41584

FEASIBILITY STUDY

VOLUME I

ANALYSIS OF ALTERNATIVES

DuPont Necco Park Site
Niagara Falls, New York

October 11, 1995 **DERS Project No. 3293**

Prepared by

DuPont Environmental Remediation Services
Barley Mill Plaza 27
P. O. Box 80027
Wilmington, Delaware 19880-0027

400001

VOLUME I

ANALYSIS OF ALTERNATIVES

DuPont Necco Park Site
Niagara Falls, New York

Revised October 11, 1995 **DERS Project No. 3293**

Prepared for

DuPont Niagara Plant
26th and Buffalo Avenue
Niagara Falls, New York 14302

by

DuPont Environmental Remediation Services
Barley Mill Plaza 27
P.O. Box 80027
Wilmington, Delaware 19880-0027

ANALYSIS OF ALTERNATIVES

DuPont Necco Park Site
Niagara Falls, New York

Revised October 11, 1995 **DERS Project No. 3293**

Prepared for

DuPont Niagara Plant
26th and Buffalo Avenue
Niagara Falls, New York 14302

by

DuPont Environmental Remediation Services
Barley Mill Plaza 27
P.O. Box 80027
Wilmington, Delaware 19880-0027

Joseph McCarthy

Joseph M. McCarthy, PE
Principal Engineer

Paul F. Mazierski

Paul F. Mazierski, PG
Senior Geologist

R. Gordon Burnett /PFM

R. Gordon Burnett
Project Director

CONTENTS

Executive Summary xxi

1.0 INTRODUCTION 1-1
1.1 Overview 1-1
1.2 Site Location 1-2
1.3 Site Background 1-4
1.4 Previous Investigations 1-5
1.5 Previous Response Actions 1-7
1.6 Regional Physiography 1-10
1.6.1 Regional Soil 1-10
1.6.2 Regional Bedrock Geology 1-11
1.6.3 Regional Structural Geology 1-12
1.6.4 Regional Hydrogeology 1-14
1.6.4.1 Man-made Passageway Capture Zones 1-17
1.6.5 Regional Hydrology 1-22
1.7 Site Physiography 1-23
1.7.1 Site Soil 1-23
1.7.2 Site Bedrock Geology 1-24
1.7.3 Site Hydrogeology 1-24
1.7.4 Site Hydrology 1-32
1.8 Nature And Extent of Contamination 1-32
1.8.1 Overburden 1-34
1.8.2 Groundwater and DNAPLs 1-34
1.8.3 Source Area Definition 1-35
1.8.4 Far-Field Area Definition 1-36
1.9 Effects of Response Actions 1-39
1.9.1 DNAPL Recovery 1-40
1.9.2 Groundwater Recovery 1-41
1.9.3 Groundwater Flow and Solute Transport in Fractured Media 1-43

CONTENTS
(Continued)

2.0 RESPONSE ACTION OBJECTIVES 2-1
2.1 Risk Evaluation 2-1
2.1.1 Human Health Risk 2-2
2.1.2 Negligible Health Risks 2-3
2.1.3 Ecological Risk 2-3
2.2 Statutory And Regulatory Requirements 2-4
2.3 Response Action Objectives 2-5
2.4 Target Response Goals 2-7
2.5 Media Areas/Volumes 2-7
2.5.1 Overburden 2-8
2.5.2 DNAPL 2-8
2.5.3 Source Area Groundwater 2-9
2.5.4 Far-Field Groundwater 2-10

3.0 TECHNOLOGY SCREENING AND EVALUATION 3-1
3.1 Technology Screening and Evaluation Procedure 3-1
3.2 General Response Actions 3-2
3.3 Identification and Screening of Technologies 3-4
3.4 Process Option Evaluation 3-5
3.4.1 Process Option Evaluation Criteria 3-5
3.4.1.1 Effectiveness 3-5
3.4.1.2 Implementability 3-6
3.4.1.3 Cost 3-6
3.4.2 Evaluation 3-7
3.5 Overburden Process Option Evaluation 3-7
3.5.1 No Action—Overburden 3-8
3.5.2 Overburden Access Restrictions 3-8
3.5.2.1 Overburden Deed Restrictions 3-9
3.5.2.2 Fencing 3-9
3.5.2.3 Security Personnel 3-10

CONTENTS
(Continued)

3.5.3 Overburden Monitoring	3-10
3.5.3.1 Overburden Air Monitoring	3-10
3.5.4 Overburden Capping	3-11
3.5.4.1 Existing Overburden Clay Cap	3-12
3.5.4.2 Overburden NYS 360 Cap	3-12
3.5.4.3 Overburden Asphalt Cap	3-14
3.5.4.4 Overburden RCRA-type Cap (NYS 373)	3-15
3.5.5 Overburden Vertical Barriers	3-16
3.5.5.1 Overburden Slurry Walls	3-16
3.5.5.2 Overburden Grout Curtains	3-17
3.5.5.3 Overburden Sheet Piles	3-19
3.5.6 Overburden Horizontal Bottom Barrier	3-21
3.5.7 Overburden Excavation	3-22
3.5.8 Overburden Thermal Treatment	3-22
3.5.8.1 Overburden Incineration	3-22
3.5.8.2 Overburden Radio Frequency Heating	3-24
3.5.8.3 Overburden Thermal Desorption	3-25
3.5.8.4 Overburden In Situ Vitrification	3-26
3.5.8.5 Commercial Incineration of Overburden	3-27
3.5.9 Overburden Biological Treatment	3-27
3.5.9.1 Overburden In Situ Biological Treatment	3-28
3.5.9.2 Overburden Ex Situ Biological Treatment	3-28
3.5.10 Overburden Physical/Chemical Treatment	3-29
3.5.10.1 Overburden Soil-Vapor Extraction	3-30
3.5.10.2 Overburden In Situ Soil Flushing	3-30
3.5.10.3 Overburden Soil Washing	3-31
3.5.10.4 Overburden Dual-phase Extraction	3-32
3.5.10.5 Overburden In Situ Stabilization	3-33
3.5.10.6 Overburden Ex Situ Stabilization	3-34
3.5.11 Overburden Vapor-phase Treatment	3-36

CONTENTS
(Continued)

3.5.12 Overburden Disposal 3-36
3.5.12.1 Overburden Disposal at an On-site Landfill 3-37
3.5.12.2 Overburden Disposal at Commercial Landfill 3-37
3.5.13 Summary of Overburden Technology Process Option Evaluation 3-38
3.6 DNAPL Process Option Evaluation 3-38
3.6.1 No Action—DNAPL 3-40
3.6.2 Access Restrictions—DNAPL 3-40
3.6.2.1 DNAPL Area Deed Restrictions 3-40
3.6.2.2 Groundwater-Use Controls—DNAPL 3-41
3.6.3 DNAPL Monitoring 3-41
3.6.4 DNAPL Vertical Barriers 3-42
3.6.4.1 DNAPL Vertical Barriers—Slurry Walls 3-42
3.6.4.2 DNAPL Vertical Barriers—Grout Curtains 3-44
3.6.4.3 DNAPL Vertical Barriers—Sheet Piles 3-46
3.6.5 DNAPL Extraction 3-48
3.6.5.1 DNAPL Extraction Wells 3-48
3.6.5.2 DNAPL Extraction Trenches 3-50
3.6.6 DNAPL Thermal Treatment 3-51
3.6.6.1 DNAPL Radio Frequency Heating 3-51
3.6.6.2 DNAPL In Situ Vitrification 3-52
3.6.6.3 Commercial Incineration of DNAPL 3-52
3.6.7 DNAPL Physical/Chemical Treatment 3-53
3.6.7.1 DNAPL Soil-Vapor Extraction 3-53
3.6.7.2 DNAPL In Situ Surfactant Flushing 3-54
3.6.7.3 DNAPL Dual-phase Extraction 3-55
3.6.7.4 DNAPL In Situ Stabilization 3-56
3.6.7.5 DNAPL Vapor-phase Treatment 3-57
3.6.8 Summary of DNAPL Technology Process Option Evaluation 3-58
3.7 Source Area Groundwater Process Option Evaluation 3-58
3.7.1 No Action—Source Area Groundwater 3-60

CONTENTS
(Continued)

3.7.2 Source Area Groundwater Monitoring 3-60
3.7.3 Source Area Groundwater Access Restrictions 3-61
3.7.3.1 Source Area Groundwater Deed Restrictions 3-61
3.7.3.2 Source Area Groundwater-Use Controls 3-61
3.7.4 Source Area Groundwater Vertical Barriers 3-62
3.7.4.1 Source Area Groundwater Vertical Barriers—Slurry Walls 3-62
3.7.4.2 Source Area Groundwater Vertical Barriers—Grout Curtains 3-64
3.7.4.3 Source Area Groundwater Vertical Barriers—Sheet Piles 3-66
3.7.5 Source Area Groundwater Hydraulic Control 3-67
3.7.5.1 Source Area Groundwater Extraction Wells 3-68
3.7.5.2 Source Area Groundwater Interceptor Trenches .. 3-69
3.7.6 Source Area Groundwater Biological Treatment 3-70
3.7.6.1 Source Area Groundwater In Situ Aerobic Biological Treatment 3-70
3.7.6.2 Source Area Groundwater Ex Situ Aerobic Biological Treatment 3-71
3.7.6.3 Source Area Groundwater In Situ Anaerobic Biological Treatment 3-72
3.7.6.4 Source Area Groundwater Ex Situ Anaerobic Biological Treatment 3-74
3.7.6.5 Source Area Groundwater Biological Treatment with Passive Treatment Walls 3-75
3.7.6.6 Source Area Groundwater Natural Attenuation 3-76
3.7.7 Source Area Groundwater Physical/Chemical Treatment 3-76
3.7.7.1 Source Area Groundwater Treatment—Air Sparging 3-77
3.7.7.2 Source Area Groundwater Treatment—Dual-phase Extraction 3-77
3.7.7.3 Source Area Groundwater Treatment—

CONTENTS
(Continued)

Precipitation 3-78
3.7.7.4 Source Area Groundwater Treatment—Air Stripping 3-79
3.7.7.5 Source Area Groundwater Treatment—Steam Stripping 3-80
3.7.7.6 Source Area Groundwater Treatment—Carbon Adsorption 3-81
3.7.7.7 Source Area Groundwater Treatment—Chemical Oxidation 3-82
3.7.7.8 Source Area Groundwater Treatment—Reverse Osmosis 3-83
3.7.7.9 Source Area Groundwater Treatment—Ion Exchange 3-84
3.7.7.10 Source Area Groundwater Treatment—Filtration 3-85
3.7.7.11 Source Area Groundwater Treatment—Microfiltration 3-85
3.7.7.12 Source Area Groundwater Vapor-phase Treatment 3-86
3.7.8 Source Area Groundwater Thermal Treatment—Incineration 3-87
3.7.9 Off-Site Treatment of Source Area Groundwater 3-87
3.7.9.1 Off-site Treatment of Source Area Groundwater at a Commercial WWTP 3-87
3.7.9.2 Off-site Treatment of Source Area Groundwater at the POTW 3-88
3.7.10 On-site Discharge of Source Area Groundwater 3-89
3.7.10.1 Source Area Groundwater Injection Wells 3-89
3.7.10.2 Source Area Groundwater Injection Trenches 3-90
3.7.11 Off-site Discharge of Source Area Groundwater 3-91
3.7.11.1 Off-site Discharge of Source Area Groundwater to the POTW 3-91
3.7.11.2 Off-site Discharge of Source Area Groundwater to Surface Water 3-92

CONTENTS
(Continued)

3.7.11.3 Off-site Discharge of Source Area Groundwater by Injection Wells 3-92
3.7.12 Summary of Source Area Groundwater Technology Process Option Evaluation 3-93
3.8 Far-Field Groundwater Process Option Evaluation 3-93
3.8.1 No Action—Far-Field Groundwater 3-94
3.8.2 Far-Field Groundwater Monitoring 3-95
3.8.3 Far-Field Groundwater-Use Controls 3-95
3.8.4 Far-Field Groundwater Extraction 3-96
3.8.4.1 Far-Field Groundwater Extraction with Extraction Wells 3-96
3.8.4.2 Far-Field Groundwater Extraction with Existing Utility Drains 3-96
3.8.5 Far-Field Groundwater Biological Treatment 3-97
3.8.5.1 Far-Field Groundwater Natural Attenuation 3-98
3.8.5.2 Far-Field Groundwater In Situ Aerobic Biological Treatment 3-98
3.8.5.3 Far-Field Groundwater Ex Situ Aerobic Biological Treatment 3-99
3.8.5.4 Far-Field Groundwater In Situ Anaerobic Biological Treatment 3-101
3.8.5.5 Far-Field Ex Situ Anaerobic Biological Treatment 3-102
3.8.6 Far-Field Groundwater Physical/Chemical Treatment 3-103
3.8.6.1 Far-Field Groundwater Treatment—Precipitation 3-103
3.8.6.2 Far-Field Groundwater Treatment—Air Stripping 3-104
3.8.6.3 Far-Field Groundwater Treatment—Steam Stripping 3-105
3.8.6.4 Far-Field Groundwater Treatment—Carbon Adsorption 3-106
3.8.6.5 Far-Field Groundwater Treatment—Chemical Oxidation 3-107

CONTENTS
(Continued)

3.8.6.6 Far-Field Groundwater Treatment—Reverse Osmosis 3-108
3.8.6.7 Far-Field Groundwater Treatment—Ion Exchange 3-109
3.8.6.8 Far-Field Groundwater Treatment—Filtration 3-109
3.8.6.9 Far-Field Groundwater Treatment—Microfiltration 3-110
3.8.6.10 Far-Field Groundwater—Vapor-Phase Treatment 3-111
3.8.7 Far-Field Groundwater Thermal Treatment—Incineration 3-111
3.8.8 Off-site Treatment of Far-Field Groundwater 3-112
3.8.8.1 Off-Site Treatment of Far-Field Groundwater at a Commercial WWTP 3-112
3.8.8.2 Off-site Treatment of Far-Field Groundwater at the POTW 3-113
3.8.9 On-site Discharge of Far-Field Groundwater 3-114
3.8.9.1 Far-Field Groundwater On-site Injection Wells 3-114
3.8.9.2 Far-Field Groundwater On-site Injection Trenches 3-115
3.8.10 Off-site Discharge of Far-Field Groundwater 3-116
3.8.10.1 Off-site Discharge of Far-Field Groundwater to the POTW 3-116
3.8.10.2 Off-site Discharge of Far-Field Groundwater to Surface Water 3-116
3.8.10.3 Off-site Discharge of Far-Field Groundwater by Injection Wells 3-117
3.8.11 Summary of Far-Field Groundwater Technology Process Option Evaluation 3-117
3.9 Summary 3-118

CONTENTS
(Continued)

4.0 RESPONSE ALTERNATIVE SCREENING 4-1
4.1 Introduction 4-1
4.2 RAA Development 4-1
4.2.1 Overburden 4-2
4.2.2 DNAPL 4-3
4.2.3 Source Area Groundwater 4-4
4.2.4 Far-Field Groundwater 4-5
4.3 Alternative Descriptions 4-7
4.3.1 Overburden Alternative Descriptions 4-7
4.3.2 DNAPL Alternatives Descriptions 4-9
4.3.3 Source Area Groundwater Alternative Descriptions 4-10
4.3.4 Far-Field Groundwater Alternatives 4-12
4.4 Overburden Alternative Evaluation 4-13
4.4.1 Overburden Alternative 1 (OB1) 4-14
4.4.2 Overburden Alternative 2 (OB2) 4-14
4.4.3 Overburden Alternative 3 (OB3) 4-16
4.4.4 Overburden Alternative 4 (OB4) 4-17
4.4.5 Overburden Alternative 5 (OB5) 4-19
4.4.6 Overburden Alternative 6 (OB6) 4-21
4.4.7 Overburden Alternative 7 (OB7) 4-23
4.4.8 Overburden Alternative 8 (OB8) 4-25
4.4.9 Overburden Alternative 9 (OB9) 4-28
4.5 DNAPL Alternative Evaluation 4-29
4.5.1 DNAPL Alternative 1 (D1) 4-31
4.5.2 DNAPL Alternative 2 (D2) 4-31
4.5.3 DNAPL Alternative 3 (D3) 4-32
4.5.4 DNAPL Alternative 4 (D4) 4-34
4.5.5 DNAPL Alternative 5 (D5) 4-36
4.5.6 DNAPL Alternative 6 (D6) 4-38
4.5.7 DNAPL Alternative 7 (D7) 4-41

CONTENTS
(Continued)

4.6 Source Area Groundwater Alternative Evaluation 4-43
4.6.1 Source Area Groundwater Alternative 1 (SGW1) 4-43
4.6.2 Source Area Groundwater Alternative 2 (SGW2) 4-44
4.6.3 Source Area Groundwater Alternative 3 (SGW3) 4-45
4.6.4 Source Area Groundwater Alternative 4 (SGW4) 4-47
4.6.5 Source Area Groundwater Alternative 5 (SGW5) 4-48
4.6.6 Source Area Groundwater Alternative 6 (SGW6) 4-50
4.6.7 Source Area Groundwater Alternative 7 (SGW7) 4-51
4.6.8 Source Area Groundwater Alternative 8 (SGW8) 4-52
4.6.9 Source Area Groundwater Alternative 9 (SGW9) 4-54
4.6.10 Source Area Groundwater Alternative 10 (SGW10) 4-55
4.6.11 Source Area Groundwater Alternative 11 (SGW11) 4-57
4.6.12 Source Area Groundwater Alternative 12 (SGW12) 4-59
4.6.13 Source Area Groundwater Alternative 13 (SGW13) 4-62
4.6.14 Source Area Groundwater Alternative 14 (SGW14) 4-65
4.7 Far-Field Groundwater Alternative Evaluation 4-67
4.7.1 Far-Field Groundwater Alternative 1 (FGW1) 4-68
4.7.2 Far-Field Groundwater Alternative 2 (FGW2) 4-69
4.7.3 Far-Field Groundwater Alternative 3 (FGW3) 4-69
4.6.4 Far-Field Groundwater Alternative 4 (FGW4) 4-71
4.6.5 Far-Field Groundwater Alternative 5 (FGW5) 4-72
4.6.6 Far-Field Groundwater Alternative 6 (FGW6) 4-73
4.8 Summary of Media-specific Alternatives Evaluation 4-75

5.0 DETAILED ANALYSIS OF ALTERNATIVES 5-1
5.1 Introduction 5-1
5.1.1 Summary of Current Conditions 5-2
5.1.2 RAA Description 5-4
5.1.2.1 Alternative 1 5-5
5.1.2.2 Alternative 2 5-5
5.1.2.3 Alternative 3 5-5

CONTENTS
(Continued)

5.1.2.4 Alternative 4 5-6
5.1.2.5 Alternative 5 5-6
5.1.2.6 Alternative 6 5-7
5.1.2.7 Alternative 7 5-7
5.1.2.8 Alternative 8 5-8
5.1.2.9 Alternative 9 5-9
5.1.2.10 Alternative 10 5-9
5.1.2.11 Alternative 11 5-10
5.1.2.12 Alternative 12 5-11
5.1.2.13 Alternative 13 5-11
5.1.3 Evaluation Criteria 5-12
5.1.3.1 Overall Protection of Human Health and Environment 5-13
5.1.3.2 Compliance with ARARs 5-13
5.1.3.3 Long-term Effectiveness and Permanence 5-14
5.1.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment 5-14
5.1.3.5 Short-term Effectiveness 5-15
5.1.3.6 Implementability 5-15
5.1.3.7 Cost 5-16
5.1.3.8 State Acceptance 5-16
5.1.3.9 Community Acceptance 5-17
5.1.4 Comparative Evaluation of Alternatives 5-17
5.1.5 Analysis of RAAs Using Estimated Constituent Transport Rates 5-17
5.2 Detailed Evaluation Of Alternatives 5-17
5.2.1 Alternative 1 5-17
5.2.1.1 Description 5-17
5.2.1.2 Overall Protection of Human Health and Environment 5-18
5.2.1.3 Compliance with ARARs 5-19
5.2.1.4 Long-term Effectiveness and Permanence 5-21

CONTENTS
(Continued)

5.2.1.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-21
5.2.1.6 Short-term Effectiveness 5-22
5.2.1.7 Implementability 5-22
5.2.1.8 Cost 5-22
5.2.2 Alternative 2 5-22
5.2.2.1 Description 5-22
5.2.2.2 Overall Protection of Human Health and Environment 5-24
5.2.2.3 Compliance with ARARs 5-25
5.2.2.4 Long-term Effectiveness and Permanence 5-27
5.2.2.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-28
5.2.2.6 Short-term Effectiveness 5-29
5.2.2.7 Implementability 5-29
5.2.2.8 Cost 5-30
5.2.3 Alternative 3 5-30
5.2.3.1 Description 5-30
5.2.3.2 Overall Protection of Human Health and Environment 5-32
5.2.3.3 Compliance with ARARs 5-34
5.2.3.4 Long-term Effectiveness and Permanence 5-35
5.2.3.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-36
5.2.3.6 Short-term Effectiveness 5-37
5.2.3.7 Implementability 5-38
5.2.3.8 Cost 5-38
5.2.4 Alternative 4 5-39
5.2.4.1 Description 5-40
5.2.4.2 Overall Protection of Human Health and Environment 5-41
5.2.4.3 Compliance with ARARs 5-43

CONTENTS
(Continued)

5.2.4.4 Long-term Effectiveness and Permanence 5-44
5.2.4.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-46
5.2.4.6 Short-term Effectiveness 5-47
5.2.4.7 Implementability 5-48
5.2.4.8 Cost 5-48
5.2.5 Alternative 5 5-49
5.2.5.1 Description 5-49
5.2.5.2 Overall Protection of Human Health and Environment 5-52
5.2.5.3 Compliance with ARARs 5-53
5.2.5.4 Long-term Effectiveness and Permanence 5-55
5.2.5.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-56
5.2.5.6 Short-term Effectiveness 5-57
5.2.5.7 Implementability 5-57
5.2.5.8 Cost 5-58
5.2.6 Alternative 6 5-59
5.2.6.1 Description 5-59
5.2.6.2 Overall Protection of Human Health and Environment 5-62
5.2.6.3 Compliance with ARARs 5-63
5.2.6.4 Long-term Effectiveness and Permanence 5-64
5.2.6.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-65
5.2.6.6 Short-term Effectiveness 5-66
5.2.6.7 Implementability 5-67
5.2.6.8 Cost 5-67
5.2.7 Alternative 7 5-68
5.2.7.1 Description 5-68
5.2.7.2 Overall Protection of Human Health and Environment 5-71

CONTENTS
(Continued)

5.2.7.3 Compliance with ARARs 5-72
5.2.7.4 Long-term Effectiveness and Permanence 5-74
5.2.7.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-75
5.2.7.6 Short-term Effectiveness 5-76
5.2.7.7 Implementability 5-77
5.2.7.8 Cost 5-78
5.2.8 Alternative 8 5-79
5.2.8.1 Description 5-79
5.2.8.2 Overall Protection of Human Health and Environment 5-81
5.2.8.3 Compliance with ARARs 5-83
5.2.8.4 Long-term Effectiveness and Permanence 5-84
5.2.8.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-85
5.2.8.6 Short-term Effectiveness 5-86
5.2.8.7 Implementability 5-87
5.2.8.8 Cost 5-88
5.2.9 Alternative 9 5-89
5.2.9.1 Description 5-89
5.2.9.2 Overall Protection of Human Health and Environment 5-92
5.2.9.3 Compliance with ARARs 5-93
5.2.9.4 Long-term Effectiveness and Permanence 5-95
5.2.9.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-96
5.2.9.6 Short-term Effectiveness 5-97
5.2.9.7 Implementability 5-99
5.2.9.8 Cost 5-100
5.2.10 Alternative 10 5-101
5.2.10.1 Description 5-101

CONTENTS
(Continued)

5.2.10.2 Overall Protection of Human Health and Environment 5-104
5.2.10.3 Compliance with ARARs 5-105
5.2.10.4 Long-term Effectiveness and Permanence 5-107
5.2.10.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-108
5.2.10.6 Short-term Effectiveness 5-109
5.2.10.7 Implementability 5-110
5.2.10.8 Cost 5-111
5.2.11 Alternative 11 5-112
5.2.11.1 Description 5-112
5.2.11.2 Overall Protection of Human Health and Environment 5-115
5.2.11.3 Compliance with ARARs 5-116
5.2.11.4 Long-term Effectiveness and Permanence 5-118
5.2.11.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-119
5.2.11.6 Short-term Effectiveness 5-119
5.2.11.7 Implementability 5-120
5.2.11.8 Cost 5-121
5.2.12 Alternative 12 5-122
5.2.12.1 Description 5-122
5.2.12.2 Overall Protection of Human Health and Environment 5-126
5.2.12.3 Compliance with ARARs 5-127
5.2.12.4 Long-term Effectiveness and Permanence 5-128
5.2.12.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-130
5.2.12.6 Short-term Effectiveness 5-131
5.2.12.7 Implementability 5-132
5.2.12.8 Cost 5-134

CONTENTS
(Continued)

5.2.13 Alternative 13 5-135
5.2.13.1 Description 5-135
5.2.13.2 Overall Protection of Human Health and Environment 5-138
5.2.13.3 Compliance with ARARs 5-139
5.2.13.4 Long-term Effectiveness and Permanence 5-140
5.2.13.5 Reduction of Toxicity, Mobility, and Volume through Treatment 5-142
5.2.13.6 Short-term Effectiveness 5-143
5.2.13.7 Implementability 5-144
5.2.13.8 Cost 5-146
5.3 Comparative Evaluation Of Alternatives 5-147
5.3.1 Protection of Human Health and the Environment 5-147
5.3.2 Compliance with ARARs 5-148
5.3.3 Long-term Effectiveness and Permanence 5-149
5.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment 5-150
5.3.5 Short-term Effectiveness 5-151
5.3.6 Implementability 5-151
5.3.7 Cost 5-152
5.3.8 Summary 5-152

CONTENTS
(Continued)

FIGURES

Figure 1-1	Site Location Map
Figure 1-2	Local Topography
Figure 1-3	Remedial Action Elements at Necco Park
Figure 1-4	Grout Curtain Profile
Figure 1-5	Overburden Stratigraphic Cross Section
Figure 1-6	Bedrock Geology of Western New York
Figure 1-7	Stratigraphic Section of the Lockport Formation
Figure 1-8	Zone of High Transmissivity Location Map
Figure 1-9	Components of the NYPA Robert Moses Power Project
Figure 1-10	Regional Man-made Passageways and Upper Lockport Potentiometric Surface Contours
Figure 1-11	Geologic Cross Section
Figure 1-12	Piezometric Map: A Zone
Figure 1-13	Piezometric Map: B Zone, Unstressed Conditions
Figure 1-14	Post-Grout Curtain Conceptual Capture Zone: B Zone
Figure 1-15	Piezometric Map: C Zone, Unstressed Conditions
Figure 1-16	Post-Grout Curtain Conceptual Capture Zone: C Zone
Figure 1-17	Piezometric Map: D Zone, Unstressed Conditions
Figure 1-18	D Zone Conceptual Capture Zone
Figure 1-19	Piezometric Map: E Zone Unstressed Conditions
Figure 1-20	E Zone Conceptual Capture Zone
Figure 1-21	Piezometric Map: F Zone Unstressed Conditions
Figure 1-22	F Zone Conceptual Capture Zone
Figure 1-23	Piezometric Map: G Zone
Figure 1-24	Pre-Grout Curtain Conceptual Capture Zone: B Zone
Figure 1-25	Pre-Grout Curtain Conceptual Capture Zone: C Zone
Figure 1-26	Geological Cross Section to the NYPA Conduits

CONTENTS
(Continued)

Figure 1-27	Monitor Well Location Map
Figure 1-28	Source Area
Figure 1-29	A Zone Far-Field Extent
Figure 1-30	B Zone Far-Field Extent
Figure 1-31	C Zone Far-Field Extent
Figure 1-32	D Zone Far-Field Extent
Figure 1-33	E Zone Far-Field Extent
Figure 1-34	F Zone Far-Field Extent
Figure 1-35	G Zone Far-Field Extent
Figure 1-36	Monthly DNAPL Recovery Volumes, 1989 through 1993, Necco Park
Figure 1-37	Well RW-1 Pumping versus Monitor Well Concentrations
Figure 1-38	Well RW-1 Pumping versus Monitor Well Concentrations
Figure 1-39	Well RW-2 Pumping versus Monitor Well Concentrations
Figure 1-40	TVOC Concentrations through Time: B Zone Wells
Figure 1-41	TVOC Concentrations through Time: B Zone Wells
Figure 1-42	TVOC Concentrations through Time: C Zone Wells
Figure 1-43	TVOC Concentrations through Time: C Zone Wells
Figure 1-44	Actual versus Modeled Downgradient Concentrations
Figure 1-45	Comparison of Aquifer Cleanup Times for Natural Restoration and Active Remediation
Figure 3-1	Necco Park Alternative Development Process

TABLES

Table 1-1	Production and Extraction Wells in the Niagara Falls Area
Table 1-2	Necco Park Aqueous Indicator Parameter List
Table 1-3	DNAPL Components
Table 1-4	Zone-specific Off-site Loadings
Table 2-1	Potential Chemical-specific ARARs

CONTENTS
(Continued)

Table 2-2	Potential Location-specific ARARs
Table 2-3	Potential Action-specific ARARs and TBCs
Table 2-4	Chemical-specific ARARs and Acceptable Risk-based Concentrations for Groundwater
Table 2-5	Target Remediation Goals for Groundwater
Table 3-1	Overburden Technology Identification and Screening
Table 3-2	DNAPL Technology Identification and Screening
Table 3-3	Source Area Groundwater Technology Identification and Screening
Table 3-4	Far-Field Groundwater Technology Identification and Screening
Table 3-5	Summary of Technologies Retained
Table 3-6	Physical Characteristics of Necco Park Organic Constituents
Table 3-7	Overburden Process Option Evaluation
Table 3-8	DNAPL Process Option Evaluation
Table 3-9	Source Area Groundwater Process Option Evaluation
Table 3-10	Far-Field Groundwater Process Option Evaluation
Table 3-11	Summary of Process Options Retained
Table 4-1	Overburden Alternatives
Table 4-2	DNAPL Alternatives
Table 4-3	Source Area Groundwater Alternatives
Table 4-4	Far-Field Groundwater Alternatives
Table 4-5	Summary of Media-specific Alternative Screening
Table 5-1	Alternative Components
Table 5-2	Evaluation of Potential ARARs
Table 5-3	CECOS POTW Discharge Limits
Table 5-4	Summary of Alternative Evaluation
Table 5-5	Summary of Alternatives Comparison

CONTENTS
(Continued)

APPENDIX

Appendix A	Procedure for Estimating Loading Rates to the Far Field Area for Modeled Alternatives
Appendix B	Groundwater Flow and Solute Transport Modeling
Appendix C	Necco Park Source Area Definition
Appendix D	HELP Model Comparison
Appendix E	Cost Estimates
Appendix F	Cost per Constituent Loading Reduction Ratio Calculation
Appendix G	Glossary

EXECUTIVE SUMMARY

Introduction

This Analysis of Alternatives (AOA) report was prepared for the Necco Park site in Niagara Falls, New York, by DuPont, the site owner. The AOA was prepared pursuant to a September 28, 1989, Administrative Order on Consent (AOC) signed by DuPont and United States Environmental Protection Agency (EPA) and addresses requirements of Item H of the Statement of Work attached to the AOC.

Purpose of the AOA is to identify, develop, screen, and evaluate response action alternatives (RAAs) leading to a recommendation by EPA for an appropriate remedial action for Necco Park. The AOA was conducted in accordance with the AOA work plan and is based on information from *Necco Park Investigation Report* prepared for DuPont by Woodward-Clyde Consultants (WCC 1993) and previous studies undertaken by DuPont for the site.

Necco Park is a 24-acre site used for disposal of industrial wastes by DuPont from the mid-1930s to 1977, at which time the site was closed and remedial investigations initiated. Waste materials included building and plant debris, off-grade product, and solid and liquid production wastes. Necco Park is located in a heavily industrialized area and is bounded on three sides by commercial disposal facilities. Local topography is dominated by an adjacent sanitary landfill directly east and hazardous waste landfill cells directly south of the site.

Natural groundwater generally requires treatment prior to domestic use due to high mineral concentrations and hydrogen sulfide levels. Additionally, various industrial activities in the area unrelated to Necco Park have contaminated regional groundwater. Drinking water is provided by the city of Niagara Falls, drawn from abundant resources of the Niagara River. Installation of drinking-water wells is controlled by Niagara County. Groundwater flow at Necco Park is generally to the south in upper bedrock fracture zones and to the west in middle and lower fracture bedrock zones.

Response Actions to Date

DuPont has undertaken a number of response actions at Necco Park and has spent in excess of $40 million to date to investigate and control off-site contamination. Actions include capping the site to prevent contact with waste materials, source removal by DNAPL extraction from monitor and recovery wells, installation of a partial grout curtain to enhance the cone of influence from groundwater recovery operations, installation and operation of three groundwater recovery wells, and treatment of groundwater at a commercial wastewater treatment plant (WWTP).

The combined effects of Necco Park's upgradient grout curtain and pumping of two recovery wells completed in upper bedrock are believed to have resulted in substantial containment and control of groundwater in the source area in upper bedrock zones. This has resulted in the decline of contamination levels in most upper bedrock monitor wells located directly downgradient of the source area. Contaminant levels in seven of nine wells have decreased by over two orders of magnitude (99 percent decrease) from previous downgradient concentrations. Current contaminant concentrations in five of six downgradient wells have dropped to levels ranging from 10 to 385 micrograms per liter (µg/l), which are above target response goals based on maximum contaminant levels (MCLs). Although modeling indicates that natural flushing or removal of contaminants from bedrock fractures occurs rapidly in the Lockport Formation, chemical constituents may have diffused into bedrock matrix and may continue to act as a low-level source of contamination throughout areas downgradient of Necco Park. Therefore, complete source containment and/or downgradient pumping may not achieve MCLs in areas downgradient of Necco Park.

Groundwater flow is greatly influenced by New York Power Authority (NYPA) water transport conduits to the west of Necco Park and by local bedrock storm sewer tunnels. NYPA conduits are two parallel bedrock tunnels running from the Niagara River north to the Forebay Canal and Robert Moses Generating Stations. The conduits are surrounded by a drainage system in direct hydraulic connection with fracture zones that extend beneath Necco Park. Construction of the NYPA conduits caused a general lowering of water levels in the Lockport Formation and resulted in conversion of local residents to public water supplies as domestic wells dried up or natural water quality deteriorated due to high sulfide content of deeper groundwater.

Groundwater entering the NYPA conduit drainage system west of Necco Park is transported south to the intersection with Falls Street storm sewer tunnel. A portion of the groundwater in the NYPA drain system will enter the Falls Street tunnel along a 500-foot length where Falls Street tunnel and the conduits intersect. The city of Niagara Falls repaired the intersection of the Falls Street tunnel and the NYPA conduit drain system in an effort to reduce this hydraulic connection prior to rediversion of Falls Street tunnel flow to the Niagara Falls publicly owned treatment works (POTW) in 1993. However, the city's efforts to sever the hydraulic connection between the drain system and the Falls Street tunnel appears to have not been completely successful, and there remains a hydraulic connection between the two structures, resulting in discharge of a portion of the NYPA drain waters into the Falls Street tunnel (see page 1-21). Falls Street tunnel discharges to the Niagara Falls POTW, where water is treated prior to final discharge to the Niagara River.

The groundwater sink caused by the NYPA conduit drainage system and Falls Street tunnel storm sewer results in capture of a substantial portion of dissolved Necco Park constituents in groundwater, and diversion of a portion of constituents to the Niagara Falls POTW for treatment. The Niagara Falls POTW treats 100 percent of normal flow through the Falls Street tunnel and the majority of flow resulting from storm events.

In addition to these effects, it is estimated that loadings to the Niagara River have been reduced since 1982. On a site-specific basis, it is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both of the DuPont response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Response Action Objectives

A Risk Assessment report (TRC 1993) was prepared for EPA to evaluate potential risk posed by chemical constituents in environmental media at Necco Park. The quantitative groundwater risk assessment determined that groundwater contamination does not pose a current human health risk because no known exposure to groundwater occurs under current-use scenarios. A potential human health risk would exist if private drinking-water wells were installed downgradient of Necco Park. However, the city of Niagara Falls controls installation of wells, and abundant public water supply is currently available and provided to residents downgradient of the site. Additionally, the generally poor natural water quality, including poor color, odor, and taste, precludes installation of domestic wells without additional water treatment.

Sediment, surface water, and air at Necco Park were assessed and found to be insignificant contributors to health risk. Potential risk from volatilized compounds infiltrating basements was evaluated and found to not pose a risk to human health. Ecological risks were evaluated for aquatic biota in the Niagara River and Forebay Canal. Tissue concentrations were calculated to be several orders of magnitude below maximum fish flesh criteria to protect piscivorous wildlife.

Response action objectives (RAOs) were developed in negotiation between DuPont and EPA to consider protection of human health and environment and in recognition of regulatory requirements. While not dictated by risk to human health or environment, the following RAOs were established:

- Restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination
- Control of source material [dense nonaqueous-phase liquid (DNAPL) and contaminated soil] to minimize direct exposure and impact on groundwater quality

Several bedrock zones are impacted by DNAPL. The inability of current technology to recover more than small percentages of DNAPL from fractured rock or to restore groundwater to drinking-water quality in fractured bedrock zones containing DNAPL makes complete restoration of groundwater in those areas impossible.

Matrix diffusion of chemical constituents into fracture zones from the bedrock downgradient of Necco Park may be a secondary source of contamination. Field observations, modeling results, and published literature appear to suggest that restoration of groundwater to potable drinking water—as impacted by Necco Park constituents—may not be possible.

Development of Remedial Action Alternatives

General response actions (GRAs) were developed to satisfy, in part or in whole, RAOs for each identified media at Necco Park. Potentially applicable technologies were initially screened for each media based on technical implementability. Technology process options were then evaluated against the criteria of effectiveness, implementability, and cost.

Technology process options that survived screening and evaluation steps were combined to develop media-specific RAAs. Media-specific RAAs were evaluated and screened against effectiveness, implementability, and cost. The most promising media-specific RAAs were combined to form sitewide RAAs.

Consistent with EPA guidance, a no action alternative was developed for each media-specific RAA and was carried through the screening process for each media to provide a baseline for comparison purposes.

Detailed Analysis of Alternatives

Thirteen sitewide RAAs were developed from media-specific RAAs, including a no action alternative, as required by EPA guidance. Each RAA was evaluated against seven of the nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria. In all alternatives, downgradient areas (far field) were controlled by groundwater capture by NYPA conduit drainage system and a portion of the water treated by Niagara Falls POTW. One alternative included total groundwater recovery in the far field. A comparative analysis was completed to evaluate RAAs against each other for seven of the nine CERCLA criteria.

However, none of the alternatives may meet regulatory requirements due to the presence of DNAPL in fractured bedrock and potential effects of matrix diffusion. Far-field groundwater concentrations may continue to exceed target response goals for all alternatives assuming matrix diffusion.

1.0 INTRODUCTION

1.1 Overview

This Analysis of Alternatives (AOA) report was prepared by DuPont Environmental Remediation Services (DERS) pursuant to the September 28, 1989, Administrative Order on Consent [AOC; Index No. II, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-90221] signed by DuPont and United States Environmental Protection Agency (EPA). This report specifically addresses requirements of Item H of the Statement of Work attached to the consent order. Other investigative requirements of the Statement of Work were satisfied by the October 19, 1993, *Necco Park Investigation Report* prepared by Woodward-Clyde Consultants (WCC).

The AOA was conducted in accordance with DERS' August 5, 1993, *Analysis of Alternatives Work Plan* for Necco Park; CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA); and the EPA document entitled *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988).

The purpose of the AOA is to identify, develop, screen, and evaluate response action alternatives (RAAs) leading to a recommendation by EPA for an appropriate remedial action for Necco Park. The objective of the analysis is to provide information needed to determine an appropriate course of action to protect human health and environment.

This AOA report is comprised of six sections. Section 1.0 provides background information regarding site location, site description, site history, and nature and extent of contamination.

Section 2.0 presents response action objectives (RAOs) developed for Necco Park. RAOs address contaminants, media, and exposure pathways of interest and specify preliminary response goals (PRGs).

Section 3.0 presents general response actions (GRAs) developed for each media to attain RAOs. Technologies associated with GRAs are identified and screened on the basis of practical implementability, then process options for each GRA are further screened on the basis of implementability, effectiveness, and cost.

Section 4.0 presents media-specific RAAs developed by combining technologies identified as appropriate in the Section 3.0 screening process. These alternatives are evaluated using the same criteria of effectiveness, implementability, and cost. Media-specific alternatives offering attractive response potential are retained for developing sitewide alternatives and detailed evaluation.

Section 5.0 presents detailed descriptions of sitewide alternatives. An evaluation of each sitewide alternative is presented with respect to the following criteria:

- Overall protection of human health and environment
- Compliance with applicable, relevant, and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

A comparison of sitewide alternatives with respect to each criteria is also presented in Section 5.0. References for the AOA are presented in Section 6.0.

1.2 Site Location

Necco Park is located approximately 1.5 miles north of the Niagara River in a predominantly industrial area of Niagara Falls, New York. Necco Park is located off Niagara Falls Boulevard in the city of Niagara Falls (Lot 5 of Block 1) and the town of Niagara (Lot 1 of Block 2), New York (see Figure 1-1). Necco Park is located approximately ½ mile northwest of Interstate Highway I-190 at Niagara Falls Boulevard exit.

Necco Park is bounded on three sides by disposal facilities. Immediately north and east of the site lies the Newco solid waste landfill, an active Subtitle D facility owned by Browning-Ferris Industries (BFI). Immediately south of the site are three inactive hazardous waste landfill cells and a wastewater pretreatment facility owned by CECOS International, Inc. An access road and a Conrail (Niagara Junction Railway Company) right-of-way bounds the site to the west.

Land near Necco Park is almost exclusively zoned for commercial or industrial use. Several major manufacturing facilities are located within 1 mile of the site, and two manufacturers—Sigri Great Lakes Carbon and Carbide/Graphite Group (formerly Airco Carbon)—are 1,000 feet and 300 feet from the site, respectively. Nearest residential neighborhoods are located approximately 2,000 feet to the south and 2,500 feet to the west, respectively.

Several regional man-made passageways affect groundwater flow in the region. Falls Street tunnel, a storm sewer constructed in bedrock, is located approximately 2,400 feet southwest of the site and flows west to the city of Niagara Falls publicly owned treatment works (POTW). Two large (50-by-70-foot) New York Power Authority (NYPA) water conduits, located approximately 3,700 feet west of the site, divert water from the Niagara River north to the NYPA Forebay Canal and Robert Moses Generating Stations. The water conduits are surrounded by a drainage system designed to reduce hydrostatic pressures on the concrete tunnel linings. The drainage system is in direct hydraulic connection with the regional groundwater system. Construction of the NYPA caused a general lowering of water levels in the bedrock throughout the region and resulted in the conversion of local residents to public water supplies as local domestic wells dried up. The conduit drainage system continues to capture groundwater flow from the area, including Necco Park. Direct hydraulic connection also exists between NYPA conduits and Falls Street tunnel, resulting in discharge of conduit drainage waters into Falls Street tunnel, where the water is eventually discharged to the POTW for treatment.

Local topography at and around Necco Park has been modified significantly by landfill activities and industrial operations (see Figure 1-2). Prior to disposal activities at Necco Park, BFI, and CECOS, the average natural ground surface elevation was about 575 feet above mean sea level (MSL). The natural local land surface sloped to the southeast. The local topography is now dominated by a number of topographic highs at the BFI sanitary landfill directly east of the site and the CECOS secure hazardous waste landfill cells directly south of the site. Peak elevations of the BFI and CECOS landfills are approximately 665 feet and 630 feet above MSL, respectively.

In general, ground surface at Necco Park slopes from two topographic highs near the center of the landfill (peak elevations of 595 and 593 feet above MSL) to the edges of the site (average 580 feet above MSL). A system of drainage swales along the edges of Necco Park collects surface runoff from Necco Park and some portion of surface runoff from other nearby landfills.

1.3 Site Background

Necco Park is a 24-acre inactive industrial waste disposal site originally used as a recreational park by the Niagara Electrochemical Company (from which the name Necco is derived). DuPont purchased the site in 1930.

As part of initial investigations conducted at the site, an operational history for Necco Park from the mid-1930s to 1977 was developed based on DuPont records and an interpretation of historic aerial photographs. During that period, the site received a number of liquid and solid wastes generated from a variety of processes operated at the nearby DuPont Niagara Plant. These wastes included fly ash, sodium salts and cell bath residue (i.e., barium, calcium, and sodium chloride), cell and building rubble, chlorinolysis wastes, and off-grade products. Liquid wastes were generally disposed of in shallow earthen lagoons on the southeastern portion of the site; the remainder of the site functioned primarily as a solid waste landfill.

Specific knowledge of activities at Necco Park prior to 1964 is limited. The following wastes were disposed of in the largest quantities:

- Fly ash
- Building demolition and miscellaneous plant debris
- Sodium sludge waste salts, cell bath, and floor sweepings (i.e., barium, calcium, and sodium chloride)
- Sodium cell rubble (i.e., thermal brick, corroded steel)
- Polyvinyl acetate solids and stilling bottoms (i.e., vinyl acetate with high-boiling tars)
- Chlorinolysis wastes (i.e., high-boiling residues such as hexachlorobenzene, hexachlorobutadiene, and hexachloroethane)
- Liming residues [i.e., sludge saturated with tri- and tetrachloroethene (TCE and PCE)]
- Scrap organic mixtures, off-grade product
- Glycol polymer (*Terathane*®) scrap (i.e., filter press cloth, filter press sludge)
- Refined adiponitrile wastes (high-boiling residues)

Available evidence indicates that approximately 186 million pounds of liquid and solid industrial wastes were disposed of at the site. These wastes were reported to contain organic constituents such as carbon tetrachloride, chloroform, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, methylene chloride, PCE, and TCE.

In 1977, Necco Park was identified as a potential source of groundwater contamination, and disposal activities were promptly discontinued.

1.4 Previous Investigations

In February 1977, New York State requested that DuPont take action to correct groundwater contamination at Necco Park. The site was closed, and groundwater investigations were initiated in September 1977. Since that time, numerous investigations and remedial studies have been conducted. Preliminary investigations by Calspan (1978), Recra Research (1979), Roy F. Weston (1978, 1979, 1981, 1982), and WCC (1984) focused primarily on assessing conditions in the immediate vicinity of Necco Park and establishing a groundwater monitoring network.

A number of supplemental investigations and remedial studies needed to design and implement a remediation program were conducted from 1984 to 1988. An endangerment assessment (WCC 1985) was conducted to evaluate potential risks. This study concluded that no significant threat to human health and environment was anticipated to result from Necco Park groundwater contamination under continued use of existing public water supply system. EPA conducted a risk assessment for Necco Park in 1993 (see Section 2.1), concluding that groundwater contamination currently poses no risk since the entire city of Niagara Falls is supplied potable water by the existing public water-supply system (TRC 1993). However, the risk assessment also noted that groundwater contamination at Necco Park may pose a potential risk to human health in the future (TRC 1993). Potential future risks were based on the assumptions that a private well is installed as a potable water supply downgradient of the site, the current recovery well system is not operating, and all contaminants are attributable to Necco Park.

In January 1988, DuPont and EPA agreed to a Consent Decree (Civil Action No. 85-0626-E) that specified additional investigations, reporting requirements, and other legal issues pertaining to Necco Park. To expedite completion of the project, DuPont had begun work on Consent Decree investigations in July 1985. Descriptions of the investigations conducted to satisfy requirements of the Consent Decree and their results were presented in the *Necco Park Interpretive Report* (WCC 1991).

In September 1989, DuPont and EPA signed the current AOC. This order specified additional investigations beyond those pursuant to the 1988 Consent Decree. Descriptions of investigations required by the order and results were presented in the *Necco Park Investigation Report* (WCC 1993).

1.5 Previous Response Actions

Several response actions were implemented to mitigate the impact and spread of contamination. These remedial actions are identified in Figure 1-3 and are described as follows.

During 1978 and 1979, a clay cap was constructed over the 24-acre site. The final compacted cover consisted of a minimum of 18 inches of clay (Class SC and CL). Data collected from soil borings at the site indicate that the average cap thickness is approximately 24 inches (WCC 1993). The cap is overlain by a 6-inch cover of topsoil and grass.

In 1982, two existing monitor wells (D-12 and 52) were converted to recovery wells (RW-1 and RW-2) to control off-site migration of contaminated groundwater in the upper bedrock fracture zones (B and C zones). Extracted groundwater is pumped to a CECOS commercial wastewater treatment facility located adjacent to Necco Park where it is treated and discharged to the Niagara Falls POTW. Wells RW-1 and RW-2 have been used as recovery wells from 1982 to the present.

Under optimal conditions, wells RW-1 and RW-2 are pumped at an average rate of 10 to 15 gallons per minute (gpm) and 5 to 10 gpm, respectively. However, mechanical difficulties have occasionally curtailed continuous operation of well RW-2, particularly from early 1992 through 1993. Efforts to improve the system's operational efficiency, including pump and line replacement and construction of an automated acid addition system for well RW-2, were undertaken during this time period. Initial evaluations of the recovery well network's effectiveness indicated that continuous operation of the wells created a hydraulic barrier across the entire southern perimeter of the Necco Park property in the first two bedrock water-bearing zones, B and C zones (Weston 1982). However, after additional monitor wells were installed during subsequent investigations, a reevaluation of the recovery well system's effectiveness revealed that some off-site flow from these two zones was occurring, particularly along the eastern site boundary in C zone (WCC 1984). The primary influence of well RW-2 was observed in B zone, and the primary influence of well RW-1 was observed in C zone.

To enhance groundwater pumping system's effectiveness, a grout curtain, termed Subsurface Formation Repair (SFR), was constructed from July 1988 through September 1989 (during construction seasons). The SFR consisted of a single line of pressure-grouted borings, spaced 10 feet on center and installed, in general, from the top of the bedrock to a depth of 80 feet below grade (see Figure 1-4). The SFR extends along the entire western and northern perimeter of Necco Park and to just over one-half of the eastern perimeter. The southern perimeter and southern portion of the eastern perimeter were left ungrouted due to the possible presence of DNAPL and to allow for recovery of contamination that had migrated beyond the Necco Park boundary. To reduce potential for upgradient increase in the water-table elevation in the overburden, the upper 10 feet of bedrock were not grouted on the northern perimeter. The SFR was constructed using thick grout mixes, fine-grained grouting materials, and high-injection pressures.

Hydraulic impact of the SFR was evaluated by comparing hydraulic conditions prior to, and for several months following, grout curtain installation. The SFR *Interim Performance Report* (WCC 1990) concluded that the SFR was performing as designed. Cones of depression associated with wells RW-1 and RW-2, when operating continuously at rates comparable to pre-SFR, were found to have been enhanced, providing hydraulic influence extending throughout the southern boundary of Necco Park in B and C zones.

Data indicates that wells RW-1 and RW-2 and the SFR have been successful in reducing off-site migration of contamination in B and C zones. Contaminant concentrations in seven of nine monitor wells at the edge of the source area or downgradient of the source area have declined more than two orders of magnitude (99 percent reduction) since completion of the SFR. Total volatile organic compound (TVOC) concentrations have stabilized at levels between 10 and 385 micrograms per liter (µg/l) in five of six downgradient monitor wells. These data may be indicative of either incomplete containment of the source area by some small percentage or matrix diffusion. If observed concentrations are indicative of matrix diffusion, attainment of target response goals in the far-field may be limited. This will be further discussed in Section 1.9.

In 1992, a third recovery well, RW-3, was installed and began operation at Necco Park. Well RW-3 penetrates D, E, and F zones, is located at the center of the southern

Necco Park property line, and is pumped at an average rate of 3.5 to 4 gpm. When well RW-3 is pumped continuously, a shallow cone of depression extending throughout the central portions of the Necco Park property is observed in D, E, and F zones.

Annual groundwater sampling and analytical testing is conducted at 38 monitor wells on or near the Necco Park perimeter. Samples are analyzed for Necco Park indicator parameters and results are used to support development of the AOA and evaluation of remedial alternatives.

DuPont represents that they have expended considerable resources to address Necco Park. DuPont reports that, to date, approximately $40 million has been spent to isolate or control contamination at the Necco Park property. The following table summarizes response actions taken by DuPont at the Necco Park property.

Dates Implemented	Response Action
1977 to 1978	Close and cap landfill
1982 to 1987	Site investigation, groundwater collection system, and groundwater treatment
1988 to 1989	Continued operation of groundwater recovery and treatment system, initiate DNAPL recovery (6,000 gallons), site investigations, SFR (grout curtain)
1989 to 1992	Continued operation of groundwater recovery and treatment system, DNAPL recovery, addition of third recovery well
1993 to 1994	AOA report, continued groundwater recovery and treatment, DNAPL recovery

1.6 Regional Physiography

1.6.1 Regional Soil

Unconsolidated overburden material in the Niagara Falls area consists of glacially derived sand, silt, and clay and miscellaneous fill (Muller 1977). Natural unconsolidated overburden deposits—in ascending order from top of bedrock to top of grade—can be divided into the following three units (see Figure 1-5):

- Glacial till
- Glaciolacustrine sediment
- Recent alluvium

An areally extensive but relatively thin ground moraine comprised of silty clay to sandy till unconformably overlies bedrock in much of the Niagara Falls area. This till deposit corresponds to materials deposited during the Late Wisconsin glaciation in the western New York area. Ground moraine is normally marked by end moraines composed of similar materials and by sand and gravel deposited at ice-marginal environments or in glacial outwash plains. Near Necco Park, till characteristically consists of stiff red-brown clay with varying amounts of sand, silt, and gravel.

Overlying the till is usually a variable thickness of glaciolacustrine sediment consisting of sand, silt, and clay deposited as the continental ice sheets retreated northward 12,000 years ago. This sediment, commonly represented as varied silt and clay, was deposited in temporary lakes formed at the stagnant or retreating ice front (proglacial lakes). In the Niagara Falls area, this lacustrine sediment is associated with deposition in glacial Lake Tonawanda, a large postglacial lake formed on flatland between the Niagara and Onondaga Escarpments (Tesmer 1981). Although lacustrine deposits are relatively thin, they typically exceed the combined thickness of the till and alluvium deposits and, because of their thickness and fine-grained nature, act as aquitards to vertical groundwater movement.

A 1- to 2-foot thickness of recent alluvium and topsoil unconformably overlies the glaciolacustrine sediment in undisturbed areas. In the Niagara Falls area, sections of natural overburden have been removed, replaced with miscellaneous fill, or similarly disturbed by human activities.

1.6.2 Regional Bedrock Geology

The western New York region is underlain by a thick succession of Paleozoic sedimentary rocks that form the northern flank of the Allegheny Basin. These strata dip toward the south at a slope of approximately 29 feet per mile. As a result of this gentle dip and recent glacial erosion, bedrock exposure in western New York is expressed as broad east-west-trending bands parallel to the southern shore of Lake Ontario (see Figure 1-6). The Niagara Falls area is underlain by strata representing Ordovician and Silurian systems. The upper Ordovician, represented by the Queenston Formation, consists of a thick, laterally extensive, soft red-brown mudstone with minor sandstone beds. The Silurian system is represented, from oldest to youngest, by the Medina, Clinton, and Lockport Groups.

Topographically, the western New York region is relatively flat. The three most prominent topographic features in the area include the Niagara Gorge, Niagara Escarpment, and Onondaga Escarpment. The Niagara and Onondaga Escarpments coincide with exposures of two relatively resistant bedrock units, the Lockport Dolomite and Onondaga Limestone.

The Lockport Dolomite is Middle Silurian in age (415 million years). Throughout the Niagara Falls area, it consists of approximately 140 feet of relatively competent dolomite overlain by overburden. The Lockport Dolomite forms the caprock for Niagara Falls and Niagara Escarpment. The Lockport Formation is primarily dolomitic and characterized generally by a brownish gray to dark gray color, medium granularity, medium to thick bedding, stylolites, carbonaceous partings, vugs, and poorly preserved fossil remnants. It is divided into five principal members based on slight textural variations within this general description. The five members (Zenger 1965), from the top down, are

- Oak Orchard Member (80 to 120 feet thick).
- Eramosa Member (16 to 18 feet thick).
- Goat Island Member (19 to 25 feet thick).
- Gasport Member (15 to 30 feet thick).
- DeCew Member (8 to 10 feet thick).

A typical stratigraphic section of the Lockport Formation is presented in Figure 1-7. Underlying the DeCew Member of the Lockport Formation is the Rochester Shale Formation. The Rochester Shale is typically 55 to 65 feet thick in the Niagara Falls area and is described as a dark bluish to brownish gray, calcareous shale with occasional argillaceous limestone layers. The upper Rochester Shale tends to be more dolomitic than the lower, especially where it contacts the DeCew Member. This contact, although gradational at most locations, tends to be more abrupt and undulating in the Niagara Falls area. This has been attributed to localized channeling in the top of the Rochester Shale in the Niagara Falls area prior to deposition of the DeCew Member. The maximum depth of all hydrogeologic investigations at Necco Park was limited to the top 10 feet of the Rochester Shale.

1.6.3 Regional Structural Geology

The dominant structural feature in the Niagara area is a south-dipping homocline affecting Paleozoic rocks of western and southern New York. Bedding dips are characteristically gentle, on the order of 29 feet per mile in the Niagara region. Local deviations in the dominant regional structure have been attributed to monoclinal flexures and faulting.

A large-scale, tectonically related, structural system of lineaments has been suggested to affect the rocks of western Ontario and western New York. These lineaments are interpreted to be faults with displacements ranging from 10 to 100 feet. The faults, which are assumed to be related to basement structures, dissect the rock mass into blocks tilted by tectonic stress. These faults are believed to have been formed as early as 430 million years ago (during the early Silurian) and continue to be the loci of relatively minor, sporadic seismic activity.

Vertical fractures related to regional stress patterns are present in the Lockport Formation. Observations made during construction of the NYPA Robert Moses Power Project indicated that vertical joints were most frequently observed in the upper 20 or 30 feet of the Lockport Dolomite, where a high degree of weathering had occurred (Johnston 1964).

Where joints have been further opened through dissolutioning, they act as vertical and horizontal conduits of groundwater between bedding-plane fracture zones. The prominent sets of vertical joints in the Niagara Falls area are oriented N65°E and N30°W. Near the bedrock surface, joints tend to be open and well developed. However, they become relatively tight and poorly developed at depth. The frequency of vertical fractures may vary with depth between areas. Studies conducted by the United States Geological Survey (USGS; Yager and Kappel 1987) suggest that vertical fracture frequency increases along regional structural lineaments related to the large-scale structural pattern mentioned previously.

Horizontal fracture zones coincident with various bedding planes are distributed throughout the Lockport Formation. In the Niagara Falls area, bedding-plane fracture zones tend to be horizontally continuous and can be traced for several miles. Numerous investigations have illustrated that these horizontal bedding-plane fracture zones are primary pathways for groundwater movement through the Lockport Formation (Johnston 1964; Yager and Kappel 1987). The following factors contribute to formation of these bedding-plane fracture zones:

- Variations in lithology inherent with bedding planes, which facilitate differential responses to weathering, solutioning, and stress and strain factors
- Tectonic or isostatic rebound related stresses, which create breaks or fractures along zones of weakness
- Groundwater flow, which causes further opening of fractures through dissolutioning

1.6.4 Regional Hydrogeology

Groundwater in the Lockport Formation flows generally toward Niagara Gorge and the lower Niagara River. Niagara River downstream of Niagara Falls receives discharge from the bedrock groundwater flow system. Niagara River upstream of Niagara Falls acts as a groundwater recharge area. However, studies, including the regional groundwater assessment, demonstrate that the NYPA conduits and several sewers/tunnels act as regional groundwater sinks. Water levels in the Lockport Formation dropped throughout the region after construction of the conduits, resulting in the conversion of local residents to the use of public water supplies as domestic wells dried up or natural water quality deteriorated due to high sulfide content of the deeper groundwater. Groundwater entering the conduit drainage system near Necco Park discharges into Falls Street tunnel where these structures intersect. Falls Street tunnel discharges to the Niagara Falls POTW, where the effluent is treated.

Groundwater recharge in the upper Niagara River is enhanced by exposure of the bedrock surface immediately upstream of Niagara Falls where swift currents have removed the covering sediment. Other areas and hydrogeologic features that are believed to act as recharge areas include

- A relatively narrow zone characterized by high-yield wells, referred to as the zone of high transmissivity, extending from Niagara River near the DuPont and Olin Chemical plants to the northeast approximately six miles.
- The NYPA reservoir.
- Surface-water bodies such as Gill Creek.

Overburden materials in the region are dominated by fine-grained glaciolacustrine deposits and glacial tills. Hydraulic conductivities of these units are typically on the order of 1×10^{-7} centimeters per second [cm/sec; WCC/Conestoga Rovers Associates (CRA) 1992]. Therefore, groundwater flow in these units is restricted. A perched groundwater zone is sometimes observed in recent silty/sand alluvium that overlies fine-grained glacial deposits. Because of the thin nature of alluvium, the tendency for perched water to reside in topographic depressions, and generally flat topography, these perched water zones are often limited. Groundwater movement in these perched zones is influenced by coarse backfill materials placed around underground utilities, functioning as preferential pathways for groundwater flow. However, these effects are typically limited to areas directly adjacent to the utility. Although vertical flow of groundwater from overburden to bedrock does occur (particularly where natural overburden materials have been disturbed or removed), vertical flow rates are generally low and do not significantly impact the regional bedrock flow regime.

Groundwater flows horizontally and, to a lesser extent, vertically in the Lockport Formation. Horizontal flow occurs predominantly through bedding-plane fracture zones. These water-bearing bedding-plane fracture zones are primary conduits for groundwater flow through the Lockport Formation. The bedding-plane fracture zones have been found to be areally extensive and affect groundwater flow for distances of several miles. Seven relatively continuous water-bearing zones were identified during construction of the twin NYPA conduits (Johnston 1964). Vertical groundwater flow occurs through vertical joints sets, fractures, and faults created through stress relief during tectonic events and glacial rebound.

Vertical fracturing is most prevalent in the upper 30 feet of the Lockport Formation, where stress relief and solutioning have been most pronounced. Although vertical joints have been observed to be water bearing, groundwater flow through these vertical fractures is limited compared to horizontal flow through bedding-plane zones. The water-bearing capability of vertical fractures decreases strongly with depth. Horizontal bedding-plane fracture zones have been found to behave as separate and hydraulically distinct water-producing units (Yager and Kappel 1987). The underlying Rochester Shale generally acts as a confining layer and restricts further downward groundwater migration.

During the hydrogeologic study of the Lockport Formation for construction of the NYPA conduits (Johnston 1964), a relatively narrow zone containing high-yield wells was identified (see Figure 1-8). Yields as high as 2,000 gpm were recorded in this zone of high transmissivity, which extends from the Niagara River in the vicinity of the DuPont Niagara and Olin Chemicals plants to the northeast approximately six miles. Additional studies by the USGS suggest that this zone of high transmissivity is related to increased vertical fracturing. Increased vertical fracturing was observed where the NYPA conduits cross Royal Avenue (approximately 6,000 feet southwest of Necco Park). In this area, vertical fracturing was noted on both sides of the excavation during construction of the NYPA conduits (Johnston 1964). This fracturing resulted in frequent trench wall failures, and a high-yield well installed near Royal Avenue was pumped for over a month before dewatering was achieved.

Groundwater sources are not used for domestic purposes in the Niagara region because of aquifer yield and water quality issues with the Lockport Formation and close proximity to the large fresh water supply of the Niagara River. Groundwater obtained from the Lockport Formation often contains elevated sulfur and other mineral content and is not used as a potable water supply (WCC/CRA 1992). Upper zones of the Lockport Formation historically contained potable water supplies; however, approximately one-third of the wells in the Lockport Formation produced hydrogen sulfide, which gave a questionable odor and taste to the water (Johnston 1964). Concerns regarding aquifer yield have resulted from hydraulic effects of the NYPA conduits which have lowered water levels in the upper Lockport throughout the area. Remaining water resources drew from the deeper Lockport zones, which produced "black water." A public water supply system was constructed coincident with the NYPA conduits to provide a suitable alternative and support growth throughout the county. Control restrictions are placed on the drilling of new wells by the city of Niagara Falls. No known domestic wells are present in the area at this time. Other than the previously mentioned northeast-trending zone of high transmissivity, the Lockport Formation is considered a minor aquifer, with well yields on the order of 50 gpm or less. Groundwater withdrawals from the Lockport Formation in the Niagara Falls area are limited to industrial cooling water use or for groundwater remediation purposes.

The regional groundwater quality of the Lockport Formation has been heavily affected by industrial sources of contamination. In addition to Necco Park, eight major sites have been identified as contributing to groundwater contamination in the region. To address this contamination and chemical loadings to the Niagara River, a Four-Party Agreement was signed in 1987. The four parties [Environment Canada, EPA, Ontario Ministry of the Environment, and New York State Department of Environmental Conservation (NYSDEC)] committed to reducing by 50 percent toxic loadings entering the Niagara River by 1996. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW. Details are provided in the following subsections.

1.6.4.1 Man-made Passageway Capture Zones

Groundwater flow in the bedrock regime is greatly influenced by a number of man-made features. These include water transport and storage structures related to the NYPA Robert Moses Power Project, several sewers and tunnels excavated into bedrock and the overburden, bedrock grouting, and groundwater extraction. Each of these features has varying effects on regional and near-site groundwater flow.

Completed in the early 1960s, the NYPA Robert Moses Power Project water diversion and storage structures have a great influence on regional groundwater flow. Components having the greatest effect are the NYPA conduits, which transport water north to the Robert Moses Power Generating Stations; the Forebay Canal, an L-shaped excavation linking the conduits to the generating stations; and the storage reservoir, a 2.97-square-mile surface impoundment east of the Forebay Canal (see Figure 1-9).

The NYPA conduits consist of twin buried tunnels of poured concrete constructed in parallel trenches 52 feet wide. The depth of the NYPA conduits varies between 100 feet (at the intake structures) and 160 feet (near the Forebay Canal) below ground surface, well into bedrock. Each conduit is jacketed by a drain system designed to balance hydrostatic pressure on the conduit walls. The drain system is comprised of 6-inch vertical drains placed every 10 feet along both sides of the conduit; these drain into a continuous system of floor drains along the length of the conduits. The drain system jacket is hydraulically connected to the conduit structures at two locations. Each location uses weirs to balance hydraulic head in the NYPA conduits and surrounding jacket. A portion of the groundwater (or conduit water) that collects in the drain system west of Necco Park discharges to the Falls Street tunnel through bedrock fractures. This water is treated at the Niagara Falls POTW prior to discharge to the Niagara River.

Based on all available data, all but a small percentage of groundwater leaving Necco Park flows either into Falls Street tunnel (B and C zones or upper Lockport) or into the NYPA conduit drain system (D through G zones). A portion of the groundwater that collects in the drain system west of Necco Park discharges to the Falls Street tunnel through bedrock fractures and then to treatment at the POTW. Studies of regional groundwater flow in the Niagara Falls area by the USGS indicate that the conduit drain system acts as a line discharge for groundwater in the upper Lockport Formation along its entire length (Miller and Kappel 1987). Groundwater in the upper Lockport Formation both east and west of the conduit flows toward the conduits and into the conduit drain system. This is further discussed in Section 1.7.3.

The Forebay Canal is an unlined excavation into bedrock approximately 4,000 feet long, 500 feet wide, and 110 feet deep. The Forebay Canal excavation is generally limited to the Lockport Formation, but the east end (in the vicinity of the NYPA conduits) does penetrate Rochester Shale. Water enters the Forebay Canal through conduits, where it is either diverted to the Robert Moses Generating Station or to the reservoir, depending on the power generation schedule. Water levels in the Forebay Canal fluctuate daily based on the seasonal diversion schedule, power demand, and Niagara River flow rate. In general, from 8:00 AM to 4:00 PM (during peak power-demand periods), water is released from the reservoir to increase water levels in the Forebay Canal. During periods of low power demand, water is pumped from the Forebay Canal to the reservoir in anticipation of peak demand, thus lowering water levels in the Forebay Canal. Daily water levels in the Forebay Canal fluctuate as much as 25 feet during low flow conditions in the Niagara River, which occur during summer and fall. During the spring, when more water can be diverted from the Niagara River, daily water-level fluctuations in the Forebay Canal range from 5 to 10 feet.

The Forebay Canal is in hydraulic communication with the conduit drain system through bedding-plane fracture zones exposed in the walls of the Forebay Canal. The Forebay Canal transmits hydraulic pressure changes from the Forebay Canal southward. USGS studies have concluded that water-level fluctuations in the Forebay Canal have been observed to cause near-instantaneous water-level changes in wells along the conduits as far as 3.4 miles down-conduit and in wells as far as 0.5 miles on either side of the conduits (Miller and Kappel 1987).

The NYPA reservoir covers approximately 3 square miles and can store 19.5 billion gallons of water behind a 55-foot-high containment dike. The floor of the reservoir is the exposed bedrock surface. Although a bedrock grout curtain was constructed around the entire edge of the reservoir to reduce leakage, the reservoir is a regional source of groundwater recharge for the Lockport Formation. Water-level fluctuations in the reservoir have only a minor effect on surrounding bedrock groundwater elevations.

Falls Street tunnel also has a great influence on bedrock groundwater flow in the Niagara Falls area. A gravity-fed sewer constructed in the early 1900s, it extends 16,000 feet from 56th Street and John Street to the lower Niagara River near the Rainbow Bridge (see Figure 1-10). For most of its length, it is an unlined rock tunnel. Used as a combined sewer for decades, in 1985 it was converted to a storm sewer.

Where the Falls Street tunnel crosses the NYPA conduits, it is a 500-foot Section of 84-inch-diameter concrete pipe, 300 feet of which is encased in a concrete vault. A study conducted in 1987 by the city of Niagara Falls identified the 500-foot section of the Falls Street tunnel where it crosses the conduits as the major groundwater discharge location for an 11-square-mile area, the north/south axis of which coincides with the NYPA conduits (O'Brien and Gere Engineers et al. 1987). Regional hydraulic effects of the Falls Street tunnel were also evaluated by the USGS in 1989 and 1990 (Kappel 1995a). A total of five synoptic water-level measurement rounds were conducted between October 1984 and June 1990 to investigate the effect of the Falls Street tunnel and NYPA conduit drain system on regional flow. Potentiometric surface contours for a measurement round conducted between October 30 and November 3, 1989, are presented in Figure 1-10 (Kappel 1995b). Approximately 8.8 million gallons per day (mgd) of infiltration, representing 75 percent of normal dry-weather flow of the tunnel, was estimated to enter the tunnel in the 500-foot section that passes over the NYPA conduits. As a result, the Falls Street tunnel was repaired in 1989. Studies subsequent to these repairs indicated that groundwater levels in the vicinity of the Falls Street tunnel/NYPA conduit section have risen on the order of 5 feet, but that this rise in water levels has not eliminated the Falls Street tunnel and NYPA conduits as line sinks for regional shallow bedrock groundwater flow. Current estimates are that 4 to 5 mgd of infiltration enter the Falls Street tunnel in the vicinity of Falls Street tunnel/NYPA conduits intersection (Kappel 1995a).

In support of toxic loadings reduction to the Niagara River of the Four-Party Agreement, Falls Street tunnel was connected to the Niagara Falls POTW. Since 1992, all dry-weather flow and the majority of flow from storm events is directed to the POTW, where it is treated prior to discharging to the Niagara River. Approximately 95 percent of the total flow carried by the tunnel is treated by the POTW, based on discussions with POTW personnel. The balance bypasses the plant to the Niagara River during peak storm events. Chemical analyses indicated that infiltration at Falls Street tunnel/NYPA conduit crossing accounted for approximately 28 pounds per day (lbs/day) of total volatile organic loadings, approximately 85 percent of loadings from the Falls Street tunnel treated by the POTW prior to repairs.

In addition to Falls Street tunnel, a number of other tunnels and sewers affect groundwater flow in bedrock. These include John Street sewer and New Road tunnel. In general, these tunnels and sewers act as line sinks for groundwater. Their influence is generally limited to the area immediately adjacent to the tunnel or sewer.

New Road tunnel extends from a location slightly north of Porter Avenue and connects to Falls Street tunnel at 47th Street (see Figure 1-10). From

Porter Avenue to Falls Street tunnel, New Road tunnel consists of a 5-by-6-foot unlined tunnel in the bedrock. An investigation of the Frontier Chemicals site at the section of Royal Avenue and 47th Street indicated that New Road tunnel and Falls Street tunnel act as sinks for the upper Lockport Formation in that area, causing a lowering of water levels in the upper Lockport Formation in the vicinity of the tunnels.

John Street sewer extends from 66th Street west to the intersection of John Street and 56th Street, where it connects to Falls Street tunnel. The sewer is a 42-inch concrete pipe throughout its entire 3,280-foot length. Available information on John Street sewer indicates that, although it closely follows the bedrock surface, the entire length of the sewer is located in overburden.

