater from the treatment facility into the aquifer or Manasquan River.

There is an exemption to NJPDES discharge to surface water if the discharge is in compliance with the instructions of an onsite coordinator, pursuant to 40 CFR 15.10 (National Oil and Hazardous Substances Pollution Plan) or 33 CFR 153.10 (Pollution by Oil and Hazardous Substances) or the State Spill Compensation Control Act (N.J.S.A. 58; 10-23.11 et. seq.) (Barbara Greer, NJDEP, 1983.)

Water Diversion Permit -- Water Allocations. Under the Water Supply Management Law, N.J.S.A. 58A:1 et. seq. New Jersey Administrative Code, 7:19 et seq., any person diverting more than 100,000 gallons per day (70 gallons per minute) from surface or groundwater must establish their privilege to divert water and to obtain a water supply allocation permit (Ernest Harden, NJDEP, 1983.)

Fish and Game Laws -- N.J.S.A. 23.5-29. The Fish and Game Law requires a permit by a person, corporation, or agency to shut off or draw off waters of any pond, stream or lake in the State. The primary purpose of this permit is to insure protection of the State's fishery resources.

The extraction of groundwater, treatment and discharge into the Manasquan River is not anticipated to require a permit under N.J.S.A. 23.5-29 because of the limited flow rate in the upper headwaters of the Manasquan River (Ernest Harden, NJDEP, 1983).

Approval to Disrupt a Landfill. A written approval must be obtained from NJDEP prior to any excavation, disruption or removal of any deposited material from either an active or discontinued landfill. All requests for approval must include an operational plan stating the area involved, depth of such excavation with final grades, estimated cubic yards of material to be excavated, site where excavated material is to be redeposited and estimated time required for completion of excavation procedures.

ermits administered by
edure set forth in
t seq.) Permits
ctivities: water-
ment, and sewer

are as fol-
mit applica-
w, or accept
ion be sub-
ptance. If
entiti-
erning
lly not
rmit
the

ten-
re-

ild, Modify, or Operate an Air Pollution Control Device. lutants are regulated under federal and State statutes ed by the NJDEP Bureau of Air Pollution Control. Toxic subject to law are found under the federal Clean Air Act, 42 112, National Emission Standards for Hazardous Air Pollut- nd 42 CFR 1857 et seq., Criteria Pollutants, and N.J.A.C. 7, Control and Prohibition of Air Pollution by Toxic Sub- es. If volatile toxic organic emissions from an air-stripping process are above threshold levels, pollutant control devices ld be required. The emissions from the carbon filter system cur- ntly suggested (after an air stripper is employed for the former) ust not exceed allowable limits. Otherwise, a permit to construct, install, or alter air pollution control devices and a certificate to operate such equipment must be obtained. The permit review process will be detailed and extensive but could be accomplished within 2 months.

If hazardous wastes at Lone Pine Landfill are processed by a mobile incineration system, a separate air quality permit will be necessary. Many stages of trial burn testing must be conducted before any such system would be eligible for permitting by NJDEP. It is unlikely that satisfactory air quality performance levels for incineration technologies will be attained before spring 1983.

Permit Review. The permit review process in New Jersey is not consolidated. Each permit is reviewed individually by the particular branch of the State government authorized to grant that permit. Little interdivisional review of permits exists. All permits required for the project can undergo review simultaneously, but the dates of commencement and completion of review are not intended to

The time schedule required for permit and review of initial remedial measures at Lone Pine will probably be compressed. NJDEP officials estimate that because of the nature and objective of the proposed actions, most permits can be granted within 1 to 2 months of submittal.

Preapplication Permit Review. A preapplication review conference can be arranged if requested by the prospective permit applicant. A preapplication review minimizes delay caused by initial permit denial or by requests for additional information prior to initiation of review. The preapplication review conference enables the reviewing agencies to voice their concerns about the proposed project and allows an applicant an overall view of project implementability.

A preapplication review for permits administered by the NJDEP is initiated by the Office of the Commissioner upon applicant request.

Because of the significant public health and safety issues involved at the Lone Pine site, it is recommended that preapplication review meetings be held with State officials prior to submittal of permit forms.

Permit Application Forms. All permit applications submitted to the NJDEP must include a copy of NJDEP Form CP #1. That form provides the NJDEP with basic general information pertaining to the project. In addition, those permits covered by the 90-Day Act must also include return receipts of certified mail notification of the municipal clerks, environmental commissions, and planning boards affected. New Jersey does not have a State environmental impact statement program. Completion of permit applications and onset of review should not initiate a NEPA environmental impact statement (EIS) requirement. However, information contained within the environmental analyses presented in various sections of the proposed initial remedial action

can be attached to appropriate permit application forms. Review by the State of New Jersey can commence as soon as all information needed to complete permit applications is submitted to the appropriate agencies.

Local Requirements

Approval of a Soil Erosion and Sediment Control Plan. For all activities that disturb more than 5,000 square feet and for which the State of New Jersey requires a building permit (excluding single-family homes), a soil-erosion and sediment-control plan must be submitted to the local Soil Conservation District (P.L. 1975 c.251, Soil Erosion and Sediment Control Act, N.J.S.A. 4:24-39). This plan must sequence construction and accomplish temporary and permanent stabilization of disturbed areas to minimize loss of soil, wind and water. All other permits should be obtained prior to review of the soil erosion and sediment control plan by the USDA Monmouth County Soil Conservation District. Note that this erosion-control permit will not be required at Lone Pine Landfill unless a building permit is needed. Determination as to whether or not a State building permit will be required must await completion of final design plans.

Construction Easement Approval. A construction easement will have to be obtained from private property owners north of the Manasquan River if dredging is to be performed in the river. Construction of a temporary access road for dredging equipment may require encroachment on private property. Since ownership of the river is shared by an adjacent property owner, approval must be given by the same.

environmental engineers, scientists,
planners, & management consultants CDM®

98

Recd 1/4/82
JAS

SAMPLING AND ANALYSIS PROTOCOL FOR REMEDIAL INVESTIGATION AT LONE PINE LANDFILL

FREEHOLD, NEW JERSEY

Prepared By

Camp Dresser & McKee, Inc.
One Center Plaza
Boston, MA 02108

December 1982

987

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
II.	SITE DESCRIPTION AND HISTORICAL BACKGROUND	2
III.	SITE SPECIFIC SAMPLING AND ANALYSIS PROCEDURES	2
	A. Groundwater Monitoring Well Installation	2
	B. Groundwater Samples	3
	C. Falling Head Tests	6
	D. Sediment Samples	7

APPENDIX A: GROUNDWATER MONITORING WELL INSTALLATION PROCEDURE

APPENDIX B: FALLING HEAD TEST FIELD PROCEDURE

988

LONE PINE LANDFILL SAMPLING AND ANALYSIS PLAN

I. INTRODUCTION

A site and task specific Health and Safety Plan (HSP) has been developed and submitted separately for activities to be conducted in the vicinity of the Lone Pine Landfill in Monmouth County, New Jersey. The HSP delineated specific procedures and personnel to perform Surficial Conditions Mapping and provided specific procedures for Subsurface Soil Sampling, Rock Coring, and HNU operation. In addition, HSP provided site specific health and safety procedures to be implemented during the feasibility study.

This Sampling and Analysis Plan (SAP) is being prepared as a supplement to the HSP, and provides additional information relative to the data collection program to be conducted in the vicinity of Lone Pine Landfill. Groundwater monitoring wells will be installed, and falling head tests will be performed on the newly installed wells as well as some of the existing wells. Also, sediment samples will be collected. The purpose of the data collection effort is to better define the local geologic and hydrologic conditions and the areas where groundwater and sediments are currently contaminated.

This SAP provides the following information:

- specific locations for groundwater monitoring well installation
- procedures for monitoring well installation at Lone Pine Landfill
- procedure for falling head tests in groundwater monitoring and production wells

989

- procedures for sampling the monitoring wells and sediments, transportation methods and Chain-of-Custody procedures.

II. SITE DESCRIPTION AND HISTORICAL BACKGROUND

Lone Pine Landfill is located within Freehold Township in Monmouth County, New Jersey. The site encompasses approximately 90 of the 150 acres owned by the Lone Pine Corporation. The terrain is characterized by gently rolling hills expressing low topographic relief. The toe on the northernmost side of the landfill is 600 ft from the Manasquan River. The Delaware River Basin/Atlantic Ocean drainage divide is a few miles west of the landfill.

The area is underlain by unconsolidated deposits of the Coastal Plain physiographic province. To the north of the Manasquan River, Red sand outcrops. Hornerstown marl outcrops in a thin band trending parallel to the river, and Vincetown sand is exposed at the southern edge of the landfill.

Lone Pine Landfill operated for twenty years before it was closed in 1979. Hazardous wastes were disposed of in the landfill during its final years of operation. A groundwater sampling program conducted in 1981 indicated that the Red Bank and Vincentown aquifers were contaminated with volatile organic compounds down-gradient from the landfill. Surface water samples showed that the contaminated groundwater also discharges to the Manasquan River.

III. SITE SPECIFIC SAMPLING AND ANALYSIS PROCEDURES

A. Groundwater Monitoring Well Installation

A series of monitoring wells will be installed for the purpose of observing the local geologic and hydrologic conditions, and to collect water samples that will indicate the extent of the local contaminant migration.

990

A detailed description of the procedure to be used when installing the wells and a figure indicating the well locations are contained in Appendix A.

B. Groundwater Samples

Sample Type: Observation Wells Sample Code: OW

Objective: To collect a representative groundwater sample from the newly installed observation wells, which will aid in the identification of the sources and extent of local groundwater contamination. One round of samples will be collected approximately ten days after the completion of well installation.

Sample Collection Method: Centrifugal pump or manual bailing

Reference: 3816013

Special Sampling Equipment: Centrifugal pump and bottom filling bailer.

Number of Sampling Locations: Five wells to be installed by CDM (Appendix A presents figure with locations).

Total Samples: -seven (7) samples, one from each well plus two duplicates.

Sample Containers and Preservatives: Reference 3817007

	Sample Type	Container	Volume	Preservative
(1)	Refractory Priority Pollutant Organics	Glass Amber	4000 ml	Cool 4°C
(2)	Volatile Organic	VOA Vial	2x 40 ml	Cool 4°C
(3)	Trace Metal Scan	PE Round	1000 ml	HNO_3 pH<2

acid base pesticides PCB's

991

All sample containers will be provided with teflon lined septum seal caps. Prelabeled sampling and shipping containers will be provided by:

CDM Boston Laboratory
One Center Plaza
Boston, Massachusetts 02108

ATT: Eileen Kireilis

Samples will be analyzed by a USEPA contractor laboratory.

Quality Assurance:

The specific sampling and analysis plan will be subject to the requirements of the generic quality assurance plan. Specific quality control tasks are:

1. Complete set of field blanks for each sampling day.

+ rip blank

2. Duplicate set of samples.

Sampling Team:

Camp Dresser & McKee will collect the groundwater samples. The sampling team will be composed of the following members:

Sampling Team Leader and On-Site Coordinator	David Schafer (CDM)
Health and Safety Officer	Not Required
Sampling Engineer	Michael Calise (CDM)
Logistics Support Technician	Not Required

99

Personal Protection: Reference 3817011

The sampling team will be required to use Class D protection. The Sampling Team leader will be responsible for adherence to health and safety protocols.

Additional Requirements: Reference 3817004

Each well casing will be marked with a permanent, easily visible label. If it is not possible to label a casing, a labeled stake should be driven adjacent to the well casing. The labels should contain the following coding:

LPL Site Code

OW-AAA AAA = Well Number

The actual samples will be numbered consecutively, as collected, utilizing an additional group descriptor for sequence identification. The general sample coding is as follows:

LPL - OW - AAA - BBB

LPL = Site Codes AAA = Sampling Location

OW = Sample Type Code BBB = Sequence Number

For any given well sampling location, the Site Code, Sample Type, and Sampling Location will remain constant and for all such samples collected, only the Sequence Number will change to identify separate samples, as shown in Table III-1.

993

Chain of Custody Procedure/Documentation: Reference 3817005

Field Notebook	Procedure 3817001
Chain of Custody Form	Procedure 3817005
Organic Traffic Control Sheet	Procedure 3817006
Inorganic Traffic Control Sheet	Procedure 3817006

C. Falling Head Tests

Objective: To measure the local horizontal permeability of the aquifiers near installed monitoring wells.

Reference:

Number of Sampling Locations: Falling head tests will be performed at twenty-five wells in the Lone Pine Landfill area. These include the twenty monitoring wells installed by the EPA Field Investigation Team (FIT) and the five wells being installed by CDM. These wells are identified as EPA1 through EPA10 (2 wells at each location) and CDM1, CDM2, CDM3, CDM4, and CDM4A on Figure A-1. No samples will be collected for laboratory analysis.

Sampling Team:

Camp Dresser & McKee will conduct the falling head tests in the field. The field team will consist of the following members:

Field Team Leader and On-Site Coordinator	David Schafer (CDM)
Field Engineer	Michael Calise (CDM)

Personal Protection: Reference 3817011

994

The sampling team will be required to use Class D protection. The Sampling Team Leader will be responsible for adherence to health and safety protocols.

D. Sediment Samples

Sample Type: Stream Sediment Sample code: SD

Objective: Collect representative sediment samples (5) and appropriate quality control samples along the course of the Manasquan River and its unnamed tributary. The results of the analysis of these samples will be used to verify the results of previous studies of bottom sediment quality in the stream and in the vicinity of the Lone Pine Landfill. The extent and degree of contamination in the bottom sediments of the stream will determine the remedial options, including dredging, that will be evaluated.

Stream Hydraulic Parameters

Length of course under study:	3000-4000 ft.
Average flow:	2 cfs
Depth:	1.0-1.5 ft.
Width:	8-12 ft.
Bottom conditions:	soft and sandy with extensive anthropogenic debris

Sampling Method: Grab Reference: 3816012

Special Sampling Equipment: Shallow water sediment sampler (Horizon 5462-00-WE) Single Tube Core Sampler (Wildco 2400-A15)

Number of Sampling Locations: five (5) Map Reference: Figure III-1

Total Number of Samples: six (6), including duplicate

Sampling Containers and Preservatives Reference 3817007

Sample Type	Container	Volume	Preservative
(6) PP/Organic including Volatiles	Glass Amber	500 ml (wide mouth)	Cool 4°C
(7) Task 1 Metals Task 2 Metals Cyanide	Glass (wide mouth)	500 ml	Cool 4°C

(X) used to specify analysis, containers and preservatives required in the following sections.

All containers supplied with teflon-lined caps. Prelabeled sampling and shipping containers will be supplied by:

CDM Boston Laboratory
One Center Plaza
Boston, Massachusetts 02108
Attention: Eileen Kireilis

Samples will be analyzed by a USEPA contractor laboratory.

Quality Assurance Reference 3817011

996

The specific sampling and analytical plan will be subject to the requirements of the generic quality assurance plan. Specific quality control tasks are described below:

Duplicate set of samples from site (designated below)

Sampling Team Reference 3817009

Camp Dresser & McKee will collect the sediment samples at the same time the groundwater samples are collected. The sampling team will be composed of the following individuals and positions.

Sampling Team Leader and On-Site Coordinator	- David Schafer (CDM)
[illegible] & Safety Officer	- Not Required
Sampling Engineer (1)	- Camp Dresser & McKee (CDM)
Logistics Support Technician	- Not Required

Personal Protection

The sampling team will be required to use Class D protection when collecting and handling the sediment samples. The sampling team leader will be responsible for compliance with the specific requirements of the Health and Safety Plan developed for the Lone Pine Landfill Investigation Program.

97

Special Precautions/Hazards

These samples are generally classified as environmental, considered to contain low concentrations of contaminants. Care should be taken when entering the stream to collect the samples. The "buddy system" must be used. Sample locations may be frozen. Caution should be exercised when working on or near ice. Possibility of exposure must be considered.

Additional Requirements Reference 3817004

Each of the sampling locations will be identified using stakes prior to collecting the sample using methods specified in generic site investigation protocol. The sampling locations will be (Reference 7002) identified by the following coding system:

LPL-SD-AAA

LPL Site Code - Lone Pine Landfill

SD Sample Type - Sediment

AA Sampling Station

The actual samples will be numbered consecutively, utilizing a fourth group of characters. The sample numbers will be assigned, just prior to the commencement of the sampling program, by the Sampling Team Leader (CDM). The general sampling coding method is described below:

LPL-SD-AAA-BBB

LPL = Site Code

948

SD = Sample Type

AAA = Station Code

BBB = Sequence Number

For any given sediment sampling location, the site code (LPL), sample type (SD) and sampling location (AAA) will remain constant for all samples collected at that location. Only the sequence number will change to identify separate samples, as shown in Table III-2.

Chain of Custody Procedure/Documentation Reference 3817005

Field Notebook	Procedure 3817011	[x]
Chain of Custody Form	Procedure 3817005	[x]
Organic Traffic Control Sheet	Procedure 3817006	[x]
Inorganic Traffic Control Sheet	Procedure 3817006	[x]
Viar Shipping List	Procedure 3817006	[x]
Photographic Evidence	Procedure 3817002	[x]

Sample Traffic Control (Tentative) Reference 3817006

SEND ORGANIC SAMPLES (1)(2)

To: Mead Compuchem
3308 Chapel Hill/Nelson Highway
Research Triangle Park, NC 27709
Attn.: Angie Frye

CASE NUMBER: to be specified

SEND INORGANIC SAMPLES (3)(4)

To: Versar
6621 Electronic Drive
Springfield, VA 22151
Attn.: Bill Nivens

CASE NUMBER: to be specified

999

Special Instructions

Sediment (SD) sampling locations will be permanently marked using stakes. Photographic evidence of the sampling locations will be required. Staking and photographic evidence procedures are found in the Generic Site Investigation Protocol for Uncontrolled Hazardous Waste Sites: Site Location Procedure and Photographic Evidence (Reference 3817002.).

Method (Reference 3817002)

TABLE III-1

GROUNDWATER SAMPLING LOCATIONS AND ANALYTICALS SPECIFICATIONS

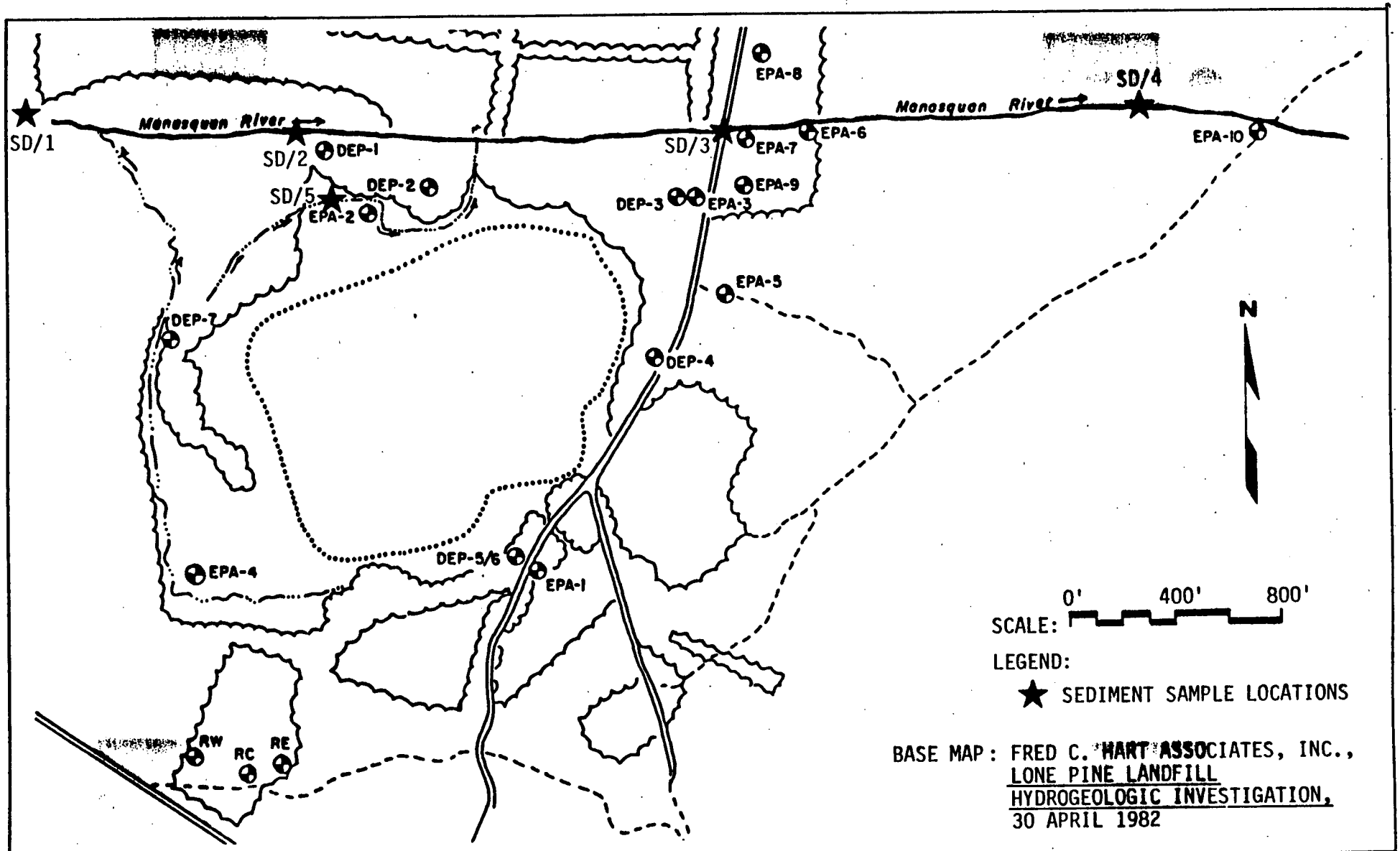
Sampling Location	Map Reference	Sample/Site Designation	Sampling Containers/ Analysis	Remarks
1	CDM-1	LPL-OW010	1,2,3	
2	CDM-2	LPL-OW020	1,2,3	
	CDM-2	LPL-OW021	1,2,3	Duplicate
3	CDM-3	LPL-OW030	1,2,3	
4	CDM-4	LPL-OW040	1,2,3	
4A	CDM-4A	LPL-OW051	1,2,3	
	CDM-4A	LPL-OW051	1,2,3	Duplicate
		LPL-OW120	2	Field Blank

TABLE III-2

SEDIMENT SAMPLING LOCATIONS AND ANALYTICAL SPECIFICATIONS

Sampling Location Description	Map Reference	Sample/Site Designation	Sampling Containers/ Analysis
D. Sediment Samples (SD)			
Manasquan River/Sample No. 1	SD/01	LPL-SD-01	(6) (7)
Manasquan River/Sample No. 2	SD/02	LPL-SD-02	(6) (7)
Manasquan River/Sample No. 3	SD/03	LPL-SD-03	(6) (7)
Manasquan River/Sample No. 4	SD/04	LPL-SD-04	(6) (7)
Manasquan River/Sample No. 5	SD/05	LPL-SD-05	(6) (7)
Duplicate Sample Station SD-03	SD/03	LPL-SD-06	(6) (7)
Contingency Sample No. 1	X	LPL-SD	(6) (7)
Contingency Sample No. 2	X	LPL-SD	(6) (7)

1002



ZONE 1 **FEASIBILITY STUDY**	LONE PINE LANDFILL FREEHOLD N.J. APPROXIMATE LOCATIONS OF SEDIMENT SAMPLES	CAMP DRESSER & McKEE INC. One Center Plaza Boston, Massachusetts 02108 DECEMBER 1982 FIGURE: III-1

1003

APPENDIX A

GROUNDWATER MONITORING WELL INSTALLATION PROCEDURE

Re: Groundwater Monitoring Wells
at the Lone Pine Landfill

Dear

Enclosed is a request for proposals to construct five (5) monitoring wells at a hazardous waste site in Freehold, New Jersey. Proposals for this work must be received in writing prior to October 28, 1982 in the offices of Camp Dresser & McKee Inc. Included with the drilling proposals, the drilling subcontractor shall append 1) a detailed Health and Safety Plan as described in the RFP and 2) a complete list and bref description of similar work performed within the last year by the firm and by the individual driller who will perform this work, including reference names and phone numbers.

The actual work is scheduled to begin the week of November 15, 1982 and will take an estimated 6-8 days to complete. Due to the care (and unknown time considerations) with which this work must be accomplished, payment will be made on a time and materials basis. Driller selection will be made on the basis of price, given that there is demonstrated experience and reliability, and a suitable health and safety plan.

Request for a site visit, if required, should be received by CDM prior to October 22, 1982 and a site meeting will be arranged. The site is located on Burke Road in Freehold, New Jersey. In all cases, award of Contract (example attached) is subject to USEPA approval and verification of personnel qualifications.

Questions regarding the monitoring well construction should be addressed to Henry Boucher at CDM.

Very truly yours,

CAMP DRESSER & MCKEE INC.

1005

REQUEST FOR PROPOSALS

MONITORING WELL INSTALLATION

LONE PINE LANDFILL

FREEHOLD, NEW JERSEY

GENERAL

The objectives of the proposed work are to obtain subsurface soil samples and install piezometers in five (5) locations in Freehold, New Jersey, as indicated on the attached map. The work will be performed under the direction of Camp Dresser & McKee Inc. (CDM) (hereinafter called the ENGINEER).

Due to potentially hazardous conditions on, or adjacent to, the Lone Pine site, all on-site workers must follow the health and safety information on the type of safety equipment which will be required; the duties and responsibilities of the drilling contractor; and other information relative to bid preparation.

DRILLING PROCEDURES

In general, drilling conditions are expected to include 20-25 feet of sands, 10-15 feet of clays, and another 40-50 feet of sands and silts, but will vary from one boring location to the next. Bedrock will not be encountered. Contaminated groundwater is expected

1006

in some locations. Attached to this RFP are two generalized well construction sketches corresponding to the two types of wells to be installed as well as a site map locating the monitoring wells. At three locations two wells will be installed. The approximate well depths and types are as follows:

Well	Depth (ft)	Well Type
1	25 - 30	1
2	25 - 30	1
3	25 - 30	1
4	15 - 20	1
4A	25 - 35	2

Split spoon samples will be collected at Wells 1, 2, 3, and 4A, and will consist of continuous samples to below the water table surface (4°-10° estimated) and at 5 foot intervals after that (or as directed by CDM°s field engineer). In general the two types of wells will be

constructed as follows:

Type 1 (Shallow)

1. Clear site for work.*

2. Split spoon sample (if required).

3. Drive and wash 4 inch I.D. thin wall flush joint casing to the depth specified by the ENGINEER.

4. Set piezometer, sand pack, and grout as directed by the ENGINEER (expected hole backfill as indicated on the drilling sketches).

5. Develop well (with air surging or pumping as appropriate) as approved by ENGINEER.

6. Cement protective casing in place. A 2 foot thick cement pad shall be used.

Type 2 (Deep)

1. Split spoon sample.

2. Drive and wash 6 inch I.D. thin wall flush joint casing into the clay to the depth specified by the ENGINEER.

3. Set 4 inch I.D. thin wall casing inside the 6 inch casing and advance using a drive and wash technique to the depth specified by the ENGINEER. Flush the 4 inch casing with clean water.