Hydrologic investigations of other sites influenced by the Falls Street tunnel and regional work by the USGS (Kappel 1995b) have shown that a regional flow divide exists along the east-west trending Falls Street tunnel/John Avenue sewer system in the upper Lockport. The upper Lockport includes water-producing fracture zones in approximately the upper 30 feet of the Lockport Dolomite (Kappel 1995a). This corresponds to the B and C zones at Necco Park. Groundwater flows to the south in B and C zones within the Necco Park study area, which is located north of the Falls Street tunnel/John Avenue sewer system. Investigations at Occidental Chemicals Buffalo Avenue plant indicate that groundwater flow in the upper Lockport south of the Falls Street tunnel and John Avenue sewer is to the north/northwest toward the Falls Street tunnel (CRA 1993). Based on this data, the east/west trending Falls Street tunnel/John Avenue sewer system acts as a regional flow divide. Although the Falls Street tunnel does begin at a point south of Necco Park and flow in the Necco study area is to the south, the hydraulic influence of the Falls Street tunnel, as indicated in the USGS regional study, extends some distance east of the Falls Street tunnel/John Street sewer intersection (see Figure 1-10). Therefore, although insufficient information is available to determine the exact flow path, all but a small percentage of B and C zone groundwater ultimately discharges to the Falls Street tunnel and can not flow any further south than Johns Street sewer. Capture of all but a small percentage of flow in the B and C zones by the Falls Street tunnel is consistent with statements regarding capture of off-site flow for the adjacent BFI/CECOS site (USEPA/NYSDEC 1994, 1995).

Throughout the Niagara Falls area, a number of industrial facilities pump groundwater from the Lockport Formation for industrial purposes and for groundwater remediation programs. Companies that operate various production and/or recovery wells include DuPont, Olin Corporation, Occidental Chemical, and BFI/CECOS International. A summary of production and extraction wells for these industries is provided in Table 1-1. Although operation of these production and/or recovery wells is integral to a given facility's process capabilities or a designed remediation system, the extent of capture zones is relatively localized compared to the regional groundwater flow system. Numerous recovery well systems are evidence of the widespread industrial contamination of the Lockport Formation throughout the area.

At several locations in the Niagara Falls area—most of which are associated with the NYPA Robert Moses Power Project—grout curtain walls have been constructed to form barriers to groundwater flow. The purpose of these grout curtains is to limit loss of groundwater through infiltration into bedrock, reduce hydrostatic pressure, and enhance groundwater containment. Grout curtain walls were constructed adjacent to the NYPA reservoir, the NYPA intakes/conduits, the NYPA Forebay Canal, and the Necco Park groundwater recovery system. All of these grout curtains generally have a localized effect on bedrock groundwater.

1.6.5 Regional Hydrology

The Niagara River is the dominant regional surface-water body. The Niagara River drains the relatively small Erie basin as well as Lakes Erie, Superior, Huron, and Michigan. The Niagara River flows 34 miles north from Lake Erie to Lake Ontario. Over its length, a precipitous 326-foot drop in elevation occurs; 167 feet of that drop occur at the Horseshoe and American Falls. While flow in the Niagara River is approximately 202,000 cubic feet per second (cfs) upstream of the falls, withdrawals for production of hydroelectric power by the NYPA Robert Moses Power Project and the Canadian Sir Adam Beck Power Project lower the flow to only 50,000 to 100,000 cfs at the Horseshoe and American Falls. The flow over Niagara Falls is controlled by a diversion schedule stipulated in the Treaty of 1950 between Canada and the United States.

The 7.1-mile-long Niagara Gorge, formed over the past 12,000 years as the falls eroded upstream, extends south from Niagara Escarpment. Other surface-water bodies in the area include man-made hydroelectric power reservoirs in Canada and the United States and Gill Creek, a small creek that flows south from the NYPA reservoir through the city of Niagara Falls to the Niagara River. Natural flow in Gill Creek is supplemented by a 1.6 mgd discharge from the NYPA reservoir, generally during the May through October water withdrawal schedule.

1.7 Site Physiography

Three geologic units exist beneath the Necco Park site. These units include unconsolidated overburden, Lockport Formation, and Rochester Shale Formation.

1.7.1 Site Soil

Overburden at Necco Park consists of natural and man-emplaced materials. Much of the natural overburden at Necco Park has been disturbed or removed as a consequence of disposal activities. Fill has replaced much of the natural overburden.

Natural overburden materials in the area surrounding Necco Park consist of two primary units: glaciolacustrine and glacial till. Glaciolacustrine deposits are further subdivided into two subunits. The lower glaciolacustrine unit consists primarily of compacted clay with fine silt interbeds or varves. The upper glaciolacustrine unit typically consists of an orange to yellow clayey sandy silt. The interface between the lower and upper glaciolacustrine subunits is often the site of perched water generally 1 to 1.5 feet thick.

Glacial till lies beneath the glaciolacustrine units and is typically composed of a red, silty to gravelly clay. The contact between the till and the lower glaciolacustrine unit is identified by the presence of sand and gravel intermixed with clay materials. Large boulders were encountered sporadically a few feet above the top of bedrock during drilling operations.

Overburden thicknesses vary considerably within the boundaries of Necco Park. Thicknesses range from less than 2 feet in the southwest to greater than 22 feet in the southeast. Because topography in the area is relatively flat, thickening of the overburden reflects the gradual dip of the bedrock surface.

1.7.2 Site Bedrock Geology

The Lockport Formation underlies unconsolidated overburden deposits (see Figure 1-11). In general, top of bedrock is relatively unweathered. The Lockport Formation within the study area ranged in thickness from 142 to 151 feet. Site lithologic descriptions generally match those for the region. Five key marker horizons, which provide reliable indications of bedding orientation and stratigraphic position, were identified within the Lockport Formation during previous investigations. They include an oolite bed in the Oak Orchard Member, top of the Eramosa Member, top of the Goat Island Member, and top of the DeCew Member.

The top of the Rochester Shale Formation serves as a fifth marker horizon. Rochester Shale consists predominantly of a dark gray to gray-blue dolomitic shale. The contact between Lockport Formation and Rochester Shale varied from gradational to relatively abrupt. These variations have been attributed to localized channelization shortly after deposition.

1.7.3 Site Hydrogeology

A series of horizontal bedding-plane fracture zones in the Lockport Formation similar to those described for the region has been delineated at Necco Park. Groundwater beneath Necco Park flows in overburden under unconfined conditions and in the separate, fairly continuous bedding-plane fracture zones in dolomite bedrock of the Lockport Formation under confined conditions. These fracture zones behave as separate and hydraulically distinct water-producing units (Yager and Kappel 1987). Letter designations were assigned to these principal water-bearing zones as follows: A zone refers to saturated overburden and B, C, CD, D, E, F, and G zones refer to identified Lockport Formation bedding-plane fracture zones (see Figure 1-11). The interface between the DeCew Member of the Lockport Formation and Rochester Shale is defined as J zone.

The primary direction of horizontal groundwater flow within each fracture was determined using piezometric surface maps (WCC 1991; 1993). Groundwater in B and C zones generally flows to the south in areas beyond the radius of influence of the operational recovery well system. Hydrologic investigations of sites in the vicinity of the NYPA conduit/Falls Street tunnel intersection (CRA 1993) and regional investigations by the USGS (Kappel 1995b) have shown that a regional flow divide exists along the east-west trending Falls Street tunnel/John Avenue sewer system in the upper Lockport. The upper Lockport, which includes water-producing fracture zones in approximately the upper 30 feet of the Lockport Dolomite (Kappel 1995a), corresponds to the B and C zones at Necco Park. Although the Falls Street tunnel does begin at a point south of Necco Park and flow in the Necco study area is to the south, the hydraulic influence of the Falls Street tunnel, as indicated in the USGS regional study, extends some distance east of the Falls Street tunnel/John Street sewer intersection (see Figure 1-10). Therefore, although insufficient information is available to determine the exact flow path, all but a small percentage of B and C zone groundwater ultimately discharges to the Falls Street tunnel and cannot flow any further south than Johns Street sewer . Capture of all but a small percentage of flow in the B and C zones by the Falls Street tunnel is consistent with statements regarding capture of off-site flow for the adjacent BFI/CECOS site (USEPA/NYSDEC 1994, 1995). Groundwater in D, E, F, and G zones generally flows in a westerly direction toward the NYPA power conduits.

Although extrapolation of the N55°E-N60°E trend of the previously mentioned zone of high transmissivity intersects Necco Park, the zone has not been observed within Necco Park. Rock core descriptions and hydraulic testing conducted during advancement of three angled bedrock coreholes confirmed that the major water-bearing capacity of the Lockport Dolomite in the Necco Park area is associated with the horizontal bedding-plane fracture zones. A narrow band of increased vertical fracturing was not identified and, although vertical fracturing was observed, it does not serve as a major water-bearing zone in the Necco Park vicinity (WCC 1993).

Overburden is defined as A zone. As a consequence of the low hydraulic conductivity (1×10^{-7} cm/sec) estimated for those areas of A zone where most liquid disposal occurred, groundwater in the overburden tends to flow vertically downward to the more transmissive bedrock units. A zone exhibits a small horizontal gradient from north to south, with a slight easterly component across the site (see Figure 1-12). When the recovery system is operated continuously at its optimum pumping rate, small depressions in the piezometric surface near recovery wells RW-1 and RW-2 are observed, resulting from downward leakage into bedrock water-bearing zones.

The uppermost water-producing bedding-plane fracture zone in the Lockport Formation within the study area is designated as B zone. It is generally observed approximately 4 feet below top of bedrock and 10 feet above C zone. B zone usually occurs within a 3-foot interval centered on a relatively porous oolite bed and dips mainly southeast at an average angle of 0.6 degrees. Projection of B zone to the northwest suggests that it subcrops in the vicinity of well cluster VH-156. Recharge of B zone most likely occurs at this subcrop area and through vertical fractures. It is probable that subcrop areas also exist for C through F fracture zones northwest of the study area because the Oak Orchard Member thins toward the Niagara Gorge.

B zone was not observed in the southeastern part of the site as a distinct water-producing fracture zone. However, the interval of rock corresponding to B zone in this area is not sufficiently impermeable to act as a complete barrier to groundwater flow. Groundwater in B zone generally flows from north to south under nonpumping conditions (see Figure 1-13). When recovery wells RW-1 and RW-2, which intersect B and C zones, are operating continuously at their respective optimal pumping rates of 15 and 10 gpm, cones of depression are created, which produce a zone of influence extending to near the eastern and western property lines of Necco Park (see Figure 1-14). This appears to indicate that most B zone groundwater at the Necco Park property is captured. All but a small percentage of groundwater not recovered by wells RW-1 and RW-2 eventually discharges to Falls Street tunnel and ultimately to the Niagara Falls POTW.

C zone generally occurs approximately 10 feet below B zone and 14 feet below top of bedrock. C zone dips to the southeast at an angle of approximately 0.7 degrees. As with B zone, C zone was not observed in the southeastern part of the site as a distinct water-producing zone, but it is not sufficiently impermeable to present a complete barrier to groundwater flow. Also as in B zone, groundwater flow in C zone is generally from north to south under nonpumping conditions (see Figure 1-15). When recovery wells RW-1 and RW-2, which intersect the B and C zones, are operating continuously at their optimal pumping rates of 15 and 10 gpm, cones of depression are created, which produce a zone of influence extending to near the eastern and western property lines of Necco Park. A conceptual capture zone can then be created (see Figure 1-16), which appears to indicate that most C zone groundwater at the Necco Park property is captured. The effects of recovery wells are best illustrated by comparing the piezometric maps for stressed and unstressed conditions (Figures 1-15 and 1-16).

CD zone occurs as a series of intermediate bedding-plane fracture zones between C and D fracture zones. In general, CD zone fractures are considered a single zone even though, in past investigations, several distinguishable fractures were noted. CD zone was encountered sporadically throughout the study area, most frequently in western portions of Necco Park. CD zone fractures are not areally extensive and are most likely discontinuous throughout the site. The fractures appear to serve as an intermediate groundwater flow pathway between C and D zones.

D zone generally occurs approximately 30 feet below C zone and 45 feet from top of bedrock. The zone dips at an angle of 0.7 degrees to the southeast. D zone is water producing in the northern half of the site, but generally not water producing in the southern half. Previous investigations indicate that D and E zones, which are typically separated by only 5 to 10 feet, may be hydraulically connected based on proximity and similar hydraulic heads. Groundwater in D zone flows west toward the NYPA conduit drain system under nonpumping conditions (see Figure 1-17). This groundwater is intercepted by the conduit drainage system where a portion of the water is discharged to the Falls Street tunnel. The ultimate discharge point for water in the Falls Street tunnel during dry-weather flow is the Niagara Falls POTW, where it is treated. When recovery well RW-3,—which intersects D, E, and F zones,—is operating continuously at its optimal pumping rate of approximately 4 gpm, a cone of depression is created which produces a zone of influence that extends throughout the south-central portions of Necco Park. A conceptual capture zone can then be created (see Figure 1-18), which appears to indicate that most D zone groundwater in the eastern half of the Necco Park property is captured.

E zone is usually observed approximately 5 to 10 feet below D zone and 50 to 55 feet below top of bedrock. The fracture zone dips to the southeast at an angle of 0.4 degrees. Although E zone was observed throughout a majority of the site, its occurrence as a water-producing zone tends to be locally discontinuous. As with the D zone, groundwater in E zone flows west toward the NYPA conduit drain system under nonpumping conditions (see Figure 1-19). Similar to the D zone, groundwater is intercepted by the conduit drainage system where a portion of the water is discharged to the Falls Street tunnel. The ultimate discharge point for water in the Falls Street tunnel during dry-weather flow is the Niagara Falls POTW, where it is treated. When recovery well RW-3, which intersects the D, E, and F zones, is operating continuously at its optimal pumping rate of 4 gpm, a cone of depression is created that produces a zone of influence extending throughout the south-central portions of Necco Park. A conceptual capture zone can then be created (see Figure 1-20), which appears to indicate that most E zone groundwater in the eastern portion of the Necco Park property is captured.

F zone occurs approximately 20 feet below D zone, 10 feet below E zone, and approximately 60 feet below top of bedrock. F zone dips toward the southeast at approximately 0.7 degrees. F zone has not been observed to be a water-producing zone in the southern part of the site. Similar to D and E zones, groundwater in F zone flows west toward the NYPA conduit drain system under nonpumping conditions (see Figure 1-21). Groundwater is intercepted by the conduit drainage system where a portion of the water discharges to the Falls Street tunnel. The ultimate discharge point for water in the Falls Street tunnel during dry-weather flow is the Niagara Falls POTW, where it is treated. When recovery well RW-3, which intersects the D, E, and F zones, is operating continuously at its optimal pumping rate of 4 gpm, a cone of depression is created, which produces a zone of influence that extends throughout the south-central portions of Necco Park. A conceptual capture zone can then be created (see Figure 1-22) which appears to indicate that most F zone groundwater in the eastern portion of the Necco Park property is captured.

G zone consists of three separate fracture zones (G_1, G_2, and G_3) between the bottom of the Oak Orchard Member and Rochester Shale. G_1 zone (Eramosa Member) is approximately 20 to 26 feet above G_2 zone and 74 to 80 feet below top of bedrock. It is not considered to be a major water-producing zone because it was only observed at two locations.

G_2 zone occurs most commonly in the lower Goat Island Member or upper Gasport Member approximately 100 feet below top of bedrock. Although G_2 zone was the most frequently observed of all G series fracture zones, its distribution is limited.

G_3 zone is most commonly observed in the upper to middle Gasport Member at a depth of approximately 115 feet below top of bedrock. Both G_2 and G_3 zones generally dip to the southeast at approximately 0.6 degrees. However, in the eastern part of the site, G_2 and G_3 zones appear to dip toward the north-northeast at approximately 0.3 degrees. G_3 zone is the deepest water-producing fracture zone encountered during Necco Park investigations. The piezometric map for G zone (see Figure 1-23) generally indicates that hydraulic gradients are very low. The primary flow direction appears to be west/northwest toward the groundwater discharge boundary at the NYPA conduits. However, some easterly components have been observed, usually during water-level fluctuations in the Forebay Canal.

J zone is defined as the interface between the DeCew Member of the Lockport Formation and Rochester Shale. DuPont and EPA agreed on a hydraulic conductivity criterion of 1×10^{-4} cm/sec in defining a fracture zone in the vicinity of a given well, as a water-bearing or nonwater-bearing interval [Consent Decree (Civil Action No. 85-0626E)]. J zone consistently exhibited very low hydraulic conductivity test results and limited loss of circulation fluid during drilling. For this reason, J zone does not appear to coincide with a major water-bearing fracture zone. Groundwater flow directions in J zone appear to be primarily to the west and south.

The SFR grout curtain was constructed at Necco Park in 1988 and 1989. It was designed to reduce the rate of bedrock groundwater flow beneath Necco Park from upgradient areas and enhance efficiency of on-site groundwater recovery operations. Recent data indicates that concentrations in seven of nine B and C zone monitor wells located downgradient of the Necco Park property have experienced decreases of two orders of magnitude in contaminant concentrations since completion of the SFR grout curtain. Conceptual capture zones prior to installation of the SFR did not appear to extend substantially past the Necco Park property (see Figures 1-24 and 1-25). Conceptual capture zones are depicted in these figures by what is interpreted from piezometric contours to be the area of influence of pumping wells. These conceptual capture zones depict the area of groundwater that may be captured by the pumping wells. As a result of grout curtain installation, it appears that cones of depression associated with recovery wells RW-1 and RW-2 have been enlarged under the same pumping rates. Current conceptual capture zones appear to have an estimated radius of influence that extends 500 to 1,000 feet to the south and west in B and C zones, inducing some contaminant recovery beyond the Necco Park property boundary (see Figures 1-14 and 1-16). Recovery well RW-3 was installed after grout curtain completion. Results of a well RW-3 pumping study indicate that consistent operation of recovery well RW-3 at its optimal pumping rate of 4 gpm causes drawdown in D, E, and F zones in the eastern portion of the Necco Park property. Conceptual capture zones resulting from these drawdowns are presented in Figures 1-18, 1-20, and 1-22 and demonstrate the conceptual zones before and after grout curtain installation.

Extrapolation of bedrock fracture zones beneath Necco Park to the west/northwest indicates that D through G zones intersect the NYPA conduit drain system (see Figure 26). Directly west of Necco Park, D through G_1 zones are exposed within the conduit excavation and are hydraulically connected to the drain system. Although G_2 and G_3 zones are not intersected by the conduit excavation directly west of Necco Park, both intersect the drain system to the northwest. Based on the southeastern dip of the fracture zones, G_2 zone intersects the conduit drain system south of Porter Road, and G_3 zone intersects the drain system between Porter Road and Lockport Road.

Regional flow studies conducted by the USGS have established that the NYPA conduit drain system acts as a groundwater discharge boundary for the upper Lockport Formation throughout its entire length (Miller and Kappel 1987). Because D through F zones are in direct communication with the NYPA conduits drain system, which intersects the dissolved constituents plume for each zone, most of the Necco Park impacted groundwater in these zones probably discharges to the drain system (Kappel 1995a). Comparison of hydraulic head distribution for each zone in the Necco Park study area and regional head observation by the USGS supports this interpretation. In D through F zones, head elevations are in the same range, with a distinct westerly gradient toward the conduits (see Figure 1-26). Although the gradient in G zone is not as pronounced, water levels in the Necco Park vicinity are also above those observed near the conduit drain system.

Based on available existing data, all but a small percentage of groundwater in D through G_2 zones that has been impacted by Necco Park will flow to the NYPA drain system. A portion of the flow in the drain system south of Porter Road is believed to discharge to Falls Street tunnel. Flow from G_3 zone also discharges to the drain system. However, the percentage of G_3 flow that is diverted south to Falls Street tunnel is not known. Contaminant loadings in the G_3 zone are estimated to be 1 to 2 percent of the total Necco Park contaminant loadings (see Appendix A).

The NYPA conduit drain system is hydraulically connected to the conduits at two pumping stations: one immediately south of the Robert Moses Generating Station Forebay (Pump Station B) and the other immediately south of Royal Avenue (Pump Station A). Each pumping station is equipped with a set of balancing weirs that allow water to flow into the drain system if the hydraulic head in the conduits exceeds the respective weir elevation. Because the drain system acts as a regional line sink, hydraulic heads in the drain system are consistently below those in the conduits. Therefore, no flow occurs from the drain system to the conduits (Kappel 1995a).

Piezometric levels are also affected by fluctuations in the NYPA water conveyance and storage systems (WCC 1988). Hydraulic head fluctuations are transmitted outward from the Forebay Canal and the NYPA conduit system to lower bedding-plane fracture zones of the Lockport Formation. Diurnal fluctuations were observed primarily in G and J zone wells near Necco Park. A range of response times was observed. Some wells responded quickly to Forebay Canal fluctuations, while others responded slowly over a period of several hours. The greatest fluctuations were observed in G zone, where 3-foot piezometric head changes were measured. While G zone gradient is typically west toward the NYPA conduits, several low hydraulic head measurements in eastern site wells in G zone indicate that a temporary easterly component to groundwater flow does occur. Fluctuations of less than 1 foot have been observed in F zone.

Other regional man-made passageways, including Falls Street tunnel, do not appear to produce any temporal fluctuations of groundwater levels at the site.

1.7.4 Site Hydrology

The surface drainage pattern in and around Necco Park has been considerably altered since the onset of landfill activities in the early 1930s. Prior to landfill operations, the area was fairly poorly drained farmland containing low, marshy areas and several intermittent swales carrying flow to the southeast. To improve drainage in the area, a storm sewer was installed in 1929 along what is presently 61st Street. The 61st Street storm sewer runs from Pine Avenue south to the Niagara River where it discharges. By 1951, drainage swales along the eastern border of Necco Park diverted water south to the 61st Street sewer. By 1966, a western drainage swale was installed from the southwestern edge of the CECOS secure cells to the southwest through the Niagara Mohawk easement and a Niagara Junction Railroad easement.

Presently, a system of drainage swales along the Necco Park border drains all surface-water flow from Necco Park to Pikes Creek, which discharges to the 47th Street combined sewer.

1.8 Nature And Extent of Contamination

Distinguishing between Necco Park related chemical constituents and contamination from surrounding industrial activity is very difficult because Necco Park is surrounded by sanitary and hazardous waste landfills, treatment units, and industries with known uncontrolled environmental releases. As part of the 1988 Consent Decree, a list of indicator parameters for Necco Park was identified. However, the listed chemicals are not necessarily site-specific to Necco Park. Other potential sources for most, if not all of these chemicals are located in the highly industrialized area of Niagara Falls east of the NYPA conduits. Therefore, presence of indicator parameters at points downgradient of Necco Park may not necessarily be the result of constituents originating solely from Necco Park. Table 1-2 presents the indicator parameters.

Overburden, bedrock, and groundwater at Necco Park have been impacted by past waste disposal activities. Available data indicated that approximately 186 million pounds of liquid and solid industrial waste were disposed of at the site. These wastes were reported to contain inorganic constituents (barium, calcium, and sodium chloride) and organic constituents such as carbon tetrachloride, chloroform, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, methylene chloride, PCE, and TCE. These wastes were disposed of and are present in overburden within the boundaries of Necco Park. Most groundwater contamination at the site is the result of dissolution of disposed chlorinated organic liquids. Dense nonaqueous-phase liquids (DNAPLs) have been observed and recovered from wells in and near the Necco Park property. Inorganic constituents disposed of at Necco Park are also present in groundwater.

Groundwater in and near Necco Park has been impacted by organic compounds, primarily chlorinated volatile and semivolatile organic compounds (SVOCs). Over 200 wells (both DuPont and non-DuPont) monitoring eight water-bearing zones have been installed in and near Necco Park since groundwater contamination was first suspected in 1977. Figure 1-27 shows the location of monitor wells installed at the site.

The evaluation of response alternatives is conducted for each affected medium at the site. Therefore, nature and extent of contamination is defined for impacted overburden, DNAPLs, and impacted groundwater. No other media associated with the site (air, sediment, or surface water) have been shown to be contaminated. Historical data, DNAPL occurrence in wells, chemical analyses of groundwater samples from wells, and groundwater flow and transport modeling have been used to define the nature and extent of contamination at and near the Necco Park property.

1.8.1 Overburden

Overburden media of concern is defined as natural soil and fill at the 24-acre Necco Park facility. Disposed materials within Necco Park are present in overburden and are currently covered with a clay cap. The site is managed as a closed facility. Therefore, materials and soil under the cap are a concern only in terms of their contribution to groundwater contamination. DNAPLs are present in overburden at Necco Park, and overburden groundwater has been impacted by disposed wastes.

1.8.2 Groundwater and DNAPLs

Studies of sites with chlorinated VOCs in groundwater clearly indicate that DNAPL constitutes a persistent, difficult-to-recover organic phase that can act as an aqueous contaminant source for long periods of time (EPA 1992). Waste disposal practices, nature of the wastes, presence of DNAPL, and complex site geology make it highly unlikely that areas impacted by DNAPL can be effectively restored to background ambient water-quality levels (EPA 1992; NRC 1994). DNAPL containment is presently recognized as the only viable remedial response action. Restoration of areas affected by aqueous contamination downgradient from DNAPL areas in fractured bedrock may be possible but is subject to significant uncertainty (NRC 1994).

Accordingly, two different groundwater areas have been defined for purposes of evaluating remedial options in remaining sections of the Necco Park AOA. According to EPA definitions (1992), impacted groundwater has been separated into two areas—a DNAPL zone (source area) and a dissolved contamination zone (far field area). The source area is defined by the presence or inferred presence of free-phase or residual DNAPL and includes both groundwater and DNAPL media. The far field is the area in which DNAPLs are not present and constituents are in the aqueous phase (i.e., dissolved in groundwater). The far-field extent was defined using a combination of data from existing monitor wells and transport modeling because existing wells in the far field do not entirely define the extent of contamination.

1.8.3 Source Area Definition

An area associated with Necco Park acting as a continuing source of constituent migration to the downgradient aqueous environment was identified. Adsorptive properties of DNAPL and its complex patterns of migration in fractured bedrock make defining areal extent of DNAPL extremely difficult. The primary criterion for defining the source area was the areal extent of free-phase or residual DNAPL. To be conservative, areas where aqueous constituent levels might theoretically indicate the presence of DNAPL were included using various solubility criteria. Solubility criteria used for this evaluation were presented in EPA publication 9355.4-07FS, *Estimating Potential of Occurrence of DNAPL at Superfund Sites* and in the works of Shiu (1988) and Feenstra, Mackay, and Cherry (1991).

Organic liquid was originally placed in overburden fill and has migrated, in part, into underlying bedrock. The Necco Park remedial investigation (RI) states that much DNAPL remains located in overburden. DNAPL has been observed in B through F bedrock fracture zones. Primary constituents of DNAPL at Necco Park are presented in Table 1-3. The density of DNAPL samples ranged from 1.61 grams per milliliter (g/ml) to 1.65 g/ml, with kinematic viscosity measurements ranging from 1.8 to 2.2 centistokes at approximately 20°C. Thus, DNAPL is slightly more resistant to flow than water.

Appendix C presents methodology and results of the source area definition analysis. Areas defined by both free-phase DNAPL areas and areas where aqueous concentrations may indicate the presence of DNAPL (i.e., solubility criteria were met) are defined as the source area. The Necco Park source area is presented in Figure 1-28. This area represents a composite where overburden (A zone) and water-bearing zones (B, C, D, E, F, and G) are considered. The actual source area for each individual zone is generally less than indicated in this figure. The distribution of DNAPL constituents hexachlorobutadiene, hexachloroethane, and hexachlorobenzene, which comprise 70 percent of DNAPL, is limited to this area. This provides additional evidence that the defined source area appropriately represents where free-phase or residual DNAPL may be located. This defined area is considered the source of the far-field aqueous plume for purposes of defining the far-field area. Soluble barium above maximum contaminant levels (MCLs) is also limited to the defined source area.

Existing monitor wells define the extent of the plume in A zone (see Figure 1-29). As discussed, A zone has very low hydraulic conductivity and groundwater flow is predominantly vertically downward to B zone. This is demonstrated by the limited horizontal TVOC migration in A zone. The extent of the dissolved plume in A zone is limited to the defined source area.

1.8.4 Far-Field Area Definition

To evaluate remedial alternatives for the far field, the extent of dissolved constituents must be defined. Although monitor wells exist downgradient of the defined source area, in some cases, these do not fully define the extent of dissolved contamination. As discussed in Section 1.7.3, a majority of groundwater flow downgradient of Necco Park is intercepted by the Falls Street tunnel in B and C zones while the D through G zones appear to be intercepted by the NYPA conduit drain system However, as constituents migrate downgradient from the source area, some horizontal spreading will occur by mechanical dispersion. Transport modeling was therefore conducted to supplement available monitor well data to estimate horizontal spreading in the far field.

TVOCs have been used in previous studies at Necco Park as the indicator parameter for defining the extent of impacted groundwater. Chlorinated organic constituents PCE, TCE, dichloroethene (DCE), vinyl chloride (VC), and chloroform represent the majority of VOCs present and behave similarly in the subsurface with respect to retardation and degradation. These dissolved VOCs result from dissolution and degradation of DNAPLs in the source area. Source area DNAPL contains appreciable amounts of SVOCs, such as hexachlorobutadiene. However, these SVOCs are much less soluble and have much higher distribution coefficients (i.e., they are not as mobile) than VOCs and have not been observed downgradient of the source area. Soluble barium above MCLs is also limited to the defined source area. Therefore, using TVOCs as the indicator parameter for defining the far field is appropriate.

The far-field aqueous plume is defined as the plume of dissolved TVOCs downgradient of the source area where DNAPL solubility criteria have not been met. Analytical data from monitor wells and transport modeling results have been used to define VOC extent in the far field. Appendix B provides a full discussion and details of modeling. Figures 1-29 through 1-35 show the estimated extent of dissolved contamination for A through G zones, respectively. TVOC concentrations in existing monitor wells from the second semiannual 1992 sampling event are posted on the figures except for C zone, where 1994 data is posted for off-site monitor wells because there have been TVOC decreases since 1992. For monitor wells used in the modeling, average concentrations are also posted. Far-field isopleths more closely reflect these average concentrations because they were used to calibrate the model. The far-field plume in B and C zones generally extends from the southern border of the source area south to Falls and Johns Street tunnels. The far-field plume in D through G zones originates at the western source area border and extends generally west to the NYPA conduits.

Existing monitor wells also define extent of the plume in B zone (see Figure 1-30). Hydraulic conductivity and groundwater velocity are relatively high in B zone, and migration beyond existing downgradient monitor wells would be expected. However, as discussed previously, two recovery wells (RW-1 and RW-2) completed in B and C zones have been operating since 1982 and appear to have halted significant migration of dissolved plume. This is further discussed in Section 1.9.2. A TVOC concentration of 68.1 µg/l was reported for well VH-154B during the second semiannual 1992 sampling round but was not used during generation of contours in Figure 1-30. This concentration was deemed anomalous because no VOCs were detected at well VH-154B prior to and following the second 1992 sampling round.

Figure 1-31 presents the extent of dissolved plume in C zone. The plume extends south to John Street tunnel. Wells RW-1 and RW-2 are also pumping groundwater from this zone. Recent data from wells VH-149C and VH-151C indicate that concentrations are declining significantly since installation of the SFR grout curtain, and the estimated far-field plume is at a much lower concentration than historic levels. Concentrations in well VH-151C during the last two sampling rounds have been less than 100 parts per billion (ppb), two orders of magnitude less than the previous average of 12,600 ppb, and may be representative of matrix diffusion limited equilibrium conditions. TVOC concentrations at well VH-147C were not used to generate contours presented in Figure 1-31. Because TVOCs have not been detected at well VH-148C, the concentration at well VH-147C may be the remnants of a plume redirected to the southwest during the period when substantial dewatering efforts were necessary to construct conduits in the vicinity of Royal Avenue. If this is the case, concentrations observed at well VH-147C may also be representative of matrix diffusion limited equilibrium conditions.

Far-field plumes in D through G zones extend to the NYPA conduits, as shown in Figures 1-32 to 1-35, respectively. Although well RW-3 is pumping from D through F zones, this well has not contained the source area in these zones. This has resulted in a plume that extends downgradient at concentrations on the same order of magnitude as source area concentrations. This is to be expected in fractured bedrock where groundwater velocities are relatively high. A TVOC concentration of 43,960 µg/l was reported for E zone well VH-155ER during the second semiannual 1992 sampling round. This concentration was deemed anomalous and was not used during generation of contours in Figure 1-33. VOC detections at well VH-155ER were consistently less than 10 µg/l for most sampling rounds conducted prior to and following the second semiannual 1992 sampling event.

TVOC off-site loadings at the source area boundary for each zone were calculated using groundwater flow rates from the calibrated *Modflow*® model and representative monitor wells at the defined source area boundary. Off-site loadings were used to evaluate response actions relative to each other. Table 1-4 summarizes off-site TVOC loadings, and details are presented in Appendix A. G zone contributes approximately 4 percent of total off-site TVOC loadings.

1.9 Effects of Response Actions

Response actions taken at Necco Park to date have resulted in partial capture of contaminant plumes in B and C zones south of the Necco Park property. Partial recovery of D through F zone constituents is achieved by well RW-3. When on-site groundwater recovery efforts are combined with the interception of far-field groundwater by the NYPA conduit drains in the D through G zones, and all but a small percentage of B and C zone far-field groundwater being intercepted by the Falls Street tunnel with subsequent treatment at the Niagara Falls POTW, it is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished. As presented in Table 1-4, mass loading reductions at the source area boundary as a result of response actions implemented at Necco Park are on the order of 40 to 45 percent (see Appendix A). Remaining loading reductions satisfying the Four-Party Agreement include flow from B and C zones, which is intercepted by the Falls Street tunnel, and a portion of flow in D through G zones, which is intercepted by the NYPA conduit drain system and discharged to the Falls Street tunnel.

Previous response actions at the site, including DNAPL recovery operations, operation of three recovery wells, and grout curtain installation, offer an excellent opportunity to develop a conceptualization of the groundwater system and provide confidence in predicting effects of possible future response actions. This section discusses effects of previous response actions and summarizes results of modeling that was conducted to understand effects of source area containment on the far-field aqueous plume.

DNAPL recovery efforts have resulted in removal of approximately 6,000 gallons from 1989 through 1994. Initially high recovery rates have steadily declined. Since 1992, DNAPL recovery rates have consistently been less than 50 gallons per month.

Groundwater recovery in B and C zones has been undertaken since 1982. Completion of the SFR grout curtain in 1989 has improved the conceptual capture zones of the two pumping wells. A decrease of two orders of magnitude (99 percent decline) in contaminant concentrations has been observed in seven of nine monitor wells downgradient of the Necco Park property. Concentrations in the far-field B and C zones fluctuate from 10 to 385 μg/l. These concentrations may be representative of matrix diffusion equilibrium conditions. In far-field groundwater, complete restoration to drinking-water standards is uncertain. If matrix diffusion is occurring, full restoration of far-field groundwater may be prevented even under the most aggressive source containment and far-field alternatives because the bedrock matrix may function as a secondary source of contamination in the far field.

1.9.1 DNAPL Recovery

DNAPL recovery efforts have removed approximately 6,000 gallons from 1989 through 1994. Total monthly DNAPL recovery volumes are presented in Figure 1-36. DNAPL recovery rates varied widely from April 1989 through December 1990, ranging from approximately 100 to 400 gallons per month. However, since that time, a fairly consistent drop in DNAPL recovery rates was observed. Since 1992, monthly DNAPL recovery rates have typically been less than 50 gallons. Investigations conducted from 1983 to 1993 have determined that southeastern portions of Necco Park have been most impacted by free-phase DNAPL (WCC 1983; 1993). A DNAPL recovery program was instituted in 1989 to remove free-phase DNAPL from monitor and recovery wells where recoverable quantities of DNAPL were observed historically.

Observations made during well installations and soil borings indicate that a majority of DNAPL is observed at the top of clay till or just above bedrock surface. In addition to the network of monitor/recovery wells used for DNAPL recovery, two pilot DNAPL recovery wells (PNRW-1 and PNRW-2) were installed to evaluate the feasibility of active DNAPL recovery in overburden. Recovery of DNAPL from well PNRW-1 and overburden monitor wells in the DNAPL recovery program demonstrate that DNAPL can be recovered from overburden, but recovery rates will be low, on the order of a few gallons a month. DNAPL accumulation rates are limited by the low conductivity of overburden materials.

DNAPL appears to slowly enter bedrock monitor wells from bedding-plane fractures. Where present, DNAPL appears to constitute a small volume compared to groundwater flowing within the fractures. Therefore, no significant DNAPL hydraulic head exists in fracture zones. Consequently, evacuation of DNAPL accumulated in the bottom of bedrock wells does not induce a DNAPL gradient in bedrock fractures and has little or no influence on DNAPL in the surrounding formation (WCC 1993). Therefore, the decline may also indicate a general volume reduction of DNAPL in that area of Necco Park.

To date, DNAPL has not been observed in recovery wells RW-1 or RW-3.

1.9.2 Groundwater Recovery

Concentrations in seven of nine B and C zone wells located at the edge of the source area or downgradient of the source area have declined by two orders of magnitude, resulting in a reduction of downgradient TVOC loadings since completion of the SFR grout curtain in 1989 (see Table 1-4 and Appendix A). Recovery wells RW-1 and RW-2 have been operating in B and C zones since 1982. As discussed in Section 1.7.3 and shown in Figures 1-14 and 1-16, operation of these wells and installation of the upgradient grout curtain have resulted in enhanced conceptual capture zones. Data from monitor wells downgradient of the conceptual capture zone demonstrates that pumping in the B and C zones has reduced far-field migration of dissolved contamination. Figures 1-37 through 1-39 present recovery well withdrawal rates over time superimposed over downgradient monitor well TVOC concentrations to support this conclusion. Figures 1-40 through 1-43 present TVOC concentrations through time for monitor wells in the B and C zones including all wells which are south, southeast, and southwest of the source area. This includes B zone wells C-83, VH-148B, VH-149B, and VH-150B and C zone wells VH-145C, VH-146C, VH-147C, VH-148C, VH-149C, VH-150C, and VH-151C. Also included are plots of TVOC concentration through time for VH-137B, a well located within the source area, and VH-152BC, a monitor well which is screened in multiple water producing zones.

Figure 1-37 shows the recovery rate of well RW-1 and demonstrates the large declines in contaminant concentrations in monitor wells VH-137B, VH-149B, and VH-150B over time. The recovery rates shown are three-month running averages. TVOC concentrations in well VH-137B, located 200 feet downgradient and within the conceptual capture zone of well RW-1, have declined from over 100,000 µg/l to less than 1,000 µg/l, a drop of over two orders of magnitudes. Through 1987, TVOC concentrations in well VH-149B, located approximately 1,000 feet downgradient and outside the conceptual capture zone of well RW-1, declined from over 4,000 to less than 200 μg/l. Since 1988, concentrations have ranged from approximately 20 to 60 μg/l, with no apparent trend. Concentrations in well VH-150B, located 700 feet downgradient and outside the conceptual capture zone of well RW-1, dropped from an initial concentration of almost 50,000 μg/l in 1987 to less than 100 μg/l in early 1989. Since that time, concentrations have ranged from 25 to 385 μg/l, with no apparent trend.

Figure 1-38 shows the recovery rate of well RW-1 and the large declines in TVOC concentration in downgradient monitor wells VH-146C and VH-149C over time. Recovery rates shown are three-month running averages. Through 1989, TVOC concentrations in well VH-146C, located approximately 800 feet downgradient and outside the conceptual capture zone of well RW-1, declined from approximately 12,000 to 4,000 μg/l. The upgradient grout curtain was completed in late 1989, which increased the conceptual capture area of well RW-1, although the pumping rates did not change significantly (see Figures 1-16 and 1-25). Since 1989, TVOC concentrations in well VH-146C have dropped from approximately 4,000 to 250 μg/l and have not exhibited the fluctuations that were observed before the SFR was installed. This represents a drop in TVOC concentration of almost two orders of magnitude over the monitoring period. Concentrations in well VH-149C, located 1,000 feet downgradient of well RW-1, were approximately 1,000 μg/l in 1986, but have since dropped to range between approximately 3 and 50 μg/l, with no apparent trend.

Figure 1-39 shows the recovery rate of well RW-2 and the large declines evidenced in TVOC concentrations in downgradient monitor wells VH-145C and VH-151C over time. Recovery rates shown are three-month running averages. Through 1989, TVOC concentrations in well VH-145C, located approximately 700 feet downgradient and just outside the conceptual capture zone of well RW-2, declined from approximately 80,000 to 40,000 μg/l. The upgradient grout curtain was completed in late 1989, which increased the conceptual capture area of well RW-2 (see Figures 1-16 and 1-25). Since then, TVOC concentrations in well VH-145C have steadily dropped from approximately 40,000 to 8,000 μg/l. Concentrations in well VH-151C, located approximately 1,500 feet downgradient of well RW-2, have been variable, but indicate an overall decline over time.

Over the last two years, concentrations have dropped from over 10,000 to less than 10 μg/l.

Figures 1-40 through 1-42 indicate that 9 of 13 wells examined display a reduction of TVOC concentrations with time. Wells VH-150C, VH-151C, and VH-152BC either have no discernible trend or display very low TVOC concentrations. Only one "side gradient" well (VH-147C) displays an increase in TVOC concentrations. Concentrations in seven of nine B and C zone wells located at the edge of the source area or downgradient of the source area have declined by two orders of magnitude including C-83, VH-148B, VH-149B, VH-150B, VH-145C, VH-146C, and VH-149C.

1.9.3 Groundwater Flow and Solute Transport in Fractured Media

The process of matrix diffusion in fractured bedrock may create a secondary source of low-level contamination that may continue to maintain concentration levels above target response goals for many years. Presence of high VOC concentrations in far-field bedrock fractures may have caused diffusion of constituents into the bedrock matrix. If the source of contamination is eliminated, the concentration gradient is reversed and the constituents will diffuse from bedrock into the clean water of the fractures, creating ongoing far-field contamination. Therefore, complete restoration of far-field groundwater to drinking water standards is uncertain. If matrix diffusion is occurring, full restoration of far-field groundwater may be prevented even under the most aggressive source containment and far-field alternatives, because the bedrock matrix may function as a secondary source of contamination in the far field.

Distribution of organic constituents in the far-field dissolved contamination can be explained based on an understanding of groundwater flow and contaminant transport at Necco Park. As discussed in Section 1.7.3, groundwater flow occurs primarily in bedding-plane fracture zones. Figure 1-11 presents a conceptual cross section of previously defined water-bearing zones (A through G zones) at the site. Contaminant transport in fractured bedrock is governed by advection, mechanical dispersion, molecular diffusion, and chemical and biological reactions. Advection is a major process in contaminant migration. Porosities in fractured rock can be small, but groundwater velocities can be several orders of magnitude above what is generally observed in granular porous media (Freeze and Cherry 1979). Relatively high groundwater velocities found in fractured rock are a major factor in contaminant migration.

Whereas molecular diffusion in granular media can often be ignored, in fractured bedrock, this process can have significant effects on transport where contaminants diffuse between the fracture and porous rock matrix (Freeze and Cherry 1979). This process is also referred to as matrix diffusion and is modeled as a dual-porosity system (i.e., the fracture and the matrix). As groundwater migrates through the fracture, a concentration gradient exists between contaminated fluid in the fracture and fluid in the porous rock matrix. Some chemical constituents will diffuse from the fracture into the matrix and, over time, the contamination will diffuse further into the matrix (Freeze and Cherry 1979). If the source of contamination is discontinued, the contaminant mass in the porous matrix will eventually diffuse back into the fracture openings as clean water moves through the fracture network, representing a long-term source of low-level contamination downgradient from the original contaminant source (Mutch et al. 1992). This is a primary reason that restoration of groundwater in fractured bedrock is subject to significant uncertainty (NRC 1994).

In fractured bedrock, contaminant migration through advection will be rapid and significant. Groundwater velocities are relatively high, and concentrations of dissolved TVOC similar to source area concentrations would be expected downgradient. This is evident in D through G zones, where monitor wells downgradient of the source area exhibit relatively high concentrations similar to those of the source area. Results of modeling sensitivity analysis (see Appendix B) show that downgradient concentrations will approach source area concentrations very quickly (less than one year) under any reasonable combination of input parameters. This is consistent with the modeling results presented in EPA's risk assessment (TRC 1993).

Although no data is available from downgradient wells in B and C zones before wells RW-1 and RW-2 began operating in 1982, TVOC concentrations of 50,000 to over 100,000 μg/l, similar to source area concentrations, would be expected in downgradient wells. Concentrations of this magnitude were observed in some of the downgradient wells (VH-137B, VH-150B, and VH-145C) in the earliest sampling events. Downgradient concentrations now are significantly lower and/or declining in most downgradient B and C zone wells compared to source area wells. This is a result of hydraulic influence of a majority of the source due to operation of wells RW-1 and RW-2.

In monitor wells downgradient of well RW-1, concentrations initially declined due to recovery well pumping, but concentrations appear to be leveling off (Figures 1-37 and 1-38). This may represent the diffusion of constituents out of the rock matrix. Operation of wells RW-1 and RW-2 has resulted in decreases in TVOC concentrations in several downgradient monitor wells, indicating that the recovery system has reduced migration of dissolved constituents.

Analytical transport modeling (see Appendix B) shows that containment of the source area will result in significant decreases in concentrations downgradient of the source area in very short periods of time (less than one year). However, downgradient concentrations will remain at residual levels that exceed target goals due to matrix diffusion. Results also show that, with some degree of source area leakage, far-field concentrations will remain whether or not matrix diffusion is occurring. Modeling and sensitivity analysis results presented in Appendix B demonstrate that, if matrix diffusion is not occurring, downgradient concentrations would be reduced to background levels in this time frame, even if retardation was occurring (discounting other industrial contaminant sources). This is shown in Figure 1-40, which presents actual and modeled concentration over time of a well 300 feet downgradient of the source area (well VH-150B) using parameters representing B zone. However, if matrix diffusion occurs, downgradient concentrations will decrease significantly in a short period but may still remain orders of magnitude above those that would be expected if no matrix diffusion is occurring (see Figure 1-40).

Modeling was also conducted to predict effects of partial source area containment (see Appendix B). Results indicate that even a very small degree of continuous source area leakage will result in downgradient concentrations above what would be expected under complete containment, as shown in Figure 1-40. Partial containment and matrix diffusion are the primary processes that will affect downgradient concentrations.

Figure 1-41 presents an example from Mutch et al. (1992) showing how matrix diffusion can significantly limit the ability of a pump-and-treat system to restore contaminated groundwater in fractured bedrock. After the contaminant source is removed, contaminants that previously diffused into the matrix then become a long-term source of contamination to fresh water moving through the fracture. Under natural flushing, concentrations decrease several orders of magnitude quickly but may asymptotically approach concentrations well above target levels. Pumping appears to accelerate aquifer cleanup compared to natural flushing but, as soon as pumping is stopped, concentrations rebound to near what would occur if no pumping had ever occurred. Even after 100 years of pumping, turning the pumps off results in contaminant concentrations rebounding to near that of nonpumping conditions.

Pumping decreases downgradient concentrations as more dilution of the constituents mass diffusing from the rock matrix occurs because of the faster groundwater flow rate. This effect is temporary because the mass leaving the matrix is limited by the diffusion coefficient and concentration gradient. Moving more water through the fracture essentially just dilutes this mass flux from the matrix to a greater degree. After pumping is halted, the flow rate is decreased and the mass flux from the matrix is less diluted, causing the concentration to rebound. Appendix B presents modeling that was conducted to demonstrate this for Necco Park. Pumping in the far field is unlikely to accomplish a restoration goal, as shown in Figure 1-41. Under these conditions, the National Research Council (1994) recommends that interim remedial objectives reflecting capabilities of current technologies be established.

Although effective source area containment can significantly reduce far-field concentrations, residual concentrations may be controlled by matrix diffusion, and far-field pumping may not effectively restore the aquifer. Modeling results presented in Appendix B may be interpreted as supporting this conclusion.

As demonstrated by the observed data and results of modeling presented in Appendix B, distinguishing between the effects of matrix diffusion and anything less than absolute 100 percent containment is difficult. Recovery well operational data and water-level measurements can significantly increase confidence of the demonstration of maintaining

100 percent containment, but some uncertainty will always be present in a fractured rock system. In any case, matrix diffusion may be a limiting process that may limit complete restoration of the far-field area.

2.0 RESPONSE ACTION OBJECTIVES

To develop and evaluate RAAs, objectives and goals of response actions need to be established. RAOs are developed to provide an appropriate level of protection for human health and environment. RAOs are based on constituents and media of interest, the conceptual model, exposure pathways and potential receptors, and possible target concentration goals for each constituent and media of interest. Target response goals are chemical-specific concentrations for each media based on ARARs or site-specific risk factors developed during the risk assessment. The conceptual model was developed in Section 1.0. This section discusses risk evaluation, ARARs, rationale behind establishing RAOs, target response goals, and media area and volumes.

2.1 Risk Evaluation

Protection of human health and environment is one of two types of "threshold" criteria for evaluating alternatives established by CERCLA. (The other "threshold" criteria—compliance with ARARs—is addressed in Section 2.2.) As provided by the National Contingency Plan (NCP), RAAs are evaluated to determine whether they adequately protect human health and environment—in both long and short term—from unacceptable risks, as defined by EPA, posed by hazardous substances, pollutants, or contaminants. To assess current and potential future risks at Necco Park, a risk assessment was conducted.

The July 29, 1993, *Final Risk Assessment* (TRC 1993) report prepared for the EPA by TRC Environmental Corporation qualitatively delineated potential risks associated with chemical constituents in various environmental media at Necco Park, including groundwater, soil, sediment, surface water, and air. A quantitative risk analysis of groundwater contamination was conducted. A quantitative risk analysis was also conducted for potential vapor infiltration into foundations and basements. A summary of TRC risk assessment conclusions is presented in sections that follow.

2.1.1 Human Health Risk

The quantitative groundwater risk assessment determined that groundwater contamination does not pose a current human health risk because no known exposure to groundwater occurs in the area of Necco Park under the current-use scenario. However, under the future groundwater use scenario (if groundwater would be used as a residential water supply), a significant potential human health risk would exist. This potential risk was calculated using a future baseline exposure scenario required by EPA methodology and the following conservative assumptions:

- Private drinking-water wells would be installed in residential neighborhoods (south and west) downgradient of Necco Park. (Public water supply currently serves these areas.)
- Existing containment and recovery wells have been permanently abandoned.
- Contaminants detected in wells beyond the property boundary are entirely attributable to past disposal activities at Necco Park. As described in Section 1.0 and the *Regional Groundwater Assessment Report* (WCC/CRA 1992), other potential sources of groundwater contamination are present in the region.

Using EPA's conservative assumptions, future risks associated with potential groundwater exposure pathways—which include residential ingestion, dermal contact, and inhalation during showering—exceed EPA's acceptable levels for both carcinogenic and noncarcinogenic risks. However, using current exposure scenarios, there is no risk. Volatile organic, semivolatile organic, and inorganic compounds all contribute to total risk. Constituents that contribute to total hypothetical exposure pathway risk are

- 1,1,2,2-tetrachloroethane.
- Carbon tetrachloride.
- VC.
- 1,1,2-trichloroethane.
- 1,1-dichloroethane.
- Hexachlorobutadiene.
- cis-1,2-dichloroethene.
- Barium.

400078

2.1.2 Negligible Health Risks

Potential risks from volatilized compounds infiltrating into basements were evaluated and were within acceptable levels. Direct contact with soil was not quantitatively evaluated as a potential exposure pathway because Necco Park is capped. Contaminated soil and DNAPL may contribute to potential groundwater risk. Ingestion of fish from downgradient surface water does not appear to pose a significant site-related human health risk. Based on these assessments, sediment, surface water, and air at Necco Park are not significant contributors to risk.

2.1.3 Ecological Risk

Potential adverse impact to ecological receptors was assessed in EPA's risk assessment by modeling Necco Park groundwater contamination concentrations reaching the Niagara River from two locations: the Forebay Canal and the Falls Street tunnel outfall. Estimated mean and maximum concentrations for all indicator contaminants within the Forebay Canal and the Niagara River were several orders of magnitude below acute and chronic ambient water-quality standards.

Mean concentrations of contaminants in the Falls Street tunnel effluent were also below acute ambient water-quality standards. However, maximum concentrations of hexachlorobutadiene, pentachlorophenol, and cyanide in the Falls Street tunnel water that discharges to the city of Niagara Falls POTW slightly exceed acute levels, and average and maximum concentrations slightly exceed chronic water-quality standards.

These conclusions are conservative because flow in the Falls Street tunnel now discharges to the Niagara Falls POTW for treatment. During storm-water flow conditions, a percentage (less than 20 percent) of the Falls Street tunnel water bypasses the POTW and discharges directly to the Niagara River. Even if Falls Street tunnel water was discharged directly to the Niagara River, adverse impact to aquatic biota from Necco Park contaminants alone would not be expected after dilution provided by the Niagara River.

Pentachlorophenol and hexachlorobenzene are compounds known to bioaccumulate in aquatic species. However, estimated fish tissue concentrations of these two contaminants in the Forebay Canal and the Niagara River were determined to be several orders of magnitude below maximum fish flesh criteria intended to protect piscivorous wildlife.

Exposure of ecological receptors to surface soil and airborne contaminants at Necco Park is insignificant because of the existing clay cap.

2.2 Statutory And Regulatory Requirements

ARARs are established to regulate and protect the quality of the environment. ARARs take the form of statutory criteria, regulations, guidance, and advisories. SARA Section 121 also designates that state requirements, when more stringent than federal requirements, will also be considered ARARs. Therefore, New York State requirements, as well as requirements of EPA and other federal agencies, are potential ARARs for Necco Park.

An *applicable* requirement is defined as any standard or limitation that specifically addresses the hazardous substance, response action, location, or other circumstance at the site. A *relevant* and *appropriate* requirement is defined as any standard, limitation, or guidance that—while not directly applicable to the hazardous substance, action, or location of the site—addresses problems or situations sufficiently similar to warrant inclusion as a requirement.

The AOA evaluation process addresses each remedial alternative's capability to attain certain preset levels of performance defined by ARARs. Each remedial alternative is assessed to evaluate how well it attains or exceeds site-specific ARARs.

ARARs are classified into the following three types:

- Chemical-specific requirements, which establish acceptable use-based concentration levels, volumes, or areas for specific contaminants in various environmental media
- Action-specific requirements, which place performance, design, or other similar controls on activities, such as National Pollutant Discharge Elimination System (NPDES) or ambient air discharge permits

- Location-specific requirements, which restrict the conduct of activities in particular locations, such as wetlands, streams, or floodplains

EPA has also requested this analysis consider other pertinent agreements or guidance documents, referred to as "to be considered" (TBC) criteria. National standards for soil have not been established. Where chemical-specific ARARs are not available, CERCLA requires that consideration be given to other guidelines. The EPA has identified NYSDEC's Technical and Administrative Guidance Memorandum (TAGM) *Determinaticn of Soil Cleanup Objectives and Cleanup Levels* as a TBC criteria for Necco Park soil. Additionally, the Four-Party Agreement, an agreement between Canadian and American environmental agencies, is a TBC criteria for potential impacts on the Niagara River. Tables 2-1, 2-2, and 2-3 list potential chemical-, location-, and action-specific ARARs and TBC criteria for Necco Park.

2.3 Response Action Objectives

RAOs are site-specific response goals established to address the nature and extent of contamination, resources currently or potentially impacted, and potential for human health and/or environmental exposure. They define response actions required, including cleanup levels, areas of attainment, points of compliance, and time frame.

RAOs are usually media-specific goals that provide an appropriate level of protection for human health and environment. Attainment of these objectives is a primary criteria in the feasibility study process. Level of protection is based on site-specific exposures and statutory standards. RAOs dictate contaminants of concern, exposure pathways, receptors, and acceptable contaminant concentrations for each exposure route.

Disposal activities at Necco Park have impacted local groundwater, and the groundwater gradient has carried chemical constituents off of the property. Several bedrock zones are impacted by inorganic and organic compounds present in waste materials. Organic constituents in groundwater are mainly due to DNAPLs that have migrated to several bedrock zones beneath Necco Park. Soil within the areal confines of Necco Park may also show elevated constituent levels, although soil is currently contained beneath a clay cap.

RAOs were developed to consider protection of human health and environment and in recognition of regulatory requirements. The following RAOs were established:

- Restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination
- Control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality

Drinking water in the area is a public water supply drawn from the Niagara River. Promulgated New York State standards designate potability as the groundwater-quality goal for the affected aquifer. Necco Park constituents in groundwater occur at levels above federal and New York State drinking-water standards and New York State groundwater-quality standards in the source area and far field. Therefore, the first RAO for Necco Park is restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. This aquifer will probably not be used as a potable water source without additional treatment because of naturally high salinity and sulfur levels and contamination from other sources. The RAO of groundwater restoration applies only to contaminants attributable to Necco Park.

As discussed in Section 1.0, several bedrock zones are impacted by the presence of DNAPL. Additionally, compounds within overburden soil may act as a contributing source to groundwater contamination. DNAPL interferes with efforts to restore groundwater quality because it is a continuing source of groundwater contamination. The inability of current technology to restore groundwater to drinking-water quality in fractured bedrock zones containing DNAPL makes complete restoration of source area groundwater unlikely (EPA 1992; NRC 1994). Therefore, source control is a RAO for zones determined to be impacted by DNAPL and/or contaminated soil.

Specific target goals for determining compliance with these RAOs are based on human health and environmental risk for potential future-use scenarios and regulatory standards. These are evaluated in Section 2.4.

2.4 Target Response Goals

EPA has established target response goals to address RAOs. These target goals set conservative exposure levels that would be protective of human health and environment even under the future use of groundwater scenario. Development of target response goals for Necco Park included the following NCP considerations:

- ARARs
- Concentrations calculated for a hazard index of 1 for noncarcinogenic constituents, assuming a theoretical residential exposure through ingestion, inhalation, and dermal contact during showering
- Concentrations of known or suspected carcinogens that represent an excess upper-bound lifetime cancer risk between 10^{-4} and 10^{-6}
- MCL goal (MCLG) set above zero for groundwater that is a potential source of drinking water
- MCL for contaminants with MCLGs set at zero for groundwater that is a potential source of drinking water
- Concentrations representative of a cumulative cancer risk level less than 10^{-6}

While these considerations provide a basis for determining protection and cleanup goals, a single set of response target goals is needed to focus evaluation on technologies, processes, and methods available to control and/or treat contaminated media. Table 2-4 lists chemical-specific concentrations of indicator compounds for each of the considerations listed. New York Groundwater-Quality Standards or MCL (whichever was lower) was selected as the preliminary target goal. Table 2-5 presents these target goals for groundwater.

2.5 Media Areas/Volumes

To permit subsequent development of RAAs, initial area and volume of media must be defined. Based on RAOs, four media have been identified at Necco Park. GRAs are developed in Section 3.0 to address RAOs for each of the following media: overburden, DNAPL, source area groundwater, and far-field groundwater. The following sections describe each medium.

2.5.1 Overburden

The overburden media of concern is defined as natural soil and fill at the 24-acre Necco Park facility. Natural soil is comprised of glaciolacustrine deposits and glacial till. Fill material consists of industrial waste material disposed at the facility during its operational history. Waste types are described in Section 1.0. Overburden ranges from 20 to 30 feet in thickness. Assuming a depth of 25 feet, the volume of overburden is estimated at approximately 1 million cubic yards.

Available data indicates that approximately 186 million pounds of liquid and solid industrial wastes were disposed of at the site. These wastes were reported to contain inorganic constituents (barium, calcium, and sodium chloride) and organic constituents such as carbon tetrachloride, chloroform, hexachlorobenzene, hexachlorobutadene, hexachloroethane, methylene chloride, PCE, and TCE.

A clay cap was constructed over overburden material in the landfill during 1978 and 1979. The final compacted cover consisted of 18 inches of clay [classified as SC and CL soil type per the Unified Soil Classification System (USCS)] in accordance with the May 1978 DuPont work plan (DuPont 1978). The clay cap is overlain by a 6-inch cover of soil and grass. The landfill cover is maintained by DuPont.

Overburden poses a potential direct contact risk and may impact groundwater quality. Therefore, the second RAO—control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality—is applicable for overburden.

2.5.2 DNAPL

DNAPL is defined as free-phase liquid organic constituents that are not bound chemically or surficially to soil or bedrock. DNAPL constituents dissolved in the aqueous plume are not considered part of the DNAPL media but are part of source area groundwater. DNAPL at Necco Park generally contains the following compounds:

- ❑ Hexachlorobutadiene

- Hexachlorethane
- Hexachlorobenzene
- Chloroform
- PCE
- 1,1,2,2-tetrachloroethane
- TCE

Organic liquid was originally placed in overburden fill and has migrated, in part, into bedrock underlying overburden. The Necco Park RI report states that much of the DNAPL remains in overburden. However, DNAPL has been observed in B through F bedrock zone fractures. In overburden, DNAPL appears to be primarily located within the lower portions of fill and within underlying natural till of Necco Park. The approximate extent of DNAPL is presented in Figure 1-28. The volume of DNAPL present in overburden and bedrock of the source area at Necco Park is unknown.

DNAPL impacts groundwater quality and may pose a direct contact risk. Therefore, the second RAO—control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality—is applicable for DNAPL.

2.5.3 Source Area Groundwater

Source area groundwater is defined as groundwater in overburden and bedrock in areas where aqueous concentrations may be indicative of the presence of DNAPL (i.e., solubility criteria were met). Source area groundwater includes both overburden groundwater and bedrock groundwater. The estimated areal extent of source area groundwater is presented in Figure 1-28. Actual observations of free-phase DNAPL have been limited to overburden (A zone) and upper bedrock (B through F zones) in the general vicinity of Necco Park. Solubility criteria indicates the potential presence of DNAPL in G zone and defines the areal extent of source area groundwater in B through F bedrock zones to just south of the CECOS landfill cells.

Necco Park constituents in source area groundwater occur at levels above federal and New York State drinking-water and groundwater-quality standards. Therefore, the first RAO—restoration of groundwater to its designated use, potable drinking water, as impacted by Necco Park contamination—is applicable to source area groundwater. However, potential presence of DNAPL along with naturally occurring constituents, will likely make the first RAO—restoration of groundwater to its designated use, potable drinking water, as impacted by Necco Park constituents—difficult or impossible to achieve in a reasonable time frame for source area groundwater (EPA 1994). RAOs based on background water quality or MCLs will generally require in excess of 99 percent of DNAPL in the source area be treated or recovered. This standard by itself poses a significant challenge to many technologies under the most favorable conditions (EPA 1994). Low-permeability soil and bedrock increase the level of difficulty for restoring aquifers. Residual DNAPL is difficult to remove completely due to adsorption and interfacial tension between DNAPL and water. Even small quantities of remaining DNAPL will continue to diffuse very slowly over time, forming an aqueous plume.

GRAs within source area groundwater will mainly focus on limiting migration of constituents to minimize impact on far-field groundwater. In general, these control measure process options are the same as aquifer restoration process options (i.e., in situ and pump-and-treat technologies).

2.5.4 Far-Field Groundwater

Far-field groundwater is defined as groundwater impacted by Necco Park constituents where the solubility criteria for DNAPL has not been met. Far-field groundwater extends generally from the southern edge of the source area south to the Falls Street tunnel, and from the western border of the source area west to the NYPA conduits. Direction of groundwater flow in B and C zones is to the south. Groundwater in D through G zones flows to the west. Far-field groundwater includes only bedrock groundwater. The estimated areal extent of far-field groundwater is presented in Figures 1-29 through 1-35.

Necco Park constituents in far-field groundwater occur at levels above federal and New York State drinking-water standards and New York groundwater-quality standards.

Therefore, the first RAO—restoration of groundwater to its designated use, potable drinking water, as impacted by Necco Park contamination—is applicable to far-field groundwater. However, as discussed in Section 1.9.3, complete restoration to drinking-water standards is subject to uncertainty. Although significant decreases in off-site loadings result from containment of the source area, the potential effects of matrix diffusion (see Section 1.9.3) may slow restoration of far-field groundwater.

3.0 TECHNOLOGY SCREENING AND EVALUATION

3.1 Technology Screening and Evaluation Procedure

Section 1.0 of the AOA report described Necco Park and the nature and extent of contamination. In Section 2.0, RAOs for Necco Park were developed based on ARARs. Volumes and areas for media of concern were also identified and defined in Section 2.0. This section of the AOA report describes procedures by which technology process options were selected for incorporation into RAAs. This procedure consists of three steps in accordance with EPA guidance (EPA 1988): development of GRAs, identification and screening of technologies, and evaluation of process options. Using process options selected by this technology screening and evaluation procedure, media-specific RAAs are developed and evaluated in Section 4.0. Site-specific RAAs are defined and evaluated against NCP criteria in Section 5.0. Figure 3-1 presents a flow diagram of the entire alternative development and evaluation process.

Step one in the technology evaluation procedure is the identification of GRAs. GRAs describe those actions that will satisfy RAOs, in part or in whole. GRAs are media-specific. When developing media-specific RAAs (see Section 4.0), combinations of GRAs may be identified to achieve RAOs.

In step two, identification and screening of technologies, the universe of potentially applicable technology types and process options is reduced by evaluating options with respect to technical implementability. The term "technology types" refers to general categories of technologies, such as capping, thermal treatment, or biological treatment. The term "technology process option" or "process option" refers to specific processes within each technology type. For example, the physical/chemical treatment technology type would include such process options as precipitation, ion exchange, and chemical oxidation. Several broad technology types may be identified for each GRA, and numerous process options may exist within each technology type. Technology types and process options were identified through a review of available literature, EPA data bases, and engineering experience for similar sites.

During step two, process options and entire technology types are retained or eliminated from further consideration based on technical implementability. Technical implementability refers to whether a technology can feasibly be implemented at the site to address specific media and contaminants. Available information was used to screen out technologies and process options that cannot be effectively implemented at Necco Park based on constituent characteristics and media properties.

In step three, process option evaluation, technology process options considered to be implementable are evaluated in greater detail before selecting one process to represent each technology type. Process options are evaluated using the following criteria: effectiveness, implementability, and cost. These criteria are applied only to technologies, media, and the GRA they are intended to satisfy and not to Necco Park as a whole. This evaluation focused on effectiveness factors at this stage, with less emphasis on implementability and cost evaluation.

One representative process is selected, if possible, for each technology type to simplify the subsequent development and evaluation of RAAs without limiting flexibility during remedial design. The representative process provides a basis for the alternative evaluation; however, the specific process option actually used to implement response actions at Necco Park may not be selected until the remedial design phase. For example, while air stripping may be chosen as a representative process option to treat organic constituents in groundwater, other options may be considered in design if additional information indicates they may be more effective. In some cases, more than one process option may be selected for a technology type. This may be done if two or more processes are sufficiently different in their performance that one would not adequately represent the other.

3.2 General Response Actions

As a first step in the development and selection of alternatives, GRAs that address significant sources and pathways of contamination were identified. GRAs are broad measures that fulfill, in part or in whole, RAOs as defined in Section 2.0. GRAs may include treatment, containment, excavation, collection, disposal, institutional actions, or a combination of these actions. GRAs are specific to the four media identified in Section 2.0:

- Overburden
- DNAPL
- Source area groundwater
- Far-field groundwater

For each media requiring attention, appropriate GRAs have been identified. The following GRAs are available to address media at Necco Park:

- *No Action*
  The no action response is the basis against which all other actions are assessed. Under the no action response, all existing response measures would stop, and no future response measures would be implemented.
- *Institutional Actions*
  Institutional actions are mechanisms used to limit human activities in or near a facility, to prevent the use of contaminated material in or near a facility, or to monitor chemical constituents in the media. Institutional actions can be used alone or in conjunction with other technologies to supplement effectiveness of a RAA when constituents remain in concentrations greater than target remediation goals after response activities have been completed. Institutional actions may include land- or water-use restrictions and monitoring.
- *Containment*
  Containment measures are designed to limit human exposure and limit migration of constituents from the source area by minimizing or eliminating potential receptor pathways or by reducing the migration potential of constituents.
- *Collection/Excavation*
  Collection or excavation responses are technologies that remove constituents or contaminated media from the impacted area. Collection responses may include technologies to recover DNAPL or contaminated groundwater. Excavation responses include technologies that physically remove contaminated soil or rock. Once removed, contaminants or contaminated media may be treated and/or disposed.

- *Treatment*
  Treatment responses are processes that act directly on the chemical constituents in the media. These technologies usually destroy or chemically alter constituents of concern to reduce or eliminate hazardous characteristics.

- *Disposal/Discharge*
  Disposal and discharge responses are methods to dispose of media, such as groundwater or soil. Many disposal and discharge technologies require some form of pretreatment.

Appropriate GRAs have been identified for each of the four media based on the media RAOs and are presented in the table that follows.

Overburden	DNAPL	Source Area Groundwater	Far-Field Groundwater
No Action	No Action	No Action	No Action
Institutional Action	Institutional Action	Institutional Action	Institutional Action
Containment	Containment	Containment	Containment
Excavation	Collection	Collection	Collection
Treatment	Treatment	Treatment	Treatment
Disposal	Disposal	Discharge	Discharge

3.3 Identification and Screening of Technologies

Identification and screening of technologies is the second step in technology evaluation. Each GRA identified in Section 3.2 has technologies associated with it that may be combined to form RAAs that meet RAOs. Technology types and process options were identified through a review of available literature, EPA data bases, and engineering experience from similar sites.

Technologies have been evaluated at this stage based on their technical implementability. Technical implementability at this stage of the evaluation procedure refers to the technical feasibility of implementing a technology. Technical implementability is used as an initial screening step to eliminate technology types or process options that are clearly ineffective or unworkable. Those technologies that were determined not to be technically implementable were screened from further evaluation.

According to EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988), this screening can be documented in a table. Summaries of this screening for each media—overburden, DNAPL, source area groundwater, and far-field groundwater—are included in Tables 3-1 through 3-4, respectively. Table 3-5 lists technologies and process options, listed under the appropriate GRA, that have been retained for further evaluation.

3.4 Process Option Evaluation

In Section 3.3 (see Tables 3-1 through 3-4), technologies and process options for each response action were screened based on technical implementability. In the next step of the evaluation, process options for technologies that were retained have been examined to determine their technical feasibility with respect to addressing RAOs for each media at Necco Park. The screening procedure was designed to identify potentially applicable process options for incorporation into RAAs.

3.4.1 Process Option Evaluation Criteria

Process options for technologies considered technically implementable were evaluated using three criteria: effectiveness, implementability, and cost. Greater emphasis was given to the effectiveness criterion at this stage.

3.4.1.1 Effectiveness

The effectiveness evaluation focused on

- Potential effectiveness of the process option in handling estimated areas or volumes of media and potential to meet goals identified in RAOs.
- Potential impact on human health and environment during construction and implementation.
- How proven and reliable the process option is with respect to chemical constituents and conditions within each media at Necco Park.

Information used in evaluating effectiveness included contaminant type and concentration, area or volume of contaminated media and, when appropriate, collection rates of liquid or gaseous media. Physical properties listed in Table 3-6 for Necco Park indicator parameters were used to evaluate potential effectiveness of various technologies. The effectiveness evaluation was based on experience with similar projects, data from technical publications, and professional engineering judgment.

3.4.1.2 Implementability

Implementability was evaluated as a measure of both technical and administrative feasibility of constructing, operating, and maintaining a process option. Technical feasibility refers to the ability to construct and reliably operate the technology until action is complete. It includes operation, maintenance, replacement, and monitoring. Administrative feasibility refers to the ability to obtain approvals from the community and local, county, state, and federal agencies; availability of treatment, disposal services, and capacity; and requirements and commercial availability of the process option. As discussed in Section 3.3, technical implementability was used as an initial screening criteria. Therefore, this subsequent, more detailed implementability evaluation of process options placed greater emphasis on administrative feasibility.

3.4.1.3 Cost

At this stage of the evaluation procedure, relative capital and operation and maintenance (O&M) costs were used rather than detailed estimates. Each process option was evaluated using engineering judgment as to whether costs are high, medium, or low relative to other process options in the same technology type.

3.4.2 Evaluation

The following sections (Sections 3.5 through 3.8) include an evaluation of process options for each media. A summary following the evaluation description is included for each process option. Rationale for screening or retaining each process option is included in the summary. The purpose of this evaluation was to select one representative process option for each technology. Representative process options are selected at this stage to develop a manageable number of remedial alternatives for subsequent evaluation. The process option actually used to implement the response action at Necco Park may not be selected until the remedial design phase.

Many process options address more than one media. For example, in situ technologies may be effective for soil, DNAPL, and groundwater. To conduct a thorough and complete evaluation, the relative effectiveness for each media was evaluated separately for process options that address more than one media. During the RAA development phases, the overall effectiveness of technologies on all site media will be considered.

3.5 Overburden Process Option Evaluation

Overburden is defined as natural soil and fill at the 24-acre Necco Park facility. Overburden material ranges from 20 to 30 feet in thickness and includes both saturated and unsaturated zones. Natural soil is comprised of glaciolacustrine deposits and glacial till. Fill material consists of industrial waste material disposed at the facility during its operational history. Waste types are described in Section 1.0. Using a representative depth of 25 feet, overburden volume is approximately 1 million cubic yards.

Available data indicate that approximately 186 million pounds of liquid and solid industrial wastes were disposed of at the site. These wastes were reported to contain inorganic constituents (barium, calcium, and sodium chloride) and organic constituents such as carbon tetrachloride, chloroform, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, methylene chloride, PCE, and TCE. Therefore, overburden technologies considered will include inorganic and organic treatment process options.

A clay cap was constructed over overburden material in the landfill during 1978 and 1979. The final compacted cover consisted of 18 inches of clay (Class SC and CL soil type) in accordance with the May 1978 DuPont work plan (DuPont 1978). The clay cap is overlain by a 6-inch cover of soil and grass. The landfill cover is maintained in good condition by DuPont.

A review of applicable technology process options for Necco Park overburden has been conducted and subjected to the evaluation process. A detailed discussion of the evaluation follows. A summary of the overburden technology process option evaluation is provided in Section 3.5.13.

3.5.1 No Action—Overburden

Under the no action technology, all ongoing measures would be halted. The clay cap and grout curtain would remain in place, but maintenance operations for the cap would be discontinued.

- *Effectiveness*
  The no action technology would not achieve any of the RAOs in part or in whole. This technology is not effective.
- *Implementability*
  The no action technology is easily implemented.
- *Cost*
  The no action technology has no additional costs associated with it.
- *Summary*
  Although the no action technology is not effective in achieving RAOs, it is retained for comparison purposes as required by the NCP.

3.5.2 Overburden Access Restrictions

Deed restrictions, fencing, and security personnel are process options identified under access restriction technology.

3.5.2.1 Overburden Deed Restrictions

Deed restrictions limit certain activities at a property that may result in greater personal or environmental exposure to constituents of concern. Such restrictions would limit future actions in the designated area such as excavation or cap disturbance.

- *Effectiveness*
  Deed restrictions would be effective in limiting future use of Necco Park overburden and would thereby limit human contact with constituents of concern in soil.
- *Implementability*
  Deed restrictions would be easily implemented.
- *Cost*
  The cost of deed restrictions, which is mainly associated with document recording fees, would be low compared to other access restriction process options.
- *Summary*
  Deed restrictions are retained for further evaluation.

3.5.2.2 Fencing

Fencing can be used to restrict unauthorized access to Necco Park. Present fencing around the BFI property has been effective in preventing unauthorized entry to the Necco Park facility.

- *Effectiveness*
  Existing fences would be effective in limiting human contact with chemical constituents in Necco Park overburden and fill.
- *Implementability*
  Fencing already exists around the BFI property that surrounds Necco Park. Upgrades, as necessary, and routine maintenance would be easily implemented.
- *Cost*
  Cost for fencing is moderate and includes material, labor, and equipment to maintain existing fences.
- *Summary*
  Fencing is retained for further evaluation.

3.5.2.3 Security Personnel

To reduce potential for unauthorized access, BFI monitors access gates to the BFI/Necco Park area.

- *Effectiveness*
  Security personnel are effective in limiting human contact with chemical constituents in overburden.
- *Implementability*
  Maintaining personnel at access gates is easily implementable and required for ongoing BFI operations.
- *Cost*
  Cost of providing security personnel would be high compared to other access restriction process options, if BFI were no longer available.
- *Summary*
  Security personnel are retained for further evaluation as they are required for ongoing BFI operations.

3.5.3 Overburden Monitoring

Air monitoring is the only monitoring process option applicable for Necco Park overburden.

3.5.3.1 Overburden Air Monitoring

Air monitoring could be implemented to determine if chemical constituents are diffusing into the air during or after a response action such as excavation. Based on the Necco Park endangerment assessment (TRC 1993), eight chemicals reported at the facility had potential to be released into air. An ambient air-sampling program was conducted in 1986. In general, the low percentage of samples with detectable levels of contaminants coupled with the lack of any consistent increases in concentrations downwind of the landfill indicate that emissions are not significantly contributing to surrounding ambient contaminant levels.

- *Effectiveness*
  Air monitoring will not be effective in attaining the RAOs. However, air monitoring may be used in conjunction with other technologies to monitor implementation of selected RAAs.

- *Implementability*
  Air monitoring is readily implementable.
- *Cost*
  Cost for air monitoring would include labor, materials, and laboratory services. Cost of air monitoring is moderate compared to other institutional action technologies such as fencing and security personnel.
- *Summary*
  Although air monitoring will not help to achieve RAOs, this technology is retained for incorporation into RAAs because it can be used to monitor RAA implementation.

3.5.4 Overburden Capping

Caps are technologies used to prevent human contact with overburden and to reduce precipitation and surface-water infiltration, thereby reducing the mobility of chemical constituents to groundwater. Caps can also eliminate or minimize volatilization of constituents.

Cap designs have the following attributes:

- Minimal precipitation infiltration through the cap
- Low maintenance requirements
- Efficient drainage
- High resistance to damage by moderate settling or subsidence
- A permeability lower than, or equal to, underlying natural soil

Numerous types of caps and capping materials are available. Selection of capping materials and cap design is influenced by specific factors such as local availability and cost of cover materials, desired functions of cover materials, nature of the wastes being covered, local climate and hydrogeology, and projected future use of the property. Four cap process options, the existing clay cap, a NYS 360 cap, an asphalt cap, and a Resource Conservation and Recovery Act (RCRA) type cap are evaluated in sections that follow.

3.5.4.1 Existing Overburden Clay Cap

A clay cap over overburden material in the landfill was constructed during 1978 and 1979. The existing clay cap consists of a minimum of 18 inches of clay with a permeability of approximately 1 x 10^{-7} cm/s. Soil borings during site investigations have indicated average cap thickness to be approximately 24 inches. Clay is overlain by 6 inches of topsoil and grass to control cap erosion. Cover soil is graded to divert surface runoff from Necco Park. The landfill cover is maintained in good condition by DuPont.

- *Effectiveness*
  The existing clay cap is effective in preventing direct contact with chemical constituents and reducing infiltration of precipitation based on an evaluation of the existing cap using EPA's Hydrologic Evaluation of Landfill Performance (HELP) model. The HELP model has predicted that approximately 1.4 gallons per minute (gpm) of precipitation (approximately 3 percent of annual precipitation) would percolate to underlying groundwater. Details of the HELP model evaluation are included in Appendix D.

- *Implementability*
  The clay cap has been constructed as a part of existing response actions. Maintenance procedures for the cap are already developed. The existing clay cap system is readily implementable.

- *Cost*
  No additional construction costs are associated with this process. Ongoing costs for cap maintenance will continue to be incurred. The relative cost of the existing clay cap is low compared to other capping process options.

- *Summary*
  The existing clay cap is retained for further evaluation.

3.5.4.2 Overburden NYS 360 Cap

For applicable solid waste landfills, New York Waste Management Facilities Rules specify design requirements for a final landfill cover. This cap would include a gas-venting system and a low-permeability cover. The low-permeability cover can be constructed of a minimum of 18 inches of compacted soil, with a maximum remolded coefficient of permeability of 1x10^{-7} cm/s. A barrier protection layer of soil not less than 24 inches thick must be installed on top of the low-permeability barrier soil cover. A topsoil layer, or alternative soil material, must be designed and constructed to maintain vegetative growth over the landfill.

A geomembrane may be substituted for the low-permeability barrier soil cover in final cover systems. The geomembrane cover must be constructed to preclude precipitation migration into the landfill. The geomembrane material must be chemically and physically resistant to materials it may come in contact with and must accommodate expected forces and stresses caused by settlement of waste. The geomembrane must have a minimum thickness of 40 mil, or 60 mil in the case of geomembranes comprised of a high-density polyethylene (HDPE) polymer. This geomembrane must be covered by a barrier protection layer of soil not less than 24 inches thick and a topsoil cover.

In general, a drainage layer consisting of coarse material such as sand or a geosynthetic drainage material is placed over the low-permeability cover to remove water that percolates through topsoil and protective soil layer. New York Solid Waste Rules allow for equivalent design of individual components of the final cover system.

The existing clay cap may be supplemented with a geomembrane or additional clay and a protective barrier to convert it to a NYS 360 cap.

- *Effectiveness*
  NYS 360 caps are effective for both short- and long-term waste containment. With appropriate contouring, NYS 360 caps provide good control of precipitation, run-on, runoff, and infiltration. The HELP model simulation indicates that with a NYS 360 cap, less than 1 percent of annual precipitation will percolate to underlying groundwater (see Appendix D).

- *Implementability*
  Design and installation methods for these caps are well established. The property would require regrading and a significant amount of additional material would be necessary to complete drainage and protective layers.

- *Cost*
  Costs for a NYS 360 cap would include labor, materials, and equipment necessary for installation. Relative installation costs of NYS 360 cap are moderate compared to other capping process options.

- *Summary*
  The NYS 360 cap is retained for further evaluation.

3.5.4.3 Overburden Asphalt Cap

An asphalt cap using material similar to a road or parking lot could be constructed over overburden. Asphalt caps are generally considered where future commercial development is expected.

- *Effectiveness*
  An asphalt cap would be effective in preventing human contact with waste material. However, because of a tendency for cracks to form, the cap may not be completely effective in limiting infiltration of precipitation into overburden.

- *Implementability*
  Installing an asphalt cap would be readily implementable. The asphalt cap would require a significant amount of maintenance to repair cracks that form due to settlement and severe winter weather in the Niagara Falls area.

- *Cost*
  Costs for an asphalt cap would include labor, material, and equipment necessary for installation. Significant maintenance costs are also incurred to maintain integrity of asphalt caps. Costs of asphalt caps are moderate compared to other capping process options.

- *Summary*
  Asphalt caps are less effective than other capping process options such as clay caps or NYS 360 caps because of the tendency for cracks to form. Therefore, this process option will be screened from further evaluation.

3.5.4.4 Overburden RCRA-type Cap (NYS 373)

The RCRA-type cap (NYS 373) would consist of approximately 4 feet of interlayered soil and geosynthetic materials constructed to meet RCRA specifications for landfill caps. The RCRA-type cap consists of the following components (from bottom to top):

- 24 inches of compacted clay to provide proper bedding for the geomembrane liner and secondary confinement against infiltration
- Geomembrane liner to prevent infiltration of rainwater into the waste
- Synthetic drainage layer to remove infiltrating precipitation
- 18 inches of cover soil to provide adequate safety against re-exposure of waste and protection of geosynthetic materials from penetrations by foreign objects
- 6 inches of top soil to support growth of grass on the cap surface
- Vegetated surface to protect the cap from erosion damage

Overburden RCRA-type caps are evaluated as follows:

- *Effectiveness*
  A RCRA-type cap would be effective in preventing human contact with overburden and would significantly limit rainwater percolation into overburden. The HELP model simulation indicates that with a RCRA-type cap, less than 1 percent of annual precipitation will percolate to underlying groundwater (see Appendix D). However, based on the HELP model simulation, the RCRA-type cap is not significantly more effective in preventing rainwater percolation through overburden than the NYS 360 cap.
- *Implementability*
  General design and installation methods for RCRA-type caps are well established. The ground surface would require regrading, and a significant amount of additional material would be necessary to complete the drainage and protective layers.
- *Cost*
  RCRA-type caps capital costs are high with respect to other capping process options because of the additional cover layers. Maintenance costs should be low to moderate. Overall costs for RCRA-type caps are high compared to other capping options.

- *Summary*
  A RCRA-type cap is retained for further evaluation.

3.5.5 Overburden Vertical Barriers

Vertical barriers refer to a variety of technologies whereby low-permeability cutoff walls or diversions are installed below ground surface to contain chemical constituents in overburden. The most commonly used subsurface barriers are slurry walls, grout curtains, and sheet piling cutoff walls.

3.5.5.1 Overburden Slurry Walls

Slurry walls are the most common subsurface barriers because they are a relatively inexpensive means of controlling groundwater flow, thereby reducing overburden constituent mobility. The term slurry wall can be applied to a variety of barriers constructed in a vertical trench that is excavated under a slurry. The slurry, usually a mixture of bentonite and water, is a high-density fluid that hydraulically shores the trench to prevent collapse and, at the same time, forms a filter cake on trench walls to prevent high fluid losses into surrounding soil. Most commonly, a soil mixture containing fines is blended with bentonite slurry and placed in the trench to form a soil-bentonite backfill wall with a resulting permeability of 1×10^{-6} to 1×10^{-8} cm/s. In some cases, the trench is excavated under a slurry of Portland cement, bentonite, and water. This mixture is left in the trench to harden into a cement-bentonite slurry wall. Of the major types of slurry walls, soil-bentonite walls offer the lowest installation costs, widest range of chemical compatibilities, and lowest permeabilities. Soil-bentonite walls also have the highest compressibility (least strength), require a large work area and, because slurry and backfill can flow, are applicable only to areas that can be graded to nearly level.

- *Effectiveness*
  Data has indicated minimal horizontal DNAPL migration in overburden [i.e., DNAPL has not been identified at any new or existing well location outside of those wells where DNAPL had been observed previously (WCC 1991)]. Potential for horizontal migration of groundwater and DNAPL through cracks or capillary spaces in overburden may be

reduced by a slurry wall. However, slurry walls would have no impact on vertical migration of groundwater or DNAPL, the primary pathway of constituent migration from overburden.

Wherever possible, slurry walls are keyed into an underlying confining zone. No underlying confining layer that could be used to seal off groundwater migration exists at Necco Park; thus the slurry wall's effectiveness may be reduced.

- *Implementability*
  Constructing a slurry wall is not technically complex. Installing a slurry wall in overburden is moderately difficult, but keying the slurry wall into bedrock is more difficult and increases costs.
- *Cost*
  Costs for slurry wall installation include labor and equipment for excavating, mixing, and emplacing soil and bentonite. Material costs are associated with cost of bentonite and possibly soil if site soil is not suitable for backfill. Disposal costs may be significant if excavated soil is not consolidated on-site. Relative mixing cost of a slurry wall is low compared to other vertical barrier process options if site soil can be used in the backfill mixture. Costs are moderate if off-site soil is required for the backfill mixture.
- *Summary*
  Slurry walls are retained for further evaluation.

3.5.5.2 Overburden Grout Curtains

Grout curtains are technologies whereby one of a variety of fluids is injected or mixed with a soil mass to form a low-permeability barrier to flow. The fluid sets in place and reduces water flow and/or strengthens the formation. The primary objective of grouting is to fill voids in overburden material to create a low-permeability zone. Grout curtains formulated from cement, clay, bentonite, alkali silicates, silicates, or organic polymers may be used to reduce groundwater flow and constituent mobility through overburden material. Selection of grout constituents depends on waste constituent chemistry and porosity of the area to be grouted. Grouted barriers are seldom used for controlling constituent migration in unconsolidated materials because of high cost.

Grout curtains in soil can be constructed through permeation grouting, jet grouting, or soil mixing. Permeation grouting involves filling soil voids with grout. To fill soil voids with grout, the permeability of soil, viscosity of the grout, and size of particulates in the grout must be considered. Soil permeability is controlled by grain-size distribution of the soil and average void size. Grout viscosity is dependent on the type of grout and how it is mixed. In general, particulate grouts have much higher viscosity than chemical grouts.

There are two main methods of permeation grouting, point injection and sleeve pipe injection. In the point injection method, casing is driven to full depth then withdrawn to the desired depth, and grout is injected. In the sleeve pipe method, a sleeve pipe is placed in a grout hole and sealed in place using a clay-cement mixture. The pipe has small holes at 1-foot intervals through which grout is pushed. Holes are covered by rubber sleeves, or manchettes, which act as one-way valves and open when the grout is pressurized. To inject grout, a double packer attached to a smaller-diameter grouting pipe is inserted into the sleeve pipe centered on a sleeve hole, the pipe is pressurized, and grout is forced through the sleeve hole and into the soil. The resultant permeability of permeation grouting cutoff walls is approximately 1×10^{-7} cm/s.

Jet grouting of soil involves the use of grout alone, grout and air, or a combination of grout, air, and water delivered by a small jet (or jets) in the drill rod at very high pressures that often reach 5,000 to 6,000 pounds per square inch (psi). After advancing to the desired depth, the rod is lifted and rotated as the jetted grout cuts away soil and creates a large cylindrical hole. Portland cement or cement-bentonite grouts are generally used when jet grouting. Cement grout mixes with soil to form a soil and cement mixture (or soilcrete) column in the ground. Excess water and soil are forced to the surface around the drill rod. The resultant permeability of a jet grouted grout curtain is 1×10^{-7} cm/s or less.

Soil mixing has been employed to construct vertical barriers. A special auger mixing shaft is rotated into the ground while simultaneously permitting injection of bentonite and water or cement, bentonite, and water slurry. Multiple mixing shafts are usually employed. A continuous wall, typically from 20 to 36 inches wide, is obtained by overlapping penetrations. Bentonite is added to mixed soil in a bentonite-water slurry. As a result, bentonite content of the mixed soil is typically limited to about 1 percent. The resultant permeability of a soil mixed vertical barrier is approximately 1 x 10^{-7} cm/s.

- *Effectiveness*
  Grout curtains are moderately effective in controlling groundwater flow through voids in soil. The main factors with grouting to achieve low permeability are to completely fill void spaces with grout and to control the lateral extent of grout penetration. Both of these tasks are very difficult and require experience to control. Grout pumped at excessively high pressure can cause hydrofracturing of soil.

  Jet grouting and soil mixing are more effective than permeation grouting for soil materials. These installation methods form effective vertical barriers for most constituents, but compatibility testing is necessary to select the proper grout mix.

- *Implementability*
  Soil grouting is implementable. Drilling or mixing in areas containing debris, rocks, or boulders may be difficult.

- *Cost*
  Cost of installing a grout curtain includes mobilization and demobilization, drilling, and cost of grout material. O&M costs will be minimal. Overall cost of installation is high relative to other overburden vertical barrier process options.

- *Summary*
  Slurry walls are easier to install in overburden, can be constructed with lower permeability, and cost less than grout curtains. Therefore, slurry walls will be retained as a representative vertical barrier process option for overburden, and grout curtains will be screened from further evaluation.

3.5.5.3 Overburden Sheet Piles

Sheet piling can be used to form a barrier to groundwater flow. Generally, steel or HDPE sheet piles are most effective for groundwater cutoff. Therefore, this screening evaluation will consider steel and HDPE sheet-piling materials for overburden. The in-place permeability of a geomembrane cutoff wall is 1×10^{-7} cm/s or less.

- *Effectiveness*
  Sheet piles are interlocking piles that form a continuous low-permeability wall when properly installed. When the wall is stressed laterally, the interlock forms a mechanical seal. While sheet piles are used for permanent waterfront structures, they are most commonly used for temporary support during construction features such as cofferdams or to keep trenches open.

  There are drawbacks to using sheeting at a hazardous waste impoundment. If the interlocks are not sealed, a route for groundwater and DNAPL migration remains, and effectiveness of the wall as a barrier will be reduced. For temporary structures, joint leaks are acceptable because infiltration is controlled by construction dewatering. However, joint leaks are generally not acceptable for permanent environmental applications. Grouting of interlocks may be required for steel sheet piles to reduce permeability. HDPE sheet-pile interlocks are generally sealed with plastic material compatible with waste constituents.

  Sheet piles must be driven into a confining layer to ensure complete containment. Sheet piles cannot be driven into underlying bedrock at Necco Park. Therefore, groundwater could migrate off-site beneath the sheet piling.

  Steel sheet piles may also corrode, making the barrier ineffective over time. Adequate corrosion protection may be required for steel sheet piles.

- *Implementability*
  The ability to drive sheets is determined by the nature of overburden material through which sheets are driven. Overburden glacial till contains rocks and boulders, thus making it difficult to implement sheet piles at Necco Park. Boulders prevent driving of sheet piles or knock piles out of interlock, potentially opening pathways for groundwater or DNAPL migration.

- *Cost*
  Purchase and installation costs of sheet piles are high when compared to other vertical barriers, such as slurry walls.

- *Summary*
  The slurry wall is a more implementable and effective technology for Necco Park overburden than sheet piles. Sheet piles are screened from further evaluation.

3.5.6 Overburden Horizontal Bottom Barrier

This technology involves placing a barrier beneath an existing facility to act as a floor to prevent downward contaminant migration. Most of these technologies involve variations of grouting or other construction support techniques. These technologies are mainly in the developmental stage and have been used infrequently in full-scale environmental applications. Integrity of the horizontal barrier is difficult to test, and all gaps or cracks in a horizontal barrier would be potential routes of contaminant migration. An intact horizontal barrier may prevent further vertical migration of DNAPL from overburden, if used in conjunction with a vertical barrier.

- *Effectiveness*
  This technology may be theoretically effective in controlling constituent migration from overburden materials, if it could be implemented. However, effectiveness would be limited because of significant technical difficulties in injecting materials necessary for barrier formation. This barrier would have to be installed in conjunction with vertical barriers to contain source materials effectively. All cracks or spaces in a horizontal barrier would be potential routes for vertical migration of constituents and DNAPL from overburden.
- *Implementability*
  This technology would be extremely difficult to implement at Necco Park for the following reasons:
  - Testing the integrity of a horizontal barrier is difficult.
  - A horizontal barrier at a facility similar to Necco Park has not yet been demonstrated.
- *Cost*
  Relative cost for installing a horizontal barrier is high compared to other containment technologies.
- *Summary*
  Implementing a horizontal barrier is difficult and has questionable effectiveness. Therefore, horizontal barriers are screened from further evaluation.

3.5.7 Overburden Excavation

Excavation of impacted soil can normally be accomplished using conventional construction equipment such as backhoes, bulldozers, and front-end loaders. In some special situations, such as steep slopes or near buildings and utilities, special equipment may be necessary.

- *Effectiveness*
  Excavation is an effective method for removal of overburden. It must be used in conjunction with containment or treatment technologies to control or remove constituents effectively.
- *Implementability*
  Excavation of overburden at Necco Park is implementable. Procedures to protect workers would be required. Excavation of the entire volume of overburden present would take a long time.
- *Cost*
  The unit cost for soil removal by excavation is low compared to treatment costs.
- *Summary*
  Excavation is retained for incorporation into ex situ treatment alternatives.

3.5.8 Overburden Thermal Treatment

The following process options have been considered: incineration, radio frequency (RF) heating, thermal desorption, and in situ vitrification.

3.5.8.1 Overburden Incineration

Incineration can be accomplished using one of several types of incinerators, including rotary kilns, infrared thermal treatment, pyrolitic, fluidized bed, multiple hearth, high-temperature fluid wall, and plasma arc.

- *Effectiveness*
  Once collected, separated, and fed to the unit, organic constituents in Necco Park overburden can be effectively destroyed by incineration. Inorganic constituents such as barium are not treatable by incineration and would require additional treatment (i.e., stabilization). Overburden material would have to be excavated to be incinerated. Excavation could produce a large amount of organic vapors that would have to be controlled. Incinerator off-gas would also have to be monitored and controlled.

Several types of incineration units could potentially be used for overburden materials. Rotary kiln incineration, consisting of a cylindrical refractory-line shell that is mounted on a slight incline, may be appropriate for waste at Necco Park. Natural gas is generally used to fuel the incinerator to attain necessary temperatures.

Infrared thermal units consist of a feed belt that carries waste into the unit where it is exposed to radiation. These units generally require a uniform feed size and are not as robust as other types of incinerators. Necco Park overburden material would likely require pretreatment because excavated material would likely consist of debris and rocks.

Pyrolitic incineration involves destruction of organic materials in the absence of oxygen at high temperatures. This process option has not been demonstrated commercially.

Fluidized bed incineration consists of a vertical refractory-lined vessel containing a bed of inert, granular, sand-like material. Combustion air is forced upward through the bed, which fluidizes the material. As waste material is injected to the bed it is combusted, and heat of combustion generated is transferred back to the bed, maintaining combustion temperature in the bed.

Multiple hearth incineration consists of a refractory-lined circular steel shell, a rotating central shaft, a series of solid flat hearths, a series of rabble arms with teeth for each hearth, an air blower, flue burners mounted on the walls, an ash removal system, and a waste feed system. Also included with some units are side ports for fuel injection, liquid waste burners, and/or afterburner. One major disadvantage with this technology is its susceptibility to thermal shock, making it unsuitable for treating highly chlorinated organic constituents.

High-temperature fluid wall incineration consists of a tubular reactor of refractory material lined with carbon electrodes in the jacket wall. Radiant energy supplied by electrodes heats an inner core to temperatures of 2100° to 2500°C. Waste materials are gravity fed through the inner core, but are isolated from the reactor core by a gaseous blanket formed by nitrogen flowing radially inward through the porous core wall. One major disadvantage of this process option is a need for wastes to be dried, free-flowing, and reduced to a size of 10 mesh or smaller prior to treatment. Mixed waste expected in the Necco Park overburden would require extensive pretreatment.

Plasma arc incineration involves wastes brought in contact with ionized gas. This process option requires that waste be in a slurry form. This process option is still in the developmental stage and has not been field proven.

- *Implementability*
  Rotary kiln incineration is a readily available technology that could be implemented at Necco Park. Infrared thermal treatment, pyrolitic incineration, fluidized bed incineration, multiple hearth incineration, high-temperature fluid wall, and plasma arc require extensive pretreatment and/or are not proven process options for soil and waste mixtures. A hazardous waste treatment permit, or its equivalent, would require regulatory approval and public hearings. Generally, incinerators are met with strong public opposition.

  Other potential difficulties in implementation include material handling and air emission controls. Feed systems that handle soil are difficult to operate continuously. Air emissions during material handling and burning activities will also have to be controlled. Very durable materials of construction are required to handle hydrochloric acid (HCl) formed from the combustion of chlorinated compounds.

- *Cost*
  Mobilization and installation of incineration equipment is very expensive. Cost for incineration includes highly skilled labor for operating material handling and highly sophisticated treatment equipment. The most significant material costs include fuel for incineration and destruction of organic compounds. Cost of incineration is high compared to other thermal process options.

- *Summary*
  Incineration is extremely difficult and costly to implement but is generally the most effective treatment method for totally destroying organic constituents. Incineration is screened from further evaluation because of the high costs and difficulties in implementation.

3.5.8.2 Overburden Radio Frequency Heating

RF heating uses electromagnetic energy to accomplish subsurface heating, thereby enhancing contaminant removal. Primary removal mechanisms, which depend on the actual heating strategy, are vaporization of low boiling point organic compounds and water; enhancement of evaporation rates of higher boiling point organic compounds; partial or complete displacement of heated pore fluids by a propagating steam condensation front; partial or complete displacement of all contactable constituents by the propagating steam front; and/or enhanced pore liquid mobilization resulting from liquid density and viscosity alterations.

- *Effectiveness*
  RF heating may not be effective in the saturated zone. Some higher boiling point constituents may not be effectively removed by this process. No application of this process option has been completed in the saturated zone or, specifically, on DNAPL.
- *Implementability*
  RF heating technology has been demonstrated on bench-scale systems but has had limited application in pilot or full-scale systems.
- *Cost*
  Cost of RF heating is high compared to other thermal treatment process options.
- *Summary*
  RF heating is not a proven technology for remediation of soil. Some constituents with high boiling points may not be effectively treated by this process. RF heating is screened from further evaluation.

3.5.8.3 Overburden Thermal Desorption

Thermal desorption units consist of a pug mill or rotary drum system equipped with heat transfer surfaces. An induced air flow conveys desorbed volatile organic/air mixtures through a condenser, carbon adsorption unit, or combustion afterburner for collection or destruction of organic constituents. The airstream is then discharged through a stack.

- *Effectiveness*
  Thermal desorption is generally used to remove VOCs (Henry's Law constant greater than 3.0 x 10^{-3} atmosphere-meter cubed per mole [atm-m^3/mole]) from soil or similar solids. Higher temperature units (greater than 600°F) would likely be required to treat higher boiling SVOCs. Inorganic constituents would not be treated effectively by this process. Pretreatment and/or screening may be required due to the nature of overburden materials at Necco Park.

- *Implementability*
  Thermal desorption units are available for commercial use. As with incineration, material handling and feed systems for these units are also difficult to implement. However, thermal desorption units are generally more acceptable to the public and less difficult to permit.

- *Cost*
  Thermal desorption units are fairly easy to mobilize and therefore are less expensive than incineration units. Labor to operate material handling and treatment equipment is also less than incineration. Higher temperature units require more fuel than low temperature units, but fuel requirements are generally lower than incineration. Depending on the unit, off-site disposal of recovered organic constituents can cause costs to increase. Cost of thermal desorption is moderate compared to other thermal treatment process options.

- *Summary*
  Thermal desorption is potentially as effective as incineration for excavated overburden material and would be less expensive and easier to implement. Therefore, thermal desorption is retained for further evaluation.

3.5.8.4 Overburden In Situ Vitrification

In situ vitrification (ISV) is a process that relies on joule resistance heating and consequent melting of overburden material to enhance contaminant removal and destruction. Primary mechanisms of operation are accelerated chemical reactions in the soil surrounding the melt and pyrolysis zone (thermal zone adjacent to the melt); recovery of organic vapors in a vacuum hood situated above the soil treatment zone; pyrolysis of DNAPLs in the melt and pyrolysis zones; and pyrolysis of combustible vapors in the vacuum hood.

- *Effectiveness*
  ISV process is not a viable candidate for in situ cleanup for overburden DNAPL below the water table because the presence of water will stop progression of the melt unless groundwater recharge is cut off. Subsurface obstructions and features can interfere with operational efficiency of the ISV process.

- *Implementability*
  The availability of a commercial ISV system is limited.

- *Cost*
  Cost of ISV is high compared to other thermal process options.
- *Summary*
  ISV has limited commercially availability and has not been demonstrated for full-scale applications on contaminated soil. Therefore, it is screened from further evaluation.

3.5.8.5 Commercial Incineration of Overburden

Commercial incinerators capable of accepting soil and waste are generally the rotary kiln type. Rotary kilns can be used to treat liquids, semisolids, and heterogeneous and homogeneous solids. Constraints to application of commercial rotary kilns include available capacity and type of wastes that are acceptable.

- *Effectiveness*
  Commercial incinerators could effectively treat Necco Park overburden material.
- *Implementability*
  Excavation, transportation, and treatment at a commercial incinerator are implementable. The capacity of commercial incinerators is limited.
- *Cost*
  Cost for transportation and treatment at a commercial incinerator would be high compared to other thermal treatment process options.
- *Summary*
  Commercial incineration of overburden materials is eliminated from further evaluation because on-site thermal treatment process options are potentially as effective at significantly lower costs.

3.5.9 Overburden Biological Treatment

Biological treatment uses indigenous or introduced aerobic or anaerobic bacteria to biodegrade organic compounds in soil and/or groundwater. Biodegradation of soil for full-scale applications has been used on a limited basis to date. It has been used to successfully treat soil containing gasoline, nonhalogenated aliphatics, certain chlorinated compounds, and aromatics. Process options considered for this technology are in situ biological treatment and ex situ biological treatment.

3.5.9.1 Overburden In Situ Biological Treatment

In situ biological treatment involves enhancing naturally occurring microbial activities found in subsurface soil or introducing active cultures to degrade organic compounds. Breakdown and removal of constituents can be accelerated by adding oxygen or other electron acceptors, inorganic nutrients, and prepared microbial populations. This technology has been developing rapidly and is one of the most promising in situ treatment techniques.

- *Effectiveness*
  Presence of DNAPL in overburden would be toxic to microorganisms. Site contaminants and low-permeability overburden generally do not favor application of in situ biological treatment at Necco Park.
- *Implementability*
  Due to the presence of DNAPL, it may be difficult to maintain microorganisms in a toxic environment effectively.
- *Cost*
  Cost for in situ biological treatment includes labor and materials to apply the nutrient solution. Cost of in situ biological treatment is moderate compared to ex situ biological process options.
- *Summary*
  Subsurface conditions of overburden and presence of DNAPL limit this technology's effectiveness at Necco Park. In situ bioremediation of overburden materials is screened from further evaluation.

3.5.9.2 Overburden Ex Situ Biological Treatment

Biodegradation can be conducted on excavated soil and sediment using a soil slurry fed to a bioreactor. Microbes in the reactor are supplied with required growth factors, such as oxygen and nutrients. Retention time is based on types of substrates and required level of treatment. Many Necco Park compounds are difficult to degrade and will require a high retention time.

A second ex situ biological treatment option is land treatment. Overburden would be deposited as waste pile on a liner where soil is irrigated and given nutrients. Chemical constituents can potentially be biodegraded by indigenous and introduced bacteria. Key parameters for this type of treatment include adequate aeration, optimum temperature, moisture and nutrient contents, and presence of an appropriate microbial population.

- *Effectiveness*
  High concentrations of DNAPL constituents in overburden may inhibit microbial growth. Off-gases would have to be controlled when overburden material is excavated.
- *Implementability*
  Generation of an acceptable slurry for a bioreactor would be difficult. Use of land treatment would be limited by climatic conditions (e.g., the severe winter weather). Deposition of excavated overburden on land may be restricted by federal land disposal restrictions. Time required to degrade organic constituents would be extensive.
- *Cost*
  Cost for ex situ biological treatment includes labor for excavation and operation of bioreactors (either slurry or land treatment units). Slurry reactors are much more expensive than land treatment units because of sophisticated equipment and process control systems. Cost of ex situ biological treatment is high compared to in situ biological treatment.
- *Summary*
  Due to high concentrations of constituents expected in Necco Park overburden, it is unlikely that ex situ bioremediation can be effectively implemented. Ex situ bioremediation of overburden is screened from further evaluation.

3.5.10 Overburden Physical/Chemical Treatment

The following process options are included in physical/chemical treatment: soil-vapor extraction (SVE), soil flushing, soil washing, dual-phase extraction (DPE), in situ stabilization, ex situ stabilization, and vapor-phase treatment.

3.5.10.1 Overburden Soil-Vapor Extraction

In SVE, a vacuum is applied through extraction wells in the unsaturated zone to create a pressure gradient that induces VOCs to diffuse through the soil to extraction wells. These off-gases are then treated through a separate process.

SVE is generally applied only to the vadose zone and is applicable only for volatile compounds with a Henry's Law constant greater than $3x10^{-3}$ atm m^3/mole.

- *Effectiveness*
  SVE is most effective at removing low molecular weight volatile chemicals from homogeneous, permeable media. SVE is less effective at removing volatile chemicals from heterogeneous and low-permeability soil. SVE is not effective in removing volatile chemicals from the saturated zone unless it is used in conjunction with a lowering of the water table. Low permeability of Necco Park overburden and nonhomogeneous nature make it unlikely that this technology will be able to draw volatile compounds through the vadose zone effectively. SVE is not effective on metals and many semivolatile organic constituents.
- *Implementability*
  To achieve the required distribution of air, a large number of wells would have to be installed. Low permeability of the soil would make it difficult to draw air through vapor extraction wells. SVE would be difficult to monitor and control.
- *Cost*
  Cost for installing and operating the SVE system of extraction points and off-gas treatment is moderate compared to other physical/chemical treatment process options.
- *Summary*
  SVE is screened from further evaluation due to limited effectiveness in low-permeability soil and large percentage of constituents that will not be treated by this process option (including SVOCs).

3.5.10.2 Overburden In Situ Soil Flushing

Organic and inorganic contaminants can be washed in situ from contaminated soil using extraction processes commonly referred to as soil flushing, solvent flushing, ground leaching, or solution mining. During this process, water or an aqueous solution is injected into or sprayed onto the area of concern. The resulting elutriate is then collected and pumped to the surface for removal, recirculation, or treatment and reinjection. During elutriation, the flushing solution mobilizes sorbed constituents by dissolution or emulsification.

- *Effectiveness*
  Effectiveness of soil flushing operations depends on permeability of the surrounding media and sorption capacity of contaminants to the soil matrix. Flushing an organic phase normally requires use of a surfactant to reduce interfacial tension between constituent and soil. Heterogeneity and relatively low permeability of the soil will inhibit effectiveness of soil flushing at Necco Park. Mobilizing organic constituents by use of surfactants may enhance migration vertically into bedrock.

- *Implementability*
  Implementability of a soil flushing system also depends on permeability of surrounding media. Low relative permeability of Necco Park overburden will significantly increase the difficulty of implementing soil flushing.

- *Cost*
  Capital costs for soil flushing are moderate compared to other physical/chemical process options. O&M costs are moderate but depend on the flushing solution and treatment/disposal methods for extracted elutriate.

- *Summary*
  Soil flushing may mobilize contaminants that are sorbed onto overburden matrix and cause an uncontrolled release of organic constituents into fractured bedrock. Additionally, the nonhomogeneous and generally low-permeability nature of overburden make it difficult to control and monitor the effectiveness of the process. Therefore, soil flushing is screened from further evaluation.

3.5.10.3 Overburden Soil Washing

Soil washing refers to a wide range of physical/chemical treatment unit operations that separate and wash soil fractions. Soil is composed of rocks, pebbles, sand, and fine fractions. Soil particle-size and density-separation operations developed for the mining industry have recently been applied for remediation of contaminated soil. These separations generally concentrate constituents of interest in fine-grained fractions and heavier soil fractions. Soil-washing processes can also extract contaminants from soil fractions using a liquid medium such as water as a washing solution. This process can be used on excavated soil that is fed into a washing unit. The process is used for removing inorganic compounds and is being developed for organic compounds. Washing fluids may be composed of water, organic solvents, water/chelating agents, water/surfactants, acids, or bases, depending on constituents to be removed.

- *Effectiveness*
  Large fractions of fine soil particles (e.g., silt, clay) are difficult to remove from washing fluid and reduce the effectiveness of the process. A treatability study would be required to determine if soil washing could adequately remove organic constituents from excavated overburden.
- *Implementability*
  Soil-washing units are commercially available but would require significant modifications to remove organic compounds effectively.
- *Cost*
  Cost for soil washing includes labor for excavation and operation of the treatment unit. Soil washing is generally used for volume reduction prior to off-site disposal. Therefore, disposal costs are a significant factor when evaluating cost-effectiveness. The cost of soil washing is high compared to other physical/chemical treatment process options. Soil washing is generally not cost-effective if fine fractions are greater than 30 percent by weight of the soil because the fine fractions are generally disposed off-site.
- *Summary*
  Soil washing is screened from further evaluation because of the presence of organic constituents, high silt content, and high relative cost compared to other physical chemical treatment options.

3.5.10.4 Overburden Dual-phase Extraction

DPE uses a high vacuum (greater than 15 inches mercury) applied to a well to extract groundwater and volatilize and extract sorbed chemicals simultaneously. DPE is normally used to remove most VOCs and some SVOCs from low-permeability soil. One reason conventional pump-and-treat systems fail to achieve cleanup levels is due to organic chemicals in the zone of groundwater fluctuation (smear zone), which acts as a long-term source of chemical dissolution to groundwater. A DPE system creates a cone of depression in the groundwater table, exposing the smear zone and enabling organic constituent extraction through volatilization. Chemicals are also extracted from groundwater in the same manner as a conventional pump-and-treat system. Although dewatering highly conductive strata may be accomplished with a sufficient number of wells, experience suggests that DPE is most effective for strata of moderate to low hydraulic conductivities.

- *Effectiveness*
  DPE could potentially be effective for volatile constituents and some semivolatile constituents in overburden. Effect on metals would be limited to those metals dissolved in extracted groundwater.

- *Implementability*
  DPE units are commercially available. Because of extreme weather in the Niagara Falls area, the DPE system evaluated would not be operated during winter.

- *Cost*
  Costs to install a DPE system include labor to install extraction wells, header pipes, and vacuum extraction equipment. Material costs are generally low because polyvinyl chloride (PVC) wells and header pipes are adequate for temporary systems that are expected to remove constituents in five years or less. More durable materials of construction may be necessary for longer remediation time periods or where high concentrations of constituents are incompatible with PVC. Operating costs include labor, electricity, and treatment/disposal of extracted vapors. Vapor-phase treatment costs could be substantial and could include condensation and disposal off-site, carbon adsorption, or thermal oxidation. The cost for this technology is high compared to other physical/chemical process options because of high capital cost for installing the required number of wells and high O&M costs.

- *Summary*
  DPE is retained for further evaluation as a representative overburden in situ process option for organic constituent removal.

3.5.10.5 Overburden In Situ Stabilization

In situ stabilization is a process whereby chemical constituents are physically bound or enclosed within a stabilized mass or chemical reactions are induced between stabilizing agent and contaminants to reduce mobility. Agents are injected into soil or mixed with soil using paddle-type augers. A significant increase in volume may occur depending on stabilizing agents used and quantities required. Wastes may also be incompatible with selected processes. Treatability studies are required to ensure that desired results are achievable.

- *Effectiveness*
  Effective treatment of nonpolar organic compounds has been demonstrated under certain conditions (EPA 1994). Many organic constituents have been claimed to be effectively treated by stabilization, but little data is available for confirmation. Treatability studies are required to assess constituent effects on physical properties of the treated overburden mass.

  To date, in situ stabilization has not been specifically used for soil containing DNAPL. It is unknown whether DNAPL migration from the overburden treatment zone can be prevented by stabilization.

- *Implementability*
  In situ stabilization is implementable, uses readily available equipment, and has high throughput rates. Application in areas with large amounts of debris is more difficult. Air emission controls may be required for volatile organic vapors generated during stabilization.

- *Cost*
  Costs for in situ stabilization includes labor and equipment to inject and mix stabilization agents with soil. Batch cement mixing-type plants are required where the quantity of stabilization agent is significant. Stabilization agents are generally inexpensive cement and admixture materials. Cost of in situ stabilization is moderate compared to other physical/chemical treatment process options.

- *Summary*
  In situ stabilization is unproven for organic contamination and potentially difficult to implement because of large amounts of debris. Therefore, in situ stabilization is screened from further evaluation.

3.5.10.6 Overburden Ex Situ Stabilization

Ex situ stabilization consists of excavating material and adding stabilization agents in a pug mill. Contaminants are physically bound or enclosed within a stabilized mass, or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility. The following factors may limit the applicability and effectiveness of the process:

- A significant increase in volume may occur, depending on stabilizing agents used and quantities required.
- Wastes may be incompatible with selected processes. Treatability studies are required to ensure that desired results are achievable.

Ex situ stabilization is most successfully applied to inorganic constituents. The technology has limited effectiveness on halogenated and nonhalogenated SVOCs and pesticides. However, systems designed to be more effective against organic constituents are being developed and tested. Ex situ stabilization is relatively simple, uses readily available equipment, and has high throughput rates compared to other on-site technologies. As an ex situ remedy, excavation associated with stabilization poses a potential health and safety risk to site workers through skin contact and air emissions. Personnel protective equipment (PPE), at a level commensurate with the constituents involved, is normally required during excavation operations.

- *Effectiveness*
  Effective treatment of nonpolar organic compounds has been demonstrated under certain conditions. Many organic constituents have been claimed to be effectively treated by stabilization, but little data is available for confirmation. Treatability studies are required to assess constituent effects on physical properties of the treated overburden mass.
- *Implementability*
  Ex situ stabilization processes are among the most mature remediation technologies. Ex situ stabilization is relatively simple, uses readily available equipment, and has high throughput rates.
- *Cost*
  Cost for ex situ stabilization includes labor, equipment, and materials to excavate and mix stabilization agents with soil. Batch cement mixing-type plants are required where the quantity of stabilization agent is significant. Stabilization agents are generally inexpensive cement and admixture materials. Cost of ex situ stabilization is high compared to other physical/chemical process options.

- *Summary*
  Ex situ stabilization is ineffective for high levels of organic contamination. Therefore, this technology is screened from further evaluation for organic constituents. However, ex situ stabilization is retained as a potential treatment option for inorganic constituents, including stabilization of material after treatment for organic compound removal.

3.5.11 Overburden Vapor-phase Treatment

Overburden vapor-phase treatment refers to technologies that would be used to treat organic vapors generated from other treatment technologies (i.e., DPE and thermal desportion). Vapor-phase treatment may include one or more of the following process options: condensation and disposal off-site, carbon adsorption, or thermal oxidation. Condensation and disposal off-site and carbon adsorption are generally appropriate where small volumes of organic vapors are expected. Thermal oxidation is generally more cost-effective for larger quantities of organic vapors.

- *Effectiveness*
  Vapor-phase treatment can effectively remove or destroy organic vapors.
- *Implementability*
  Vapor-phase treatment technologies are commercially available. Air permits or their equivalents may be required.
- *Cost*
  Cost for vapor-phase treatment includes labor to install and operate the treatment unit. Costs for vapor-phase treatment equipment are fairly inexpensive. Operating costs could be significant, depending on the quantity of vapor requiring treatment, and could include off-site disposal, carbon replacement or regeneration, and fuel for thermal oxidation. Cost for vapor-phase treatment is moderate compared to other physical/chemical process options.
- *Summary*
  Vapor-phase treatment can effectively control vapors from other overburden treatment technologies and is retained for further evaluation.

3.5.12 Overburden Disposal

Disposal has the following process options: on-site and off-site landfill.

3.5.12.1 Overburden Disposal at an On-site Landfill

This process option requires excavation and stockpiling and/or treatment of overburden. A landfill would be constructed in the excavated area. This landfill would be constructed in compliance with applicable New York landfill regulations. The landfill would include a leachate collection system, a low-permeability liner, a gas collection system, and a low-permeability cap. Excavated soil would likely have to be treated prior to placement in the newly constructed landfill cell to comply with state and federal land disposal restrictions.

- *Effectiveness*
  Excavated soil would likely have to be treated prior to placement in the newly constructed landfill. During excavation and treatment, significant volatile emissions would have to be managed. Once placed, the landfill cell would be effective in containing waste material.
- *Implementability*
  A landfill cell would be implementable if waste material meets state and federal land disposal restrictions, which are ARARs for Necco Park.
- *Cost*
  Costs for constructing a Necco Park landfill include labor, materials, and equipment to install a liner system, leachate collection piping, and cap. The cost for constructing a Necco Park landfill would be moderate compared to off-site disposal process options.
- *Summary*
  The on-site landfill is retained for further evaluation in RAAs with ex situ treatment of overburden.

3.5.12.2 Overburden Disposal at Commercial Landfill

Excavated material could be deposited at a commercial landfill.

- *Effectiveness*
  Excavated soil would have to be treated prior to transport and placement in a commercial landfill to comply with state and federal land disposal restrictions. During excavation and treatment, significant volatile emissions would have to be managed. A commercial landfill would be effective in containing treated waste material.

- *Implementability*
  Disposal at a commercial landfill is implementable if material meets state and federal land disposal restrictions, which are ARARs for Necco Park.
- *Cost*
  Cost for transportation and disposal at a commercial landfill would be high compared to on-site disposal process options.
- *Summary*
  A commercial landfill is eliminated from further evaluation because on-site disposal process options for treated material are equally as effective at significantly lower costs.

3.5.13 Summary of Overburden Technology Process Option Evaluation

Table 3-7 provides a summary of the technology process option evaluation for overburden.

3.6 DNAPL Process Option Evaluation

DNAPL, for purposes of this evaluation, is defined as free-phase liquid organic constituents that are not bound chemically or by surface forces to soil or bedrock. Volume of DNAPL present in overburden and bedrock of the source area is unknown. For purposes of this media technology evaluation, DNAPL bound to soil or dissolved in the aqueous plume of the source area is not addressed in this section because it is addressed in Sections 3.5 (Overburden) and 3.7 (Source Area Groundwater), respectively.

DNAPL constituents at Necco Park were presented in Table 1-4. The DNAPL is primarily hexachlorobutadiene but also contains hexachloroethane, hexachlorobenzene, carbon tetrachloride, chloroform, PCE, 1,1,2,2-tetrachlorethane, and TCE. Additionally, DNAPL free-phase material potentially contains polychlorinated biphenols [(PCBs); PCB detection limits are above 50 parts per million (ppm) due to matrix interference] and must be handled and disposed in accordance with Toxic Substance Control Act (TSCA) regulations.

Currently DNAPL is recovered periodically as it accumulates in monitor and groundwater recovery wells (R-2 only) at Necco Park. DNAPL recovery has been occurring since 1989, and approximately 6,000 gallons of DNAPL have been recovered.

Remediation of DNAPL poses one of the most difficult challenges in the environmental engineering field. DNAPL is especially problematic due to low water solubility, high density, and capillary forces arising from interfacial tension between DNAPLs and water. As a result, conventional pump-and-treat technologies have had poor success in remediation of DNAPL-contaminated aquifers (EPA 1994).

The major problem with DNAPLs, in terms of remediation, is the fact that DNAPLs are often quite deep, making access and detection extremely difficult. Soil and bedrock heterogeneity is also an important factor affecting DNAPL fate and transport. Site stratigraphy affects the distribution of DNAPL in the subsurface, and contaminant distribution then plays a critical role in selection of the overall approach to remediation. Success of DNAPL remedial technologies is largely a factor of soil heterogeneity and the ability to favorably alter DNAPL properties to facilitate recovery or remediation (EPA 1994).

RAOs based on background water quality or MCLs will generally require that over 99 percent of DNAPL be treated or recovered. This standard by itself poses a significant technical challenge to many technologies under the most favorable conditions (EPA 1994). Residual DNAPL is difficult or impossible to completely remove due to adsorption and interfacial tension between DNAPL and water. Even small quantities of remaining DNAPL will continue to diffuse very slowly, forming an aqueous plume. Based on these factors, the complete remediation of sites with DNAPL in fractured bedrock is not technically possible.

The following subsections provide a comprehensive evaluation of conventional and current state-of-the-art technology process options to address treatment, mobilization, and recovery of free-phase DNAPL. Several evaluated technologies were not originally developed for remediation of DNAPL contaminated sites, and some have not been demonstrated. These factors must be considered when evaluating the potential viability of remedial process options (EPA 1994). A summary of the DNAPL technology process option evaluation is provided in Section 3.6.8.

3.6.1 No Action—DNAPL

Under the no action technology, all ongoing interim remedial measures, including pumping from recovery wells and DNAPL removal, would be halted. The clay cap and grout curtain would remain in place, but maintenance operations for the cap would be discontinued.

- *Effectiveness*
  The hypothetical no action technology would not be effective in achieving RAOs.
- *Implementability*
  The no action technology is easily implemented.
- *Cost*
  The no action technology has no additional costs associated with it.
- *Summary*
  Although the no action technology is not effective in achieving RAOs, it is retained for comparison purposes.

3.6.2 Access Restrictions—DNAPL

Deed restrictions and groundwater-use controls are the process options identified under the access restriction technology.

3.6.2.1 DNAPL Area Deed Restrictions

Deed restrictions limit certain activities at a property that may result in greater personal or environmental exposure to constituents of concern. Such restrictions would limit future actions in the designated area such as excavation.

- *Effectiveness*
  Deed restrictions would be effective in limiting future use of Necco Park, thereby limiting human contact with DNAPL.

- *Implementability*
  Deed restrictions could be implemented at Necco Park. A portion of the source area is owned by CECOS and BFI. These properties are used to manage sanitary and hazardous waste. Deed restrictions are in place in these areas.
- *Cost*
  The cost of deed restrictions is low.
- *Summary*
  Deed restrictions are retained for further evaluation.

3.6.2.2 Groundwater-Use Controls—DNAPL

Groundwater-use controls consist of local ordinances or state laws that control the use of water pumped and, hence, potential exposure to DNAPL. Currently, the Niagara County Health Department requires a permit to install a water well. No such permits have been issued for the source area or far field. This requirement supplements deed restrictions in the source area.

- *Effectiveness*
  Water-use controls are effective in restricting groundwater withdrawals and potential exposure to DNAPL.
- *Implementability*
  Water-use controls are currently in place.
- *Cost*
  Cost of water-use controls is low.
- *Summary*
  Water-use controls are retained for further evaluation.

3.6.3 DNAPL Monitoring

Monitoring for DNAPL can be accomplished through normal monitor wells using bottom sampling devices or nylon rope to gauge product thickness. DNAPL monitoring is presently conducted at Necco Park as part of a DNAPL recovery program.

- *Effectiveness*
  DNAPL monitoring is effective in detecting DNAPL near groundwater wells. DNAPL outside the influence of the wells will not be detected.

- *Implementability*
  DNAPL monitoring is implementable.
- *Cost*
  Cost of DNAPL monitoring is low.
- *Summary*
  DNAPL monitoring is retained for incorporation with potential DNAPL removal technologies.

3.6.4 DNAPL Vertical Barriers

The term vertical barriers refers to a variety of methods whereby low-permeability cutoff walls or diversions are installed below the ground surface to contain chemical constituents in overburden and bedrock. The most commonly used subsurface barriers are slurry walls, grout curtain, and sheet piling cutoff walls.

3.6.4.1 DNAPL Vertical Barriers—Slurry Walls

Slurry walls are the most common subsurface barriers under appropriate conditions because they are a relatively inexpensive means of containing DNAPL. The term slurry wall can be applied to a variety of barriers that are constructed in a vertical trench that is excavated under a slurry. The slurry, usually a mixture of bentonite and water, is a high-density fluid that hydraulically shores the trench to prevent collapse and, at the same time, forms a filter cake on the trench walls to prevent high fluid losses into the surrounding soil. Most commonly, a soil mixture is blended with bentonite slurry and placed in the trench to form a soil-bentonite backfill wall with a resulting permeability of 1×10^{-6} to 1×10^{-8} cm/s. In some cases, the trench is excavated under a slurry of Portland cement, bentonite, and water. This mixture is left in the trench to harden into a cement-bentonite slurry wall. Of the major types of slurry walls, soil-bentonite walls offer lowest installation cost, widest range of chemical compatibility, and lowest permeability. Soil-bentonite walls also have high compressibility (low strength), require a large work area and, because slurry and backfill can flow, are applicable only to areas that can be graded to nearly level.

- *Effectiveness*
  DNAPL has been detected in both overburden and fractured bedrock. Slurry walls are not appropriate for fractured bedrock. Therefore, this process option may only be effective in limiting the horizontal migration of DNAPL in overburden under applicable conditions.

  Data has indicated minimal horizontal migration of DNAPL in overburden [i.e., DNAPL has not been identified at any new or existing well location outside of those wells where DNAPL had been observed previously (WCC 1991)]. Potential for horizontal migration of groundwater and DNAPL through cracks or capillary spaces in overburden may be reduced by a slurry wall. However, slurry walls would have no impact on the vertical migration of groundwater or DNAPL, the primary pathway of constituent migration from overburden.

  A slurry wall may be constructed in the path of DNAPL migration instead of completely surrounding an area. Potential exists for DNAPL to be isolated outside of a slurry wall, depending on wall location.

  Where possible, slurry walls are keyed into an underlying confining zone. No underlying confining layer that could be used to seal off DNAPL migration exists at Necco Park; thus, the slurry wall's effectiveness will be reduced.

- *Implementability*
  Constructing a slurry wall is not technically complex. However, significant design and work activities geared toward protecting Necco Park workers and minimizing exposure potential for receptors beyond the Necco Park boundary would be required. Installing a slurry wall in overburden is moderately difficult, but keying the slurry wall into bedrock, if required, is more difficult and increases costs.

- *Cost*
  Costs for slurry wall installation include labor and equipment for excavating, mixing, and emplacing soil and bentonite. Material costs are associated with cost of bentonite and possibly soil if site soil is not suitable for backfill. Disposal costs may be significant if excavated soil is not consolidated on-site. Relative cost of a slurry wall is low compared to other vertical barrier process options if site soil can be used in backfill mixture. Costs are moderate if off-site soil is required for the backfill mixture.

- *Summary*
  Slurry walls as containment for DNAPL in overburden are retained for further evaluation. Slurry walls are not implementable in bedrock and are therefore eliminated from further consideration for bedrock.

3.6.4.2 DNAPL Vertical Barriers—Grout Curtains

Grout curtains refer to a technology whereby one of a variety of fluids is injected or mixed with a soil mass or injected into bedrock. The fluid sets in place and reduces water flow and/or strengthens the formation. Primary objective of grouting is to fill voids in overburden or bedrock to create a low-permeability zone. Grout curtains formulated from cement, clay, bentonite, alkali silicates, silicates, or organic polymers may be used to reduce DNAPL flow and constituent mobility. Selection of grout constituents depends on chemistry of the facility's constituents and porosity of the area to be grouted. Grouted barriers are seldom used for controlling constituent migration in unconsolidated materials because of high cost.

Grout curtains can be constructed in overburden through permeation grouting, jet grouting, or soil mixing. Grout curtains in bedrock would be constructed by pressure grouting. Permeation grouting involves filling soil voids with grout. Permeability of the soil, viscosity of the grout, and size of particulates in the grout must be considered. Soil permeability is controlled by the grain size, which affects the average void size. Viscosity of the grout is dependent on the type of grout and how it is mixed. In general, particulate grouts have much higher viscosity than chemical grouts.

There are two main methods of soil permeation grouting, point injection and sleeve pipe injection. In the point injection method, a casing is driven to full depth then withdrawn to the desired depth, and grout is injected. In the sleeve pipe method, a sleeve pipe is placed in a grout hole and sealed in place by a clay-cement mixture. The pipe has small holes at 1-foot intervals through which grout is pushed. The holes are covered by rubber sleeves, or manchettes, which act as one-way valves and open when the grout is pressurized. To inject grout, a double packer attached to a smaller-diameter grouting pipe is inserted into the sleeve pipe centered on a sleeve hole, the pipe is pressurized, and grout is forced through the sleeve hole and into the soil. The resultant permeability of permeation-grouting cutoff walls is approximately 1 x 10^{-7} cm/s.

Jet grouting of soil involves the use of grout alone, grout and air, or a combination of grout, air, and water delivered by a small jet, or jets, in the drill rod at very high pressures that often reach 5,000 to 6,000 psi. After advancing the drill rod to the desired depth, the rod is lifted and rotated as jetted grout cuts away soil and creates a large cylindrical hole. Portland cement or cement-bentonite grouts are generally used when jet grouting. Cement grout mixes with soil to form a soil and cement mixture (or soilcrete) column in the ground. The excess water and soil are forced to the surface around the drill rod. The resultant permeability of a jet-grouted grout curtain is 1 x 10^{-7} cm/s or less.

Soil mixing has been employed to construct vertical barriers. A special auger mixing shaft is rotated into the ground while simultaneously permitting injection of bentonite and water, or cement, bentonite, and water slurry. Multiple mixing shafts are usually employed. A continuous wall, typically from 20 to 36 inches wide, is obtained by overlapping penetrations. Bentonite is added to the mixed soil in the form of bentonite-water slurry. As a result, the bentonite content of the mixed soil is typically about 1 percent. The resultant permeability of a soil-mixed vertical barrier is approximately 1 x 10^{-7} cm/s.

In bedrock, grout curtains are constructed by pressure grouting. The existing Necco Park grout curtain was constructed using a single-line, split-spacing pressure grouting method. This was accomplished by drilling and grouting vertical holes. Primary holes were placed on 40-foot centers, with spacing becoming progressively smaller through quaternary holes on 5-foot centers.

- *Effectiveness*
  Grout curtains may be effective in controlling DNAPL flow through voids in soil or bedrock. The main concern with grouting to achieve low permeability is complete filling of void spaces with grout and control of the lateral extent of grout penetration. Both of these tasks

are very difficult and require experience to control. Grout pumped at excessively high pressure can cause hydrofracturing of soil.

Jet grouting and soil mixing are more effective than permeation grouting for soil materials. These installation methods form effective vertical barriers for most constituents, but compatibility testing is necessary to select the proper grout mix.

A grout curtain may be constructed in the path of DNAPL migration instead of completely surrounding an area. Potential exists for DNAPL to be isolated outside of a grout curtain depending on the grout curtain location.

Grout curtains constructed by pressure grouting may be effective in controlling lateral DNAPL flow in bedrock.

- *Implementability*
  Soil and bedrock grouting are implementable.
- *Cost*
  The cost of installing a grout curtain includes mobilization and demobilization, drilling, disposal of drill cuttings, and purchase, mixing, and injection of grout material. O&M costs will be low. The overall cost of groundwater installation for soil is high relative to other vertical barrier process options.
- *Summary*
  Slurry walls are easier to install in the overburden, can be constructed with lower permeability, and cost less than grout curtains. Therefore, grout curtains in the overburden will be screened from further evaluation.

  Grout curtains in bedrock constructed by pressure grouting are retained for further evaluation.

3.6.4.3 DNAPL Vertical Barriers—Sheet Piles

Sheet piling may be used to form a barrier to DNAPL flow under appropriate conditions and when installed properly. Generally, steel or HDPE sheet piles are the most effective for DNAPL cutoff. However, sheet piles cannot be constructed in bedrock. Therefore, this screening evaluation will only consider steel and

HDPE sheet-piling materials for the overburden area. The in-place permeability of a geomembrane cutoff wall is 1×10^{-7} cm/s or less.

- *Effectiveness*
  Sheet piles are interlocking piles that form a continuous low-permeability wall when properly installed. When the wall is stressed laterally, the interlock forms a mechanical seal. While sheet piles are used for permanent waterfront structures, they are most commonly used for temporary support during construction features such as cofferdams or to keep trenches open.

  There are drawbacks to using sheeting at a hazardous waste impoundment. If the interlocks are not sealed, a route for groundwater and DNAPL migration remains, and the effectiveness of the wall as a barrier will be reduced. For temporary structures, joint leaks are acceptable because infiltration is controlled by construction dewatering. However, joint leaks are generally not acceptable for permanent environmental applications. Grouting of interlocks may be required for steel sheet piles to reduce permeability. HDPE sheet-pile interlocks are generally sealed with plastic material compatible with waste constituents.

  Sheet piles must be driven into a confining layer to ensure complete containment. DNAPL could migrate from the source area beneath sheet piling because the sheet piles cannot be driven into the underlying bedrock at Necco Park. Excavation of overburden and installation of sheet piles would be necessary to key into bedrock. This would be more difficult and costly to implement than typical driven sheet installations.

  Sheet piles may be constructed in the path of DNAPL migration instead of completely surrounding an area. Potential exists for DNAPL to be isolated outside of a sheet pile area, depending on its location.

  Steel sheet piles may also corrode, making the barrier ineffective over time. Adequate corrosion protection may be required for steel sheet piles.

- *Implementability*
  The ability to drive or vibrate sheets is determined by the nature of the overburden material through which the sheets are driven. Glacial till of the overburden contains rocks and boulders, thus making it difficult to install sheet piles at Necco Park. Boulders prevent the driving of sheet piles or knock the piles out of interlock, potentially forming open pathways for groundwater or DNAPL migration.

- *Ccst*
  Cost to purchase and install sheet piles is high when compared to other vertical barriers such as slurry walls.

- *Summary*
  The slurry wall is a more implementable and effective technology for Necco Park overburden than sheet piles. Sheet piles in overburden are screened from further evaluation due to the presence of boulders in overburden and related installation difficulties. Sheet piling is not implementable in bedrock. Therefore, sheet piling is screened from further evaluation for bedrock.

3.6.5 DNAPL Extraction

Two process options are considered for DNAPL extraction: extraction wells and trenches.

3.6.5.1 DNAPL Extraction Wells

Extraction wells, either horizontal or vertical, may be used to recover DNAPL. No proven remedial technologies exist that can completely remove subsurface DNAPL in reasonable time frames (EPA 1993). Though conventional pump-and-treat methods have had generally poor success in DNAPL remediation (EPA 1994), limited DNAPL removal has been accomplished through an existing groundwater recovery well (RW-2) at Necco Park. This recovery well is located in a known DNAPL area. Pumping water from this well is believed to draw DNAPL droplets into the well where they settle, coalesce, and accumulate.

Generally, locating pockets of mobile DNAPL in overburden or fractured bedrock is difficult. Residual quantities of DNAPL cannot be completely removed because DNAPL may diffuse into and sorb onto the porous interfracture matrix (Parker et al 1994). Thus, DNAPL adsorbed to bedrock will act as a continuing source of groundwater contamination.

Currently, DNAPL is recovered as it accumulates from monitor and recovery wells at Necco Park, mainly well RW-2. Testing of an overburden pilot DNAPL recovery well (PNRW-1) and overburden monitor wells accumulating DNAPL (VH-131A and VH-139A) indicate DNAPL can be recovered from overburden wells, but recovery rates will be low, on the order of a few gallons per month. Top-of-bedrock NAPL bedrock pilot recovery well (PNRW-2) did not accumulate DNAPL. From split-spoon sampling and drainage examination, it appears DNAPL in overburden is primarily located within the lower portion of the fill and within underlying reworked clay. Some DNAPL will drain from the fill and clay, based on samples from NB-10 and NB-20 and the measured yields from wells VH-131A, VH-139A, and PNRW-1. However, rate of DNAPL accumulation will be limited by the low hydraulic conductivity of these materials.

In bedrock, DNAPL appears to enter monitor wells very slowly from bedding-plane fractures. Monitor wells were drilled 5 feet into competent rock below the water-bearing fracture zone to be monitored. The bottom 5 feet of these wells tend to act as accumulation sumps for DNAPL entering the wells. DNAPL droplets entering wells from water-bearing fractures will sink to the bottom and accumulate.

Conventional pump-and-treat methods have limited success in remediation of DNAPL (EPA 1994). Locating and removing pockets of DNAPL in bedrock is difficult. However, limited DNAPL recovery from bedrock may be accomplished in known DNAPL areas by pumping water, which entrains DNAPL droplets and draws them into the well where they settle, coalesce, and accumulate. Comparatively little DNAPL recovery is possible by pumping only DNAPL from the bottom of bedrock wells as demonstrated by the pilot top-of-bedrock NAPL recovery well (PNRW-2). Well location or orientation may enhance recovery.

DNAPL recovery has been conducted at Necco Park since 1989. Approximately 6,000 gallons of DNAPL have been recovered from a network of monitor and recovery wells where a recoverable volume of DNAPL has been observed historically.

- *Effectiveness*
  Extraction wells are capable of removing small volumes of DNAPL, relative to the total volume of DNAPL at Necco Park. This technology cannot address DNAPL that does not occur near a recovery well because the zone of influence for DNAPLs is generally very small. It will also not recover DNAPL that is sorbed onto soil or moved in fractured rock.
- *Implementability*
  DNAPL recovery, as presently conducted or with additional wells, is implementable.
- *Cost*
  Costs for DNAPL extraction wells are moderate compared to other extraction process options.
- *Summary*
  DNAPL recovery using extraction wells is retained for further evaluation.

3.6.5.2 DNAPL Extraction Trenches

DNAPL can be recovered from overburden soil using recovery trenches. Trenches are not considered for recovery of DNAPL from bedrock zones because of implementability difficulties.

- *Effectiveness*
  Trenches could potentially cover a larger area than extraction wells. Trenching to recover DNAPL from overburden requires excavation through waste material, which will require organic vapor control and worker protection. This technology cannot address DNAPL that does not occur near a trench.
- *Implementability*
  DNAPL recovery through the use of a recovery trench is implementable. Installation of trenches through areas containing boulders or debris would be difficult. Special construction techniques

would be required to prevent trench collapse (i.e., sheeting, shoring, or slurry excavation techniques). Soil generated during excavation would require disposal.

- *Cost*
  Capital costs for recovery trenches are moderate compared to other extraction technologies.
- *Summary*
  DNAPL extraction trenches are retained for further evaluation.

3.6.6 DNAPL Thermal Treatment

The following thermal process options have been evaluated for free-phase DNAPL removal and treatment: RF heating, ISV, and commercial incineration.

3.6.6.1 DNAPL Radio Frequency Heating

RF heating is an enhanced recovery process that uses electromagnetic energy to accomplish subsurface heating, thereby enhancing contaminant removal. Primary removal mechanisms, which depend on the actual heating strategy, are vaporization of low boiling point organic compounds and water; enhancement of evaporation rates of higher boiling point organic compounds; partial or complete displacement of heated pore fluids by a propagating steam condensation front; partial or complete displacement of all contactable DNAPLs by the propagating steam front; and/or enhanced pore liquid mobilization resulting from liquid density and viscosity alterations.

- *Effectiveness*
  RF heating may not be effective in the saturated zone. Some higher boiling point constituents may not be effectively removed by this process. No application of this process option has been completed in the saturated zone or, specifically, on DNAPL.
- *Implementability*
  The RF heating technology has limited availability.
- *Cost*
  The cost of radio frequency heating is high compared to other thermal treatment process options.

- *Summary*
  RF heating is not a proven technology for DNAPLs. Some constituents with high boiling points may not be effectively treated by this process. RF heating is screened from further evaluation.

3.6.6.2 DNAPL In Situ Vitrification

ISV is a process that relies on joule resistance heating and consequent melting of overburden material and DNAPL to enhance contaminant removal and destruction. Primary mechanisms are accelerated chemical reactions in the soil surrounding the melt and pyrolysis zone (thermal zone adjacent to the melt); recovery of organic vapors in a vacuum hood situated above the soil treatment zone; pyrolysis of DNAPLs in the melt and pyrolysis zones; and pyrolysis of combustible vapors in the vacuum hood.

- *Effectiveness*
  The ISV process is not a viable candidate for in situ cleanup for overburden DNAPL below the water table because the presence of water will stop the progression of the melt unless groundwater recharge is cut off. Subsurface obstructions and features can interfere with operational efficiency of the ISV process.
- *Implementability*
  The availability of a commercial ISV system is limited.
- *Cost*
  Cost of ISV is high compared to other thermal process options.
- *Summary*
  In situ vitrification has limited commercially available and has not been demonstrated for full-scale applications of DNAPL treatment. Therefore, it is screened from further evaluation.

3.6.6.3 Commercial Incineration of DNAPL

Off-site commercial incinerators are currently used to thermally destroy DNAPL collected at Necco Park. A RCRA- and TSCA-permitted incinerator is required because DNAPL potentially contains PCBs (PCB detection limits are greater than 50 ppm due to matrix interference).

- *Effectiveness*
  Commercial incinerators can effectively treat the Necco Park DNAPL.
- *Implementability*
  Transportation and treatment at a commercial incinerator are implementable. However, a RCRA-and TSCA-permitted incinerator must be used because DNAPL is considered a hazardous waste that potentially contains PCBs. Therefore, off-site capacity is limited to those incinerators permitted through both TSCA and RCRA authority.
- *Cost*
  Unit cost for disposing of DNAPL at a commercial incinerator would be high compared to on-site treatment process options. However, because the expected volume of DNAPL generated is low, lack of capital expenditure make this process option moderate in cost.
- *Summary*
  Commercial incineration of recovered DNAPLs is retained for further evaluation.

3.6.7 DNAPL Physical/Chemical Treatment

The following process options are included in physical/chemical treatment: SVE, soil flushing, soil washing, DPE, air sparging, in situ stabilization, ex situ stabilization, and vapor-phase treatment.

3.6.7.1 DNAPL Soil-Vapor Extraction

In SVE, a vacuum is applied through extraction wells in the unsaturated zone to create a pressure gradient that induces VOCs to diffuse through soil to the extraction wells. These off-gases are then treated through another process. SVE generally applies only to the vadose zone and is applicable only to volatile compounds with a Henry's Law constant greater than $3x10^{-3}$ atm-m^3/mole.

- *Effectiveness*
  SVE is most effective at removing low molecular weight volatile chemicals from homogeneous, permeable media. SVE is less effective at

removing volatile chemicals from heterogeneous and low-permeability soil. SVE is not effective in removing volatile chemicals from the saturated zone unless it is used in conjunction with a lowering of the water table. The low permeability of the Necco Park overburden and the nonhomogeneous nature make it unlikely that this technology will be able to draw volatile compounds through the vadose zone effectively. SVE is not effective on metals and many SVOCs.

- *Implementability*
  To achieve the needed distribution of air, a significant number of wells would have to be drilled. The low permeability of the soil would make it difficult to draw air through the vapor extraction wells. SVE would be difficult to monitor and control.

- *Cost*
  The cost for installing and operating the SVE system of extraction points and off-gas treatment is moderate compared to other physical/chemical treatment process options.

- *Summary*
  SVE is screened from further evaluation due to limited effectiveness in low-permeability soil and the large percentage of constituents that will not be treated by this process option, including SVOCs.

3.6.7.2 DNAPL In Situ Surfactant Flushing

Organic and inorganic contaminants may be washed in situ from contaminated soil under appropriate conditions using extraction processes commonly referred to as surfactant soil flushing, solvent flushing, ground leaching, or solution mining. During this process, water or an aqueous solution is injected into or sprayed onto the area of concern. The resulting elutriate is then collected and pumped to the surface for removal, recirculation, or treatment and reinjection. During elutriation, the flushing solution mobilizes sorbed contaminants by dissolution or emulsification.

- *Effectiveness*
  Effectiveness of surfactant flushing operations depends on permeability of the surrounding media and sorption capacity of chemical constituents to the soil matrix. Flushing an organic phase normally requires the use of a surfactant to reduce interfacial tension between constituent and soil. Heterogeneity and relatively low permeability of soil will inhibit

effectiveness of surfactant flushing at Necco Park. Mobilizing organic constituents by use of surfactants may enhance migration vertically into bedrock.

- *Implementability*
  Implementability of a surfactant flushing system also depends on permeability of the surrounding media. The low relative permeability of Necco Park overburden will significantly increase the difficulty of implementing surfactant flushing.

- *Cost*
  Capital costs for surfactant flushing are moderate compared to other physical/chemical process options. O&M costs are moderate but depend on the flushing solution and the treatment/disposal methods for the extracted elutriate.

- *Summary*
  Surfactant flushing may mobilize contaminants that are sorbed onto overburden matrix and cause an uncontrolled release of organic constituents into fractured bedrock. Additionally, the nonhomogeneous nature of the overburden makes it difficult to control the process. Therefore, surfactant flushing is screened from further evaluation.

3.6.7.3 DNAPL Dual-phase Extraction

DPE uses a high vacuum (greater than 15 inches mercury) applied to a well to extract groundwater and volatilize and extract sorbed chemicals simultaneously. DPE is normally used to remove most VOCs and some SVOCs from low-permeability soil. Conventional pump-and-treat systems fail to achieve cleanup levels because organic chemicals may have accumulated in the zone of groundwater fluctuation (smear zone), which acts as a long-term source of chemical dissolution to groundwater. A DPE system creates a cone of depression in the groundwater table, exposing the smear zone and enabling organic constituent extraction through volatilization. Chemicals are also extracted from groundwater in the same manner as a conventional pump-and-treat system. Although dewatering highly conductive strata may be accomplished with a sufficient number of wells, limited experience suggests that DPE is most effective for strata of moderate to low hydraulic conductivities.

- *Effectiveness*
  DPE could potentially be effective for volatile constituents and some semivolatile constituents in the overburden. The effect on metals would be limited to those dissolved in extracted groundwater. The effectiveness in recovering free-phase DNAPL has not been proven.
- *Implementability*
  DPE units are commercially available.
- *Cost*
  Cost for this technology is high compared to other physical/chemical process options because of high capital cost for installing the required number of wells and high O&M costs.
- *Summary*
  DPE is retained for further evaluation as a representative in situ process option for DNAPL volatilization and removal.