4. Advance the bore hole and split spoon sample to the necessary depth using a 3-1/2 inch or larger roller cone bit and drilling fluid (water and Revert). The 4 inch I.D. casing

may be advanced, if necessary, to maintain an open bore hole. The final depth of each hole will be directed by the ENGINEER on site.

5. Set piezometer, sand pack, and grout as directed by the ENGINEER (expected hole backfill as indicated on the drilling sketches).

6. Develop the well (with air surging or pumping as appropriate) as approved by the ENGINEER.

7. Cement protective casing in place. A 2 foot thick cement pad shall be used.

Also the following procedures will apply:

1. Bentonite pellets will be used to seal the annular space above sand packing in each well (as indicated on the construction sketches).

2. Bentonite pellets will also be used to seal the annular space of the clay in Type 2 wells (as indicated on the construction sketches).

3. Filter sand should be Ottawa or other approved graded sand.

4. Sand will also be placed below the well casings and screens.

5. Drill pipe, rod, and other lubrication shall only be Dow-Corning High Vacuum grease.

6. Strict cleaning procedures will be employed as described as follows.

Equipment Cleaning Procedures

1. All downhole (rods, spoons, bits, augers, thin wall casing piezometer casing and screens) and other contact equipment (pumps, portable mud pit, etc.) will be steam cleaned (or flushed as appropriate and directed) with clear water from an EPA approved water source prior to starting work at each drilling location and at the conclusion of the project. Portable steam cleaning equipment and water tanks will be provided by the contractor for this purpose. The cleaning will be witnessed by the field ENGINEER.

2. All equipment shall be cleaned and stored above ground on saw horses or other appropriate equipment. Cleaned equipment must be stored in a clean manner acceptable to the field ENGINEER.

3. All split spoons (3 required) will be cleaned prior to each use: first with water and laboratory detergent and a brush, rinsed with Methanol, and rinsed again with clear clean water. If oily samples are encountered, additional cleaning procedures as directed by the field engineer will be followed. The contractor shall provide all the equipment and supplies for cleaning purposes.

ACCESSIBILITY

All sites are expected to be accessible to track-mounted drilling equipment or all terrain type rigs. The contractor should be prepared with a chain saw and other brush cutting equipment to facilitate access.

MATERIALS AND SUPPLIES

The contractor is required to provide all equipment, supplies, and materials (plus a 30% contingency) to complete the work as described, including but not limited to the following:

1. Track-mounted or equivalent drilling machinery including thin wall casing supplies, materials, all necessary 4-inch I.D. thin wall flush joint temporary casing for construction of the bore holes.

2. Well riser 2-1/2 inch diameter galvanized steel flush joint threaded riser - 250 feet estimated.

3. Well screens 5 feet long by 2-1/2 inch diameter threaded with bottom cap - eight #40 slot stainless steel well screens estimated (no hand fabricated screens permitted).

4. Split spoon samplers - 2-inch O.D., 1-3/8 inch I.D. steel barrel, 24 inches in length. The standard penetration test shall be perfomred at each sampling location. Three split spoon samplers with top end check valves are the minimum required.

5. Adequate quantities of Ottawa or other approved sand.

6. Adequate quantities of bentonite pellets for well seals. Tamping equipment for bentonite.

7. Adequate quantities of cement for slurry grout.

8. Suitably sized air compressor with airline oil filter and at least 100 feet of small-diameter pipe or tubing for well development.

9. Drilling fluid, portable mud tank, and mixing equipment as necessary.

10. Centrifugal pump and dropline for well development and testing.

11. Portable steam cleaning equipment. Adequate clean water storage capacity to maintain continuous drilling and/or equipment cleaning operations (not drill rig mounted).

12. Adequate clean water storage capacity to maintain continuous drilling and/or equipment cleaning operations (not drill rig mounted).

13. Drill pipe lubricant (Dow-Corning high vacuum grease).

14. Pesticide Grade methanol.

15. Liquinox or Alconox laboratory detergent for split spoon cleaning.

16. Four clean 55 gallon drums acceptable to the ENGINEER for storage of drill cuttings.

17. Saw horses for steam cleaning and equipment storage.

An equipment check by the ENGINEER will be performed prior to the start of the project. Time required for the acquisition of supplies and materials either prior to or during the project will be at the Contractor°s expense and not considered billable.

Records

The Contractor shall keep complete records of each boring, which show his interpretation of the results of the borings. Such records shall be signed by the driller and furnished to the ENGINEER as the work progresses. The records shall contain, but not be limited to, the following information:

General Information

- Date and project number.
- Location and identifying number of test boring and reference to survey data.

Soil Borings

- Results of all details for each borehole, which shall be arranged in tabular form giving full information on the vertical arrangement, thickness, and visual classification of the

materials penetrated.

- Depths of top and bottom, type, and number of each sample taken. All samples shall be numbered consecutively.
- Height of drop and weight of hammer for taking drive samples and for driving casing.
- Number of blows required for each twelve (12) inch penetration of split-spoon samplers.
- Size, length, and depth of bottom of casing and/or augers used in each borehole.
- Depth to groundwater table at each borehole and time of observation.
- Descriptions of samples.

Well Data

- Type, size, and depth of groundwater monitoring wells including screened interval and casing length.
- Depth and length of collapsed sand, well-graded sand, and bentonite backfill.
- Depth and type of unusual conditions.

SUBMISSION OF REPORTS AND SAMPLES

Borehole Logs

Upon completion of each boring, a signed copy of the field log shall be given to the ENGINEER at the site. Within three weeks after the completion of field work the Contractor shall submit typed copies of the borehole logs to the office of the ENGINEER.

Soil Samples

Within one week of the completion of the drilling program, the Contractor shall turn custody of split-spoon samples over to the ENGINEER.

Site Health and Safety Protocol

The Contractor will establish and implement a Health & Safety Plan for the Lone Pine Uncontrolled Hazardous Waste Site, as low levels of potentially hazardous wastes may be encountered. Elements of this plan will include:

- o Baseline Medical Surveillance for all site personnel.
- o Requirements for personal protective equipment and respiratory protection.
- o Specification of job classification and safe working procedure.
- o Tracing protocols for on-site personnel.
- o Special Medical Procedures and Emergency First Aid Requirements for on-site monitoring of employees during work

activities.

- o Emergency Procedures - Contingency Plan
- o Evacuation Procedures - Contingency Plan

The safety and health plan will be periodically updated, as required to reflect changes in the nature of the hazards and/or operating conditions encountered at Lone Pine Landfill.

Measurement And Payment Provisions

GENERAL

Payment will be made, based on an approved monthly estimate in accordance with the provisions stated in section five (5) of the general contract provisions.

The payment estimate shall be prepared in accordance with the following provisions for measurement and payment.

Item #1 Mobilization and Demobilization

Payments for mobilization and demobilization will be made at the lump sum bid price. The payment shall be full compensation for movement (travel costs and time) of all required equipment, personnel, materials, and supplies to and from the site of the work included in this price shall be premiums for insurance in addition to normal coverage (when required).

This payment item shall include all labor not otherwise provided for under other items for which costs have been established.

Item #2

Well drilling and construction payment for performing the specified well drilling and monitoring well construction will be made on a per diem basis for the actual number of days worked. The quantity paid will be the number of days or fraction thereof, measured to the nearest hour that the contractor performs the specified work.

Payment is considered full compensation for all labor costs, all necessary equipment (drilling rig, pumps, drive casings, etc.) living and other expenses for personnel required to be away from the home office, all expendable supplies and materials, including level C health and safety equipment, equipment cleaning supplies & materials, 55 gallon barrels, drilling fluid, lubricants, and water, etc.

No payment for time will be made when the drill rigs and/or crews are out of production due to equipment failures or lack of materials, supplies and/or equipment to perform the specified work. No payment under this item will be made for lost time due to inclement weather, utility clearances, food breaks, or other circumstances beyond the control of the ENGINEER. The field engineer shall be considered the judge in determining if payment is authorized.

Item #3 Materials of Construction

Payment for these items will be on the number of units installed or used during monitoring well construction, measured to the nearest whole unit (foot, bag, or each). Payment is considered full compensation for furnishing (at the site) the materials used for the project. Installation of monitoring wells are covered in Item #2.

Item #4 Level C Personnel Protective Equipment

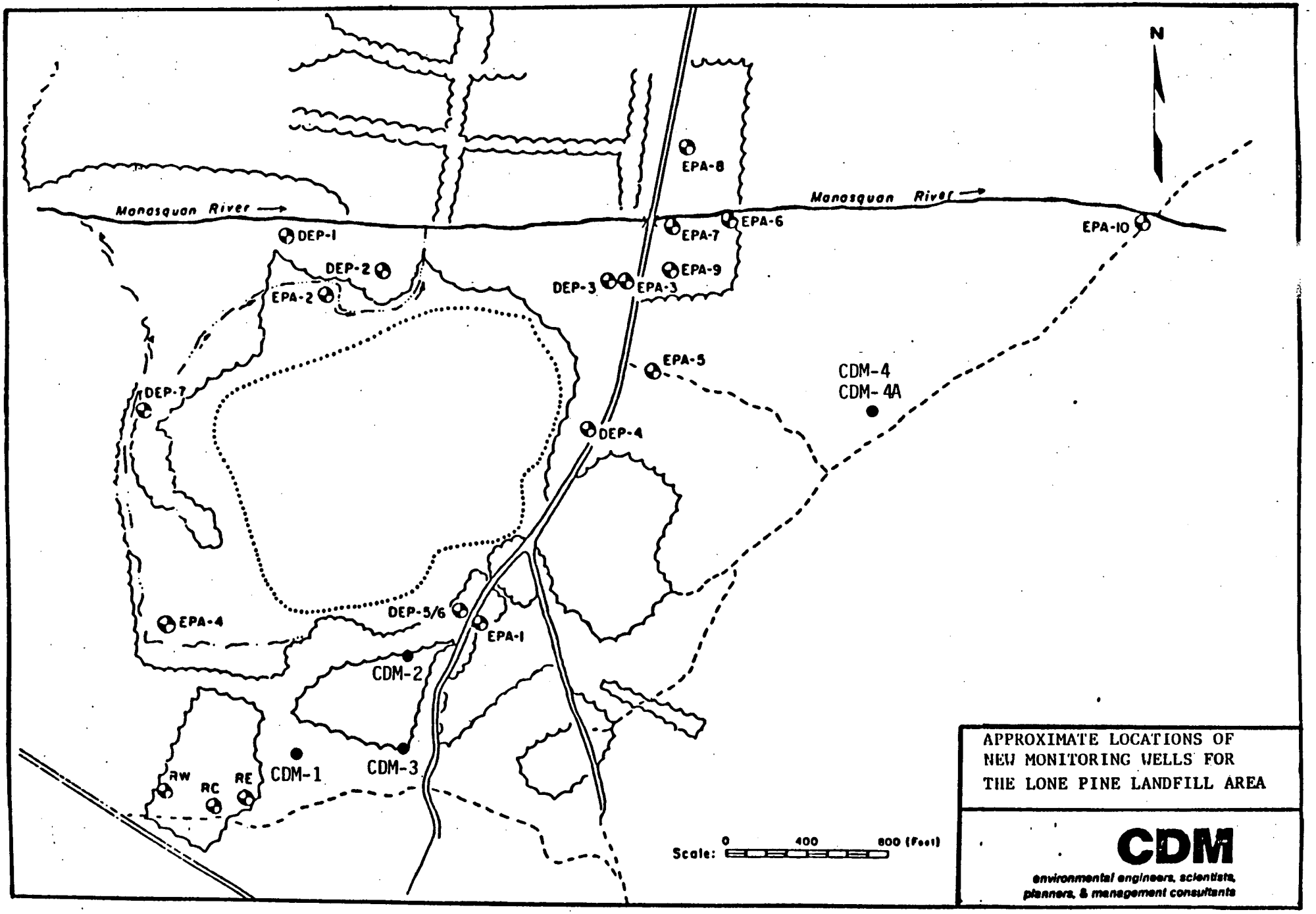
Payment for Item 4 will be made for time required to use Level C personnel protective equipment on the site. The basis of measurement will be the day or fraction thereof measured to the nearest hour. This item is in addition to Item #2 and is considered full compensation for all equipment supplies or other materials necessary for personnel protection during Level C (if required) work.

Unit prices shall hold in the event that the Contractor is instructed to perform either more or less work than is indicated. If the bidder is a corporation, indicate state of incorporation under signature, and affix corporate seal; if a partner, give full names and residential addresses, if different from business address.

Notice of acceptance should be mailed, telegraphed or delivered to the undersigned bidder at the following address:

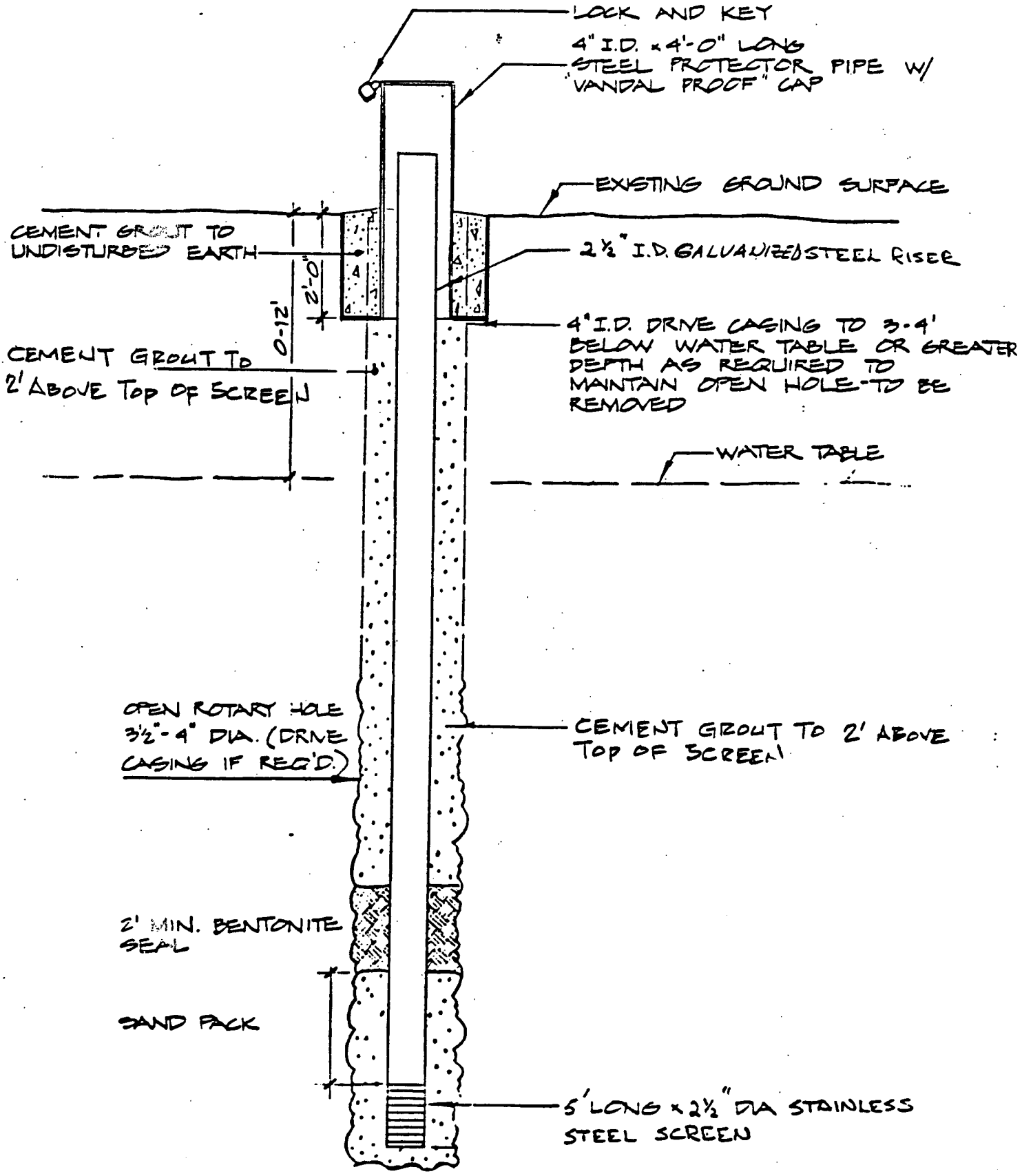
INSURANCE

All bids must include Certificate of Insurance in accordance with Section 6.3.1 of the attached standard contract.


N
Manasquan River
Manasquan River
EPA-8
EPA-6
EPA-7
EPA-10
DEP-1
DEP-2
EPA-2
DEP-3
EPA-3
EPA-9
EPA-5
CDM-4
CDM-4A
DEP-7
DEP-4
EPA-4
DEP-5/6
EPA-1
CDM-2
CDM-1
CDM-3
RW
RC
RE
Scale: 0 400 800 (Feet)
APPROXIMATE LOCATIONS OF
NEW MONITORING WELLS FOR
THE LONE PINE LANDFILL AREA
CDM
environmental engineers, scientists,
planners, & management consultants

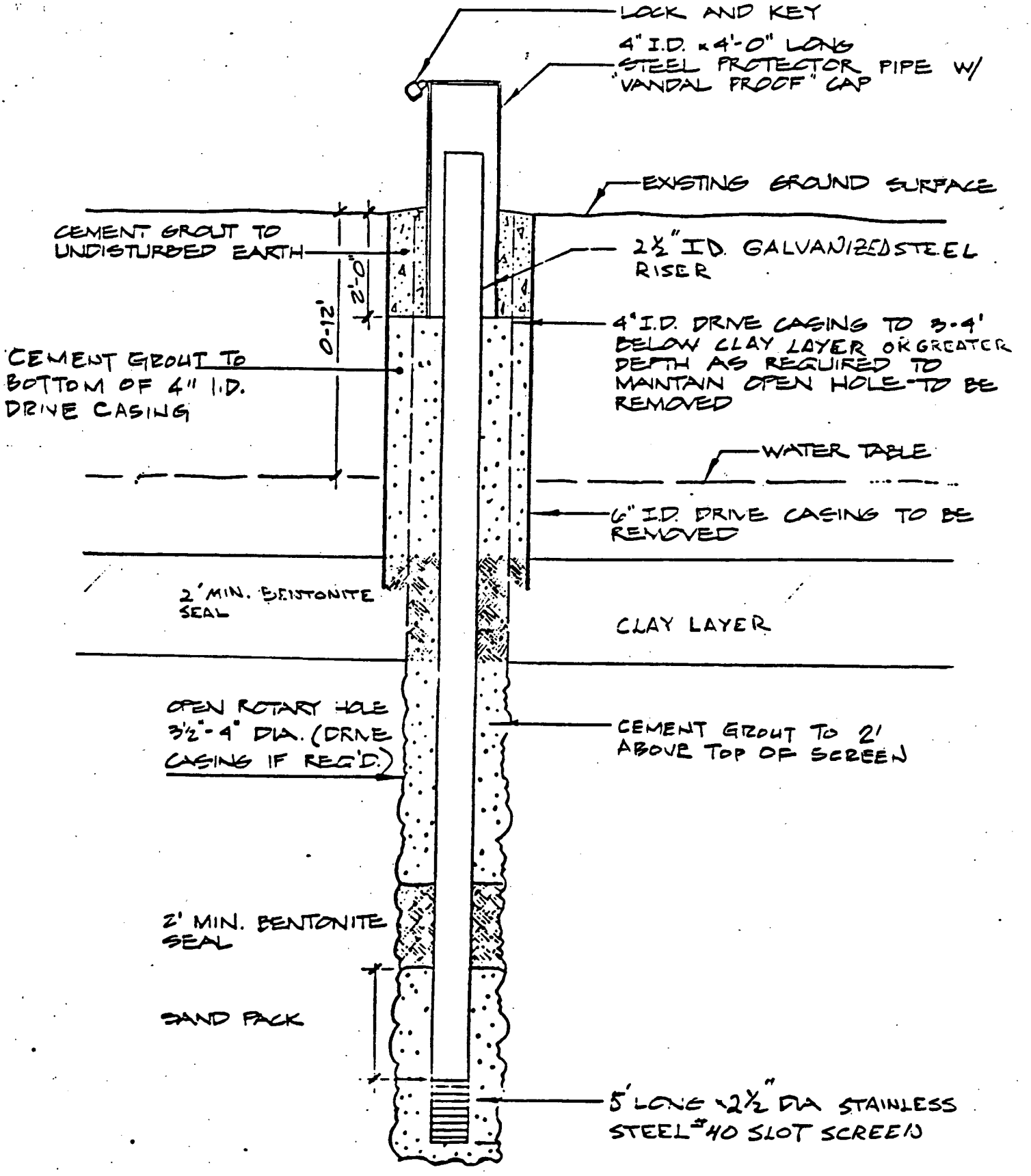
1021

TYPE I WELL



1022

TYPE II WELL


LOCK AND KEY
4" I.D. x 4'-0" LONG STEEL PROTECTOR PIPE W/ "VANDAL PROOF" CAP
EXISTING GROUND SURFACE
CEMENT GROUT TO UNDISTURBED EARTH
2½" I.D. GALVANIZED STEEL RISER
0-12'
2'-0"
4" I.D. DRIVE CASING TO 3-4' BELOW CLAY LAYER OR GREATER DEPTH AS REQUIRED TO MAINTAIN OPEN HOLE-TO BE REMOVED
CEMENT GROUT TO BOTTOM OF 4" I.D. DRIVE CASING
WATER TABLE
6" I.D. DRIVE CASING TO BE REMOVED
2' MIN. BENTONITE SEAL
CLAY LAYER
OPEN ROTARY HOLE 3½"-4" DIA. (DRIVE CASING IF REQ'D.)
CEMENT GROUT TO 2' ABOVE TOP OF SCREEN
2' MIN. BENTONITE SEAL
SAND PACK
5' LONG x 2½" DIA STAINLESS STEEL #40 SLOT SCREEN

APPENDIX B

FALLING HEAD TEST FIELD PROCEDURE

Falling Head Test

1.0 Introduction

The purpose of a falling head test is to measure the local horizontal permeability of a strata near a given well. The horizontal permeability is one parameter that aids in the evaluation of groundwater transport.

2.0 Equipment

2.1 Bucket of clean water and/or a bottom filling bailer.

2.2 Groundwater elevation measuring device.

2.3 Stop watch

3.0 Procedure

The procedure consists of either introducing water into the well riser or extracting water from the well and measuring the rate of disappearance or re-appearance of water.

In the case of introducing water into the well, the water is poured in and an initial elevation is noted immediately when the pouring ceases. When water is extracted using the bailer, the initial elevation is noted immediately upon removal of the bailer from the well. In each case the water level in the well is subsequently noted at the following times: 0.25, 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, and 32.0

minutes. The water level observations are ceased at 32 minutes or when the well is 90% recovered from its disturbance, whichever occurs first. If possible, the water introduction and extraction methods should both be attempted at every location.

Results should be recorded on the accompanying form.

CDM

FALLING HEAD TEST FIELD DATA

SITE: _____

LOCATION: _____

CLIENT: _____

DATE: _____ SAMPLER: _____

WEATHER CONDITIONS: _____ WELL NUMBER: _____

Time	Water Level
____	____
____	____
____	____
____	____
____	____
____	____
____	____
____	____
____	____
____	____

Time Units: _____

Water Level Units: _____

Static Water Level: _____

(102/15)

Falling Head Test

1.0 Introduction

The purpose of a falling head test is to measure the local horizontal permeability of a strata near a given well. The horizontal permeability is one parameter that aids in the evaluation of groundwater transport.

2.0 Equipment

2.1 Bucket of clean water and/or a bottom filling bailer.

2.2 Groundwater elevation measuring device.

2.3 Stop watch

3.0 Procedure

The procedure consists of either introducing water into the well riser or extracting water from the well and measuring the rate of disappearance or re-appearance of water.

In the case of introducing water into the well, the water is poured in and an initial elevation is noted immediately when the pouring ceases. When water is extracted using the bailer, the initial elevation is noted immediately upon removal of the bailer from the well. In each case the water level in the well is subsequently noted at the following times: 0.25, 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, and 32.0

minutes. The water level observations are ceased at 32 minutes or when the well is 90% recovered from its disturbance, whichever occurs first. If possible, the water introduction and extraction methods should both be attempted at every location.

Results should be recorded on the accompanying form.

CDM

FALLING HEAD TEST FIELD DATA

SITE: _____

LOCATION: _____

CLIENT: _____

DATE: _____ SAMPLER: _____

WEATHER CONDITIONS: _____ WELL NUMBER: _____

Time	Water Level
____	____
____	____
____	____
____	____
____	____
____	____
____	____
____	____
____	____
____	____

Time Units: _____

Water Level Units: _____

Static Water Level: _____

(102/15)

(030)

Recd 1/17/83

ADDENDUM TO THE SAMPLING AND ANALYSIS PROTOCOL FOR REMEDIAL INVESTIGATION AT LONE PINE LANDFILL

FREEHOLD, NEW JERSEY

Prepared By

Camp Dresser & McKee Inc.
One Center Plaza
Boston, MA 02108

January 1983

1031

ADDENDUM TO THE SAMPLING AND ANALYSIS PROTOCOL FOR REMEDIAL INVESTIGATION AT LONE PINE LANDFILL

This addendum to the Sampling and Analysis Protocol for Remedial Investigation at Lone Pine Landfill, December 1982, addresses and clarifies several items in the protocol pertaining to Quality Assurance (QA), monitoring well installation and falling head tests.

The December 1982 sampling and analysis protocol document plus this addendum constitute the complete Sampling and Analysis Protocol for the Lone Pine remedial investigation.

QUALITY ASSURANCE

Quality Assurance Responsibility. Overall Quality Assurance responsibility at CDM for the Superfund contract belongs to the Manager of Quality Assurance, who reports to the Superfund Project Director.

Quality assurance for sampling and relevant analytical portions of the Superfund project is monitored by a Sampling and Analytical Quality Assurance (SAQA) Officer who reports directly to the Manager of Quality Assurance and the Project Director. The SAQA Officer is responsible for the control of documentation of all field and analytic methods that form the Generic Site Investigation Protocol.

The Sampling and Analytical Coordinator is responsible for scheduling and controlling the activities of the sampling team. The coordinator also supervises the Sample Traffic Control Center and is directly responsible for the allocation of samples to the Sample Management Office - designated laboratories.

Quality Assurance Objectives for Precision, Accuracy, Representativeness and Completeness. CDM's Generic Site Investigation protocol for uncontrolled hazardous waste sites addresses in general terms program requirements for accuracy, precision, representativeness, and completeness.

Specific requirements for these elements of CDM's quality assurance program for the Lone Pine Landfill field investigation program are delineated as follows.

The criterion of accuracy (the comparison of a reported value to a known value) for field programs may only be applied to the analytical component of the data. Accuracy of analytical data from EPA contractor laboratories is the responsibility of the Environmental Monitoring Systems Laboratory (EMSL), Las Vegas. The accuracy of field data for environmental samples may not be determined by definition.

The criterion of precision (reproducibility of the measurement) may be applied to the field data for the Lone Pine program. The overall precision of the field measurement is a combination of the analytical and sampling precision. The analytical precision of the contractor laboratory is the responsibility of EMSL, Las Vegas. The sampling precision is defined by the procedures utilized.