3.6.7.4 DNAPL In Situ Stabilization

In situ stabilization is a process whereby chemical constituents are physically bound or enclosed within a stabilized mass or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility. Agents are injected into soil or mixed with soil using paddle-type augers. In situ stabilization technology is only applicable for soil and therefore will only address DNAPL in overburden and not affect DNAPL in bedrock zones. A significant increase in volume may occur, depending on stabilizing agents used and quantities required. Wastes may also be incompatible with selected processes. Treatability studies are required to ensure that desired results are achievable.

In situ stabilization is evaluated as follows:

- *Effectiveness*
  Effective treatment of nonpolar organic compounds has been demonstrated under certain conditions. However, many organic constituents have been claimed to be effectively treated by stabilization, but little data is available for confirmation. Treatability studies are

required to assess constituent effects on physical properties of the treated overburden mass.

To date, in situ stabilization has not been specifically used for soil containing DNAPL. It is unknown whether DNAPL migration from the overburden treatment zone can be prevented by stabilization. In situ stabilization will not affect DNAPL in bedrock zones.

- *Implementability*
  In situ stabilization is relatively simple, uses readily available equipment, and has high throughput rates. Application in areas with large amounts of debris is more difficult. Air emission controls may be required for volatile organic vapors generated during stabilization.
- *Cost*
  Cost for in situ stabilization includes labor and equipment to inject and mix stabilization agents with soil. Batch cement mixing-type plants are required where the quantity of stabilization agent is significant. Stabilization agents are generally inexpensive cement and admixture materials. Cost of in situ stabilization is moderate compared to other physical/chemical treatment process options.
- *Summary*
  In situ stabilization is unproven for free-phase organic constituents and is potentially difficult to implement because of large amounts of debris. Therefore, in situ stabilization is screened from further evaluation.

3.6.7.5 DNAPL Vapor-phase Treatment

DNAPL vapor-phase treatment refers to technologies that would be used to treat organic vapors generated from other treatment technologies (i.e., DPE). Vapor-phase treatment may include one or more of the following process options: condensation and disposal off-site, carbon adsorption, or thermal oxidation. Condensation and disposal off-site and carbon adsorption generally are appropriate where small volumes of organic vapors are expected. Thermal oxidation is generally more cost-effective for larger quantities of organic vapors.

- *Effectiveness*
  Vapor-phase treatment can effectively remove or destroy organic vapors.

- *Implementability*
  Vapor-phase treatment technologies are commercially available. Air permits or their equivalents may be required.
- *Cost*
  Cost for vapor-phase treatment includes labor to install and operate the treatment unit. Costs for vapor-phase treatment equipment are fairly inexpensive. Operating costs could be significant, depending on the quantity of vapor requiring treatment and could include off-site disposal, carbon replacement or regeneration, and fuel for thermal oxidation. Cost for vapor-phase treatment is moderate compared to other physical/chemical process options.
- *Summary*
  Vapor-phase treatment can effectively control vapors from other DNAPL treatment technologies and is retained for further evaluation.

3.6.8 Summary of DNAPL Technology Process Option Evaluation

Table 3-8 provides a summary of the technology process option evaluation for DNAPL.

3.7 Source Area Groundwater Process Option Evaluation

Source area groundwater is defined as groundwater in overburden and bedrock in areas where DNAPL has been observed or aqueous concentrations may be indicative of DNAPL (i.e., solubility criteria were met). Estimated areal extent of source area groundwater was presented in Figure 1-28. Actual observations of free-phase DNAPL have been limited to overburden (A zone) and upper and middle bedrock zones (B through F zones) in the general vicinity of Necco Park. Solubility criteria indicates potential presence of DNAPL in lower bedrock (G zone) and expands the source area groundwater in B through F bedrock zones to just south of the CECOS landfill cells.

Potential presence of DNAPL will likely make the first RAO—restoration of groundwater to its designated use, potable drinking water, as impacted by Necco Park constituents—difficult or impossible to achieve in a reasonable time frame for source area groundwater (EPA 1994). As discussed in Section 3.6, RAOs based on background water quality or MCLs will generally require that over 99 percent of DNAPL in the source area be treated or recovered. This standard by itself poses a significant challenge to many technologies under most favorable conditions (EPA 1994). Low-permeability soil and bedrock increase the level of difficulty for restoring aquifers. Residual DNAPL is impossible to completely remove due to adsorption and interfacial tension between DNAPL and water. Even small quantities of residual DNAPL will continue to diffuse very slowly over time into the aqueous plume.

Control measures within source area groundwater will mainly focus on limiting constituent migration to minimize impact on far-field groundwater. In general, these control measure process options are the same as aquifer restoration process options (i.e., in situ and pump-and-treat technologies).

Groundwater treatment technologies considered will address Necco Park aqueous indicator parameters in Table 1-3. Groundwater indicator parameters include inorganic, volatile organic, and semivolatile organic constituents. Primary inorganic constituents are barium and chloride. VOCs are primarily chlorinated derivatives of methane and ethane. SVOCs include hexachlorobenzene, hexachlorobutadiene, hexachloroethane, phenol, methyl phenol, and chlorinated phenolic constituents.

Recovery wells RW-1 and RW-2 have been removing source area groundwater from B and C-zones since 1982. As discussed in Section 1.7.3, and shown in Figures 1-14 and 1-16, operation of these wells and subsequent installation of the upgradient grout curtain have resulted in zones of influence that encompass the majority of the source area in these zones. Monitor well data also demonstrates that groundwater recovery in the B and C zones has reduced and prevented most far-field migration of dissolved Necco Park constituents (see Section 1.8.4).

A review of applicable technologies for Necco Park source area groundwater has been conducted and subjected to the evaluation process. A detailed discussion of the evaluation follows. A summary of the source area groundwater technology process option evaluation is provided in Section 3.7.12.

3.7.1 No Action—Source Area Groundwater

Under the no action technology, all ongoing existing response measures would be halted. The clay cap and grout curtain would remain in place, but maintenance operations for the cap would be discontinued. Current pumping and treatment of groundwater would be discontinued as well as groundwater monitoring.

- *Effectiveness*
  The no action technology would not be effective in achieving RAOs. This technology is not effective.
- *Implementability*
  By its nature, the no action technology is easily implemented.
- *Cost*
  The no action technology has no additional costs associated with it.
- *Summary*
  Although the no action technology is not effective in achieving RAOs, it is retained for comparison purposes as required by the NCP.

3.7.2 Source Area Groundwater Monitoring

To verify the nature and extent of contamination and to track the movement, degradation, and alteration of contaminants as they move from Necco Park, a groundwater monitoring program has been implemented. Existing source area monitor wells have been sampled and analyzed on a regular basis during interim remedial actions and remedial investigations. Groundwater elevations from monitor wells and piezometers are also used to evaluate hydraulic control for the existing source area groundwater extraction system.

- *Effectiveness*
  Groundwater monitoring will not be effective in attaining RAOs. However, groundwater monitoring may be used in conjunction with other technologies to monitor effectiveness of RAAs.
- *Implementability*
  Groundwater monitor wells can be sampled and measured on a regular basis. Groundwater monitoring is readily implementable.
- *Cost*
  Relative cost of groundwater monitoring is low compared to other institutional action technologies.

- *Summary*
  Although groundwater monitoring technology is not effective in achieving RAOs, it is retained for incorporation into RAAs.

3.7.3 Source Area Groundwater Access Restrictions

Two process options were evaluated for access restriction technology: deed restrictions and water-use controls.

3.7.3.1 Source Area Groundwater Deed Restrictions

Deed restrictions limit certain activities at a property that may result in greater personal or environmental exposure to the constituents of concern. Such restrictions would limit future actions in the designated area, such as well drilling other than for remediation purposes.

- *Effectiveness*
  Deed restrictions would be effective in limiting future activities in the source area.
- *Implementability*
  Deed restrictions could be implemented at Necco Park. A portion of the source area is owned by CECOS and BFI. These properties have been and are presently used to manage sanitary and hazardous wastes. Deed restrictions are in place in these areas.
- *Cost*
  Cost of deed restrictions would be low compared to other access restriction technologies.
- *Summary*
  Deed restrictions are retained for further evaluation.

3.7.3.2 Source Area Groundwater-Use Controls

Groundwater-use controls consist of local ordinances or state laws that limit use of water pumped from a well in a designated area. Currently, the Niagara County Health Department requires a permit to install a water well. No such permits have been issued for the source area or far field. This requirement supplements deed restrictions in the source area.

- *Effectiveness*
  Water-use controls are effective in controlling groundwater withdrawals in the source area.
- *Implementability*
  Water-use controls are currently in place.
- *Cost*
  Cost of water-use controls would be low.
- *Summary*
  Water-use controls are retained for further evaluation.

3.7.4 Source Area Groundwater Vertical Barriers

Vertical barriers are a variety of methods whereby low-permeability cutoff walls or diversions are installed below ground surface to contain chemical constituents. Most commonly used subsurface barriers are slurry walls, grout curtains, and sheet piling cutoff walls.

3.7.4.1 Source Area Groundwater Vertical Barriers—Slurry Walls

Slurry walls are the most common subsurface barriers because they are a relatively inexpensive means of controlling groundwater mobility. The term slurry wall can be applied to a variety of barriers that are constructed in a vertical trench that is excavated under a slurry. Slurry, usually a mixture of bentonite and water, is a high-density fluid that hydraulically shores the trench to prevent collapse and, at the same time, forms a filter cake on trench walls to prevent high fluid losses into surrounding soil. Most commonly, a soil mixture is blended with bentonite slurry and placed in the trench to form a soil-bentonite backfill wall with a resulting permeability of 1×10^{-6} to 1×10^{-8} cm/s. In some cases, the trench is excavated under a slurry of Portland cement, bentonite, and water. This mixture is left in the trench to harden into a cement-bentonite slurry wall. Of the major types of slurry walls, soil-bentonite walls offer lowest installation costs, widest range of chemical compatibilities, and lowest permeabilities. Soil-bentonite walls have high compressibility (low strength), require a large work area and, because the slurry and backfill can flow, are applicable only to areas that can be graded to nearly level.

- *Effectiveness*
  Source area groundwater exists in both overburden and fractured bedrock. Slurry walls are not appropriate for fractured bedrock. Therefore, this process option might only be effective in limiting the horizontal migration of groundwater in overburden.

  Potential for horizontal migration of groundwater through cracks or capillary spaces in overburden may be reduced by a slurry wall. However, slurry walls would have no impact on vertical migration of groundwater, the primary pathway of constituent migration from the overburden aquifer.

  Wherever possible, slurry walls are keyed into an underlying confining zone. No underlying confining layer that could be used to seal off groundwater migration exists at Necco Park; thus, slurry wall effectiveness will be reduced.

- *Implementability*
  Constructing a slurry wall is not technically complex. However, significant design and work activities geared toward protecting Necco Park workers and minimizing exposure potential for receptors beyond the Necco Park boundary would be required. Installing a slurry wall in the overburden is moderately difficult, but keying the slurry wall into bedrock, if required, is more difficult and increases costs.

- *Cost*
  Cost for slurry wall installation includes labor and equipment for excavating, mixing, and emplacing soil and bentonite. Material costs are associated with cost of bentonite and possibly soil if site soil is not suitable for backfill. Disposal costs may be significant if soil is not consolidated on-site. Relative cost of a slurry wall is low compared to other vertical barrier process options if site soil can be used in the backfill mixture. Costs are moderate if off-site soil is required for the backfill mixture.

- *Summary*
  Slurry walls for containment of groundwater in overburden are retained for further evaluation. Slurry walls are not implementable in bedrock and are therefore eliminated from further consideration for bedrock.

3.7.4.2 Source Area Groundwater Vertical Barriers—Grout Curtains

Grout curtains refer to a technology whereby one of a variety of fluids is injected or mixed with a soil mass or injected into bedrock. Fluid sets in place and reduces water flow and/or strengthens the formation. The primary objective of grouting is to fill voids in overburden or bedrock to create a low-permeability zone. Grout curtains formulated from cement, clay, bentonite, alkali silicates, silicates, or organic polymers may be used to reduce groundwater flow and constituent mobility. Selection of grout constituents depends on the chemistry of the facility's constituents and the porosity of the area to be grouted. Grouted barriers are seldom used for controlling migration of constituents in unconsolidated materials because of high cost.

Grout curtains can be constructed in the overburden through permeation grouting, jet grouting, or soil mixing. Grout curtains in bedrock would be constructed by pressure grouting. Permeation grouting involves filling the soil voids with grout. To fill soil voids with grout, the permeability of the soil, viscosity of the grout, and size of the particulates in the grout must be considered. Soil permeability is controlled by the grain size of the soil, which affects its average void size. The viscosity of the grout is dependent on the type of grout and how it is mixed. In general, particulate grouts have much higher viscosity than chemical grouts.

There are two main methods of soil permeation grouting, point injection and sleeve pipe injection. In the point injection method, the casing is driven to full depth then withdrawn to the desired depth, and the grout is injected. In the sleeve pipe method, a sleeve pipe is placed in a grout hole and sealed in place by a clay-cement mixture. At 1-foot intervals, the pipe has small holes through which the grout is pushed. The holes are covered by rubber sleeves, or manchettes, which act as one-way valves and open when the grout is pressurized. To inject grout, a double packer attached to a smaller-diameter grouting pipe is inserted into the sleeve pipe centered on a sleeve hole, the pipe is pressurized, and the grout is forced through the sleeve hole and into the soil. The resultant permeability of permeation-grouting cutoff walls is approximately 1×10^{-7} cm/s.

Jet grouting of soil involves the use of grout alone, grout and air, or a combination of grout, air, and water delivered by a small jet (or jets) in the drill rod at very high pressures that often reach 5,000 to 6,000 psi. After advancing the drill rod to the desired depth, it is lifted and rotated as the jetted grout cuts away the soil and creates a large cylindrical hole. Portland cement or cement-bentonite grouts are generally used when jet grouting. Cement grout mixes with the soil to form a soil and cement mixture (or soilcrete) column in the ground. The excess water and soil are forced to the surface around the drill rod. The resultant permeability of a jet-grouted grout curtain is 1×10^{-7} cm/s or less.

Soil mixing has been employed to construct vertical barriers. A special auger mixing shaft is rotated into the ground while simultaneously permitting the injection of bentonite and water, or cement, bentonite, and water slurry. Multiple mixing shafts are usually employed. A continuous wall, typically from 20 to 36 inches wide, is obtained by overlapping penetrations. Bentonite is added to the mixed soil in the form of bentonite-water slurry. As a result, the bentonite content of the mixed soil is typically limited to about 1 percent. The resultant permeability of a soil-mixed vertical barrier is approximately 1×10^{-7} cm/s.

In bedrock, grout curtains are constructed by pressure grouting. The existing Necco Park grout curtain was constructed using a single-line, split-spacing pressure grouting method. This was accomplished by drilling and grouting vertical holes. Primary holes were placed on 40-foot centers, with spacing becoming progressively smaller through quaternary holes on 5-foot centers.

- *Effectiveness*

  Grout curtains are moderately effective in controlling groundwater flow through voids in soil. The main concern with grouting to achieve low permeability is the complete filling of the void spaces with grout and the control of the lateral extent of grout penetration. Both of these tasks are very difficult and require skillful experience to control. Grout pumped at excessively high pressure can cause hydrofracturing of the soil.

  Jet grouting and soil mixing are more effective than permeation grouting for soil materials. These installation methods form effective vertical barriers for most constituents, but compatibility testing is necessary to select the proper grout mix.

Grout curtains are effective in controlling flow in bedrock.

- *Implementability*
  Soil and bedrock grouting are implementable.
- *Cost*
  The cost of installing a grout curtain includes mobilization and demobilization, drilling, and purchase, mixing, and injection of grout material. O&M costs will be minimal. The overall cost of installation for soil is high relative to other vertical barrier process options.
- *Summary*
  Slurry walls are easier to install in the overburden, can be constructed with lower permeability, and cost less than grout curtains. Therefore, grout curtains in the overburden will be screened from further evaluation.

  Grout curtains in bedrock are retained for further evaluation.

3.7.4.3 Source Area Groundwater Vertical Barriers—Sheet Piles

Sheet piling may be used to form a barrier to groundwater flow under appropriate conditions when installed properly. Generally, steel or HDPE sheet piles are the most effective for groundwater cutoff; however, sheet piles cannot be driven into bedrock. Therefore, this screening evaluation will only consider steel and HDPE sheet-piling materials for overburden. The in-place permeability of a geomembrane cutoff wall is 1 x 10^{-7} cm/s or less.

- *Effectiveness*
  Sheet piles are interlocking piles that form a continuous low-permeability wall when properly installed. When the wall is stressed laterally, the interlock forms a mechanical seal. While sheet piles are used for permanent waterfront structures, they are most commonly used for temporary support during construction features such as cofferdams or to keep trenches open.

  There are drawbacks to using sheeting at a hazardous waste impoundment. If interlocks are not sealed, a route for groundwater migration remains, and effectiveness of the wall as a barrier will be reduced. For temporary structures, joint leaks are acceptable because infiltration is controlled by construction dewatering. However, joint leaks are generally not acceptable for permanent environmental applications. Grouting of interlocks may be required for steel sheet piles to reduce permeability. HDPE sheet-pile interlocks are generally sealed with plastic material compatible with waste constituents.

Sheet piles must be driven into a confining layer to ensure complete containment. Groundwater could migrate from the source area beneath sheet piling because the sheet piles cannot be driven into the underlying bedrock at Necco Park. Excavation of overburden and installation of sheet piles would be necessary to key into bedrock. This would be more difficult and costly to implement than typical driven sheet installations.

Steel piles may also corrode, making the barrier ineffective over time. Adequate corrosion protection may be required for steel sheet piles.

- *Implementability*
  The ability to drive or vibrate sheets is determined by the nature of the overburden material through which the sheets are driven. Glacial till of the overburden contains rocks and boulders, thus making it difficult to install sheet piles at Necco Park. Boulders prevent the driving of sheet piles or knock the piles out of interlock, potentially forming open pathways for the groundwater migration.
- *Cost*
  Cost to purchase and install sheet piles is high when compared to other vertical barriers such as slurry walls.
- *Summary*
  The slurry wall is a more implementable and effective technology for Necco Park overburden than sheet piles. Sheet piles in overburden are screened from further evaluation due to the presence of boulders in overburden and related installation difficulties. Sheet piling is not implementable in bedrock. Therefore, sheet piling is screened from further evaluation for bedrock.

3.7.5 Source Area Groundwater Hydraulic Control

Hydraulic control of groundwater involves one of the following options:

- Containment of a plume by pumping to prevent off-site groundwater flow
- Diversion of groundwater to prevent upgradient groundwater from flowing through a source of contamination.

The following process options are applicable for source area groundwater hydraulic control: extraction wells and trenches.

3.7.5.1 Source Area Groundwater Extraction Wells

This technology involves pumping to control hydraulic gradients at the downgradient source area boundaries and potential treatment and discharge. Extraction wells can withdraw groundwater continuously or through pulsed pumping. Extraction wells may also prove effective in combination with containment options, such as slurry walls or grout curtains and capping, in controlling groundwater levels and creating inward hydraulic gradients in the source area.

Extraction wells include both vertical and horizontal wells. Vertical wells are drilled using conventional drilling rigs. Horizontal drilling is a possible method for installing groundwater extraction wells that may be evaluated during design. Production rates from horizontal wells are typically higher than those expected from vertical wells in the same formation, largely due to greater screen lengths possible with horizontal wells. The downhole drilling assembly consists of a dual-wall drill string and an expanding bit that drills a hole large enough to permit casing to be installed during drilling. The casing protects the hole from collapse. After the well is drilled to the desired length, an inner drilling assembly is withdrawn, and a plastic or steel well casing is left in place. The downhole system is guided using measurements from a tool face indicator that records inclination of the drilling assembly and transmits readings to the surface.

- *Effectiveness*
  Source area extraction of groundwater by wells is expected to be effective in preventing migration of the dissolved contaminants from the source area. Volume of water that would have to be pumped is presumed to be manageable and can be reduced if used in conjunction with existing and additional vertical barriers.

- *Implementability*
  Source area pumping is implementable. Existing recovery wells and grout curtain have limited the migration of constituents (see

Section 1.8.4). Additional wells may be placed within the source area in locations known to contain chemical constituents to improve migration control.

Horizontal drilling requires relatively specialized equipment and has not been widely used at remediation sites. Well failures are possible during system installation and potential exists for wells to collapse. Recent developments in horizontal well drilling have resulted in improvements to bedrock-type wells.

- *Cost*
  Cost of constructing and operating extraction wells is moderate compared to other extraction process options.
- *Summary*
  Extraction wells are retained for further evaluation.

3.7.5.2 Source Area Groundwater Interceptor Trenches

Interceptor trenches may be constructed to physically intercept shallow groundwater flow. Interceptor trenches are passive systems for collection and control of groundwater within overburden. Groundwater may be collected in a common sump and treated prior to discharge. An effective system may require use of some type of overburden cutoff to limit collection of clean water. Trenches are not considered for recovery of groundwater from the source area bedrock zones because of implementability difficulties.

- *Effectiveness*
  Interceptor trenches are an effective process option for collection of groundwater from overburden source area.
- *Implementability*
  Trenching systems may extend over a more continuous zone than extraction wells. Installation of trenches through areas containing boulders or debris would be difficult. Special construction techniques would be required to prevent trench collapse (i.e., sheeting, shoring, or slurry excavation techniques). Soil generated during excavation would require disposal.
- *Cost*
  Cost of constructing and operating interceptor trench systems is moderate.

- *Summary*
  Source area groundwater trench systems are retained for further evaluation.

3.7.6 Source Area Groundwater Biological Treatment

The following process options have been identified for biological treatment: in situ aerobic, ex situ aerobic, in situ anaerobic, ex situ anaerobic, passive treatment walls, and intrinsic bioremediation.

3.7.6.1 Source Area Groundwater In Situ Aerobic Biological Treatment

In situ bioremediation is a group of associated technologies or methods used to stimulate naturally occurring microorganisms to biodegrade organic compounds. Aerobic bioremediation refers to biological activities that require oxygen. In situ bioremediation involves altering environmental conditions to enhance microbial catabolism or co-metabolism of organic contaminants, which results in breakdown and eventual detoxification of constituents. Given proper nutrients and sufficient oxygen, indigenous microorganisms can degrade a wide range of compounds. Implementing a bioremediation system would include drilling nutrient delivery and oxygenation wells, constructing a nutrient delivery system (e.g., feed tanks, piping), and possibly installing a groundwater recycling system. Generally, high concentrations of organic constituents, particularly chlorinated organic constituents, are toxic to microorganisms and, therefore, bioremediation may be inhibited by DNAPL.

- *Effectiveness*
  Metals such as barium cannot be treated by bioremediation. Low permeability of Necco Park overburden soil also discourages movement of oxygen and nutrients through the soil matrix, making aerobic bioremediation more difficult. Bioremediation is unproven in fractured bedrock systems. At the current developmental stage of this technology, aerobic bioremediation is ineffective for application to the entire Necco Park source area groundwater.

- *Implementability*
  To compensate for low soil permeability, many wells would need to be drilled at different depths. Each of these wells would have to be monitored and nutrient feed rates adjusted accordingly.

  Injecting any compound (e.g., nutrients, adjusting agents) into groundwater will have to meet the substantive requirements of the NYSDEC's State Pollutant Discharge Elimination System (SPDES) program. Extracted groundwater would also be required to comply with SPDES requirements before injection.

- *Cost*
  Costs associated with in situ bioremediation include capital cost of drilling wells and constructing the piping system. O&M costs include cost for nutrients, energy costs for air injections, and O&M personnel labor costs. This technology's cost is moderate compared to other biological treatment process options.

- *Summary*
  In situ aerobic treatment has low effectiveness in the source area because of the presence of DNAPL in low-permeability soil and bedrock systems. Therefore, it is screened from further evaluation.

3.7.6.2 Source Area Groundwater Ex Situ Aerobic Biological Treatment

In conventional suspended-growth aerobic treatment, groundwater is added to an aerated tank containing a suspended slurry of microorganisms. The hydraulic retention time of the system can vary from a few hours to many days, depending on organic loading of the system and degradation rate of constituents. Biomass and treated wastewater are separated by gravity sedimentation in a clarifier following the aeration tank. Most biomass is recycled back to the aeration tank. Excess biomass resulting from growth of microorganisms must be periodically wasted from the system to maintain a constant biological solids inventory.

Another option is use of a fixed-film biological reactor. Fixed-film biological reactors have been designed expressly for treatment of low total organic carbon (TOC) wastewaters, such as groundwater. By using a fixed film, rather than a mixed-reactor design, washout of bacterial populations due to low organic inputs is less of a consideration. These systems operate under low carbon-to-surface-area ratios and are capable of achieving very low effluent concentrations of biodegradable compounds. Units typically consist of submerged plastic growth media inside a reactor, with a one to two hour hydraulic retention time. Aeration is supplied by a blower through diffusers. Nutrients such as nitrogen and phosphorus must be added to the wastewater if the groundwater is deficient in these elements.

- *Effectiveness*
  Metals such as barium cannot be treated by aerobic treatment. Possible presence of inhibitory compounds may restrict the ability of microorganisms to degrade constituents of concern. A treatability study would be required to determine if ex situ aerobic treatment of source area groundwater might be effective.
- *Implementability*
  If effective, an ex situ aerobic groundwater treatment system would be implementable.
- *Cost*
  Costs associated with ex situ aerobic treatment are moderate compared to other biological process options.
- *Summary*
  Ex situ aerobic treatment is retained as a representative biological process option for treatment of organic constituents. To treat the range of organic constituents at the site, alternating ex situ aerobic and anaerobic biological reactors in series may be necessary.

3.7.6.3 Source Area Groundwater In Situ Anaerobic Biological Treatment

In situ anaerobic bioremediation is a group of associated technologies or methods used to stimulate naturally occurring soil microorganisms to biodegrade organic compounds anaerobically (without oxygen). This process involves altering environmental conditions to enhance microbial co-metabolism of organic contaminants, which breaks down and detoxifies constituents. Given proper nutrients, organic substrates, and electron acceptors, indigenous microorganisms can degrade a wide range of compounds, including lower molecular weight halogenated hydrocarbons such as unsaturated alkyl halides (e.g., PCE, TCE) and saturated alkyl halides (e.g., 1,1,1-trichloroethane).

Under anaerobic conditions, chlorines are sequentially removed from compounds (e.g., PCE is reduced in sequence to TCE, which is reduced to 1,2-DCE, which is reduced to VC, which is further reduced to ethene). This process is known as reductive dehalogenation. Reductive dehalogenation of chlorinated aliphatic solvents appears to require either sulfate-reducing, fermenting, or methanogenic conditions.

Microbes require a suitable environment to support growth and activity, including available electron acceptors (e.g., oxygen, nitrate, iron, sulfate, or bicarbonate), nitrogen, phosphorus, trace minerals, appropriate temperature, and appropriate pH. Under sulfate-reducing conditions, microbes convert sulfate to hydrogen sulfide, typically with pyruvate, lactate, or molecular hydrogen as their electron donor. Methanogenic bacteria use a limited number of simple organic substrates to form methane. High levels of sulfate are inhibitory to methanogenic bacteria.

Source area groundwater in situ anaerobic bioremediation refers to implementing a remediation at Necco Park and areas where solubilities indicate potential presence of DNAPL. This technology would only be used to address source area contamination in the aqueous phase. Nonaqueous-phase liquid constituents are likely to be toxic to microorganisms.

- *Effectiveness*
  Use of in situ anaerobic bioremediation technology is under development and has not been demonstrated full scale in low-permeability overburden. A treatability study would be required to determine if anaerobic bioremediation could be effective at Necco Park. Such a treatability study would be a complex and time-intensive effort that might or might not prove to be beneficial to the Necco Park remedial program. Many uncertainties accompany the application of this technology in fractured bedrock. Even if results of the treatability study were to show that bioremediation were potentially effective, groundwater pumping would still be required. Demonstration of successful bioremediation would be an additional remedial technique that would enhance a groundwater control or capture program. Effectiveness would have to be evaluated by a treatability study.

In situ anaerobic bioremediation cannot effectively reduce constituent concentrations in source area groundwater in reasonable time frames because of the presence of DNAPL, which acts as a continuing source.

- *Implementability*
  Implementation of an in situ anaerobic bioremediation system would require many nutrient feed wells. Monitoring and controlling the process would be difficult, especially in fractured bedrock.

- *Cost*
  To ensure proper nutrient distribution, a significant number of wells would be installed. However, overall capital costs are moderate. O&M costs are moderate depending on the substrates and nutrients added and time required to achieve cleanup levels. Overall cost of the technology is moderate compared to other biological treatment process options.

- *Summary*
  In situ anaerobic treatment is screened from further evaluation due to its ineffectiveness where DNAPL is present in low-permeability soil and bedrock systems.

3.7.6.4 Source Area Groundwater Ex Situ Anaerobic Biological Treatment

Ex situ anaerobic treatment has been primarily applied to stabilize biological solids from municipal wastewater treatment systems and to degradate high-strength industrial wastewaters. More recently it has been recognized that microorganisms that develop under anaerobic conditions are capable of dehalogenating organic compounds.

- *Effectiveness*
  Metals such as barium cannot be treated by biological treatment. The presence of inhibitory compounds may restrict the ability of the microorganisms to degrade the contaminants of concern. A treatability study would be required to determine if ex situ anaerobic treatment of source area groundwater is effective.

- *Implementability*
  If effective, an ex situ anaerobic groundwater treatment system would be implementable.

- *Cost*
  Costs associated with ex situ anaerobic treatment are high compared to other biological process options.

- *Summary*
  Ex situ anaerobic treatment is retained as a representative biological process option for treatment of organic constituents. To treat the range of organic constituents at the site, alternating ex situ anaerobic and aerobic biological reactors in series may be necessary.

3.7.6.5 Source Area Groundwater Biological Treatment with Passive Treatment Walls

Passive treatment walls are permeable reactive structures installed using conventional slurry wall construction technology. The walls are constructed of granular materials to allow groundwater flow through the structure under ambient groundwater gradients. Treatment is achieved using a combination of reactive granular backfill and a variety of additives or surface coatings such as nutrients and bacteria for in situ biodegradation; redox controls and/or metal catalysts to aid in metals precipitation and chemical dehalogenation; organic carbon for enhanced denitrification; and selective sorbents to increase the retardation capacity of the in situ wall. The dissolved-phase contaminants are exposed to reactive amendments and/or microbial consortia in the permeable treatment wall. Factors such as rates of reaction and maintenance of favorable conditions will affect wall thickness and longevity.

- *Effectiveness*
  This technology has not been applied for full-scale remediation. The extension of this process option to fractured bedrock is unlikely. Excessive biological growth and precipitation may compromise long-term performance of the permeable wall. Additionally, some constituents may not be treated completely, potentially resulting in residual compounds with greater toxicity.

- *Implementability*
  Degradation of dissolved contaminants has been shown on pilot scale only. Technology and elements required to construct and implement permeable walls are readily available.

- *Cost*
  Costs associated with passive treatment walls are moderate compared to other biological process options.

- *Summary*
  Passive treatment walls are screened from further evaluation due to limited effectiveness and unproven full-scale use.

3.7.6.6 Source Area Groundwater Natural Attenuation

Natural attenuation is a process whereby naturally occurring chemical, physical, and biological processes reduce chemical concentrations, bioavailability, mobility, and toxicity. Natural attenuation is achieved through both destructive mechanisms and nondestructive mechanisms. Destructive mechanisms include natural aerobic and anaerobic biodegradation and hydrolysis. Nondestructive mechanisms include sorption, volatilization, dispersion, complexation, precipitation, and biological uptake.

- *Effectiveness*
  Natural attenuation would not be effective in reasonable time frames because of the presence of DNAPL in source area groundwater.
- *Implementability*
  Natural attenuation relies on natural processes to remediate contamination and is therefore readily implementable.
- *Cost*
  Costs associated with intrinsic remediation are low compared to other biological process options.
- *Summary*
  Natural attenuation of source area groundwater is screened from further evaluation because it is not effective in reasonable time frames due to the presence of DNAPL.

3.7.7 Source Area Groundwater Physical/Chemical Treatment

The following process options have been identified for physical chemical treatment: air sparging, DPE, precipitation, air stripping, steam stripping, carbon adsorption, chemical oxidation, reverse osmosis (RO), ion exchange, filtration, microfiltration, and vapor-phase treatment.

3.7.7.1 Source Area Groundwater Treatment—Air Sparging

Air sparging relies on the air-stripping mechanism to remove volatile contaminants from the saturated zone. Injection or "sparging" of clean air into the saturated zone is coupled with vacuum extraction to recover volatile contaminants within the vadose zone. Air-sparging design is empirically based, and design strategy revolves around limitations imposed by subsurface geology, contaminant volatility, and nature and areal extent of chemical constituents.

- *Effectiveness*
  Air sparging is most suitable for granular soil and requires a minimum soil hydraulic conductivity of 1×10^{-3} cm/sec (EPA 1994). Necco Park overburden has a conductivity lower than this. Therefore, it is unlikely that air sparging will be effective. Because air sparging changes the pressure regime in the vicinity of the sparger, DNAPL may be potentially mobilized beyond the treatment zone or vertically downward below the sparger. Air sparging is unproven in fractured bedrock.
- *Implementability*
  Air sparging may not be implementable for bedrock or overburden with a hydraulic conductivity less than 1×10^{-3} cm/s.
- *Cost*
  Cost of air sparging is moderate compared to other physical/chemical treatment process options.
- *Summary*
  Air sparging is screened from further evaluation because of the low permeability of Necco Park overburden and because the technology is unproven in fractured bedrock.

3.7.7.2 Source Area Groundwater Treatment—Dual-phase Extraction

DPE uses a high vacuum (greater than 15 inches mercury) applied to a well to extract groundwater and volatilize and extract sorbed chemicals simultaneously. DPE is normally used to remove most VOCs and some SVOCs from low-permeability soil. Conventional pump-and- treat systems frequently fail to achieve cleanup levels because organic chemicals may have accumulated in the zone of groundwater fluctuation (smear zone), which acts as a long-term source of chemical dissolution to groundwater. A DPE system creates a cone of depression in the groundwater table, exposing the smear zone and enabling organic constituent extraction through volatilization. Chemicals are also extracted from groundwater in the same manner as a conventional pump-and-treat system. Although dewatering highly conductive strata may be accomplished with a sufficient number of wells, limited experience suggests that DPE is most effective for strata of moderate to low hydraulic conductivities.

- *Effectiveness*
  DPE could potentially be effective for volatile constituents and some semivolatile constituents in overburden. Effect on metals would be limited to those metals dissolved in extracted groundwater. Standard pump-and-treat systems are likely as effective in extracting and treating groundwater.
- *Implementability*
  DPE units are commercially available.
- *Cost*
  Cost for this technology is high compared to other physical/chemical process options because of high capital cost for installing the required number of wells and high O&M costs.
- *Summary*
  DPE is screened from further evaluation because standard pump-and-treat systems are equally as effective, more proven, and less costly for source area groundwater.

3.7.7.3 Source Area Groundwater Treatment—Precipitation

Precipitation is a physico-chemical process in which some or all of a substance in solution is converted into the solid phase by shifting chemical equilibrium relationship of inorganic substances. While some organic compounds are also removed, effectiveness in removal of organic constituents is generally limited. Once precipitated, wastewater flows to a flocculation chamber in which precipitated particles are gently mixed to allow them to agglomerate and form larger, more easily settled particles. From the flocculation tank, water goes to a clarifier for gravity separation of agglomerated particles from wastewater. Filtration may be required following clarification to achieve treatment standards.

Sludge must be dewatered prior to disposal. Precipitated sludge may be considered hazardous depending on metals content and process application.

- *Effectiveness*
  Precipitation would be effective in treating inorganic constituents in groundwater. Precipitation has limited effect in treating organic constituents. However, some organic constituents may adsorb to solids during precipitation.
- *Implementability*
  Precipitation is implementable. Disposal options would depend on sludge characteristics.
- *Cost*
  Costs associated with precipitation are low compared to other physical/chemical process options.
- *Summary*
  Precipitation of inorganic constituents in source area groundwater is retained for further evaluation.

3.7.7.4 Source Area Groundwater Treatment—Air Stripping

Generally used for the removal of VOCs, air stripping of semivolatile compounds is feasible, although less effective. Organic constituents are partitioned from groundwater to air by greatly increasing the surface area of contaminated water exposed to air. Feasibility of air stripping is based on Henry's Law constant of organic constituents in the water stream. Henry's Law constant is an air/water partitioning constant, which is defined as the ratio of the compound's vapor pressure to its water solubility. Generally, organic compounds with Henry's Law constants greater than 3.0×10^{-4} atm-m^3/mole can be effectively air stripped. Compounds with low volatility at ambient temperature may require pre-heating of groundwater. Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.

Clogging of stripping column packing material due to inorganic constituents in groundwater (especially dissolved ferrous iron, which precipitates as insoluble ferric hydroxide species upon aeration) and biofouling are common problems. Air strippers must be taken out of service and packing materials rinsed periodically with an acid wash.

Air-stripping systems for groundwater generally include liquid-phase polishing and vapor-phase treatment unit operations. In most cases, carbon adsorption is used for liquid-phase polishing to remove any trace organic constituents remaining in the groundwater after stripping. Other technologies, such as chemical oxidation, can also be used for final polishing. Organic vapors removed by air stripping are commonly removed by vapor-phase carbon adsorption. Depending on the amount of carbon needed, a carbon regeneration system may be required. In some cases, thermal oxidation or condensation of vapors may be appropriate for vapor-phase treatment.

- *Effectiveness*
  Air stripping would be effective in treating most volatile organic constituents in groundwater. Semivolatile constituents would require additional treatment. Air stripping is not effective for removing metals.
- *Implementability*
  Air stripping is implementable.
- *Cost*
  Costs associated with air stripping are moderate compared to other physical/chemical process options.
- *Summary*
  Air stripping of source area groundwater is retained for further evaluation.

3.7.7.5 Source Area Groundwater Treatment—Steam Stripping

Steam stripping is similar to air stripping except that steam is substituted for air as the mass transfer medium. Conditions for effective application of steam stripping include the presence of low volatility compounds (Henry's Law constant less than 3.0×10^{-4} atm-m^3/mole) and high concentrations of chemical constituents (greater than 100 milligram per liter [mg/l]) for recovery. It is particularly effective for

SVOCs that have a low boiling point. Highly chlorinated compounds that have elevated boiling points are not amenable to steam stripping.

- *Effectiveness*
  Steam stripping would be effective in treating the organic constituents in groundwater.
- *Implementability*
  Steam stripping is implementable.
- *Cost*
  Costs associated with steam stripping are high compared with other physical/chemical process options due to energy costs to create steam.
- *Summary*
  Air stripping with liquid-phase carbon adsorption is generally as effective and less costly than steam stripping. Therefore, steam stripping is screened from further evaluation.

3.7.7.6 Source Area Groundwater Treatment—Carbon Adsorption

Carbon adsorption is a technology whereby groundwater is pumped through a series of canisters containing activated carbon to which dissolved organic constituents adsorb. Activated carbon selectively adsorbs organic constituents by a surface attraction phenomenon in which organic molecules are attracted to internal pores of carbon granules. Solubility and concentration of contaminants and type and pore size of carbon can impact process performance. Adsorption depends on the strength of molecular attraction between adsorbent and adsorbate, molecular weight, type and characteristic of adsorbent, electrokinetic charge, pH, and surface area. When micropore surfaces become saturated with organic constituents, carbon is "spent" and must either be replaced with virgin carbon or thermally regenerated and returned to service.

Activated carbon is an effective and reliable means of removing low-solubility organic constituents, and it is suitable for treating a wide range of organic constituents of widely varying concentrations. Some metals and inorganic species also have shown excellent to good adsorption potential. However, these metals and naturally occurring organic material can foul the system.

Activated carbon may be implemented into more complex treatment systems. The process is suited to mobile treatment systems as well as to on-site construction. Space requirements are small, startup and shutdown are rapid, and numerous contractors are experienced in the operation of mobile units.

- *Effectiveness*
  Carbon adsorption would be effective in treating many organic constituents in groundwater. However, carbon adsorption is generally less effective on smaller molecular weight compounds or more soluble compounds (i.e., chloroform, phenols).
- *Implementability*
  Carbon adsorption is implementable.
- *Cost*
  Costs associated with carbon adsorption are moderate compared to other physical/chemical process options due to carbon regeneration or replacement costs.
- *Summary*
  Carbon adsorption of source area groundwater is retained for further evaluation.

3.7.7.7 Source Area Groundwater Treatment—Chemical Oxidation

In chemical oxidation, oxidation state of the treated compound is raised through chemical addition. Organic compounds can ultimately be oxidized to carbon dioxide and water, although such extensive treatment is generally not necessary. The most powerful form of oxidation and the method of choice for groundwater treatment is generally ultraviolet (UV) catalyzed oxidation. Chemical oxidants commonly used include ozone and hydrogen peroxide. Organic constituents for which successful UV oxidation has been reported include halogenated volatile constituents, pesticides, chlorinated phenols, PCBs, and dioxins. UV oxidation has been applied for treatment of organic constituents at a number of groundwater remediations.

- *Effectiveness*
  A potential disadvantage of oxidation is that intermediaries formed may be more toxic than starting compounds, although this may typically be controlled by selection of reactor residence time and oxidant dosage. A

given disadvantage is that the process is relatively nonselective in that any oxidizable substance will be attacked. This can dramatically increase the required dosage of oxidant.

Chemical oxidation may be effective in treating most organic constituents in the source area groundwater.

- *Implementability*
  Chemical oxidation is implementable.
- *Cost*
  Costs associated with chemical oxidation are high compared to other physical/chemical process options due to chemical and energy costs.
- *Summary*
  Chemical oxidation is more expensive without a significant increase in effectiveness compared to air stripping and carbon adsorption. Therefore, chemical oxidation is screened from further evaluation.

3.7.7.8 Source Area Groundwater Treatment—Reverse Osmosis

Osmosis is the movement of a solvent from a dilute solution through a semipermeable membrane to a more concentrated solution. RO is the application of sufficient pressure to the concentrated solution to overcome osmotic movement and force solvent to the more dilute side. This allows for a buildup of a concentrated solution on one side while relatively pure water is transported through the membrane.

RO has been used to reduce the concentration of both organic and inorganic dissolved solids, as well as low molecular weight organic constituents such as alcohols, ketones, aldehydes, and amines. However, RO units are subject to chemical fouling and plugging. Also, wastewater will require pretreatment to remove any oxidizing materials, particulates, or oil and grease.

- *Effectiveness*
  Inorganic compounds may have to be removed prior to treatment to prevent membrane fouling. RO membranes will not reject all constituents of concern.
- *Implementability*
  RO may be implementable with pretreatment and post treatment.

- *Cost*
  Costs associated with RO are high compared to other physical/chemical treatment process options.
- *Summary*
  RO is more expensive and less effective than chemical precipitation for organic compounds and air stripping and carbon adsorption for inorganic constituents. Therefore, RO is screened from further evaluation

3.7.7.9 Source Area Groundwater Treatment—Ion Exchange

Ion exchange is a process in which charged ions can be removed from a waste stream and substituted with less harmful ions from exchange material. Most exchange materials are synthetic compounds containing functional groups with exchangeable ions attached. The exchange reaction is reversible, which allows for regeneration of exchange material. Selective resins are available that preferentially exchange certain ions, such as heavy metals.

Design of ion exchange systems must consider total suspended solids and total quantity of charged species in groundwater. Although ion exchange systems can readily treat a changing composition wastewater, care must be taken to keep suspended solids to less than 50 mg/l to reduce plugging.

- *Effectiveness*
  Ion exchange may be effective in treating some inorganic constituents in source area groundwater. It has no effect on organic constituents.
- *Implementability*
  Ion exchange is implementable.
- *Cost*
  Costs associated with ion exchange are high compared to other physical/chemical process options due to the cost of resin.
- *Summary*
  Ion exchange is more expensive and possibly less effective than precipitation for inorganic constituents. Therefore, ion exchange is screened from further evaluation.

3.7.7.10 Source Area Groundwater Treatment—Filtration

Filtration is a physical process in which suspended solids are removed from solutions by forcing fluid through a porous media. The suspended solids are trapped or enmeshed in the media. As more suspended solids are trapped in the filter media, the filter becomes clogged, and flow through the filter is reduced. When this occurs, the filter media must be cleaned. The media is cleaned by reversing flow through the filter and fluidizing the media bed. The solids are then washed from the media. The backwash contains a high concentration of solids that require further treatment.

- *Effectiveness*
  Filtration would be an effective process option when used in conjunction with another process option such as carbon adsorption or chemical precipitation.
- *Implementability*
  Filtration is implementable.
- *Cost*
  Costs associated with filtration are moderate.
- *Summary*
  Filtration is retained for further evaluation.

3.7.7.11 Source Area Groundwater Treatment—Microfiltration

Microfiltration is a low pressure (20 to 40 psi) membrane process that removes particulate matter through membrane pores. Solids are kept in a recirculation stream that periodically discharges to a filter press for dewatering. Microfiltration units are generally more expensive and require more maintenance than standard sand or multimedia filtration units, but can achieve lower solids concentrations in the effluent.

- *Effectiveness*
  Microfiltration would be an effective method for removing inorganic constituents.
- *Implementability*
  Microfiltration is implementable.

- *Ccst*
  Costs associated with microfiltration are high.

- *Summary*
  Microfiltration is screened from further evaluation because it is more expensive than filtration without a significant increase in process effectiveness. Microfiltration may be considered during the design phase if treatability studies indicate filtration is not the most effective process option.

3.7.7.12 Source Area Groundwater Vapor-phase Treatment

Source area groundwater vapor-phase treatment refers to technologies that would be used to treat organic vapors generated from other treatment technologies (i.e., DPE and air stripping). Vapor-phase treatment may include one or more of the following process options: condensations and disposal off-site, carbon adsorption, or thermal oxidation. Condensation and disposal off-site and carbon adsorption generally are appropriate where small volumes of organic vapors are expected. Thermal oxidation is generally more cost-effective for larger quantities of organic vapors.

- *Effectiveness*
  Vapor-phase treatment can effectively remove or destroy organic vapors.

- *Implementability*
  Vapor-phase treatment technologies are commercially available. Air permits or their equivalents may be required.

- *Cost*
  Cost for vapor-phase treatment includes labor to install and operate the treatment unit. Costs for vapor-phase treatment equipment are fairly inexpensive. Operating costs could be significant, depending on the quantity of vapor requiring treatment, and could include off-site disposal, carbon replacement or regeneration, and fuel for thermal oxidation. Cost for vapor-phase treatment is moderate compared to other physical/chemical process options.

- *Summary*
  Vapor-phase treatment can effectively control vapors from other source area groundwater treatment technologies and is retained for further evaluation.

3.7.8 Source Area Groundwater Thermal Treatment—Incineration

The only thermal treatment process option identified for source area groundwater is incineration.

- *Effectiveness*
  Thermal treatment of groundwater could potentially destroy organic constituents dissolved in groundwater. Metals would not be affected by thermal treatment.
- *Implementability*
  Incineration of groundwater is difficult to implement. Groundwater would have to be mixed with fuel to burn efficiently. Very durable materials of construction are required to handle HCl formed from the combustion of chlorinated compounds. Generally, incinerators are met with strong public opposition.
- *Cost*
  Mobilization and installation of incineration equipment is very expensive. Significant labor and material costs are required for operation. Cost of incineration is high compared to other physical/chemical process options for source area groundwater.
- *Summary*
  Thermal treatment of source area groundwater is screened from further evaluation because other physical/chemical process options are equally as effective at a significantly lower cost.

3.7.9 Off-Site Treatment of Source Area Groundwater

Two process options have been identified for off-site treatment of source area groundwater: commercial WWTPs and POTW.

3.7.9.1 Off-site Treatment of Source Area Groundwater at a Commercial WWTP

Commercial WWTPs are available to accept groundwater collected from Necco Park. The facilities may need a RCRA permit because extracted groundwater may exceed RCRA toxicity characteristics for specific constituents. For purposes of this evaluation, the CECOS WWTP was considered representative of available commercial WWTPs. Alternate commercial WWTPs may be considered if the chosen remedy exceeds CECOS available capacity or if another facility can treat groundwater more cost-effectively than CECOS.

The CECOS WWTP, located next to Necco Park, is capable of treating source area groundwater, depending on the anticipated groundwater flow rate. Treatment processes used at CECOS are equalization, chemical precipitation, and filtration for inorganic constituent and solids removal. Organic constituents are removed by air stripping and liquid-phase carbon adsorption. Vapor-phase carbon adsorption is used to treat organic vapors from the air stripper. Treated water is discharged to the POTW.

- *Effectiveness*
  CECOS process is effectively treating groundwater pumped from the existing groundwater recovery system. Similar commercial WWTPs should be equally as effective.
- *Implementability*
  CECOS has indicated they have available excess capacity for up to 110 gpm of groundwater flow. This estimated available flow capacity assumes a nominal design capacity of 210 gpm and 100 gpm reserved for other non-DuPont wastewater streams, including CECOS landfill leachate. Therefore, Necco Park source area groundwater flow rates greater than 110 gpm would require capital expansion at CECOS or use of alternate commercial WWTPs.
- *Cost*
  Unit costs associated with commercial WWTP treatment are high compared to other off-site treatment process options.
- *Summary*
  Treatment of source area groundwater by a commercial WWTP is retained for further evaluation.

3.7.9.2 Off-site Treatment of Source Area Groundwater at the POTW

In this section, POTW treatment refers to using the Niagara Falls POTW as the only treatment system for extracted source area groundwater. Discharge to the POTW after pretreatment is discussed in Section 3.7.11.

The Niagara Falls POTW uses very sophisticated physical/chemical treatment unit operations to treat domestic and industrial wastewater. The POTW uses the following unit operations:

- Equalization
- Solids removal
- Carbon adsorption

Actual flow rates and constituent mass loadings are required before the POTW can determine if they will accept the groundwater extracted from Necco Park.

- *Effectiveness*
  POTW physical/chemical unit operations could effectively treat source area groundwater. Groundwater flow from Necco Park would not significantly alter the POTW's treatment effectiveness.
- *Implementability*
  Assuming the POTW has sufficient capacity and will accept the selected remedy flow rate, treatment at the POTW would be implementable.
- *Cost*
  Unit costs associated with treatment at the POTW are low to moderate, depending on constituent mass loadings, compared to other off-site treatment process options.
- *Summary*
  Treatment of source area groundwater by the POTW is retained for further evaluation.

3.7.10 On-site Discharge of Source Area Groundwater

Two process options were evaluated for on-site discharge: injection wells and injection trenches.

3.7.10.1 Source Area Groundwater Injection Wells

Treated source area groundwater could be injected into the Necco Park bedrock aquifer through injection wells.

- *Effectiveness*
  Bedrock fracture zones have moderate hydraulic conductivities that would allow for on-site discharge by injection of groundwater. However, injecting water would surcharge the area and could affect potential groundwater containment systems.

- *Implementability*
  Injection wells are implementable. Injection within source area bedrock could potentially impact adjacent landfill cells. A SPDES permit or its equivalent would be required.

- *Cost*
  Costs associated with on-site injection wells are high compared to other discharge process options.

- *Summary*
  On-site injection wells are screened from further evaluation because other source area groundwater discharge options are equally as effective and may have less impact on adjacent landfill cells.

3.7.10.2 Source Area Groundwater Injection Trenches

Treated groundwater could be injected into the Necco Park overburden aquifer through injection trenches.

- *Effectiveness*
  Overburden has a generally low permeability, which would make discharge by injection difficult. Discharging into the overburden aquifer may cause groundwater mounding and may impact the surrounding landfill cells.

- *Implementability*
  Injection trenches are implementable. A SPDES permit or its equivalent would be required.

- *Cost*
  Costs associated with injection trenches are moderate compared to other discharge process options.

- *Summary*
  Injection trenches are screened from further evaluation because other source area groundwater discharge options are equally as effective and may have less impact on adjacent landfill cells.

3.7.11 Off-site Discharge of Source Area Groundwater

Process options evaluated for off-site discharge are POTW, surface water, and off-site injection wells.

3.7.11.1 Off-site Discharge of Source Area Groundwater to the POTW

The Niagara Falls POTW may be considered an off-site discharge process option for specific remedies in which groundwater would be treated prior to discharge. Groundwater treated at an off-site commercial WWTP is not included in this option, even if ultimate discharge is to the POTW because disposal of treated water is the responsibility of the commercial WWTP.

The Niagara Falls POTW uses very sophisticated physical/chemical treatment unit operations to treat domestic and industrial wastewater. The POTW uses the following unit operations:

- Equalization
- Solids removal
- Carbon adsorption

Actual flow rates and constituent mass loadings are required before the POTW can determine if it will accept groundwater extracted from Necco Park.

- *Effectiveness*
  The POTW could handle treated source area groundwater.
- *Implementability*
  Assuming the POTW has sufficient capacity, discharge to the POTW would be implementable.
- *Cost*
  Costs associated with discharge at the POTW are high compared to other off-site discharge options because of sewer-use fees.
- *Summary*
  Discharge of pretreated source area groundwater to the POTW is screened from further evaluation because other off-site discharge options are equally as effective at a lower cost.

3.7.11.2 Off-site Discharge of Source Area Groundwater to Surface Water

Treated groundwater could be discharged to Niagara River. A discharge pipe would be constructed from the treatment unit to a storm sewer just south of CECOS secure cell No. 3.

- *Effectiveness*
  Niagara River could effectively handle treated groundwater.
- *Implementability*
  A SPDES permit or its equivalent would be required to discharge to Niagara River. Existing storm sewers could be used to convey treated groundwater to Niagara River.
- *Cost*
  Costs associated with discharge to Niagara River are mainly associated with SPDES monitoring and are moderate compared to other off-site discharge process options.
- *Summary*
  Discharge to Niagara River is retained for further evaluation

3.7.11.3 Off-site Discharge of Source Area Groundwater by Injection Wells

Treated groundwater could be reinjected into off-site bedrock through injection wells.

- *Effectiveness*
  Bedrock fracture zones have moderate hydraulic conductivities, which may allow the discharge of groundwater by injection.
- *Implementability*
  Injection wells are implementable. Access and right-of-ways may be difficult to obtain for off-site properties. A SPDES permit or its equivalent would be required.
- *Costs*
  Costs associated with off-site injection wells are high compared with other discharge process options. Costs are higher because of new discharge piping, wells required for injection, monitoring of discharge, and maintenance of wells.
- *Summary*
  Off-site injection is retained for further evaluation.

3.7.12 Summary of Source Area Groundwater Technology Process Option Evaluation

Table 3-9 provides a summary of the technology process option evaluation for source area groundwater.

3.8 Far-Field Groundwater Process Option Evaluation

Far-field groundwater is defined as bedrock groundwater that has been impacted by Necco Park constituents but where solubility criteria for DNAPL has not been met. Far-field groundwater extends generally from the southern edge of the source area south to the Falls Street tunnel, and from the western border of the source area west to the NYPA conduits. Direction of groundwater flow in B and C zones is to the south. Groundwater in D through G zones flows to the west. These utility drains (the Falls Street tunnel and NYPA conduit drains south of Porter Road) act as groundwater sinks. A majority of the water in the NYPA conduit drains flows into the Falls Street tunnel. All of the water in the Falls Street tunnel is treated by the Niagara Falls POTW during dry weather conditions. The estimated areal extent of far-field groundwater in each zone was presented in Figures 1-29 to 1-35. A complete discussion of the impact of the man-made passageways is found in Section 1.6.4.1.

Although groundwater is not currently a source of drinking water, the first RAO—restoration of groundwater to its designated use, potable drinking water, as impacted by Necco Park constituents—is the applicable RAO for far-field groundwater. However, as discussed in Sections 1.8.4 and 1.9.3, complete restoration to drinking-water standards is subject to uncertainty. Although significant decreases in off-site loadings result from containment of the source area, the potential effects of matrix diffusion may slow or prevent complete restoration of far-field groundwater.

The evaluation in this section focuses on technologies that are potentially effective in partially restoring far-field groundwater in a reasonable time frame. However, restoration is also dependent on the level of source control achieved, which cannot be evaluated until sitewide alternatives are developed (see Section 5.0).

Far-field groundwater treatment technologies will address Necco Park indicator parameters listed in Table 1-3. Groundwater indicator parameters include inorganic constituents, VOCs, and SVOCs. Necco Park indicator inorganic constituents have not been detected above ARAR levels in the far field. However, removal of inorganic compounds may be necessary to improve efficiency of required treatment technologies (i.e., air stripping or carbon adsorption). The majority of indicator parameters found in the far field are the more soluble VOCs. Organic compounds in general, particularly SVOCs, are found at much lower concentrations than those found in source area groundwater.

A review of applicable technologies for Necco Park far-field groundwater has been conducted and subjected to the evaluation process. A detailed discussion of the evaluation follows. A summary of the far-field groundwater technology process option evaluation is provided in Section 3.8.11.

3.8.1 No Action—Far-Field Groundwater

Under the no action technology, all ongoing existing response measures would be halted. The clay cap and grout curtain would remain in place, but maintenance operations for the cap would be discontinued. The current pump-and-treat system would be discontinued as well as groundwater monitoring, including far-field groundwater.

- *Effectiveness*
  The no action technology would not be effective in achieving RAOs.
- *Implementability*
  The no action technology is implementable.
- *Summary*
  The no action technology has no additional costs associated with it.
- *Summary*
  Although the no action technology is not effective in achieving RAOs, it is retained for comparison purposes as required by the NCP.

3.8.2 Far-Field Groundwater Monitoring

To verify the nature and extent of the groundwater plume and to track movement, degradation, and alteration of chemical constituents, a groundwater monitoring program has been implemented. Select far-field wells have been sampled and analyzed on a regular basis during interim remedial actions and remedial investigation. Additional wells could be added, if necessary, to monitor the far field. Groundwater elevations from monitor wells and piezometers could also be used to evaluate hydraulic control for potential extraction systems.

- *Effectiveness*
  Groundwater monitoring will not be effective in attaining RAOs. However, groundwater monitoring may be used in conjunction with other technologies to monitor effectiveness of remedial alternatives.
- *Implementability*
  Groundwater monitor wells can be sampled and measured on a scheduled basis. Groundwater monitoring is readily implementable.
- *Cost*
  Relative cost of groundwater monitoring is low compared to other institutional action technologies.
- *Summary*
  Although the groundwater monitoring technology is not effective in achieving RAOs, it can be used to monitor the remedial alternatives and is retained for incorporation into RAAs.

3.8.3 Far-Field Groundwater-Use Controls

Groundwater-use controls are local ordinances or state laws that limit use of water pumped from a well in the far-field area. Currently, the Niagara County Health Department requires a permit to install a water well. No such permits have been issued for the source area or far field. This requirement supplements deed restrictions in the source area.

- *Effectiveness*
  Groundwater-use controls are effective in controlling future activities in the far field.
- *Implementability*
  Groundwater-use controls are in place.

- *Cost*
  Cost of groundwater-use controls would be low.
- *Summary*
  Groundwater-use controls are retained for further evaluation.

3.8.4 Far-Field Groundwater Extraction

3.8.4.1 Far-Field Groundwater Extraction with Extraction Wells

This technology involves pumping and collecting contaminated groundwater for potential treatment and discharge. Extraction could be achieved through either continuous or pulsed pumping.

- *Effectiveness*
  Extraction wells are potentially an effective means of recovering groundwater to control the aqueous plume and reduce potential contaminant migration/loadings to Niagara River and to lower overall constituent concentrations.
- *Implementability*
  Depending on the design of a groundwater pump-and-treat system, far-field extraction wells may have to be located on private property. Right-of-ways for the wells and associated piping would be required.
- *Cost*
  Cost of constructing and operating far-field extraction wells is high compared to other extraction process options.
- *Summary*
  Extraction wells for far-field groundwater are retained for further evaluation.

3.8.4.2 Far-Field Groundwater Extraction with Existing Utility Drains

The Falls Street tunnel and NYPA conduit drains act as line sinks or discharges for regional bedrock (B through G zones) groundwater flow in the vicinity of Necco Park (see Section 1.6.4.1). A portion of the water in the NYPA conduit drains flows into the Falls Street tunnel. All of the water in the Falls Street tunnel is treated by the Niagara Falls POTW during dry weather conditions, and POTW personnel report that a predetermined amount (approximately 80 percent) is treated during wet weather conditions.

Falls Street tunnel is a gravity-fed sewer constructed in the early 1900s that extends 16,000 feet from 56th Street and John Street. The tunnel outfall was diverted from the Niagara River to the Niagara Falls POTW in 1989. For most of its length, the tunnel consists of an unlined rock tunnel. Groundwater in B and C bedrock zones flows south from Necco Park toward the Falls Street tunnel. Therefore, this tunnel acts as a groundwater sink for B and C bedrock zones in the vicinity of Necco Park.

In the vicinity of Necco Park, D through G zone groundwater flows toward the NYPA conduits and is collected by the conduit drain system, which ultimately discharges to the Niagara Falls POTW through the Falls Street tunnel, as discussed in Section 1.6.4.1.

- *Effectiveness*
  The Falls Street tunnel and the NYPA conduit drains are effective in collecting a portion of the far-field groundwater. A portion of the groundwater collected is effectively treated by the Niagara Falls POTW.
- *Implementability*
  Use of Falls Street tunnel and NYPA conduit drains to extract far-field groundwater is implementable.
- *Cost*
  Cost of using the Falls Street tunnel and NYPA conduit drains is low compared to other extraction process options.
- *Summary*
  Use of utility drains for groundwater extraction is retained for further evaluation.

3.8.5 Far-Field Groundwater Biological Treatment

The following process options have been identified for biological treatment: natural attenuation, in situ aerobic, ex situ aerobic, in situ anaerobic, and ex situ anaerobic.

3.8.5.1 Far-Field Groundwater Natural Attenuation

Natural attenuation is a process whereby naturally occurring chemical, physical, and biological processes reduce chemical concentrations, bioavailability, mobility, and toxicity. Natural attenuation is achieved through both destructive mechanisms and nondestructive mechanisms. Destructive mechanisms include aerobic and anaerobic biodegradation and hydrolysis. Nondestructive mechanisms include sorption, volatilization, dispersion, complexation, precipitation, and biological uptake.

- *Effectiveness*
  Natural attenuation would be an effective method of treating far-field constituents.
- *Implementability*
  Natural attenuation relies on natural processes to remediate contamination and is therefore readily implementable.
- *Cost*
  Costs associated with natural attenuation are low.
- *Summary*
  Natural attenuation for far-field groundwater is retained for further evaluation.

3.8.5.2 Far-Field Groundwater In Situ Aerobic Biological Treatment

In situ bioremediation is a group of associated technologies or methods used to stimulate naturally occurring microorganisms to biodegrade organic materials. Aerobic bioremediation refers to biological activities that require oxygen. In situ bioremediation involves altering environmental conditions to enhance microbial catabolism or co-metabolism of organic contaminants, which results in breakdown and eventual detoxification of constituents. Given proper nutrients and sufficient oxygen, indigenous microorganisms can degrade a wide range of organic compounds. Implementing a bioremediation system would include drilling nutrient delivery and oxygenation wells, constructing a nutrient delivery system (e.g., feed tanks, piping), and possibly installing a groundwater recycling system.

- *Effectiveness*
  Metals such as barium cannot be treated by bioremediation.

Bioremediation is unproven in fractured bedrock. At the current developmental stage of this technology, overall effectiveness of aerobic bioremediation is unknown. Halogenated hydrocarbons are generally degraded under anaerobic conditions. A treatability study would be required to determine if in situ aerobic treatment is effective.

- *Implementability*
  Monitoring and control of in situ bioremediation in a complex fractured bedrock aquifer system would be difficult. Nutrient feed wells and extraction wells may need to be located on private property. It may be difficult to obtain right-of-ways and frequent access to private property.

- *Cost*
  Costs associated with in situ bioremediation include the capital cost of drilling the wells and constructing the piping system. O&M costs include the cost for nutrients, energy costs for air injections, and O&M personnel labor costs. Cost of in situ aerobic treatment is moderate compared to other biological treatment process options because of moderate capital costs and high O&M costs.

- *Summary*
  In situ aerobic bioremediation could potentially be more effective than natural biological and physical processes but at a significantly greater cost. Therefore, in situ aerobic bioremediation is screened from further evaluation.

3.8.5.3 Far-Field Groundwater Ex Situ Aerobic Biological Treatment

In conventional suspended growth aerobic treatment, wastewater is added to an aerated tank containing a suspended slurry of microorganisms. Hydraulic retention time of the system can vary from a few hours to many days, depending on organic loading of the system and degradation rate of the contaminants. The biomass and treated wastewater are separated by gravity sedimentation in a clarifier following the aeration tank. Most of the settled biomass is recycled back to the aeration tank. Excess biomass resulting from the growth of the microorganisms must be periodically wasted from the system to maintain a constant biological solids inventory.

Another option is the use of a fixed-film biological reactor. Fixed-film biological reactors have been designed expressly for the treatment of low TOC wastewaters, such as groundwater. By using a fixed film, rather than a mixed-reactor design, washout of bacterial populations due to low organic inputs is less of a consideration. These systems operate under low carbon-to-surface-area ratios and are capable of achieving very low effluent concentrations of biodegradable compounds.

The units typically consist of submerged plastic growth media inside a reactor, with a one to two hour hydraulic retention time. Aeration is supplied by a blower through diffusers. Nutrients such as nitrogen and phosphorus must be added to wastewater if the groundwater is deficient in these elements.

- *Effectiveness*
  Metals such as barium cannot be treated by aerobic treatment. The presence of inhibitory compcunds may restrict the ability of microorganisms to degrade the contaminants of concern. A treatability study would be required to determine if ex situ aerobic treatment of far-field groundwater is effective.
- *Implementability*
  Ex situ aerobic groundwater treatment system would be difficult to implement. Extraction wells may need to be located on private property. It may be difficult to obtain right-of-ways and frequent access to private property.
- *Cost*
  The costs associated with ex situ aerobic treatment are high compared to other biological treatment process options.
- *Summary*
  Ex situ aerobic treatment could potentially be more effective than natural biological and physical processes but at a significantly higher cost. Therefore, ex situ aerobic treatment is screened from further evaluation.

3.8.5.4 Far-Field Groundwater In Situ Anaerobic Biological Treatment

In situ anaerobic bioremediation is a group of associated technologies or methods used to stimulate the naturally occurring soil microorganisms to biodegrade organic compounds anaerobically (without oxygen). This process involves altering environmental conditions to enhance microbial co-metabolism of organic contaminants, which breaks down and detoxifies constituents. Given proper nutrients, organic substrates, and electron acceptors, indigenous microorganisms can degrade a wide range of compounds, including lower molecular weight halogenated hydrocarbons such as unsaturated alkyl halides (e.g., PCE, TCE) and saturated alkyl halides (e.g., 1,1,1-trichloroethane).

Under anaerobic conditions, chlorines are sequentially removed from contaminants (e.g., PCE is reduced in sequence to TCE, which is reduced to 1,2-DCE, which is reduced to VC, which is further reduced to ethene). This process is known as reductive dehalogenation. Reductive dehalogenation of chlorinated aliphatic solvents appears to require either sulfate-reducing, fermenting, or methanogenic conditions.

Microbes require a suitable environment to support growth and activity, including available electron acceptors (e.g., oxygen, nitrate, iron, sulfate, or bicarbonate), nitrogen, phosphorus, trace minerals, appropriate temperature, and appropriate pH. Under sulfate-reducing conditions, microbes convert sulfate to hydrogen sulfide, typically with pyruvate, lactate, or molecular hydrogen as their electron donor. Methanogenic bacteria use a limited number of simple organic substrates to form methane. High levels of sulfate are inhibitory to methanogenic bacteria.

- *Effectiveness*
  The effectiveness of far-field anaerobic bioremediation is limited because of the large size of the area to be treated. A treatability study would be required to determine if anaerobic bioremediation is effective in far-field groundwater. Such a treatability study would be a complex and time-intensive effort that might or might not prove to be beneficial to the Necco Park remedial program. Many uncertainties accompany application of this technology in fractured bedrock.

- *Implementability*
  To distribute nutrients in the far field effectively, a large number of wells would have to be drilled. Nutrient delivery and extraction wells may be located on private properties, which would require right-of-ways and frequent access for routine O&M.

- *Cost*
  Cost is moderate relative to other biological process options because of moderate capital costs and the O&M costs.

- *Summary*
  In situ anaerobic bioremediation is screened from further evaluation because other natural biological and physical process options (i.e., natural attenuation) may be equally as effective at a significantly lower cost.

3.8.5.5 Far-Field Ex Situ Anaerobic Biological Treatment

Ex situ anaerobic treatment has been primarily applied in the stabilization of biological solids from municipal wastewater treatment systems and for degradation of high-strength industrial wastewaters. More recently, it has been recognized that microorganisms that develop under anaerobic conditions are capable of dehalogenating organic compounds.

- *Effectiveness*
  Metals such as barium cannot be treated by anaerobic treatment. The presence of inhibitory compounds may restrict the ability of microorganisms to degrade the constituents of concern. A treatability study would be required to determine if ex situ anaerobic treatment of source area groundwater is effective.

- *Implementability*
  If effective, an ex situ anaerobic groundwater treatment system would be implementable. Extraction wells may be located on private properties, which would require right-of-ways and frequent access for routine O&M.

- *Cost*
  Costs associated with ex situ anaerobic treatment are moderate compared to other biological treatment process options.

- *Summary*
  Ex situ anaerobic treatment is screened from further evaluation because natural biological processes may be equally as effective at a significantly lower cost.

3.8.6 Far-Field Groundwater Physical/Chemical Treatment

The following process options have been identified for physical/chemical treatment: precipitation, air stripping, steam stripping, carbon adsorption, chemical oxidation, RO, ion exchange, filtration, microfiltration, and vapor-phase treatment .

3.8.6.1 Far-Field Groundwater Treatment—Precipitation

Precipitation is a physico-chemical process in which some or all of a substance in solution is converted into the solid phase by shifting chemical equilibrium relationships of inorganic substances in solution. While some organic compounds are also removed, effectiveness in removal of organic constituents is generally limited. Once precipitated, wastewater flows to a flocculation chamber in which precipitated particles are gently mixed to allow them to agglomerate and form larger, more easily settled particles. From the flocculation tank, the water goes to a clarifier for gravity separation of agglomerated particles from wastewater. Filtration may be required following clarification to achieve treatment standards. Sludge must be dewatered prior to disposal. The precipitated sludge may be considered hazardous, depending on metals content and process application.

- *Effectiveness*
  Precipitation may be effective in treating the inorganic constituents in groundwater. Precipitation has limited effect in treating organic constituents.
- *Implementability*
  Precipitation is implementable. Disposal options would depend on sludge characteristics.
- *Cost*
  Costs associated with precipitation are low compared to other physical/chemical process options.

- *Summary*
  Precipitation of inorganic constituents in far-field groundwater is retained for further evaluation.

3.8.6.2 Far-Field Groundwater Treatment—Air Stripping

Air stripping is generally used for the removal of VOCs and may also be used for SVOCs, although less effectively. Organic constituents are partitioned from groundwater to air by greatly increasing the surface area of contaminated water exposed to air. Feasibility of air stripping is based on Henry's Law constant of organic constituents in the water stream. Henry's Law constant is an air/water partitioning constant, which is defined as the ratio of the compound's vapor pressure to its water solubility. Generally, organic compounds with Henry's Law constants greater than 3×10^{-4} atm-m^3/mole can be effectively air stripped. Compounds with low volatility at ambient temperature may require pre-heating of groundwater. Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.

Clogging of stripping column packing material due to inorganic constituents in groundwater (especially dissolved ferrous iron, which precipitates out as insoluble ferric hydroxide species upon aeration) and biofouling are common problems. Air strippers must be taken out of service and packing materials rinsed periodically with an acid wash.

Air-stripping systems for groundwater generally include liquid-phase polishing and vapor-phase treatment unit operations. In most cases, carbon adsorption is used for liquid-phase polishing to remove any trace organic constituents remaining in the groundwater after stripping. Other technologies, such as chemical oxidation, can also be used for final polishing. Organic vapors removed by air stripping are commonly removed by vapor-phase carbon adsorption. Depending on the amount of carbon needed, a carbon regeneration system may be required. In some cases, thermal oxidation or condensation of vapors may be appropriate for vapor-phase treatment.

- *Effectiveness*
  Air stripping would be effective in treating most volatile organic constituents in groundwater. SVOCs would require additional treatment. Air stripping is not effective for removing metals.
- *Implementability*
  Air stripping is implementable.
- *Cost*
  Costs associated with air stripping are moderate compared to other physical/chemical process options.
- *Summary*
  Air stripping of far-field groundwater is retained for further evaluation.

3.8.6.3 Far-Field Groundwater Treatment—Steam Stripping

Steam stripping is similar to air stripping except that steam is substituted for air as the mass transfer medium. Conditions for effective application of steam stripping include the presence of low volatility compounds (Henry's Law constant less than 3×10^{-4} atm-m^3/mole) and high concentrations of chemical constituents (greater than 100 mg/l) for recovery. It is particularly effective for SVOCs that have a low boiling point. Highly chlorinated compounds that have elevated boiling points are not amenable to steam stripping.

- *Effectiveness*
  Steam stripping would be effective in treating the organic constituents in groundwater.
- *Implementability*
  Steam stripping is implementable.
- *Cost*
  Costs associated with steam stripping are high compared with other physical/chemical process options due to energy costs to create steam.

- *Summary*
  Air stripping with liquid-phase carbon adsorption is generally as effective and less costly than steam stripping Therefore, steam stripping is screened from further evaluation.