CDM monitors the precision of field measurements by submitting blind duplicate samples to the contractor laboratory at the 10% level. Blind blanks are also submitted to contractor laboratory to monitor sampling equipment, sample container, and/or laboratory contamination.

Considering the demonstrated laboratory precision of the contractor laboratories (25% for VOA's, ± 40% for acid/base neutrals, and ± 20% for inorganic parameters) and the variability associated with sampling a complex matrix, an overall precision of ± 50% on blind duplicates is considered acceptable. It should be noted, however, that no field data will be rejected, but will be reported with appropriate qualifications and documentation.

The criterion of representativeness (does subsample have the same measurable characteristics as the total sample substate). Representativeness is defined by the sampling method utilized. Blind duplicate samples collected as part of the field programs monitor the representativeness of samples. A precision or "sameness" of ± 60% is acceptable for ordinary sample matrices.

The criterion of completeness (all samples scheduled to be collected are collected). CDM will collect all samples scheduled to be collected. If any sample is uncollectable (well blocked, etc.) or is lost during transportation to the contractor laboratory, a decision will be made on a case-by-case basis if an alternative sample will be required. This decision will be based on cost effectiveness and the technical requirements of the field investigation program.

Field Blanks. For the sediment sampling, a distilled water field blank will be carried into the field and analyzed for each day of sediment sampling.

For groundwater sampling, by complete set of field blanks is meant one blank for each sample type to be analyzed.

MONITORING WELL INSTALLATION AND FALLING HEAD TESTS

1. On the deep (type II) well sketch, the bentonite seal at the clay layer can be deleted. The cement grout will be continuous from 2 feet above the screen to the surface.

2. The stainless steel well screens will be #20 slot instead of #40 slot.

MONITORING WELL INSTALLATION AND FALLING HEAD TESTS (Continued)

3. The source of drilling water and introduced water for the falling head tests is planned to be potable water from a Township hydrant in the vicinity of the site. This should avoid the potential for introducing further groundwater contamination.

4. Falling head tests at the newly installed wells will be conducted one day after the wells have been sampled.

Received 2/22/82

DRAFT

REMEDIAL RESPONSE ACTIVITIES

ZONE I

UNCONTROLLED HAZARDOUS WASTE DISPOSAL SITES

DRAFT
QUALITY ASSURANCE PLAN

Lone Pine Landfill, New Jersey
Work Assignment Z-1-17 Under
Contract No. 68-03-1612

JANUARY 1983

JAS

CAMP DRESSER & McKEE INC.
CH2M HILL
CONESTOGA-ROVERS & ASSOCIATES LIMITED
HALEY & ALDRICH, INC.

1035

CDM

environmental engineers, scientists, planners, & management consultants

CAMP DRESSER & McKEE INC.

One World Trade Center, Suite 2637
New York, New York 10048
212 432-6700

Z-1-17
Lone Pine Landfill
549-38-FI-QUAL
F2,4
( )
N. Schlissel
Distribution
8 February 1983
QUAL

8 February 1983

Donald Deieso
U.S. EPA, Region II
26 Federal Plaza
New York, N.Y. 10278

William M. Kaschak
U.S. EPA (WH-548 E)
401 M Street, SW
Washington, D.C. 20460

Jack Stanton
New Jersey DEP
Division of Waste Management
32 E. Hanover Street
Trenton, N.J. 08620

William J. Wise
U.S. EPA
Contracts Management Division
26 West St. Clair Street - Room 257
Cincinnati, OH 45268

Gentlemen:

Camp Dresser & McKee Inc. is submitting for your review the enclosed draft Quality Assurance Plan for Work Assignment No. Z-1-17, Lone Pine Landfill Feasibility Study. This plan is submitted in fulfillment of Task 8.4 of the final work plan.

We are available to discuss any questions that arise during your review of this submittal. Following receipt of your comments, we will revise the draft plan as necessary.

Yours very truly,

CAMP DRESSER & McKEE INC.

Norma L. Schlissel
Project Manager

APPROVED BY:

Gary A. Dunbar
Project Director

NLS/ds
Enclosure

1036

DRAFT

QUALITY ASSURANCE PLAN

1.0 INTRODUCTION

This Quality Assurance Plan for the Lone Pine Landfill Feasibility Study has been developed for implementation in project monitoring, sampling, evaluation and design activities. The principal objective of Quality Assurance (QA) is to obtain information that is scientifically and legally defensible and has the necessary levels of precision and accuracy for use in decisions concerning the control, removal or management of hazardous wastes at the Lone Pine Landfill and the control of their effect on the surrounding environment.

2.0 QUALITY ASSURANCE PLAN ELEMENTS

2.1 Sampling and Analysis Quality Assurance

A draft Generic Site Investigation Protocol was developed for the Zone 1 Uncontrolled Hazardous Waste Sites Remedial Action Project (Superfund) to describe the procedures and techniques to be utilized as a means of assuring the quality of samples collected at uncontrolled hazardous waste sites. This generic document serves as a depository for procedures and techniques referenced in the site-specific Lone Pine Landfill sampling plan. Among the procedures addressed in the generic protocol document relevant to the Lone Pine Landfill study are the following:

1037

(1) General quality assurance objectives for data measurement, in terms of precision, accuracy, completeness, and representativeness.

(2) Sampling procedures.

(3) Sample custody.

(4) Certain equipment calibration procedures, references and frequency.

(5) Certain field and laboratory analytical procedures.

(6) Internal quality assurance checks and frequency.

(7) Quality assurance performance audits.

(8) Quality assurance reports to management.

(9) Preventive maintenance procedures and schedule.

The reader is referred to the generic site investigation protocol document for a description of these procedures. Several of these objectives and procedures are further described below:

Quality Assurance Objectives for Precision, Accuracy, Representativeness and Completeness

CDM's Generic Site Investigation protocol for uncontrolled hazardous waste addresses in general terms program requirements for accuracy, precision, representativeness, and completeness.

1038

Specific requirements for these elements of CDM's quality assurance program for the Lone Pine Landfill field investigation program are delineated as follows.

The criterion of accuracy (the comparison of a reported value to a known value) for field programs may only be applied to the analytical component of the data. Accuracy of analytical data from EPA contractor laboratories is the responsibility of the Environmental Monitoring Systems Laboratory (EMSL), Las Vegas. The accuracy of field data for environmental samples may not be determined by definition.

The criterion of precision (reproducibility of the measurement) may be applied to the field data for the Lone Pine program. The overall precision of the field measurements is a combination of the analytical and sampling precision. The analytical precision of the contractor laboratory is the responsibility of EMSL, Las Vegas. The sampling precision is defined by the procedures utilized.

CDM monitors the precision of field measurements by submitting blind duplicate samples to the contractor laboratory at the 10% level. Blind blanks are also submitted to contractor laboratory to monitor sampling equipment, sample container, and/or laboratory contamination.

Considering the demonstrated laboratory precision of the contractor laboratories (25% for VOA's $\pm$ 40% for acid/base neutrals, and $\pm$ 20% for inorganic parameters) and the variability associated with sampling a complex matrix, an overall precision of $\pm$ 50% on blind duplicates is considered acceptable. It should be noted, however, that no field data will be rejected, but will be reported with appropriate qualifications and documentation.

1039

The criterion of representativeness (does subsample have the same measureable characteristics as the total sample substate.) Representativeness is defined by the sampling method utilized. Blind duplicate samples collected as part of the field programs monitor the representativeness of samples. A precision or "sameness" of ± 60% is acceptable for ordinary sample matrices.

The criterion of completeness (all samples scheduled to be collected are collected). CDM will collect all samples scheduled to be collected. If any sample is uncollected (well blocked, etc.) or is lost during transportation to the contractor laboratory, a decision will be made on a case-by-case basis if an alternative sample will be required. This decision will be based on cost effectiveness and the technical requirements of the field investigation program.

Quality Assurance Audits, Reports to Management and Corrective Action

For each site where samples are collected, an unannounced audit investigating conformance with QA/QC procedures will be performed by the Sampling and Analysis Quality Assurance Officer (SAQA) during the project performance period. A written report on the results of this audit, along with (if necessary) a notice of non-conformance will be submitted to the

- Manager of Quality Assurance
- Site Project Manager
- Sampling and Analytical Coordinator
- Project Director

1040

The Non-Conformance Notice (NCN) will describe any nonconforming conditions and set a date for response and corrective action. This notice will be filed in the Document Control Center (DCC) and SAQA files. The response will be reviewed by the SAQA and, if satisfactory, will be approved in writing. Approval notice will also be filed in the DCC and SAQA files. Copies of the response and the approval notice will be sent to the Manager of Quality Assurance.

At the completion of a particular site response, a final quality assurance audit will be performed. A final report will be prepared which will summarize any deviations from approved methods and their impacts on results. This report will be a part of the overall QA Project Summary Report.

Reference: Draft Generic Site Investigation Protocol
For Incontrolled Hazardous Waste Sites,
Method No. 3817015

2.2 Technical Review of Deliverables

All deliverables described in the final work plan will be reviewed in accordance with formal procedures. The following table lists the deliverables to be reviewed and identifies the type of review and person(s) to perform the review. The reviewers, selected for their expertise in the pertinent technical areas of review, will have been independent of the production of the deliverable.

1041

DELIVERABLES AND REVIEW

Deliverable	QA/QC Review
Preliminary Work Plan	Peer
Final Work Plan	Peer
Current Situation Report (Task 1)	Peer
Health and Safety Plan	Expert
Response Objectives and Evaluation Criteria Report (Task 2)	Peer
Identification of Technologies and Alternatives Report (Task 3)	Peer
Alternatives Evaluation Preliminary Report (Task 5)	TRC
Final Report including Conceptual Design (Tasks 6 and 7)	TRC
Quality Assurance Plan	PD

Subcontractor Selection	PD
Monthly Technical Progress Report	PD
Monthly Financial Management Report	PD

Legend

Peer - Review by experienced peer(s)

Expert - Review by a single technical expert

PD - Review by Project Director

TRC - Review by Technical Review Committee, a group of senior CDM personnel, none of whom is directly involved with the feasibility study. Their function is to critically review the quality of the work and to provide expert advice.

Each technical review will be documented, generally by a memorandum. The document will identify the reviewers and their comments, responses, and resulting changes to the deliverable. The memorandum will be distributed to the Project Director and Manager of Quality Assurance.

1043

The proposed review program, actual performance of the reviews and all documentation of the reviews will be included by the Manager of Quality Assurance in an audit of the QA program. The Manager of Quality Assurance will prepare a summary report at the completion of the project to document the implementation of the technical review program over the duration of the project. This summary will become part of the overall QA project summary report.

2.3 Quality Assurance Project Summary Report

The final report for the feasibility study will contain a QA section which summarizes the quality assurance activities and documentation for the project.

(SPH5/22)

1044

REMEDIAL RESPONSE ACTIVITIES

UNCONTROLLED HAZARDOUS WASTE DISPOSAL SITES

REVISED DRAFT
HEALTH AND SAFETY PLAN

Lone Pine Landfill, New Jersey
Work Assignment Z-1-17 Under
Contract No. 68-03-1612

January 1983

JAS

CAMP DRESSER & McKEE INC.
CH2M HILL
CONESTOGA-ROVERS & ASSOCIATES LIMITED
HALEY & ALDRICH, INC.

1045

REVISED DRAFT
HEALTH AND SAFETY PLAN

Lone Pine Landfill, New Jersey
Work Assignment Z-1-17 Under
Contract No. 68-03-1612

January 1983

JAS

046

TABLE OF CONTENTS

INTRODUCTION 1

I. SITE DESCRIPTION 2

II. HISTORICAL BACKGROUND 3

III. SITE MAP (FIGURE 1) 4

IV. SITE AND TASK SPECIFIC HEALTH AND SAFETY PROCEDURES 5

A. Surficial Conditions Mapping 5

B. Well Borings and Groundwater Monitor Installations 6

APPENDIX I GENERAL SITE INVESTIGATION PROTOCOL FOR UNCONTROLLED HAZARDOUS WASTE SITES

Procedures: #3816024 - Surficial Conditions Survey
#3816031 - Subsurface Soil Sampling
#3816010 - Rock Coring Procedures
#3816008 - HNU P1101

APPENDIX II CHEMICAL DATA SHEETS

List: benzene
phenol
trichloroethylene
vinyl chloride

APPENDIX III SITE PERSONNEL PROTECTION AND SAFETY EVALUATION FORMS

Tasks: Surficial Mapping - On-Site
Well Borings - Off-Site Only

APPENDIX IV GENERIC HEALTH AND SAFETY PLAN

DRAFT

LONE PINE LANDFILL HEALTH AND SAFETY PLAN

INTRODUCTION

A site and task specific Health and Safety Plan (HSP) has been developed for activities to be conducted in the vicinity of the Lone Pine Landfill in Monmouth County, New Jersey. This HSP will delineate specific procedures and personnel to perform individual tasks as well as general health and safety procedures to be implemented during this feasibility study. The HSP is comprised of two major elements:

- Specific Health and Safety information compiled for Lone Pine Landfill site, and the activities to be performed,

- CDM's Corporate Generic Health and Safety Plan.

The Generic Health and Safety Plan found in Appendix I outlines procedures to be implemented during investigations and remedial actions at uncontrolled hazardous waste sites and controlled substances work areas. Some of the procedures covered in the generic plan are as follows:

- control of site access to non-contractor personnel and other "visitors"
- safe work procedures
- training protocol for on-site personnel
- special medical procedures
- emergency first aid
- requirement for on-site monitoring of employees during work activities

DRAFT

1028

The following information has been compiled specifically for the field investigations to be conducted at the Lone Pine Landfill:

- o General Project Description
- o Health and Safety Procedures for Site Activities:
  1) Well Borings and Installations
  2) Surficial Conditions
  3) Observations and Mapping
- o Health and Safety data on known or suspected chemicals that may be encountered during the investigation
- o Required Personal Protection
- o Emergency Phone Numbers and Services
- o Duties and Responsibilities of On-Site Personnel

I. SITE DESCRIPTION

Lone Pine Landfill is located within Freehold Township in Monmouth County, New Jersey. The site encompasses about 90 of the 150 acres owned by the Lone Pine Corporation. The terrain is characterized by gently rolling hills expressing low topographic relief. The toe of slope at the northernmost part of the landfill is 600 feet from the Manasquan River. A few miles to the west of the landfill lies the Delaware River Basin/Atlantic Ocean drainage divide.

Lone Pine landfill is underlain by unconsolidated deposits of the Coastal Plan physiographic province. To the north of the Manasquan River, Red Bank Sand is exposed in outcrop. Hornerstown Marl outcrops is a thin band trending parallel to the river. Vincentown Sand is exposed at the sourthern edge of the landfill.

DRAFT

1049

II. HISTORICAL BACKGROUND

Lone Pine Landfill is an uncontrolled hazardous waste site which operated for 20 years until it was closed in 1979. Hazardous materials were alledgedly disposed of in the landfill during its final years of operation.

A groundwater sampling program conducted in late Fall, 1981, indicated that the deep semi-confined Red Bank aquifier is contaminated with volatile organic compounds down gradient of the landfill. Lower concentrations of organics were also found in groundwater samples taken from the surficial aquifier. Analysis of Manasquan River water showed that this contaminated groundwater may be discharging directly to the river.

DRAFT

1052

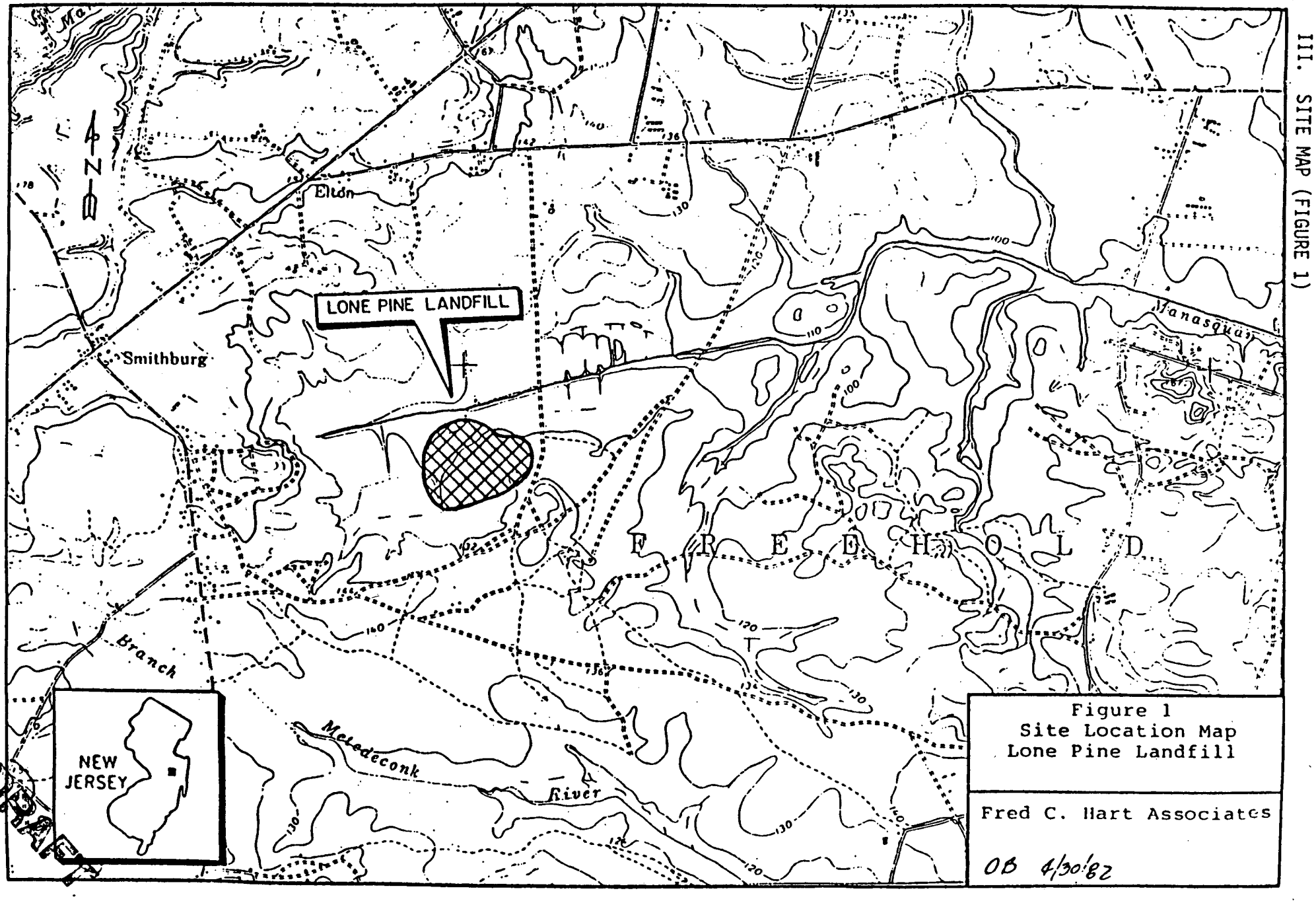


Figure 1
Site Location Map
Lone Pine Landfill

Fred C. Hart Associates

OB 4/30/82

1051

IV. SITE AND TASK SPECIFIC HEALTH AND SAFETY PROCEDURES

A. Surficial Conditions Mapping

Task Objective - To update surficial conditions map of Lone Pine Landfill Site, including indication of surficial geologic units, areas of apparent fill and site grading, boundaries of fill areas, location of surface water bodies, location of leachate seepts, limits of vegetation etc., and surface drainage courses.

(Procedure Reference: #3816024 - Appendix I)

Specific Safety Requirements:

1. Protection Level: C (Reference Appendix IV - Table 1)

2. Mapping Team Personnel: Tom Pedersen - CDM/Boston
   Mike Calise - CDM/New York

   One member of the mapping team shall have been trained in health and safety procedures and in the use of monitoring equipment.

3. Protective Equipment - Mapping Team members shall wear a full-face air purifying respirator with GMC-H cartridges, saran-coated Tyvek coveralls, disposable boot covers, and over gloves. They shall also carry an escape mask.

4. Monitoring Equipment - A member of the mapping team shall operate an HNU organic vapor analyzer to monitor organic vapor levels during field activities.

5. Operational Procedures - Mapping Team members should take care not to come in contact with any waste materials found on-site. If HNU readings increase to 5 ppm (as isobutylers) above background levels, (as isobutylene) above background, the mapping team should withdraw. Personnel in SCBA should return with air sampling equipment to complete the activity.

DRAFT

1052

6. Decontamination Procedures - Tyvek coveralls, overboots and gloves, and all other disposable outerwear will be disposed of at the end of each day in a sealed plastic bag and left on-site.

7. Special Hazards - Organic compounds that have been found in groundwater samples and could possibly be released during surficial mapping include the following:

benzene	trichloroethylene
1,2 trans dichloroethylene	phenol
ethyl benzene	vinyl chloride
1,2 dichloroethane	toluene

Chemical data sheets on some of these compounds are found in Appendix II.

B. Well Borings and Groundwater Monitor Installations - <u>Off-Site Only</u>

Task Objective - Subsurface soil borings will be performed around the perimeter of the landfill site to obtain soil and groundwater samples from the natural soils. The following procedures are to be followed only when drilling outside of the landfill area where no contaminated material is expected to be encountered.

(Procedure Reference: #3816031 - Subsurface Soil Sampling, and #3816010 - Rock Coring - Appendix I)

DRAFT

1057

Specific Safety Requirements:

1. Protection Level: D (Reference Appendix IV - Table 1)

2. Personnel - The on-site coordinator will monitor compliance with the drilling subcontractor safety and health procedures. A member of CDM's Field Investigation Team (FIT) will be present during any borings or sampling to monitor the air quality.

3. Protective Equipment - Personnel observing the borings shall wear Tyvek coveralls, disposable boots, disposable gloves, escape masks, and safety glasses. They shall also have on-site full face air purifying respirators with combination organic vapor cartridges.

4. Monitoring Equipment - A team member shall operate on HNU organic vapor analyzer to continuously monitor organic vapor concentrations in the breathing zone.

5. Operational Procedures - If HNU readings increase above background levels, the full face respirator shall be donned immediately. If HNU readings increase to greater than 5 ppm over background levels, all personnel shall withdraw from the drilling site. Personnel in SCBA should return with air sampling equipment to quantify and identify the contaminant.

6. Special Hazards - Organic compounds that have been found in groundwater samples and could possibly be released during drilling include the following:

benzene	trichloroethylene
1,2 dichloroethane	phenol
1,2 trans dichloroethylene	vinyl chloride
ethyl benzene	toluene

Chemical data sheets on some of these compounds are found in Appendix II.

DRAFT

(057

7. Community Effects - Well borings and groundwater monitor installations will be performed offsite only (outside the) landfill). Offsite wells are expected to be relatively uncontaminated. Based on this assumption, no health and safety effects on the neighboring community are expected from these activities. If conditions encountered at the drilling site are significantly different than expected, drilling operations should cease and specific health and safety procedures and personnel will be delineated, including appropriate contingency plans for potential effects on the neighboring community, as dictated by the site conditions.

APPENDIX I

GENERAL SITE INVESTIGATION PROTOCOL
FOR UNCONTROLLED HAZARDOUS WASTE SITES

Procedures

#3816024 - Surficial Conditions Survey

#3816031 - Subsurface Soil Sampling

#3816010 - Rock Coring Procedures

#3816008 - HNU P1101

DRAFT

SURFICIAL CONDITIONS MAPPING

1.0 INTRODUCTION

Surficial conditions mapping involves walking the site to observe and document the existing geologic and hydrogeologic conditions and locate areas in which contaminated materials may be encountered. Surficial deposits, man-made elements, surface drainage courses, vegetative types, visible leachate and other site features should be identified and located on a base map.

2.0 EQUIPMENT

2.1 Compass, pocket-transit type
2.2 Map, topographic; several copies (site base of USGS quadrangle)
2.3 Photographs, aerial (if available)
2.4 Scale (engineer's or architect's)
2.5 Protractor
2.6 Pencils, color (full selection)
2.7 Pen, drawing, with indelible ink
2.8 Hammer, geologist's
2.9 Notebook, field, bound
2.10 Camera, 35 mm., with film (black and white print, color print, color slide)
2.11 Shovel
2.12 Tape measure,.100 ft. length
2.13 Collapsible folding ruler, 6 ft. length
2.14 Stakes, survey
2.15 Flagging
2.16 Level, hand

3.0 DECONTAMINATION OF EQUIPMENT

To reduce the risk of transfer of contaminants onto and off of the site, decontamination of all equipment by steam-cleaning procedures is

DRAFT

recommended prior to entering or leaving the site. Equipment which cannot be steam-cleaned should be washed.

The following general washing procedure is recommended:

- o Brush loose soil particles off of equipment.
- o Wash equipment with laboratory grade detergent.
- o Rinse equipment with tap water (minimum of 3 rinses).
- o Rinse equipment with distilled water.
- o Rinse equipment with reagent grade methanol.
- o Allow methanol to evaporate before reusing the equipment.

All wash and rinse water must be collected and disposed of in a manner established by the On-Site Coordinator.

Equipment which cannot be decontaminated by such procedures, such as maps, cameras, photographs, compasses, levels, and notebooks, should be handled in a manner which will minimize direct contact with hazardous materials. These items should not be placed in direct contact with the ground.

4.0 PROCEDURE

4.1 The area to be mapped must be defined and the approximate boundaries of the area should be delineated on the base map. The following items are specified before mapping begins:

- o Scale
- o Map symbols
- o Color/pattern code

4.1.1 The map scale should be established by the Project Geologist. The map scale must allow for clear delineation and identification of all items of interest on the base map.

4.1.2 Where applicable, map symbols are in accordance with U.S. Bureau of Reclamination (USBR) graphical standards, and specialized

DRAFT

symbols devised by the Engineering Geology Group of the Geological Society of London. Where required, specialized and/or unusual map symbols should be selected by the Project Geologist.

4.1.3 Colors and/or patterns applied to surficial maps should be in accordance with selected standards. The Project Geologist should indicate whether colors or patterns are to be used on the map.

4.2 If recent aerial photographs of the area are available at an appropriate scale, a preliminary photogeologic map can be constructed prior to commencement of field mapping. Map units should be delineated by the appropriate colors or patterns. The photogeologic map can be used to delineate general site conditions and to establish traverses for field mapping.

4.3 Traverse routes are established by the Project Geologist on the base map before field mapping begins. Traverse routes can be established on the basis of site topography and/or photogeologic mapping as described in Step 4.2 Traverse routes may be altered during the course of the mapping at the discretion of the Field Geologist.

4.4 Field stations are established at locations where measurements are made or samples are obtained. Field stations should be clearly identified with numbered survey stakes and flagging. A field notebook should be maintained with entries of numerically identified field stations and the data collected at each station. At the time of mapping, field stations should be located relative to immobile objects identified on the base map using pocket transit and pace mapping techniques. The pace of the Field Geologist should be determined before mapping begins, and all pocket transits should be set to the magnetic declination indicated on the most recent available USGS topographic quadrangle map of the area.

DRAFT

4.5 At the completion of each day of field mapping, contacts and symbols must be inked and colors or patterns applied to the map.

4.6 All rock outcrops in the map area must be identified and shown in true location and shape on the map. Measurements of structural features of the rock are recorded in the field notebook.

4.7 The map legend should indicate the main lithologic and structural characteristics of each of the geologic or hydrogeologic units identified in the area. The legend should reflect the correct stratigraphy of the geologic units: the oldest unit should be at the bottom of the legend and the youngest unit should be at the top of the legend. Detailed descriptions of the units usually appear in report text, in columnar sections and on edited boring logs.

4.8 The initial page of each day's notes should contain notations pertaining to the weather conditions, members of the field party and other appropriate information. Entries are made in a clearly printed hand and should be dated. Each page of the project notebook contains notations made on one day only. All notations are initialed by the person making the entry.

5.0 REFERENCES

Geological Society of London. 1972. The Preparation of Maps and Plans in Terms of Engineering Geology. Quarterly Journal of Engineering Geology. 5(4): 295-382.

U.S. Bureau of Reclamation. 1968. Engineering Geology Manual, TechnicalInstructions No. 1, Preparation of Engineering Geologic Maps and Sections. Office of Chief Engineer. Denver, CO 82 p.

American Geological Institute, 1964 and later, Data Sheets, 1-3, Geologic Map Symbols, and Data Sheet 20, Fault Symbols. Washington D.C.

DRAFT

Compton, R.R. 1962. Manual of Field Geology. John Wiley & Sons, Inc., N.Y. 378 p.

DRAFT.

1961

SUBSURFACE SOIL SAMPLING

1.0 GENERAL

The objective of subsurface sampling is to obtain soil from known depths in order to evaluate site characteristics, detect the presence of any contaminants and to evalutate the potential for pollutant migration. In the following sections, the equipment and techniques used to collect subsurface soil samples are described. General procedures which shall be followed during soil sample collection, including the cleaning of sampling equipment, are presented in method number 3816009.

2.0 BOREHOLE DRILLING

Subsurface soil samples from boreholes can be obtained at specified depths or continuously. Several techniques can be utilized for advancing borings including jetting, wash boring, auger boring, or rotary drilling. These techniques are briefly described in procedure number 3816013. Jetting, is not appropriate where soil samples are of concern.

In some instances borehole advancement, in connection with soil sampling, is accomplished by continuous sampling.

3.0 SOIL SAMPLING

The boring techniques utilized to excavate a borehole result in considerable disturbance of soil and do not allow for accurate determination of the depth from which soil materials have been excavated. Therefore split spoon, thin wall tubes or other sampling techniques must be used in conjunction with boring operations to obtain soil samples.

Subsurface samples may be obtained at predetermined depths, at every change in lithology or continuously. Continuous sampling provides the most accurate record of subsurface conditions for interpretive purposes.

DRAFT

3.1 Split Spoons

Split spoons are devices used to obtain subsurface samples of up to 2.5 feet in length within hollow stem auger flights, cased borings, and mudded holes. The 1.75 to 2.5 in. ID split spoon samplers are advanced into the undisturbed material beneath the bottom of the casing or borehole by use of weighted hammer and drill rod. The relationship between hammer weight, drop and blows required to advance the split spoon in 6-inch increments is an indicatoin of density or consistency of subsurface soils. After the split spoon has been driven the prescribed depth, it is removed carefully to avoid loss of soil materials. In non-cohesive or saturated soils a nest shall be used to help retain the sample.

Following removal of the split spoon from the casing, it shall be detached from the drill rod and opened to allow for visual classification of the sample. When less than a 10-inch sample has been obtained, a second cleaned sampler shall be lowered into the hole and a second sample shall be obtained. The first sample collected, if any, shall be retained unless greater sample recovery is obtained during the subsequent sampling attempts. The entire sample (except the top several inches of possibly "disturbed" material) shall be retained.

Samples of cohesive clays or silts shall be wrapped in aluminum foil prior to storage in jars, to preserve as undisturbed a sample as possible.

Once an adequate sample is collected, the sample shall be inspected, described, planed in wide mouth jars, labeled, and stored for transportation to the laboratory.

If volatile organic analyses are to be performed, VOA vials shall be filled immediately from the split spoon before jarring. Subsamples for other specific chemical analyses shall be taken as soon as possible as required.

DRAFT

3.2 Thin Wall Tubes

Thin wall tubes are hollow pipes which are pressed or driven into the soil without rotation to obtain core samples of relatively undisturbed soils.

Thin wall tube samplers are generally 1.875 in ID, 2 in OD and 2 to 3 feet long, but may be of any size convenient for sampling. The thin wall tube has a sharp cutting edge and a positive inside clearance.

Thin wall tube samplers may be pushed or driven into soils inside hollow stem auger flights, wash bore casings or uncased boreholes. The tubes are pushed into the soil without rotation until the desired depth is attained or to refusal. If the sample tubes can not be advanced by pushing, it may be necessary to drive the tube into the soil, without rotation, using hammers and drill rods. The tubes are generally allowed to remain in the boring for 10 to 15 minutes to allow buildup of skin friction prior to removal. The sampler is then rotated to shear the sample from the soil below and carefully removed from the borehole.

Following removal of the tube sampler from the drilling equipment, the sampler is inspected to ensure that an adequate length of sample as been obtained. This sampling procedure shall be repeated until an adequate soil core is obtained provided that the material being sampled is of a nature which would permit retention in the sampler.

Upon successful retrieval of a soil core it shall be described and recorded in the log book and any disturbed soil shall be removed from each end of the tube. Samples for volatile organic analysis must be extracted from the soil sample as soon after the sampler is withdrawn as possible. During transport to the sampling station, the tube should be capped with a non-reactive material. For other parameters, the shelby tube shall be sealed by pouring three 1/4 inch layers of liquid wax such as Socony Vacuum Product 2300 in each end allowing the wax to solidify between each layer. The remaining space

DRAFT

shall be filled to the end of the cylinder with Ottawa sand or other similar sand and allowed to settle and compact. Plastic caps shall be taped over the ends of the cylinder and then sealed by successively dipping the ends into liquid wax. The tube shall then be labeled. Care should be taken in handling to label the top and bottom of the tube.

DRAFT

1065

ROCK CORING PROCEDURE

1.0 INTRODUCTION

Rock coring techniques are used to obtain a continuous sample of rock at the project site for field logging and to provide samples of intact rock for laboratory testing. Additional information about the rock mass is available by careful observation of rig performance during drilling, drilling rate, bit wear, and loss of drilling fluid.

2.0 EQUIPMENT

2.1 Drill rig, with crew and coring equipment
2.2 Barrel, core, and bit
2.3 Rods, drill
2.4 Water supply
2.5 Time piece
2.6 Boxes, core (standard size)
2.7 Pen, indelible
2.8 Labels
2.9 Camera (optional)
2.10 Hammer, Schmidt (optional)
2.11 Knife, pocket
2.12 Lens, hand, magnifying
2.13 Collapsible folding ruler, 6-ft. length
2.14 Tape, cloth 100-ft. length
2.15 Device, sounding
2.16 Reference materials and forms
2.17 Notebook, field, bound

3.0 DECONTAMINATION OF EQUIPMENT

To reduce the risk of transfer of contaminants onto and off of the site, decontamination of all equipment by steam-cleaning procedures is required prior to entering or leaving the site.

DRAFT

1066

To reduce the risk of transfer of contaminants within the site, decontamination of all equipment and containers by washing equipment is required between sampling locations.

The following general washing procedure is recommended:

- o Brush loose soil particles off of equipment.
- o Wash equipment with laboratory grade detergent.
- o Rinse equipment with tap water (minimum of three rinses).
- o Rinse equipment with distilled water.
- o Rinse equipment with reagent grade methanol.
- o Allow methanol to evaporate before reusing the equipment.

All wash and rinse water should be collected and disposed of in a manner established by the On-Site Coordinator.

Specific procedures should be established for each site based on the degree of hazard associated with the material and the amount of contact with hazardous material resulting from the work.

Equipment which cannot be decontaminated by such procedures, such as field notebooks, forms, and photographic equipment should be handled in a manner which will minimize direct contact with core samples of drilling fluids.

4.0 PROCEDURE

4.1 Prior to commencing the field explorations, the Project Geologist should specify the following items:

- o Locations of rock-coring explorations.
- o Depth of rock-core penetration.
- o Length of core-run (usually 5 ft.)
- o Specific rock-coring procedures.

4.2 The Field Geologist should identify the locations of rock-core explorations with survey stakes and flagging. Locations of the

DRAFT

explorations should be approximately determined by the Field Geologist using pocket-transit and pace method and should be plotted on the site base map.

4.3 The Project Geologist should indicate the information to be recorded by the Field Geologist during the rock-coring operation. The recorded information should include but not necessarily be limited to the following:

- o Drill rate (minutes per foot)
- o Type and size of bit
- o Core number
- o Depth range
- o Core recovery (inches)
- o Rock Quality Designation (RQD in percent; for NX-size core only).

4.4 The rock core should be classified by the Field Geologist using a rock classification system established by the Project Geologist, who manages the exploration program.

4.5 There is no universal core barrel or drilling equipment for rock coring. The geologic and topographic conditions as well as the requirements of the project will dictate the type of equipment to be employed.

The following factors can result in good core production and should be observed during rock coring.

4.5.1 Prepare a level and stable drilling platform before commencing the boring.

4.5.2 Keep the drill stem as nearly vertical as possible. On deep core holes, true alignment of the casing is critical. The driller may elect to use a heavy drilling mud instead of casing to support the

DRAFT

1068

bore hole walls; this procedure is not as desirable under some conditions, but acceptable if satisfactory information is obtained.

4.5.3 Wash the casing out thoroughly before inserting the core barrel.

4.5.4 Inspect the selected core barrel and bit for wear, general cleanliness, and free movement of all parts. Reject any barrel or bit that appears unsatisfactory.

4.5.5 Pump recirculated drill fluid down the drill rods and observe a return flow before commencing drilling operations.

4.5.6 Carefully measure all lengths of rod, core barrel, and stick-up through all phases of drilling for accurate depth determination.

4.5.7 Drill with minimal vertical pressure and rotation. Most rigs are equipped with a selection of gear ratios and a variable hydraulically-controlled feed mechanism. Driller expertise in selecting the correct combination of speed and feed rate is invaluable.

4.5.8 Water return should be no more than just sufficient to bring the bore hole cuttings to the surface.

4.5.9 Place the core carefully in the core box from left to right, top to bottom.

4.5.10 If 100 percent recovery was not obtained, the bore hole should be sounded to determine if the missing core still remains in the bottom of the borehole.

5.0 REFERENCES

Acker III, W.L. 1974. Basic Procedures for Soil Sampling and Core Drilling. Acker Drill Co., Inc., Scranton, PA. 246 p.

DRAFT

1069

American Society of Civil Engineers. 1972. Subsurface Investigation for Design and Construction of Foundations of Buildings: Part II. Proceedings, Journal of Soil Mechanics and Foundations Division, Volume 98, Number SM6. pp. 557-578.

American Society for Testing and Materials. 1977. Annual Book of ASTM Standards, Part 19. Designation D213-70. Philadelphia, PA. pp. 260-262.

Golder, H.Q. 1971. Sampling of Soil and Rock. American Society for Testing and Materials, Special Technical Publication 483. Philadelphia, PA. pp. 3-9.

Hvorslev, M.J. 1949. Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MI. 521 p.

International Society for Rock Mechanics. 1975. Recommendations on Site Investigation Techniques. 56 p.

Longyear. 1972. Soil Sampling Methods and Equipment. Longyear Company, Minneapolis, MN. 112 p.

Mohr, H.A. 1943. Exploration of Soil Conditions and Sampling Operations. Bulletin No. 376. Soil Mechanics Series No. 21, Graduate School of Engineering, Harvard University, Cambridge, MA. 79 p.

Sprague & Henwood, Inc. 1975. Core Drilling Equipment. Scranton, PA.

U.S. Department of the Army. 1972. Soil Sampling. Standard Corps of Engineers Practices. Engineer Manual E1110-2-1907, Washington DC.

DRAFT

1070

HNU PI 101

1.0 INTRODUCTION

The Model 101 has been designed to measure the concentration of trace gases in many industrial or plant atmospheres. The instrument has similar capabilities outdoors. The analyzer employs the principle of photoionization for detection. This process is termed photoionization because the absorption of ultraviolet light (a photon) by a molecule leads to ionization via:

$$RH + h\nu \quad RH^{+} + e-$$

where RH = trace gas,
hv = a photon with an energy greater than or equal to an Ionization Potential of RH

The sensor consists of a sealed ultraviolet light source that emits photons which are energetic enough to ionize many trace species (particularly organics) but do not ionize the major components of air such as O_2, N_2, CO, CO_2, or H_2O. A chamber adjacent to the ultraviolet source contains a pair of electrodes. When a positive potential is applied to one electrode, the field created drives any ions, formed by absorption of UV light, to the collector electrode where the current (proportional to concentration) is measured. The useful range of the instrument is from a fraction of a ppm to about 2,000 ppm.

2.0 CALIBRATION

All operating procedures should be as specified by the manufacturer unless otherwise noted.

Equipment needed:

- o calibration gas
- o tubing and fittings
- o rotameter or bubble flowmeter

DRAFT

2.1 CDM employs a two-point standardization procedure to facilitate proper instrument calibration over the 0-20 ppm and 0-200 ppm operating ranges. Two distinct mixtures of isobutylene in air are used as the calibration gases. Each will give a 3/4 scale deflection of its respective operating range. Isobutylene was chosen because the instrument's relative sensitivity to it is high and it is a non-toxic gas.

2.2 Prior to using the PI 101, check the function switch on the control panel to make sure it is in the OFF position. The probe nozzle, electrode casing and connector cable are stored inside the instrument cover. The probe is assembled by screwing the probe nozzel into the casing. The 12 pin interface connector for the probe is located just below the span adjustment on the face of the instrument. Carefully match the Alignment Key in the probe connector to the 12 pin connector on the control panel and then twist the probe connector until a distinct snap and lock is felt.

When calibrating the instrument, refer to and completely fill out the PI 101 Recalibration form.

2.3 Turn the function switch to the BATTERY CHECK position. The needle on the meter should read within or above the green battery arc on the scaleplate. If the needle is in the lower portion of the battery arc, or the red LED comes on, the instrument should be recharged prior to making any measurements.

2.4 If the battery needs recharging, place the mini phone plug into jack on left side of the bezel connector prior to plugging charger into 120V AC. When disconnecting charger, remove from 120V AC before removing mini phone plug. The battery is completely recharged overnight (ca. 14 hours). To ensure that the charger is functioning, turn the function switch to the battery check position, place phone plug into jack and plug charger into AC outlet. The meter should go upscale if the charger is working and is correctly inserted into the jack.

DRAFT.

The instrument can be operated during the recharge cycle, however this will lengthen the time required to completely recharge the instrument battery.

2.5 Next, turn the funtion switch to the ON position. In this position, the UV light source should be on. To verify, check into the end of the probe to see the purple glow of the lamp. Do not look directly at the lamp itself.

2.6 To zero the instrument, turn the function switch to the STANDBY position and rotate the zero potentiometer until the meter reads zero. Clockwise rotation of the zero potentiometer produces an upscale deflection while counterclockwise rotation yields a downscale deflection. Note: No zero gas is needed, since this is an electronic zero adjustment. If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted, if necessary. Wait 15 or 20 seconds to ensure that the zero reading is stable. If necessary, readjust the zero.

2.7 The instrument is now ready for the calibration procedure. Set the function switch to the 0-200 PPM scale.

2.8 The recommended and most accurate procedure for calibration of the instrument from a pressurized container is to connect one site of a "T" to the pressurized container of mid-range calibration gas, another side of the "T" to a rotameter and the third side of the "T" directly to the 8" extension to the photoionization probe (see Figure 1). Crack the valve of the pressurized container until a slight flow is indicated on the rotameter. The instrument draws in the volume of sample required for detection, and the flow in the rotameter indicates an excess of sample. Now adjust the span pot so that the instrument is reading the exact value of the calibration gas. (After the instrument span setting is changed, the instrument should be turned back to the standby position and the electronic zero should be readadjusted, if necessary, and respan).

DRAFT

2.9 Next, set the function switch to the 0-20 ppm scale. Connect the pressurized container of low range calibration gas to the instrument as described above.

2.10 Do not adjust the span pot. The observed reading on the 0-20 ppm scale should be ± 3 ppm of the acutal concentration of the low range calibration gas. If this is not the case, recalibrate the mid-range scale. If the low range reading consistently falls outside of the recommended tolerances, the probe light source window most likely needs cleaning. When the observed reading is within the required tolerances, the instrument is fully calibrated.

3.0 OPERATION

3.1 With the instrument fully calibrated, it is now ready for use. Any results obtained should be reported as parts per million (ppm) as Isobutylene. Some important performance specifications and power requirements of the PI 101 are listed here.

Performance

- o range 0.1 to 2000 ppm
- o detection limit 0.1 ppm
- o sensitivity (max) 0-2 ppm FSD over 100 division meter scale
- o repeatability ± 1% of FSD
- o linear range 0.1 to 600 ppm
- o useful range 0.1 to 2000 ppm
- o response time < 3 sec to 90% of full scale
- o ambient humidity to 95% RH
- o operating temperature ambient to 40°C*

Power requirements of operating times:

- o continuous use, battery >10 hours
- o continuous use with HNU recorder reduces instrument battery operating time to 1/2 normal time
- o recharge time, max <14 hours, 3 hours to 90% of full charge
- o recharge current, max .4 Amps @ 15 VDC

*Instrument is temperature compensated so that a 20°C change in temperature corresponds to a change in reading of < ± 2% full scale at maximum sensitivity.

DRAFT

3.2 The instrument is equipped with an automatic solid state battery protection circuit. When the battery voltage drops below approx. 11 volts, this circuit will automatically turn off the power to the instrument. This prevents deep discharging of the battery and considerably extends the battery life. If the instrument is unintentionally left on overnight, the battery will be unharmed because of the battery protection circuit. If the instrument battery check reads low and the lamp doesn't fire, plug the charger into the instrument. The power to the analyzer should then be returned.

3.3 A small DC operated fan is used to pull air through the photoionization sensor at a flow rate of three to seven hundred centimeters per minutes (0.5 lpm). The fan provides nearly instantaneous response times while consuming little power. With the function switch turned to one of the operating ranges, the fan is turned on automatically. The instrument is now analyzing the surrounding atmosphere.

3.4 To obtain the most accurate reading, the function switch should be set on the lowest possible operating range. An audible alarm can be set at a predetermined concentration if it is so desired.

3.5 A black "magic marker" is kept with the PI 101 at all times to enable the operator to check if the instrument will still provide a given response. With the marker pen held at the end of the probe, an approximate reading of 5 ppm should be obtained.

3.6 If the probe is held close to AC power lines or power transformers, an error may be observed. For management made in close proximity to such items, their effect on measurements can be determined by the following procedure. Zero the instrument in an electrically quiet area, in the standby position, then move the instrument to the questionable area involved. If AC pickup is going to be a problem, the meter (in the standby position) will indicate the magnitude of the error.

DRAFT

3.7 A list of relative photoionization sensitivites is presented in Table 1 for the operators own use. A much more specific list is available from the CDM Boston Laboratory.

4.0 REFERENCE

Instruction Manual for Model PI 1010 Photoionization Analyzer Printed by HNU Systems, Inc., Copyright 1975.

DRAFT

1076

RELATIVE PHOTOIONIZATION SENSITIVITIES FOR VARIOUS GASES

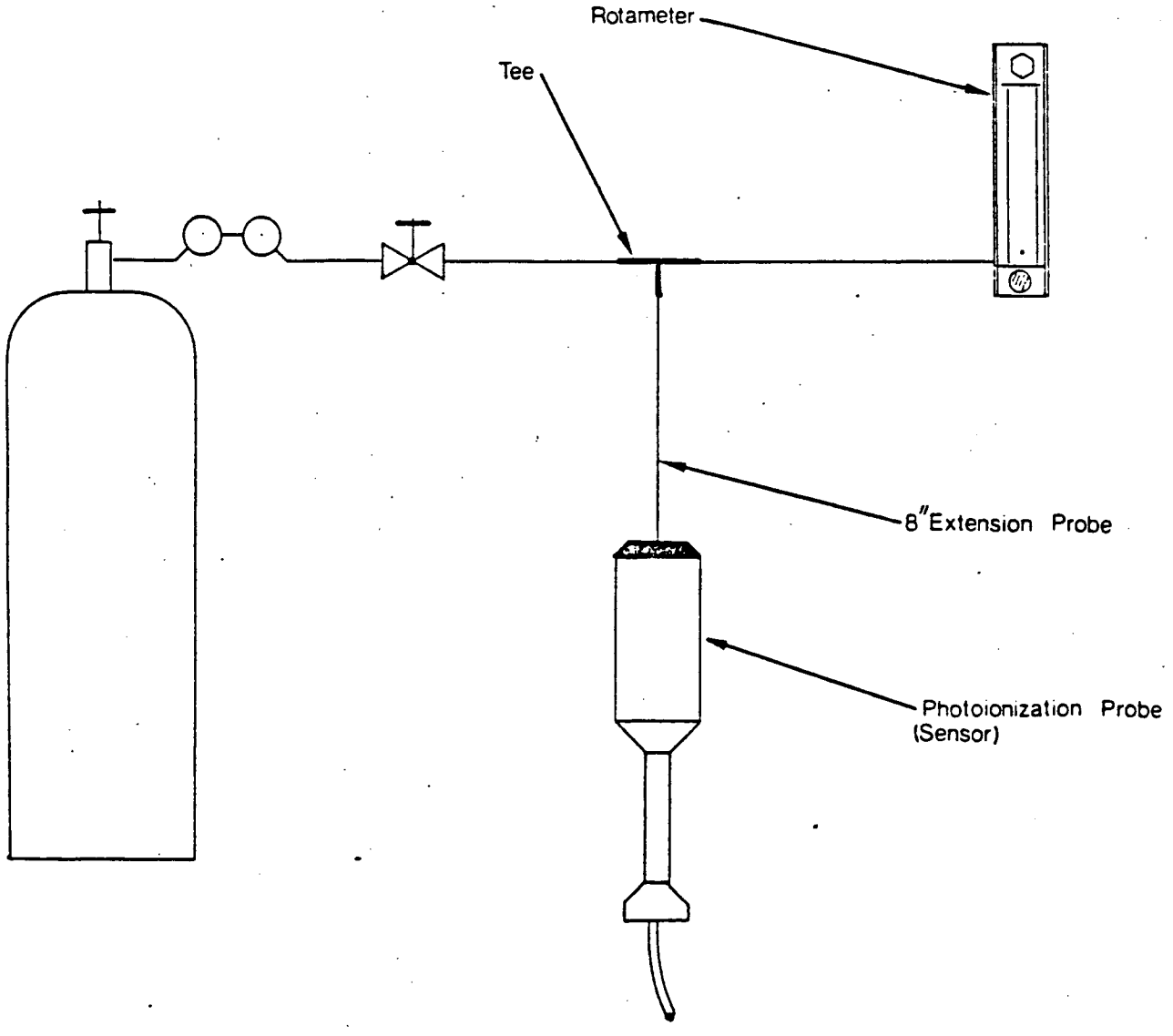
(Sensitivities in ppm)

Chemical Grouping	Relative Sensitivity	Examples
Aromatic	10.0	Benzene, Toluene, Styrene
Aliphatic Amine	10.0	Diethylamine
Chlorinated Unsaturated	5-9	Vinyl Chloride, Vinylidene Chloride, Trichloroethylene
Carbonyl	5-7	MEK, MIBK, Acetone, Cyclohexene,
Unsaturated	3-5	Acrolein, Propylene, Cyclohexene, Allyl Alcohol
Sulfide	3-5	Hydrogen Sulfide, Methyl Mercaptan
Paraffin (C_5-C_7)	1-3	Pentane, Hexane, Heptane
Ammonia	0.3	---
Paraffin (C_1-C_4)	0	Methane, Ethane

DRAFT

FIGURE 1

RECOMMENDED CALIBRATION PROCEDURE FOR PHOTOIONIZATION ANALYZER



DRAFT

1078

HNU PI 101 RECALIBRATION FORM

DATE _____ RECALIBRATED BY _____

INSTRUMENT SERIAL NO _____

STANDARD REFERENCE FOR CALIBRATION GAS:

midrange _____ ± _____ ppm _____

lowrange _____ ± _____ ppm _____

RECEIVED FROM _____ PROGRAM _____

Was instrument recalibrated in field? yes ____ no ____

Battery Check? yes ____ no ____ (if no, recharge)

Intitial Zero (0-20 ppm range) _____ ppm _____ VDC

Challenge with midrange standard.

Initial Reading Designated _____ ppm _____ VDC

Observed _____ ppm _____ VDC

Potentiometer Setting (as found) _____

Final Reading (after recalibration) _____ ppm _____ VDC

Potentiometer Setting (Final) _____

Post Calibration Zero (0-20 ppm range) _____ ppm _____ VDC

Challenge with low range standard.

Initial Reading Designated _____ ppm _____ VDC

Observed _____ ppm _____ VDC

Final Zero (0-20 ppm range) Observed _____ ppm _____ VDC

Final _____ ppm _____ VDC

PREVENTIVE MAINTENANCE PERFORMED: Source Window Cleaned? yes ____ no ____

Other: _____

ADDITIONAL NOTES: _____

DRAFT COPY

CALIBRATED BY _____ DATE _____

1079

BENZENE

DRAFT

C_6H_6

TLV, 10 ppm (≈ 30 mg/m³), Appendix A2 — Suspected Carcinogen

STEL, 25 ppm (≈ 75 mg/m³), Appendix A2

Benzene is a colorless, non-polar liquid, with an odor characteristic of aromatic hydrocarbons. It has a molecular weight of 78.11, a boiling point of 80.1° C, a melting point of 5.5° C, a vapor pressure of 75 mm Hg at 20° C and a specific gravity of 0.87865 at the same temperature. Benzene has a flash point of −11.1° C (closed cup, 12° F), making it a dangerous fire hazard. It was formerly derived almost exclusively by distillation of coal tar, but now comes primarily from petroleum, either by extruction or by dealkylation of toluene. Benzene is slightly soluble in water, but soluble in all proportions in alcohol, acetone and ether..

At one time benzene was an important solvent, especially for rubber, as a diluent in lacquers, and in paint removers. At present such uses are minimal; most benzene is consumed in the chemical industry, as a raw material for

1080

numerous organic chemicals. It is found in gasoline from trace amounts to as much as 30% concentration in some countries.

As an acute poison benzene produces narcotic effects comparable to those of toluene; it is a more potent narcotic than the alkanes or naphthenes of similar boiling points. But the effect of chronic exposure to this compound is by far the most serious disease caused by any of the common hydrocarbon solvents. Its action on the bone marrow may result in detectable alterations, and, in some instances, aplastic anemia. The reported LD_{50} orally in young adult rats is 3.8 mL/kg.[1]

It is unique among hydrocarbons as a myelotoxicant.[2] More than 140 fatal cases of benzene poisoning had been recorded prior to 1959.[3] Vigliani and Saita[4] listed 26 deaths from chronic benzene poisoning in two provinces in Italy between 1960 and 1963. Eleven of these were diagnosed as leukemia, which may develop several years after cessation of exposure to benzene.