3.8.6.4 Far-Field Groundwater Treatment—Carbon Adsorption

Carbon adsorption is a technology whereby groundwater is pumped through a series of canisters containing activated carbon to which dissolved organic constituents adsorb. Activated carbon selectively adsorbs organic constituents by a surface attraction phenomenon in which organic molecules are attracted to internal pores of carbon granules. Solubility and concentration of contaminants and type and pore size of carbon can impact process performance. Adsorption depends on the strength of molecular attraction between adsorbent and adsorbate, molecular weight, type and characteristic of adsorbent, electrokinetic charge, pH, and surface area. When micropore surfaces become saturated with organic constituents, carbon is "spent" and must either be replaced with virgin carbon or be thermally regenerated and returned to service.

Activated carbon is an effective and reliable means of removing low-solubility organic constituents and it is suitable for treating a wide range of organic constituents of widely varying concentrations. Some metals and inorganic species also have shown excellent to good adsorption potential. However, these metals and naturally occurring organic material can foul the system.

Activated carbon is easily implemented into more complex treatment systems. The process is well suited to mobile treatment systems as well as to on-site construction. Space requirements are small, startup and shutdown are rapid, and numerous contractors are experienced in the operation of mobile units.

- *Effectiveness*
  Carbon adsorption would be effective in treating organic constituents in groundwater.
- *Implementability*
  Carbon adsorption is implementable.

- *Cost*
  Costs associated with carbon adsorption are moderate compared to other physical/chemical process options due to carbon regeneration or replacement costs.

- *Summary*
  Carbon adsorption of far-field groundwater is retained for further evaluation.

3.8.6.5 Far-Field Groundwater Treatment—Chemical Oxidation

In chemical oxidation, oxidation state of the treated compound is raised through chemical addition. Organic compounds can ultimately be oxidized to carbon dioxide and water, although such extensive treatment is generally not necessary. The most powerful form of oxidation and method of choice for groundwater treatment is generally UV catalyzed oxidation. Chemical oxidants commonly used include ozone and hydrogen peroxide. Organic constituents for which successful UV oxidation has been reported include halogenated volatile constituents, pesticides, chlorinated phenols, PCBs, and dioxins. UV oxidation has been applied for treatment of organic constituents at a number of groundwater remediations.

- *Effectiveness*
  A potential disadvantage of oxidation is that intermediaries formed may be more toxic than starting compounds, although this can typically be controlled by proper selection of reactor residence time and oxidant dosage. A given disadvantage is that the process is relatively nonselective in that any oxidizable substance will be attacked. This can dramatically increase the required dosage of oxidant.

  Chemical oxidation should be effective in treating most organic constituents in groundwater.

- *Implementability*
  Chemical oxidation is implementable.

- *Cost*
  Costs associated with chemical oxidation are high compared to other physical/chemical process options due to chemical and energy costs.

- *Summary*
  Chemical oxidation is more expensive, without a significant increase in effectiveness, compared to air stripping and carbon adsorption. Therefore, chemical oxidation is screened from further evaluation.

3.8.6.6 Far-Field Groundwater Treatment—Reverse Osmosis

Osmosis is the movement of a solvent from a dilute solution through a semipermeable membrane to a more concentrated solution. RO is the application of sufficient pressure to the concentrated solution to overcome osmotic movement and force solvent to the more dilute side. This allows for a buildup of a concentrated solution on one side while water is transported through the membrane.

RO has been used to reduce the concentration of both organic and inorganic dissolved solids, as well as low molecular weight organic constituents such as alcohols, ketones, aldehydes, and amines. However, RO units are subject to chemical fouling and plugging. Also, wastewater may require pretreatment to remove any oxidizing materials, particulates, or oil and grease.

- *Effectiveness*
  Inorganic compounds may have to be removed prior to treatment to prevent membrane fouling. RO membranes will not reject all constituents of concern.
- *Implementability*
  RO may be implementable with pretreatment and post-treatment.
- *Cost*
  Costs associated with RO are high.
- *Summary*
  RO is more expensive and less effective than chemical precipitation for inorganic constituents and air stripping and carbon adsorption for organic constituents. Therefore, RO is screened from further evaluation.

3.8.6.7 Far-Field Groundwater Treatment—Ion Exchange

Ion exchange is a process in which charged ions can be removed from a waste stream and substituted with less harmful ions from exchange material. Most exchange materials are synthetic compounds containing functional groups with exchangeable ions attached. The exchange reaction is reversible, which allows for regeneration of exchange material. Selective resins are available that preferentially exchange certain ions, such as heavy metals.

Design of ion exchange systems must consider total suspended solids and total quantity of charged species in groundwater. Although ion exchange systems can readily treat a changing composition wastewater, care must be taken to keep suspended solids to less than 50 mg/l to reduce plugging.

- *Effectiveness*
  Ion exchange may be effective in treating some inorganic constituents in groundwater. It has negligible effect on organic constituents.
- *Implementability*
  Ion exchange is readily implementable.
- *Cost*
  Costs associated with ion exchange is high compared to other physical/chemical process options due to the cost of resin.
- *Summary*
  Ion exchange is more expensive and less effective than precipitation for inorganic constituent removal. Therefore, ion exchange is screened from further evaluation.

3.8.6.8 Far-Field Groundwater Treatment—Filtration

Filtration is a physical process in which suspended solids are removed from solutions by forcing fluid through a porous media. The suspended solids are trapped or enmeshed in the media. Typically, the media consists either of sand or sand plus anthracite or coal. As more suspended solids are trapped in the filter media, the filter becomes clogged, and flow through the filter is reduced. When this occurs, the filter media must be cleaned. The media is cleaned by reversing flow through the filter and fluidizing the media bed. The solids are then washed from the media. The backwash contains a high concentration of solids that require further treatment.

- *Effectiveness*
  Filtration would be an effective process option when used in conjunction with another process option such as carbon adsorption or chemical precipitation.
- *Implementability*
  Filtration is readily implementable.
- *Cost*
  Costs associated with filtration are moderate compared to other physical/chemical process options.
- *Summary*
  Filtration is retained for further evaluation.

3.8.6.9 Far-Field Groundwater Treatment—Microfiltration

Microfiltration is a low pressure (20 to 40 psi) membrane process that removes particulate matter through membrane pores. Solids are kept in a recirculation stream that periodically discharges to a filter press for dewatering. Microfiltration units are generally more expensive and require more maintenance than standard sand or multimedia filtration units, but can achieve lower solids concentrations in the effluent.

- *Effectiveness*
  Microfiltration would be an effective method for removing inorganic constituents.
- *Implementability*
  Microfiltration is readily implementable.
- *Cost*
  Costs associated with microfiltration are high compared to other physical/chemical process options.
- *Summary*
  Microfiltration is screened from further evaluation because it is more expensive than filtration without a significant increase in process effectiveness.

3.8.6.10 Far-Field Groundwater—Vapor-Phase Treatment

Far-field groundwater vapor-phase treatment refers to technologies that would be used to treat organic vapors generated from other treatment technologies (i.e., air stripping). Vapor-phase treatment may include one or more of the following process options: condensation and disposal off-site, carbon adsorption, or thermal oxidation. Condensation and disposal off-site and carbon adsorption are generally appropriate where small volumes of organic vapors are expected. Thermal oxidation is generally more cost-effective for larger quantities of organic vapors.

- *Effectiveness*
  Vapor-phase treatment can effectively remove or destroy organic vapors.
- *Implementability*
  Vapor-phase treatment technologies are commercially available. Air permits or their equivalents may be required.
- *Cost*
  Cost for vapor-phase treatment includes labor to install and operate the treatment unit. Costs for vapor-phase treatment equipment are fairly inexpensive. Operating costs could be significant, depending on the quantity of vapor requiring treatment, and could include off-site disposal, carbon replacement or regeneration, and fuel for thermal oxidation. Cost for vapor-phase treatment is moderate compared to other physical/chemical process options.
- *Summary*
  Vapor-phase treatment can effectively control vapors from other far-field groundwater treatment technologies and is retained for further evaluation.

3.8.7 Far-Field Groundwater Thermal Treatment—Incineration

The only thermal treatment process option for far-field groundwater is incineration.

- *Effectiveness*
  Thermal treatment of groundwater could potentially destroy organic constituents dissolved in groundwater. Metals would not be affected by thermal treatment.
- *Imple:nentability*
  Incineration of groundwater is difficult to implement. The groundwater would have to be mixed with fuel to burn efficiently. Very durable materials of

construction are required to handle HCl formed from the combustion of chlorinated compounds. Generally, incinerators are met with strong public opposition.

- *Cost*
  Mobilization and installation of incineration equipment is very expensive. Significant labor and material costs are required for operation. The cost of incineration is high compared to other physical/chemical process options for far-field groundwater.

- *Summary*
  Thermal treatment of far-field groundwater is screened from further evaluation because other physical/chemical process options are equally as effective at a significantly lower cost.

3.8.8 Off-site Treatment of Far-Field Groundwater

Two process options have been identified for off-site treatment: commercial WWTP and POTW.

3.8.8.1 Off-Site Treatment of Far-Field Groundwater at a Commercial WWTP

Commercial WWTPs are available to accept groundwater collected in the far field. The facilities would need a RCRA permit if extracted groundwater exceeds RCRA toxicity characteristics for specific constituents. For purposes of this evaluation, the CECOS WWTP was considered representative of available commercial WWTPs. Alternate commercial WWTPs may be considered if the chosen remedy exceeds CECOS available capacity or if another facility can treat groundwater more cost-effectively than CECOS.

The CECOS WWTP, located next to Necco Park, is capable of treating far-field area groundwater constituents, depending on the anticipated groundwater flow rate. Treatment processes used at CECOS are equalization, chemical precipitation, filtration, air stripping, and liquid- and vapor-phase carbon adsorption. Treated water is discharged to the POTW.

- *Effectiveness*
  CECOS process is effectively treating groundwater pumped from the existing groundwater recovery system. Similar commercial WWTPs would be equally as effective.

- *Implementability*
  CECOS has indicated that they have available capacity for up to 110 gpm of groundwater flow expected by DuPont. This estimated available flow capacity assumes a nominal design capacity of 210 gpm and 100 gpm reserved for other nonDuPont wastewater streams, including CECOS landfill leachate. Far-field groundwater extraction rates are expected to significantly exceed 110 gpm and would require capital expansion at CECOS or use of alternate commercial WWTPs.

  Significant capital expansion at Necco Park would be required to build collection, loading, and transportation facilities for off-site shipment to alternate commercial WWTPs. Present facilities for discharge to CECOS are through an aboveground pipeline. To allow for off-site shipment, railcars would likely be used to collect extracted groundwater. A rail spur and loading facilities would have to be constructed and connected to rail services west of the site.

- *Cost*
  Costs associated with commercial WWTP treatment are high compared to other off-site treatment process options. Significant capital costs would be required to expand CECOS or allow off-site shipment to another commercial WWTP.

- *Summary*
  Treatment at CECOS for far-field groundwater is screened from further evaluation due to insufficient hydraulic capacity and capital costs to increase capacity. Treatment at alternate off-site commercial WWTPs is screened from further evaluation due to difficulties in implementation and high costs required to build storage and loading facilities for off-site transportation.

3.8.8.2 Off-site Treatment of Far-Field Groundwater at the POTW

In this section, POTW treatment refers to using the Niagara Falls POTW as the only treatment system for extracted groundwater. Discharge to the POTW after pretreatment is discussed in Section 3.8.10. The Niagara Falls POTW uses very sophisticated physical/chemical treatment unit operations to treat domestic and industrial wastewater. The POTW uses the following unit operations:

- Equalization
- Solids removal
- Carbon adsorption

Actual flow rates and constituent mass loadings are required before the POTW can determine if they will accept extracted far-field groundwater.

- *Effectiveness*
  POTW could effectively treat far-field groundwater. The groundwater flow from Necco Park would not significantly alter the POTW's treatment effectiveness.
- *Implementability*
  Assuming the POTW has sufficient capacity and will accept the selected remedy flow rate, treatment at the POTW would be implementable.
- *Cost*
  Costs associated with treatment at the POTW are moderate compared to other off-site treatment process options.
- *Summary*
  Treatment by the POTW is retained for further evaluation.

3.8.9 On-site Discharge of Far-Field Groundwater

Two process options were evaluated for on-site discharge: injection wells and injection trenches.

3.8.9.1 Far-Field Groundwater On-site Injection Wells

Treated far-field groundwater could be injected into the Necco Park bedrock aquifer through injection wells.

- *Effectiveness*
  Bedrock fracture zones have moderate hydraulic conductivities, which would allow for discharge of treated groundwater by injection in the far

field. However, injecting water would surcharge the area and could affect potential groundwater control systems.

- *Implementability*
  Injection wells are implementable. A SPDES permit or its equivalent would be required.
- *Cost*
  Costs associated with injection wells are high compared to other discharge process options because of potential high maintenance costs to prevent well plugging.
- *Summary*
  On-site injection wells are screened from further evaluation because other far-field groundwater discharge options are equally as effective and have less maintenance requirements.

3.8.9.2 Far-Field Groundwater On-site Injection Trenches

Treated groundwater could be injected into the Necco Park overburden aquifer through injection trenches.

- *Effectiveness*
  Overburden has a generally low permeability, which would make discharge by injection difficult. Necco Park does not have adequate area to handle the expected hydraulic loading of a far-field pump-and-treat system. Discharging into the overburden aquifer may cause groundwater mounding and may impact the surrounding landfill cells.
- *Implementability*
  Injection trenches are not implementable due a lack of space.
- *Cost*
  Costs associated with injection trenches are moderate compared to other discharge process options.
- *Summary*
  On-site injection trenches are screened from further evaluation because of lack of hydraulic capacity and potential groundwater mounding.

3.8.10 Off-site Discharge of Far-Field Groundwater

Process options evaluated for off-site discharge of far-field groundwater are POTW and surface water.

3.8.10.1 Off-site Discharge of Far-Field Groundwater to the POTW

The Niagara Falls POTW may be considered an off-site discharge process option for specific remedies in which groundwater would be treated prior to discharge. Groundwater treated at an off-site commercial WWTP is not included in this option, even if ultimate discharge is to the POTW, because disposal of the treated water is the responsibility of the commercial WWTP.

- *Effectiveness*
  The POTW could handle treated far-field groundwater.
- *Implementability*
  Assuming the POTW has sufficient capacity and would accept the selected remedy flow rate, discharge to the POTW would be implementable.
- *Cost*
  The costs associated with discharge at the POTW are high compared to other off-site discharge process options because of sewer-use fees.
- *Summary*
  Discharge to the POTW is screened from further evaluation because other off-site discharge options are equally as effective at a lower cost.

3.8.10.2 Off-site Discharge of Far-Field Groundwater to Surface Water

Treated groundwater could be discharged to Niagara River. A discharge pipe would be constructed from the treatment unit to existing SPDES outfall just south of CECOS secure cell No. 3.

- *Effectiveness*
  Niagara River could effectively handle treated groundwater.

- *Implementability*
  An SPDES permit or its equivalent would be required to discharge to Niagara River. Existing SPDES outfalls could be used to convey treated groundwater to Niagara River.
- *Cost*
  Costs associated with discharge to Niagara River are mainly associated with SPDES monitoring and are moderate compared to other off-site discharge process options.
- *Summary*
  Discharge to Niagara River is retained for further evaluation.

3.8.10.3 Off-site Discharge of Far-Field Groundwater by Injection Wells

Treat:d groundwater could be reinjected into off-site bedrock through injection wells.

- *Effectiveness*
  Bedrock fracture zones have moderate hydraulic conductivities, which may allow the discharge of groundwater by injection.
- *Implementability*
  Injection wells are implementable. Access and right-of-ways may be difficult to obtain for off-site properties. A SPDES permit or its equivalent would be required.
- *Costs*
  Costs associated with off-site injection wells are high compared with other discharge process options. Costs are higher because of new discharge piping and wells required for injection monitoring of discharge and maintenance of wells.
- *Summary*
  Off-site injection of far-field groundwater is retained for further evaluation.

3.8.11 Summary of Far-Field Groundwater Technology Process Option Evaluation

Table 3-10 provides a summary of the technology process option evaluation for far-field groundwater.

3.9 Summary

Table 3-11 lists representative technology process options for each media retained for incorporation into media-specific RAAs in Section 4.0.

4.0 RESPONSE ALTERNATIVE SCREENING

4.1 Introduction

Section 1.0 of the AOA report described Necco Park and the nature and extent of contamination. In Section 2.0, the RAOs for Necco Park were developed based on ARARs. The following RAOs were developed:

- Restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination
- Control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality

Volumes and areas of media of concern were also identified in Section 2.0. Section 3.0 identified appropriate technologies for addressing constituents in the four media at Necco Park. This section describes development and evaluation of media-specific RAAs. Site-specific RAAs are described and evaluated in Section 5.0 from media-specific RAAs selected by the screening procedure.

Three steps are typically conducted during RAA screening. First, alternatives are identified and defined by selecting individual technologies or combining technologies to form an RAA for the specific media of concern. Second, alternatives are evaluated on a general basis to determine their effectiveness in attaining RAOs, implementability, and overall cost. Third, a decision is made based on this evaluation as to which alternatives should be retained for further analysis and which alternatives should be screened from further consideration.

4.2 RAA Development

Technologies retained from Section 3.0 have been combined into RAAs for review and screening in this section. Media-specific RAAs are described and evaluated based on their effectiveness, implementability, and cost. These RAAs will then be screened based on the degree to which they attain the RAOs. This screening aids in streamlining the analysis while ensuring that the most promising alternatives are considered.

In developing RAAs, protection of human health and environment was considered. Groundwater contamination from Necco Park does not pose a current risk to human health because there is no current direct exposure to groundwater (TRC 1993). Future groundwater uses are expected to be limited because an abundant drinking-water source exists, and natural groundwater quality is undesirable as a result of high levels of salinity and sulfur.

In all alternatives except the no action alternative, a cap at Necco Park would be maintained, thereby eliminating the potential of human and ecological receptor contact with overburden. Direct human and ecological receptor exposure to DNAPL is unlikely because of its subsurface location. Therefore, assuming continued use of existing public water supply system, all RAAs would be protective of human health and environment.

Sections 4.2.1 through 4.2.4 discuss media of concern and technologies retained for media-specific RAA development. As stated in Section 3.0, one representative process option was selected, if possible, for each technology type to simplify development and evaluation of alternatives without limiting flexibility during remedial design. The representative process provides a basis for the alternative evaluation; however, the specific process option actually used to implement the response action at Necco Park may not be selected until the RAA design phase. The no action technology was retained for each media as required by NCP.

4.2.1 Overburden

Overburden has been defined as natural soil and fill a the 24-acre Necco Park facility. Natural soil consists of glaciolacustrine deposits and glacial till. Overburden thickness ranges from 20 to 30 feet. Assuming a depth of 25 feet, the volume of overburden is approximately 1 million cubic yards.

Overburden alternatives are intended to address the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality.

Institutional action process options retained for overburden include deed restrictions, fencing, security personnel, and air monitoring. Containment process options retained for overburden are clay cap, a NYS 360 cap, a NYS 373 cap, and slurry wall. Slurry walls are a representative vertical barrier process option, but other barriers may be considered in remedial design. Excavation of overburden is also retained. Excavation of selected areas with expected higher organic constituent concentrations and excavation of all overburden will be evaluated separately. DPE, thermal desorption, ex situ stabilization, and vapor-phase treatment are process options retained for treatment actions. On-site disposal was retained as a disposal process option.

4.2.2 DNAPL

DNAPL has been defined as free-phase DNAPL at Necco Park and generally contains the following compounds:

- Hexachlorobutadiene
- Hexachlorethane
- Hexachlorobenzene
- Chloroform
- PCE
- 1,1,2,2-tetrachloroethane
- TCE

Organic liquids were originally placed in overburden and have migrated, in part, into bedrock underlying the overburden. Much of the DNAPL appears to be located in overburden (WCC 1992). However, free-phase DNAPL has been observed in B through F zone fractures. In overburden, DNAPL appears to be primarily located within lower portions of fill and within underlying till of Necco Park. The volume of DNAPL present is unknown.

DNAPL alternatives are intended to address the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality.

Institutional action process options retained for DNAPL include deed restrictions, groundwater-use controls, and DNAPL monitoring. Containment process options retained are slurry walls and grout curtains. Slurry walls are a representative vertical barrier process option, but other barriers may be considered in remedial design. Free-phase DNAPL has not been observed in G zone. Therefore, a grout curtain in B through F zones and a grout curtain in B through G zones will be considered separately. Extraction process options are extraction wells (horizontal and vertical) and trenches. Off-site incineration is included as a treatment technology to destroy extracted DNAPL. DPE with vapor-phase treatment is a representative in situ treatment process option.

4.2.3 Source Area Groundwater

Source area groundwater is defined as groundwater in overburden and bedrock in areas where aqueous concentrations may indicate the presence of DNAPL (i.e., solubility criteria were met) or where DNAPL has been observed. Source area groundwater includes both overburden and bedrock groundwater.

The goal of source area groundwater alternatives is to reduce or eliminate constituent loading to the far field. Current technology cannot completely remove DNAPL from the source area; consequently, DNAPL will be a continuing source of groundwater contamination.

Institutional action process options retained for source area groundwater include groundwater monitoring, deed restrictions, and groundwater-use controls. Containment process options are slurry wall, grout curtain, and hydraulic control (extraction wells and trenches). Groundwater recovery trenches, slurry wall, and hydraulic control are appropriate process options for containing A zone groundwater. Grout curtain and hydraulic control are appropriate process options for bedrock zones. Containment in A through F zones and in A through G zones will be considered separately.

Treatment of groundwater extracted by trenches or wells would be necessary. The nature of extracted groundwater from the existing pump-and-treat system and groundwater monitoring results indicate that groundwater contains both organic and inorganic constituents. Therefore, a groundwater treatment process train was developed to address both organic and inorganic constituents for the purpose of this evaluation.

Ex situ aerobic treatment and ex situ anaerobic treatment were retained as potential groundwater treatment technologies. However, air stripping, vapor-phase carbon adsorption, and liquid-phase carbon adsorption will be considered as representative organic constituent treatment process options for on-site treatment of groundwater. As stated in Section 3.0, one representative process was selected, if possible, for each technology type to simplify development and evaluation of alternatives without limiting flexibility during remedial design. The representative process provides a basis for the alternative evaluation; however, the specific process option actually used to implement the response action at Necco Park may not be selected until the RAA design phase. Organic constituent treatment process options that were screened (e.g., steam stripping, chemical oxidation) or biological treatment (aerobic or anaerobic) may be selected for implementation during design phase depending on effluent water-quality requirements.

Precipitation and filtration were retained as representative inorganic constituent treatment process options for on-site groundwater treatment. Inorganic constituent treatment process options that were screened (e.g., ion exchange, RO, and microfiltration) may be selected for implementation during design phase depending on effluent quality requirements.

Off-site source area groundwater treatment process options that were considered are commercial treatment and POTW treatment.

Representative discharge process options for treated source area groundwater are discharge to surface water and injection. POTW discharge, which was screened from further evaluation, may be selected as the discharge process option in design phase.

4.2.4 Far-Field Groundwater

Far-field groundwater is defined as groundwater impacted by Necco Park constituents where solubility criteria for DNAPL has not been met (see Figures 1-29 through 1-35).

Far-field groundwater extends generally from the southern edge of the source area south to the Falls Street tunnel, and from the western border of the source area west to the NYPA conduits. Direction of groundwater flow in B through C zones is to the south. Groundwater in D through G zones flows to the west. Far-field groundwater includes only bedrock groundwater.

Far-field alternatives address the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination.

Institutional action process options retained for far-field groundwater include groundwater monitoring and groundwater-use controls. Hydraulic control (extraction wells, utility drains) is the only containment process option retained. Varying extents of hydraulic control (50, 75, and 100 percent) are considered separately.

Treatment of groundwater extracted by hydraulic control would be necessary. The extracted groundwater is expected to have lower constituent concentrations than source area groundwater. The volume of water extracted to achieve 50, 75, and 100 percent containment is expected to be greater than the volume of groundwater extracted in source area groundwater alternatives, based on groundwater modeling studies described in Section 1.0.

Air stripping, vapor-phase carbon adsorption, and liquid-phase carbon adsorption were retained as representative organic constituent treatment process options for on-site treatment of groundwater. As stated in Section 3.0, one representative process was selected, if possible, for each technology type to simplify development and evaluation of alternatives without limiting flexibility during remedial design. The representative process provides a basis for the alternative evaluation; however, the specific process option actually used to implement the response action at Necco Park may not be selected until the RAA design phase. Organic constituent treatment process options that were screened (e.g., steam stripping, chemical oxidation) may be selected for implementation during design phase depending on effluent quality requirements.

Precipitation and filtration were retained as representative inorganic constituent treatment process options for on-site treatment of far-field groundwater. Inorganic constituent treatment process options that were screened (e.g., ion exchange, RO, and microfiltration) may be selected for implementation during design phase depending on discharge requirements.

Representative discharge process options for treated groundwater are discharge to surface water and injection. POTW discharge, which was screened from further evaluation, may be selected as the discharge process option in the design phase.

POTW treatment was retained as an off-site treatment process option.

4.3 Alternative Descriptions

Sections 4.3.1 through 4.3.4 describe media-specific alternatives. Sections 4.4 through 4.7 evaluate alternatives developed for each specific media (overburden, DNAPL, source area groundwater, far-field groundwater).

4.3.1 Overburden Alternative Descriptions

Nine alternatives have been developed for Necco Park overburden (OB) to address the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Components of each overburden alternative are summarized in Table 4-1.

Alternative OB1 is no action. Alternatives OB2 through OB6 are overburden containment alternatives. Alternatives OB7 through OB9 encompass both containment and overburden treatment alternatives. Each alternative is summarized as follows:

- Alternative OB1 is no action for overburden. This alternative consists of discontinuing ongoing remedial measures (i.e., cap maintenance).
- Alternative OB2 is the current overburden system. This alternative consists of maintenance of existing fencing, maintaining security personnel, and ongoing maintenance of the existing clay cap on the Necco Park property.

Alternatives OB3 through OB9 contain deed restrictions, existing maintenance of fencing, and security personnel as institutional actions. Air monitoring would be conducted as necessary during implementation of these alternatives.

- Alternative OB3 consists of institutional actions (deed restriction, existing maintenance of fencing, and security personnel), upgrading the existing cap by adding a protective layer, and regrading.
- Alternati·'e OB4 consists of institutional actions (deed restrictions, existing maintenance of fencing, and security personnel) and upgrading the existing cap by installing a low-permeability liner.
- Alternative OB5 consists of institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), a cap upgrade, and installing a downgradient slurry wall along the southern perimeter of the 24-acre facility to prevent horizontal constituent migration. The cap upgrade used for this alternative and subsequent alternatives will be based on the evaluation of alternatives OB3 and OB4.
- Alternative OB6 consists of institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), a cap upgrade, and installing a perimeter slurry wall around the 24-acre facility to prevent horizontal constituent migration.

Alternatives OB7 through OB9 include both containment and treatment technologies.

- Alternative OB7 consists of institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), a cap upgrade, and installing a DPE system with vapor-phase, liquid-phase, and aqueous-phase treatment. The primary purpose of DPE is to remove and treat organic overburden constituents.
- Alternative OB8 consists of excavating selected areas within Necco Park containing higher organic constituent concentrations, thermally desorbing excavated material, stabilizing residuals, and placing them into an on-site landfill. Alternative OB6 also consists of a cap upgrade, a downgradient slurry wall, and institutional actions (deed restrictions, existing maintenance of fencing, and security personnel).
- Alternative OB9 consists of excavating all overburden, thermally desorbing excavated material, stabilizing residuals, and placing them into an on-site landfill. Alternative OB9 also contains institutional actions (deed restrictions, existing maintenance of fencing, and security personnel).

4.3.2 DNAPL Alternatives Descriptions

Seven DNAPL (D) media alternatives have been developed to meet the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Components of each DNAPL alternative are summarized in Table 4-2.

Alternative D1 is the no action alternative. Alternative D2 is continued O&M of existing systems. Alternatives D3 through D6 are physical containment alternatives with source removal. Alternative D7 is an in situ DNAPL treatment alternative. DNAPL alternatives are discussed in the paragraphs that follow.

- Alternative D1 is no action for DNAPL. This alternative consists of discontinuing all ongoing remedial operations (i.e., DNAPL monitoring, extraction, and incineration).
- Alternative D2 is the current DNAPL collection operation. This alternative consists of DNAPL monitoring, DNAPL extraction from existing wells, and incineration of extracted DNAPL.

Alternatives D3 through D7 include deed restrictions and DNAPL monitoring as institutional actions, DNAPL extraction through existing wells, and incineration of extracted DNAPL at an off-site facility.

- Alternative D3 includes institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), DNAPL extraction through existing wells, and disposal. Alternative D3 also includes enhanced DNAPL extraction from new wells or a trench. Extracted DNAPL would be incinerated at an off-site facility.
- Alternative D4 includes institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), DNAPL extraction from existing wells, and disposal. Alternative D4 also includes a downgradient slurry wall to control horizontal DNAPL migration in A zone.
- Alternative D5 includes institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), additional DNAPL extraction, and disposal. Alternative D5 also includes a downgradient slurry wall along the southern perimeter of the Necco Park facility to control horizontal DNAPL migration in A zone and a grout curtain around the source area to control horizontal DNAPL migration in B through F zones.

- Alternative D6 includes institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), additional DNAPL extraction, and disposal. Alternative D6 also includes a downgradient slurry wall to control horizontal DNAPL migration in A zone and a grout curtain to control horizontal DNAPL migration in B through G zones.
- Alternative D7 includes institutional actions (deed restrictions, existing maintenance of fencing, and security personnel), additional DNAPL extraction, and disposal. Alternative D7 also includes DPE with vapor-phase aqueous phase and liquid-phase treatment of constituents.

4.3.3 Source Area Groundwater Alternative Descriptions

Fourteen alternatives have been developed for the source area groundwater (SGW) media. Alternative SGW1 is the no action alternative. Alternative SGW2 is continued O&M of existing systems. Alternatives SGW3 through SGW7 consist of varying degrees of hydraulic control with different groundwater treatment options for extracted groundwater. Alternatives SGW11 through SGW14 consist of varying degrees of hydraulic control and differing physical containment options. Alternatives are as follows and are summarized in Table 4-3:

- Alternative SGW1 is the no action alternative for source area groundwater. This alternative consists of discontinuing all ongoing remedial operations (i.e., groundwater monitoring, hydraulic control, and commercial treatment). Groundwater-use controls and the existing grout curtain would remain in place.
- Alternative SGW2 is continued O&M of the current source area groundwater system. This alternative consists of groundwater monitoring, groundwater-use controls, existing grout curtain, hydraulic control in B through F zones, and commercial treatment.

Alternatives SGW3 through SGW14 include groundwater monitoring, deed restrictions, and groundwater-use controls as institutional actions.

- Alternative SGW3 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), existing grout curtain, a downgradient slurry wall, A zone hydraulic control, and commercial treatment.
- Alternative SGW4 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), existing grout curtain, enhanced hydraulic control of B through F zones, and commercial treatment.

- Alternative SGW5 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), existing grout curtain, a downgradient slurry wall, enhanced hydraulic control of A through F zones, and commercial treatment.
- Alternative SGW6 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), existing grout curtain, total hydraulic control of B through F zones, and commercial treatment.
- Alternative SGW7 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), existing grout curtain, total hydraulic control of B through F zones, and POTW treatment.
- Alternative SGW8 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), existing grout curtain, total hydraulic control of B through F zones, and on-site treatment with surface-water discharge or injection.

Alternatives SGW9 through SGW14 will contain the most appropriate groundwater treatment system from alternatives SGW6, SGW7, or SGW8.

- Alternative SGW9 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), a downgradient slurry wall, existing grout curtain, total hydraulic control of A through F zones, and groundwater treatment.
- Alternative SGW10 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), existing grout curtain, total hydraulic control of B through G zones, and groundwater treatment.

Alternatives SGW11 through SGW14 include a perimeter grout curtain around the source area to enhance hydraulic control and provide physical containment within bedrock zones. For these alternatives, hydraulic control will be achieved by creating an inward gradient across the grout curtain. This inward gradient acts as secondary containment and provides total hydraulic control within the source area.

- Alternative SGW11 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), total hydraulic control of B through F zones, groundwater treatment, and a grout curtain surrounding the source area in B through F zones.

- Alternative SGW12 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), a downgradient slurry wall, total hydraulic control of A through F zones, groundwater treatment, and a grout curtain surrounding the source area in B through F zones.
- Alternative SGW13 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), total hydraulic control of B through G zones, groundwater treatment, and a grout curtain surrounding the source area in B through G zones.
- Alternative SGW14 includes institutional actions (groundwater monitoring, deed restrictions, and groundwater-use controls), total hydraulic control of B through G zones, groundwater treatment, and a grout curtain surrounding the source area in B through F zones.

4.3.4 Far-Field Groundwater Alternatives

Six alternatives have been developed for the far-field groundwater (FGW) media. Alternative FGW1 is the no action alternative. Alternative FGW2 is continued maintenance of existing monitoring. Alternatives FGW3 through FGW6 consist of various degrees of hydraulic control and treatment systems. The alternatives are as follows and are summarized in Table 4-4:

- Alternative FGW1 is the no action alternative for far-field groundwater. Groundwater-use controls, containment by existing utility drains, and natural attenuation would continue. Existing utility drains are NYPA conduits and Falls Street tunnel. The influence of the utility drains is discussed in Section 1.0 and considered as a process option in Section 3.0.
- Alternative FGW2 is continued maintenance of existing activities for far-field groundwater. This consists of groundwater monitoring, groundwater-use controls, natural attenuation, and containment by utility drains.

Alternatives FGW3 through FGW6 include extraction of groundwater by recovery wells.

- Alternative FGW3 consists of providing recovery of 50 percent of far-field groundwater (by contaminant loading), POTW treatment, natural attenuation, groundwater-use controls, and containment through utility drains.
- Alternative FGW4 consists of providing recovery of 75 percent of far-field groundwater, POTW treatment, natural attenuation, groundwater-use controls, and containment through utility drains.

- Alternative FGW5 consists of providing recovery of 100 percent of far-field groundwater, POTW treatment, natural attenuation, groundwater-use controls, and containment through utility drains.
- Alternative FGW6 consists of providing recovery of 100 percent of far-field groundwater, on-site treatment, injection of treated groundwater, natural attenuation, groundwater-use controls, and supplemental containment through utility drains.

4.4 Overburden Alternative Evaluation

The following subsections describe the evaluation of overburden alternatives presented in Section 4.3.1. These alternatives were assembled to address the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Overburden alternatives do not directly address the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. However, overburden alternatives may have beneficial impact on other media, such as source area groundwater, by restricting constituent migration within overburden. Benefits of these overburden technologies across media will be evaluated in Section 5.0, Detailed Analysis of Alternatives.

Overburden is defined as natural soil and fill at the 24-acre Necco Park facility. Overburden material ranges from 20 to 30 feet in thickness and includes both saturated and unsaturated zones. Using a depth of 25 feet, the volume of overburden is approximately 1 million cubic yards.

Available information indicates that approximately 186 million pounds of building debris, production material, and liquid and solid industrial wastes were disposed of at the site. These wastes were reported to contain inorganic constituents (barium, calcium, and sodium chloride) and organic constituents such as carbon tetrachloride, chloroform, hexachlorobenzene, hexachlorobutadiene, hexachloroethane, methylene chloride, PCE, and TCE.

Overburden alternatives are summarized in Table 4-1.

4.4.1 Overburden Alternative 1 (OB1)

The objective of alternative OB1 is to create a baseline against which to compare other overburden alternatives. Alternative OB1 would consist of discontinuing cap maintenance and repair.

- *Effectiveness*
  The second RAO, control of source material to minimize direct exposure and impact on groundwater quality, may not be achieved. Discontinuation of cap maintenance would result in cap deterioration over time due to freeze-thaw effects, burrowing by animals, and other factors. Cap deterioration may create a direct exposure route to Necco Park constituents by vapor-phase constituents and airborne soil particles. Cap deterioration would also permit precipitation to percolate through source material at an accelerated rate and increase the mobility of constituents within overburden.

  Fencing and security personnel would remain in place and would limit unauthorized access to Necco Park.

  Constituent toxicity and volume would be unaffected by the no action alternative. Constituent mobility, through vaporization, airborne particles, and precipitation percolation, may increase over time due to cap deterioration.

  Discontinuing maintenance activities would have minimal short-term impact on human health and environment.

- *Implementability*
  Alternative OB1 is implementable. Alternative OB1 would consist of discontinuing cap maintenance activities such as mowing and cap repair.

- *Cost*
  Negligible costs are associated with alternative OB1 and assumed to be zero for this evaluation.

- *Summary*
  Alternative OB1 is retained for further evaluation as required by NCP. Alternative OB1 does not achieve RAOs. Constituent mobility may increase over time due to cap deterioration.

4.4.2 Overburden Alternative 2 (OB2)

The objectives of alternative OB2 are to

- Reduce precipitation percolation through source materials.
- Prevent contact with source material.

This alternative includes continuation of present overburden response activities. Present activities for overburden include cap maintenance (e.g., mowing and the repair of settled areas), fencing, and security personnel.

- *Effectiveness*

  Cap maintenance helps to achieve the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Reducing percolation will help reduce the potential for constituents to migrate into source area groundwater. An evaluation of the existing cap using EPA's HELP model indicates that the existing cap prevents 64 to 97 percent of annual precipitation from reaching the overburden (see Appendix D). The range of precipitation is due to uncertainty regarding the permeability of the existing clay cap. Clay with permeability ranging from 1×10^{-7} cm/s to 1×10^{-9} cm/s was used in cap construction. When a permeability of 1×10^{-7} cm/s is used, the HELP model predicts that the cap prevents 97 percent of annual precipitation from reaching overburden. EPA requested that a permeability of 1×10^{-5} cm/s be used in the HELP model. Using this higher permeability, the HELP model predicted that the cap prevents 64 percent of annual precipitation from reaching overburden.

  Institutional actions, such as fencing and security personnel, and the existing cap also help to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure.

  Constituent toxicity and volume would be unaffected by alternative OB2. However, the clay cap helps to reduce overburden constituent mobility by reducing precipitation percolation. The cap also prevents direct exposure to overburden.

  Maintaining overburden-related operations would have minimal short-term impact on human health and environment.

- *Implementability*

  Alternative OB2 is implementable. Implementation of this alternative consists of continuing cap maintenance, including regular mowing and repairing subsidence.

- *Cost*

  The net present value of alternative OB2 is approximately $0.4 million and consists of the O&M present worth cost of mowing, cap repair, facility maintenance, and runoff treatment. Cost components are presented in Appendix E.

- *Summary*
  Alternative OB2 is effective in minimizing exposure to overburden material and reducing impact on groundwater. Alternative OB2 is retained for further evaluation.

4.4.3 Overburden Alternative 3 (OB3)

The objectives of alternative OB3 are to

- Reduce precipitation percolation through source materials.
- Prevent contact with source material.

This alternative would include an upgrade of the existing clay cap to comply with the requirements of a NYS 360 cap, cap maintenance (e.g., mowing and the repair of settled areas), fencing, deed restrictions, and security personnel. Cap upgrade would consist of testing the permeability of the existing clay cap to ensure that its permeability is 1×10^{-7} cm/s or less. If sections of the cap have increased in permeability due to freeze-thaw cycles, additional clay may be added to reduce permeability. A sufficient protection layer would then be added to protect cap integrity. The cap would be graded to enhance runoff. Actual elements of cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions.

- *Effectiveness*
  Alternative OB3 helps to achieve the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Reducing precipitation percolation helps reduce the potential of constituents migrating into source area groundwater. An evaluation of an upgraded cap using EPA's HELP model indicates that the cap would prevent up to 97 percent of annual precipitation from percolating to overburden, an increase of 0 to 34 percent over existing cap conditions. Maintenance would be required to ensure effectiveness.

  The cap prevents direct exposure to overburden material. Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure.

  Constituent toxicity and volume would be unaffected by the cap upgrade alternative. However, the cap reduces overburden constituent mobility by preventing precipitation percolation.

Upgrading the existing cap would have minimal short-term impact on human health and environment.

- *Implementability*
  Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer, cutting, filling and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications will be determined during design activities.
- *Cost*
  The net present cost of alternative OB3 is approximately $2.9 million. The construction cost is approximately $2.5 million and includes permeability testing, stripping and stockpiling topsoil, repairing existing cap, adding a protective layer, replacing topsoil, and seeding. O&M present worth cost is approximately $0.4 million and consists of the present worth cost of mowing, cap repair, facility maintenance, and runoff treatment. Cost components are presented in Appendix E.
- *Summary*
  Alternative OB3 is effective in minimizing exposure to overburden material and reducing impact on groundwater. Alternative OB3 is retained for further evaluation.

4.4.4 Overburden Alternative 4 (OB4)

The objectives of the alternative OB4 are to

- Reduce precipitation percolation through source materials.
- Prevent contact with source material.

This alternative includes replacing the existing clay cap with a NYS 373 cap, cap maintenance (e.g., mowing and repair of settlement areas), fencing, deed restrictions, and security personnel. Cap replacement would include excavating the existing vegetative and protective layer, adding clay or a geosynthetic liner, installing a drainage layer, and replacing the protective and vegetative layer. Actual elements of the upgrade would be determined during remedial design.

- *Effectiveness*
  Alternative OB4 helps to achieve the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on

groundwater quality. Reducing precipitation percolation helps reduce the potential of constituents migrating into source area groundwater. An evaluation of a new cap using EPA's HELP model indicates that a new cap would prevent approximately 100 percent of precipitation from percolating into overburden (see Appendix D). Maintenance would be required to ensure effectiveness.

Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure. The new cap also prevents direct exposure to overburden material.

Constituent toxicity and volume would be unaffected by the cap replacement alternative. However, the cap would help to reduce overburden constituent mobility by preventing precipitation percolation.

Excavation activities required to replace the existing cap would have greater potential for short-term impact on human health and environment than the existing cap.

- *Implementability*
  Replacing the existing cap is implementable. Construction activities may include excavating existing vegetative and protective layer; cutting, filling and regrading for storm-water control; adding a geosynthetic membrane; and adding a drainage and protective layer. Actual details would be determined during design activities.

- *Cost*
  The net present cost of alternative OB4 is approximately $4.5 million. The construction cost is approximately $4.1 million and includes stripping the existing topsoil, repairing and regrading the existing clay, installing a 40-mil HDPE liner, installing a geonet drain and geotextile filter, adding a protective cover, replacing stockpiled soil, and seeding. O&M present worth cost is approximately $0.4 million and consists of the present worth cost of mowing, cap repair, facility maintenance, and runoff treatment. Cost components are presented in Appendix E.

- *Summary*
  Alternative OB4 is effective in minimizing exposure to overburden material and reducing impact on groundwater. However, alternative OB3 has similar effectiveness in reducing infiltration as alternative OB4 (100 percent versus 97 percent), while the cost of alternative OB4 is significantly higher than alternative OB3. Therefore, alternative OB4 will be screened from further evaluation.

4.4.5 Overburden Alternative 5 (OB5)

The objectives of alternative OB5 are to

- Control horizontal migration of constituents in A zone.
- Reduce precipitation percolation through source materials.
- Prevent contact with source material.

This alternative includes installation of a slurry wall along the southern boundary and the southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. Leachate collection wells would be installed in the landfill near the slurry wall to create an inward hydraulic gradient across the slurry wall and prevent mounding within the Necco Park overburden. These wells will be addressed in the appropriate source area groundwater alternative. Cap upgrade, cap maintenance (e.g., mowing and the repair of settlement areas), fencing, deed restrictions, and security personnel are also included in this alternative.

- *Effectiveness*
  The slurry wall would prevent horizontal migration of constituents in A zone. This would help minimize the impact of overburden constituents on downgradient A zone groundwater. Constituent toxicity and volume would be unaffected by the downgradient slurry wall alternative.

  Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

  The cap upgrade helps to achieve the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Reducing precipitation percolation helps reduce the potential of constituents migrating into source area groundwater. An evaluation of an upgraded cap using EPA's HELP model indicates that the cap would prevent up to 97 percent of annual precipitation from percolating to overburden, an increase of 0 to 34 percent over existing cap conditions. Maintenance would be required to ensure effectiveness.

The cap prevents direct exposure to overburden material. Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure.

- *Implementability*

  The elements of alternative OB5 are implementable using standard civil engineering methods and equipment. However, construction activities would be more difficult than cap construction because of extensive excavation through overburden. As stated previously, slurry wall construction may create organic vapors that would require monitoring and possibly control. Methods such as vapor-suppressing foam may be necessary to protect human health and environment. These methods will increase difficulty and time required to implement the alternative.

  Excavated material may not be appropriate for backfilling the trench due to inorganic and organic constituents or physical components. Compatibility testing during predesign would be necessary to determine if overburden material is suitable for backfill. Unsuitable excavated material would be consolidated and placed under the cap in the Necco Park facility. Clean fill would be imported as necessary as backfill material for the slurry wall.

- *Cost*

  The net present cost of alternative OB5 is approximately $20.0 million. The construction cost is approximately $5.1 million and includes slurry wall construction, installation of an overburden groundwater recovery well system, on-site disposal of spoils, and upgrade of the existing cap. O&M present worth cost is approximately $14.9 million and consists of the present worth cost of recovery well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, mowing, cap repair, facility maintenance, and runoff treatment. Cost components are presented in Appendix E.

- *Summary*

  A downgradient slurry wall would be effective in reducing horizontal constituent mobility. The cap component of this alternative would be effective in reducing exposure to overburden constituents and reducing vertical constituent mobility. Alternative OB5 is retained for further evaluation.

4.4.6 Overburden Alternative 6 (OB6)

The objectives of alternative OB6 are to

- Control horizontal migration of constituents in overburden.
- Reduce precipitation percolation through source materials.
- Prevent contact with source material.

This alternative would include installation of a slurry wall on the perimeter of the 24-acre Necco Park facility. Upgrading the existing cap, cap maintenance (e.g., mowing and the repair of settlement areas), fencing, deed restrictions, and security personnel are also included in this alternative.

- *Effectiveness*

  The slurry wall would prevent horizontal migration of constituents in A zone, helping to minimize the impact of overburden constituents on downgradient A zone groundwater. The primary route for overburden constituent migration is downward. Based on hydraulic gradients, overburden constituents may horizontally migrate to the south. A slurry wall on the northern perimeter of Necco Park would only prevent incidental constituent migration (e.g., DNAPL migration through cracks or fissures that does not follow hydraulic gradients).

  Constituent toxicity and volume would be unaffected by the complete slurry wall alternative.

  Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

  The cap upgrade helps to achieve the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Reducing precipitation percolation helps reduce the potential of constituents migrating into source area groundwater. An evaluation of an upgraded cap using EPA's HELP model indicates that the cap would prevent up to 97 percent of annual precipitation from percolating to overburden (see Appendix D), an increase of 0 to 34 percent over existing cap conditions. Maintenance would be required to ensure effectiveness.

The cap prevents direct exposure to overburden material. Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure.

- *Implementability*
  The elements of alternative OB6 are implementable using standard civil engineering methods and equipment. However, construction activities would be more difficult than cap construction because of extensive excavation through waste materials. As stated previously, slurry wall construction may create organic vapors that would require monitoring and possibly control. Methods such as vapor-suppressing foam may be necessary to protect human health and environment. Vapor-suppressing foam would increase difficulty and time required to implement the alternative.

  Excavated material may not be appropriate for backfilling the trench due to inorganic and organic constituents or physical components. Compatibility testing during predesign would be necessary to determine if overburden material is suitable for backfill. Unsuitable excavated material would be consolidated and placed under the cap in the Necco Park facility. Clean fill would be imported as necessary as backfill material for the slurry wall.

  In the past, CECOS has shown concern about the potential mounding effect of a grout curtain downgradient of its facilities. A slurry wall downgradient of its facility may cause similar concerns. Potential groundwater mounding would be addressed during RAA design phase and engineered solutions such as a groundwater diversion trench upgradient of the slurry wall may be required.

- *Cost*
  The net present cost of alternative OB6 is approximately $22.1 million. The construction cost is approximately $7.2 million and includes slurry wall construction, installation of an overburden groundwater recovery well system, on-site disposal of spoils, and upgrade of the existing cap. O&M present worth cost is approximately $14.9 million and consists of the present worth cost of recovery well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, mowing, cap repair, facility maintenance, and runoff treatment. Cost components are presented in Appendix E.

- *Summary*
  The primary direction of A zone groundwater migration is downward. Horizontal A zone groundwater movement is to the south. A slurry wall on the north boundary and the northern sections of the eastern and western boundaries would have minimal impact on restricting horizontal migration of overburden constituents. A slurry wall in these sections may also require an upgradient groundwater extraction or drainage system to prevent mounding in the adjacent

property. Alternative OB6 is screened from further evaluation because of additional costs and limited increase in effectiveness compared to Alternative OB5.

4.4.7 Overburden Alternative 7 (OB7)

The objectives of alternative OB7 are to

- Remove constituents from the overburden.
- Treat removed constituents.
- Reduce precipitation infiltration into source materials.
- Prevent contact with source material.

This alternative would include installation and operation of a DPE system consisting of extraction wells, vapor-phase and liquid-phase treatment, cap upgrade on completion of the DPE process, cap maintenance (e.g., mowing and the repair of settlement areas), fencing, deed restrictions, and security personnel.

- *Effectiveness*

  The DPE system controls source material through treatment. The high vacuum DPE system would draw vapor-phase volatile and semivolatile organic constituents from overburden. Organic constituents would be treated by a vapor-phase treatment such as thermal oxidation or vapor-phase carbon adsorption. DPE reduces the mass of the groundwater contamination source. The DPE system would also remove groundwater and/or DNAPL by the application of the high vacuum. Liquids would be separated and DNAPL sent off-site for incineration. Groundwater would be treated at the CECOS facility.

  Constituent toxicity, volume, and mobility would be reduced by extraction and treatment through the DPE alternative. Treating extracted vapors through thermal oxidation or vapor-phase carbon would reduce the volume and toxicity of organic constituents by converting the compounds to carbon dioxide, water, and HCl. The volume of constituents in the overburden would be reduced as liquid- and vapor-phase constituents are extracted. DPE may reduce constituent mobility by volatilizing the most mobile compounds. The clay cap helps to reduce overburden constituent mobility by preventing percolation of precipitation.

  Overall DPE effectiveness would have to be demonstrated through bench and pilot treatability studies.

  The cap upgrade helps to achieve the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Reducing precipitation percolation helps reduce the potential of constituents migrating into source area groundwater. An evaluation of an upgraded cap using EPA's HELP model indicates that the cap would prevent up to 97 percent of annual precipitation from percolating to overburden, an increase of 0 to 34 percent over existing cap conditions. Maintenance would be required to ensure effectiveness.

Institutional actions (such as fencing and security) and a DPE system would help to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure.

- *Implementability*
  Institutional actions, upgrading of the existing cap, and installation of the DPE system are implementable. A bench- and pilot-scale treatability study would be required to determine effectiveness and operating parameters of a full-scale DPE system. Treatability studies would require one to three years to complete.

  A DPE system would require a power and water supply to operate. Water utilities do not currently exist at Necco Park and therefore would have to be installed prior to DPE system construction. Limited electrical power is available at Necco Park, but would require upgrades for a DPE system.

- *Cost*
  The net present cost of alternative OB7 is approximately $14.8 million. The construction cost is approximately $6.2 million and includes a pilot study, wells, piping, pumps, tanks, utilities, instrumentation, a building, vapor-phase treatment unit, and a cap upgrade. O&M present worth cost is approximately $8.4 million and consists of the present worth cost of aqueous-phase treatment at CECOS WWTP, O&M of the DPE system, operation and maintenance of the vapor phase treatment system, and liquid phase disposal. Operation and maintenance assumes that the DPE system will be in operation for five years. Operation of the system for longer than five years will increase the net present cost of this alternative. Cost components are presented in Appendix E.

  This cost assumes that a DPE system would be shut down during winter months. Significant upgrades are required for the DPE system to operate during winter months. These upgrades would significantly increase costs for a DPE system.

  Many unknowns are associated with estimating construction and operation costs of a DPE system (e.g., the number of wells needed, extent of vapor-phase treatment required, volume of liquid-phase constituents). A pilot study would be required to estimate the cost of this alternative more accurately.

- *Summary*
  Alternative OB7 is an in situ overburden alternative that reduces the volume, toxicity, and possibly mobility of overburden constituents through treatment. However, overburden drilling may create a route for DNAPL migration to the bedrock. Alternative OB7 is retained for further evaluation.

4.4.8 Overburden Alternative 8 (OB8)

The objectives of alternative OB8 are to

- Remove constituents from overburden.
- Treat removed constituents.
- Control horizontal migration of contamination in the A zone.
- Reduce precipitation percolation through source materials.
- Prevent contact with source material.

This alternative would include excavating areas with higher levels of constituent concentrations and treating excavated soil by a thermal desorption unit. A soil volume of 345,000 cubic yards was estimated based on the areas where liquid material was disposed and a depth of 25 feet. Off-gases would be treated by vapor treatment such as thermal oxidation. Treated overburden from the thermal desorption unit would be further treated by ex situ stabilization if necessary. Treated soil would be placed back into Necco Park. Once treatment is completed, the cap would be upgraded. A slurry wall would also be installed downgradient of the 24-acre Necco Park facility. Maintenance and institutional actions would be continued.

- *Effectiveness*
  Excavation and treatment of overburden controls source material. Organic constituents would be removed from overburden by thermal desorption and vapor-phase treatment. This treatment reduces the mass of source material. Constituent toxicity, volume, and mobility would be reduced through treatment. Treating desorbed vapors through thermal oxidation or vapor-phase carbon would reduce the toxicity of organic constituents by converting compounds into carbon dioxide, water, and HCl. Volume of constituents would be reduced as organic material is desorbed from the overburden matrix. Stabilization of the treated soil (if required), the slurry wall, and the cap upgrade reduce overburden constituent mobility.

The cap upgrade helps to achieve the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Reducing precipitation percolation helps reduce the potential of constituents migrating into source area groundwater. An evaluation of an upgraded cap using EPA's HELP model indicates that the cap would prevent up to 97 percent of annual precipitation from percolating to overburden (see Appendix D), an increase of 0 to 34 percent over existing cap conditions. Maintenance would be required to ensure effectiveness. Excavating and treating overburden would also help to achieve the second RAO by removing overburden constituents, thereby reducing the mass of source material contributing to groundwater contamination.

Overall effectiveness of thermal desorption and stabilization would have to be demonstrated through bench-scale and pilot-scale treatability studies.

Institutional actions (such as fencing and security personnel), a slurry wall, and an upgraded cap also help to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure. The cap also prevents direct exposure to overburden.

The slurry wall prevents horizontal migration of contaminants in A zone. This would help to reduce overburden constituents' impact on downgradient A zone groundwater.

This alternative may have negative short-term impact on human health and environment. Excavating overburden and construction of the slurry wall may be a significant source of volatile emissions. Vapor-suppressing foam or a physical enclosure may be needed to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for contamination migration to bedrock.

- *Implementability*
  Alternative OB8 is implementable. A bench- and pilot-scale treatability study would be required to determine effectiveness and operating parameters of a full-scale thermal desorption system. Treatability studies would require one to three years to complete.

  As stated previously, excavating overburden may create uncontrolled organic vapors. Methods such as vapor-suppressing foam or a physical enclosure may be necessary to protect human health and environment. These methods will increase difficulty and time required to implement the alternative.

  Excavated material is expected to contain a significant amount of debris. Thermal desorption units have specific feed-size requirements. Excavated material may have to be pretreated by particle-size separation or by particle-size reduction prior to thermal desorption. This pretreatment step would add complexity to the treatment system.

Operating a thermal desorption unit may be opposed by the public. Thermal desorption units are not designed to destroy constituents, but rather to physically separate organic constituents from the overburden matrix. Therefore, a vapor-phase treatment unit must be used in conjunction with thermal oxidation to treat airborne constituents. The local community may be concerned that organic vapors would not be completely treated by vapor-phase treatment and, therefore, might pose a threat to human health. Although vapor-phase treatment units are designed to prevent hazardous emissions, local communities frequently oppose the construction of off-gas incinerators based on their concern that treatment is not reliable.

- *Cost*
  The net present cost of alternative OB8 is approximately $254.7 million. The construction cost is approximately $242.1 million and includes excavation, treatment through thermal desorption and stabilization, slurry wall construction, and cap upgrade. O&M present worth cost is approximately $12.6 million and consists of the present worth cost of mowing, cap repair, aqueous-phase treatment at CECOS WWTP, and runoff treatment. Cost components are presented in Appendix E.

- *Summary*
  Selective excavation and subsequent treatment would reduce the toxicity, volume, and mobility of overburden constituents through removal and treatment. However, this alternative would only partially achieve the RAOs because some contaminated overburden would remain in place. Additionally, this alternative would be a significant short-term risk to human health and environment and would be excessively expensive to implement.

  Excavating overburden may be a source of organic vapors that would require control to protect human health and environment. Use of vapor-suppressing foam or a physical enclosure would make implementation of this alternative difficult. Debris in the excavated material would also add complexity to this alternative.

  The cost of this alternative is an order of magnitude greater than containment alternatives; however, there is not a significant increase in overall protectiveness of human health and environment.

  Based on its limited effectiveness in achieving RAOs, the short-term risks, and the high cost, this alternative is screened from further evaluation.

4.4.9 Overburden Alternative 9 (OB9)

The objectives of alternative OB9 are to

- Remove constituents from overburden.
- Treat removed constituents.
- Control horizontal migration of contamination in A zone.
- Reduce precipitation percolation through source materials.
- Prevent contact with source material.

This alternative would include excavating all overburden and treating excavated soil using a thermal desorption unit. Assuming an overburden depth of 25 feet, approximately 1 million cubic yards of material would be excavated and treated. Off-gases would be treated by vapor treatment such as thermal oxidation. Treated overburden from the thermal desorption unit would be treated by ex situ stabilization, if necessary. Treated soil would be placed back into Necco Park, and a cap would be installed. Maintenance and institutional actions would be continued.

- *Effectiveness*

  Excavating and treating overburden would help to achieve the first RAO by removing overburden constituents, thereby reducing the mass of the groundwater contamination source.

  Excavation and treatment of overburden controls source material. Organic constituents would be removed from overburden by thermal desorption and vapor-phase treatment. This treatment reduces the mass of source material. Constituent toxicity, volume, and mobility would be reduced through treatment by this alternative. Treating desorbed vapors through thermal oxidation or vapor-phase carbon would reduce the toxicity of organic constituents by converting compounds into carbon dioxide, water, and HCl. Volume of constituents would be reduced as organic material is desorbed from the overburden matrix.

  Overall effectiveness of thermal desorption and stabilization would have to be demonstrated through bench-scale and pilot-scale treatability studies.

  Institutional actions (such as fencing and security personnel), a slurry wall, and an upgraded cap also help to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. Fencing and security personnel prevent unauthorized access to the Necco Park facility, thereby minimizing direct exposure.

This alternative may have negative short-term impact on human health and environment. Excavating overburden may be a significant source of volatile emissions. Vapor-suppressing foam or a physical enclosure may be needed to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for contamination migration to bedrock.

- *Implementability*
  Alternative OB9 is implementable. A bench- and pilot-scale treatability study would be required to determine effectiveness and operating parameters of a full-scale thermal desorption system. Treatability studies would require one to three years to complete.

  As stated previously, excavating overburden may create uncontrolled organic vapors. Methods such as vapor-suppressing foam or a physical enclosure may be necessary to protect human health and environment. These methods will increase difficulty and time required to implement the alternative.

  Excavated material is expected to contain a significant amount of debris. Thermal desorption units have specific feed-size requirements. Excavated material may have to be pretreated by particle-size separation or by particle-size reduction prior to thermal desorption. This pretreatment step would add complexity to the treatment system.

  Operating a thermal desorption unit may be opposed by the public. Thermal desorption units are not designed to destroy constituents, but rather to physically separate organic constituents from the overburden matrix. Therefore, a vapor-phase treatment unit must be used in conjunction with thermal oxidation to treat airborne constituents. The local community may be concerned that organic vapors would not be completely treated by vapor-phase treatment and therefore might pose a threat to human health. Although vapor-phase treatment units are designed to prevent hazardous emissions, local communities frequently oppose the construction of off-gas incinerators based on their concern that treatment is not reliable.

- *Cost*
  The net present cost of alternative OB9 is approximately $683.2 million. The construction cost is approximately $682.9 million and includes excavation, treatment through thermal desorption, and stabilization. O&M present worth cost is approximately $0.4 million and consists of the present worth cost of mowing and runoff treatment. Cost components are presented in Appendix E.

- *Summary*
  Complete excavation would reduce the toxicity, volume, and mobility of overburden constituents through treatment. This alternative would achieve, to the

fullest extent possible, control of source material (contaminated soil) to minimize direct exposure and impact on groundwater quality. However, DNAPL in fractured bedrock would continue to act as a source of groundwater contamination. Additionally, this alternative would be a significant short-term risk to human health and environment.

Excavating overburden may be a source of organic vapors that would require control to protect human health and environment. Use of vapor-suppressing foam or a physical enclosure would make implementation of this alternative difficult. Debris in the excavated material would also add complexity to this alternative.

The cost of this alternative is an order of magnitude greater than containment alternatives; however, there is not a significant increase in overall protectiveness in human health and environment.

Based on its short-term risks and extreme cost while failing to substantially improve risk to human health and environment, this alternative is screened from further evaluation.

4.5 DNAPL Alternative Evaluation

This section describes the evaluation of DNAPL alternatives. These alternatives were assembled to address the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. DNAPL alternatives do not directly address the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. However, DNAPL alternatives may have beneficial impact on other media such as source area groundwater. The benefits of these DNAPL technologies across media will be evaluated in Section 5.0, Detailed Analysis of Alternatives.

DNAPL is defined as free-phase liquid organic constituents that are not bound chemically or by surface forces to soil or bedrock. The volume of DNAPL present in overburden and bedrock of the source area is unknown. For purposes of this alternative evaluation, DNAPL bound to soil or dissolved in the aqueous plume of the source area are not addressed in this section because they are addressed in Sections 4.4 (Overburden) and 4.6 (Source Area Groundwater), respectively.

DNAPL is primarily hexachlorobutadiene, but also contains hexachloroethane, hexachloroethene, hexachlorobenzene, carbon tetrachloride, chloroform, PCE, 1,1,2,2-tetrachloroethane, and TCE. Additionally, DNAPL free-phase material potentially contains PCBs (PCB detection limits are above 50 ppm due to matrix interference) and must be handled and disposed in accordance with TSCA regulations.

DNAPL alternatives are summarized in Table 4-2.

4.5.1 DNAPL Alternative 1 (D1)

The objective of alternative D1 is to create a baseline against which to compare other DNAPL alternatives. Alternative D1 would consist of discontinuing DNAPL monitoring, recovery, and incineration.

- *Effectiveness*
  Alternative D1 would not achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality.

  Constituent toxicity, volume, and mobility would be unaffected by alternative D1.

  Discontinuing DNAPL monitoring and extraction would have minimal short-term impact on human health and environment.
- *Implementability*
  Alternative D1 is implementable.
- *Cost*
  Negligible costs are associated with alternative D1 and assumed to be zero for this evaluation.
- *Summary*
  Alternative D1 is retained for further evaluation as required by NCP. Alternative D1 does not achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality.

4.5.2 DNAPL Alternative 2 (D2)

The objectives of alternative D2 are to

- Reduce DNAPL volume.
- Treat extracted DNAPL to reduce toxicity.

This alternative would include continuation of existing DNAPL response activities. Present activities for DNAPL include monitoring and extraction of DNAPL through existing monitor and recovery wells. To date, approximately 6,000 gallons of DNAPL have been extracted using this procedure.

- *Effectiveness*
  DNAPL extraction helps to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. DNAPL is a source of groundwater and soil contamination. Extracting DNAPL reduces the mass available for groundwater contamination.

  DNAPL extraction reduces volume of source material in the environment. Incineration effectively destroys DNAPL, thereby reducing its toxicity.

  Extraction wells are capable of removing small volumes of DNAPL, relative to the total volume of DNAPL at Necco Park.

  Minimal short-term impact is associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during removal, transportation, and incineration processes. However, PPE is used to minimize exposure.
- *Implementability*
  Alternative D2 is implementable. To date, approximately 6,000 gallons of DNAPL have been extracted using this procedure.
- *Cost*
  The net present cost of alternative D2 is approximately $0.9 million, which is the present worth cost of DNAPL observation and evacuation, characterization, and disposal. Cost components are presented in Appendix E.
- *Summary*
  Alternative D2 reduces the volume, toxicity, and mobility of DNAPL with minimal short-term risk and relatively low cost. This alternative is retained for further evaluation.

4.5.3 DNAPL Alternative 3 (D3)

The objectives of alternative D3 are to

- Reduce DNAPL volume.
- Treat extracted DNAPL to reduce its toxicity.

This alternative includes continuation of the existing DNAPL extraction procedure and adding additional wells or a trench to increase the volume of DNAPL extracted. The current DNAPL extraction process includes monitoring and extracting DNAPL from monitor and recovery wells. Additional extraction would include installing wells or an overburden trench to increase the volume of DNAPL extracted.

- *Effectiveness*

  DNAPL extraction helps to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. DNAPL is a source of groundwater and soil contamination. Extracting DNAPL reduces DNAPL mass in the environment, thereby reducing a source of groundwater contamination.

  DNAPL extraction reduces volume of source material in the environment. Incineration effectively destroys DNAPL, thereby reducing its toxicity.

  A pilot study has been conducted to determine the feasibility of extracting DNAPL. Testing overburden pilot DNAPL recovery well (PNRW-1) and overburden monitor wells accumulating DNAPL (VH-131A and VH-139A) indicates that DNAPL can be recovered from overburden wells, but recovery rates will be low, on the order of a few gallons per month. Another bedrock pilot recovery well (PNRW-2) did not accumulate DNAPL. From the split-spoon sampling and drainage examination, DNAPL in the overburden appears to be located primarily within the lower portion of the fill and within underlying reworked clay. Some DNAPL will drain from the fill and clay, based on samples from wells NB-10 and NB-20 and the measured yields from wells VH-131A, VH-139A, and PNRW-1. However, DNAPL accumulation rate will be limited by the low hydraulic conductivity of these materials.

  In bedrock, DNAPL appears to enter monitor wells very slowly from bedding-plane fractures. The monitor wells were drilled 5 feet into the competent rock below the water-bearing fracture zone monitored. The lower 5 feet of these wells, therefore, tend to act as accumulation sumps for DNAPL entering these wells. DNAPL droplets entering the wells from water-bearing fractures will sink to the bottom of the well and accumulate. Locating and removing pockets of DNAPL in bedrock is difficult. Little DNAPL recovery is possible by pumping only DNAPL from the bottom of bedrock wells as shown by the pilot bedrock recovery well (PNRW-2).

  Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

Installing an extraction trench may have negative short-term impact on human health and environment. An extraction trench would require excavating into overburden. During excavation and stockpiling of overburden material, organic constituents may volatilize into the air. Workers can use respiratory protection and PPE to avoid exposure. Vapor-suppressing foam or a physical enclosure may be needed to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a local, short-term route for contamination migration to bedrock. A dedicated DNAPL extraction well would have little short-term impact because less overburden would be disturbed than by the installation of a DNAPL recovery trench.

- *Implementability*
  Additional DNAPL extraction is implementable. As stated previously, construction of a trench may create uncontrolled organic vapors. Methods such as application of vapor-suppressing foam or a physical enclosure may be necessary to protect human health and environment. These methods will increase difficulty and time required to implement the alternative.

- *Cost*
  The net present cost of alternative D3 is approximately $1.1 million. The construction cost is approximately $33,000 and includes installation of one DNAPL extraction well. O&M present worth cost is $1.1 million and consists of the present worth cost of DNAPL observation and evacuation, characterization, and disposal. Cost components are presented in Appendix E.

- *Summary*
  Installing a DNAPL extraction trench in overburden has a relatively high cost and may have short-term impact to human health and environment. The effectiveness of this alternative in extracting DNAPL may be limited. The cost of dedicated DNAPL extraction wells is significantly lower than an extraction trench, and dedicated wells have less short-term impact. This alternative is retained for further evaluation.

4.5.4 DNAPL Alternative 4 (D4)

The objectives of alternative D4 are to

- Prevent the horizontal migration of DNAPL in A zone.
- Reduce DNAPL volume.
- Treat extracted DNAPL to reduce its toxicity.

This alternative includes installing a perimeter A zone slurry wall on the southern boundary and the southern portions of the eastern and western boundaries of the Necco Park facility. This alternative would also include continuation of existing DNAPL extraction activities. DNAPL would also be extracted through A zone wells that would be installed to control water level within Necco Park.

- *Effectiveness*

  The downgradient slurry wall would control horizontal DNAPL migration in A zone, thereby minimizing impact on A zone groundwater quality in adjacent properties. The slurry wall will not affect vertical DNAPL migration.

  DNAPL extraction would help to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. DNAPL is a source of groundwater and soil contamination. Extracting DNAPL reduces mass of chemical constituents available as a contamination source.

  The long-term stability of some slurry wall materials in contact with high organic concentrations has not been demonstrated. Experiments have shown that the permeability of bentonite increases when exposed to high concentrations of organic constituents such as TCE. Materials resistant to the effects of organic constituents on permeability, such as attapulgite, may be substituted. Treatability studies during remedial design would be required.

  DNAPL extraction reduces constituent volume and incineration reduces constituent toxicity. The slurry wall minimizes horizontal DNAPL mobility.

  Minor short-term impact is associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, the volume of extracted DNAPL is generally small, and PPE can be used to minimize exposure.

  Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

- *Implementability*

  Institutional actions and DNAPL extraction are implementable. As stated previously, construction of a slurry wall may create organic vapors that would require monitoring and possible control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Excavated material may not be appropriate for backfilling the trench due to organic contamination. If unsuitable, excavated material would be consolidated and placed beneath the cap in the Necco Park facility. Clean fill would be required for use as backfill material to mix with bentonite for slurry wall construction.

- *Cost*
  The net present cost of alternative D4 is approximately $18.2 million. The construction cost is approximately $2.7 million and includes slurry wall construction, overburden recovery well, and on-site spoils disposal. O&M present worth cost is $15.5 million and consists of the present worth cost of recovery well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and DNAPL extraction and disposal. Cost components are presented in Appendix E.

- *Summary*
  A downgradient slurry wall would be effective in reducing potential A zone DNAPL migration. This alternative is retained for further evaluation.

4.5.5 DNAPL Alternative 5 (D5)

The objectives of alternative D5 are to

- Prevent the horizontal migration of DNAPL in A through F zones.
- Reduce DNAPL volume.
- Treat extracted DNAPL to reduce its toxicity.

This alternative includes extending the existing grout curtain from B through F zones around the source area and installing a downgradient slurry wall in A zone around the 24-acre Necco Park facility. This alternative would also include continuation of existing DNAPL activities. Present activities for DNAPL include monitoring and extraction of DNAPL through existing monitor and recovery wells. DNAPL removal would be enhanced by extraction from new A zone wells.

- *Effectiveness*
  DNAPL extraction helps to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. DNAPL is a source

of groundwater and soil contamination. Extracting DNAPL reduces the mass of this contamination source.

DNAPL has been observed in A through F zones. The grout curtain would control horizontal DNAPL migration in B through F zones, reducing the impact of DNAPL on downgradient water quality. Some DNAPL would be isolated outside the grout curtain and would continue to migrate. A slurry wall would control A zone horizontal DNAPL migration, thereby reducing impact on overburden groundwater quality in adjacent properties. However, the slurry wall and grout curtain will not affect vertical DNAPL movement.

DNAPL extraction and incineration reduces constituent volume, toxicity, and mobility. DNAPL removal reduces the volume of source material in the environment. Incineration effectively destroys DNAPL, thereby reducing its toxicity. The slurry wall minimizes horizontal DNAPL mobility in A zone. The grout curtain reduces horizontal DNAPL mobility in B through F zones.

Drill cuttings from grout curtain installation may be a source of organic vapors. Workers can use respiratory protection to avoid exposure. Drilling through areas of known DNAPL may create a downward route for DNAPL migration. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Site and RCRA Facilities—Update* states,

> "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized, short-term vertical pathways for DNAPL movement may be created during the drilling process.

Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, extracted DNAPL volume is expected to be small, and PPE can be used to minimize exposure.

- *Implementability*
  Alternative D5 is implementable. An upgradient grout curtain has been successfully installed at Necco Park. Installation procedures and grout mixtures have already been established. The grout curtain in this alternative requires access to and drilling on adjacent property (CECOS). Permission and access agreements must be obtained from CECOS and other property and right-of-way owners prior to grout curtain installation. Limited space is available for drilling activities because of physical restrictions such as existing landfills, roads, power lines, railroad tracks, and underground brine lines. These physical barriers would have to be avoided when installing the grout curtain; therefore, implementation time may increase. The access road and power line may have to be relocated to install the grout curtain.

  As stated previously, slurry wall construction may create organic vapors that would require monitoring and possible control, which would increase difficulty and time required to implement the alternative. Clean fill may be required for backfilling the trench due to organic contamination.

- *Cost*
  The net present cost of alternative D5 is approximately $44.4 million. The construction cost is approximately $13.2 million and includes installation of the grout curtain and slurry wall system. O&M present worth cost is $31.2 million and consists of the present worth cost of maintaining the recovery well and treating extracted water at CECOS WWTP. Cost components are presented in Appendix E.

- *Summary*
  Alternative D5 would reduce potential for DNAPL to migrate out of the source area. This alternative is retained for further evaluation.

4.5.6 DNAPL Alternative 6 (D6)

The objectives of alternative D6 are to

- Prevent horizontal migration of DNAPL in A through F zones.
- Prevent potential migration of DNAPL in G zone.
- Reduce DNAPL volume.
- Treat extracted DNAPL to reduce its toxicity.