Most deaths from benzene have resulted from exposures of the order of 200 ppm or more. In a few instances concentrations of 1000 or even 2000 ppm have been recorded in workplaces where deaths occurred. Some of these are: Legge,[5] 210 to 1050 ppm; Greenburg,[6] 70 to 1800 ppm, with over half above 200; Bowditch,[7] 100 to 200+ measured; one leukemia case described by Hunter[8] and Mallory[9] six years after exposure at over 200 ppm; Greenburg,[10] 25 to 1000 ppm in four rooms; Helmer,[11] 140 to 200 ppm after improvements; Savilahti,[12] 318, 433 and 470 ppm; Kozlova,[13] 47 to 310 ppm; Vigliani,[4] 190 to 660 ppm, after four years death from leukemia; Juzwiak,[14] 31 to 156 ppm; Aksoy,[15] 150 to 650 ppm, and 210 to 650 ppm,[16] 26 patients with acute leukemia or preleukemia; Ikeda,[17] 100 to 800 ppm, 7 deaths, all females, none from leukemia.

Winslow,[18] however, reported blood changes in workers where concentrations of benzene vapor below 100 ppm were found. Heimann and Ford[19] found one death and three cases with blood changes where air analysis for benzene showed a concentration of 105 ppm. Wilson[20] reported three fatal cases in a plant where the average concentration of benzene vapor was 100 ppm. In a fifth room, associated with benzene poisoning, Greenburg[10] found 11 to 57 ppm. So far as can be determined the lowest *measured* concentration of benzene vapor associated with a fatal case of benzene intoxication (due to aplastic anemia) was the 60 ppm reported by Hardy and Elkins in 1948,[21] in a plant where repeated air analyses were made, and a number of other workers showed some blood abnormalities.

Blaney[22] found little evidence of benzene intoxication in a group of 90 workers regularly exposed to benzene for about 13 years. Concentrations were generally low, but urinary phenol measurements indicated some exposures of the order of 25 ppm.[23] A followup several years later showed no evidence of persisting blood dyscrasias. No cases of leukemia are known to have occurred in this group of workers. Pagnotto *et al*[24] found workers in rubber spreading operations involving naphtha with a relatively high benzene content exposed to benzene in concentrations which were for the most part between 6 and 25 ppm. A number of blood studies showed a few abnormalities but only two were seious to warrant special consideration. In one case the possibility of leukemia was raised, but on being removed from his job and given iron therapy the worker recovered. Because of several job changes his benzene exposure could not be reliably estimated.

The other worker was in a group studied intensively over a period of several years by Pagnotto.[25] He had a red count below four million, a hemoglobin below twelve grams and suffered from nose bleeds. His benzene exposure, as estimated from several urinary phenol determinations, was to about 40 ppm. After his exposure to benzene was terminated, his blood picture gradually returned to normal. The 38 workers in this plant were followed up for 15 years after the use of naphtha containing benzene was discontinued. None showed any signs of permanent blood abnormalities. There were three deaths, none being from leukemia. It was concluded that 25 ppm of benzene vapor is safe for most workers, but that since the margin of safety is small, a TLV of 10 ppm was recommended.[25] Elkins[26] in a summary of the findings in the rubber spreading industry, came to a similar conclusion.

These conclusions were consistent with those of Fuchs[27] in 1969, who found variations in the blood pictures of three workers but did not consider that the changes were proved to result from their benzene exposures of 19, 28 and 43 ppm, respectively. He also stated that he could find no data in the literature on proved benzene poisoning in concentrations below 16 ppm, nor could he find any Soviet report which cited reasons for decreasing the Russian MAC to 6 ppm.

Two investigators have studied the effects on rats of exposures at relatively low levels of benzene vapor extended periods. Deichmann *et al*[28] found that after 5 to 8 weeks of 5 hour/day, 5 days/week exposure at 44 and 47 ppm, rats developed a moderate degree of leukopenia, but that none resulted from 15 to 31 ppm. Nau *et al*[29] found a decrease in the white blood cell counts of rats following 756 hours of exposure at 50 ppm of benzene on a schedule of 8 hours/day, 5 days/week. Reduced amounts of DNA in the white cells, a depression in myelocytic activity, and an increase in the relative numbers of red cell precursors in the bone marrow were also observed.

There have been numerous reviews of the literature of benzene intoxication. Noteworthy are those of the National Academy of Sciences in 1976[30] and the NIOSH criteria document on benzene, published in 1974.[31] As a result of this extremely thorough review, NIOSH recommended a workplace time weighted average standard of 10 ppm, with a ceiling of 25 ppm.

In 1976, however, NIOSH issued a revised recommendation for an occupational exposure standard for benzene.[32] The key to this recommendation is the statement in the introduction that *"Because it is not at present possible to establish a safe exposure level for a carcinogen, the NIOSH recommendation is to restrict exposure to very low levels which can still be reliably measured in the workplace."* A number of references are given, primarily to support the characterization of benzene as a carcinogen (leukemogen). Thus most relate to leukemia cases associated with heavy benzene exposures, either measured or inferred from association with numerous cases of aplastic anemia or other blood dyscrasias. Others are epidemiologic studies on cancer in which no evidence of the degree, or even fact, of benzene exposure is cited. Thus in at least two of these papers,[33,34] the word "benzene" does not appear. In these and other papers the incidence of various types of cancer,

1801

including leukemia, was found to be higher than in the general population among certain groups of rubber workers. Monson and Nakano[35] found 55 cases of leukemia, vs. 43 expected, among rubber workers. It was noted that benzene has been used extensively in the rubber industry, but is no longer employed, although it is a contaminant of extensively used naphtha solvents. The degree of exposure to benzene in the rubber industry during the first half of the 1940-1950 decade may well have been excessive. Wilson[20] has noted deaths and blood abnormalities among workers in the rubber industry during the war years who were exposed, on the average, to concentrations of benzene vapor of 100 ppm. Neither Monson-Nakano or other authors of similar papers quoted in the NIOSH update mention whether or not aplastic anemia or other blood dyscrasias, apart from leukemia, occurred in the groups of workers that were studied.

Nevertheless OSHA, in 1977, issued an Emergency Temporary Standard (ETS)[36] establishing a TWA limit of 1 ppm for benzene vapor. (Enforcement of this standard was voided by the courts). Much of the evidence substantiating this action was the same as that quoted in the NIOSH update. However, one additional paper was cited by Infante *et al*,[37] in which nine leukemia deaths were reported from two rubber film casting plants where benzene vapor concentrations allegedly ranged from 0 to 15 ppm. This report was critically examined in OSHA hearings on a permanent standard, with essentially the same provisions as the ETS, which were held during the summer of 1977. The data on benzene exposure in the two plants in question, especially during the first part of the ten year employment period (1940 to 1950) covered by the study, were found to be incomplete, unreliable and contradictory. Even in 1976 a NIOSH report of one of the plants involved, or its successor, showed concentrations in excess of 15 ppm at several locations.[38] A study by Harris *et al*[39] in 1973 and 1974 revealed similar findings, although the overall average of all sample results was slightly above 1 ppm. During the period 1940 to 1945 or so, when many of the involved workers were employed, the permissible concentration for benzene exposure (ASA standard) was 100 ppm. In common with the papers cited by the NIOSH update, no information on other blood abnormalities was given in the Infante report.

Epidemiologic studies of workers exposed to measured low concentrations of benzene vapor have yielded negative or inconclusive results. Thorpe[40] after studying the occurrence of leukemia in a population of 38,000 workers in a variety of European petroleum and petrochemical operations, some of whom were exposed at levels of benzene that occasionally reached 20 ppm, over a period of ten years, found that deaths from leukemia "were not abnormal" for the countries involved (18 vs. 23.23 expected).

Retrospective studies of employees of a large chemical company, exposed for many years to benzene, mostly at low levels, revealed no excess mortality.[41,42] A cohort of 594 workmen were divided into four exposure groups: very low exposures, less than 2 ppm as time weighted average (TWA); low exposures, 2-9 ppm; moderate exposures, 9-24 ppm; and high exposures, above 25 ppm. In many areas there was exposure to other chemicals as well as to benzene. The duration of exposure was also divided into four groups, with 186 workers having in excess of 20 years.

Of 102 deaths, two were due to anemia, two to leukemia, and one had leukemia as a complication. Of these five cases, only one, an autopsy-confirmed pernicious anemia, involved a previous exposure to benzene of significance, 5520 ppm months. The other anemia death, diagnosed as being of the aplastic type, was of a worker with 453 ppm months of benzene exposure. Two of the leukemia cases involved exposures of 545 and 305 ppm months, respectively, while the third was of a worker with only 18 ppm months benzene exposure.

To put these exposure data in perspective, three of the deceased workers had had exposures to benzene equivalent to 40 years' employment in concentrations slightly above or below 1 ppm; the exposure of the fourth, if spread over 30 years, would have been at a concentration of 0.05 ppm.

The predicted deaths from anemia and leukemia were 0.2 and 1 respectively. The fact that, apart from the pernicious anemia death, there appeared to have been no dose response relationship, apparently led to the conclusion of the authors that *"no mortality findings directly attributable to benzene exposure were observed"*.

The NIOSH update mentions the consistent observations of chromosomal aberrations associated with benzene exposure, but further comments that the implications of these findings with respect to benzene leukemia are still not clear. The possbility of a chromosomal instability acting as a stimulus for a latent leukemogenic virus has been speculated upon.[43] This question was discussed at some length at the International Workshop on the Toxicology of Benzene, held in Paris in November 1976. Tough[44] had previously reported that marked aberrations were found only in plants where concentrations of benzene vapor were believed to be between 25 and 250 ppm, and that no significant changes were observed at 12 ppm. Forni,[45] however, stated that there had been a few positive, as well as negative, reports at levels between 5 and 25 ppm. The consensus of opinion was that the significance of the finding of increased chromosome aberrations for the occurrence of benzene leukemia was still not clear. Maugeri and Pollini[46] reported that among Italian shoe workers *"almost all the cases of haemopathy due to benzol which lead to death show features of terminal leukemia, ... and (the leukemias) were always preceded by aplastic conditions"*.

Opinions of the workshop participants relative to the appropriate TLV for benzene were varied. The final recommendation was to retain 10 ppm as a permissible TWA, which must not be exceeded, but it was also specified that benzene should not be employed when substitute materials were available.

DeGowin's report[47] of a case of leukemia following an apparent benzene-induced aplastic anemia contains a discussion which implies that there is evidence that aplastic anemia *per se* may lead to leukemia, and that delayed cases of this disease are not confined to aplastic anemia due to benzene.

It is the opinion of the Committee that the characterization of benzene as a leukemogen, by NIOSH, is, in essense, valid, although benzene may be what Truhaut has described as a "secondary carcinogen".[48] An A2 notation should be applied to benzene in the TLV listings.

On the other hand, the Committee does not agree with the NIOSH recommendation of 1 ppm as an occupational

DRAFT

1088

exposure standard, insofar as the TLV can be defined as such a standard. There is little evidence that exposure to benzene at concentrations below 25 ppm causes blood dyscrasias of any kind. Setting the TLV at 10 ppm, as a time-weighted average, provides an added margin of safety.

If the standard is to be set at the lowest practicable detectable limit, it is the opinion of some members of the Committee that a value lower than 1 ppm should be selected. In the absence of interfering substances benzene vapor can be measured with reasonable accuracy in concentrations at least as low as 0.1 ppm; in the presence of certain interferences, it may be difficult to achieve the prescribed accuracy and reliability even at concentrations somewhat above 1 ppm.

Because the effects the TLV is designed to prevent are chronic in nature, a ceiling designation is not appropriate and a STEL of 25 ppm is recommended.

Other recommendations: ANSI (1969) 10 ppm; Czechoslovakia (1969) 16 ppm; USSR (1972) 1.6 ppm; DDR (1973) 16 ppm; Sweden (1975) 10 ppm; BRD (1974) 0 ppm (treats as carcinogen).

References:

1. *Merck Index*, 9th ed., p. 138, Merck & Co., Inc., Rahway, NJ (1976).
2. **Gerarde, H.W.:** *Toxicology & Biochemistry of Aromatic Hydrocarbons*, Elsevier Publishing Co., NY (1960).
3. **Elkins, H.B.:** *Chemistry of Industrial Toxicology*, p. 103, Wiley & Sons, NY (1959).
4. **Vigliani, E.C. Saita, G.:** *New Eng. J. Med. 271*:872 (1964).
5. **Legge, T.M.:** *J. Ind. Hyg. 1*:539 (1920).
6. **Greenburg, L.:** *U.S. Public Health Reports 41*:1357 (1926).
7. **Bowditch, M., Elkins, H.:** *J. Ind. Hyg. & Tox. 21*:321 (1939).
8. **Hunter, F.T.:** *Ibid.*, p. 331.
9. **Mallory T.B.** *et al*: *Ibid.*, p. 355.
10. **Greenburg, L.** *et al*: *Ibid.*, p. 395.
11. **Helmer, K.J.:** *Acta Med. Scand. 118*:354 (1944).
12. **Savilahti, M.:** *Arch. Gewerbepath. u. Gewerbehyg. 15*:147 (1956).
13. **Koslova, T.A., Volkova, A.P.:** *Gig. Sanit. 25*:29 (1960). Cited by NIOSH in ref. 31.
14. **Juzwiak, I.:** *Med. Przemylowa 20*:67 (1969). *Ibid.*
15. **Aksoy, M.** *et al*: *Brit. J. Ind. Med. 29*:56 (1972).
16. **Aksovy, M.** *et al*: *Blood 44*:837 (1974).
17. **Ikeda, M.:** Poisoning Due to Benzene and its Substitutes in Japan, *International Workshop on the Toxicology of Benzene*, Paris (1976).
18. **Winslow, C.E.A.:** *J. Ind. Hyg. 9*:69 (1927).
19. **Heimann, H., Ford, C.B.:** *NY Ind. Hyg. Bull.*, p. 224 (November 1940).
20. **Wilson, R.H.:** *J. Lab. Clin. Med. 27*:1517 (1942).
21. **Hardy, H.L., Elkins, H.B.:** *J. Ind. Hyg. & Tox. 30*:196 (1948).
22. **Blaney, L.:** *Ind. Med. & Surg. 19*:227 (1950).
23. **Walkley, J.E.** *et al*: *Am. Ind. Hyg. Assoc. J. 22*:362 (1961).
24. **Pagnotto, L.D.** *et al*: *Ibid.*, p. 417.
25. **Pagnotto, L.D.** *et al*: Benzene Exposure in the Rubber Coating Industry; a Followup. Presented at the *American Industrial Hygiene Conference*, New Orleans (May 1977).
26. **Elkins, H.B.:** Significance of Benzene Exposure Among Workers in Rubber Spreading Operations. Presented at the *International Workshop on the Toxicology of Benzene*, Paris (1976).
27. **Fuchs, A.:** in *Documentation of the MAC in Czechoslovakia*, Prague (1969).
28. **Deichmann, W.B.** *et al*: *Tox. Appl. Pharm. 5*:201 (1963).
29. **Nau, C.A.** *et al*: *Arch. Env. Health 12*:382 (1966).
30. **National Academy of Sciences:** *Health Effects of Benzene;* a review (1976).
31. **NIOSH:** *Criteria for a Recommended Standard for Occupational Exposure to Benzene* (1974).
32. **NIOSH:** *Revised Recommendation for an Occupational Exposure Standard for Benzene* (August 1976).
33. **McMichael, A.J.** *et al*: *J. Occup. Med. 16*:458 (1974).
34. **Andjelkovic, D.** *et al*: *Ibid. 18*:387 (1976).
35. **Monson, R.R., Nakano, K.K.:** *Am. J. Epidem. 103*:284 (1976).
36. **OSHA:** Emergency Temporary Standard for Occupational Exposure to Benzene. *Federal Register 42*:22516 (May 3, 1977).
37. **Infante, P.F.** *et al*: *Leukemia Among Workers Exposed to Benzene*. A manuscript (1977).
38. **Young, R.** *et al*: *Walk Through Survey of Goodyear Tire & Rubber Co.*, St. Mary's, OH. A manuscript (1977).
39. **Harris, R.L. Jr.:** Testimony before OSHA hearings on the proposed standards for occupational exposure to benzene, Washington, DC (August 1977).
40. **Thorpe, J.J.:** *J. Occup. Med. 16*:375 (1974).
41. **Ott, M.G.** *et al*: *Mortality Among Individuals Occupationally Exposed to Benzene*. A manuscript (1975).
42. **Fishbeck, W.A.:** Testimony before OSHA hearings on the proposed standards for occupational exposure to benzene, Washington, DC (August 1977).
43. **Todaro, G.J., Huebner, R.J.:** *Proc. Nat. Acad. Sci. 69*:1009 (1972). Cited by NIOSH in ref. 31.
44. **Tough, I.M.** *et al*: *Eur. J. Cancer 6*:49 (1970).
45. **Forni, A.:** Report in the *Proceedings of International Workshop on the Toxicology of Benzene*, Paris (1976).
46. **Maugeri, S., Pollini, G.:** Benzene Haemopaty; Cellular Damage and Chromosome Changes; Personal Researches, *Ibid.*
47. **DeGowin, R.L.:** *J.A.M.A. 185*:748 (1963).
48. **Truhaut, R.:** *Proceedings of the XI International Cancer Congress*, Florence, Italy (1974).

1083

RESPIRATORY PROTECTION FOR PHENOL

Condition	Minimum Respiratory Protection* Required Above 5 ppm
Vapor or Particulate Concentration	
50 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s) and dust and mist filter(s). Any supplied-air respirator. Any self-contained breathing apparatus.
100 ppm or less	A chemical cartridge respirator with a full facepiece, organic vapor cartridge(s), and dust and mist filter(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister and dust and mist filter. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 100 ppm** or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors and particulates. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of phenol; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 100 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.

• **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

• Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

• If phenol is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill.
2. If in the solid form, for small quantities, sweep onto paper or other suitable material, place in an appropriate container and burn in a safe place (such as a fume hood). Large quantities may be reclaimed; however, if this is not practical, dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.
3. If in the liquid form, for small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber.

• Waste disposal methods:

Phenol may be disposed of:

1. If in the solid form, by making packages of phenol in paper or other flammable material and burning in a suitable combustion chamber, or by dissolving phenol in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber.
2. If in the liquid form, by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill, or by atomizing the liquid in a suitable combustion chamber.

REFERENCES

• American Conference of Governmental Industrial Hygienists: "Phenol," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.

• American Industrial Hygiene Association: "Phenol," *Hygienic Guide Series*, Detroit, Michigan, 1957.

• Baskin, A. D. (ed.): *Handling Guide for Potentially Hazardous Commodities*, Railway Systems and Management Association, Chicago, 1972.

• Boutwell, R. K., and Bosch, D. K.: "The Tumor-promoting Action of Phenol and Related Compounds for Mouse Skin," *Cancer Research*, 19:413-424, 1959.

• Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

• Community Air Quality Guides: "Phenol and Cresol," *American Industrial Hygiene Association Journal*, 30:425-428, 1969.

• Deichmann, W. B., and Witherup, S.: "Phenol Studies VI: The Acute and Comparative Toxicity of Phenol and o-, m-, and p-Cresols for Experimental Animals," *Journal of Pharmacolology and Experimental Therapy*, 80, 233, 1944.

• Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957.

• Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.

• Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

• *Hygienic Information Guide No. 40 – Phenol*, Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Occupational Health, 1968.

• Jacobs, M.: *The Analytical Chemistry of Industrial Poisons, Hazards, and Solvents*, Interscience, New York, 1956.

• Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-4, Phenol*, Washington, D.C., 1964.

• Merliss, R. R.: "Phenol Marasmus," *Journal of Occupational Medicine*, 14:55-56, 1972.

• National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . . Occupational Exposure to Phenol*, HEW Publication No. (NIOSH) 76-196, GPO No. 017-033-00184-7, U.S. Government Printing Office, Washington, D.C., 1976.

• Ohtsuji, H., and Ikeda, M.: "Quantitative Relationship between Atmospheric Phenol Vapour and Phenol in the Urine of Workers in Bakelite Factories," *British Journal of Industrial Medicine*, 29:70-73, 1972.

• Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

• Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

• Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.

• Summer, W.: *Odor Pollution of Air: Causes and Control*, L. Hill, London, 1975.

• Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.

• Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies – Phenol*, New York, 1966.

DRAFT

1085

electrical appliances, automotive parts, foundry sand molds, and utensil handles; manufacture of friction materials, bonded abrasives, coated abrasives, wood particle board, and insulation materials	
Use in industrial coatings in drum and can linings, milk and beer-processing equipment, water tanks and air-conditioning equipment, decorative laminates, and textile coatings	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of thermosetting phenolic resins, epoxy, polycarbonate, phenoxy, and polysulfone; synthesis of aprolactam for use in nylon 6 fibers, plastics, and films	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of agricultural chemicals and intermediates; synthesis of pharmaceuticals, rubber and plastic plasticizers, antioxidants, curing agents, and intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of stabilizers and preservatives for dyes, perfumes, and fungicides	Process enclosure; local exhaust ventilation; personal protective equipment
Use during solvent refining of lubrication oil and wax; use in synthesis of additives for gasoline and lubricating fluids and intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of intermediates in polyester production; production of corrosion-resistant polyester and polyester polyols; use in synthesis of dye intermediates	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of surface-active agents and detergent intermediates; in synthesis of explosives	Process enclosure; local exhaust ventilation; personal protective equipment
Use in manufacture of disinfectant agents and products for industrial and household use	Process enclosure; local exhaust ventilation; personal protective equipment
Use in synthesis of synthetic cresols and xylenols	Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

- **Eye Exposure**

If solid or liquid phenol or liquids containing phenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If solid or liquid phenol or liquids containing phenol get on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If solid or liquid phenol or liquids containing phenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention immediately.

- **Breathing**

If a person breathes in large amounts of phenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

- **Swallowing**

When solid or liquid phenol or liquids containing phenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• Method

Sampling and analyses may be performed by collection of phenol in a bubbler containing sodium hydroxide, followed by treatment with sulfuric acid, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure phenol may be used. An analytical method for phenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 6, 1980, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00369-6).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with solid or liquid phenol or liquids containing phenol.

• If employees' clothing has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing which has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of phenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the phenol, the person performing the operation should be informed of phenol's hazardous properties.

• Where there is any possibility of exposure of an employee's body to solid or liquid phenol or liquids containing phenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

• Non-impervious clothing which becomes contaminated with phenol should be removed immediately and not reworn until the phenol is removed from the clothing.

• Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of solid or liquid phenol or liquids containing phenol contacting the eyes.

• Where there is any possibility that employees' eyes may be exposed to solid or liquid phenol or liquids containing phenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

• Skin that becomes contaminated with phenol should be immediately washed or showered with soap or mild detergent and water to remove any phenol.

• Any clothing which becomes wet with liquid phenol or liquids containing phenol should be removed immediately and not reworn until the phenol is removed from the clothing.

• Eating and smoking should not be permitted in areas where solid or liquid phenol or liquids containing phenol are handled, processed, or stored.

• Employees who handle solid or liquid phenol or liquids containing phenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to phenol may occur and control methods which may be effective in each case:

Operation	Controls
Application and curing of bonding resin in plywood manufacture; application and curing of molding resins in manufacture of molded articles, such as	Process enclosure; local exhaust ventilation; personal protective equipment

DRAFT

1087

2. *Periodic Medical Examination:* The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

Phenol in the vapor form or in solution is an irritant to the eyes, mucous membranes, and skin; systemic absorption causes central nervous system effects as well as liver and kidney damage. Sudden collapse is characteristic of gross overexposure. In animals, prolonged inhalation of the vapor at 30 to 60 ppm induced respiratory difficulty, lung damage, and paralysis. Systemic absorption by animals caused muscle twitching and severe convulsions. There are no reports of human fatalities from inhalation of the vapor, although one case of severe poisoning has been reported. Ingestion of lethal amounts (as little as 1 g) cause severe burns of the mouth and throat, marked abdominal pain, cyanosis, muscular weakness, collapse, coma, and death; tremors, convulsions, or muscle twitching were occasionally observed but were not severe. A laboratory technician repeatedly exposed to unknown vapor concentrations and liquid spilled on the skin developed anorexia, weight loss, weakness, muscle aches and pain, and dark urine; during several months of nonexposure there was gradual improvement in his condition, but after brief reexposure he suffered an immediate worsening of symptoms with prompt darkening of the urine and tender enlargement of the liver. Brief intermittent industrial exposures to vapor concentrations of 48 ppm of phenol (accompanied by 8 ppm of formaldehyde) caused marked irritation of eyes, nose, and throat. Concentrated phenol solutions are severely irritating to the human eye and cause conjunctival swelling; the cornea becomes white and hypesthetic; loss of vision has occurred in some cases. Solutions of phenol have a marked corrosive action on any tissue on contact; on skin, there is local anesthesia and a white discoloration, and the area may subsequently become gangrenous; severe dermatitis will result from contact with dilute solutions, and prolonged exposure may result in ochronosis. In workers making phenol-formaldehyde plastic, the urinary level of total phenol, free plus conjugated, was proportional to the air concentration of phenol up to 12.5 mg/m³ of workroom air. Mice were treated twice weekly for 72 weeks by application of 1 drop of a 10% solution of phenol in benzene to the shaved dorsal skin; after 52 weeks of treatment there were papillomas in 5 of 14 mice, and 1 fibrosarcoma appeared at 58 weeks.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 94.11
2. Boiling point (760 mm Hg): 182 C (359 F)
3. Specific gravity (water = 1): 107 (solid); 1.05 (liquid)
4. Vapor density (air = 1 at boiling point of phenol): 3.24
5. Melting point: 41 C (106 F)
6. Vapor pressure at 20 C (68 F): 0.36 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 8.4
8. Evaporation rate (butyl acetate = 1): Less than 0.01

• **Reactivity**

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers (especially calcium hypochlorite) may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving phenol.
4. Special precautions: Liquid phenol will attack some forms of plastics, rubber, and coatings. Hot liquid phenol will attack aluminum, magnesium, lead, and zinc metals.

• **Flammability**

1. Flash point: 79 C (174 F) (closed cup)
2. Autoignition temperature: 715 C (1319 F)
3. Flammable limits in air, % by volume: Lower: 1.7; Upper: 8.6
4. Extinguishant: Alcohol foam, carbon dioxide, dry chemical

• **Warning properties**

1. Odor Threshold: Summer reports that the odor threshold of phenol is 3 ppm; the Manufacturing Chemists Association reports 0.3 ppm; Thienes and Haley report 5 ppm.
2. Irritation Levels: The *Documentation of TLV's* reports that intermittent exposures to 48 ppm phenol have been observed to produce eye, nose, and throat irritation. Formaldehyde was also present in this atmosphere at a concentration of 8 ppm. The Respirator Review Committee considers the source of the eye irritation to be the 8 ppm formaldehyde rather than the phenol.
3. Evaluation of Warning Properties: Since the odor threshold of phenol is at or below the permissible exposure limit, phenol is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of phenol. Each measurement

Occupational Health Guideline for Phenol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: C_6H_5OH
- Synonyms: Carbolic acid; monohydroxybenzene
- Appearance and odor: Colorless to pink solid or thick liquid with a characteristic, sweet, tarry odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for phenol is 5 parts of phenol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 19 milligrams of phenol per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 20 mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 60 mg/m^3 averaged over a 15-minute period. The NIOSH Criteria Document for Phenol should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Phenol can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may enter the body through the skin.