This alternative includes constructing a grout curtain from B through G zones around the Necco Park and CECOS facility and installing a downgradient slurry wall in A zone of the 24-acre Necco Park facility. This alternative would also include continuation of existing DNAPL response activities. Present activities for DNAPL include monitoring and extracting DNAPL through existing monitor and recovery wells. DNAPL removal would be enhanced by extraction from new A zone wells.

- *Effectiveness*

  DNAPL has been observed in A through F zones. The grout curtain would control horizontal DNAPL migration in B through F zones, reducing the impact of DNAPL on downgradient water quality. A slurry wall would also control A zone horizontal DNAPL migration, thereby reducing impact on overburden groundwater quality in adjacent properties. However, the slurry wall and grout curtain will not affect vertical DNAPL movement.

  DNAPL extraction helps to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. DNAPL is a source of groundwater and soil contamination. Extracting DNAPL reduces the mass of this contamination source.

  DNAPL extraction and incineration reduces constituent volume, toxicity, and mobility. DNAPL removal reduces the volume of source material in the environment. Incineration effectively destroys DNAPL, thereby reducing its toxicity. The slurry wall minimizes horizontal DNAPL mobility in A zone. The grout curtain reduces horizontal DNAPL mobility in B through F zones. A grout curtain in G zone would prevent horizontal DNAPL migration if it migrates into G zone. Some DNAPL would be isolated outside of the grout curtain and would continue to migrate.

  Drill cuttings from grout curtain installation may be a source of organic vapors. Workers can use respiratory protection to avoid exposure. Drilling through areas of known DNAPL may create a downward route for DNAPL migration. The EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Site and RCRA Facilities—Update* states,

  > "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

  DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized, short-term vertical pathways may be created for DNAPL movement during the drilling process.

Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, volatile organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, extracted DNAPL volume is expected to be small, and PPE can be used to minimize exposure.

- *Implementability*

  Alternative D6 is implementable. An upgradient grout curtain has been successfully installed at Necco Park. Installation procedures and grout mixtures have already been established. The grout curtain in this alternative requires access to and drilling on adjacent property (CECOS). Permission and access agreements must be obtained from CECOS and other property and right-of-way owners prior to grout curtain installation. Limited space is available for drilling activities because of physical restrictions such as existing landfills, roads, power lines, railroad tracks, and underground brine lines. These physical barriers would have to be avoided when installing the grout curtain; therefore, implementation time may increase. The access road and power line may have to be relocated to install the grout curtain.

  As stated previously, slurry wall construction may create organic vapors that would require monitoring and possible control, which would increase difficulty and time required to implement the alternative. Clean fill may be required for backfilling the trench due to organic contamination.

- *Cost*

  The net present cost of alternative D6 is approximately $70.6 million. The construction cost is approximately $36.7 million and includes installation of the grout curtain and slurry wall system. O&M present worth cost is approximately $33.9 million and consists of the present worth cost of maintaining the recovery well and treating extracted water at CECOS WWTP. Cost components are presented in Appendix E.

- *Summary*
  DNAPL has not been observed in G zone. Installing a grout curtain through this zone would be expensive for a relatively small increase in limiting DNAPL migration when compared to F zone grout curtain alternative. However, this alternative will be retained as a representative G-zone DNAPL control alternative.

4.5.7 DNAPL Alternative 7 (D7)

The objectives of alternative D7 are to

- Remove DNAPL from A zone and upper bedrock zones.
- Treat removed constituents.

This alternative would include installing a DPE system consisting of extraction wells and vapor- and liquid-phase treatment. This alternative would also include continuation of existing DNAPL response activities. Present activities for DNAPL include monitoring and extraction of DNAPL through existing monitor and recovery wells.

- *Effectiveness*
  A pilot study would be required to determine the effectiveness of DPE at Necco Park. However, the low permeability of overburden and the nature of DNAPL components (volatile and semivolatile constituents) generally indicate that DPE may be effective in removing DNAPL. However, the percentage of DNAPL that could be removed can only be determined by a pilot study.

  The DPE system controls source material through treatment. The high-vacuum DPE system may volatilize DNAPL in A zone and upper bedrock zones. Organic constituents would be treated by a vapor-phase treatment such as thermal oxidation or vapor-phase carbon adsorption. The application of the high vacuum may remove DNAPL as a liquid from overburden or bedrock. Liquids would be separated and DNAPL would be incinerated at an off-site facility. DPE reduces the mass of the groundwater contamination source.

  DNAPL extraction helps to achieve the second RAO, control of source material to minimize direct exposure and impact on groundwater quality. DNAPL is a source of groundwater and soil contamination. Extracting DNAPL reduces mass of this contamination source.

  Constituent toxicity, volume, and mobility would be reduced by the DPE alternative. Treating extracted vapors through thermal oxidation or vapor-phase carbon would reduce the toxicity of organic constituents. A zone constituent volume would be reduced as liquid- and vapor-phase constituents are extracted.

Drill cuttings may be a minor source of organic vapors during DPE system installation. Workers can use respiratory protection to avoid exposure. Additionally, drilling through overburden may create a localized, short-term route for DNAPL migration to bedrock.

- *Implementability*
  Institutional actions, upgrading the existing cap, and installation of the DPE system are implementable. A bench- and pilot-scale treatability study would be required to determine effectiveness and operating parameters of a full-scale DPE system. Treatability studies would require one to three years to complete.

  A DPE system would require a power and water supply to operate. Water utilities do not currently exist at Necco Park and therefore would have to be installed prior to DPE system construction. Limited electrical power is available at Necco Park, but would require upgrades for a DPE system.

- *Cost*
  The net present cost of alternative D7 is approximately $13.2 million. The construction cost is approximately $4.1 million and includes a pilot study, wells, piping, pumps, tanks, utilities, instrumentation, a building, and a vapor-phase treatment unit. O&M present worth cost is approximately $9.1 million and consists of the present worth cost of aqueous-phase treatment at CECOS WWTP, O&M of the DPE system, O&M of the vapor-phase treatment system, and liquid-phase disposal. O&M assumes that the DPE system will be in operation for five years. Operation of the system for longer than five years will increase the net present cost of this alternative. Cost components are presented in Appendix E.

  This cost assumes that a DPE system would be shut down during winter months. Significant upgrades are required for the DPE system to operate during winter months, and these upgrades would significantly increase the cost of a DPE system.

  Many unknowns are associated with estimating construction and operation costs of a DPE system (e.g., the number of wells needed, extent of vapor-phase treatment required, volume of liquid-phase constituents). A pilot study would be required to estimate the cost of this alternative more accurately.

- *Summary*
  Alternative D7 is an in situ DNAPL alternative that reduces the volume, toxicity, and possibly mobility of DNAPL constituents. Potential for short-term impact exists as a result of drilling in overburden. Overburden drilling may also create a route for DNAPL migration to bedrock. The DPE alternative is retained for further evaluation.

4.6 Source Area Groundwater Alternative Evaluation

This section describes the evaluation of source area groundwater alternatives. Restoration of source area groundwater cannot be achieved in reasonable time frames due to the presence of DNAPL in soil and fractured bedrock. No technology currently exists that can completely remove DNAPL from fractured bedrock; consequently, DNAPL will act as a continuing source of source area groundwater contamination. Source area groundwater alternatives can reduce constituent loading to the far field.

Source area groundwater is defined as groundwater in overburden and bedrock in areas where DNAPL has been observed or aqueous concentrations may indicate the presence of DNAPL (i.e., solubility criteria were met). The estimated areal extent of source area groundwater was presented in Figures 1-29 through 1-35. Actual observations of free-phase DNAPL have been limited to overburden (A zone) and upper and middle bedrock (B through F zones) in the general vicinity of the site. The solubility criteria indicates potential presence of DNAPL in lower bedrock (G zone) and expands the source area groundwater in B through F bedrock zones to just south of the CECOS landfill cells.

Source area groundwater alternatives are summarized in Table 4-3.

4.6.1 Source Area Groundwater Alternative 1 (SGW1)

The objective of alternative SGW1 is to create a baseline with which to compare other source area groundwater alternatives. Alternative SGW1 would consist of discontinuing groundwater monitoring and pumping from the existing recovery wells RW-1, RW-2, and RW-3.

- *Effectiveness*
  Alternative SGW1 would not achieve the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination.

  Constituent toxicity and volume would be unaffected by alternative SGW1. Constituent mobility would increase because source area groundwater recovery would be discontinued.

  Discontinuing maintenance activities would have minimal short-term impact on human health and environment.

- *Implementability*
  Alternative SGW1 is implementable.
- *Cost*
  Negligible costs are associated with alternative SGW1 and are assumed to be zero for evaluation purposes.
- *Summary*
  Alternative SGW1 is retained for further evaluation as required by NCP. Alternative SGW1 does not achieve the first or second RAO. Constituent mobility may increase due to discontinuation of groundwater recovery.

4.6.2 Source Area Groundwater Alternative 2 (SGW2)

The objective of alternative SGW2 is to control source area groundwater in B through F zones, thereby reducing contaminant loading to the far field.

This alternative includes continuation of existing source area groundwater response activities. Hydraulic control using the existing grout curtain and pumping wells RW-1, RW-2, and RW-3 at an average total rate of approximately 20 gpm would continue. This groundwater would continue to be treated at the CECOS WWTP and discharged to the POTW. Groundwater monitoring would also continue.

- *Effectiveness*
  When wells RW-1 and RW-2 are operating at their optimal pumping rates, a majority of the southern perimeter of the Necco Park property in the B and C zones is hydraulically influenced. Grout curtain installation along the north perimeter of Necco Park has reduced the volume of groundwater entering Necco Park. The area of influence associated with groundwater recovery wells appears to have been enhanced, and hydraulic control of groundwater flow from Necco Park in B and C zones appears to have been improved. Well RW-3 extracts groundwater from the D, E, and F zones.

  Alternative SGW2 reduces the toxicity, mobility, and volume of source area groundwater constituents. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Minimal short-term effects on human health and environment are associated with this alternative.

- *Implementability*
  Alternative SGW2 is implementable. Operating procedures and reliable treatment have been established.
- *Cost*
  The net present cost of alternative SGW2 is approximately $19.5 million. The construction cost is approximately $0.3 million and includes a portion of the cost for a capital upgrade of the CECOS WWTP. O&M present worth cost is approximately $19.2 million and consists of the present worth cost of recovery well maintenance, monitor well maintenance, groundwater monitoring, treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E.
- *Summary*
  Alternative SGW2 reduces toxicity, volume, and mobility of source area groundwater constituents. Alternative SGW2 is retained for further evaluation.

4.6.3 Source Area Groundwater Alternative 3 (SGW3)

The objective of alternative SGW3 is to control source area groundwater, thereby reducing contaminant loading to the far field in A through F zones.

This alternative includes continuation of existing source area groundwater response activities and installing a downgradient slurry wall on the southern boundary and the southern sections of the eastern and western boundaries of Necco Park. Overburden wells would be installed to prevent groundwater mounding inside the slurry wall. The volume of water extracted from these A zone wells is expected to be 1 to 5 gpm. Hydraulic control using the existing grout curtain and pumping wells RW-1, RW-2, and RW-3 at an average total rate of approximately 20 gpm would continue. The total flow rate from all zones (A through F) would be approximately 21 to 25 gpm. Extracted groundwater would be treated at the CECOS WWTP and discharged to the POTW.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*

  The slurry wall would prevent horizontal migration of constituents in A zone. This would help minimize the impact of overburden groundwater on downgradient A zone groundwater. However, A zone groundwater migration is primarily downward.

  When wells RW-1 and RW-2 are operating at their optimal pumping rates, a majority of the southern perimeter of the Necco Park property in the B and C zones is hydraulically influenced. Grout curtain installation along the north perimeter of Necco Park reduced the volume of groundwater entering Necco Park. The area of influence associated with groundwater recovery wells appears to have been enhanced, and hydraulic control of groundwater flow from Necco Park in B and C zones appears to have been improved. Well RW-3 extracts groundwater from D, E, and F zones.

  This alternative reduces toxicity, mobility, and volume of source area groundwater constituents. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

- *Implementability*

  Alternative SGW3 is implementable. As stated previously, slurry wall construction may create uncontrolled organic vapors. Methods such as application of vapor-suppressing foam or a physical enclosure may be necessary to protect human health and environment. These methods will increase difficulty and time required to implement the alternative. Clean fill may be required for backfilling the slurry trench due to inorganic and organic contamination.

- *Cost*

  The net present cost of alternative SGW3 is approximately $25.0 million. The construction cost is approximately $2.7 million and includes slurry wall construction, A zone recovery well system installation, and on-site spoils disposal.

O&M present worth cost is $22.3 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E.

- *Summary*
  This alternative reduces toxicity, volume, and mobility of source area groundwater constituents. This alternative is retained for further evaluation.

4.6.4 Source Area Groundwater Alternative 4 (SGW4)

The objective of the enhanced hydraulic control alternative is to control 80 percent of contaminant loading from the source area groundwater in B through F zones.

This alternative would include hydraulic control using the existing grout curtain, existing pumping wells RW-1, RW-2, and RW-3, and additional wells to contain source area groundwater in B through F zones. The approximate groundwater recovery required to reduce contaminant loading by 80 percent compared to alternative SGW1 is 70 gpm. Groundwater would be treated at the CECOS WWTP and discharged to the POTW.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*
  Alternative SGW4 reduces toxicity, mobility, and volume of source area groundwater constituents. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Minimal short-term effects on human health and environment are associated with this alternative.

- *Implementability*
  Alternative SGW4 is implementable. Implementation of this alternative includes installation of new recovery wells, pumps, and associated discharge piping. The CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park groundwater treatment, would be able to treat extracted groundwater adequately.

- *Cost*
  The net present cost of alternative SGW4 is approximately $35.7 million. The construction cost is approximately $1.2 million and includes recovery well system installation and the CECOS capital upgrade. O&M present worth cost is $34.5 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve 80 percent reduction in constituent loading is approximate. Additional flow required to achieve 80 percent reduction would result in an increase in total cost. Similarly, if groundwater recovery rates less than 70 gpm are adequate to achieve a 80 percent reduction, total cost would be lower.

- *Summary*
  This alternative reduces toxicity, volume, and mobility of source area groundwater constituents. This alternative is retained for further evaluation.

4.6.5 Source Area Groundwater Alternative 5 (SGW5)

The objective of alternative SGW5 is to control 80 percent of contaminant loading from the source area in A through F zones.

This alternative would include installing a downgradient slurry wall on the southern boundary and the southern sections of the eastern and western boundaries of Necco Park. Overburden wells would be installed to maintain the water table inside the slurry wall. The volume of water extracted from these wells is expected to be 1 to 5 gpm. Hydraulic control would be achieved using the existing grout curtain, existing pumping wells RW-1, RW-2, and RW-3, and additional wells to contain source area groundwater in A through F zones. The approximate groundwater recovery required to reduce contaminant loading by 80 percent in B through F zones is 70 gpm. This groundwater would be treated at the CECOS WWTP and discharged to the POTW.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking water-well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*
  Groundwater recovery reduces contaminant loading to the far field. The slurry wall would prevent horizontal migration of constituents in A zone. This would

help to minimize the impact of overburden groundwater on downgradient A zone groundwater. However, A zone groundwater migration is primarily downward.

Alternative SGW5 reduces toxicity, mobility, and volume of source area groundwater constituents. Constituent mobility and volume are reduced as groundwater is extracted. The downgradient slurry wall also reduces constituent mobility. Toxicity is reduced as groundwater is treated.

Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, volatile organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

- *Implementability*
  Alternative SGW5 is implementable. As stated previously, construction of a slurry wall may create uncontrolled organic vapors. Methods such as application of vapor-suppressing foam or a physical enclosure may be necessary to protect human health and environment. These methods will increase difficulty and time required to implement the alternative. Clean fill may be required for backfilling the slurry trench due to inorganic and organic contamination.

  Implementation of this alternative includes installation of new recovery wells, pumps, and associated discharge piping. The CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would have adequate capacity to treat extracted groundwater.

- *Cost*
  The net present cost of alternative SGW5 is approximately $41.3 million. Construction cost is approximately $3.7 million and includes recovery well system installation the CECOS capital upgrade. O&M present worth cost is $37.6 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve 80 percent reduction in constituent loading is approximate. Additional flow required to achieve 80 percent reduction would result in an increase in total cost. Similarly, if groundwater recovery rates less than 70 gpm are adequate to achieve an 80 percent reduction, total cost would be lower.

- *Summary*
  This alternative reduces toxicity, volume, and mobility of source area groundwater constituents. This alternative is retained for further evaluation.

4.6.6 Source Area Groundwater Alternative 6 (SGW6)

Alternative SGW6's objective is to control contaminated groundwater within the source area in B through F zones, thereby reducing contaminant loading to the far field.

This alternative would also include hydraulic control using existing grout curtain, existing pumping wells RW-1, RW-2, and RW-3, and additional wells to provide total containment of source area groundwater in B through F zones. The approximate pumping rate required to create a hydraulic barrier in B through F zones is 155 gpm. This groundwater would be treated at the CECOS WWTP and discharged to the POTW.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*
  Alternative SGW6 reduces source area groundwater constituent toxicity, mobility, and volume. Groundwater recovery reduces contaminant loading to the far field. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Minimal short-term effects on human health and environment are associated with this alternative.

- *Implementability*
  Alternative SGW6 is implementable. Implementation of this alternative includes installation of new recovery wells, pumps, and associated discharge piping. CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would require expansion to accommodate additional flow. This expansion may include new or upgraded equalization tank, air stripper, and carbon adsorption units.

- *Cost*
  The net present cost of alternative SGW6 is approximately $55.6 million. Construction cost is approximately $3.1 million and includes expansion of the CECOS WWTP and installation of a recovery well system. O&M present worth

cost is $52.5 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of B through F zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 155 gpm are adequate to achieve total hydraulic control, cost would be lower.

- *Summary*
  This alternative reduces the toxicity, volume, and mobility of source area groundwater constituents. This alternative is retained for further evaluation.

4.6.7 Source Area Groundwater Alternative 7 (SGW7)

Alternative SGW7's objective is to control contaminated groundwater within the source area in B through F zones, thereby reducing contaminant loading to the far field.

This alternative would also include hydraulic control using the existing grout curtain, existing pumping wells RW-1, RW-2, and RW-3, and additional wells to provide total containment of source area groundwater in B through F zones. The approximate pumping rate required to create a hydraulic barrier in B through F zones is 155 gpm. This alternative is the same as alternative SGW6 except that extracted groundwater would be treated at the POTW.

This alternative includes groundwater monitoring and deed restrictions. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*
  Alternative SGW7 reduces the toxicity, mobility, and volume of source area groundwater constituents and reduces contaminant loading to the far field. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Minimal short-term impacts are associated with this alternative.

- *Implementability*
  Implementation of this alternative includes installation of new recovery wells and associated piping. A connection to the sanitary sewer system would be constructed.

The POTW and associated sanitary sewer lines have hydraulic capacity to treat extracted groundwater. However, extracted groundwater is likely to be considered a characteristic hazardous waste due to relatively high concentrations of hexachlorobutadiene and TCE. The POTW would determine whether to accept Necco Park wastewater without pretreatment. If pretreatment is necessary, a treatment system would have to be constructed at Necco Park (see alternative SGW8).

- *Cost*
  The net present cost of alternative SGW7 is approximately $21.0 million. Construction cost is approximately $1.5 million and includes a connection to the sanitary sewer and installation of a recovery well system. O&M present worth cost is $19.5 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at the POTW, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of B through F zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 155 gpm are adequate to achieve total hydraulic control, cost would be lower.

  Cost assumes that wastewater would be conveyed through the existing sanitary sewer lines. The unit cost of wastewater treatment was calculated based on the proposed 1995 POTW rate structure and estimated groundwater quality.

- *Summary*
  Alternative SGW7 has the same effectiveness as alternative SGW6. Although the cost for alternative SGW7 is potentially lower than alternative SGW6, many uncertainties are associated with alternative SGW7. The most important factor in evaluating this alternative compared to alternatives SGW6 and SGW8 is whether pretreatment prior to discharge to the sanitary sewer would be required. If pretreatment is required, the cost of this alternative would be greater than the cost for alternative SGW6. Due to these uncertainties, POTW treatment is screened from further evaluation.

4.6.8 Source Area Groundwater Alternative 8 (SGW8)

Alternative SGW8's objective is to control contaminated groundwater within the source area in B through F zones, thereby reducing contaminant loading to the far-field.

This alternative would include hydraulic control using the existing grout curtain, existing pumping wells RW-1, RW-2, and RW-3, and additional wells to provide total containment of source area groundwater in B through F zones. The approximate pumping rate required to create a hydraulic barrier in B through F zones is 155 gpm. This alternative is the same as alternative SGW6 except that extracted groundwater would be treated at an on-site treatment facility.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*
  Alternative SGW8 reduces the toxicity, mobility, and volume of source area groundwater constituents and reduces contaminant loading to the far field. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Minimal short-term impacts are associated with this alternative.

- *Implementability*
  Implementation of this alternative includes the installation of new recovery wells, pumps, associated discharge piping, and construction of a new groundwater treatment facility. Construction of an on-site facility, while technically feasible, would require two to five years of design, permit applications, and construction. A treatment facility would require a power and water supply. Water utilities would have to be installed prior to construction. Limited electrical power is available at Necco Park, but would require upgrades for a treatment system.

- *Cost*
  The net present cost of alternative SGW8 is approximately $51.6 million. Construction cost is approximately $6.8 million and includes construction of an on-site treatment facility and installation of a well system. O&M present worth cost is approximately $44.8 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater monitoring, and O&M of an on-site treatment plant. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of B through F zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 155 gpm are adequate to achieve total hydraulic control, cost would be lower.

- *Summary*
  This alternative reduces toxicity, volume, and mobility of source area groundwater constituents. This alternative requires more time to implement and has a similar cost compared to alternative SGW6. Therefore, this alternative is screened from further evaluation.

4.6.9 Source Area Groundwater Alternative 9 (SGW9)

Alternative SGW9's objective is to control contaminated groundwater within the source area in A through F zones, thereby reducing contaminant loading to the far field.

This alternative is the same as alternative SGW6 except that A zone hydraulic control would be accomplished using a downgradient slurry wall installed on the southern boundary and the southern section of the eastern and western boundaries of Necco Park. The existing grout curtain, existing pumping wells RW-1, RW-2, and RW-3, and additional wells are also included to provide total containment of source area groundwater in A through F zones. The approximate pumping rate required to create a hydraulic barrier in A through F zones is 160 gpm. Based on an evaluation of groundwater treatment alternatives (SGW6, SGW7 and SGW8), treatment at CECOS WWTP is assumed for this alternative. However, treatment at the POTW or an on-site treatment facility would be considered during remedial design.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*
  The slurry wall limits horizontal migration of groundwater in A zone. However, A zone groundwater migration is primarily downward. Alternative SGW9 reduces source area groundwater constituent toxicity, mobility, and volume and reduces contaminant loading to the far field. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, volatile organic constituents may volatilize into the air.

Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

- *Implementability*
  Alternative SGW9 is implementable. Implementation of this alternative includes installation of new recovery wells, pumps, and associated discharge piping. CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would require expansion to accommodate the additional flow. This expansion may include new or upgraded equalization tank, air stripper, and carbon adsorption units.

  As stated previously, slurry wall construction may create uncontrolled organic vapors. Application of vapor-suppressing foam may be necessary to protect human health and environment. Vapor-suppressing foam will increase difficulty and time required to implement the alternative. Clean fill may be required for backfilling the slurry trench due to inorganic and organic contamination.

- *Cost*
  The net present cost of SGW9 is approximately $61.1 million. The construction cost is approximately $5.5 million and includes expanding the CECOS facility, installing the slurry wall, on-site spoils disposal, and recovery well system installation. O&M present worth cost is $55.6 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of A through F zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 160 gpm are adequate to achieve total hydraulic control, cost would be lower.

- *Summary*
  This alternative reduces toxicity, volume, and mobility of source area groundwater constituents. This alternative is retained for further evaluation.

4.6.10 Source Area Groundwater Alternative 10 (SGW10)

Alternative SGW10's objective is to control contaminated groundwater within the source area in B through G zones, thereby reducing contaminant loading to the far field.

This alternative would include hydraulic control using the existing grout curtain, existing pumping wells RW-1, RW-2, and RW-3, and additional wells to contain source area groundwater in B through G zones. The approximate pumping rate required to create a hydraulic barrier in B through G zones is 210 gpm. Based on an evaluation of groundwater treatment alternatives (SGW6, SGW7 and SGW8), treatment at CECOS WWTP is assumed for this alternative. However, treatment at the POTW or an on-site treatment facility would be considered during remedial design.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also be implemented to limit the use of source area groundwater.

- *Effectiveness*
  Alternative SGW10 reduces groundwater constituent toxicity, mobility, and volume and reduces contaminant loading to the far field. Constituent mobility and volume are reduced as groundwater is extracted. Toxicity is reduced by groundwater treatment.

  Groundwater modeling has predicted that approximately 55 gpm would have to be withdrawn from G zone alone to achieve source area hydraulic control. This extraction, however, would result in only a minor reduction in overall contaminant loading to the far field when compared to hydraulic control of B through F zones (see discussion of organic loading in Section 1.0). The significant increase in pumping rate (35 percent greater than hydraulic control B through F zones) yields only a minor decrease in contaminant loading.

  Minimal short-term effects on human health and environment are associated with this alternative.

- *Implementability*
  Alternative SGW10 is implementable. Implementation of this alternative includes installation of new recovery wells, pumps, and associated discharge piping. CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would require significant expansion to accommodate additional flow. This expansion may include new or upgraded equalization tank, air stripper, and carbon adsorption units.

- *Cost*
  The net present cost of alternative SGW10 is approximately $69.0 million. Construction cost is approximately $3.6 million and includes CECOS expansion and recovery well installation. O&M present worth cost is approximately $65.4 million and consists of the present worth cost of recovery and monitor well

maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of A through G zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 210 gpm are adequate to achieve total hydraulic control, cost would be lower.

- *Summary*
  Alternative SGW10 is slightly more effective in reducing contaminant loading to the far field than alternative SGW6. However, G zone groundwater extraction would result in only a minor reduction in overall contaminant loading (approximately 1 pound) to the far field when compared to hydraulic control of B through F zones. The significant increase in pumping rate (35 percent greater than hydraulic control B through F zones) yields only a minor decrease in contaminant loading. The cost of SGW10 is also significantly higher than alternative SGW6. A cost per constituent loading reduction ratio was calculated to determine the cost-effectiveness of addressing the G zone through pumping (see Appendix F). The cost per constituent loading reduction ratio is the estimated total mass of constituents that would be recovered over 30 years divided by the present worth cost of the alternative. This ratio was calculated for upper, middle, and lower zones. It was determined that the cost per pound removed was an order of magnitude higher in G zone compared to upper and middle zones. Therefore, alternative SGW10 is screened from further evaluation. However, SGW13 will be retained as a representative G zone source control alternative (see Section 4.6.13).

4.6.11 Source Area Groundwater Alternative 11 (SGW11)

The objective of alternative SGW11 is to control source area groundwater by containing groundwater within the source area in B through F zones using a grout curtain and groundwater pumping, thereby reducing contaminant loading to the far-field.

This alternative would consist of constructing a grout curtain around the source area, from B through F zones (approximately 80 feet deep). Groundwater would be recovered in B through F zones to maintain an inward hydraulic gradient. This pumping would act as secondary containment. The predicted flow rate needed to achieve an inward hydraulic gradient is approximately 65 gpm. Based on an evaluation of groundwater treatment alternatives (SGW6, SGW7 and SGW8), treatment at CECOS WWTP is assumed for this alternative. However, treatment at the POTW or an on-site treatment facility would be considering during remedial design.

This alternative also includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also be implemented to limit the use of source area groundwater.

- *Effectiveness*
  Alternative SGW11 reduces toxicity, mobility, and volume of source area groundwater constituents. The grout curtain limit horizontal mobility of source area groundwater in B through F zones. Constituent volume is reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Drilling through areas of known DNAPL may create a downward route for DNAPL migration. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Sites and RCRA Facilities—Update* states,

  > "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

  DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized short-term vertical pathways may be created for DNAPL movement during the drilling process.

- *Implementability*
  Alternative SGW11 is implementable. An upgradient grout curtain has been successfully installed at Necco Park. Installation procedures and grout mixtures have already been established. The grout curtain in this alternative requires access to and drilling on adjacent properties (CECOS). Permission and access agreements must be obtained from CECOS and other property and right-of-way owners prior to grout curtain installation. Limited space is available for drilling activities because of physical restrictions such as existing landfills, roads, power lines, railroad tracks, and underground brine lines. These physical barriers would have to be avoided when installing the grout curtain; therefore, implementation time may increase. The access road and power line may have to be relocated to install the grout curtain.

  The CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would be able to adequately treat extracted groundwater.

- *Cost*

  The net present cost of alternative SGW11 is approximately $44.4 million. Construction cost is approximately $11.0 million and includes grout curtain construction, recovery well system installation, and on-site spoils disposal. O&M present worth cost is $33.4 million and consists of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of B through F zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 65 gpm are adequate to achieve total hydraulic control, the cost would be lower.

  Grout curtain installation costs are difficult to estimate because of uncertainties associated with the time and amount of grout needed to achieve target permeabilities. The unit cost used for this estimate ($30 per square foot) was based on the cost of installing the existing grout curtain. However, vendor quotes indicate that the cost of installing a grout curtain can range from $30 per square foot to $80 per square foot. The wide range of grout curtain unit costs should be considered when evaluating this cost.

- *Summary*

  Alternative SGW11 helps to achieve the first RAO in the far field by reducing the source of far-field groundwater contamination. This alternative reduces the toxicity, volume, and mobility of source area groundwater constituents. This alternative is retained for further evaluation.

4.6.12 Source Area Groundwater Alternative 12 (SGW12)

The objective of alternative SGW12 is to control source area groundwater by containing groundwater within the source area in A through F zones using a downgradient slurry wall, a grout curtain, and groundwater pumping, thereby reducing contaminant loading to the far field.

This alternative would consist of installing a slurry wall on the southern boundary and the southern section of the eastern and western boundaries of Necco Park. In addition, a grout curtain would be constructed around Necco Park and the CECOS facility from B through F zones (approximately 80 feet deep). Groundwater would be recovered in A through F zones to maintain an inward hydraulic gradient. This pumping would act as secondary containment. The predicted flow rate needed to achieve secondary containment is approximately 70 gpm. Based on an evaluation of groundwater treatment alternatives (SGW6, SGW7 and SGW8), treatment at CECOS WWTP is assumed for this alternative. However, treatment at the POTW or an on-site treatment facility would be considered during remedial design.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*

  The grout curtain limits horizontal mobility of source area groundwater in B through F zones and groundwater extraction reduces contaminant loading to the far field. The downgradient slurry wall limits the horizontal mobility of source area groundwater in A zone. However, the primary direction of A zone groundwater migration is downward. Alternative SGW12 reduces toxicity, mobility, and volume of source area groundwater constituents. Constituent volume is reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Drilling through areas of DNAPL may create a downward route for DNAPL migration. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Sites and RCRA Facilities—Update* states,

  > "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

  DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized short-term vertical pathways may be created for DNAPL movement during the drilling process.

  Installing a slurry wall may have negative short-term impact on human health and environment. A slurry wall would require excavating a 20- to 30-foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, volatile organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized short-term route for constituent or DNAPL migration to bedrock.

- *Implementability*

Alternative SGW12 is implementable. An upgradient grout curtain has been successfully installed at Necco Park. Installation procedures and grout mixtures have already been established. The grout curtain in this alternative requires access to and drilling on adjacent properties (CECOS). Permission and access agreements must be obtained from CECOS and other property and right-of-way owners prior to grout curtain installation. Limited space is available for drilling activities because of physical restrictions such as existing landfills, roads, power lines, railroad tracks, and underground brine lines. These physical barriers would have to be avoided when installing the grout curtain; therefore, implementation time may increase. The access road and power line may have to be relocated to install the grout curtain.

As stated previously, slurry wall construction may create uncontrolled organic vapors. Application of vapor-suppressing foam may be necessary to protect human health and environment. Vapor-suppressing foam will increase difficulty and time required to implement the alternative. Clean fill may be required for backfilling the slurry trench due to inorganic and organic contamination.

The CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would be able to adequately treat extracted groundwater.

- *Cost*

The net present cost of alternative SGW12 is approximately $49.7 million. The construction cost is approximately $13.2 million and includes grout curtain and slurry wall construction, recovery well system installation, and on-site spoils disposal. O&M present worth cost is $36.5 million and consists of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of B through F zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 70 gpm are adequate to achieve total hydraulic control, cost would be lower.

Grout curtain installation costs are difficult to estimate because uncertainties associated with the time and amount of grout needed to achieve target permeabilities. The unit cost used for this estimate ($30 per square foot) was based on the cost of installing the existing grout curtain. However, vendor quotes indicate that the cost of installing a grout curtain can range from $30 per square foot to $80 per square foot. The wide range of grout curtain unit costs should be considered when evaluating this cost.

- *Summary*
  Alternative SGW12 reduces contaminant loadings to far-field groundwater. This alternative reduces toxicity, volume, and mobility of source area groundwater constituents. This alternative is retained for further evaluation.

4.6.13 Source Area Groundwater Alternative 13 (SGW13)

The objective of alternative SGW13 is to control source area groundwater by containing groundwater within the source area in B through G zones using a grout curtain and groundwater pumping, thereby reducing contaminant loading to the far field.

This alternative would consist of constructing a grout curtain around Necco Park and the CECOS facility from B through G zones (approximately 160 feet deep). Groundwater would be recovered in B through G zones to maintain an inward hydraulic gradient. This pumping would act as secondary containment. The predicted flow rate needed to achieve secondary containment is approximately 75 gpm. Based on an evaluation of groundwater treatment alternatives (SGW6, SGW7 and SGW8), treatment at CECOS WWTP is assumed for this alternative. However, treatment at the POTW or an on-site treatment facility would be considered during remedial design.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would also limit the use of source area groundwater.

- *Effectiveness*
  Alternative SGW13 reduces toxicity, mobility, and volume of source area groundwater constituents and reduces contaminant loading to the far field. The grout curtain limits horizontal mobility of source area groundwater in B through G zones. Constituent volume is reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

Drilling through areas of DNAPL may create a downward route for DNAPL migration. The EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Sites and RCRA Facilities—Update* states,

> "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized short-term vertical pathways may be created for DNAPL movement during the drilling process.

G zone grouting requires that an additional 80 feet of bedrock be grouted compared B through F zones grout curtain installation (alternative SGW8) Groundwater modeling has predicted that approximately 10 gpm would have to be withdrawn from G zone to achieve source area hydraulic control. Additional grout curtain and groundwater extraction, however, would result in only a minor reduction in overall contaminant loading (approximately 1 pound) to the far field when compared to grouting and hydraulic control of B through F zones. The significant increase in grout curtain installation (100 percent greater than grouting A through F zones) results in only a minor decrease in contaminant loading to the far field.

- *Implementability*
  Alternative SGW13 is implementable. An upgradient grout curtain has been successfully installed at Necco Park. Installation procedures and grout mixtures have already been established. The grout curtain in this alternative requires access to and drilling on adjacent properties (CECOS). Permission and access agreements must be obtained from CECOS and other property and right-of-way owners prior to grout curtain installation. Limited space is available for drilling activities because of physical restrictions such as existing landfills, roads, power lines, railroad tracks, and underground brine lines. These physical barriers would have to be avoided when installing the grout curtain; therefore, implementation time may increase. The access road and power line may have to be relocated to install the grout curtain.

  Implementation of this alternative also includes installation of new recovery wells and associated piping. The CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would be able to adequately treat extracted groundwater.

- *Cost*

  The net present cost of alternative SGW13 is approximately $70.7 million. The construction cost is approximately $34.5 million and includes grout curtain construction, recovery well system installation, and on-site spoils disposal. O&M present worth cost is $36.2 million and consists of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of B through F zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 75 gpm are adequate to achieve total hydraulic control, cost would be lower.

  Grout curtain installation costs are difficult to estimate because of uncertainties associated with the time and amount of grout needed to achieve target permeabilities. The unit cost used for this estimate ($30 per square foot) was based on the cost of installing the existing grout curtain. However, vendor quotes indicate that the cost of installing a grout curtain can range from $30 per square foot to $80 per square foot. The wide range of grout curtain unit costs should be considered when evaluating this cost

- *Summary*

  Alternative SGW13 is slightly more effective in reducing contaminant loading to the far field than alternative SGW12. G zone grout curtain and groundwater extraction would result in only a minor reduction in overall contaminant loading to the far field when compared to controlling B through F zones. The significant increase in grout curtain size (100 percent greater than grouting A through F zones) yields only a minor decrease in contaminant loading. SGW13's cost is significantly higher than cost for alternative SGW12. A cost per constituent loading reduction ratio was calculated to determine the cost-effectiveness of addressing the G zone through pumping (see Appendix F). The cost per constituent loading reduction ratio is the estimated total mass of constituents that would be recovered over 30 years divided by the present worth cost of the alternative. This ratio was calculated for upper, middle, and lower zones. It was determined that the cost per pound removed was an order of magnitude higher in G zone compared to upper and middle zones. However, alternative SGW13 is retained as a representative G zone source area groundwater control alternative.

4.6.14 Source Area Groundwater Alternative 14 (SGW14)

The objective of alternative SGW14 is to control source area groundwater by containing groundwater within the source area in B through G zones using a grout curtain and groundwater pumping, thereby reducing contaminant loading to the far field.

This alternative would consist of constructing a grout curtain around the source area from B through F zones (approximately 80 feet deep). Groundwater would be recovered in B through G zones to maintain an inward hydraulic gradient using extraction wells. The predicted flow rate needed to achieve hydraulic control is approximately 130 gpm. Based on an evaluation of groundwater treatment alternatives (SGW6, SGW7 and SGW8), treatment at CECOS WWTP is assumed for this alternative. However, treatment at the POTW or an on-site treatment facility would be considering during remedial design.

This alternative includes groundwater monitoring and deed restrictions that would prohibit installation of a drinking-water well on the property. Groundwater-use controls would limit the use of source area groundwater.

- *Effectiveness*

  Alternative SGW14 reduces toxicity, mobility, and volume of source area groundwater constituents and reduces contaminant loadings to the far field. The grout curtain limits the horizontal mobility of source area groundwater in B through F zones. Constituent volume is reduced as groundwater is extracted. Toxicity is reduced as groundwater is treated.

  Drilling through areas of DNAPL may create a downward route for DNAPL migration. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Sites and RCRA Facilities—Update* states,

  > "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration ... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

  DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized short-term vertical pathways may be created for DNAPL movement during the drilling process.

Groundwater modeling has predicted that approximately 55 gpm would have to be withdrawn from G zone to achieve source area hydraulic control. This extraction, however, would result in only a minor reduction in overall contaminant loading (less than 1 pound) to the far field when compared to hydraulic control of B through F zones. The significant increase in pumping rate results in only a minor decrease in contaminant loading.

- *Implementability*
  Alternative SGW14 is implementable. An upgradient grout curtain has been successfully installed at Necco Park. Installation procedures and grout mixtures have already been established. The grout curtain in this alternative requires access to and drilling on adjacent properties (CECOS). Permission and access agreements must be obtained from CECOS and other property and right-of-way owners prior to grout curtain installation. Limited space is available for drilling activities because of physical restrictions such as existing landfills, roads, power lines, railroad tracks, and underground brine lines. These physical barriers would have to be avoided when installing the grout curtain; therefore, implementation time may increase. The access road and power line may have to be relocated to install the grout curtain.

  Implementation of this alternative includes the installation of new recovery wells and associated piping. The CECOS WWTP, which has approximately 110 gpm available capacity for Necco Park use, would require expansion to accommodate additional flow. This expansion may include a new equalization tank, a new air stripper, and additional carbon adsorption units.

- *Cost*
  The net present cost of alternative SGW14 is approximately \$61.4 million. The construction cost is approximately \$13.0 million and includes grout curtain construction, recovery well system installation, and on-site spoils disposal. O&M present worth cost is approximately \$48.4 million and consists of the present worth cost of recovery and monitor well maintenance, groundwater monitoring, groundwater treatment at CECOS WWTP, and reporting. Cost components are presented in Appendix E. The flow rate to achieve hydraulic control of B through G zones is based on computer modeling of the source area. Additional pumping required to achieve total hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 130 gpm are adequate to achieve total hydraulic control, cost would be lower.

  Grout curtain installation costs are difficult to estimate because of uncertainties associated with the time and amount of grout needed to achieve target permeabilities. The unit cost used for this estimate (\$30 per square foot) was based on the cost of installing the existing grout curtain. However, vendor quotes indicate that the cost of installing a grout curtain can range from \$30 per square foot to $80 per square foot. The wide range of grout curtain unit costs should be considered when evaluating this cost

- *Summary*
  Alternative SGW14 has similar effectiveness in reducing contaminant loading to the far field as alternative SGW12. G zone groundwater extraction would result in only a minor reduction in overall contaminant loading (approximately 1 pound) to the far field when compared to controlling B through F zones. The significant increase in pumping rate yields only a minor decrease in contaminant loading. Alternative SGW14's cost is significantly higher than alternative SGW12 for this relatively minor decrease in contaminant loading. A cost per constituent loading reduction ratio was calculated to determine the cost-effectiveness of addressing G zone through pumping (see Appendix F). The cost per constituent loading reduction ratio is the estimated total mass of constituents that would be recovered over 30 years divided by the present worth cost of the alternative. This ratio was calculated for upper, middle, and lower zones. It was determined that the cost per pound removed was an order of magnitude higher in G zone compared to upper and middle zones. Alternative SGW14 is screened from further evaluation. However, alternative SGW13 was retained as a representative G zone source area groundwater control alternative.

4.7 Far-Field Groundwater Alternative Evaluation

This section describes the evaluation of far-field groundwater (FGW) alternatives. These alternatives were assembled to address the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. Far-field groundwater alternatives do not address the second RAO, control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality.

Far-field groundwater is defined as bedrock groundwater beyond the source area that has been impacted by Necco Park constituents but where the solubility criteria for DNAPL has not been met. Far-field groundwater extends generally from the southern edge of the source area south to the Falls Street tunnel, and from the western border of the source area west to the NYPA conduits. Direction of groundwater flow in the B and C zones is to the south. Groundwater in the D through G zones flows to the west. These utility drains (the Falls Street tunnel and NYPA conduit drains) act as groundwater sinks. A portion of the water in the NYPA conduit drains flows into the Falls Street tunnel. All of the water in the Falls Street tunnel is treated by the Niagara Falls POTW during dry weather conditions. The estimated areal extent of far-field groundwater was presented in Figures 1-29 to 1-35.

Far-field groundwater alternatives are summarized in Table 4-4.

4.7.1 Far-Field Groundwater Alternative 1 (FGW1)

The objective of alternative FGW1 is to create a baseline against which to compare other far-field groundwater alternatives. Alternative FGW1 would consist of discontinuing far-field groundwater monitoring. Groundwater-use controls controlling the installation of residential wells in the far-field area would continue to exist. Utility drains would continue to intercept far-field groundwater, and natural attenuation would continue.

- *Effectiveness*
  Assuming the hypothetical control of 100 percent of source material, alternative FGW1 may not achieve the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. Restoration of aqueous contamination downgradient from DNAPL areas in a fractured bedrock system may be possible but is subject to significant uncertainty (NRC 1994). Potential restoration of the far-field is discussed in Section 1.9.

  As groundwater is intercepted by the existing utility drains, constituent volume and mobility are reduced. Toxicity of constituents is reduced by natural attenuation.

  No short-term impact is associated with alternative FGW1.

- *Implementability*
  Alternative FGW1 is implementable.

- *Cost*
  Negligible costs are associated with alternative FGW1 and assumed to be zero for this evaluation.

- *Summary*
  Alternative FGW1 is retained for further evaluation as required by NCP.

4.7.2 Far-Field Groundwater Alternative 2 (FGW2)

The purpose of alternative FGW2 is to continue to monitor the extent of impacted groundwater and to evaluate existing mechanisms that act on Necco Park constituents (e.g., containment through utility drains and natural attenuation). Alternative FGW2 consists of groundwater monitoring, groundwater-use controls, containment through existing utility drains, and natural attenuation.

- *Effectiveness*
  Assuming hypothetical control of 100 percent of source material, alternative FGW2 may not achieve the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. Restoration of aqueous contamination downgradient from DNAPL areas in a fractured bedrock system may be possible but is subject to significant uncertainty (NRC 1994). Potential restoration of the far field is discussed in Section 1.9.

  As groundwater is intercepted by existing utility drains, constituent volume and mobility are reduced. Toxicity of constituents is reduced by natural attenuation.

  Minimal short-term impacts are associated with the existing systems alternative.

- *Implementability*
  Alternative FGW2 is implementable.

- *Cost*
  The net present cost of alternative FGW2 is approximately $2.5 million. O&M present worth cost is approximately $2.5 million and consists of the present worth cost of groundwater monitoring. Cost components are presented in Appendix E.

- *Summary*
  Alternative FGW2 is retained for further evaluation.

4.7.3 Far-Field Groundwater Alternative 3 (FGW3)

The purpose of alternative FGW3 is to intercept and remove 50 percent of groundwater constituents in the far field that enters the utility drains. This alternative includes installation of groundwater recovery wells and treatment at the POTW. Approximately 200 gpm would be extracted to intercept 50 percent of the far-field groundwater constituents (see Section 1.0). Alternative FGW3 also includes groundwater monitoring, groundwater-use controls, containment through existing utility drains, and natural attenuation.

- *Effectiveness*
  Assuming the hypothetical control of 100 percent of source material, alternative FGW3 may not achieve the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. Restoration of aqueous contamination downgradient from DNAPL areas in a fractured bedrock system may be possible but is subject to significant uncertainty (NRC 1994). Potential restoration of the far field is discussed in Section 1.9.

  As groundwater is intercepted by recovery wells and existing utility drains, constituent volume and mobility are reduced. Toxicity of constituents is reduced by natural attenuation and groundwater treatment at the POTW.

  Minimal short-term impacts to human health and environment are associated with alternative FGW3.

- *Implementability*
  Alternative FGW3 requires installation of recovery wells, pumps, and discharge piping in the far-field area. The far field consists of industrial, commercial, and residential areas. Permission to install wells on the private property, and access agreements would be required. Extensive drilling and pipe-laying operations on public and private property would be required.

  Pretreatment may be required prior to discharging to the POTW.

- *Cost*
  The net present cost of alternative FGW3 is approximately \$26.3 million. The construction cost is approximately \$3.1 million and includes recovery well system installation and connection to the sanitary sewer. O&M present worth cost is \$23.2 million and consists of monitor and recovery well maintenance, groundwater monitoring, groundwater treatment at the POTW, and reporting. Pretreatment costs are not included in the O&M estimate. Cost components are presented in Appendix E. The flow rate to achieve 50 percent control of far-field contamination is approximate. Additional flow required to achieve hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 200 gpm are adequate to achieve 50 percent hydraulic control, total cost would be lower.

- *Summary*
  Alternative FGW3 is not significantly more effective than alternative FGW2 in restoring far-field groundwater to its designated use—potable drinking water (see Section 1.0). However, this alternative is significantly more expensive than alternative FGW2. Therefore, this alternative is screened from further evaluation.

4.6.4 Far-Field Groundwater Alternative 4 (FGW4)

The purpose of alternative FGW4 is to intercept and remove 75 percent of groundwater constituents in the far-field that enter the utility drains. This alternative includes installation of groundwater recovery wells and treatment at the POTW. Approximately 300 gpm would be extracted to intercept 75 percent of far-field groundwater (see Section 1.0). Alternative FGW4 also includes groundwater monitoring, groundwater-use controls, containment through existing utility drains, and natural attenuation.

- *Effectiveness*
  Assuming the hypothetical control of 100 percent of source material, alternative FGW4 may not achieve the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. Restoration of aqueous contamination downgradient from DNAPL areas in a fractured bedrock system may be possible but is subject to significant uncertainty (NRC 1994). Potential restoration of the far field is discussed in Section 1.9.

  As groundwater is intercepted by recovery wells and existing utility drains, constituent volume and mobility are reduced. Toxicity of constituents is reduced by natural attenuation and groundwater treatment at the POTW.

  Minimal short-term impacts to human health and environment are associated with alternative FGW4.

- *Implementability*
  Alternative FGW4 requires installation of recovery wells, pumps, and discharge piping in the far-field area. The far field consists of industrial, commercial, and residential areas. Permission to install wells on the private property and access agreements would be required. Extensive drilling and pipe-laying operations on public and private property would be required.

  Pretreatment may be required prior to discharging to the POTW.

- *Cost*
  The net present cost of alternative FGW4 is approximately $35.7 million. Construction cost is approximately $3.3 million and includes recovery well system installation and connection to the sanitary sewer. O&M present worth cost is

approximately $32.4 million and consists of the present worth cost of monitor and recovery well maintenance, groundwater monitoring, groundwater treatment at the POTW, and reporting. Pretreatment costs are not included in the O&M estimate. Cost components are presented in Appendix E. The flow rate to achieve 75 percent control of far-field contamination is approximate. Additional flow required to achieve hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 300 gpm are adequate to achieve 75 percent hydraulic control, total cost would be lower.

- *Summary*
  Alternative FGW4 is not significantly more effective than alternative FGW2 in restoring far-field groundwater to its designated use—potable drinking water (see Section 1.0). However, this alternative is significantly more expensive than alternative FGW2. Therefore, this alternative is screened from further evaluation.

4.6.5 Far-Field Groundwater Alternative 5 (FGW5)

The purpose of alternative FGW5 is to intercept and remove 100 percent of groundwater constituents in the far field that enters the utility drains. This alternative includes installation of groundwater recovery wells in the B through G zones and treatment at the POTW. Approximately 400 gpm would be extracted to intercept 100 percent of far-field groundwater constituents (see Section 1.0). Alternative FGW5 also includes groundwater monitoring, groundwater-use controls, containment through existing utility drains, and natural attenuation.

- *Effectiveness*
  Assuming the hypothetical control of 100 percent of source material alternative FGW5 will not achieve the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination. Restoration of aqueous contamination downgradient from DNAPL areas in a fractured bedrock system may be possible but is subject to significant uncertainty (NRC 1994). Potential restoration of the far field is discussed in Section 1.9.

  As groundwater is intercepted by recovery wells and existing utility drains, constituent volume and mobility are reduced. Toxicity of constituents is reduced by natural attenuation and groundwater treatment at the POTW.

  Minimal short-term impacts to human health and environment are associated with alternative FGW5.

- *Implementability*
  Alternative FGW5 requires installation of recovery wells, pumps, and discharge piping in the far-field area. The far field consists of industrial, commercial, and residential areas. Permission to install wells on the private property and access agreements would be required. Extensive drilling and pipe-laying operations on public and private property would be required.

  Pretreatment may be required prior to discharging to the POTW.

- *Cost*
  The net present cost of alternative FGW5 is approximately $46.5 million. Construction cost is approximately $3.8 million and includes recovery well system installation and connection to the sanitary sewer. O&M present worth cost is approximately $42.7 million and consists of the present worth cost of monitor and recovery well maintenance, groundwater monitoring, groundwater treatment at the POTW, and reporting. Pretreatment costs are not included in the O&M estimate. Cost components are presented in Appendix E. The flow rate to achieve 100 percent control of far field contamination is approximate. Additional flow required to achieve hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 400 gpm are adequate to achieve 100 percent hydraulic control, total cost would be lower.

- *Summary*
  This alternative is retained to provide the most comprehensive scenario for addressing far-field groundwater.

4.6.6 Far-Field Groundwater Alternative 6 (FGW6)

The purpose of alternative FGW6 is to extract 100 percent of groundwater contamination from the far field. This alternative includes installation of groundwater recovery wells in the B through G zones and treatment at a new treatment plant at Necco Park. Treated groundwater would be discharged through injection wells at Necco Park. The injection wells would be installed in the far-field rather than the source area to prevent potential migration of source area groundwater. Approximately 400 gpm of groundwater would be extracted to achieve 100 percent control of the far field. Alternative FGW6 also includes groundwater monitoring, groundwater-use controls, containment through the use of the existing utility drains, and natural attenuation.

- *Effectiveness*
  Assuming the hypothetical control of 100 percent of source material, alternative FGW6 will not achieve the first RAO, restoration of groundwater to its designated

use—potable drinking water—as impacted by Necco Park contamination. Restoration of aqueous contamination downgradient from DNAPL areas in a fractured bedrock system may be possible but is subject to significant uncertainty (NRC 1994). Potential restoration of the far field is discussed in Section 1.9.

As groundwater is intercepted by the recovery wells and existing utility drains, constituent volume and mobility are reduced. Toxicity of constituents is reduced by groundwater treatment and natural attenuation. Injection of treated groundwater may be less effective than surface-water discharge due to the tendency for injection wells to clog.

Minimal short-term impacts are associated with alternative FGW6.

- *Implementability*
  Alternative FGW6 requires installing recovery wells and piping in the far-field area. The far-field consists of industrial, commercial, and residential areas. An area for recovery well installation and piping to the sanitary sewer would have to be purchased or leased.

  Piping would have to be installed at Necco Park. This piping would require obtaining right-of-ways through residential, commercial, and industrial areas.

  Construction of an on-site facility, while technically feasible, would require two to five years of design, permit applications, and construction. A treatment facility would require a power and water supply. Water utilities would have to be installed prior to construction. Limited electrical power is available at Necco Park, but would require upgrades for a treatment system.

- *Cost*
  To discharge in excess of 400 gpm of treated groundwater, many injection wells would have to be drilled. These injection wells would have to drilled in known DNAPL areas, potentially creating a route for DNAPL migration. Injection wells have a tendency to clog, which would require frequent maintenance to correct. The cost of alternative FGW6 is approximately $128.8 million. Construction cost is approximately $13.2 million and includes recovery well system installation, construction of an on-site treatment plant, and drilling injection wells. O&M present worth cost is approximately $115.6 million and consists of the present worth cost of monitor and recovery well maintenance, groundwater monitoring, groundwater treatment at an on-site facility, and reporting. Cost components are presented in Appendix E. The flow rate to achieve 100 percent control of far-field contamination is approximate. Additional flow required to achieve hydraulic control would result in an increase in total cost. Similarly, if groundwater recovery rates less than 400 gpm are adequate to achieve 100 percent hydraulic control, total cost would be lower.

- *Summary*
  This alternative has similar effectiveness but costs more and is more difficult to implement than alternative SGW5. Therefore, this alternative is screened from further evaluation.

4.8 Summary of Media-specific Alternatives Evaluation

Table 4-5 summarizes the media-specific alternatives and indicates whether they have been screened out or retained for further evaluation.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 Introduction

The purpose of this section is to evaluate and compare sitewide RAAs to select an appropriate RAA. Section 1.0 of this AOA report described Necco Park and the nature and extent of contamination. In Section 2.0, RAOs for Necco Park were developed based on ARARs. Volumes and areas of media of concern were also identified in Section 2.0. Section 3.0 identified appropriate technologies for addressing constituents in the four media at Necco Park. Technologies retained from Section 3.0 were combined into RAAs for review and screening. Section 4.0 described development and evaluation of media-specific RAAs. Media-specific RAAs were screened based on degree to which they attain RAOs.

In this section, sitewide RAAs were developed based on the retained media-specific RAAs. Feasibility of the sitewide RAAs is examined in detail. This detailed analysis consists of the following components:

- Summary of current conditions at Necco Park
- Development and definition of each alternative with respect to volume, mass, or area of contaminated media; technologies to be implemented; and performance requirements associated with those technologies
- An assessment of each alternative based on seven of the evaluation criteria specified in NCP
- A comparative analysis of alternatives to assess relative performance

The summary of current conditions at the site is provided in Section 5.1.1 and provides the basis for comparing the RAAs. RAAs are developed and defined in Section 5.1.2. A description of each evaluation criteria and specific considerations for Necco Park are provided in Section 5.1.3. RAA evaluation criteria, as specified in NCP, are

- Overall protection of human health and environment.
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, and volume through treatment.

- Short-term effectiveness.
- Implementability.
- Cost.
- State acceptance.
- Community acceptance.

State and community acceptance were not evaluated at this stage because they are addressed during the public comment period. Finally, the comparative evaluation of alternatives is included in Section 5.3.

5.1.1 Summary of Current Conditions

Prior to conducting the detailed evaluation of RAAs, it is important to consider potential current risks, response actions taken to date, and technical difficulties in addressing RAOs developed for Necco Park. Based on current conditions, there are no risks to human health and environment. However, potential future risks have been identified if groundwater were to be used as drinking water. RAOs have been developed for the site which may be difficult, if not impossible, to achieve due to the presence of DNAPL in fractured bedrock, the potential impact of matrix diffusion, and limitations of existing technologies.

Based on ARARs identified for the site and considering potential exposure scenarios, the following RAOs were established (see Section 2.3):

- Restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination
- Control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality

Under current conditions, there are no risks to human health and environment caused by Necco Park (see Section 2.1). Groundwater does not pose a human health risk because it is not used for drinking-water purposes. Drinking water in the Niagara Falls area is provided by the local public utility, which draws water from the Niagara River upstream of Necco Park. It is unlikely that groundwater in the vicinity of Necco Park will be used for drinking water in the future because of the abundant surface-water supply and issues regarding aquifer yield and natural groundwater quality..

Potential adverse impacts to ecological receptors were also determined to be negligible. Groundwater concentrations would not be expected to adversely impact aquatic biota in the Niagara River considering potential pathways and dilution provided by the Niagara River. Additionally, a portion of the constituent loadings leaving the source area are collected by utility drains (NYPA drain conduits and the Falls Street tunnel). These utility drains act as groundwater sinks. A portion of the water in the NYPA conduit drains flows into the Falls Street tunnel. All water in the Falls Street tunnel is treated by the Niagara Falls POTW during dry weather conditions.

Based on the RAOs, four media were defined to develop and evaluate RAAs. Media-specific technologies and alternatives were developed and evaluated in Sections 3.0 and 4.0 for overburden, DNAPL, source area groundwater, and far-field groundwater. The sitewide RAAs include technologies to address each of these media.

DuPont has undertaken several response actions at Necco Park to protect human health and environment. Response actions to date have exceeded $40 million and include

- Capping the site to prevent contact with waste materials and minimize precipitation percolation through source material.
- Extraction of DNAPL from monitor and recovery wells.
- Installation of three groundwater recovery wells.
- Installation of a partial grout curtain to enhance groundwater recovery.
- Treatment of recovered groundwater at a commercial WWTP.

In addition to actions taken by DuPont, actions taken by the Niagara Falls POTW have reduced chemical loadings to the Niagara River. In 1987, the Four-Party Agreement was signed to reduce loadings of toxic chemicals by 50 percent to the Niagara River by 1996. At the time of the 1987 Four-Party Agreement, Falls Street tunnel discharge was the largest point-source contributor of six of 10 priority toxic chemicals. According to EPA and NYSDEC reports (EPA/NYSDEC 1994), total dry-weather discharge from

Falls Street tunnel was reduced by approximately 70 percent through rediversion of flow to the Niagara Falls POTW in 1989. Additionally, in June 1993, the city of Niagara Falls agreed to convey all residual dry-weather flow and the majority of storm event flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. This has resulted in treatment of an estimated 95 percent of Falls Street tunnel discharge. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

RAOs developed for Necco Park may be difficult, if not impossible, to achieve due to the presence of DNAPL in fractured bedrock, potential impacts of matrix diffusion, and limitations of existing technologies. In the source area, restoration is believed to be impossible to achieve due to the presence of DNAPL. There is currently no available technology to completely remove DNAPL from fractured bedrock. Therefore, DNAPL will act as a continuing source of source area groundwater contamination. In far-field groundwater, complete restoration to drinking water standards is uncertain. If matrix diffusion is occurring, full restoration of the far-field groundwater may be prevented, even under the most aggressive source containment and far-field alternatives, because the bedrock matrix may function as a secondary source of contamination in the far-field. The second RAO, control of source material to minimize direct exposure and impact on groundwater quality, may also be difficult to achieve because of the presence of DNAPL. Source control in a bedrock aquifer is problematic because of natural gravitational forces which affect DNAPL movement and difficulties in predicting and controlling flow through fracture zones.

5.1.2 RAA Description

Sections 5.1.2.1 through 5.1.2.13 describe in detail the 13 sitewide alternatives developed. A summary of components of each alternative is provided in Table 5-1.

5.1.2.1 Alternative 1

Alternative 1 consists of discontinuation of all existing response actions. Groundwater recovery from wells RW-1, RW-2, and RW-3 and all groundwater monitoring would be stopped. DNAPL extraction would be discontinued. The grout curtain and the clay cap would remain in place; however, maintenance of the cap would be discontinued. Access controls (fencing and security personnel) would continue to be maintained by CECOS. Utility drains would continue to intercept far-field groundwater. Natural attenuation of far-field groundwater would continue.

5.1.2.2 Alternative 2

Alternative 2 consists of continuation of present response activities at Necco Park. Groundwater recovery from wells RW-1, RW-2, and RW-3 would continue at a rate of approximately 20 gpm. Extracted groundwater would be treated at the CECOS WWTP and discharged to the POTW. Groundwater monitoring and the current DNAPL extraction program would continue. The grout curtain and cap would remain in place. The cap would continue to be maintained through mowing and repair of subsidence. Access controls (fencing and security personnel) would continue to be maintained by CECOS. Utility drains would continue to intercept far-field groundwater. Natural attenuation of far-field groundwater would continue.

5.1.2.3 Alternative 3

Alternative 3 would include an upgrade of the existing clay cap to comply with requirements of a NYS 360 (or equivalent) cap and additional DNAPL extraction through a dedicated recovery well. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.4 Alternative 4

Alternative 4 includes installation of a slurry wall in overburden along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal.

This alternative would also include an upgrade of the existing clay cap, as necessary, to comply with requirements of a NYS 360 (or equivalent) cap. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.5 Alternative 5

Alternative 5 consists of construction and operation of a DPE system on the 24-acre Necco Park site. The DPE system consists of extraction wells, pumps, piping, and vapor- and liquid-phase treatment to remove and destroy organic constituents. The DPE system would also provide a level of hydraulic control through removal of groundwater from A zone and upper bedrock zones.

A pilot test would be required to determine the most effective design for a DPE system. This alternative assumes that the DPE system would be in operation for approximately five years and that the system would be shut down during November through March.

Also included in this alternative is groundwater recovery from wells RW-1, RW-2, and RW-3, groundwater treatment at CECOS, and groundwater monitoring. During operation of the DPE system, groundwater recovery rates from wells RW-1 and RW-2 may be reduced or halted because the DPE system would recover groundwater from upper bedrock zones. Once DPE operation is complete, total recovery rate from wells RW-1, RW-2 and RW-3 would be approximately 20 gpm. The cap would be upgraded upon completion of the DPE system. The current DNAPL extraction program would continue. The existing grout curtain would remain in place. The cap would be maintained to ensure integrity. Access controls (fencing and security personnel) would continue to be maintained by CECOS. The utility drains would continue to intercept far-field groundwater. Natural attenuation of far-field groundwater would continue to occur.

5.1.2.6 Alternative 6

The goal of alternative 6 is to reduce constituent loading to the far field by 80 percent compared to alternative 1. Alternative 6 includes installation of additional recovery wells to increase groundwater recovery rate to achieve an 80 percent reduction in constituent loading to the far field compared to the no action alternative. The estimated total recovery rate to achieve an 80 percent reduction in constituent loading to the far field compared to the no action alternative is 70 gpm. Recovered groundwater would be treated at the CECOS WWTP and discharged to the POTW. In addition, a new, dedicated DNAPL extraction well would be installed.

The cap would be upgraded in this alternative through permeability testing and placement of additional low-permeability material, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.7 Alternative 7

In alternative 7, a slurry wall would be installed in overburden along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal. Alternative 7 includes an increase in groundwater recovery rate to achieve an 80 percent reduction in constituent loading to the far field compared to alternative 1. To increase groundwater recovery, additional recovery wells would be installed. The estimated recovery rate to achieve an 80 percent reduction in constituent loading to the far field compared to the nc action alternative is 70 gpm. Recovered groundwater would be treated at the CECOS WWTP and discharged to the POTW.

The cap would be upgraded in this alternative through permeability testing and the placement of additional low-permeability material, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.8 Alternative 8

Alternative 8 consists of construction and operation of a DPE system on the 24-acre Necco Park site. The DPE system consists of extraction wells, piping, and vapor- and liquid-phase treatment. The DPE system would remove groundwater from A zone and upper bedrock zones. This alternative also includes an increase in groundwater recovery rates to achieve an 80 percent reduction in constituent loading to the far field compared to the no action alternative. To increase groundwater recovery, additional recovery wells would be installed. The estimated recovery rate to achieve an 80 percent reduction in constituent loading to the far field compared to the no action alternative is 70 gpm. Recovered groundwater would be treated at the CECOS WWTP and discharged to the POTW.

A pilot test would be required to determine the most effective design for a DPE system. This alternative assumes that the DPE system would be in operation for approximately five years and that the system would be shut down during November through March.

The cap would be upgraded upon completion of the DPE system, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.9 Alternative 9

Alternative 9 consists of completion of a grout curtain tied into the existing SFR, around the source area, extending from B through F zones (approximately 80 feet deep). Groundwater would be recovered in B through F zones to maintain an inward hydraulic gradient across the curtain. Estimated flow rate to achieve an inward hydraulic gradient in B through F zones in the source area is approximately 65 gpm. Extracted groundwater would be treated at the CECOS WWTP and discharged to the POTW.

In this alternative, a slurry wall would be installed in overburden along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal.

Groundwater extraction from inside the grout curtain and slurry wall would result in total hydraulic control of source area groundwater in A through F zones.

The cap would be upgraded in this alternative, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.10 Alternative 10

Alternative 10 consists of groundwater extraction from wells RW-1, RW-2, and RW-3 as well as additional extraction to achieve total hydraulic control of A through F zones in the source area. Approximate pumping rate required to create a complete hydraulic barrier in A through F zones in the source area is approximately 155 gpm.

In this alternative, a slurry wall would be installed along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal.

Groundwater extraction from B through F zones and overburden groundwater recovery would result in total hydraulic control of source area groundwater in A through F zones.

The cap would be upgraded in this alternative, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.11 Alternative 11

Alternative 11 consists of construction and operation of a DPE system on the 24-acre Necco Park site. The DPE system consists of extraction wells, pumps, controls, piping, and vapor- and liquid-phase treatment. The DPE system would remove groundwater from A zone and upper bedrock zones. This alternative includes an increase in groundwater recovery rates to achieve total control of source area groundwater in A through F zones. Estimated recovery rate to achieve total hydraulic control in the source area is approximately 160 gpm. Recovered groundwater would be treated at CECOS and discharged to the POTW. The CECOS WWTP has an available capacity of 110 gpm and would require expansion to treat an additional 50 gpm.

A pilot test would be required to determine the most effective design for a DPE system. This alternative assumes that the DPE system would be in operation for approximately five years and that the system would be shut down during November through March.

The cap would be upgraded upon completion of the DPE system, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.12 Alternative 12

Alternative 12 consists of completion of a grout curtain tied into the existing SFR, around the source area, extending from the B through G zones (approximately 160 feet deep). A total pumping rate of approximately 70 gpm would be necessary to maintain an inward hydraulic gradient in B through G zones within the source area. Extracted groundwater would be treated at the CECOS WWTP and discharged to the POTW.

In this alternative, a slurry wall would be installed in overburden along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal.

Groundwater extraction from inside the grout curtain and slurry wall would result in total hydraulic control of source area groundwater in A through G zones. The cap would be upgraded in this alternative, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.2.13 Alternative 13

Alternative 13 consists of completion of a grout curtain around the source area, from B through F zones (approximately 80 feet deep). The grout curtain would be tied into the existing SFR. Groundwater would be recovered in B through F zones to maintain an inward hydraulic gradient. Estimated flow rate needed to achieve an inward hydraulic gradient is approximately 65 gpm. Extracted groundwater would be treated at the CECOS WWTP and discharged to the POTW.

In this alternative, a slurry wall would also be installed along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal.

The goal of groundwater extraction from inside the grout curtain and slurry wall would be total hydraulic control of source area groundwater in A through F zones.

Groundwater would also be pumped from the far field in an effort to intercept and remove 100 percent of groundwater constituents from the Necco Park area prior to entering the NYPA conduit system. Approximately 400 gpm would be extracted in the far field to attempt to intercept 100 percent of the far-field groundwater. This water would be treated at the POTW.

The cap would be upgraded in this alternative, as necessary. Also included in this alternative is the continued O&M of existing systems described in Section 5.1.2.2.

5.1.3 Evaluation Criteria

Each of the retained RAAs has been assessed against seven of the nine NCP criteria. The remaining two criteria, state and community acceptance, will be addressed as part of the AOA review process. The seven evaluation criteria identify key differences among the alternatives and provide sufficient information to select an appropriate response for the site. The criteria account for technical, cost, institutional, and risk concerns. Descriptions of each criterion is provided in the following subsections.

5.1.3.1 Overall Protection of Human Health and Environment

This criterion is used to assess the reduction of risk provided by each RAA. This evaluation is a primary criterion for selection of a RAA. Evaluation of overall protectiveness focuses on how a specific alternative achieves protection over time, how risks are reduced or controlled, and risks to human health and environment remaining after completion of response activities.

5.1.3.2 Compliance with ARARs

This criterion examined the ability of a RAA to meet site ARARs and achieve RAOs. The following RAOs were developed (see Section 2.0):

- Restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination
- Control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality

RAOs developed for Necco Park may be difficult, if not impossible, to achieve due to the presence of DNAPL in fractured bedrock, potential impacts of matrix diffusion, and limitations of existing technologies. In the source area, restoration is believed to be impossible to achieve due to the presence of DNAPL. There is currently no available technology to completely remove DNAPL from fractured bedrock. Therefore, DNAPL will act as a continuing source of source area groundwater contamination. In far-field groundwater, complete restoration to drinking water standards is uncertain. If matrix diffusion is occurring, full restoration of the far-field groundwater may be prevented, even under the most aggressive source containment and far-field alternative, because the bedrock matrix may function as a secondary source of contamination in the far-field. The second RAO, control of source material to minimize direct exposure and impact on groundwater quality, may also be difficult to achieve because of the presence of DNAPL. Source control in a bedrock aquifer is problematic because of natural gravitational forces which affect DNAPL movement and difficulties in predicting and controlling flow through fracture zones.

Attainable points of compliance with ARARs and the use and significance of areas or volumes in which target goals are not attained are evaluated under this criteria. A summary table of each alternative and its ability to meet each of the ARARs is provided in Table 5-2.

5.1.3.3 Long-term Effectiveness and Permanence

The long-term effectiveness of an alternative has been evaluated on the basis of its ability to

- Achieve a permanent solution.
- Minimize long-term maintenance requirements.
- Minimize potential for exposure to any untreated or remaining material or treatment residuals at the conclusion of response activities.

This evaluation primarily focuses on the magnitude of remaining risks and adequacy and reliability of control measures required to manage those risks. A solution that achieves significant long-term or permanent risk reduction is highly rated in this category.

5.1.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

This criterion addresses the statutory preference for response actions that permanently and significantly reduce toxicity, mobility, and volume through treatment of hazardous materials. This statutory preference is satisfied when treatment is used to destroy constituents, reduce the total mass or volume through treatment of constituents, and/or irreversibly reduce constituent mobility. This criterion focuses on the amount of hazardous material destroyed or removed from the environment, quantity of treatment residuals, and risk reduction resulting from response actions.

5.1.3.5 Short-term Effectiveness

Short-term effectiveness considers risks to human health and environment during construction and implementation phases of the response action. Specifically, this criterion examines potential adverse health effects on workers, surrounding community, and other impacted persons, as well as potential environmental impact that could result from implementing the response action. Short-term effectiveness also evaluates time aspects of the response action. Implementation time (time required to design, permit, and construct), risk mitigation time (time projected to reach human health protective levels), time needed to achieve protection of human health and environment, and time needed to attain ARARs are all evaluated.

5.1.3.6 Implementability

Implementability considers technical and administrative feasibility of implementing the alternative and availability of services, materials, and equipment required to implement the alternative.

Technical feasibility includes an evaluation of construction and operation difficulties and unknowns, reliability of technologies employed to meet projected performance levels and schedules, ease of undertaking the response action, ability to monitor response action effectiveness, and probability that future response actions will be necessary.

Administrative feasibility considers activities required to coordinate response actions with pertinent regulatory agencies. Regulatory acceptance of an alternative eases response implementation. Therefore, regulatory acceptance of the alternative will greatly impact implementability. This is most prominent in an alternative's need for environmental and construction permits. The role of legal constraints, the need for right-of-ways, and impact on neighboring property are also administrative implementability issues that are evaluated. Availability of service and materials, skilled labor, off-site facilities, and commercial technologies are also examined.

5.1.3.7 Cost

This criterion is used to evaluate capital cost, annual O&M costs, and present worth of the alternative. Capital and O&M cost estimates have projected accuracy of plus 50 and minus 30 percent (EPA 1988).

Capital costs include direct expenditures for equipment, labor, material, site work, and land purchase necessary to implement response actions, as well as indirect costs related to engineering, financial and legal services, permit applications, startup and shakedown, and contingency allowances.

Annual O&M costs include postconstruction costs necessary to ensure continued operational effectiveness of a response action. These costs will include labor, maintenance, materials, residual waste management, treatment residuals management, energy, administration, insurance, continuing engineering, sampling, analytical expenditures, and regulatory review and interface.