- **Effects of overexposure**

1. Short-term Exposure: Phenol has a marked corrosive effect on any tissue. When it comes in contact with the eyes, it may cause severe damage and blindness. On contact with the skin, it does not cause pain but causes a whitening of the exposed area. If the chemical is not removed promptly, it may cause a severe burn or systemic poisoning. Systemic effects may occur from any route of exposure, especially after skin contact.

2. Long-term Exposure: Repeated or prolonged exposure to phenol may cause chronic phenol poisoning. The symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly a skin rash. Liver damage and discoloration of the skin may occur.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to phenol.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to phenol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of convulsive disorders or abnormalities of the skin, respiratory tract, liver, or kidneys would be expected to be at increased risk from exposure. Examination of the liver, kidneys, and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Darkening of the urine has occurred in persons exposed to phenol after accidental ingestion or skin contact. A urinalysis should be performed, including at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. Urinary phenol is useful if good individual background levels are available.

—Liver function tests: Since liver damage has been observed in humans exposed to phenol, a profile of liver function should be performed by using a medically acceptable array of biochemical tests.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

DRAFT

1089

TRICHLOROETHYLENE

DRAFT

$CCl_2=CHCl$

TLV, 50 ppm (≈ 270 mg/m³)

STEL, 150 ppm (≈ 805 mg/m³)

Trichloroethylene is a nonflammable, colorless liquid of sweetish odor. It has a molecular weight of 131.4 and a specific gravity of 1.4649. The boiling point is 87° C and solidifies at -84.8° C. The vapor pressure at 20° C equals 58 mm Hg. It is practically insoluble in water, but highly soluble in lipids. (Partition coefficient at 37° C: blood-air 9, oil-air 943). In the presence of oxygen and short ultraviolet wavelength, trichloroethylene is decomposed to phosgene and hydrochloric acid.

Trichloroethylene is used for degreasing, dry cleaning, and as a solvent. In the past, trichloroethylene was used as an extractant in food-processing (FDA had approved residue below 25 ppm in decaffeinated ground coffee and 10 ppm for instant coffee). This was discontinued in 1975, when NCI issued an alert, warning that trichloroethylene may be a carcinogen. Its use as an anesthetic was aban-

doned because of its decomposition in the soda-lime circuit into toxic and flammable dichloroacetylene, phosgene and carbon monoxide.

The sites of biological effects of trichloroethylene: 1) CNS (euphoria, analgesia, anesthesia); 2) Liver (necrosis, hepatomas); 3) Kidney (necrosis); 4) Lung (tachypnea); 5) Heart (arrhythmias); 6) Skin (irritation, vesication; paralysis of the fingers immersed in liquid trichloroethylene); 7) Bone marrow (myelotoxic anemia).

The knowledge of acute toxicity of trichloroethylene comes mainly from its use as an anesthetic.[1] Tachypnea and ventricular arrhythmias are equated with overdosage (inhaled concentrations greater an 15000 ppm).

Vernon and Ferguson[2] found that a two-hour exposure of a volunteer to 1000 ppm of trichloroethylene resulted in adverse effects on visual perception and motor skill; but two-hour exposures at 300 ppm and 100 ppm produced no significant effect. In a later report, the same authors[3] noted that low levels of alcohol in the blood (20-30 mg/100 mL) markedly augmented the effect of the two-hour exposures to trichloroethylene at concentrations of 300 and 1000 ppm.

Hepatic injury was observed in rats[4] exposed for 2 hours to a trichloroethylene concentration of 10,000 ppm, when the rats were pre-treated with phenobarbital, Aroclor 1254, hexachlorobenzene, 3-methyl cholanthrene or pregnenolone-16-α-carbonitrile. Liver injuries are associated with extensive metabolism of trichloroethylene in the body.

Death in laboratory animals from acute exposure to trichloroethylene vapor also results from respiratory failure or cardiac arrest.[5,6] Trichloroethylene is reported to have direct action on the bone marrow of rabbits, causing myelotoxic anemia.[7] It caused residual brain damage in dehydrated rats[8] exposed to 3000 ppm of trichloroethylene. Eight-hour exposure to any concentration higher than 3000 ppm might be fatal.[9]

Adams and associates[9] found no adverse effects when monkeys were exposed repeatedly at 400 ppm, rats and rabbits at 200 ppm, and guinea pigs at 100 ppm. Adams *et al* concluded from their animal studies that exposure to 100 ppm is probably safe for humans.

Stopps and McLaughlin[10] exposed volunteers to 100 ppm of trichloroethylene and found no changes in various performance tests, but did note some changes at higher concentrations. Steward and associates[11] reported that volunteers exposed to 200 ppm of trichloroethylene for seven hours a day showed mild responses such as slight fatigue and sleepiness on the fifth day of exposure. There were no measurable objective responses. Also, Triebig *et al*[12] exposed seven healthy volunteers to 100 ppm of trichloroethylene for five days observing no impairments of the examined person's mental or psychological capacities. On the other hand, Ertle *et al*,[13] in a similar study, observed fatigue, lassitude and headache in his volunteers.

Several European authorities, reported symptoms in workers exposed to concentrations generally below 100 ppm. Ahlmark and Forssman[14] estimated exposure to trichloroethylene by measuring the urinary excretion of trichloroacetic acid. They found the chief symptoms to be abnormal fatigue, irritability, headache, gastric disturbances and intolerance to alcohol. Ahlmark and Friberg[15] tentatively suggested 30 ppm as a desirable limit for the time-weighted average occupational exposure.

Haas[16] and Grandjean *et al*[17] found a variety of nervous disturbances in a group of 50 workers exposed to trichloroethylene vapor at concentrations ranging from 1 to 335 ppm. These disturbances increased with the length of exposure (up to five years or more), and were distinctly more frequent when trichloroethylene concentrations exceeded 40 ppm.

Bardodej and Vyskocil[18] also recommended a limit of about 40 ppm, finding signs and symptoms of chronic trichloroethylene poisoning including intolerance to alcohol, tremors, giddiness and anxiety at an exposure above 40 ppm.

Lilis and co-workers[19] reported that workers exposed at concentrations averaging about 10 ppm (12% of the tests showed values about 40 ppm) complained of headache, dizziness and sleepiness.

Smyth and associates reported an oral LD_{50} to be 4.92 mg/kg and, after four hours exposure, a lethal concentration to be 8000 ppm.[20] Rats were used in both instances.

Trichloroethylene was found neither embryotoxic nor teratogenic in Sprague-Dawley rats and Swiss Webster mice inhaling trichloroethylene for seven hours at a concentration of 300 ppm on days 6-15 of gestation.[21]

Trichloroethylene was found to be weakly mutagenic in the metabolizing E. coli mutagenic systems.[22]

Recently trichloroethylene came under investigation as a possible carcinogen. The concern was initiated by a report from the National Cancer Institute[23] that hepatocellular carcinomas resulted from oral administration of trichloroethylene to mice. In this bioassay, male and female rats (Osborne-Mendel) and mice (B6C3F1) were exposed to trichloroethylene for 18 months with an observation period of 3-6 months following exposure. Rats were given doses at either 1000 mg/kg or 500 mg/kg, 5 times/week. Male mice were given 2400 or 1200 mg/kg and female mice 1800 mg/kg or 900 mg/kg doses 5 times/week. Hepatocellular carcinomas were not seen in the rats; 30 of the 98 (30.6%) mice given the low dose, and 41 of the 95 (43.2%) mice given the high dose developed hepatocellular carcinomas. Only 1 (2.5%) of the 40 control mice developed a carcinoma.

A cohort study on trichloroethylene exposure and cancer in man, conducted recently in Scandinavian countries[24] in 7,688 workers exposed to relatively small concentrations of trichloroethylene, did not reveal any excess cancer mortality. Half of the population under study was exposed to trichloroethylene for more than 10 years: 548 persons were exposed to trichloroethylene concentrations greater than 30 ppm, 3,095 persons to concentrations smaller than 30 ppm. The exposure was evaluated from urinary excretion of trichloroacetic acid, 100 mg/L being associated with an eight-hour exposure of 30 ppm of trichloroethylene, a time-weighted exposure.

A TLV of 50 ppm and 150 ppm as a STEL are recommended for trichloroethylene to provide workers with adequate protection against the toxic effect.

Other recommendations: ANSI (1967) 100 ppm; NIOSH (1978) 25 ppm; Czechoslovakia (1969) 45 ppm, for brief exposures 225 ppm; Germany (1970) 50 ppm; Sweden 30 ppm; USSR (1967) 2 ppm.

1041

References:

1. **Dobkin, A.B., Byles, P.H.:** *Clinical Anesthesia Halogenated Anesthetics,* J.F. Artusio, Ed., pp. 43-65, F.A. Davis Co., Philadelphia, PA (1963).
2. **Vernon, R.J., Ferguson, R.K.:** *Arch. Env. Health 18:*894 (1969).
3. **Ferguson, R.K., Vernon, R.J.:** *Ibid. 20:*462 (1970).
4. **Moslen, M.T., Reynolds, E.S., Szabo, S.:** *Biochem. Pharm. 26:* 369 (1977).
5. **Patty, F.R.:** *Industrial Hygiene & Toxicology,* Vol. II, pp. 1309-1313, Interscience Publishers, NY (1963).
6. **Mikiskova, H., Mikiska, A.:** *Brit. J. Ind. Med. 25:*81 (1968).
7. **Mazza, V., Brancaccio, A.:** *Folia Med. 50:*318 (1967).
8. **Baetjer, A.M., Annau, Z., Abbey, H.:** *Arch. Env. Health 20:*712 (1970).
9. **Adams, E.M., Spencer, H.C., Rowe, V.K.** *et al: Arch. Ind. Hyg. & Occup. Med. 4:*469 (1951).
10. **Stopps, G.J., McLaughlin, M.:** *Am. Ind. Hyg. Assoc. J. 28:*43 (1967).
11. **Steward, R.D., Dodd, H.C., Gay, H.H.** *et al: Arch. Env. Health 20:*64 (1970).
12. **Triebig, G., Essing, H.G., Schaller, K.H.** *et al: Zbl. Bakt. Hyg., I. Abt. Orig. B. 163:*383 (1976).
13. **Ertle, T., Henschler, D., Muller, G.** *et al: Arch. Toxikol. 29:*171 (1972).
14. **Ahlmark, A., Forssman, S.:** *Arch. Ind. Hyg. & Occup. Med. 3:*386 (1951).
15. **Ahlmark, A., Friberg, L.:** *Nordisk Hyg. Tidskrift 36:*165 (1955).
16. **Haas, P.A.:** Industriehygienische Untersuchungen uber das Trichloroaethylen, Thesis #2979, *Technische Hochschule,* Zurich (1960).
17. **Granjean, E., Munchinger, R., Turrian V.** *et al: Brit. J. Ind. Med. 12:*131 (1955).
18. **Bardodej, Z., Vyskocil, J.:** *Arch. Ind. Health 13:*581 (1956).
19. **Lilis, R., Stanescu, D., Muica, N.** *et al: Med. d. Lavoro 60:*595 (1969).
20. **Smyth, H.F. Jr.** *et al: Am. Ind. Hyg. Assoc. J. 30:*470 (1969).
21. **Schwetz, B.A., Leong, B.K.J., Gehring, P.J.:** *Tox. Appl. Pharm. 32:*84 (1975).
22. **Greim. H., Bonse, G., Radwan, Z.** *et al: Biochem. Pharm. 24:*2 013 (1975).
23. **National Cancer Institute:** *Carcinogenesis Bioassay of Trichloroethylene,* CAS No. 79-02-6, National Cancer Inst. Tech. Rep. Series No. 2 (February 1976), US Dept. of Health Ed. & Welfare, DHEW Publ. No. (NIH) 76-802, Washington, DC.
24. **Axelson, O., Andersson, K., Hogstedt, C.** *et al: J. Occup. Med. 20:*194 (1978).

DRAFT

VINYL CHLORIDE

DRAFT

Chloroethene

$CH_2 = CHCl$

TLV, 5 ppm (≈ 10 mg/m³) — Appendix A1a — Recognized Carcinogen

A colorless, highly flammable gas with an ethereal odor, vinyl chloride has a molecular weight of 62.50. It boils at -13.9° C and freezes at -159.7° C. Vinyl chloride is usually handled as a liquid under pressure, and containing a polymerization inhibitor (phenol). It is slightly soluble in water, but dissolved by alcohol and ether.

The chief use of vinyl chloride is as a raw material for the manufacture of polyvinyl chloride resins. It is also employed in organic syntheses.

Since vinyl chloride is a gas at room temperature and pressure, the common route of toxic exposure is by inhalation. As with many liquified gases, contact of the skin or

1093

eyes with escaping compressed vinyl chloride can produce freezing frostbite.[1]

Vinyl chloride has long been considered to be very low in toxicity by acute inhalation. Lehmann and Flury[2] summarized the literature and reported work by Schauman who considered vinyl chloride to be a candidate surgical anesthetic. Schauman reported little pathological change even after repeated exposure to anesthetic concentrations. Further work on the anesthetic potential of vinyl chloride indicated that vinyl chloride was unsafe for use as a surgical anesthetic in dogs and that because of its flammability, poor efficacy and its ability to cause cardiac irregularities at anesthetic concentrations vinyl chloride was not suitable for use as an anesthetic in humans.

Despite the early reports ascribing low toxicity to vinyl chloride, injury during the production of polyvinyl chloride (PVC) resins was reported as early as 1949. Significantly this report came from Europe where production of PVC in Europe preceded U.S. production by several years and today the quantity produced in Europe still exceeds U.S. production by about two fold. In 1949, Tribuhk *et al*[3] reported numerous effects in PVC workers in what, by today's standards, must be considered as primitive production facilities. These authors found a *"considerable number of cases of hepatitis among workers"* but were more concerned with other hepatotoxic chemicals such as chlorinated diphenyl and chlorinated naphthylene (Holowax [sic]), than they were with vinyl chloride.

As a result of two deaths in Canada, the acute inhalation toxicity of vinyl chloride was studied by Mastromatteo *et al*[4] who reported that exposure of mice, rats and guinea pigs to 10, 20 and 30 volume percent vinyl chloride caused the following mortality:

NUMBER OF DEATHS IN DIFFERENT GROUPS OF FIVE MICE, RATS AND GUINEA PIGS EXPOSED FOR THIRTY MINUTES TO VARYING CONCENTRATIONS OF VINYL CHLORIDE IN AIR

Vinyl Chloride concentration (percent by volume in air)	Laboratory animal			
	Mice	Rats	Guinea pigs	TOTAL
10	0/5	0/5	0/5	0/15
20	1/5	0/5	0/5	1/15
30	5/5	5/5	1/5*	11/15
40	—	—	2/5*	2/5

*A delayed death occurred within 24 hours following exposure.

Some pulmonary hyperemia and engorgement was observed by these investigators, but liver and kidney injury were remarkably low. Deaths were due to narcosis.

The first report of studies to determine the effect of long-term repeated exposure (6 months) were summarized by Torkelson, Oyen and Rowe[1] as follows:

"Repeated exposures of laboratory animals at several concentrations of vinyl chloride in air were conducted to determine the chronic toxicity of this material towards animals in order to assess the hazard to humans. Vinyl chloride was found to have a slight capacity to cause liver and kidney injury on repeated exposures. Male and female rats showed micropathological changes after repeated daily 7-hour exposures at 500 ppm for 4.5 months. Repeated 7-hour exposured at 200 ppm for six months resulted in micropathological changes in the livers of rabbits and statistically significant increases in the average weight of the livers of male and female rats, but no detectable changes in dogs and guinea pigs. Repeated 7-hour exposures at 100 ppm resulted in slight increases in the average weight of rat livers, the other species were not affected. All species studied tolerated repeated daily 7-hour exposures at 50 ppm for six months with no detectable injury.

Repeated daily 1-hour exposures at 200 and 100 ppm of vinyl chloride were without effect, longer exposures caused a slight increase in liver weight.

The standard for evaluating regular daily 7- or 8-hour exposures may be defined as the concentration below which practically all analytical results must fall. The value of 100 ppm is suggested as this standard for vinyl chloride, with a time-weighted average for all exposures not to exceed 50 ppm."

Lester, Greenberg and Adams[5] took exception to the conclusion of Torkelson *et al* (1961) that 50 ppm should be a maximum time-weighted average exposure for workers. On the basis of 3 months exposure of rats to 2 volume percent and 19 days to 5 volume percent, they concluded that 500 ppm was acceptable as a TLV despite minor changes which they observed in rat livers and which they considered *"were within the normal range and were not pathologic in nature."*

Since 1949 numerous articles describing conditions and problems in PVC production plants have appeared particularly in the Eastern European literature. Filatova and Gronsberg,[6] Gabor *et al*,[7] Suciu *et al*,[8] Gabor *et al*,[9] Grigorescu and Toba,[10] Antonyuzhenko,[11] and Kudryavtseva[12] have all described the effects of apparent gross chronic exposure. These papers and abstracts are difficult to interpret since there are generally inadequate descriptions of the exposure conditions and analysis of the workroom air, so no dose-response relationship can be determined. The injuries and effects described by the authors are not consistent with the levels of exposures claimed by the authors nor are the levels of exposure consistent with past or even present-day chemical technology. Furthermore, mixtures of chemicals are involved making it possible to ascribe the effect to any one of them.

For example, Suciu *et al*[8] (through translation) described nervous disorders including euphoria with whistling and laughing, incoordination and dizziness similar to alcohol intoxication. However, Suciu *et al* ascribes these results to exposure of the order of 5.5 mg/m³ (2 ppm v/v) which is not consistent with other publications which indicate these effects will be apparent only if concentrations greatly exceed 10,000 to 20,000 ppm v/v. Therefore, the following conclusions by the authors can be construed as being the result of massive and apparently repeated exposures:

1. *Vinyl chloride and the vinyl monomers possess a narcotic action and produce, depending upon concentration, in addition to characteristic neurologic manifestation, a state of euphoria (12%), followed by a state of inebriation similar to that of alcohol intoxication. In certain cases narcosis can appear.*

After leaving the working environment, a state of somnolence (45%) persists, with hypersomnia. Vinyl chloride acts on the skin and produces a sensation of formication and of heat.

2. *After repeated exposure, a neurologic asthenia sets in which somnolence predominates.*
3. *After a variable period of time, dyspeptic disturbances are added to the neurologic manifestations; these are at first not characteristic; they are in the form of epigastric pains (16%), swelling, discomfort, feeling of heaviness in the right hypochrondium (7%) or the left (5%) with anorexia, particularly for fats.*

   In 30.2% of the cases, congestive hepatomegaly appears, which may mimic toxic hepatitis without jaundice; some cases may become chronic.

   In 6% of the cases, the hepatomegaly is accompanied by splenomegaly. The proteinogram and the aldolases are the most sensitive tests and show changes similar to those of acute hepatitis: increase in α-globulins and of the β- and γ-globulins; and thymol test, Greenstedt's reaction and the zinc sulfate test are positive only in few of the cases.
4. *After 3 years of exposure in 9% of the cases a syndrome typical of ulcer without radiologic changes becomes manifest.*
5. *In 6% of the cases the Raynaud syndrome has appeared, particularly among the young men. Plethysmography shows in half of the cases an inhibition of the vasomotor centers.*
6. *In addition, allergic dermatitis in 4.4% of the cases, and scleroderma in 3.6%, has been observed.*
7. *The clinical and laboratory findings are of great importance in occupational pathology because in numerous cases diseases appear in man that cannot be reproduced in the animal (Raynaud's syndrome and scleroderma).*

   The sudden and frequent appearance of these manifestations in the PVC division of several plants, and in certain divisions in normal individuals who are still relatively young, and their disappearance in the majority of the cases after the institution of protective measures and change of work, have shown us decisively that vinyl chloride and the vinyl monomers have played a part in the production of these manifestations. (End of author's summary).

In 1967, reports appeared in the literature describing a condition known as acroosteolysis in workmen engaged in polymerization of vinyl chloride to polyvinyl chloride. Harris and Adams[13] reported on two cases in Europe. Wilson *et al*[14] reported on 37 cases in the B. F. Goodrich Company. Juhe *et al*[15] described a syndrome consisting of (arranged in decreasing order of occurrence) thrombopenia, splenomegaly, liver damage, obstruction of ventilation, circulatory obstruction, and skin and bone alteration.

As a result of this problem, the University of Michigan in 1967 was retained by the Manufacturing Chemists Association to investigate acroosteolysis in sponsoring American companies. The results of a large scale epidemiological study of workers then currently employed in vinyl chloride and polyvinyl chloride production were reported in three publications by this group Dinman *et al*,[16] Cook *et al*[17] and Dodson *et al*.[18]

Dinman *et al*[16] summarized the study as follows:

"An epidemiological study was performed covering 5,011 employees with 21,510 man-years experience in various phases of vinyl chloride (VC) and polyvinyl chloride (PVC) manufacturing in 32 plants throughout the United States and Canada. The total number of definitive cases of acroosteolysis (AOL) was 25; 16 other individuals were under suspicion. This condition is clearly associated with the hand cleaning of polymerizers. Workers engaged in other phases of VC or PVC manufacturing do not appear to be at risk of developing AOL. The importance of Raynaud's phenomenon as a concomitant of AOL us emphasized. Several statistical approaches for rapid medical survey are suggested. Acroosteolysis appears to be a systemic rather than local disease. Presently, neither the etiological agent nor its portal of entry is known."

Cook *et al*[17] describes the polyvinyl chloride production process in considerable detail. They concluded that although no etiological agent could be identified, *"There appeared to be a correlation between the extent of degassing prior to entry into the reactor"* and the incidence of acroosteolysis.

Mutchler and Kramer[19] presented a paper at the 1968 Gordon Research Conference which was subsequently published (1972), which reported on *The Correlation of Clinical and Environmental Measurements for Workers Exposed to Vinyl Chloride.* The authors drew the following conclusion:

"Our findings suggest that repeated exposure to vinyl chloride at TWA levels of 300 ppm or above for a working lifetime together with a very low level of vinylidene chloride may result in slight changes in certain physiologic and clinical laboratory parameters. The possibility of some impairment in liver function tests must be considered, even though no overt clinical disease was evident in any of the individuals studied. We shall continue our study, but suggest that similar studies to help clarify the effects of this material be performed for other worker populations exposed to vinyl chloride alone."

P. L. Viola, in an attempt to produce acroosteolysis in animals, exposed rats 4 hours per day, 5 days per week to 30,000 ppm (3%) vinyl chloride vapor. In his first report on the results of 12 months exposure, he described metaplastic changes in the bones which he considered similar to the human disease acroosteolysis. He made no mention of having observed cancer in these animals until the Tenth International Cancer Congress in May 1970. In the abstracts of this meeting, and subsequently in May 1971, Viola, Bigotti and Caputo[21] reported tumors of the skin, lungs and bones occurring first after 10 months of exposure. The authors summarized this work as follows:

"Rats (Ar/IRE Wistar strain) exposed for 12 months to vapors of vinyl chloride developed tumors of the skin, lungs, and bones. The cutaneous tumors, which always appeared in the area in which submaxillary and parotid glands are located, have been histologically recognized as epidermoid carcinomas, papillomas, and mucoepidermoid carcinomas. The morphological characteristics of lung tumors, which

DRAFT.

1095

occurred in a lower percentage, were mainly of the adenocarcinoma type, with the exception of a single epidermoid tumor originating from the epithelial covering cells. In a minor number of rats, a large proliferation of cartilaginous tissue diagnosed as osteochondroma developed in the metacarpal and metatarsal regions of the four limbs."

The report by Viola *et al*[21] is apparently the earliest publication in which carcinogenic activity has been ascribed to vinyl chloride in man or animals. Although there were obvious deficiencies in Viola's study, such as his very impure sample, the presence of food and bedding in the exposure chamber, the excessive exposure concentration as well as in the statistical evaluation and interpretation of the lesions, the report was of serious concern and resulted in additional animal and epidemiological studies which are currently underway in Italy by Maltoni,[22] Maltoni and Lefemine[23,24] and in the U.S., Keplinger *et al*.[25]

On January 22-23, 1974, the B. F. Goodrich Company notified its employees, NIOSH, the Kentucky State Department of Labor, and the public, that three workers had died of angiosarcomas of the liver. The case reports of the first subject has been published by Creech and Johnson.[26] The subject, a 36 year old male, was hospitalized January 5, 1970 and subsequently succumbed September 27, 1971. He had worked in PVC production from November 1955 until his illness. The history, clinical course and pathologic findings are consistent with the others who died of angiosarcoma.

The work of Maltoni and Lefemine[23,24] has been reported publicly at the OSHA hearing, Washington, D.C., February 15, 1974, and included in the 1974 publication of the Second International Symposium on Cancer Detection and Prevention, Bologna, Italy, April 9-12, 1973. In these studies groups of rats as well as mice and hamsters have been exposed at concentrations of 10,000 to 50 ppm vinyl chloride vapor. Maltoni and Lefemine (1974) reported carcinomas of the Zymbal glands, nephroblastoma and angiosarcomas of the livers of rats at concentrations of 250 ppm to 10,000 ppm but not at 50 ppm. Subsequent unpublished information (August 31, 1974) reported, *"1 liver angiosarcoma, 1 extrahepatic angiosarcoma and 1 nephroblastoma, in three animals of the first experiment, exposed at 50 ppm of VC for 1 year, and surviving 135 weeks from the beginning of the treatment."* The authors conclude that,

> *"a dose-response relationship clearly emerges, as far as angiosarcomas and nephroblastomas are concerned, in the lower dose ranges: from 500 ppm to 50 ppm for angiosarcomas, and from 250 ppm to 50 ppm for nephroblastomas. A comparison of the results available at the present moment in rats exposed for 12 months and 4 months (BT1 and BT3 experiments) shows that the neoplastic response, as far as angiosarcomas and nephroblastomas are concerned, is affected by the length of exposure to VC."*

In their experiment BT3 Maltoni and Lefemine reported possible *in utero* production of angiosarcomas in offspring of pregnant rats exposed at 10,000 and 6,000 ppm.

Keplinger *et al*,[25] in a study sponsored by American companies, have confirmed the findings of Maltoni and Lefemine. In this study, groups of 100 rats, mice and hamsters of each sex are being exposed seven hours per day, five days per week to either 2,500, 200 to 500 ppm vinyl chloride monomer. After seven months of exposure angiosarcoma and lung adeaomas have been observed in mice at all exposure levels. Although the data are preliminary in nature and require confirmation, angiosarcomas were apparently also observed in rats at 2,500 and 200 ppm and in a single hamster at 2,500 ppm. This study is still in progress and will not be completed until 1976 or 1977.