A present-worth analysis has been used to evaluate expenditures that occur over different time periods. For most alternatives, the time period used for this calculation is 30 years. This analysis will be conducted by discounting all future costs to the current year using a 7 percent discount rate as required by EPA. This analysis will allow the cost of RAAs to be compared on the basis of single-dollar figures, representing the amount of money needed in year zero to finance estimated costs associated with the response action over its planned life.

5.1.3.8 State Acceptance

This criterion will be used to evaluate technical and administrative issues and concerns that NYSDEC may have regarding the RAA. This criteria will be addressed during the AOA review process.

5.1.3.9 Community Acceptance

This criterion incorporates public comments into the evaluation of the RAA. Public concerns and comments regarding the AOA report will be considered by EPA during the response action selection process.

5.1.4 Comparative Evaluation of Alternatives

The comparative analysis consists of a discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each of the first seven criterion. Quantitative and qualitative differences of alternatives are presented.

5.1.5 Analysis of RAAs Using Estimated Constituent Transport Rates

Estimation of constituent transport rates over a boundary is a useful tool with which to evaluate the effectiveness of individual RAAs and to compare alternatives. In the past, off-site loading rates for Necco Park have been estimated using several methods (WCC 1991; 1993).

For the purposes of the Necco Park AOA, a method for estimating potential constituent transport rates out of the source area was developed. Constituent transport rates were calculated in a manner similar to those used during previous investigations at Necco Park. A description of the loadings estimation method developed for this study is presented in Appendix A.

5.2 Detailed Evaluation Of Alternatives

5.2.1 Alternative 1

5.2.1.1 Description

Evaluation of a no action alternative is required by NCP. The objective of alternative 1 is to create a baseline with which to compare all other RAAs. Alternative 1 consists of the discontinuation of all existing response actions. Groundwater recovery from wells RW-1, RW-2, and RW-3 and all groundwater monitoring would be stopped. DNAPL recovery would be discontinued. The grout curtain and cap would remain in place; however, maintenance of the cap would be discontinued. Access controls would continue to be implemented by CECOS, regardless of the activities associated with Necco Park. Maintenance of the existing cap would be discontinued under this alternative. The cap consists of approximately 2 feet of clay with an approximate permeability of 1×10^{-7} cm/s. The cap reduces the amount of precipitation that percolates through source materials at Necco Park, preventing contamination of water and minimizing the potential for contamination in soil to migrate. The cap also prevents direct contact with source material.

Without maintenance, deep-rooted vegetation such as trees and shrubs may begin to grow on the cap. Deep roots could create secondary pathways for precipitation to percolate through contaminated soil and increase potential for constituent migration. Subsidence of the cap may create pools or puddles of water, thereby increasing percolation rate. This water may also percolate through source material and become contaminated.

5.2.1.2 Overall Protection of Human Health and Environment

The existing clay cap greatly reduces potential for human contact with source material. Direct human exposure to DNAPL is unlikely because of its subsurface location. Future groundwater uses are expected to be limited because there is an abundant existing public drinking-water source, and natural groundwater quality issues regarding the presence of high levels of salinity and sulfur.

Under alternative 1, all current pumping of recovery wells would cease. This would result in increased constituent loading to the far field compared to existing conditions. Groundwater modeling has been conducted to estimate constituent loading for comparison purposes for the no action alternative. Modeling has predicted the following results:

- No loading for overburden (A zone)
- 8.8 lbs/day loading for upper zones (B and C zones)
- 12.8 lbs/day loading for middle zones (D through F zones)
- 1.0 lbs/day loading for lower zone (G zone)
- Total constituent loading to the far field of approximately 22.6 lbs/day

Initially, the clay cap would continue to be an effective barrier against contact with contaminated soil. However, over an extended period of time, lack of maintenance may allow portions of the cap to deteriorate, potentially creating a pathway for contact with contaminated overburden materials. This would result in an increase in precipitation percolation, which could increase constituent mobility. Also, an increase in volatilization of organic vapors may occur.

Potential for direct exposure to DNAPL is low because of its subsurface location. DNAPL would continue to act as a continuing source of source area and far-field groundwater contamination.

5.2.1.3 Compliance with ARARs

Table 5-2 lists the potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to the no action alternative. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by the NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. Actions taken to control discharge from Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW. However, under Alternative 1, no actions would be taken and no groundwater pumping would occur at Necco Park. Therefore, loadings to the far-field would increase, potentially exceeding the 50 percent target reduction goal.

Under alternative 1, target response goals will not be met in either the source area or far-field groundwater area. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the continued presence of DNAPL and waste materials, which will act as continuing sources of groundwater contamination. However, because of complexities inherent in a fractured bedrock environment, no proven methods currently exist for complete DNAPL remediation. Therefore, achievement of target goals in the source area is not technically feasible.

Alternative 1 will result in an increase in organic loading to B and C zone far-field groundwater compared to existing conditions. Higher loadings will further increase aqueous concentrations in the far field, which are currently above target goals. Therefore, for alternative 1, the first RAO will not be met in the far field.

Under alternative 1, the second RAO will not be achieved. DNAPL will continue to act as a source of groundwater contamination in the source area and far field. As the cap loses integrity over time, constituents may contribute further chemical loadings to the lower water-bearing zones as an increased volume of precipitation percolates through source materials.

New York Rules for Inactive Hazardous Waste Disposal Sites (6 NYCRR, Part 375), the Coastal Zone Management Act, and New York Solid Waste Regulations (6 NYCRR, Part 360) would not be met under alternative 1. The soil cleanup levels specified in New York TAGM 4046, a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible.

Alternative 1 will comply with remaining ARARs.

5.2.1.4 Long-term Effectiveness and Permanence

Discontinuation of groundwater recovery would increase the mass of constituents migrating to the far-field in all bedrock zones, degrading source area and downgradient groundwater quality to the south and west of Necco Park.

Without maintenance, deep-rooted vegetation may begin to grow on the cap, creating secondary pathways for precipitation to migrate through source material and reducing cap effectiveness. Additional percolation may also increase potential for constituents to become mobilized. Over an extended period of time, lack of maintenance may result in some of the cap eroding and may create a pathway for human contact with waste material and volatilization of organic vapors.

5.2.1.5 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 1 will not reduce toxicity, mobility, or volume of contamination through treatment. Mobility of constituents in groundwater may increase with the discontinuation of groundwater recovery. Although the total mass of contamination will not be changed, the volume of contaminated media may increase as constituent migration in groundwater increases and increased volumes of precipitation percolate through the cap as it degrades. In addition, cap degradation may increase the mobility of organic vapors.

5.2.1.6 Short-term Effectiveness

Short-term effectiveness evaluates impacts on human health and environment during implementation of this alternative. Alternative 1 requires no implementation; therefore, this alternative will have no adverse short-term effects.

5.2.1.7 Implementability

By its nature, alternative 1 would be easy to implement. Operation of groundwater recovery equipment and all other remediation activities could be easily discontinued.

5.2.1.8 Cost

Negligible costs are associated with the alternative 1 and are presumed to be zero for comparison purposes.

5.2.2 Alternative 2

5.2.2.1 Description

Objectives of alternative 2 are to reduce constituent loading to the far field, minimize precipitation percolation through source material, prevent contact with constituents, and reduce the volume of DNAPL. Alternative 2 includes the following technologies (see Table 5-1):

- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Maintenance of the existing cap
- Groundwater monitoring
- DNAPL recovery
- Continuing existing access controls
- Far-field groundwater interception by utility drains
- Natural attenuation of far-field groundwater

Under this alternative, the annual average groundwater recovery rate using wells RW-1, RW-2, and RW-3 would continue to be approximately 20 gpm. Recovered groundwater would continue to be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal at CECOS to meet the POTW discharge requirements. Discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries and residents.

This alternative includes continued use of the existing grout curtain. The purpose of the existing grout curtain is to provide a physical barrier to off-site groundwater flow. The existing grout curtain appears to enhance the cones of depression created by pumping of recovery wells and appears to increase hydraulic control of groundwater flow and constituent migration from Necco Park in B and C zones.

Maintenance of the existing cap is included in this alternative. The cap consists of approximately 2 feet of clay with an approximate permeability of 1×10^{-7} cm/s (see Appendix D). The cap reduces the amount of precipitation that percolates through the fill materials, preventing potential contamination of surface runoff and minimizing the potential for contamination in soil to migrate. The cap also prevents potential direct contact with waste material. Maintenance activities, including mowing and cap repairs, would continue. Mowing prevents the growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay, topsoiling, and seeding.

Groundwater monitoring would be continued for this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. A small number of existing groundwater monitor wells would also be periodically sampled to monitor the effectiveness of the alternative. Thirty-eight perimeter and off-site monitor wells are currently sampled and tested to monitor the extent of groundwater contamination. This monitoring program is sufficient to delineate the extent of contamination within B and C zones. The program demonstrates general extent of contamination in middle and lower zones and provides data regarding trends in contaminant concentrations.

DNAPL recovery operations would be continued in this alternative. DNAPL that is recovered will be treated at an off-site facility.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

Far-field groundwater in the D through G zones would continue to be intercepted by the NYPA conduit drains while a portion of the B and C zones would be intercepted by the Falls Street tunnel. Natural attenuation would continue to reduce constituent concentrations.

5.2.2.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to the no action alternative, alternative 2 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area.

Groundwater modeling has been conducted to estimate constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 12.3 lbs/day for the middle zones (D through F zones)
- 1.0 lbs/day for the lower zone (G zone)
- A total constituent loading reduction to the far field of approximately 40 percent compared to alternative 1

The clay cap would continue to be an effective barrier against contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the existing clay cap. The continued presence of access controls would also limit potential for human exposure to constituents.

Alternative 2 is anticipated to have modest impact on DNAPL migration until source material becomes depleted. However, continuing the DNAPL recovery program will have some influence on reducing the total volume of DNAPL at Necco Park. Potential for direct exposure to DNAPL is low because of its subsurface location. DNAPL would act as a continuing source of far-field groundwater contamination.

5.2.2.3 Compliance with ARARs

Table 5-2 lists potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 2. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by the NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in the B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the source area or far-field groundwater areas. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of DNAPL and waste material that will act as a continuing source of groundwater contamination. However, no proven methods currently exist for complete DNAPL removal. Therefore, achievement of target goals in the source area is not technically feasible for this alternative or any other described in this AOA.

As stated in Section 5.2.2.2, alternative 2 will reduce constituent loading to the far field by approximately 40 percent compared to alternative 1 based on the model used to compare RAAs. However, this reduction will not be enough to reduce all constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Constituent loading to the far field will be reduced by approximately 40 percent.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

Alternative 2 will comply with the remaining specified ARARs.

5.2.2.4 Long-term Effectiveness and Permanence

Alternative 2 reduces the mass of constituents that migrate to the far field, thereby improving downgradient groundwater quality. Groundwater modeling has estimated a 40 percent reduction in constituent loading to the far field compared to the no action alternative. Currently, no risk exists because exposure to groundwater and source material does not occur. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically, potentially allowing some temporary constituent migration.

When wells RW-1 and RW-2 are operating at their optimal pumping rates, an area of influence across a majority of the southern perimeter of the Necco Park property in the B and C bedrock zones is observed. Grout curtain installation along the north perimeter of Necco Park has reduced the volume of groundwater entering Necco Park. The conceptual cones of depression associated with groundwater recovery wells appear to have been enhanced, and hydraulic control of groundwater flow from Necco Park in B and C zones appears to have been improved. Well RW-3 extracts groundwater from D, E, and F zones.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

Clay caps are a widely used and accepted method for landfill/waste disposal area closure. The clay cap is a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. Clay used for the cap is a chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the clay cap are relatively minor. The vegetative layer must be mowed regularly to prevent growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.2.5 Reduction of Toxicity, Mobility, and Volume through Treatment

Groundwater recovery and treatment is a commonly used remediation technology for reducing mobility and volume through treatment of aqueous contamination. Data from seven of nine monitor well downgradient of the wells RW-1 and RW-2 conceptual capture zones demonstrate that groundwater recovery in the B and

C zones has been effective in reducing far-field migration of dissolved contamination. As previously stated, groundwater modeling estimates that this alternative will reduce constituent loading to the far field by 40 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. However, a portion of far-field groundwater is intercepted by the utility drains and treated at the POTW. Groundwater treatment at the CECOS WWTP reduces the toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field.

DNAPL recovery reduces the volume of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. Off-site thermal treatment of recovered DNAPL reduces constituent toxicity. Remaining DNAPL, until depleted, would continue to have potential to migrate horizontally and vertically.

5.2.2.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Because the existing systems alternative requires no additional construction, this alternative will not have any adverse short-term effects.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE will be used to minimize exposure.

5.2.2.7 Implementability

Alternative 2 includes continuation of the O&M of existing remedial activities. This alternative would be easily implemented.

5.2.2.8 Cost

Detailed cost components are itemized in Appendix E and summarized in the following paragraphs:

- Construction—$0.3 million
- Annual O&M— $1.7 million
- Present worth (30 years, 7 percent)—$20.9 million

Construction cost consists of contribution by DuPont to a capital upgrade of the CECOS WWTP. O&M cost consists of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.3 Alternative 3

5.2.3.1 Description

Objectives of alternative 3 are to minimize precipitation percolation through source material, reduce the volume of DNAPL, reduce constituent loading to the far field, and prevent contact with constituents. Alternative 3 includes the following technologies (see Table 5-1):

- Cap upgrade
- DNAPL recovery
- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring

- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through waste materials, preventing potential contamination of this water and minimizing potential for constituents in soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden waste material.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents the growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs would be conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay.

An additional DNAPL extraction well would be installed in overburden in the southern corner of the 24-acre facility. This well, in addition to the existing monitor and recovery wells, would be monitored regularly. DNAPL will be extracted and thermally treated at an off-site commercial facility.

Under this alternative, the annual average groundwater recovery rate using wells RW-1, RW-2, and RW-3 would continue to be approximately 20 gpm. Recovered groundwater would continue to be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal at CECOS. The discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is a advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries and residents.

This alternative includes continued use of the existing grout curtain. The purpose of the existing grout curtain is to enhance cones of depression created by pumping of recovery wells and increase hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued for this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of the far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.3.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. Caps minimize potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to the no action alternative, alternative 3 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area, but would be no more effective than alternative 2 (existing systems) in reducing contaminant loading to the far field. Groundwater modeling has been conducted to determine the reduction in constituent loading to the far field. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 12.3 lbs/day for middle zones (D through F zones)
- 1.0 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 40 percent compared to alternative 1

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing cap in preventing contact with constituents or in reducing contaminant loading to the far field. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

Alternative 3 is anticipated to have modest impact on DNAPL migration until the DNAPL source is depleted. However, the additional DNAPL recovery well will have some influence on reducing the total volume of DNAPL at Necco Park. The potential for direct exposure to DNAPL is low because of its subsurface location. DNAPL would act as a continuing source of source area groundwater contamination despite the dedicated recovery well.

5.2.3.3 Compliance with ARARs

Table 5-2 lists potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 3. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the source area or far field. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of DNAPL, which will act as a continuing source of groundwater contamination. However, no proven methods currently exist for complete DNAPL removal. Therefore, achievement of target goals in the source area is not technically feasible for this alternative or any other in this AOA.

As stated in Section 5.2.3.2, alternative 3 will reduce constituent loading to the far field by approximately 40 percent compared to no action. The loading reduction is essentially the same as the loading reduction in alternative 2.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Constituent loading to the far field will be reduced by approximately 40 percent.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

Alternative 3 will comply with remaining specified ARARs.

5.2.3.4 Long-term Effectiveness and Permanence

The long-term effectiveness of alternative 3 is not significantly different than alternative 2. Both alternatives have similar effectiveness in reducing constituent loading to the far field.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. Clay used for the cap is a chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

Alternative 3 reduces the mass of constituents that migrate to the far field, thereby improving downgradient groundwater quality. Groundwater modeling has estimated a 40 percent reduction in constituent loading to the far field compared to the no action alternative. Currently, no risk exists because exposure to groundwater and source material does not occur.

The volume of DNAPL extracted from the new, dedicated DNAPL well in addition to existing wells cannot be predicted because DNAPL migration in fractured bedrock systems is complex. Once DNAPL is extracted, thermal destruction of DNAPL constituents is permanent.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

5.2.3.5 Reduction of Toxicity, Mobility, and Volume through Treatment

DNAPL recovery reduces the volume, mobility, and toxicity of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. The purpose of an additional DNAPL recovery well would be to increase the volume of DNAPL that is removed from the environment. Off-site thermal treatment of recovered DNAPL reduces constituent toxicity.

Groundwater recovery and treatment is a commonly used remediation technology for reducing mobility and volume through treatment of aqueous contamination. As previously stated, groundwater modeling indicates that this alternative will reduce constituent loading to the far field by 40 percent relative to the no action alternative. A portion of the contaminated groundwater migrating to the far field is intercepted by the utility drains and treated at the Niagara Falls POTW. Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field in response to this source reduction.

5.2.3.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Upgrading the cap may have negative short-term effects as overburden is excavated and volatile constituents are released into the air. Disturbance of overburden under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Installing a DNAPL extraction well may have negative short-term impacts on human health and environment. During excavation and stockpiling of overburden material, organic constituents may volatilize into the air. Workers can use respiratory protection and PPE to avoid exposure. Additionally, drilling through overburden may create a local, short-term route for contamination migration to bedrock. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Site and RCRA Facilities—Update* states,

> "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.3.7 Implementability

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications will be determined during design activities.

Construction of an additional DNAPL extraction well is implementable with appropriate precautions and engineering controls to minimize short-term risks.

5.2.3.8 Cost

Costs for alternative 3 are summarized as follows:

- Construction—$2.8 million
- Annual O&M— $1.7 million
- Present worth (30 years, 7 percent)—$23.5 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs. Construction cost includes the cost of installing a DNAPL extraction well and upgrading the cap. The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring

- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.4 Alternative 4

5.2.4.1 Description

Objectives of alternative 4 are to minimize horizontal migration of constituents in A zone, minimize precipitation percolation through source material, reduce the volume of DNAPL, reduce constituent loading to the far field, and prevent contact with constituents. Alternative 4 includes the following technologies (see Table 5-1):

- Downgradient slurry wall
- Leachate recovery from overburden wells
- DNAPL recovery
- Cap upgrade
- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

This alternative includes installation of an overburden slurry wall along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. The primary goal of an overburden slurry wall is to minimize potential DNAPL migration in A zone. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collected in points for DNAPL removal. The rate of groundwater extraction required to prevent mounding is estimated to be less than 5 gpm. Extracted groundwater would be treated at the CECOS WWTP.

Overburden collection wells would also function as collection points for DNAPL extraction. The new overburden collection wells, in addition to existing monitor and recovery wells, would be monitored regularly. DNAPL that accumulates in these wells would be extracted and thermally treated at an off-site incinerator.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1×10^{-7} cm/s or less. If sections of the cap do not meet permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through waste materials, preventing potential contamination of this water and minimizing potential for constituents in soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing depressions with new clay.

Under this alternative, the annual average groundwater recovery rate using wells RW-1, RW-2, and RW-3 would continue to be approximately 20 gpm. Recovered groundwater would continue to be pumped through aboveground piping to the CECOS WWTP. Groundwater would include organic and inorganic constituent removal at CECOS and subsequent discharge to the POTW. The discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries and residents.

This alternative includes continued use of the existing grout curtain. The purpose of the existing grout curtain is to enhance cones of depression created by pumping of recovery wells and increase hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued under this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of the far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.4.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. Caps minimize potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

The downgradient slurry wall prevents horizontal DNAPL migration and source area groundwater in A zone. However, the primary route for DNAPL and groundwater migration is downward. The slurry wall would have no impact on limiting vertical DNAPL migration.

Additional DNAPL recovery from overburden leachate collection wells may have some effect on reducing the total volume of DNAPL at Necco Park. The potential for direct exposure to DNAPL is extremely low because of its subsurface location. DNAPL would act as a continuing source of source area groundwater contamination.

Compared to alternative 1, alternative 4 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area, but would be no more effective than alternative 2 (existing systems) in reducing contaminant loadings to the far field. Groundwater modeling has been conducted to determine constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 12.3 lbs/day for middle zones (D through F zones)
- 1.0 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 40 percent compared to alternative 1

The upgraded cap would be an effective barrier against contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.4.3 Compliance with ARARs

Table 5-2 lists potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 4. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by the NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both of the DuPont response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the source area or far field. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of source material, which will act as a continuing source of groundwater contamination. However, no proven methods currently exist for complete DNAPL remediation. Therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.4.2, alternative 4 will reduce constituent loading to the far field by approximately 40 percent based on the model used to compare RAAs. However, this reduction will not be enough to reduce all constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Constituent loading to the far field will be reduced by 40 percent.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

Alternative 4 will comply with the remaining specified ARARs.

5.2.4.4 Long-term Effectiveness and Permanence

The slurry wall would prevent horizontal DNAPL migration. However, the primary route of DNAPL migration is downward. The slurry wall would have no impact on preventing downward DNAPL migration.

The long-term stability of some slurry wall materials in contact with high organic concentrations has not been demonstrated. Experiments have shown that permeability of bentonite increases when exposed to high concentrations of organics such as TCE. However, slurry wall construction materials such as attapulgite may be substituted. Compatibility studies during remedial design may be required to determine appropriate slurry wall materials.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. However, the upgraded cap would not be more effective than the existing cap in preventing contact with source material. Clay used for the cap is chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

Alternative 4 reduces the mass of constituents that migrate to the far field, thereby improving downgradient groundwater quality. Groundwater modeling has estimated a 40 percent reduction in constituent loading to the far field compared to the no action alternative. Currently, no risk exists because exposure to groundwater and source material does not occur.

The volume of DNAPL extracted from leachate collection wells in addition to the existing wells cannot be predicted because DNAPL migration in the subsurface is complex. Once DNAPL is extracted, thermal destruction of DNAPL constituents is permanent.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, Alternative 5 reduces the mass of constituents that migrate to the far field, thereby improving downgradient groundwater quality. Groundwater modeling has estimated a 40 percent reduction in constituent loading to the far field compared to the no action alternative. Currently, no risk exists because exposure to groundwater and source material does not occur.

This alternative relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

5.2.5.5 Reduction of Toxicity, Mobility, and Volume through Treatment

The DPE system would reduce toxicity, mobility and volume of constituents in overburden and upper bedrock zones through treatment. The volume of constituents is reduced as liquid-, vapor-, and aqueous-phase constituents are withdrawn by the high vacuum. The quantity of DNAPL removed cannot be determined without additional data. DNAPL and aqueous-phase constituent mobility is also reduced by the DPE system as a result of the pressure differential. As constituents are treated by thermal oxidation, CECOS WWTP, and off-site incineration, toxicity is reduced.

Groundwater recovery and treatment is a commonly used remediation technology for reducing mobility and volume through treatment of aqueous contamination. As previously stated, groundwater modeling indicates that this alternative will reduce constituent loading to the far field by 40 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW. Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field in response to this reduced source.

5.2.5.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Installing a DPE system would require drilling of up to 100 to 300 overburden and upper bedrock wells. During drilling, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility.

Additionally, excavating through overburden may create a localized, short-term route for constituent or DNAPL migration to bedrock. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Site and RCRA Facilities—Update* states,

> "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

Upgrading the cap may have negative short-term effects as overburden is excavated and volatile constituents are released into the air. Disturbance of overburden under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.5.7 Implementability

Alternative 5 is implementable. As previously stated, drilling overburden wells may create organic vapors that would require monitoring and possibly control.

Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Bench- and pilot-scale treatability studies would be required to determine effectiveness and operating parameters of a full-scale DPE system. A DPE system would require power upgrades and the addition of a water supply at the facility to operate. Necco Park uses power supplied from BFI to operate existing recovery wells; however, available power is insufficient for a full-scale DPE system. Therefore utilities would have to be installed prior to DPE system operation.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications would be determined during design activities.

5.2.5.8 Cost

Costs for alternative 5 are summarized as follows:

- Construction—$6.5 million
- Annual O&M— $2.6 million
- Present worth (30 years, 7 percent)—$32.1 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs.

Construction cost includes the cost of installing a DPE system, on-site disposal of spoils, and upgrading the cap. The DPE system consists of extraction wells, vacuum pumps, piping, condenser, liquid tank, thermal oxidizer with scrubber, controls, and a building. A pilot study is also included in the DPE system cost.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- DPE system O&M
- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.6 Alternative 6

5.2.6.1 Description

Objectives of this alternative are to reduce constituent loading to the far field by 80 percent compared to the no action alternative, minimize precipitation percolation through contaminated soil, prevent contact with constituents, and reduce the volume of DNAPL. Alternative 6 includes the following technologies (see Table 5-1):

- Groundwater recovery by new wells in D through F zones
- Additional DNAPL recovery
- Cap upgrade

- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

Under this alternative, total groundwater recovery rate would be increased by pumping from new recovery wells and the three existing recovery wells, RW-1, RW-2, and RW-3. The actual number and locations of wells would be determined during the design phase of this project.

The groundwater recovery rate for this alternative is estimated to be approximately 70 gpm. Groundwater would be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal at CECOS to meet POTW discharge requirements. The discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet the permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through the waste materials, preventing potential contamination of this water and minimizing potential for constituents in soil to migrate. The upgraded cap would prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents the growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay.

This alternative includes continued use of the existing grout curtain. The purpose of the existing grout curtain is to enhance cones of depression created by pumping of recovery wells and increase hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued for this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

An additional DNAPL extraction well would be installed in overburden in the southern corner of the 24-acre facility. This well, in addition to the existing monitor and recovery wells, would be regularly monitored. DNAPL will be extracted and thermally treated at a commercial facility.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and CECOS/BFI personnel monitoring the only access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.6.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to alternative 1, alternative 6 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area. Groundwater modeling has been conducted to determine constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 2.85 lbs/day for middle zones (D through F zones)
- 1.0 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 80 percent compared to alternative 1

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing cap in preventing contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.6.3 Compliance with ARARs

Table 5-2 lists the potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 6. The following paragraphs summarize key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in the treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the near or far-field groundwater areas. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, would not be met in the source area as a result of the presence of DNAPL, which will act as a continuing source of groundwater contamination. However, no proven methods exist for complete DNAPL removal; therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.6.2, modeling has indicated enhanced hydraulic control will reduce constituent loadings to the far field by approximately 80 percent compared to the no action alternative. However, this reduction will not be enough to reduce all constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Modeling has indicated that constituent loading to the far field will be reduced by approximately 80 percent compared to the no action alternative.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate remedial actions.

Alternative 6 will comply with the remaining specified ARARs.

5.2.6.4 Long-term Effectiveness and Permanence

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically. However, a short-term shutdown would not significantly increase constituent loading to the far field.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

The volume of DNAPL extracted from the new DNAPL well and the existing wells cannot be predicted because DNAPL migration in fractured bedrock is complex. Once DNAPL is extracted, thermal destruction of DNAPL constituents is permanent.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. The clay used for the cap is a chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. The maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent the growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.6.5 Reduction of Toxicity, Mobility, and Volume through Treatment

Groundwater recovery and treatment is a commonly used remediation technology for reducing toxicity, mobility, and volume of aqueous constituents. As previously stated, groundwater modeling indicates that the additional hydraulic control alternative will reduce constituent loading to the far field by 80 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW.

Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field in response to this reduced source.

DNAPL recovery reduces the volume of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. The additional DNAPL recovery well would increase the volume of DNAPL that is removed from the environment. Off-site thermal treatment of recovered DNAPL reduces constituent toxicity. The remaining DNAPL would continue to have potential to migrate horizontally and vertically.

The upgraded cap would reduce migration of overburden constituents by minimizing precipitation percolation through overburden.

5.2.6.6 Short-term Effectiveness

Alternative 6 can be designed and installed in a relatively short period of time, approximately two to three years. The CECOS WWTP has excess available capacity and, therefore, major upgrades of the plant will not be required. After startup of the new system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air. Disturbing overburden material under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.6.7 Implementability

Excess capacity is available at the CECOS WWTP for implementation of this alternative. However, the flow rate exceeds the DuPont present contract amount and would require contract renegotiation. Additional recovery wells and associated piping required for this alternative would require right-of-ways from adjacent property owners. Electrical supply lines would also have to be extended to power the recovery wells.

Estimated time required for the design, permitting, and construction of the new groundwater recover system is two to three years.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications will be determined during design.

5.2.6.8 Cost

Costs for alternative 6 are summarized as follows:

- Construction—$3.8 million
- Annual O&M—$2.9 million
- Present worth (30 years, 7 percent)—$39.7 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs.

Construction cost includes the cost of installing additional recovery wells. Recovery well cost include well drilling, pumps, piping, electric supply, and control.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.7 Alternative 7

5.2.7.1 Description

Objectives of this alternative are to minimize horizontal migration of constituents in A zone, reduce constituent loading to the far field by 80 percent compared to the no action alternative, reduce precipitation percolation through contaminated soil, prevent contact with constituents, and reduce the volume of DNAPL. Alternative 7 includes the following technologies (see Table 5-1):

- Downgradient slurry wall
- Groundwater recovery by new wells in D through F zones
- Additional DNAPL recovery
- Cap upgrade

- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

This alternative includes slurry wall installation along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. The primary goal of an overburden slurry wall is to minimize potential DNAPL migration in A zone. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal. The rate of groundwater extraction required to prevent mounding in A zone is estimated to be approximately 5 gpm. Extracted groundwater would be treated at the CECOS WWTP and subsequently discharged to the POTW. Discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries.

Overburden collection wells would also function as collection points for DNAPL extraction. New overburden collection wells, in addition to existing monitor and recovery wells, would be monitored regularly. DNAPL that accumulates in these wells would be extracted and thermally treated at an off-site incinerator.

Under this alternative, the groundwater recovery rate would be increased by pumping from new recovery wells and the three existing recovery wells, RW-1, RW-2, and RW-3. The actual number and locations of wells would be determined during the design phase of this project. Groundwater recovery rate for this alternative is approximately 70 gpm. Groundwater would be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal to meet POTW discharge requirements.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet the permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through waste materials, preventing the potential contamination of this water and minimizing the potential for constituents in soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents the growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay.

This alternative includes continued use of the existing grout curtain. The purpose of the existing grout curtain is to enhance cones of depression created by pumping of recovery wells and increase hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued for this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor the effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations

5.2.7.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to alternative 1, alternative 7 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area, but would be no more effective than alternative 6 in reducing contaminant loadings to the far field. Groundwater modeling has been conducted to determine constituent loading. The modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 2.85 lbs/day for middle zones (D through F zones)
- 1.0 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 80 percent compared to alternative 1

The downgradient slurry wall prevents horizontal DNAPL migration and source area groundwater in A zone. Additional DNAPL recovery through leachate collection wells will have some influence on reducing total volume of DNAPL at Necco Park. The potential for direct exposure to DNAPL is low because of its subsurface location. DNAPL would act as a continuing source of source area groundwater contamination.

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing cap in preventing contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.7.3 Compliance with ARARs

Table 5-2 lists the potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 7. The following paragraphs summarize key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in the treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the source area or far-field groundwater area. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, would not be met in the source area as a result of the presence of DNAPL, which will act as a continuing source of groundwater contamination. However, no proven methods exist for complete DNAPL removal; therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.7.2, modeling has indicated that enhanced hydraulic control will reduce constituent loadings to the far field by approximately 80 percent compared to the no action alternative. However, this reduction will not be enough to reduce all constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Modeling has indicated that constituent loading to the far field will be reduced by approximately 80 percent compared to alternative 1.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate remedial actions.

Alternative 7 will comply with the remaining specified ARARs.

5.2.7.4 Long-term Effectiveness and Permanence

Long-term stability of some slurry wall materials in contact with high organic concentrations has not been demonstrated. Experiments have shown that permeability of bentonite increases when exposed to high concentrations of organic constituents such as TCE. Materials resistant to the effects of organic constituents on permeability (such as attapulgite) may be substituted. Treatability studies during remedial design may be required.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically. However, a short-term shutdown would not significantly increase constituent loading to the far field.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

The volume of DNAPL extracted from the new well and the existing wells cannot be predicted because DNAPL migration in the subsurface is complex. Once DNAPL is extracted, thermal destruction of DNAPL constituents is permanent.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. The clay used for the cap is a chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. The maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent the growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.7.5 Reduction of Toxicity, Mobility, and Volume through Treatment

The downgradient slurry wall would control horizontal migration of source area groundwater and DNAPL in A zone, thereby minimizing impact on A zone groundwater quality in adjacent properties.

Groundwater recovery and treatment is a commonly used remediation technology for reducing toxicity, mobility, and volume of aqueous constituents. As previously stated, groundwater modeling indicates that additional hydraulic control with downgradient slurry wall alternative will reduce constituent loading to the far field by 80 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW.

Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will act to reduce constituent concentrations in the far field in response to this reduced source.

DNAPL recovery reduces the volume of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. The additional DNAPL recovery well would increase the volume of DNAPL that is removed from the environment. Off-site thermal treatment of recovered DNAPL reduces constituent toxicity. Remaining DNAPL would continue to have potential to migrate horizontally and vertically.

5.2.7.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Installing a slurry wall may have negative short-term impacts on human health and environment. A slurry wall would require excavating a 20- to 30- foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized, short-term route for constituent or DNAPL migration to bedrock.

Alternative 7 can be designed and installed in approximately two to three years. The CECOS WWTP has excess available capacity and, therefore, major upgrades of the plant will not be required. After startup of the new system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air. Disturbing overburden material under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.7.7 Implementability

The downgradient slurry wall is implementable. As previously stated, construction of a slurry wall may create organic vapors that would require monitoring and possibly control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Excavated material may not be appropriate for backfilling the trench due to organic contamination. If unsuitable, excavated material would be consolidated and placed beneath the cap in the Necco Park facility. Clean fill would be required for use as backfill material to mix with bentonite for slurry wall construction.

Excess capacity is available at the CECOS WWTP for implementation of this alternative. However, the flow rate exceeds the DuPont present contract amount and would require contract renegotiation. The additional recovery wells and associated piping required for this alternative would require right-of-ways from adjacent property owners. Electrical supply lines would also have to be extended to power the recovery wells.

As previously stated, alternative 7 could be implemented relatively quickly. The estimated time required for the design, permitting, and construction of the new system is two to three years.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications would be determined during design.

5.2.7.8 Cost

The costs for alternative 7 are summarized as follows:

- Construction—$6.1 million
- Annual O&M—$3.2 million
- Present worth (30 years, 7 percent)—$45.3 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs.

Construction cost includes the cost of installing a recovery well system and a downgradient slurry wall. Recovery well system cost includes well drilling, pumps, piping, electric supply, and control. Slurry wall costs include excavation, on-site disposal of spoils, fill, bentonite, and slurry wall installation.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.8 Alternative 8

5.2.8.1 Description

Objectives of alternative 8 are to reduce the volume of DNAPL, reduce constituent loading to the far field by 80 percent compared to no action, minimize precipitation percolation through source material, and prevent contact with constituents. The alternative includes the following technologies (see Table 5-1):

- DPE
- Additional source area groundwater recovery by new wells in D through F zones
- DNAPL recovery
- Cap upgrade
- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

Alternative 8 consists of construction and operation of a DPE system on the 24-acre Necco Park site. The DPE system would consist of vacuum extraction wells, piping, and vapor- and liquid-phase treatment. Vapor-phase constituents would be treated through thermal oxidation. Aqueous-phase constituents would be treated at the CECOS WWTP. Liquid-phase constituents would be treated at an off-site incinerator. Bench-scale and pilot-scale treatability studies would be required to determine the most appropriate treatment train.

The DPE would remove organic vapors, DNAPL, and source area groundwater from A zone and upper bedrock zones at the facility. It is estimated that the system would be in operation for three to five years. The DPE system would be shut down November through March. During operation of the DPE system, groundwater extraction from wells RW-1 and RW-2 may be reduced. Once the

DPE operation is complete, groundwater recovery from wells RW-1, RW-2, and RW-3 would resume recovery at existing rates and the cap upgraded.

Under this alternative, the groundwater recovery rate would be increased by pumping from new recovery wells and the three existing recovery wells, RW-1, RW-2, and RW-3. The actual number and locations of wells would be determined during the design phase of this project. Total groundwater recovery rate for this alternative is approximately 70 gpm. Groundwater would be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal at CECOS to meet POTW discharge requirements. The discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries and residents.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through the waste materials, preventing potential contamination of this water and minimizing potential for constituents in soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents the growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay.

After operation of the DPE system, annual average groundwater recovery rate using wells RW-1, RW-2, and RW-3 and the new wells would be approximately 70 gpm. Recovered groundwater would continue to be treated at the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal to meet POTW discharge requirements.

This alternative includes continued use of the existing grout curtain. The existing grout curtain enhances cones of depression created by pumping of recovery wells and increases hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued for this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor the effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.8.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to alternative 1, alternative 8 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area, but would be no more effective than alternative 6 in reducing contaminant loading to the far field. Groundwater modeling has been conducted to determine constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 2.85 lbs/day for the middle zones (D through F zones)
- 1.0 lbs/day for the lower zone (G zone)
- A total constituent loading reduction of approximately 80 percent compared to alternative 1.

The DPE system would reduce migration of DNAPL and source area groundwater in A zone. DPE would reduce the total volume of DNAPL at Necco Park. Potential for direct exposure to residual DNAPL is low because of its subsurface location. DNAPL would act as a continuing source of source area groundwater contamination.

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing clay cap in preventing contact with constituents or reducing contaminant loading to the far field. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.8.3 Compliance with ARARs

Table 5-2 lists the potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to the DPE alternative. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in the treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the source area or far field. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of DNAPL, which will act as a continuing source of groundwater contamination. However, no proven methods currently exist for complete DNAPL remediation. Therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.8.2, alternative 8 will reduce constituent loading to the far field by approximately 80 percent compared to no action. However, according to modeling performed for this AOA, the reduction will not be enough to reduce all constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Constituent loading to the far field through source area groundwater recovery will be reduced by 80 percent. The DPE system could substantially reduce the volume of DNAPL in overburden and shallow bedrock zones. However, the actual effectiveness of DPE at Necco Park cannot be predicted without the use of a pilot study.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

Alternative 8 will comply with the remaining specified ARARs.

5.2.8.4 Long-term Effectiveness and Permanence

Effectiveness of a DPE system at Necco Park cannot be determined without a pilot study. However, based on the low permeability of overburden and the nature of constituents (volatile and semivolatile constituents), DPE should be an effective means of removing constituents. The DPE system would remove the maximum mass of constituents possible in a relatively short period (three to five years). Extended use of the DPE system would result in minimal additional constituent removal. Once constituents are treated through thermal oxidation, CECOS treatment, or off-site incineration, the constituents are permanently destroyed.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically. However, a short-term shutdown would not significantly increase constituent loading to the far field.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. The clay used for the cap is a chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent the growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.8.5 Reduction of Toxicity, Mobility, and Volume through Treatment

The DPE system would reduce toxicity, mobility, and volume of constituents in overburden and upper bedrock zones through treatment. The volume of constituents is reduced as liquid-, vapor-, and aqueous-phase constituents are withdrawn by high vacuum. DNAPL and aqueous-phase constituent mobility is also reduced by the DPE system. As constituents are treated by thermal oxidation, CECOS WWTP, and off-site incineration, toxicity is reduced.

Groundwater recovery and treatment is a commonly used remediation technology for reducing mobility and volume through treatment of aqueous contamination. As previously stated, groundwater modeling indicates that this alternative will reduce constituent loading to the far field by 80 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW.

Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field in response to this reduced source.

The upgraded cap would reduce migration of overburden constituents by minimizing precipitation percolation through overburden.

5.2.8.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Installing a DPE system would require drilling of up to 100 to 300 overburden and upper bedrock wells. During drilling, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized, short-term route for constituent or DNAPL migration to bedrock.

The additional hydraulic control alternative can be designed and installed in a relatively short period of time, approximately two to three years. The CECOS WWTP has excess available capacity and, therefore, major upgrades of the plant will not be required. After startup of the new system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air. Disturbing overburden material under the existing cap would be minimal, and the release of vapor-phase constituents would be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.8.7 Implementability

Alternative 8 is implementable. As previously stated, drilling overburden wells may create organic vapors that would require monitoring and possibly control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Bench- and pilot-scale treatability studies would be required to determine effectiveness and operating parameters of a full-scale DPE system. A DPE system would require power upgrades and water supply at the facility to operate.

Excess capacity is available at the CECOS WWTP for the implementation of this alternative. However, the flow rate exceeds the DuPont present contract amount and would require contract renegotiation. Additional recovery wells and associated piping required for this alternative would require right-of-ways from adjacent property owners. Electrical supply lines would also have to be extended to power the recovery wells.

As previously stated, alternative 8 could be implemented relatively quickly. The estimated time required for the design, permitting, and construction of the new system is three to five years.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications will be determined during design activities.

5.2.8.8 Cost

Costs for alternative 8 are summarized as follows:

- Construction—$7.5 million
- Annual O&M— $3.8 million
- Present worth (30 years, 7 percent)—$46.8 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs.

Construction cost includes the cost of installing a DPE system, additional groundwater extraction wells, on-site disposal of spoils, and upgrading the cap. The DPE system consists of extraction wells, vacuum pumps, piping, condenser, liquid tank, thermal oxidizer with scrubber, controls, and a building. A pilot study is also included in the DPE system cost.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover

- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- DPE system O&M
- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.9 Alternative 9

5.2.9.1 Description

Objectives of this alternative are to minimize constituent loading to the far field, create a physical barrier to DNAPL migration, minimize precipitation percolation through contaminated soil, prevent contact with contaminated soil, and reduce the volume of DNAPL. Alternative 9 includes the following technologies (see Table 5-1):

- Grout curtain (B-F)
- Downgradient slurry wall
- Groundwater recovery by new wells in D through F zones
- Additional DNAPL recovery
- Cap upgrade
- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls

- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

The existing grout curtain would be extended around the source area. The eastern boundary of the CECOS landfill would be grouted in B through F zones. This grout curtain section is approximately 950 feet long. The western boundary of the CECOS landfill would be grouted in B through F zones. This grout curtain section is approximately 750 feet long. The southern boundary of the CECOS landfill would also be grouted in B through F zones. This grout curtain section would be approximately 1,750 feet long. The new sections of grout curtain would be installed using techniques similar to those employed for the existing grout curtain.

For this alternative, groundwater modeling has shown that the groundwater recovery rate would be increased by pumping from new recovery wells and two of the existing recovery wells, wells RW-1 and RW-2. The purpose of the groundwater recovery system would be to maintain a hydraulic gradient across the grouted area. The actual number and locations of wells would be determined during the design phase of this project.

Total groundwater recovery rate for this alternative is approximately 70 gpm. Groundwater would be treated at the CECOS WWTP and subsequently discharged to the POTW. Discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries.

This alternative includes installation of a slurry wall in overburden along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. The primary goal of an overburden slurry wall is to minimize potential DNAPL migration in A zone. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collected in points for DNAPL removal. The rate of groundwater extraction required to prevent mounding is estimated to be approximately 5 gpm. Extracted groundwater would be treated at the CECOS WWTP.

Overburden collection wells would also function as collection points for DNAPL extraction. New overburden collection wells, in addition to existing monitor and recovery wells, would be monitored regularly. DNAPL that collects in these wells would be extracted and thermally treated at an off-site incinerator.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1×10^{-7} cm/s or less. If sections of the cap do not meet the permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through the waste materials, preventing potential contamination of this water and minimizing potential for constituents in the soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents the growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay.

This alternative includes continued use of the existing grout curtain and a new grout curtain. The purpose of the grout curtain is to enhance cones of depression associated with recovery wells and hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued under this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.9.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to alternative 8, alternative 9 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area. Groundwater modeling has been conducted to determine constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.19 lbs/day for upper zones (B and C zones)
- 0.66 lbs/day for middle zones (D through F zones)
- 1.0 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 90 percent compared to alternative 1

Compared to existing systems, constituent loading in the upper zone is greater because some DNAPL will not be contained within the grouted area. This DNAPL would act as a source of contamination in the upper zone.

The new grout curtain would encapsulate all but a small fraction of the DNAPL. Because pressure grouting significantly reduces permeability of bedrock aquifers, the new grout curtain sections will limit DNAPL migration.

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing clay cap in preventing contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.9.3 Compliance with ARARs

Table 5-2 lists the potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 9. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated resulting in treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals included in the ARARs will not be met in the source area or far field. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of DNAPL that will continue to contaminate groundwater. However, no proven methods for complete DNAPL removal exist; therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.9.2, modeling has indicated that source area vertical barriers and pumping will reduce constituent loading to the far field by approximately 90 percent compared to the no action alternative. However, this reduction will not be enough to reduce constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO would not be achieved. Grouting is the only technology available to seal cracks in fractured bedrock through which DNAPL migrates. By creating a vertical barrier through F zone, the ability for DNAPL to migrate horizontally is limited. However, some DNAPL would be isolated outside of the grout curtain.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

This alternative will comply with the remaining specified ARARs.

5.2.9.4 Long-term Effectiveness and Permanence

A grout curtain (B through F zones) would reduce the mass of constituents that migrates to the far field. Groundwater modeling has estimated a 90 percent reduction in constituent loading to the far field and that his loading reduction will eventually reduce constituent concentrations in the far field.

The long-term stability of some slurry wall materials in contact with high organic concentrations has not been demonstrated. Experiments have shown that permeability of bentonite increases when exposed to high concentrations of organic constituents such as TCE. However, slurry wall materials such as attapulgite may be substituted. Treatability studies during remedial design may be required to determine appropriate slurry wall materials.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically. However, a short-term shutdown would not significantly increase far-field contaminant loading.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

The volume of DNAPL extracted from the new leachate collection wells and existing wells cannot be predicted because DNAPL migration in the subsurface is complex. Once DNAPL is extracted, the thermal destruction of DNAPL constituents is permanent.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. The clay used for the cap is chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent the growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.9.5 Reduction of Toxicity, Mobility, and Volume through Treatment

The grout curtain would reduce horizontal DNAPL migration in B through F zones. The downgradient slurry wall would control horizontal migration of source area groundwater and DNAPL in A zone, thereby minimizing impact on A zone groundwater quality in adjacent properties.

Groundwater recovery and treatment is a commonly used remediation technology for reducing toxicity, mobility, and volume of aqueous constituents. As previously stated, groundwater modeling indicates that alternative 9 will reduce constituent loading to the far field by 90 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW.

Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field in response to this reduced source.

DNAPL recovery reduces the volume of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. The additional DNAPL recovery well would increase the volume of DNAPL that is removed from the environment. Off-site thermal treatment of recovered DNAPL reduces constituent toxicity. The remaining DNAPL would continue to have potential to migrate horizontally and vertically.

The upgraded cap would reduce migration of overburden constituents by minimizing precipitation percolation through overburden.

5.2.9.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Drill cuttings from grout curtain installation may be a minor source of organic vapors. However, workers can use respiratory protection to avoid exposure. Drilling through areas of known DNAPL may create a downward route for DNAPL migration. EPA's

May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Site and RCRA Facilities—Update"* states,

> "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized, short-term vertical pathways may be created for DNAPL movement during the drilling process.

Installing a slurry wall may have negative short-term impacts on human health and environment. A slurry wall would require excavating a 20- to 30- foot deep trench through overburden. Organic constituents may volatilize into the air during excavation, handling, and consolidation of overburden materials at the facility. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized, short-term route for constituent or DNAPL migration to bedrock.

Alternative 9 can be designed and installed in three to five years. The CECOS WWTP has excess available capacity and, therefore, major upgrades of the plant will not be required. After startup of the enhanced system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air. Disturbing overburden material under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.9.7 Implementability

Sufficient capacity would be available at the CECOS WWTP for implementation of alternative 9. However, the flow rate exceeds the DuPont present contract amount and would require contract renegotiation. Additional recovery wells and associated piping required for this alternative would require right-of-ways. Electrical supply lines would also have to be extended to power the recovery wells.

Construction of a grout curtain around the source area will be difficult due to existing landfills, utilities, and lack of access. Construction of a source area grout curtain presents considerable construction difficulties. Construction of new grout curtains to the east of Necco Park would be difficult because only a narrow strip of land is accessible for use as a working area. A nearby methane-recovery system could limit construction. Construction of a new grout curtain section to the south would be difficult because the adjacent access road is the only available working area. This would require construction of new access roads and diversion of private traffic. A drainage ditch and close proximity to underground Texas Brine lines will further complicate construction. A grout section to the west would be restricted by railroad tracks.

Prior to installation, soil borings would be needed to determine the proper location of a grout curtain. Permission would also need to be obtained from CECOS and BFI prior to constructing such a grout curtain. In the past, CECOS has shown concern about the effects of a grout curtain on water levels beneath its facilities. Specifically, a concern was expressed that a grout curtain spanning B zone would result in an unacceptable increase in the elevation of overburden water table on the CECOS property to the north of Necco Park. If construction of a new grout curtain is challenged, it would significantly delay implementation of this alternative.

Construction of the grout curtain would include drilling through areas of suspected DNAPL. This drilling could create a pathway for DNAPL migration. In addition, drilling would generate contaminated soil and rock that could expose workers to contamination. Contaminated soil and rock must be disposed of beneath the Necco Park landfill cap.

The downgradient slurry wall is implementable. As previously stated, slurry wall construction may create organic vapors that would require monitoring and possibly control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Excavated material may not be appropriate for backfilling the trench due to organic contamination. If unsuitable, excavated material would be consolidated and placed beneath the cap in the Necco Park facility. Clean fill would be required for use as backfill material to mix with bentonite for slurry wall construction.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications would be determined during design.

5.2.9.8 Cost

Costs for alternative 9 are summarized as follows:

- Construction—$15.6 million
- Annual O&M—$3.1 million
- Present worth (30 years, 7 percent)—$53.8 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs.

Construction cost includes the cost of installing a grout curtain, additional groundwater extraction wells, on-site disposal of spoils, and upgrading the cap.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.10 Alternative 10

5.2.10.1 Description

Objectives of this alternative are to minimize aqueous constituent migration from the source area in the A through F zones, minimize precipitation percolation through overburden soil, prevent contact with constituents, and reduce the volume of DNAPL. Alternative 9 includes the following technologies (see Table 5-1):

- Groundwater recovery by new wells in D through F zones
- Downgradient slurry wall
- Cap upgrade

- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

Groundwater modeling has predicted that complete hydraulic control of the source area would be achieved through installation and operation of new recovery wells and the three existing recovery wells, RW-1, RW-2, and RW-3. The actual number and locations of wells would be determined during the design phase of this project. Total bedrock groundwater recovery rate for this alternative is estimated to be approximately 155 gpm. Groundwater would be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal to meet the POTW discharge requirements. The discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries.

This alternative includes slurry wall installation along the southern boundary and the southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. The primary goal of an overburden slurry wall is to minimize potential migration of DNAPL in A zone. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal. The rate of groundwater extraction required to prevent mounding is estimated to be approximately 5 gpm. Extracted groundwater would be treated at the CECOS WWTP.

Overburden collection wells would also function as collection points for DNAPL extraction. The new overburden collection wells, in addition to existing monitor and recovery wells, would be monitored regularly. DNAPL that accumulates in these wells would be extracted and thermally treated at an off-site incinerator.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through waste materials, preventing potential contamination of this water and minimizing potential for constituents in soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing depressions with new clay.

This alternative includes continued use of the existing grout curtain. The existing grout curtain thereby enhances cones of depression associated with recovery wells and hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued under this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.10.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to alternative 1, alternative 10 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area. Groundwater modeling has been conducted to determine constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 0.02 lbs/day for middle zones (D through F zones)
- 1.01 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 95 percent compared to alternative 1

The downgradient slurry wall prevents horizontal DNAPL migration and source area groundwater in A zone. Additional DNAPL recovery through leachate collection wells will have some influence on reducing the total volume of DNAPL at Necco Park. Potential for direct exposure to DNAPL is low because of its subsurface location. DNAPL would act as a continuing source of source area groundwater contamination.

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing clay cap in preventing contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.10.3 Compliance with ARARs

Table 5-2 lists the potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 10. The following paragraphs summarize key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in the treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both

DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the source area or far field. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, would not be met in the source area as a result of the presence of DNAPL, which will act as a continuing source of groundwater contamination. However, no proven methods exist for complete DNAPL removal; therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.10.2, modeling has indicated total source area hydraulic control with downgradient slurry wall alternative will reduce constituent loadings to the far field by approximately 95 percent compared to the no action alternative. However, this reduction will not be enough to reduce constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Modeling has indicated that constituent loading to the far field will be reduced by approximately 95 percent compared to the no action alternative.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate remedial actions.

Alternative 10 will comply with the remaining specified ARARs.

5.2.10.4 Long-term Effectiveness and Permanence

Long-term stability of some slurry wall materials in contact with high organic concentrations has not been demonstrated. Experiments have shown that permeability of bentonite increases when exposed to high concentrations of organic constituents such as TCE. However, slurry wall construction materials such as attapulgite may be substituted. Treatability studies during remedial design may be required to determine appropriate slurry wall materials.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes periodic fouling in the pumps and piping. To repair the system, the pump must be shut down periodically. However, a short-term shutdown would not significantly increase far-field contaminant loading.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

The volume of DNAPL extracted from the leachate collection wells and existing wells cannot be predicted because DNAPL migration in the subsurface is complex. Once DNAPL is extracted, the thermal destruction of DNAPL constituents is permanent.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. The clay used for the cap is a chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent the growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.10.5 Reduction of Toxicity, Mobility, and Volume through Treatment

Groundwater recovery and treatment is a commonly used remediation technology for reducing toxicity, mobility, and volume of aqueous constituents. As previously stated, groundwater modeling indicates that the total source area hydraulic control with downgradient slurry wall alternative will reduce constituent loading to the far field by 95 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW.

Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will act to reduce constituent concentrations in the far field in response to this reduced source.

The downgradient slurry wall would control horizontal migration of DNAPL and groundwater in A zone, thereby minimizing impact on A zone groundwater quality in adjacent properties. However, the primary route for A zone constituent migration is downward.

DNAPL recovery reduces the volume of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. The additional DNAPL recovery wells would increase the volume of DNAPL that is removed from the environment. Off-site thermal treatment of recovered DNAPL reduces constituent toxicity. The remaining DNAPL would continue to have potential to migrate horizontally and vertically.

The upgraded cap would reduce migration of overburden constituents by minimizing precipitation percolation through overburden.

5.2.10.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Installing a slurry wall may have negative short-term impacts on human health and environment. A slurry wall would require excavating a 20- to 30- foot deep trench through overburden. Organic constituents may volatilize into the air during excavation, handling, and consolidation of overburden materials at the facility. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized, short-term route for constituent or DNAPL migration to bedrock.

Alternative 10 can be designed and installed in approximately two to five years. Implementation time for this alternative is higher than other pump-and-treat alternatives because of the need to increase the treatment capacity of the CECOS WWTP. The CECOS WWTP, which has approximately 110 gpm capacity for Necco Park use, would require expansion by 50 gpm to accommodate the additional flow. This expansion may include new or upgraded equalization tank, air stripper, and carbon adsorption units. After startup of the new system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air.

Disturbing overburden material under the existing cap would be minimal, and release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.10.7 Implementability

The CECOS WWTP, which has approximately 110 gpm capacity for Necco Park use, would require expansion by approximately 50 gpm to accommodate additional flow from this alternative. This expansion would require contract negotiations and may include new or upgraded equalization tank, air stripper, and carbon adsorption units. Additional recovery wells and associated piping required for this alternative would require right-of-ways from adjacent property owners. Electrical supply lines would also have to be extended to power the recovery wells. As previously stated, alternative 10 could be implemented relatively quickly. The estimated time required for the design, permitting, and construction of the new system is two to five years.

The downgradient slurry wall is implementable. As previously stated, construction of a slurry wall may create organic vapors that would require monitoring and possibly control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Excavated material may not be appropriate for backfilling the trench due to organic contamination. If unsuitable, excavated material would be consolidated and placed beneath the cap in the Necco Park facility. Clean fill would be required for use as backfill material to mix with bentonite for slurry wall construction.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications would be determined during design.

5.2.10.8 Cost

The costs for alternative 10 are summarized as follows:

- Construction—$7.8 million
- Annual O&M—$4.6 million
- Present worth (30 years, 7 percent)—$65.1 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs.

Construction cost includes the cost of installing a recovery well system and a downgradient slurry wall. Recovery well system cost include well drilling, pumps, piping, electric supply, and control. Slurry wall costs include excavation, on-site disposal of spoils, fill, bentonite, and slurry wall installation.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.11 Alternative 11

5.2.11.1 Description

Objectives of alternative 11 are to reduce the volume of DNAPL, hydraulically contain the source area in the A through F zones, minimize precipitation percolation through source material, and prevent contact with constituents. The alternative includes the following technologies (see Table 5-1):

- DPE
- Additional groundwater recovery by new wells in D through F zones
- DNAPL recovery
- Cap upgrade
- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

Alternative 11 consists of construction and operation of a DPE system on the 24-acre Necco Park site. The DPE system would of vacuum extraction wells, piping, and vapor- and liquid-phase treatment. Vapor-phase constituents would be treated through thermal oxidation. Aqueous-phase constituents would be treated at the CECOS WWTP. Liquid-phase constituents would be treated at an off-site incinerator. Bench-scale and pilot-scale treatability studies would be required to determine the most appropriate treatment train.

DPE would remove organic vapors, DNAPL, and source area groundwater from A zone and upper bedrock zones at the facility. It is estimated that the system would be in operation for three to five years. During operation of the DPE system, groundwater extraction from wells RW-1 and RW-2 may be reduced. Once the DPE operation is complete, groundwater recovery from wells RW-1, RW-2, and RW-3 would resume recovery at existing rates and the cap upgraded.

Under this alternative, the groundwater recovery rate would be increased by pumping from new recovery wells and the three existing recovery wells, RW-1, RW-2, and RW-3. The actual number and locations of wells would be determined during the design phase of this project.

Total bedrock groundwater recovery rate for this alternative is approximately 155 gpm. Groundwater would be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal to meet the POTW discharge requirements. Discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through the waste materials, preventing potential contamination of this water and minimizing potential for constituents in soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents the growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay.

After operation of the DPE system, the annual average groundwater recovery rate using wells RW-1, RW-2, and RW-3 and the new wells would be approximately 155 gpm. Recovered groundwater would continue to be pumped through aboveground piping to the CECOS WWTP. Groundwater treatment would include organic and inorganic constituent removal to meet the POTW discharge requirements.

This alternative includes continued use of the existing grout curtain. The existing grout curtain appears to enhance cones of depression created by pumping of recovery wells and appears to increase hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued for this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

Existing access controls would be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park.

Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of the far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.11.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to alternative 1, alternative 11 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area, but not more than alternative 10. Groundwater modeling has been conducted to determine constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.01 lbs/day for upper zones (B and C zones)
- 0.02 lbs/day for middle zones (D through F zones)
- 1.0 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 95 percent compared to alternative 1

The DPE system would reduce migration of DNAPL and source area groundwater in A zone. DPE would reduce the total volume of DNAPL at Necco Park. The potential for direct exposure to residual DNAPL is low because of its subsurface location. DNAPL would act as a continuing source of source area groundwater contamination.

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing clay cap in preventing contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.11.3 Compliance with ARARs

Table 5-2 lists the potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to the DPE with total source area hydraulic control alternative. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated, resulting in treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both

DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals will not be met in the source area or far field. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of DNAPL, which will act as a continuing source of groundwater contamination. However, no proven methods currently exist for complete DNAPL remediation. Therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.11.2, alternative 11 will reduce constituent loading to the far field by approximately 95 percent based on the model used to compare RAAs. However, this reduction will not be enough to reduce all constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO will be partially achieved. Constituent loading to the far field through source area groundwater recovery will be reduced by 95 percent. The DPE system could substantially reduce the volume of DNAPL in overburden and shallow bedrock zones. However, actual effectiveness of DPE at Necco Park cannot be predicted without the use of a pilot study.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

Alternative 11 will comply with the remaining specified ARARs.

5.2.11.4 Long-term Effectiveness and Permanence

The effectiveness of a DPE system at Necco Park cannot be determined without a pilot study. However, based on the low permeability of overburden and the nature of constituents (volatile and semivolatile constituents), DPE should be an effective means of removing constituents. The DPE system would remove the maximum mass of constituents possible in a relatively short period (three to five years). Extended use of the DPE system would result in minimal additional constituent removal. Once constituents are treated through thermal oxidation, CECOS treatment, or off-site incineration, the constituents are permanently destroyed.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically. However, a short-term shutdown would not significantly increase far-field contaminant loading.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. Clay used for the cap is a chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.11.5 Reduction of Toxicity, Mobility, and Volume through Treatment

The DPE system would reduce toxicity, mobility, and volume of constituents in overburden and upper bedrock zones through treatment. The volume of constituents is reduced as liquid-, vapor-, and aqueous-phase constituents are withdrawn by the high vacuum. DNAPL and aqueous-phase constituent mobility is also reduced by the DPE system. As constituents are treated by thermal oxidation, CECOS WWTP, and off-site incineration, toxicity is reduced.

Groundwater recovery and treatment is a commonly used remediation technology for reducing toxicity, mobility, and volume of aqueous constituents. As previously stated, groundwater modeling indicates that the DPE with total source area hydraulic control alternative will reduce constituent loading to the far field by 95 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW.

Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in the recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field in response to this reduced source.

5.2.11.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Installing a DPE system would require drilling of up to 100 to 300 overburden and upper bedrock wells. During drilling, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized, short-term route for constituent or DNAPL migration to bedrock.

This alternative can be designed and installed in approximately two to five years. Implementation time is greater than other pump-and-treat alternatives because the hydraulic capacity of the CECOS WWTP would have to be expanded. The CECOS WWTP, which has approximately 110 gpm capacity for Necco Park use, would require expansion to accommodate the additional flow. This expansion may include new or upgraded equalization tank, air stripper, and carbon adsorption units. After startup of the new system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air. Disturbing overburden material under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.11.7 Implementability

The CECOS WWTP, which has approximately 110 gpm capacity for Necco Park use, would require expansion by 50 gpm to accommodate the additional flow. This expansion would require contract negotiations and may include new or upgraded equalization tank, air stripper, and carbon adsorption units. The additional recovery wells and associated piping required for this alternative would require right-of-ways from adjacent property owners. Electrical supply lines would also have to be extended to power the recovery wells. Estimated time required for design, permitting, and construction of the new system is two to five years.

Alternative 11 is implementable. As previously stated, drilling overburden wells may create organic vapors that would require monitoring and possibly control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Bench- and pilot-scale treatability studies would be required to determine effectiveness and operating parameters of a full-scale DPE system. A DPE system would require a power upgrade and water supply at the facility to operate. Appropriate utilities do not currently exist at Necco Park and therefore would have to be installed prior to DPE system operation.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications will be determined during design activities.

5.2.11.8 Cost

Costs for alternative 11 are summarized as follows:

- Construction—$9.4 million
- Annual O&M— $5.2 million
- Present worth (30 years, 7 percent)—$67.4 million

Detailed cost components are itemized in Appendix E and summarized in the following paragraphs.

Construction cost includes cost of installing a DPE system, additional groundwater extraction wells, on-site disposal of spoils, and upgrading the cap. The DPE system consists of extraction wells, vacuum pumps, piping, condenser, liquid tank, thermal oxidizer with scrubber, controls, and a building. A pilot study is also included in the DPE system cost.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- DPE system O&M
- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.12 Alternative 12

5.2.12.1 Description

Objectives of this alternative are to minimize constituent loading to the far field, create a physical barrier to DNAPL migration, minimize precipitation percolation through contaminated soil, prevent contact with contaminated soil, and reduce

DNAPL volume. Alternative 12 includes the following technologies (see Table 5-1):

- Grout curtain (B-G)
- Downgradient slurry wall
- Groundwater recovery by new wells in D through G zones
- Additional DNAPL recovery
- Cap upgrade
- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

The existing grout curtain would be extended around the source area. The eastern boundary of the CECOS landfill would be grouted in B through G zones. This grout curtain section is approximately 950 feet long. The western boundary of the CECOS landfill would be grouted in B through G zones. This grout curtain section is approximately 750 feet long. The southern boundary of the CECOS landfill would also be grouted in B through G zones. This grout curtain section would be approximately 1,750 feet long. The new sections of grout curtain would be installed using techniques similar to those employed for the existing grout curtain.

For this alternative, groundwater modeling has shown that groundwater recovery rates would be increased by pumping from new recovery wells and two of the existing recovery wells, wells RW 1 and RW 2. The purpose of the groundwater recovery system would be to maintain a hydraulic gradient across the grouted area. The actual number and locations of wells would be determined during the design phase of this project.

Total estimated groundwater recovery rate for this alternative is approximately 75 gpm. Groundwater would be treated at the CECOS WWTP and subsequently discharged to the POTW. Discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries.

This alternative includes installation of a slurry wall in overburden along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. The primary goal of an overburden slurry wall is to minimize potential DNAPL migration in A zone. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collected in points for DNAPL removal. The rate of groundwater extraction required to prevent mounding is estimated to be approximately 5 gpm. Extracted groundwater would be treated at the CECOS WWTP.

Overburden collection wells would also function as collection points for DNAPL extraction. New overburden collection wells, in addition to existing monitor and recovery wells, would be monitored regularly. DNAPL that collects in these wells would be extracted and thermally treated at an off-site incinerator.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through waste materials, preventing potential contamination of this water and minimizing potential for constituents in the soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing the depressions with new clay.

This alternative includes continued use of the existing grout curtain and a new grout curtain. The purpose of the grout curtain is to enhance cones of depression associated with recovery wells and hydraulic control of groundwater flow and constituent migration from Necco Park.

Groundwater monitoring would be continued under this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes. Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

A portion of far-field groundwater would continue to be intercepted by existing utility drains, and natural attenuation would continue to reduce constituent concentrations.

5.2.12.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use local groundwater. The existing clay cap eliminates potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Compared to alternative 1, alternative 12 would reduce constituent loading to the far field, thereby reducing constituent concentrations in that area. However, loadings would not be reduced substantially more than alternative 11. Groundwater modeling has been conducted to determine constituent loading. Modeling for the comparative analysis has predicted the following results:

- No loading for overburden (A zone)
- 0.13 lbs/day for upper zones (B and C zones)
- 0.63 lbs/day for middle zones (D through F zones)
- 0.05 lbs/day for lower zone (G zone)
- A total constituent loading reduction of approximately 96 percent compared to alternative 1

Compared to existing systems, constituent loading in the upper zone is greater because some DNAPL will not be contained within the grouted area. This DNAPL would act as a source of contamination in the upper zone.

The new grout curtain would encapsulate all but a small fraction of the DNAPL. Because pressure grouting significantly reduces permeability of bedrock aquifers, the new grout curtain sections may limit DNAPL migration.

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing clay cap in preventing contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.12.3 Compliance with ARARs

Table 5-2 lists potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 12. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The Declaration of Intent commits to reducing toxic loading overall and to reducing by 50 percent the point and nonpoint loadings of persistent toxic chemicals of concern entering the Niagara River by 1996. In a June 1993 settlement with the city of Niagara Falls, EPA and NYSDEC obtained an agreement that required the Niagara Falls POTW to convey all residual dry-weather flow in Falls Street tunnel for treatment and removal of toxics prior to discharge. The majority of storm event flow is also treated resulting in treatment of an estimated 95 percent of Falls Street tunnel flow. As stated in Section 1.0, far-field groundwater in D through G zones is intercepted by NYPA conduit drains where flow into the Falls Street tunnel subsequently occurs. A portion of groundwater in B and C zones is intercepted by the Falls Street tunnel. Actions taken to control discharge from the Falls Street tunnel, therefore, have reduced loadings from Necco Park to the Niagara River. It is estimated that the 50 percent reduction goal in loadings to the Niagara River (set forth in the Four-Party Agreement of 1987) has been accomplished by both DuPont's response actions to date and the 1993 diversion of all dry-weather flow in Falls Street tunnel to the Niagara Falls POTW.

Target goals included in the ARARs will not be met in the source area or far field. Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of DNAPL that will continue to contaminate groundwater. However, no proven methods for complete DNAPL removal exist; therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.12.2, modeling has indicated that source area vertical barriers and pumping will reduce constituent loading to the far field by approximately 96 percent compared to the no action alternative. However, this reduction will not be enough to reduce constituent concentrations to target goals. Therefore, the first RAO will not be met in the far field.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO would not be achieved. Grouting is the only technology available to seal cracks in fractured bedrock through which DNAPL migrates. By creating a vertical barrier through G zone, the ability for DNAPL to migrate horizontally is limited. However, some DNAPL would be isolated outside of the grout curtain.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

This alternative will comply with the remaining specified ARARs.

5.2.12.4 Long-term Effectiveness and Permanence

A grout curtain (B through G zones) would reduce the mass of constituents that migrates to the far field. Groundwater modeling has estimated a 96 percent reduction in constituent loading to the far field and that his loading reduction will eventually reduce constituent concentrations in the far field.

The long-term stability of some slurry wall materials in contact with high organic concentrations has not been demonstrated. Experiments have shown that permeability of bentonite increases when exposed to high concentrations of organic constituents such as TCE. However, slurry wall materials such as attapulgite may be substituted. Treatability studies during remedial design may be required to determine appropriate slurry wall materials.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. The naturally occurring chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically. However, a short-term shutdown would not significantly increase far-field contaminant loading.

This alternative also relies on the CECOS WWTP for treatment of extracted groundwater. CECOS is obligated to manage leachate for its own landfill through at least the year 2021, providing a long-term, effective means of treating Necco Park groundwater.

The volume of DNAPL extracted from new leachate collection wells and existing wells cannot be predicted because DNAPL migration in the subsurface is complex. Once DNAPL is extracted, the thermal destruction of DNAPL constituents is permanent.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. The clay used for the cap is chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent the growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.12.5 Reduction of Toxicity, Mobility, and Volume through Treatment

The grout curtain would reduce horizontal DNAPL migration in B through G zones. The downgradient slurry wall would control horizontal migration of source area groundwater and DNAPL in A zone, thereby minimizing impact on A zone groundwater quality in adjacent properties.

Groundwater recovery and treatment is a commonly used remediation technology for reducing toxicity, mobility, and volume of aqueous constituents. As previously stated, groundwater modeling indicates that alternative 12 will reduce constituent loading to the far field by 96 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. A portion of far-field groundwater would continue to be intercepted by existing utility drains and treated at the Niagara Falls POTW.

Groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will continue to reduce constituent concentrations in the far field in response to this reduced source.

DNAPL recovery reduces the volume of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. The additional DNAPL recovery well would increase the volume of DNAPL removed from the environment. Off-site thermal treatment of recovered DNAPL reduces constituent toxicity. Remaining DNAPL would continue to have the potential to migrate horizontally and vertically.

The upgraded cap would reduce migration of overburden constituents by minimizing precipitation percolation through overburden.

5.2.12.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Drill cuttings from grout curtain installation may be a minor source of organic vapors. However, workers can use respiratory protection to avoid exposure. Drilling through areas of known DNAPL may create a downward route for DNAPL migration. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Site and RCRA Facilities—Update*" states,

> "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized, short-term vertical pathways may be created for DNAPL movement during the drilling process.

Installing a slurry wall may have negative short-term impacts on human health and environment. A slurry wall would require excavating a 20- to 30- foot deep trench through overburden, which may create a localized, short-term route for constituent or DNAPL migration to bedrock. Organic constituents may volatilize into the air during excavation, handling, and consolidation of overburden materials at the facility. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility.

Alternative 12 can be designed and installed in three to five years. The CECOS WWTP has excess available capacity and, therefore, major upgrades of the plant will not be required. After startup of the enhanced system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air. Disturbing overburden material under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.12.7 Implementability

Sufficient capacity would be available at the CECOS WWTP for implementation of alternative 12. However, the flow rate exceeds the DuPont present contract amount and would require contract renegotiations. Additional recovery wells and associated piping required for this alternative would require right-of-ways. Electrical supply lines would also have to be extended to power the recovery wells.

Construction of a grout curtain around the source area will be difficult due to existing landfills, utilities, and lack of access. Construction of a source area grout curtain presents considerable construction difficulties. Construction of new grout curtains to the east of Necco Park would be difficult because only a narrow strip of land is accessible for use as a working area. A nearby methane-recovery system could limit construction. Construction of a new grout curtain section to the south would be difficult because the adjacent access road is the only available working area. This would require construction of new access roads and diversion of private traffic. A drainage ditch and close proximity to underground Texas Brine lines will further complicate construction. A grout section to the west would be restricted by railroad tracks.

Prior to installation, soil borings would be needed to determine the proper location of a grout curtain. Permission would also need to be obtained from CECOS and BFI prior to constructing such a grout curtain. In the past, CECOS has shown concern about the effects of a grout curtain on water levels beneath its facilities. Specifically, a concern was expressed that a grout curtain spanning B zone would result in an unacceptable increase in the elevation of overburden water table on CECOS property to the north of Necco Park. If construction of a new grout curtain is challenged, it would significantly delay implementation of this alternative.

Construction of the grout curtain would include drilling through areas of suspected DNAPL. This drilling could create a pathway for DNAPL migration. In addition, drilling would generate contaminated soil and rock that could expose workers to contamination. Contaminated soil and rock must be disposed of beneath the Necco Park landfill cap.

The downgradient slurry wall is implementable. As previously stated, slurry wall construction may create organic vapors that would require monitoring and possibly control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Excavated material may not be appropriate for backfilling the trench due to organic contamination. If unsuitable, excavated material would be consolidated and placed beneath the cap in the Necco Park facility. Clean fill would be required for use as backfill material to mix with bentonite for slurry wall construction.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications would be determined during design.