Epidemiological studies on U.S. workers have been conducted by Tabershaw-Cooper Associates for the Manufacturing Chemists Association.[27] The summary of this study is as follows:

> This historical prospective mortality study of 8384 men who had at least one year of occupational exposure to vinyl chloride before December 31, 1972, demonstrated that cancers of the digestive system (primarily angiosarcoma), respiratory system, brain, and cancers of unknown site, as well as lymphomas, occurred more often than expected in those members of the study population with the greatest estimated exposure. The mortality from other cancers was lower than that of the general male population, with the exception of cancers of the buccal cavity and pharynx. The explanation for the latter finding is not apparent.

The other major findings of the study are: (1) The overall mortality of the study population was approximately 75% of what would be expected in a comparable population of U.S. males; (2) No cause of death showed a statistically significant excess over what would be expected in a comparable U.S. male population; and (3) No deaths identified as angiosarcoma of the liver were found other than those previously identified.

This is the first epidemiological study which suggests that in humans vinyl chloride may also be associated with cancer of multiple sites.

It is difficult to derive a reasonable TLV from the data presented in the literature summarized above. There is indirect evidence that intermittent exposures to vinyl chloride of the order of thousands of ppm, in this country as well as Russia, have not been infrequent in PVC plants. No data on the past (or even present) concentrations of vinyl chloride in plants where angiosarcoma cases have occurred, or not occurred, appear to be available. One report[29] indicates that 21 of 26 of the early cases of angiosarcoma occurred in former reactor cleaners. Cleaning of reactors was apparently responsible for most of the acroosteolysis cases investigated by Cook and associates,[17] and has resulted in death from acute poisoning by vinyl chloride.[36]

It is the sense of the Committee that, if the average exposure to vinyl chloride does not exceed 5 ppm, there wil be no increase in the incidence of cancer, specifically of angiosarcoma of the liver. It is probable that the cancers reported and attributed to vinyl chloride among PVC workers resulted from exposures many times this level.

NIOSH recommended a limit of 1 ppm as a TWA, with a ceiling of 5 ppm. The 1 ppm value was apparently based on the erroneous belief that this was the lowest concentration that could be readily measured.

Gehring and co-workers,[30] using a probit model, and based on studies with rats, found the predicted incidence of hepatic angiosarcomas from 8 hour/day, 5 days/week, 35 year exposure at 1 ppm to be 1.5 times 10^{-8}.

Recent papers have included a report of 4 cases of respiratory cancer among vinyl chloride workers, but no dose-response relationship.[31]

On the other hand, Fox and Collier,[32] in a study of 7000 men exposed to vinyl chloride in PVC manufacture between 1940 and 1974, found no evidence of cancers due to vinyl chloride at sites other than the liver. There are four liver cancers, two of them angiosarcomas.

Delorme and Theriault[33] described 10 cases of liver angiosarcoma among workers in vinyl chloride polymerizing plant in Quebec, which were accompanied by fibrosis of the liver. Details of 64 cases were presented by Sputas and Kaminski.[34]

Mutufugi, in Japan, noted that in contrast to western countries, in which 70 angiosarcomas cases (associated with vinyl chloride exposure) had been reported, no cancer, but many poisoning cases, have been reported in the USSR.[35]

Based on the above data, an A1a classification as a confirmed carcinogen is given vinyl chloride and a TLV of 5 ppm as a time-weighted average is suggested. If this value is not exceeded, there should be no increase in the incidence of cancer, especially angiosarcoma of the liver.

Limits adopted in other countries, subsequent to the surfacing of vinyl chloride exposure associated cancers, as are follows, according to a 1977 summary: Australia (1973) 25 ppm; Finland (1975), Holland (1973), Poland (1976), Switzerland (1976) and USSR (1977) about 10 ppm; Italy (1975) 5 ppm; Japan (1975) and Sweden (1978) 1 ppm.

References:

1. **Torkelson, T.R.** *et al*: *Am. Ind. Hyg. Assoc. J. 22(5)*:354 (1961).
2. **Lehman, K.B., Flury, F.:** *Toxicology & Hygiene of Industrial Solvents* (1938).
3. **Tribukh,** *et al*: *Arg. Saint. 10*:38 (1949).
4. **Mastromatteo, E.** *et al*: *Am. Ind. Hyg. Assoc. J. 21(5)*:394 (1961).
5. **Lester, D.** *et al*: *Ibid. 24*:265 (1963).
6. **Filatova, V.A., Gronsberg, E.S.:** *Gigiena i. Sanit. 22(1)*:33, abstract (1957).
7. **Gabor, S.** *et al*: *Prom. Toksikol. i. Klinika. Prof. Zaholevanii Khim. Etiol. Sb. 221*, abstract (1962).
8. **Suciu, I.** *et al*: *Medicina Interna (Bucharest) XV(8)*:967 (1963).
9. **Gabor, S.** *et al*: *Ingiena Bucharest 13(5)*:409 (1964).
10. **Grigorescu, I., Toba, G.:** *Rev. Chim. 17(8)*:499, abstract (1966).
11. **Antonyuzhenko, V.A.:** *Gig. Tr. Prof. Zabol. 12(3)*:50, abstract (1968).
12. **Kudryavtseva, O.F.:** *Ibid. 14(8)*:54, abstract (1970).
13. **Harris, D.K., Adams, W.G.F.:** *Brit. Med. J. 5567*:712, abstract (1967).
14. **Wilson, R.H.** *et al*: *JAMA 201(8)*:577 (1967).
15. **Juhe, S.** *et al*: *Dtsch. Med. Wschr. 98*:2034 (1973).
16. **Dinman, B.D.** *et al*: *Arch. Env. Health 22*:61 (1971).
17. **Cook, W.A.** *et al*: *Ibid.*, p. 74.
18. **Dodson, V.N.** *et al*: *Ibid.*, p. 83.
19. **Kramer, C.G., Mutchler, J.E.:** *Am. Ind. Hyg. Assoc. J. 33(1)*:19 (1971).
20. **Viola, P.L.:** *Medicina del Lavoro 61(3)* (March 1970).
21. **Viola, P.L.** *et al*: *Cancer Research 31*:516 (1971).
22. **Maltoni, C.:** *Proc. 2nd Intl. Symp. on Cancer Detection & Prevention*, Bologna, 1973, Excerpta Medica, Amsterdam (1974).
23. **Maltoni, C., Lefemine, G.:** *Lincei-Rendiconte Della Classe di Science, Tesiche, Mathmatische 56*:1 (1974).
24. **Eidem:** *Carcinogenic Bioassays of Vinyl Chloride*, unpublished data (1974).
25. **Keplinger, J.L.** *et al*: *Annals of NY Acad. of Sciences Working Group* (May 10, 1974).
26. **Creech, J.L., Johnson, M.N.:** *JOM 16(3)*:150 (1974).
27. **Tabershaw, I.R., Gaffey, W.R.:** *Ibid.*, p. 508.
28. **Patty, F.A.** *et al*: *U.S. Pub. Health Reports 45*, 1963, abstract (1930).
29. Current Intelligence, *J. Occup. Med. 16*:809 (1974).
30. **Gehring, P.T.** *et al*: *Tox. Appl. Pharm. 49*:15 (1979). IHD abstract 753/79.
31. **Buffler, P.A.** *et al*: *J. Occup. Med. 21*:195 (1979). *Ibid.* 54/79.
32. **Fox, A.J., Collier, P.F.:** *Brit. J. Ind. Med. 34*:1 (1977). *Ibid.* 501/77.
33. **Delorme, F., Theriault, G.:** *J. Occup. Med. 20*:338 (1978). *Ibid.* 688/78.
34. **Sputas, R., Kaminski, R.:** *Ibid.*, p. 427. *Ibid.* 828/78.
35. **Matufugi, H.:** *J. Science Labor 54*:585 (1978). *Ibid.* 54/79.
36. **Massachusetts Div. of Occup. Hygiene:** Unpublished report.

DRAFT

APPENDIX III

SITE PERSONNEL PROTECTION AND
SAFETY EVALUATION FORMS

Tasks

Surficial Mapping - On-Site

Well Borings - Off-Site Only

DRAFT

1098

SITE PERSONNEL PROTECTION AND SAFETY EVALUATION FORM

Form 2.1

CDM Project Number: 549-38-FI-HEAL SEF Control Number: Z-1-17-01

Prepared by: A.T. Moore/D.G. Muldoon Date: 28 September 1982

Site Name: Lone Pine Landfill Project Manager: Norma Schlissel

Site Location: Freehold, NJ On-Site Coordinator: Tom Pedersen

Activity: Surficial Mapping - On-Site Observations

Present Status: Continuous ( ) Intermittent (X)

Site Description: Abandoned hazardous waste landfill with buried drums and discharged bulk liquids. Organic solvents are the predominant wastes on-site.

Known Controlled Materials On-Site:

benzene
vinyl chloride
trichloroethylene
1,2-trans dichloroethylene
phenol

Additional Hazards: none anticipated

Informational Source: F.C. Hart Health & Safety Plan

NIOSH/OSHA Material Guideline Sheets (as attached):
benzene (DTLV)*, vinyl chloride (DTLV)*, trichloroethylene (DTLV)*, phenol

Background Environment:

Air: Some evidence of low level organic vapors on-site

Soil: Some evidence of surficial contamination with organic solvents and oils.

Surface Water: Leachate contaminated with phenol and volatile organic solvents.

Groundwater: On-site wells highly contaminated

*Documentation of the Threshold Limit Values (4th Ed.)
American Conference of Governmental Industrial Hygenists

DRAFT

1099

POTENTIAL SITE HAZARDS

- [ ] RADIOACTIVE
- [ ] EXPLOSIVE
- [ ] OXYGEN DEFICIENT
- [x] ORGANIC VAPORS
- [ ] OTHER _____
- [ ] NONE OF THE ABOVE

SITE CATEGORY

- [ ] 1
- [ ] 2
- [x] 3
- [ ] 4
- [ ] 5

PROTECTION LEVEL

- [ ] A
- [ ] B
- [x] C
- [ ] D

PERSONNEL & SAFETY EQUIPMENT (R-Required, C-Contingency)

RESPIRATORY

- [ ] SCBA
- [R] FULL FACE RESPIRATOR (CART. GMC-H _____)
- [R] ESCAPE MASK
- [ ] NONE

CLOTHING

- [ ] FULLY ENCAPSULATING SUIT
- [ ] CHEMICALLY RESISTANT SPLASH SUIT
- [R] TYVEK COVERALL (DISPOSABLE)
- [ ] COVERALL

HEAD & EYE

- [ ] HARD HAT
- [ ] GOGGLES
- [ ] FACE SHIELD
- [R] CHEMICAL EYEGLASSES

HAND PROTECTION

- [R] PVC UNDERGLOVES
- [ ] VITON GLOVES
- [R] DISPOSABLE OVERGLOVES
- [ ] NONE

FOOT PROTECTION

- [R] SAFETY BOOTS
- [R] DISPOSABLE OVERBOOTS

DECONTAMINATION * ALL OUTWEAR DISPOSABLE

- [ ] RESPIRATORY EQUIPMENT
- [ ] CLOTHING
- [ ] HAND
- [ ] FOOT PROTECTION
- [ ] HEAD & EYE

FIELD MONITORING EQUIPMENT

- [ ] OXYGEN/COMBUSTION METER
- [ ] RADIOLOGICAL SURVEY INSTRUMENT
- [ ] DETECTOR TUBES ( )
- [R] HNU
- [ ] OVA
- [ ] RESPIRABLE DUST MONITOR

DRAFT

1000

Agency	Address	Telephone No.
* Fire Department	Schanck Rd. Freehold, N.J.	(201) 462-2112
Police Department	Schanck Rd. Freehold, N.J.	(201) 462-7500
* Hospital	Freehold Area Hospital West Main St. Freehold, N.J.	(201) 431-2000
* Ambulance Service	Freehold Area Hospital West Main St. Freehold, N.J.	(201) 431-2000
Health Department	Freehold Township Schanck Rd. Freehold, N.J.	(201) 462-7900
Poison Control Center	Monmouth Medical Center 300 2nd Ave. Long Branch, N.J.	(201) 222-2210
State Environmental Agency Contact: David Henderson	N.J. DEP 1911 Princeton Ave. Trenton, N.J.	(609) 292-1210
EPA Regional Office Contact: Joel Singerman	EPA, Region II 26 Federal Plaza Room 402 N.Y., N.Y. 10278	(212) 264-9589
EPA Emergency Response Team Icom	EPA Raritan Depot Woodbridge Ave. Edison, N.J. 08837	(201) 321-6660
State Police	Colts Neck Station Cedar Drive Colts Neck, N.J.	(201) 462-5712
Federal Aeronautics Administration	Philadelphia, Pa.	(201) 364-6921
Civil Defense & Disaster Control	Headquarters East Main St. Freehold, N.J.	(201) 431-7400
*On-Site Logistical Support	Chadwick Taylor Township Health Officer Schanck Rd., Freehold, N.J.	(201) 462-7900

*Required for all Site Personnel Protection and Safety Evaluation forms

DRAFT

ON-SITE COORDINATOR RESPONSIBILITIES: Monitor ambient air using HNU photoionizer. Conduct preliminary orientation for mapping team before going on-site. Terminating mapping operation if warranted by changing on-site conditions.

PERSONNEL PROTECTION AND SAFETY REVIEW:

D.G. Muldoon
Safety & Health Manager _____ Signature _____ Date

N, Schlissel
Project Manager _____ Signature _____ Date

PRESITE VISIT SAFETY AND HEALTH BRIEFING CONDUCTED BY:

_____ Date

I have read, understood, and agreed with the information set forth in this Personnel Protection and Safety Evaluation Form (and attachments) and discussed in Presite Visit Health and Safety briefing

Tom Pedersen
Name _____ Signature _____ Date

Michael Calise
Name _____ Signature _____ Date

Name _____ Signature _____ Date

Name _____ Signature _____ Date

Name _____ Signature _____ Date

ATTACHMENTS

DRAFT

SITE PERSONNEL PROTECTION AND SAFETY EVALUATION FORM

Form 2.1

CDM Project Number: 549-38-FI-HEAL SEF Control Number: Z-1-17-02

Prepared by: A.T. Moore Date: 28 September 1982

Site Name: Lone Pine Landfill Project Manager: Norma Schlissel

Site Location: Freehold, NJ On-Site Coordinator: reserved

Activity: Well Borings - Off-Site Only (No drilling in landfill)

Present Status: Continuous ( ) Intermittent (X)

Site Description: Abandoned hazardous waste landfill with buried drums and discharged bulk liquids. Organic solvents are the predominant wastes on-site.

Known Controlled Materials On-Site:

benzene
vinyl chloride
trichloroethylene
1,2-trans dichloroethylene
phenol

Additional Hazards: none anticipated

Informational Source: F.C. Hart Health & Safety Plan

NIOSH/OSHA Material Guideline Sheets (as attached): benzene (DTLV)*, vinyl chloride (DTLV)*, trichloroethylene (DTLV)*, phenol

Background Environment:

Air: No evidence of off-site ambient contamination

Soil: No evidence of off-site surficial contamination

Surface Water: No evidence of off-site contamination

Groundwater: Off-site wells should be relatively uncontaminated

DRAFT

(103

POTENTIAL SITE HAZARDS

- [ ] RADIOACTIVE
- [ ] EXPLOSIVE
- [ ] OXYGEN DEFICIENT
- [X] ORGANIC VAPORS
- [ ] OTHER _____
- [ ] NONE OF THE ABOVE

SITE CATEGORY

- [ ] 1
- [ ] 2
- [X] 3
- [ ] 4
- [ ] 5

PROTECTION LEVEL

- [ ] A
- [ ] B
- [ ] C
- * [X] D

*for specific activity only

PERSONNEL & SAFETY EQUIPMENT (R-Required, C-Contingency)

RESPIRATORY

- [ ] SCBA
- [C] FULL FACE RESPIRATOR (CART. organic vapor
- [R] ESCAPE MASK
- [ ] NONE

CLOTHING

- [ ] FULLY ENCAPSULATING SUIT
- [ ] CHEMICALLY RESISTANT SPLASH SUIT
- [R] TYVEK COVERALL (DISPOSABLE)
- [ ] COVERALL

HEAD & EYE

- [ ] HARD HAT
- [ ] GOGGLES
- [ ] FACE SHIELD
- [R] CHEMICAL EYEGLASSES

HAND PROTECTION

- [ ] PVC UNDERGLOVES
- [ ] VITON GLOVES
- [R] DISPOSABLE OVERGLOVES
- [ ] NONE

FOOT PROTECTION

- [ ] SAFETY BOOTS
- [R] DISPOSABLE OVERBOOTS

DECONTAMINATION ALL OUTWEAR DISPOSABLE

- [ ] RESPIRATORY EQUIPMENT
- [ ] CLOTHING
- [ ] HAND
- [ ] FOOT PROTECTION
- [ ] HEAD & EYE

FIELD MONITORING EQUIPMENT

- [ ] OXYGEN/COMBUSTION METER
- [ ] RADIOLOGICAL SURVEY INSTRUMENT
- [ ] DETECTOR TUBES ( )
- [R] HNU
- [ ] OVA
- [ ] RESPIRABLE DUST MONITOR

DRAFT

1104

Agency	Address	Telephone No.
* Fire Department	Schanck Rd. Freehold, N.J.	(201) 462-2112
Police Department	Schanck Rd. Freehold, N.J.	(201) 462-7500
* Hospital	Freehold Area Hospital West Main St. Freehold, N.J.	(201) 431-2000
* Ambulance Service	Freehold Area Hospital West Main St. Freehold, N.J.	(201) 431-2000
Health Department	Freehold Township Schanck Rd. Freehold, N.J.	(201) 462-7900
Poison Control Center	Monmouth Medical Center 300 2nd Ave. Long Branch, N.J.	(201) 222-2210
State Environmental Agency Contact: David Henderson	N.J. DEP 1911 Princeton Ave. Trenton, N.J.	(609) 292-1210
EPA Regional Office Contact: Joel Singerman	EPA, Region II 26 Federal Plaza Room 402 N.Y., N.Y. 10278	(212) 264-9589
EPA Emergency Response Team Icom	EPA Raritan Depot Woodbridge Ave. Edison, N.J. 08837	(201) 321-6660
State Police	Colts Neck Station Cedar Drive Colts Neck, N.J.	(201) 462-5712
Federal Aeronautics Administration	Philadelphia, Pa.	(201) 364-6921
Civil Defense & Disaster Control	Headquarters East Main St. Freehold, N.J.	(201) 431-7400
*On-Site Logistical Support	Chadwick Taylor Township Health Officer Schanck Rd., Freehold, N.J.	(201) 462-7900

*Required for all Site Personnel Protection and Safety Evaluation forms

DRAFT

ON-SITE COORDINATOR RESPONSIBILITIES: Conduct on-site orientation for boring contractor personnel and CDM personnel. Monitor ambient concentration of organic vapors with hnu analyzer. Terminate drilling operation if warranted by changing on-site conditions.

PERSONNEL PROTECTION AND SAFETY REVIEW:

D.G. Muldoon		
Safety & Health Manager	Signature	Date
N. Schlissel		
Project Manager	Signature	Date

PRESITE VISIT SAFETY AND HEALTH BRIEFING CONDUCTED BY:

	Date

I have read, understood, and agreed with the information set forth in this Personnel Protection and Safety Evaluation Form (and attachments) and discussed in Presite Visit Health and Safety briefing

Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date
Name	Signature	Date

ATTACHMENTS

DRAFT

1106

APPENDIX IV

GENERIC HEALTH AND SAFETY PLAN

DRAFT

PERSONNEL PROTECTION AND SAFETY

LIBRARY

PERSONNEL PROTECTION AND SAFETY PLAN

1.0 GENERAL

This personnel protection and safety plan outlines procedures to be used during investigations at uncontrolled hazardous waste sites and controlled substance work areas. This plan has been developed to minimize the risk of injury or illness resulting from activities undertaken at hazardous waste sites.

CDM's Safety and Health Officer (SHO) or a designated subcontractor SHO shall be responsible for ensuring that all procedures described herein are carried out at each work site. Notice of any violation of these procedures or questions regarding them shall be directed to the SHO. Any questionable practices or work procedure disagreements which cannot be resolved by the SHO shall be referred to CDM's Ad Hoc Corporate Health and Safety Committee.

This Personnel Protection and Safety Plan is comprised of the following major subsections:

- o Site Evaluation
- o Medical Examinations
- o Training
- o Site Control and Decontamination
- o Contingency Measures
- o Checklist.

2.0 SITE EVALUATION

2.1 Initial Site Characterization and Interpretation

Prior to commencement of work at any uncontrolled hazardous waste site or controlled substance work area, an evaluation of the potential hazards associated with site investigations or remedial actions shall be undertaken. This evaluation shall be performed by CDM's Safety and Health

DRAFT

Officer or designated subcontractor and members of the Hazardous Waste Sampling Team. The site project manager is always informed of all sampling or field investigations and must approve of the proposed activities.

The initial site characterization shall be undertaken to determine if there is any evidence of insufficient oxygen levels, explosive or flammable levels of gases, high levels of chemical vapors or high levels of nuclear radiation. A protocol for the initial site characterization is described in procedure 3817012. Class B protection, at a minimum, shall be used during the initial site walkover. Use of field monitoring equipment is discussed in procedures 3816018-6021. Interpretations of the results of the survey shall be based on the criteria summarized below.[1]

2.1.1 Explosivity

Continuous ground, waist and head level readings shall be obtained in confined areas or where explosive gases are suspected if explosivity readings greater than 20 percent but less than 50 percent of the lower explosive limit (LEL) are detected. Immediate withdrawal from the site and notification of the local fire department shall be required when explosivity readings approach or exceed 50 percent of the LEL.

2.1.2 Chemical Vapors

Organic chemical vapor levels shall be monitored using H-NU or OVA meters. When specific chemical vapors are known to exist on the site, Draeger tubes specific to that compound are used. Levels in excess of compound's threshold limit value (TLV) constitute an action level for protective equipment. Avoid areas in which high levels of chemical vapors are encountered.

2.1.3 Radioactivity

If radioactivity levels approach 10.0 millirems/hour (mr/hr) a detailed site survey shall be undertaken. If activity levels are greater than 10.0 mr/hr the site should be evacuated and the assistance of a radiation health

[1] USEPA. 1980. RCRA Inspection Manual Office of Enforcement, USEPA.

DRAFT

111D

physicist obtained prior to re-entry. Normal background radioactivity is approximately 0.02 mr/hr and activity of up to 10.0 mr/hr are acceptable for investigations of short duration.

2.2 Site Categorization

Table 1 contains a summary of the site evaluation criteria to be used in assessing the degree of protection required at each site.

Site category shall be determined based upon an evaluation of the characteristics of materials present on the site and the activities to be undertaken. Protection levels required must be consistent with the level of risk associated with site work. Contingency protection levels equipment shall be provided to allow personnel to upgrade protection levels should unexpected materials be encountered or environmental conditions degrade.

The following sources provide information on the potential routes of exposure and toxic properties of waste materials which may be encountered at uncontrolled hazardous waste sites. It should be noted that these sources deal with pure generic or trade-name compounds and their physical and chemical properties will likely vary from waste materials found on a hazardous waste site.

- The Condensed Chemical Dictionary, 8th Edition G. Hawley, Van Nostrand Reinhold Co., N.Y., N.Y.
- Merck Index, An Encyclopedia of Chemicals and Drugs, Merck and Co. Rahway, N.J.
- Dangerous Properties of Industrial Materials, N. Irving Sax, Van Nostrand Reinhold Co., N.Y., N.Y.
- NIOSH/OSHA Pocket Guide to Chemical Hazards and Documentation, U.S. Dept. Health and Human Services and Department of Labor.

DRAFT

TABLE 1

UNCONTROLLED HAZARDOUS WASTE SITE EVALUATION CRITERIA

Site Category	Required Protection Level	Contingency Protection Level	Description	Criteria	Medical Exam & Monitoring	Training	Respiratory Protection	Protectivet Clothing
1	A	N/A	Highest risk. Requires highest level of respiratory, skin and eye protection.	oImmediately Dangerous to Life and Health (IDLH) atmospheres oKnown atmospheres or potential situations that would affect skin or eyes, or could be absorbed into the body through these surfaces. oOxygen deficient atmospheres in addition to above. oTotal vapors 500-1000 ppm HNU oUnknown*	Required	Required	Positive Pressure Self Contained Breathing Apparatus (SCBA)	oTotally encapsulating suit oChemical protective boots oChemical protective gloves
2	B	A*	Requires highest level of respiratory protection. Cutaneous and percutaneous exposure to small unprotected areas of body unlikely or concentration within acceptable exposure standards.	oIDLH atmospheres oAtmospheres with concentrations of substances greater than protection factors associated with full-face air purifying resoirators oAtmospheres with less than 19.5% oxygen olypes and concentrations of vapors in air do not present a cutaneous or percutaneous hazard to small unprotected parts of body oKnown absence of cutaneous or percutaneous hazard oTotal vapors 5-500 ppm HNU	Required	Required	Positive Pressure SCBA	oTwo-piece chemical resistant suit oChemical protective boots oChemical protective gloves oHard hat/face shield
3	C	B*	Types and concentrations of resirable material is known or reasonably assumed to be not greater than protection factors associated with air purifying respirators. Exposure of few unprotected areas of body unlikely to cause harm.	oAir concentrations of materials not requiring a protection factor greater than that afforded by full-face mask oBody exposure to unprotected areas less than any amount that will cause harm oNo evidence of acute or chronic effects to exposed personnel oTotal vapor reading between 0 and 5 ppm and HNU	Required	Required	Full face, air purifying respirator, fit tested	oChemical resistant clothing oHard hat oSafety boots oChemical protective boots oChemical protective gloves
4	D	C	Designated hazardous waste site. No significant immediate health hazards.	oNo indication of airborne health hazard oNo gross indications above background on HNU	Optional	Optional	Escape mask	oCoveralls oHard hat oGloves oSafety goggles
5	D	C	Controlled materials onsite at low or non-hazardous concentrations	oNo indication of health hazard	Optional	Optional	Escape Mask	oCoveralls oHard hat oGloves oSafety glasses

*Optional with guidance from Safety and Health Officer.

DRAFT

- Chemical Hazard Information System, Volume 2, Chemical Data, U.S. Coast Guard.

- Oil and Hazardous Materials Technical Assistance Data System (OHMTADS)-Available at EPA Offices.

- Industrial Hygiene and Toxicology, Frank A. Patty, Wiey Institute Publishers.

The type of protective clothing and respiratory devices required for site work is determined based on the hazard evaluation procedure summarized in Table 1 and discussed below.

2.2.1 Protective Clothing

Totally encapsulated suits are used only in confined facilities, sites containing toxics known to be absorbed through or which irritate the skin, or sites which have no established history.[2]

On sites where toxics which are absorbed through, or irritate the skin are present at acceptable exposure levels, or where exposure is unlikely, the following equipment shall be worn:

- Chemical safety glasses (prescription if required), goggles or face shield;
- Rubber soled, metal toed rubber boots;
- Liquid proof, neoprene or butyl rubber gloves which are long enough to protect the wrists shall be worn under jacket sleeves to prevent waste from running into gloves. Surgical undergloves shall be worn under the rubber gloves;
- Coveralls made of closely woven fabric;

[2]Davis, N.C. 1979. Outline of Guidelines for Entering Field Sites of Unknown Chemical Toxicity. USEPA, Office of Occupational Health & Safety.

DRAFT

- o Chemical-resistant pants with ankle ties, worn over boots;
- o Chemical-resistant, long sleeved jacket;
- o OSHA-approved hard hat or head covering made of plastic with a plastic sweatband; and
- o Interior coveralls or cooling vest.

Protective clothing at a minimum shall consist of rubber soled boots and rubber gloves.

2.2.2 Respiratory Protection

All staff will be adequately protected as specified in the Occupational Safety and Health Administrations (OSHA) respiratory protection standard 1910.134. Self-Contained Breathing Apparatus (SCBA) must be used under the positive pressure demand mode when toxic gases may be encountered on-site, when containers of unknown or hazardous materials known to pose hazard are opened, or when sampling in enclosed spaces.

SCBAs shall be NIOSH approved, and provide a tight face seal and positive pressure in the mask area.

SCBAs usually provide air for about 20 minute duration, depending on the individuals physical condition and the ambient temperature: Extreme caution must be taken when using SCBA during subfreezing weather.

Air-Purifying Respirators shall only be used in those atmospheres containing sufficient oxygen to sustain life (>19.5 percent O_2) and where SCBAs have been determined to be unnecessary by the Safety and Health officer.

Air purifying respirators will only be used by persons properly trained and fitted for these respirators. The procedures used to train and fit test personnel are found in "Respiratory Protection, A Manual and Guideline", by Lawrence R. Birkner (1980), published by the American Industrial Hygiene Association. This publication is available from the Sampling and Analytical Coordinator.

Specific chemical cartridges which provide the necessary protection for the gases or vapors present on the site shall be used. At a minimum the cartridge shall be an organic vapor or combination type.

Air-purifying respirator cartridges shall not be used in areas where gases or vapors are in excess of the limits specified on the cartridge label.

Cartridges shall be replaced after each days use or when the user senses or smells vapors or gases. Cartridges from unopened packages may be used up to the expiration date provided.

2.3 Site Evaluation Form

Prior to personnel entry to any uncontrolled hazardous waste site or controlled substance work area, each individual is required to read and sign the completed "Site Personnel Protection and Safety Evaluation Form" prepared for that specific site. This form is comprised of four major pages and the appropriate attachments, as presented in Form 1. A copy of this form is retained by each site worker and the originals must be filed in CDM's Document Control Center (DCC).

The first page of the form outlines general information on site conditions and materials known to exist on the site. NIOSH/OSHA materials guideline sheets are attached to the form to provide information on the behavior and characteristics of controlled substances.

Page two of Form 1 provides the potential hazards which may be encountered on the site and the required personnel and safety equipment.

Page three of Form 1 provides a listing of emergency telephone numbers and addresses for emergency situations. The on-site coordinator shall be responsible for maintaining maps and directions to the appropriate hospitals and fire departments.

Page four of Form 1 outlines the specific duties of the on-site coordinator and provides space for signatories of each person who will enter the site under the on-site coordinators responsibility.

DRAFT

CDM PROJECT NO. _____

DATE: _____

SITE PERSONNEL PROTECTION AND SAFETY EVALUATION FORM

PROJECT: _____ PROJECT MANAGER: _____

SITE LOCATION: _____ ON-SITE COORDINATOR: _____

_____ SAFETY AND HEALTH OFFICER: _____

SITE DESCRIPTION: _____

KNOWN CONTROLLED MATERIALS ON-SITE: _____

NIOSH/OSHA MATERIAL GUIDELINE SHEETS: _____

SAFE WORK PROCEDURES

BACKGROUND ENVIRONMENT:

AIR - _____

SOIL - _____

SURFACE WATER - _____

GROUNDWATER - _____

DRAFT

1116

POTENTIAL SITE HAZARDS

- ☐ RADIOACTIVE
- ☐ EXPLOSIVE
- ☐ OXYGEN DEFICIENT
- ☐ ORGANIC VAPORS
- ☐ OTHER _____
- ☐ NONE OF THE ABOVE

SITE CATEGORY

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

PROTECTION LEVEL

- ☐ A
- ☐ B
- ☐ C
- ☐ D

PERSONNEL & SAFETY EQUIPMENT (R-Required, C-Contingency)

RESPIRATORY

- ☐ SCBA
- ☐ FULL FACE RESPIRATOR (CART._____)
- ☐ ESCAPE MASK
- ☐ NONE

CLOTHING

- ☐ FULLY ENCAPSULATING SUIT
- ☐ CHEMICALLY RESISTANT SPLASH SUIT
- ☐ TYVEK COVERALL (DISPOSABLE)
- ☐ COVERALL

HEAD & EYE

- ☐ HARD HAT
- ☐ GOGGLES
- ☐ FACE SHIELD
- ☐ CHEMICAL EYEGLASSES

HAND PROTECTION

- ☐ PVC UNDERGLOVES
- ☐ VITON GLOVES
- ☐ DISPOSABLE OVERGLOVES
- ☐ NONE

FOOT PROTECTION

- ☐ SAFETY BOOTS
- ☐ DISPOSABLE OVERBOOTS

DECONTAMINATION

- ☐ RESPIRATORY EQUIPMENT
- ☐ CLOTHING
- ☐ HAND
- ☐ FOOT PROTECTION
- ☐ HEAD & EYE

FIELD MONITORING EQUIPMENT

- ☐ OXYGEN/COMBUSTION METER
- ☐ RADIOLOGICAL SURVEY INSTRUMENT
- ☐ DETECTOR TUBES ( )
- ☐ HNU
- ☐ OVA
- ☐ RESPIRABLE DUST MONITOR

Agency	Address	Telephone No.
Fire Department		( )
Police Department		( )
Hospital		( )
Ambulance Service		( )
Health Department		( )
Poison Control Center		( )
State Environmental Agency Contact:		( )
EPA Regional Office Contact:		( )
EPA Emergency Response Team Icom		( )
State Police		( )
Federal Aeronautics Administration		( )
Civil Defense		( )
On-Site Logistical Support		( )

DRAFT

1118

ON-SITE COORDINATOR RESPONSIBILITIES: _____

_____

_____

_____

_____

PERSONNEL PROTECTION AND SAFETY REVIEW

_____

SAFETY AND HEALTH OFFICER DATE

_____

PROJECT MANAGER DATE

I have read, understood and and will comply with the information and procedures. Personnel Protection and Safety Evaluation Form and the attached sheets.

_____

ON-SITE COORDINATOR DATE

_____

DATE

_____

DATE

_____

DATE

ATTACHMENTS

DRAFT

1119

3.0 MEDICAL EXAMINATIONS

The level of medical surveillance required for individuals who will be involved in site investigations or remedial measures is dependent on the nature of the waste present at each particular uncontrolled hazardous waste site or controlled substance work area and the duration of exposure associated with site operations.

The medical examinations instituted as part of this health and safety plan are not to be considered substitute for regular checkups designed to monitor general health. The medical examinations undertaken for this program is designed to screen for evidence of adverse effects due to exposure to toxic substances. Therefore, the examination does not provide for screening of common, non-occupational chronic disorders.

Each individual who will work at any site where full face respirators, or positive pressure self contained breathing apparatus (SCBA) alone or in conjunction with fully encapsulating suits are required, is subject to a minimum baseline cardiopulmonary examination, including a stress test.

Individuals who will work at sites where suspected toxic materials are present, or at sites where waste materials may be harmful to health under normal working conditions, shall be subject to a baseline medical examination and periodically scheduled surveillance examinations.

Baseline physical examinations shall provide a history of previous exposure, general health status and will serve as a baseline for comparative purposes. Baseline examinations include, but are not limited to the following:[3]

- o Medical history
- o General physical

[3] ADL. 1981. Draft Plan - Safety, Health & Contingency Plan for Remedial Action at PAS Oswego, NY.

DRAFT

11/20

- o Electrocardiogram
- o SMA 20
- o CBC
- o Urinalysis
- o Serum cholinesterase
- o Methemoglobin
- o Urine heavy metals
- o Chest x-ray
- o Stress test.

As part of this medical examination tetanus vaccinations should be updated and where exposure to infectious waste may occur, polio and gamma globulin innoculations are recommended.

Periodic surveillance examinations are performed after each 400 cumulative hours at a particular waste site, or at the time of site work completion, or at the time of transfer to another work site, or whenever there is evidence that employees may have been over exposed to hazardous materials.

Periodic surveillance provides a continous record of health status and also assists in the early identification of advance health effects. Periodic surveillance examinations shall consist of but not be limited to the following:

- o SMA 20
- o CBC
- o Urinalysis
- o Cholinesterase
- o Urine heavy metals
- o Methemoglobin.

Medical records for each employee shall be maintained and updated by CDMs Personnel Department and retained for 30 years.

DRAFT

4.0 TRAINING

Each individual who will be involved in site sampling or remedial work shall be briefed by the SHO or other qualified sampling team member regarding work on site and use of safety equipment.

The specific level of training required shall be determined by the SHO and sampling team coordinator and is based in part on site category classification. The on-site coordinator for each site shall be trained in the use of the H-NU photoionizer prior to site work. At least one person at the site at any time shall be qualified to use and interpret the readings from the H-NU.

Site category 1 requires Level A protection. Only those individuals who have been trained in the use of fully encapsulating suits and SCBA by the USEPA shall be permitted on these sites.

Individuals who will work at category 2 sites shall be trained in the use of SCBA by the SHO or a qualified member of the sampling team. This training shall include inspection of equipment, donning and doffing techniques and decontamination procedures. Decontamination procedures for all protective clothing shall also be incorporated in training excercises.

Individuals who will work at Category 3 sites must utilize protective equipment specified in Table 1 under Level C. Workers at these sites must be trained in the use of full face respirators and trained in donning and doffing protective clothing to minimize the risk of contamination. Each individual working under Level C protection must be properly fitted with a full face respirator. Individuals failing the fit test are not be permitted to work at Category 3 sites unless SCBA equipment is used.

For site Categories 4 and 5, minimal training will be required for most individuals experienced in field work. When deemed necessary by the SHO, escape masks shall be carried by individuals working on sites categorized as 4 or 5. Escape masks are not to be carried by any individual who has not been instructed in their proper use.

1122

5.0 SITE CONTROL & DECONTAMINATION PROCEDURES

5.1 Site Control

Site control measures are implemented at all uncontrolled hazardous waste sites or controlled substances work areas in order to minimize the risk of transfer of contaminated materials to uncontaminated areas. At each site an entry point is established and a log for site personnel maintained. Each person entering the site must sign in, noting the time and purpose for entering the site. Upon leaving the site, the individuals must sign out and indicate what, if any, samples have been removed from the site.

For sites classified as Category 1, 2 or 3, work zones are established. These work zones shall be estimated to differentiate contaminated areas from uncontaminated areas. Three zone designations are used and assigned by the SHO. These are:

- Zone I - Contaminated (HOT) Area
- Zone II - Decontamination (TRANSITION) Area
- Zone III - Non-Contaminated (CLEAN) Area.

The delineation and use of these zones is illustrated in Figure 1. The spatial separation of these zones shall be based on site specific conditions, but in general, the distance from the boundary of Zone I to Zone III must be greater than 100 feet.

Zone I is the contaminated area in which hazardous materials are known to exist. No individual is permitted into this area unless complying with the prescribed level of protection. Sampling equipment which cannot be adequately decontaminated, materials disturbed during sampling, or surplus samples shall be placed within a sealed 55-gallon steel drum lined with a 10 ml polyethylene bag. This drum shall be appropriately labeled using enamel paint and left within Zone I.

Zone II is that area through which all individuals must pass to reach Zone I. It is an area which is not contaminated but may become so due to the

1123

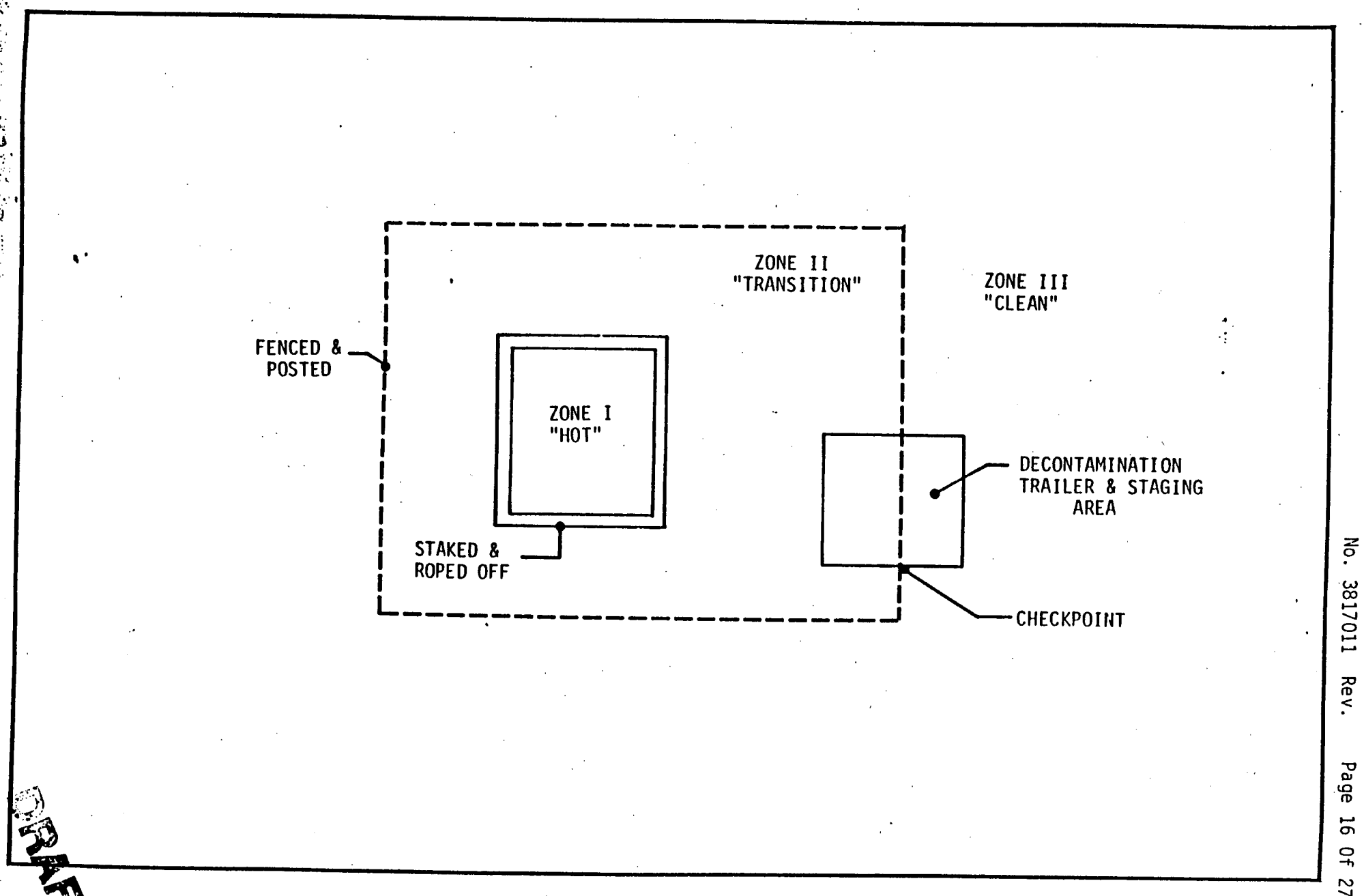


FIGURE 1

EXAMPLE SITE WORK ZONE SCHEMATIC

DRAFT

1124

exiting of personnel following activity in Zone I. All personnel and equipment decontamination operations are located within this zone. Contaminated clothing and materials removed from Zone I which cannot be adequately decontaminated shall be left within this zone in appropriately labeled 55-gallon steel drums. The Decontamination Line as described in section 5.2 shall be established within Zone II.

Zone III is the designated clean area surrounding the site which must not be contaminated due to site investigation or remedial actions. Entry from Zone III into Zone II shall only be made through a check point on the Zone III/II boundry. No individual shall enter Zone II without donning the appropriate level of protection required for decontamination purposes.

The utility trailer to be installed at each site will be placed within Zone III with the designated check point in proximity to the Zone III/II boundary. The dirty side of the trailer may extend into Zone II where appropriate.

5.2 Decontamination

In order to reduce the risk of transfer of contaminants from Zone I to Zone III, decontamination of personnel and equipment is required to take place within Zone II. The decontamination procedures shall be established for each site based on the degree of hazard associated with the site and the amount of contact with hazardous materials resulting from site work. Final decontamination procedures shall be reviewed and approved by the SHO or designated subcontractor SHO prior to implementation.

For emergency decontamination, an outdoor shower shall be located within Zone II and supplied with clean water under pressure. The shower will be located above a grate which allows for collection of all wash waters and a pump for transfer of the used water to properly marked drums for disposal on site.

Decontamination of personnel and equipment is accomplished by washing, and collection of washings and used equipment for treatment prior to deposition

DRAFT

1125

in sealed drums. A general layout of a decontamination line is illustrated in Figure 2.

Decontamination procedures are designed to remove contaminated debris or liquids from protective equipment. Sufficient water and solutions will be available at each site to wash the materials from clothing. Typical decontamination solutions may consist of either 5 percent sodium carbonate (Na_2CO_3), and 5 percent trisodium phosphate (Na_3PO_4-4 lbs. each to 10 gallons of water) or 10 percent calcium hypochlorite ($Ca(ClO)_2$-8 lbs. to 10 gallons of water) solutions. Rinse solutions generally consist of 5 percent solutions of trisodium phosphate. Decontamination solutions of dilute HC may also be used when appropriate. The final rinse for all procedures is with clean water.

Decontaminated outer garments are stored in a designated area within Zone II. Only those under garments which will be laundered or which do not need to be decontaminated in the decontamination line are brought into the trailer.

5.3 Personal Hygiene

Individuals entering Zone II are required to don the appropriate protective clothing in reverse order of removal outlined for the decontamination line.

Individuals exiting from Zone I through II and into Zone III are required to shower prior to exiting the trailer at sites classified as category 1, 2 or 3.

In order to avoid contamination, smoking is prohibited within Zones I and II and within the site trailer. No food or drink is consumed within Zones I or II. Food and drink may be consumed within designated clean areas of the trailers and Zone III areas. Hands must be washed prior to consumption of any food or drink prior to smoking.

The following must be posted on signs at points of entry to Zone II:

DRAFT

1126

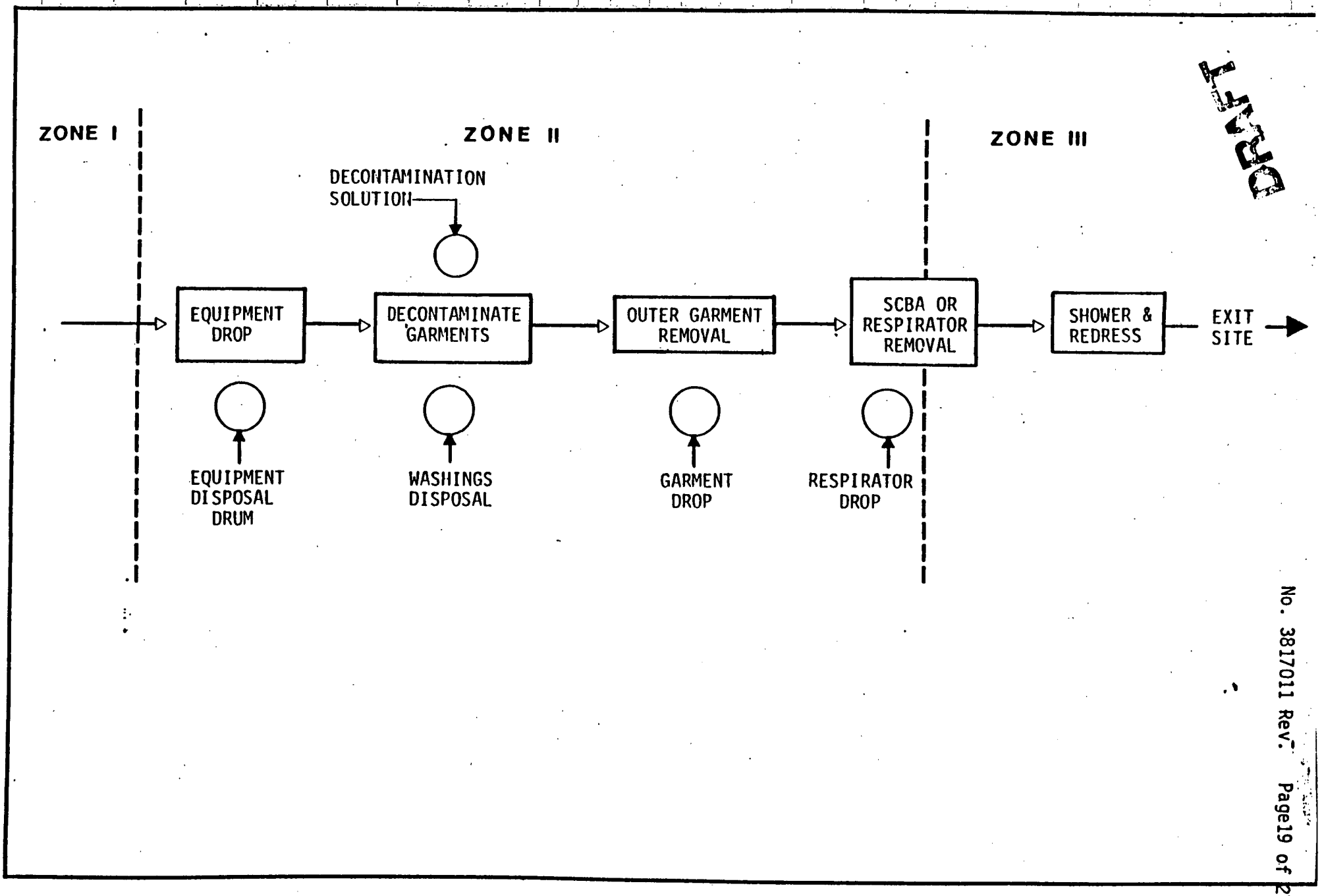


FIGURE 2

EXAMPLE DECONTAMINATION LINE SCHEMATIC

- o NO SMOKING OR CONSUMPTION OF FOOD OR DRINK PERMITTED BEYOND THIS POINT.

The following must be posted on the entry point to site trailers:

- o NO SMOKING BEYOND THIS POINT.

6.0 CONTINGENCY MEASURES

In order to implement contingency plans during emergency operations at work sites, the on-site coordinator is responsible for developing a site evacuation and notification plan for implementation should an emergency situation arise. The coordinator is also responsible for preparing accident reports. Specific contingency plans are presented in site specific documents.

6.1 Emergency Communication

Emergency telephone numbers and addresses are provided on a list prominantly displayed in the site trailer adjacent to the telephone. A copy of this shall be retained by the SHO and on-site coordinator at all times. At a minimum, telephone numbers and addresses shall be provided for the following:

- o Fire Department
- o Police Department
- o Hospital
- o Toxicologist (if not available at local hospital)
- o Ambulance Service
- o Burn Unit
- o Health Department
- o Poison Control Center
- o State Environmental Agency
  - Local
  - Headquarters
- o EPA Regional Office

DRAFT

1128

- o Civil Defence
- o EPA Emergency Response Team
- o Public Works Department
- o State Police
- o FAA
- o On-Site Logistics Support.

In addition, the emergency telephone numbers listed in Table 2 should be displayed in a prominent location within the site trailer.

The on-site coordinator is responsible for obtaining maps and directions to fire departments, police stations and hospitals in the area.

If an emergency does occur on-site requiring personnel to withdraw from the site, a prearranged signal, described in site specific plans, will be sounded by the On-Site Coordinator.

DRAFT

TABLE 2

EMERGENCY TELEPHONE NUMBERS

Organization	Division	Telephone No.
USEPA	Emergency Response Team	(201)321-6660
US Coast Guard	Environmental Response	(800)424-8802
Assoc. of America Railroads	Emergency Response	(202)293-4048
CHEMTREC	Chemical Emergencies	(800)424-9300
Dow Chemical	Emergencies	(517)636-4400
DuPont	Emergency Response	(302)774-1000
Monsanto	Safety Office	(618)271-5835
National Foam Center	Emergency Response	(215)363-1400

DRAFT

1130

6.2 Emergency First Aid

Emergency first aid treatment is only administered by trained individuals as a means of providing relief from injury and preventing further damage until professional treatment can be obtained. The members of the sampling team are trained in emergency first aid and should be consulted as available. It is also desirable that the On-Site Coordinator be trained in first aid treatment.

The following first aid equipment shall be provided at each work site.

- o American National Red Cross First Aid Handbook
- o Compresses
- o Gauze & gauze roller badage
- o Triangular bandages
- o Eye dressing packet
- o Smelling salts
- o Baking soda
- o Salt or other emetic
- o Portable eyewash unit
- o Safety rope & harvers
- o Oxygen bottles, valves, etc.
- o Soap or waterless hand cleaner and towels.
- o Back brace
- o Band aids
- o Tape
- o Scissors
- o Tweezers
- o Razors

The following emergency first aid shall be administered as required.

6.2.1. Inhalation

If warning signals are apparent the victim shall leave the contaminated air space immediately.

If unconscious, the victim should be pulled from contaminated area immediately. Rescuers must wear appropriate respiratory and protective equipment.

If victim is no longer breathing, mouth-to-mouth resuscitation or some other form of artificial respiration should be initiated away from the contaminated area.

DRAFT

6.2.2 Skin Exposure

Wash contaminated skin with copious amounts of soap and water.

Contaminated clothing should be removed immediately and the skin washed thoroughly with running water.

A shower should be used immediately if available and contaminated clothing removed while showering.

Repeat wash procedures to ensure complete decontamination.

6.2.3 Ingestion

Induce vomiting using a tablespoon of salt or powdered mustard in a glass of warm water or syrup of ipecac except when the ingested substance presents an aspiration hazard, such as from a petroleum product; or when the substance is a strong acid or alkali. Vomiting may also be induced by placing finger down throat of victim.

Treatment should continue unit vomit is clear.

6.2.4 Eye Contact

Wash eyes with copious amounts of water by holding eye open and flooding with water so that all surfaces are washed thoroughly.

Continue washing for at least 15 minutes.

6.3 Incident Reports

The on-site coordinator is responsible for preparation and submission of completed Safety and Health Incident Reports (Form 2) to the SHO.

The SHO is required to follow up on treatment and recovery and report to the Ad Hoc Health & Safety Committee as required.

DRAFT

7.0 CHECKLIST

In order to ensure the availability at each site of appropriate personnel protective equipment, the check list presented in Form 3 shall be completed by the SHO and filed in CDM's Document Control Center.

DRAFT

FORM 2

CDM PROJECT NO: _____

DATE: _____

SAFETY AND HEALTH INCIDENT REPORTS

PROJECT _____ PROJECT MGR. _____

SITE LOCATION _____ ON-SITE COOR. _____

INCIDENT SUMMARY _____

_____

_____

TIME OF INCIDENT _____

EXPOSED INDIVIDUALS _____

_____

_____

EXPOSED TO _____

_____

ACTIONS:

FIRST AID ADMINISTERED

DOCTOR EXAMINATION

DRAFT

1134