5.2.12.8 Cost

Costs for alternative 12 are summarized as follows:

- Construction—$39.1 million
- Annual O&M—$3.2 million
- Present worth (30 years, 7 percent)—$79.0 million

Detailed cost components are itemized in Appendix E and are summarized in the following paragraphs.

Construction cost includes the cost of installing a grout curtain, additional groundwater extraction wells, on-site disposal of spoils, and upgrading the cap.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover
- Replacing the stockpiled topsoil
- Seeding and mulch

O&M costs consist of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.2.13 Alternative 13

5.2.13.1 Description

Objectives of this alternative are to reduce constituent loading to the far field, create a physical barrier to DNAPL migration, recover approximately 100 percent of constituents that migrate to the far field, minimize precipitation percolation through contaminated soil, prevent contact with contaminated soil, and reduce the volume of DNAPL. Alternative 13 includes the following technologies (see Table 5-1):

- Grout Curtain (B-F)
- Downgradient slurry wall
- Groundwater recovery by new wells in D through F zones
- Additional DNAPL recovery
- Cap upgrade
- Groundwater recovery by existing wells (RW-1, RW-2, and RW-3)
- Existing grout curtain
- Groundwater monitoring
- Continuing existing access controls
- Groundwater interception by utility drains
- Natural attenuation of far-field groundwater

Under this alternative, groundwater modeling has shown that the groundwater recovery rate would be increased by pumping from new recovery wells and two of the existing recovery wells, RW-1 and RW-2. The purpose of the groundwater recovery system would be to create and maintain an inward hydraulic gradient into the source area. The actual number and locations of wells would be determined during the design phase of this project.

The source area groundwater recovery rate for this alternative is approximately 70 gpm. Groundwater would be pumped through aboveground piping to the CECOS WWTP and subsequently discharged to the POTW. Discharge from the CECOS plant is regulated in accordance with the POTW's industrial pretreatment program. As such, CECOS is required to pretreat for both hazardous and nonhazardous constituents (see Table 5-3). The POTW is an advanced wastewater treatment plant that provides additional treatment of wastewater discharged by CECOS as well as other industries.

The existing grout curtain would be extended around the source area. The eastern boundary of the CECOS landfill would be grouted in B through F zones. This grout curtain section is approximately 950 feet long. The western boundary of the CECOS landfill would be grouted in B through F zones. This grout curtain section is approximately 750 feet long. The southern boundary of the CECOS landfill would also be grouted in B through F zones. This grout curtain section would be approximately 1,750 feet long. The new sections of grout curtain would be installed using techniques similar to those employed for the existing grout curtain.

Groundwater would also be recovered from the far field. The purpose of far-field groundwater recovery would be to recover constituents that migrate from the source area prior to reaching utility drains to the south and west of Necco Park in an attempt to achieve the first RAO. Two clusters of far-field extraction wells were used for the evaluation, one to the south of Necco Park and one to the west of Necco Park. The flow rate to capture a theoretical 100 percent of contamination is estimated to be approximately 400 gpm.

This alternative includes slurry wall installation along the southern boundary and southern sections of the eastern and western boundaries of the 24-acre Necco Park facility. The primary goal of an overburden slurry wall is to minimize potential migration of DNAPL in A zone. Overburden collection wells would be installed in the landfill near the slurry wall to maintain an inward hydraulic gradient across the slurry wall, prevent mounding within Necco Park overburden, contain overburden groundwater, and function as collection points for DNAPL removal. The rate of groundwater extraction required to prevent mounding is estimated to be approximately 5 gpm. Extracted groundwater would be treated at the CECOS WWTP.

Overburden collection wells would also function as collection points for DNAPL extraction. The new overburden collection wells, in addition to the existing monitor and recovery wells, would be monitored regularly. DNAPL that collects in these wells would be extracted and thermally treated at an off-site incinerator.

Cap upgrade would consist of permeability testing of the existing clay cap to verify that its permeability is 1 x 10^{-7} cm/s or less. If sections of the cap do not meet the permeability requirements due to freeze-thaw cycles or other factors, additional clay may be added to reduce its permeability. A protection layer would then be added to ensure cap integrity. The cap would be graded to enhance runoff. Actual elements of the cap upgrade would be determined during remedial design after completion of a field program to evaluate existing cap conditions. The upgraded cap would reduce precipitation that percolates through the waste materials, preventing potential contamination of this water and minimizing potential for constituents in soil to migrate. The upgraded cap would continue to prevent potential direct contact with overburden materials.

Maintenance of the upgraded cap is included under this alternative. Maintenance activities include mowing and cap repairs. Mowing prevents growth of deep-rooted vegetation such as trees and shrubs, which may create secondary pathways for precipitation to percolate through the cap. Cap repairs are conducted when subsidence occurs and generally consist of filling and packing depressions with new clay.

This alternative includes continued use of the existing grout curtain and installation of new grout curtain. The purpose of the grout curtain is to provide a low-permeability barrier to groundwater and DNAPL flow. The grout curtain thereby enhances cones of depression associated with recovery wells and hydraulic control of groundwater flow and constituent migration from Necco Park in B through F zones.

Groundwater monitoring would be continued for this alternative. Groundwater recovery wells would be monitored periodically for waste management purposes.

Existing groundwater monitor wells would also be periodically sampled to monitor effectiveness of the alternative.

Existing access controls would also be continued. Current access controls consist of perimeter fencing and personnel monitoring the access road into Necco Park. Access is also limited by Necco Park's location (surrounded by active and closed landfills) and its close proximity to Conrail tracks and other industries.

5.2.13.2 Overall Protection of Human Health and Environment

Currently, contamination from Necco Park does not pose a risk to human health. A public water-supply system is available, precluding the need to use the local groundwater. Caps eliminate the potential for human contact with source materials. Direct human exposure to DNAPL is unlikely because of its location in the subsurface. Therefore, with continued availability and use of the abundant public water supply, this alternative would be protective of human health and environment.

Alternative 13 would reduce constituent loading to the far field, which would result in a reduction of constituent concentrations. Groundwater modeling has been conducted to determine the reduction in constituent loading. Modeling has predicted the following:

- No loading for overburden (A zone)
- 0.19 lbs/day for upper zones (B and C zones)
- 0.66 lbs/day for the middle zones (D through F zones)
- 1.0 lbs/day for the lower zone (G zone)
- A total constituent loading reduction of approximately 90 percent compared to alternative 1

Compared to existing systems, constituent loading in the upper zone is greater because some DNAPL will not be contained within the grouted area. This localized source of DNAPL would act as a source of contamination in the upper zone.

The new grout curtain would be placed in the potential path of DNAPL migration. Because pressure grouting significantly reduces permeability of bedrock aquifers, the new grout curtain sections will limit DNAPL migration.

The upgraded cap would be an effective barrier against contact with constituents. However, the upgraded cap would not be significantly more effective than the existing clay cap in preventing contact with constituents. Exposure of potential receptors to surface soil and airborne constituents would continue to be insignificant because of the presence of the upgraded cap. The continued presence of access controls would also limit potential for human exposure to constituents.

5.2.13.3 Compliance with ARARs

Table 5-2 lists potential ARARs identified in Section 2.2 and whether the ARAR is met or is not applicable to alternative 13. The following paragraphs provide a summary of key ARAR compliance issues.

The Four-Party Agreement is a TBC. The 50 percent reduction goal of the Four-Party Agreement would be achieved through pumping groundwater in the far-field.

Target goals and the first RAO, restoration of groundwater to its designated use—potable drinking water—as impacted by Necco Park contamination, will not be met in the source area because of the presence of DNAPL that will continue to contaminate groundwater. However, no proven methods for complete DNAPL removal exist; therefore, achievement of target goals in the source area is not technically feasible.

As stated in Section 5.2.13.2, modeling has indicated that this alternative will reduce constituent loading to the far field by approximately 90 percent compared to alternative 1. This source reduction in combination with far-field pumping and treatment may not reduce all constituent concentrations to target goals because of the effects of matrix diffusion. Therefore, the first RAO may not be met in the far field. However, all contaminated groundwater would be contained once steady-state pumping conditions are achieved.

This alternative does not completely comply with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." However, groundwater impacted by Necco Park is not currently used as a primary or sole source of drinking water.

The second RAO would be not achieved. Grouting is the only technology available to seal cracks in fractured bedrock through which DNAPL migrate. However, the grout curtain would not affect vertical DNAPL migration.

Soil cleanup levels specified in New York TAGM 4046, which is considered a TBC, will not be met under this alternative. However, TAGM 4046 recognizes that restoration to predisposal conditions will not always be feasible and that control and isolation technologies may be selected as appropriate response actions.

This alternative will comply with the remaining specified ARARs.

5.2.13.4 Long-term Effectiveness and Permanence

Alternative 13 would reduce the mass of constituents that migrates to the far field, thereby improving quality of downgradient groundwater. Groundwater modeling has estimated a 90 percent reduction in constituent loading to the far field. This mass loading reduction will eventually reduce constituent concentrations in the far field and improve groundwater quality, although not to drinking-water quality.

Far-field pumping would further reduce groundwater constituent concentrations and contain groundwater contamination. Currently, no risk exists because exposure to groundwater and source material does not occur.

Long-term stability of some slurry wall materials in contact with high organic concentrations has not been demonstrated. Experiments have shown that permeability of bentonite increases when exposed to high concentrations of organic constituents such as TCE. Materials resistant to effects of organic constituents on permeability (such as attapulgite) may be substituted. Compatibility testing during remedial design may be required.

Groundwater recovery systems will require maintenance to sustain long-term effectiveness. Chemical composition of Necco Park groundwater causes fouling in pumps and piping and requires periodic maintenance. To maintain the system, pumps must be shut down periodically. However, a short-term shutdown would not significantly increase far-field contaminant loading.

This alternative relies on the CECOS WWTP for treatment of extracted source area groundwater. CECOS is obligated to manage leachate for its own landfill through at least 2021, providing a long-term, effective means of treating Necco Park groundwater.

This alternative relies on the Niagara Falls POTW for treatment of extracted far-field groundwater. The POTW is a reliable and permanent means of treated extracted groundwater.

The volume of DNAPL extracted from new wells and existing wells cannot be predicted because DNAPL migration in fractured bedrock is complex. Once DNAPL is extracted, the thermal destruction of DNAPL constituents is permanent.

Caps are a widely used and accepted method for landfill/waste disposal area closure. The upgraded cap would be a reliable, dependable means of preventing contact with source material and limiting precipitation infiltration into fill material. Clay used for the cap is chemically stable and, with appropriate maintenance, should not significantly degrade due to weathering. Maintenance requirements for the upgraded cap are relatively minor. The vegetative layer must be mowed regularly to prevent growth of deep-rooted vegetation such as trees and shrubs, which act to create secondary pathways for precipitation migration. Periodic inspection and repairs for subsidence are also necessary to maintain effectiveness.

5.2.13.5 Reduction of Toxicity, Mobility, and Volume through Treatment

The grout curtain would reduce horizontal DNAPL migration in B through F zones. The downgradient slurry wall would control horizontal migration of source area groundwater and DNAPL in A zone, thereby minimizing impact on A zone groundwater quality in adjacent properties.

Groundwater recovery and treatment is a commonly used remediation technology for reducing the toxicity, mobility, and volume of aqueous constituents. As previously stated, groundwater modeling indicates that the additional hydraulic control alternative will reduce constituent loading to the far field by 90 percent relative to the no action alternative. Contaminated water that is not recovered would potentially migrate to the far field. However, far-field groundwater is intercepted by the far-field pump-and-treat system.

The far-field pump-and-treat system prevents constituent migration to NYPA conduit drains and utility drains. This would prevent discharge of untreated groundwater into the Niagara River, which occurs during storm events when the POTW cannot treat flow from Falls Street tunnel.

Source area groundwater treatment at the CECOS WWTP reduces toxicity of constituents in recovered groundwater through treatment by metals precipitation, air stripping, and vapor- and liquid-phase carbon adsorption. Natural mechanisms will act to reduce constituent concentrations in the far field in response to this reduced source. Far-field groundwater treatment at the POTW reduces toxicity of constituents in recovered groundwater through physical-chemical treatment.

DNAPL recovery reduces the volume of DNAPL at Necco Park. Since the DNAPL recovery program began, approximately 6,000 gallons of DNAPL have been removed from Necco Park. Additional DNAPL recovery wells would increase the volume of DNAPL that is removed from the environment. Off-site thermal treatment of the recovered DNAPL reduces DNAPL toxicity. Remaining DNAPL would continue to have potential to migrate horizontally and vertically.

The upgraded cap would reduce migration of overburden constituents by minimizing precipitation percolation through overburden.

5.2.13.6 Short-term Effectiveness

Short-term effectiveness evaluates impact on human health and environment during implementation of this alternative. Drill cuttings from grout curtain installation may be a source of organic vapors. Workers can use respiratory protection to avoid exposure. Drilling through areas of known DNAPL may create a downward route for DNAPL migration. EPA's May 27, 1992, memorandum entitled *Considerations in Groundwater Remediation at Superfund Site and RCRA Facilities—Update* states,

> "Caution should be exercised to prevent further migration of contaminants via boreholes, especially DNAPL migration... In DNAPL zones, drilling should generally be minimized and should be suspended when a potential trapping layer is first encountered. Drilling through DNAPL zones into deeper stratigraphic units should be avoided..."

DNAPL may be encountered in borings on the east side of the Necco Park facility. Localized, short-term vertical pathways may be created for DNAPL movement during the drilling process.

Installing a slurry wall may have negative short-term impacts on human health and environment. A slurry wall would require excavating a 20- to 30- foot deep trench through overburden. During excavation, handling, and consolidation of overburden on the facility, organic constituents may volatilize into the air. Workers can use respiratory protection to avoid exposure. Perimeter air monitoring and possibly vapor-suppressing foam may be required to prevent organic vapors from migrating from the Necco Park facility. Additionally, excavating through overburden may create a localized, short-term route for constituent or DNAPL migration to bedrock.

Alternative 13 can be designed and installed in a relatively short period of time, approximately two to five years. The CECOS WWTP has excess available capacity and, therefore, major upgrades of the plant will not be required. After startup of the new system, groundwater modeling has predicted that downgradient concentrations should reach equilibrium within two to five years.

Upgrading the cap and installing new recovery wells may have negative short-term effects as overburden is disturbed and volatile constituents are released into the air. Disturbing overburden material under the existing cap would be minimal, and the release of vapor-phase constituents would also be minimal.

Minor short-term impacts are associated with DNAPL extraction. Workers may be exposed to DNAPL constituents through inhalation or absorption during the removal, transportation, and incineration process. However, PPE can be used to minimize exposure.

5.2.13.7 Implementability

Far-field pumping and treatment requires installation of recovery wells, pumps, and discharge piping in the far-field area. The far field consists of industrial, commercial, and residential areas. Permission to install wells on private property and access agreements would be required. Extensive drilling and pipe-laying operations on public and private property would be required. Pretreatment may be required prior to discharging to the POTW.

Sufficient capacity would be available at the CECOS WWTP for treatment of source area groundwater in alternative 13. However, the flow rate exceeds the DuPont present contract amount and would require contract renegotiation. The additional recovery wells and associated piping required for this alternative would require right-of-ways. Electrical supply lines would also have to be extended to power the recovery wells.

Construction of a grout curtain around the source area would be difficult due to existing landfills, utilities, and lack of access. Construction of a source area grout curtain presents considerable construction difficulties. Construction of new grout curtains to the east of Necco Park would be difficult because only a narrow strip of land is accessible for use as a working area. A nearby methane-recovery system could limit construction. Construction of a new grout curtain section to the south would be difficult because the adjacent access road is the only available working area. This would require construction of new access roads and diversion of private traffic. A drainage ditch and close proximity to underground Texas Brine lines will further complicate construction. A grout section to the west would be limited by railroad tracks.

Construction of the grout curtain would include drilling through areas of suspected DNAPL. This drilling could create a pathway for DNAPL migration. In addition, this drilling would generate contaminated soil and rock that could expose workers to contamination. Contaminated soil and rock must be disposed of properly.

The downgradient slurry wall is implementable. As previously stated, construction of a slurry wall may create organic vapors that would require monitoring and possibly control. Vapor-suppressing foam may be necessary to protect human health and environment. Use of vapor-suppressing foam will increase difficulty and time required to implement the alternative.

Excavated material may not be appropriate for backfilling the trench due to organic contamination. If unsuitable, excavated material would be consolidated and placed beneath the cap in the Necco Park facility. Clean fill would be required for use as backfill material to mix with bentonite for slurry wall construction.

Upgrading the existing cap is implementable. Upgrades may include excavating the existing vegetative and protective layer; cutting, filling, and regrading for storm-water control; adding clay to decrease cap permeability; and adding a protective layer and topsoil. Actual specifications will be determined during design.

5.2.13.8 Cost

Costs for alternative 13 are summarized as follows:

- Construction—$19.3 million
- Annual O&M—$6.2 million
- Present worth (30 years, 7 percent)—$96.5 million

Detailed cost components are itemized in Appendix E and summarized in the following paragraphs.

Construction cost includes the cost of installing a grout curtain, a source area and far-field recovery well system, and a downgradient slurry wall. Recovery well system cost includes well drilling, pumps, piping, electric supply, and control. Slurry wall costs include excavation, on-site disposal of spoils, fill, bentonite, and slurry wall installation.

The cap upgrade cost assumes the following tasks:

- Permeability testing
- Stripping and stockpiling of topsoil
- Repairing existing clay cap and grading
- Adding a protective soil cover

- Replacing the stockpiled topsoil
- Seeding and mulch

O&M cost consists of the following:

- Recovery and monitor well maintenance
- Groundwater monitoring
- Groundwater treatment at CECOS WWTP
- DNAPL observation, evacuation, and disposal
- Cap maintenance (mowing, cap repair)
- Facility maintenance
- Runoff treatment
- Reporting

5.3 Comparative Evaluation Of Alternatives

A summary of the alternatives and the results of the RAA analysis can be found in Table 5-4. The alternatives are compared for each criteria in the subsections that follow.

5.3.1 Protection of Human Health and the Environment

All alternatives except the no action alternative provide some level of protection of the environment by reducing constituent loading to the Niagara River. This loading reduction is quantified in Table 5-3. Constituent levels in the source area will be similar for each alternative because DNAPL in fractured bedrock and in overburden cannot be fully removed. DPE will result in greater source removal, but the resultant effect on source area groundwater cannot be quantified.

Assuming that the aquifer will not be used as a potable source, no risk to human health exists for all alternatives. Under the future residential use scenario, all identified alternatives except for no action will reduce risk. This risk reduction is the result of a reduction of constituent loading to the far field. Based on modeling performed for this AOA, it appears that none of the identified alternatives will reduce future potential risks, assuming construction of a drinking-water well in the far field, to within acceptable risk range. However, due to various uncertainties in modeling fractured bedrock, some alternatives may achieve RAOs in the far field.

The cap will be maintained or upgraded in all alternatives except for no action. This cap would protect human health by preventing contact with contaminated soil. The cap also acts to minimize precipitation percolation through contaminated soil and thus minimize constituent migration. The benefit of an upgraded cap is minimal because the primary direction of A zone groundwater flow is vertically to lower zones, and alternatives 2 through 13 include groundwater extraction in upper bedrock zones, which effectively captures A zone groundwater.

5.3.2 Compliance with ARARs

All alternatives (except for alternative 13) have a similar degree of ARAR attainment. None of the identified alternatives would achieve the groundwater chemical-specific limits identified in the following ARARs: New York Safe Drinking-Water Act Standards, New York Surface-Water and Groundwater-Quality Standards and Effluent Standards, Federal Safe Drinking-Water Act, National Primary Drinking-Water Standards and Amendments, National Secondary Drinking-Water Standards, Niagara County Drinking-Water Standards, and the Coastal Zone Management Act.

No alternative completely complies with the Coastal Zone Management Act. Specifically, the Coastal Zone Management Policy 38 states that "the quality and quantity of surface-water and groundwater supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply." All other ARARs would be achieved or are not applicable to the alternatives evaluated.

Alternatives 2 through 13 reduce far-field constituent loading from the source area to varying degrees. MCLs may not be achieved in the far field due to the effects of matrix diffusion.

The second RAO is control of source material (DNAPL and contaminated soil) to minimize direct exposure and impact on groundwater quality. Alternatives 2 through 13 reduce far-field contaminant loading through groundwater extraction, thereby improving groundwater quality. Alternatives 9 through 11 and 13 include total hydraulic control of A through F zones in the source area. Alternative 12 includes hydraulic control of A through G zones in the source area. In addition to active remedial measures, all alternatives include interception of a portion of far-field groundwater by the existing utility drains where a portion of collected groundwater is then treated at the Niagara Falls POTW.

Alternatives with a downgradient slurry wall or DPE (alternatives 4, 5, and 7 through 13) limit DNAPL migration in A zone. Alternatives with a complete source area grout curtain (alternatives 9 and 13) limit horizontal DNAPL migration in B through F zones through the use of a vertical barrier. Alternative 12 includes a source area grout curtain to limit horizontal DNAPL migration in the B through G zones. Because of the unpredictable nature of DNAPL movement and the potential that DNAPL exists under the BFI landfill, no alternative can completely contain DNAPL.

Based on loading estimates made for this AOA, remedial activities at Necco Park and treatment of Falls Street tunnel discharges have accomplished the 50 percent target reduction established in the Four-Party Agreement. Alternatives 3 through 13 gradually increase loading reductions, thereby accomplishing the target reduction.

5.3.3 Long-term Effectiveness and Permanence

The constituent loading reductions for each alternative are included in Table 5-4. All alternatives, except for no action, rely on pump-and-treat technology and a grout curtain (either existing or additional) for hydraulic control. Pump-and-treat systems require periodic maintenance to maintain effectiveness of the hydraulic control system.

Alternatives 9, 12 and 13 include a downgradient grout curtain. This grout curtain may provide a permanent and reliable barrier to DNAPL migration. However, these alternatives do not contain DNAPL that may have migrated under the BFI landfill.

A low-permeability cap, which is included in alternatives 2 through 13, is effective in reducing potential contact with constituents and minimizing precipitation percolation. With maintenance, the cap is a permanent containment technology.

5.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

All alternatives, except for no action, include technologies to reduce constituent toxicity once it is removed from the environment. Alternatives that include groundwater extraction (alternatives 2 through 13) reduce aqueous constituent toxicity through treatment at the CECOS WWTP. The CECOS WWTP treats aqueous-phase constituents by metal precipitation, air stripping, vapor-phase carbon adsorption, and liquid-phase carbon adsorption. Alternative 13 includes treatment at the POTW. The POTW treats aqueous-phase constituents through physical-chemical treatment. Liquid-phase toxicity is reduced in alternatives 2 through 13 through the use of an off-site incinerator that destroys DNAPL. Vapor-phase toxicity is reduced in DPE alternatives (alternatives 5, 8, and 11) by treatment.

Existing utility drains impact the reduction of constituent mobility because they intercept groundwater flow in D through G zones and partially intercept flow in B and C zones. Effects of the utility drains are considered as part of all alternatives.

Alternatives 2 through 13 include maintaining a cap that limits percolation precipitation, thus limiting mobility of overburden constituents. Groundwater pumping and treatment also reduces constituent mobility. The extent of aqueous constituent mobility reduction can be measured by the constituent loading reduction (see Table 5-4).

Alternatives with slurry walls (alternatives 4, 7, 9, 10, 12, and 13) reduce mobility of aqueous and DNAPL constituents in A zone. Grout curtain alternatives (alternatives 9, 12, and 13) reduce mobility of DNAPL in B through F zones and G zone (alternative 12) through the use of a vertical barrier.

The reduction of aqueous-phase constituent volume can also be measured by the constituent loading reduction (see Table 5-4). Alternatives 2 through 13 include extraction of DNAPL, which reduces DNAPL volume. Alternatives that include DPE (alternatives 5, 8, and 11) may result in greater DNAPL volume reduction through the use of vacuum extraction in overburden and upper bedrock zones. Treatability studies are required to determine the extent of reduction and effect on groundwater quality.

5.3.5 Short-term Effectiveness

Once completed, all alternatives will require a similar amount of time to attain full effectiveness (steady-state constituent concentrations in the far field). Alternative 13 may reach a steady-state condition in a slightly shorter time period due to far-field pumping.

Alternatives that physically disturb overburden material may create short-term risks due to organic constituent volatilization. A significant amount of overburden material is disturbed in alternatives that include a slurry wall (alternatives 4, 7, 9, 10, 12, and 13).

Alternatives that include a grout curtain (alternatives 9, 12, and 13) or that require expansion of the CECOS WWTP (alternatives 10 and 11) will require the longest time to implement (up to five years) because of the need for extensive construction activities. DPE alternatives (alternatives 5, 8, and 11) require one to three years to construct because of the need for a pilot study.

5.3.6 Implementability

Alternatives 1 and 2 require no further construction and, therefore, are the easiest to implement. Alternative 3 requires a cap upgrade and an additional DNAPL extraction well to implement.

Alternatives 4, 7, 9, 10, 12, and 13 include a slurry wall. A slurry wall may be difficult to implement because of the need to excavate through contaminated overburden.

DPE alternatives (alternatives 5, 8, and 11) require treatability studies to determine the effectiveness of the system on Necco Park and to complete the detailed design. DPE alternatives also include an extensive well, piping, and vapor-phase treatment system.

Alternatives 10 and 11 require expansion of the CECOS WWTP. This will require agreement to expand by CECOS, followed by design and construction. Negotiations between CECOS and DuPont would be required to determine if this alternative is implementable.

Grout curtain alternatives require a long time (up to five years) to implement. The grout curtain may be difficult to implement due to physical limitations and the use of right-of-ways.

Alternative 13 would be the most difficult to implement because it includes installation of a grout curtain and construction of an extensive far-field pump-and-treat system. The far-field pump-and-treat system requires permission from commercial or residential property owners to install extraction wells. Right-of-ways are also necessary for connection to the sanitary sewer system.

5.3.7 Cost

The alternatives' costs are included in Table 5-4. Alternative 1 has the lowest present worth followed by alternatives 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13. The cost for organic loading reduction is also listed in Table 5-3.

5.3.8 Summary

A summary of the comparative evaluation is included in Table 5-5.

6.0 REFERENCES

Bodocsi, A., et al. November 1993. *Review and Evaluation of Containment Technologies for Remediation Applications.*

Calspan. 1978. *Soils Hydrologic and Groundwater Quality Investigations in the Vicinity of DuPont Necco Park Landfill.*

Constable, S. 1993. *Evaluation of Groundwater Treatment Alternatives for Necco Park.*

EPA. August 1994. *Evaluation of Technologies for In Situ Cleanup of DNAPL-Contaminated Sites.* EPA/600/R-94/120.

_____. 1993. *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration.* OSWER Directive 9234.2-25, EPA/540/R-93/080.

_____. 1993. *DNAPL Site Evaluation.* EPA/600/R-93/022.

_____. 1992. *Dense Nonaqueous-Phase Liquids*—A Workshop Summary. EPA/600/R-92/030.

_____. 1988. *Guidance on Remedial Actions for Contaminated Ground-Water at Superfund Sites.* OSWER Directive 9283.1-2, EPA/540/G-88/003.

_____. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* OSWER Directive 9355.3-01, EPA/540/G-89/004.

EPA and NYSDEC. June 1994. *Reduction of Toxic Loadings to the Niagara River from Hazardous Waste Sites in the United States: A Progress Report.*

EPA and the United States Air Force. 1993. *Reference Guide—Remediation Technologies Screening Matrix.*

Feenstra, S., et al. 1991. "A method for assessing residual NAPL based on organic chemical concentrations in soil samples," in *GWMR.* Vol. 2, No. 2.

Feenstra, S., D. M. MacKay, and J. A. Cherry. 1991. "A method for assesing residual NAPL based on organic chemical concentrations in soil samples," in *Groundwater Monitoring Review*. Vol. 11, No. 2.

Freeze, R. A. and J. A. Cherry. 1979. *Groundwater.*

Gazaway, H., et al. 1991. *Installation of a Grout Curtain at a Hazardous Waste Landfill*. ASCE Geotechnical Engineering Congress, 1991.

Hunt, James R., and N. Sitar. 1988. "Nonaqueous-phase liquid transport and cleanup," in *Water Resources Research*. Vol. 24, No. 8.

Johnson, R. H. 1964. *Groundwater in Niagara falls Area, New York with Emphasis on the Water-bearing Characteristics of the Bedrock.* New York State Conservation Department Bulletin GW-53, p. 93.

Kappel, W. M. 1995a. Personal Communication with Paul Mazierski, DuPont Environmental Remediation Services.

Kappel, W. M. 1995b. Unpublished Hydrologic Data from Regional Flow Studies Conducted from 1989 through 1995.

Mercer, James W., and R. M. Cohen. 1990. "A review of immiscible fluids in the subsurface: properties, models characterization, and remediation," in *Journal of Containment Hydrology*. Vol. 6.

Muller, E. H. 1977. *Quaternary Geology of New York Niagara Sheet*. New York State Museum and Science Service, Map and Chart Series Number 28, Albany, New York.

Mutch, R. D., J. I. Scott, and D. J. Wilson. 1993. *The Impact of Matrix Diffusion on the Cleanup of Fractured Igneous, Metamorphic, and Sedimentary Rock Aquifer.* Proceedings of the Fows Conference on Eastern Regional Groundwater Issues. September 27-29, 1993.

National Research Council. 1994. *Alternatives for Groundwater Cleanup.*

New York Center for Hazardous Waste Management. 1993. *Review and Evaluation of Containment Technologies for Remedial Applications.*

O'Brian and Gere Engineers, Gradient Corporation, GeoTrans Inc. October 1987. *Phase I Falls Street Tunnel Study.* City of Niagara Falls, New York.

Recra Research. 1979. *Well N-10 Pumping Study Raw Data and Observations of Water-Level and Water-Quality Variations.*

Shiu, W. Y., A Maijanen, A. L. Y. Ng, and D. Mackay. 1988. "Preparation of aqueous solutions of sparingly soluble organic substances: II. multicomponent system—hydrocarbon mixtures and petroleum products," in *Environ. Toxicology and Chemistry.* Vol. 7.

Tesmer, I. H. 1981. *Colossal Cataract—The Geologic History of Niagara Falls.* State University of the New York Press, Albany.

TRC. 1993. *Final Risk Assessment.* DuPont Necco Park Site, Niagara Falls, New York.

Weston, Roy F.. 1982. *Evaluation of Proposed Recovery Well System, Necco Park Landfill.*

_____. 1981 *Groundwater Information Update, Necco Park.*

_____. 1979 *Hydrogeologic Evaluation, Necco Park Landfill.*

_____. 1978. *Boring Logs, Well Installation, and Conditions Encountered while Drilling.*

Woodward-Clyde Consultants. 1993. *Investigation Report for Necco Park.*

_____. 1991. *Interpretive Report for Necco Park.*

_____. 1990. *Necco Park Subsurface Formation Repair Interim Performance Report.*

_____. 1988. *Geologic Report for Necco Park.*

_____. 1985. *Endangerment Assessment for Necco Park.*

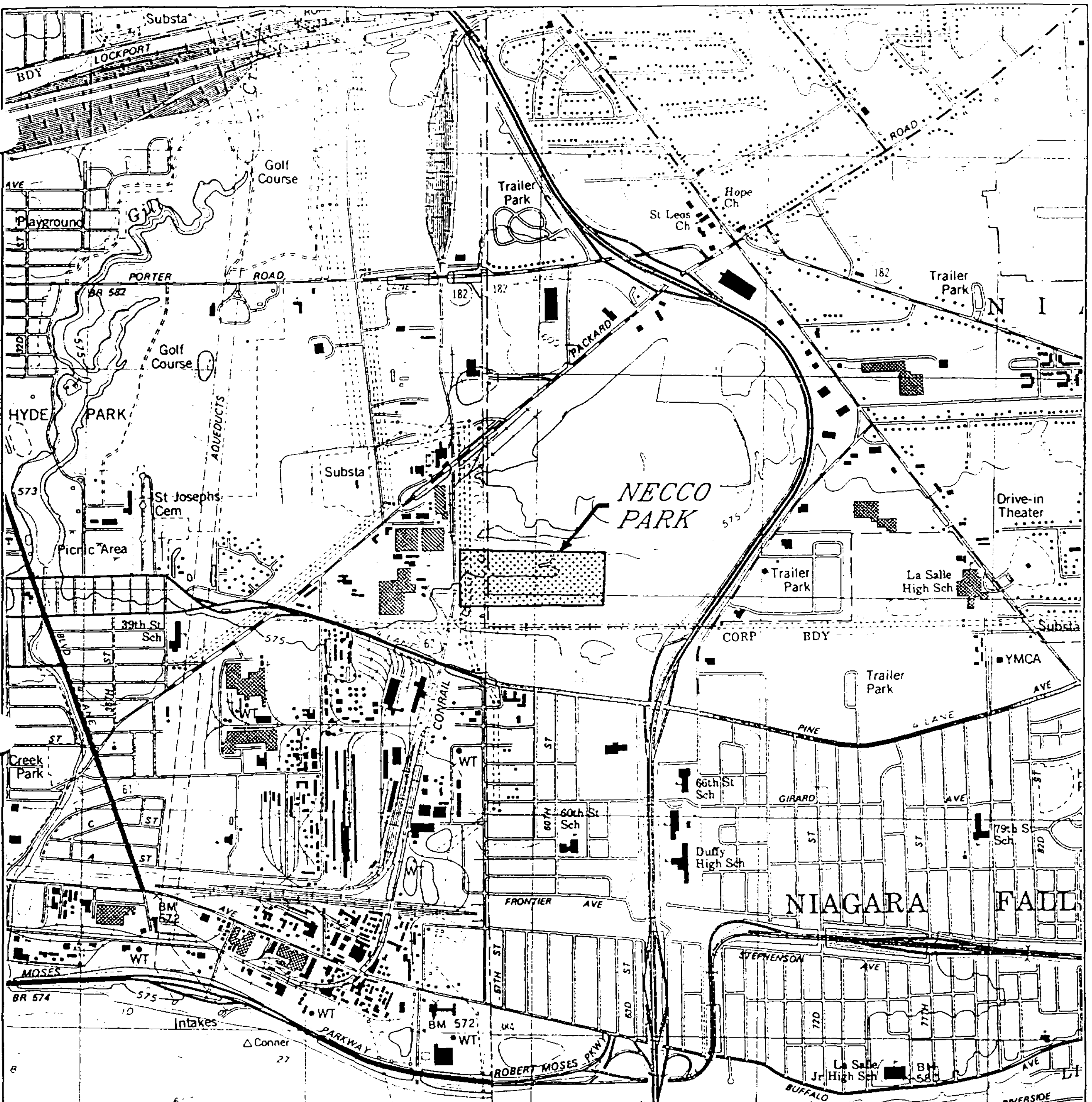
_____. 1984. *Site Assessment Studies, Necco Park* Volumes I and II.

Woodward-Clyde Consultants and Conestoga-Rovers and Associates. 1992. *Niagara Falls Regional Groundwater Assessment.* DuPont Chemicals, Occidental Chemical Corporation, Olin Chemicals.

Yeager R. M., and W. M. Kappel. 1987. *Detection and Characterization of Fractures and their Relation to Groundwater Movement in Lockport Dolomite*, Niagara County, New York. U.S. Geological Survey, Water Resources Division.

Zenger, D. H. 1965. *Stratigraphy of the Lockport Formation (Middle Silurian) in New York State.* New York State Museum and Science Service, Bulletin Number 404.

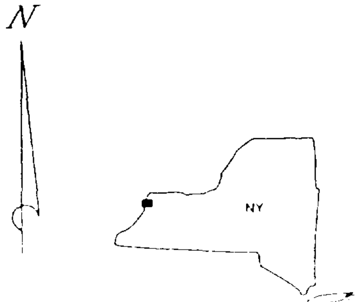
FIGURES



SCALE 1:24,000

0 2000 4000 FEET

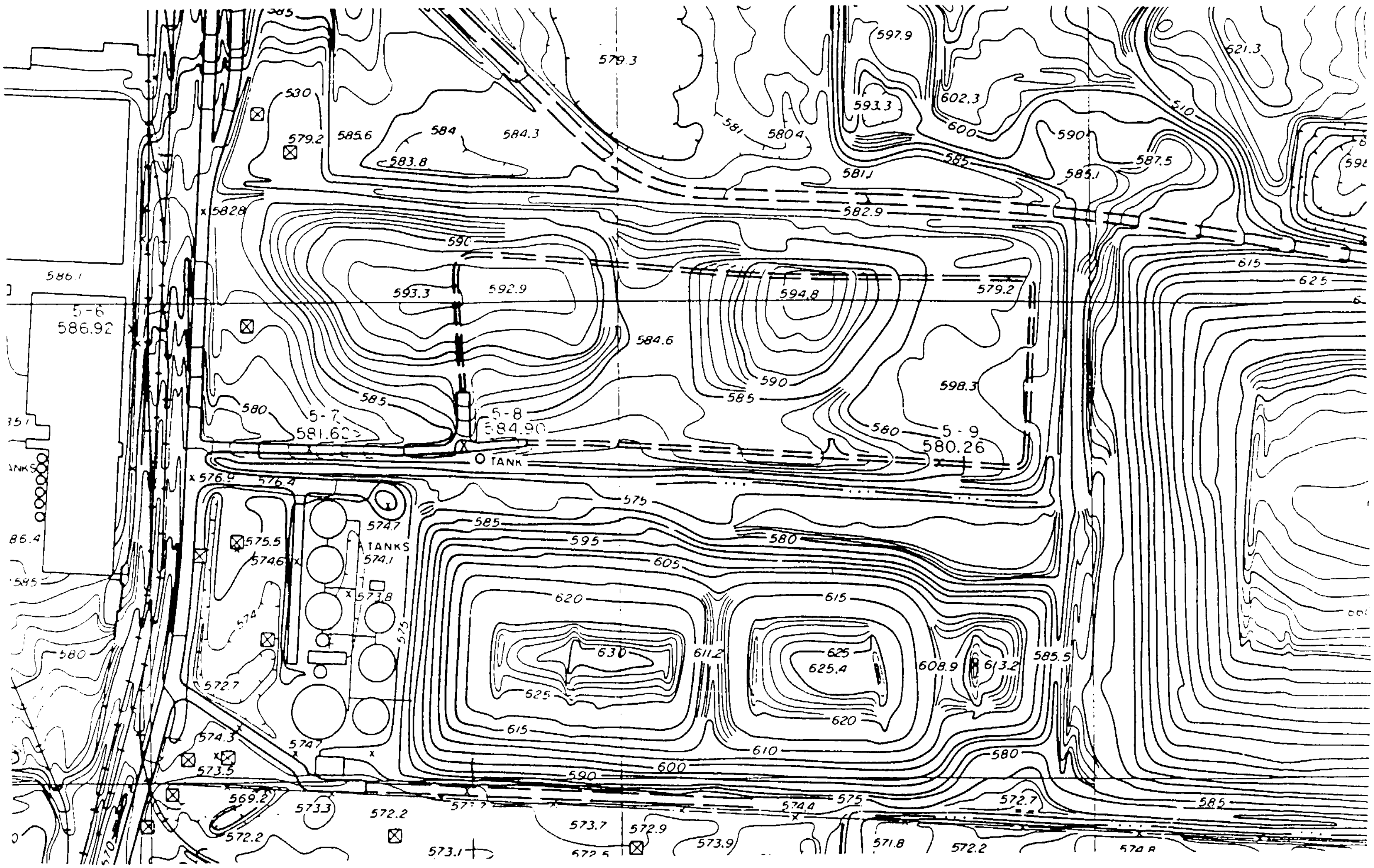
0 1 MILE

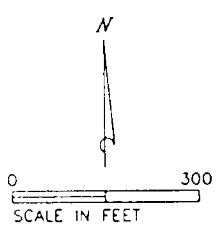


SOURCE: NIAGARA FALLS, NY-ONT & TONAWANDA WEST, NY QUADRANGLES, 7.5' SERIES

FIGURE 1-1	SITE LOCATION MAP			
	SCALE 1"=2000'	DESIGNED BY	DRAWN BY SMM	CAD DRAWING NO
	DATE 4/21/95	CHECKED PFM	APPROVED JMM	PROJECT NO 1281
DU PONT	DU PONT NECCO PARK NIAGARA FALLS, NY			
	Du Pont Environmental Remediation Services			

400438



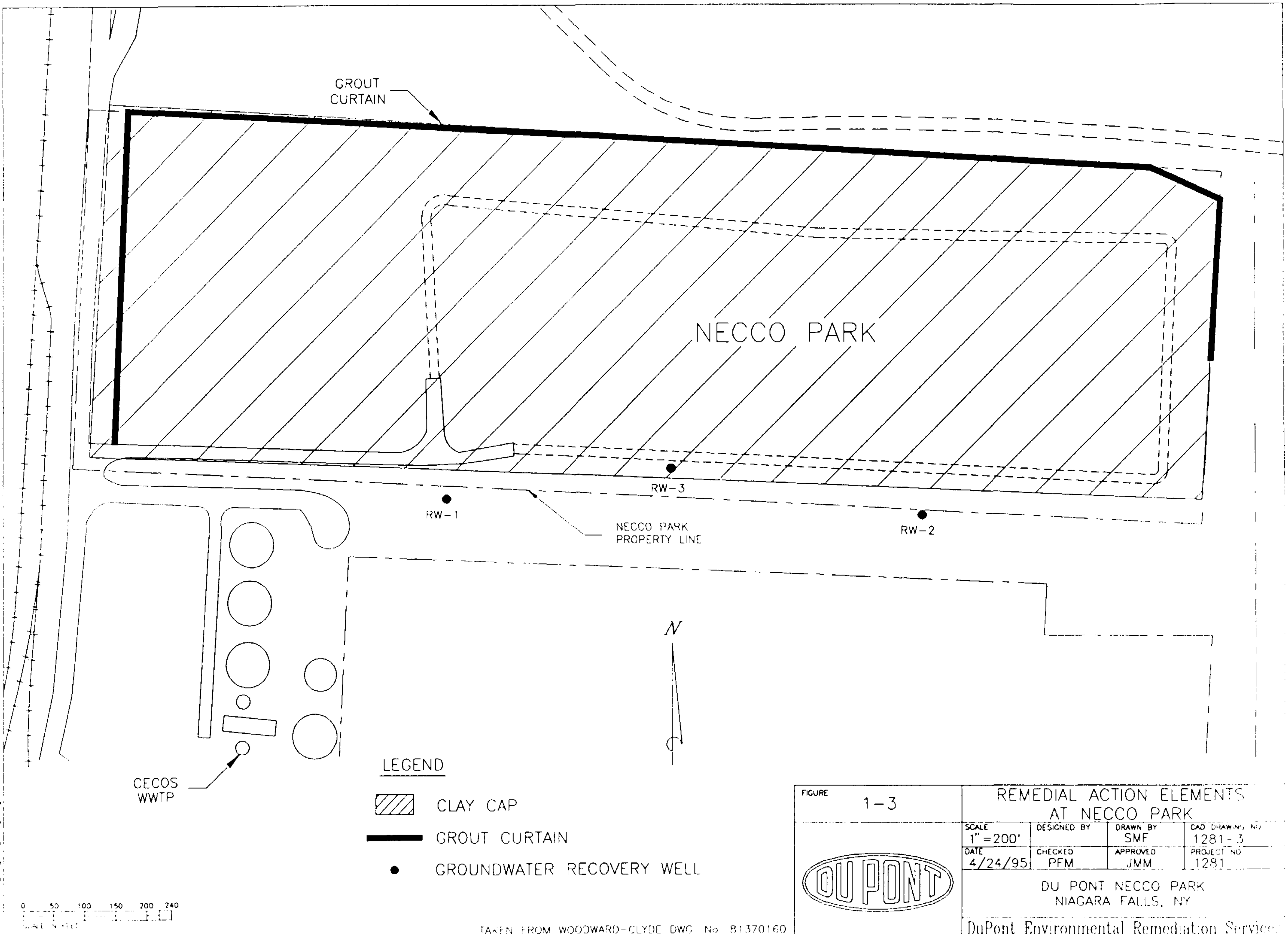


TAKEN FROM TOPOGRAPHIC MAP OF
NECCO PARK LANDFILL
ABRAMS AERIAL SURVEY CORP.

FIGURE 1–2	LOCAL TOPOGRAPHY		
	SCALE 1" = 300'	DESIGNED BY	DRAWN BY
	DATE 4/21/95	CHECKED PFM	APPROVED JMM
DUPONT	DUPONT NECCO PARK NIAGARA FALLS, NY		
	DuPont Environmental Remediation Serv		

CAD DRAWING; PROJECT NO 1281

400439



GROUT CURTAIN
NECCO PARK
RW-3
RW-1
RW-2
NECCO PARK PROPERTY LINE
N
CECOS WWTP
LEGEND
CLAY CAP
GROUT CURTAIN
GROUNDWATER RECOVERY WELL
0 50 100 150 200 240
TAKEN FROM WOODWARD-CLYDE DWG No. 81370160
FIGURE 1-3
REMEDIAL ACTION ELEMENTS AT NECCO PARK
SCALE 1"=200'
DESIGNED BY
DRAWN BY SMF
CAD DRAWING NO 1281-3
DATE 4/24/95
CHECKED PFM
APPROVED JMM
PROJECT NO 1281
DU PONT NECCO PARK
NIAGARA FALLS, NY
DuPont Environmental Remediation Services

400440

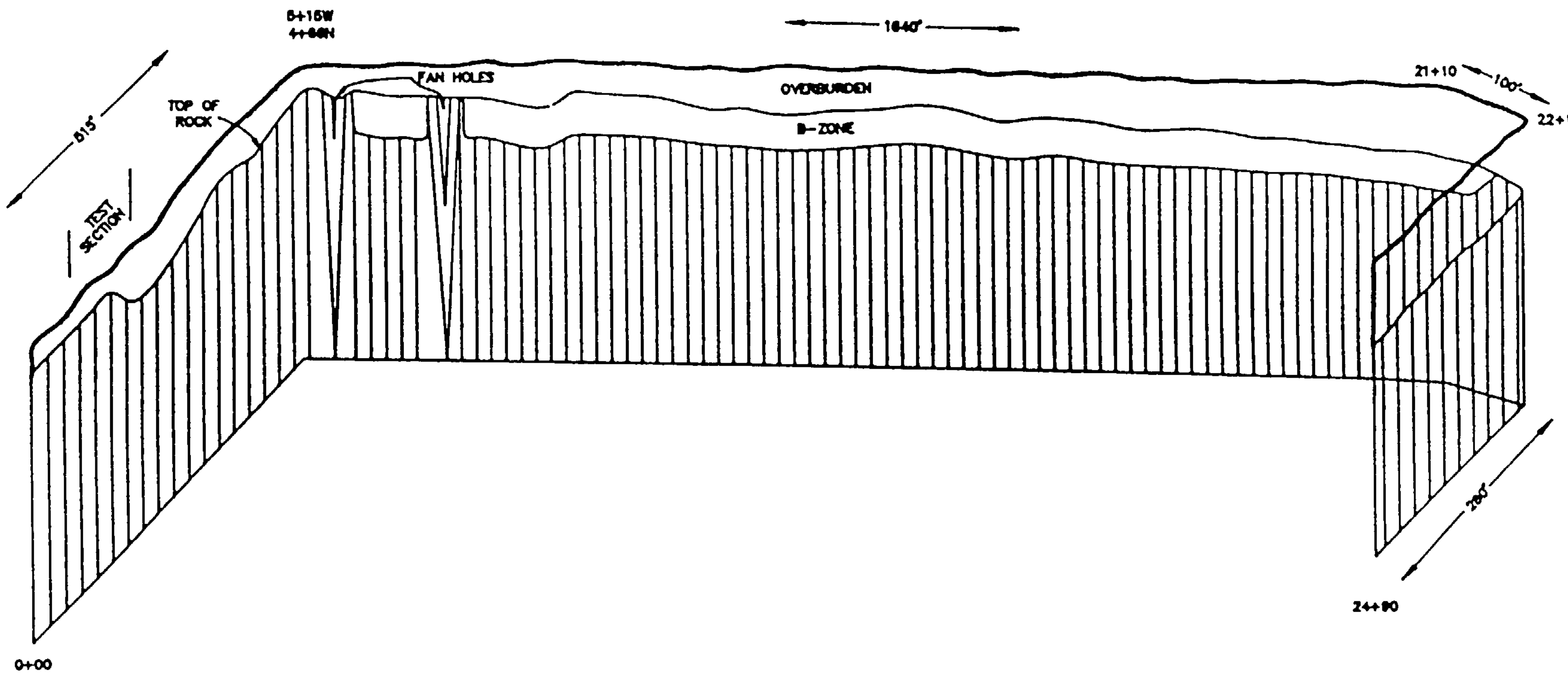
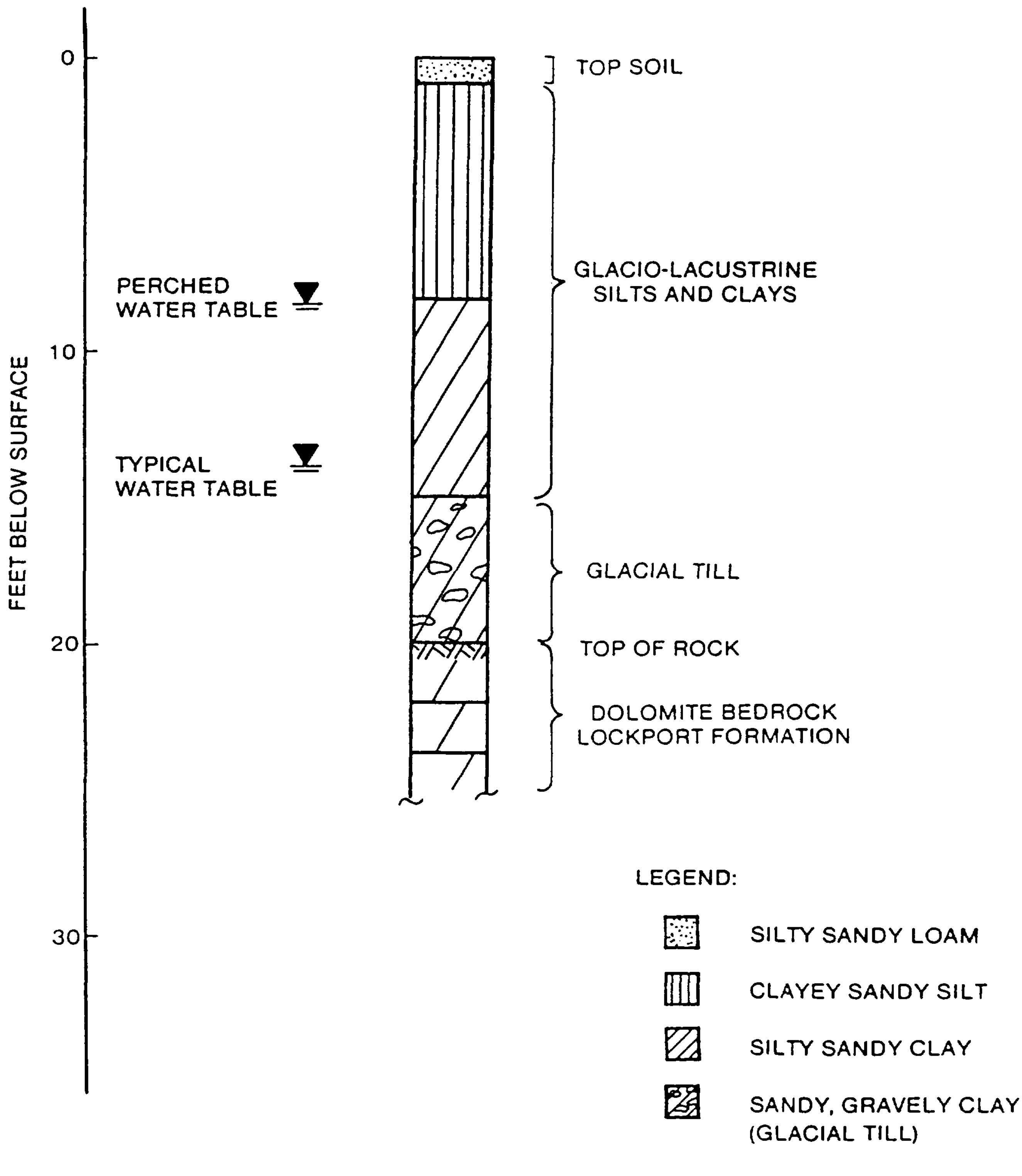


FIGURE 1-4	GROUT CURTAIN PROFILE			
	SCALE AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING
	DATE 4/21/95	CHECKED PFM	APPROVED JMM	PROJECT NO. 1281
DU PONT	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Ser.			

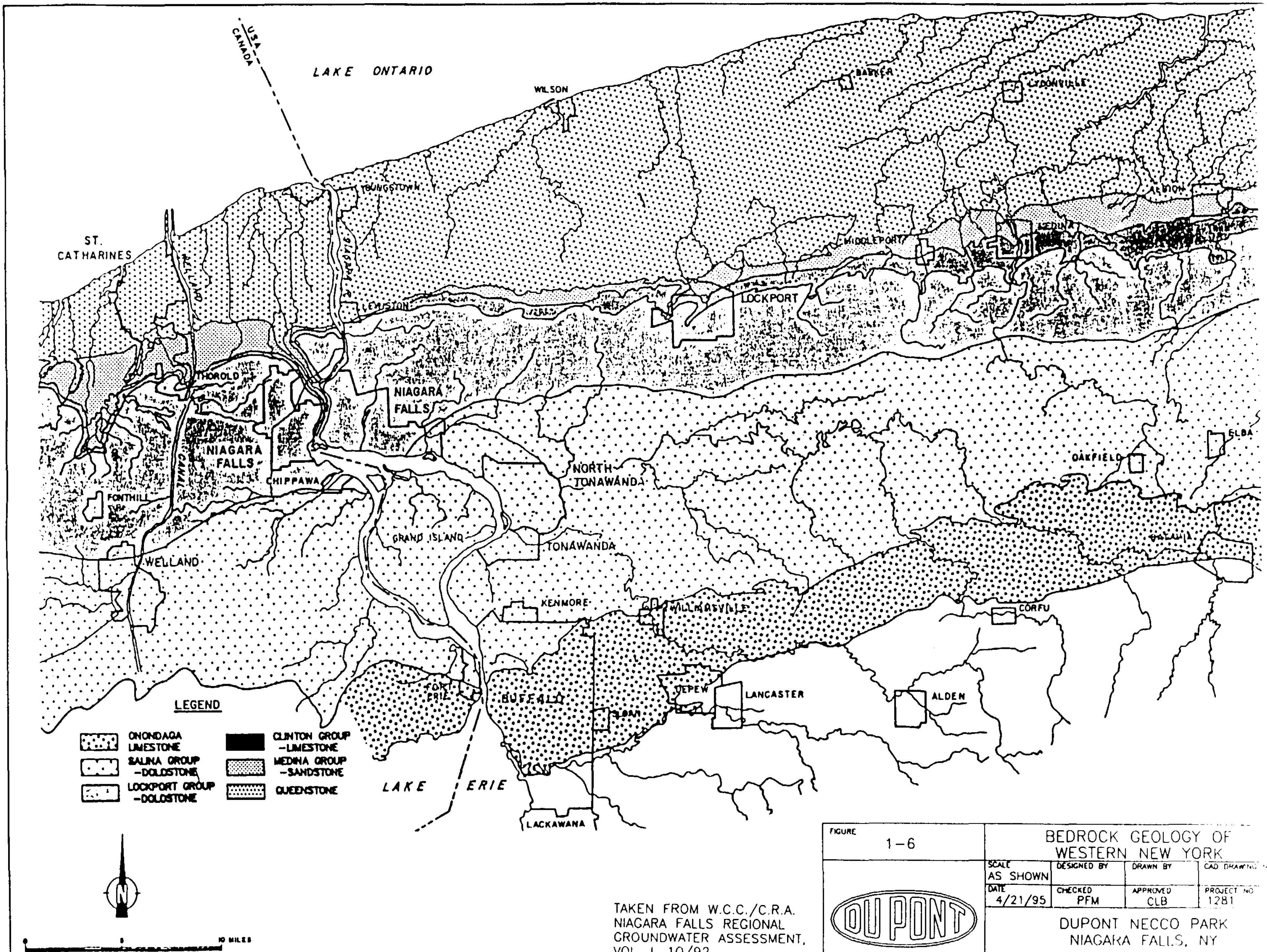
400441



TAKEN FROM W.C.C.
GEOLOGIC REPORT
NECCO PARK, VOL. I
8/88

FIGURE 1–5	OVERBURDEN STRATIGRAPHIC CROSS SECTION		
SCALE AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING NO
DATE 4/21/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281
DUPONT	DUPONT NECCO PARK NIAGARA FALLS, NY		
	DuPont Environmental Remediation Services		

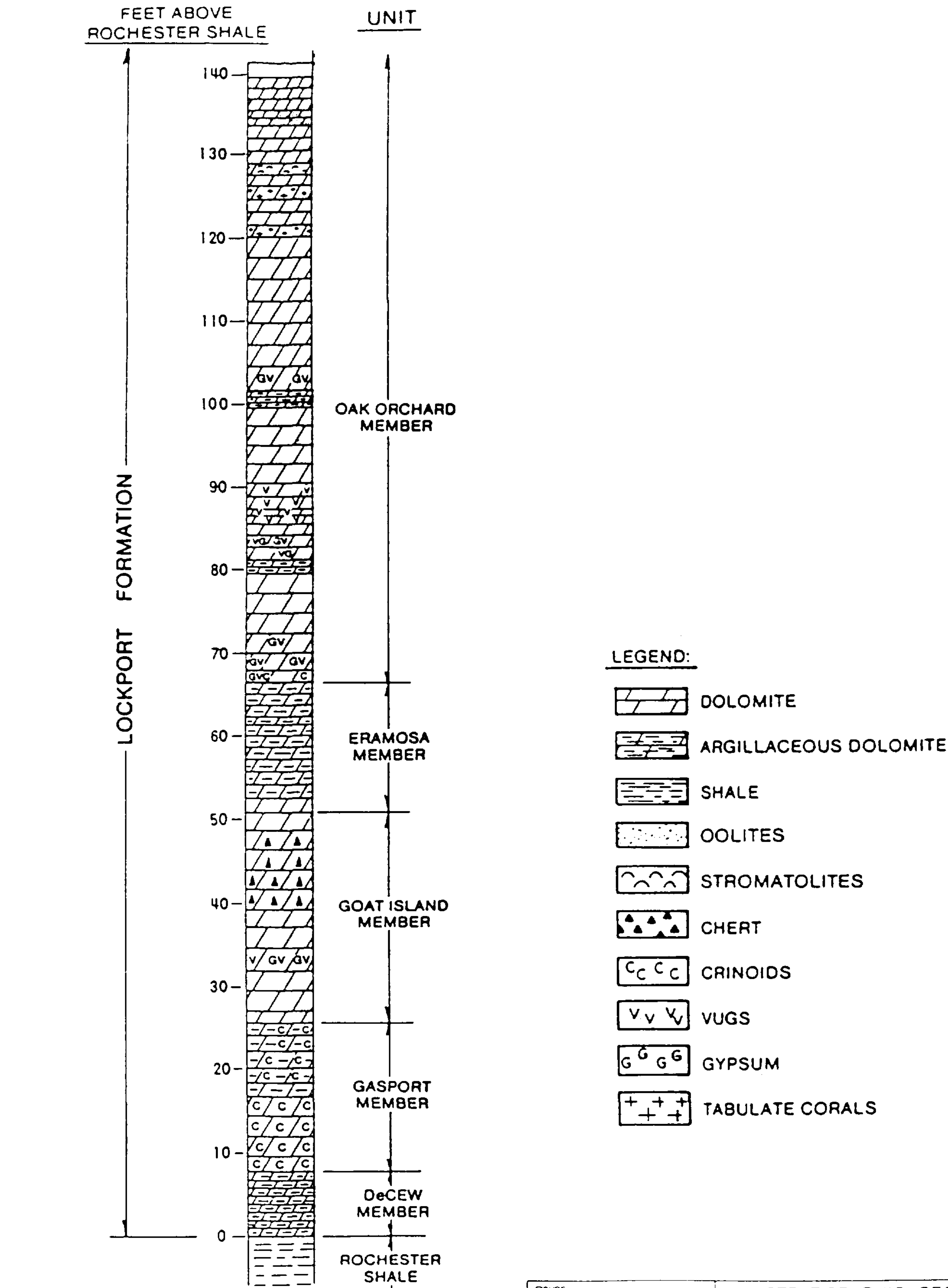
400442



TAKEN FROM W.C.C./C.R.A.
NIAGARA FALLS REGIONAL
GROUNDWATER ASSESSMENT,
VOL. I, 10/92

FIGURE	BEDROCK GEOLOGY OF WESTERN NEW YORK			
1-6	SCALE AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING
	DATE 4/21/95	CHECKED PFM	APPROVED CLB	PROJECT NO. 1281
DUPONT	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Serv			

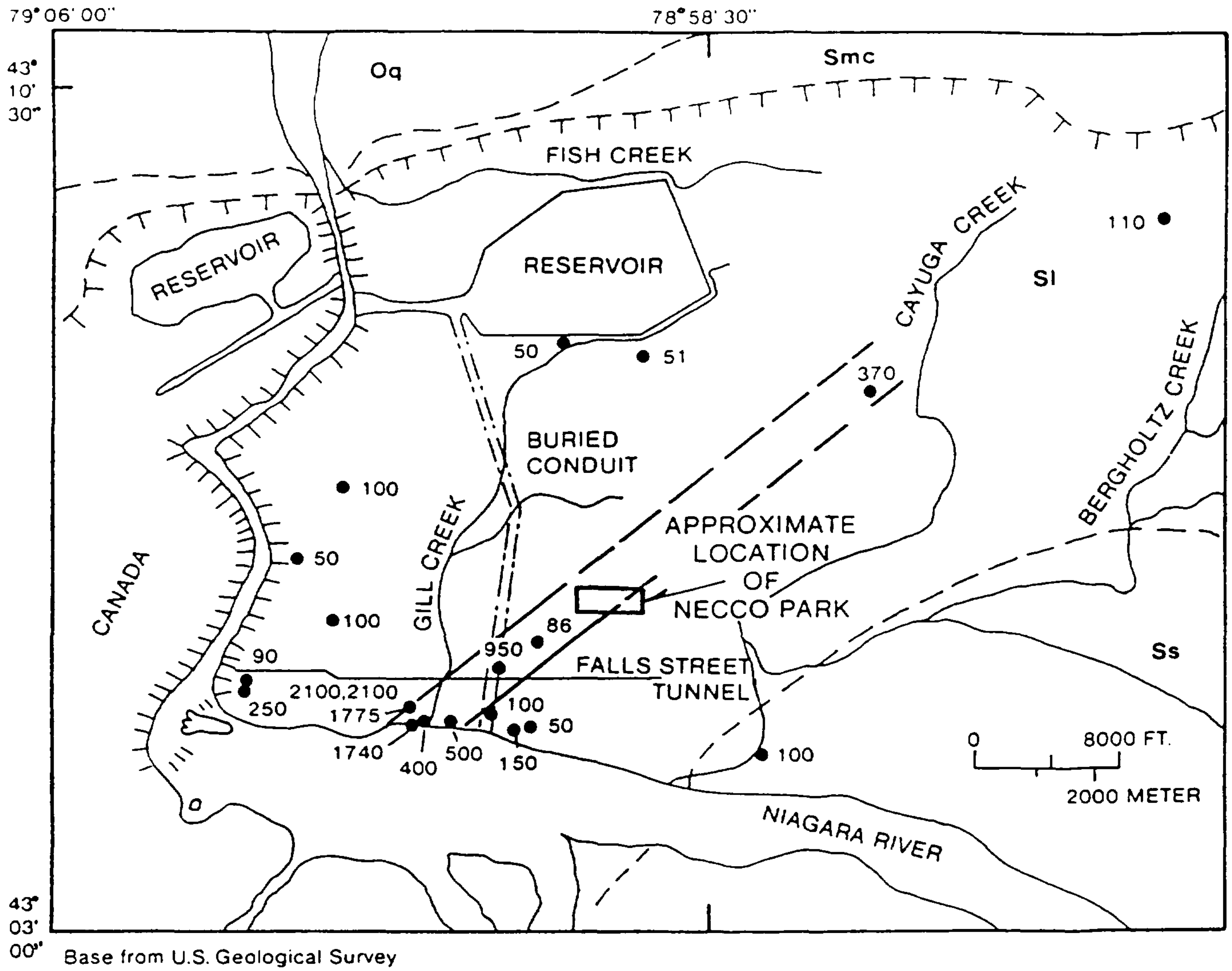
400443



TAKEN FROM W.C.C.
GEOLOGIC REPORT
NECCO PARK, VOL. I
8/88

FIGURE 1–7	STRATIGRAPHIC SECTION OF THE LOCKPORT FORMATION			
DUPONT	SCALE AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING NO
	DATE 4/21/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281
	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Services			

400444



Base from U.S. Geological Survey
Niagara Falls, 1948 and Tonowanda 1948, 1:62,500

EXPLANATION

Zone of High Transmissivity identified by Johnston (1964) Dashed where extrapolated

50 Production Well--number is well yield, in gallons per minute

Niagara escarpment

Niagara gorge

Cont act between Geologic Formation or Group

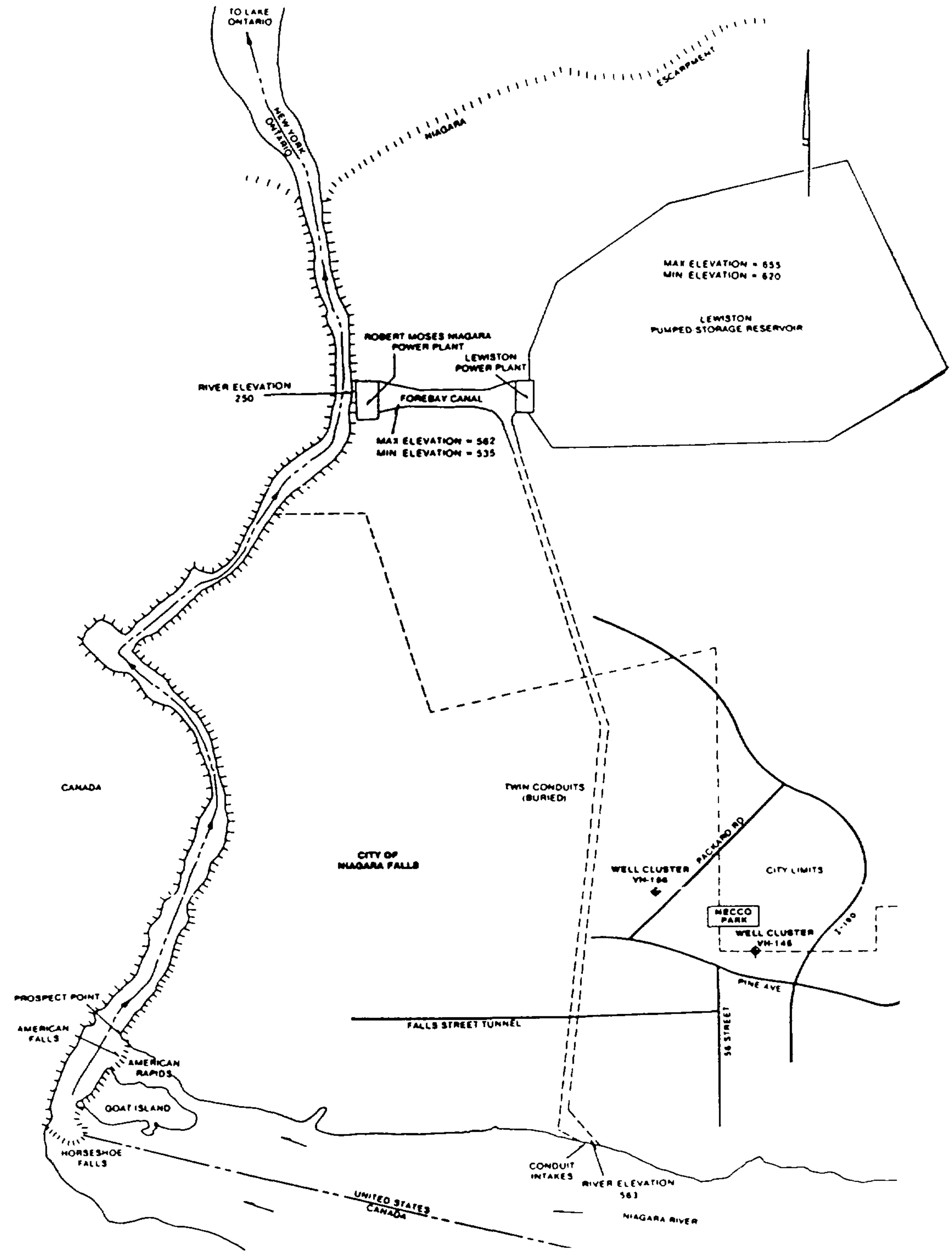
Ss	Silurian Salina Group
SI	Silurian Lockport Group
Smc	Silurian Medina and Clinton Groups
Oq	Ordovician Queenston Formation

(Adapted from Yager and Kappel, USGS 1987.)

TAKEN FROM W.C.C.
GEOLOGIC REPORT
NECCO PARK, VOL. I
8/88

FIGURE 1-8	ZONE OF HIGH TRANSMISSIVITY LOCATION MAP			
	SCALE AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING NO
	DATE 4/21/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281
DU PONT	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Services			

400445

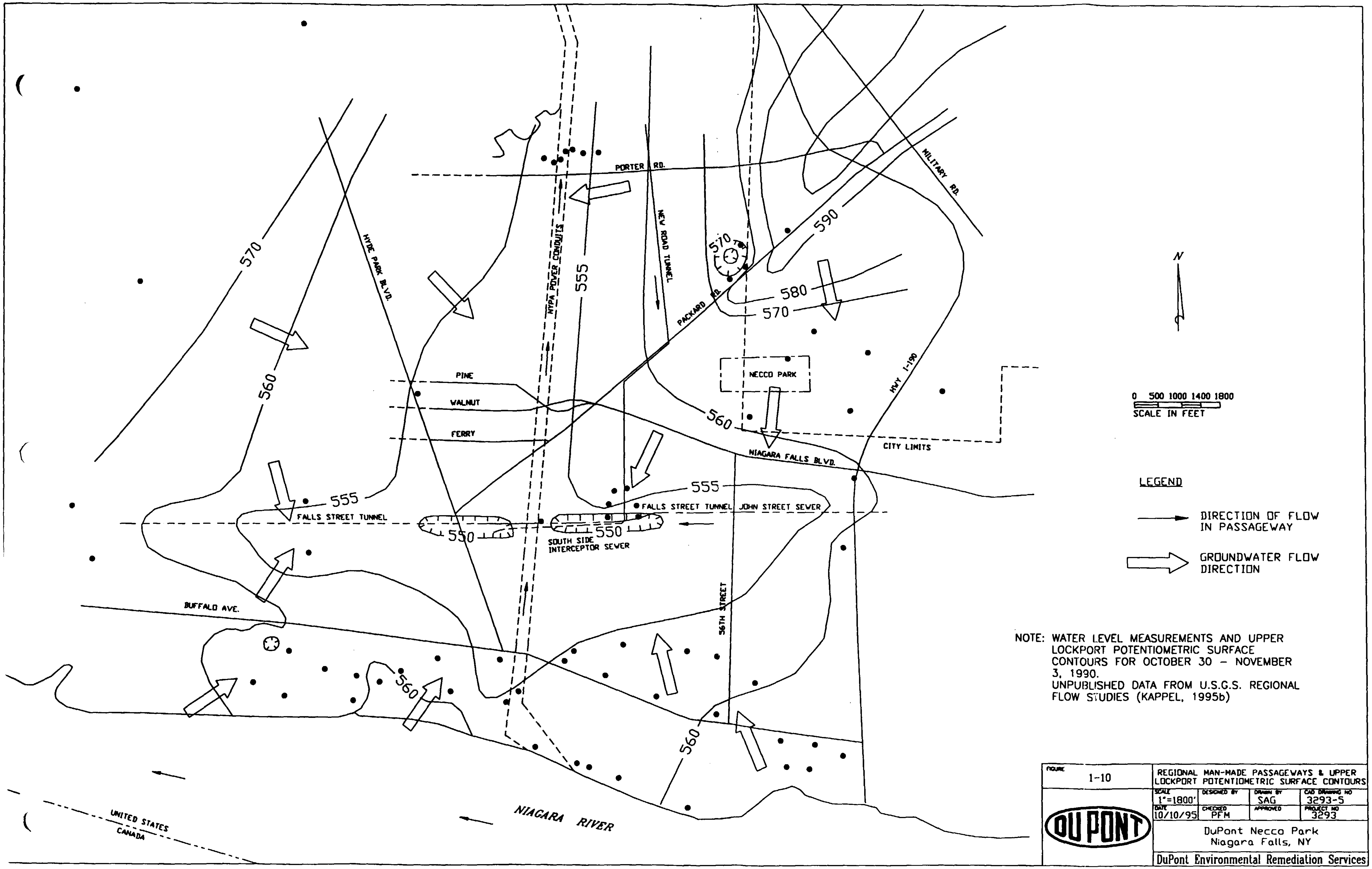


0 4000
SCALE IN FEET

TAKEN FROM PLATE 1B
WATER RESOURCES INVESTIGATIONS REPORT
86-4130
U.S.G.S

FIGURE 1-9	COMPONENTS OF THE NYPA ROBERT MOSES POWER PROJECT			
DUPONT	SCALE AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING NO
	DATE 4/21/95	CHECKED PFM	APPROVED JMM	PROJECT NO 1281
	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Services			

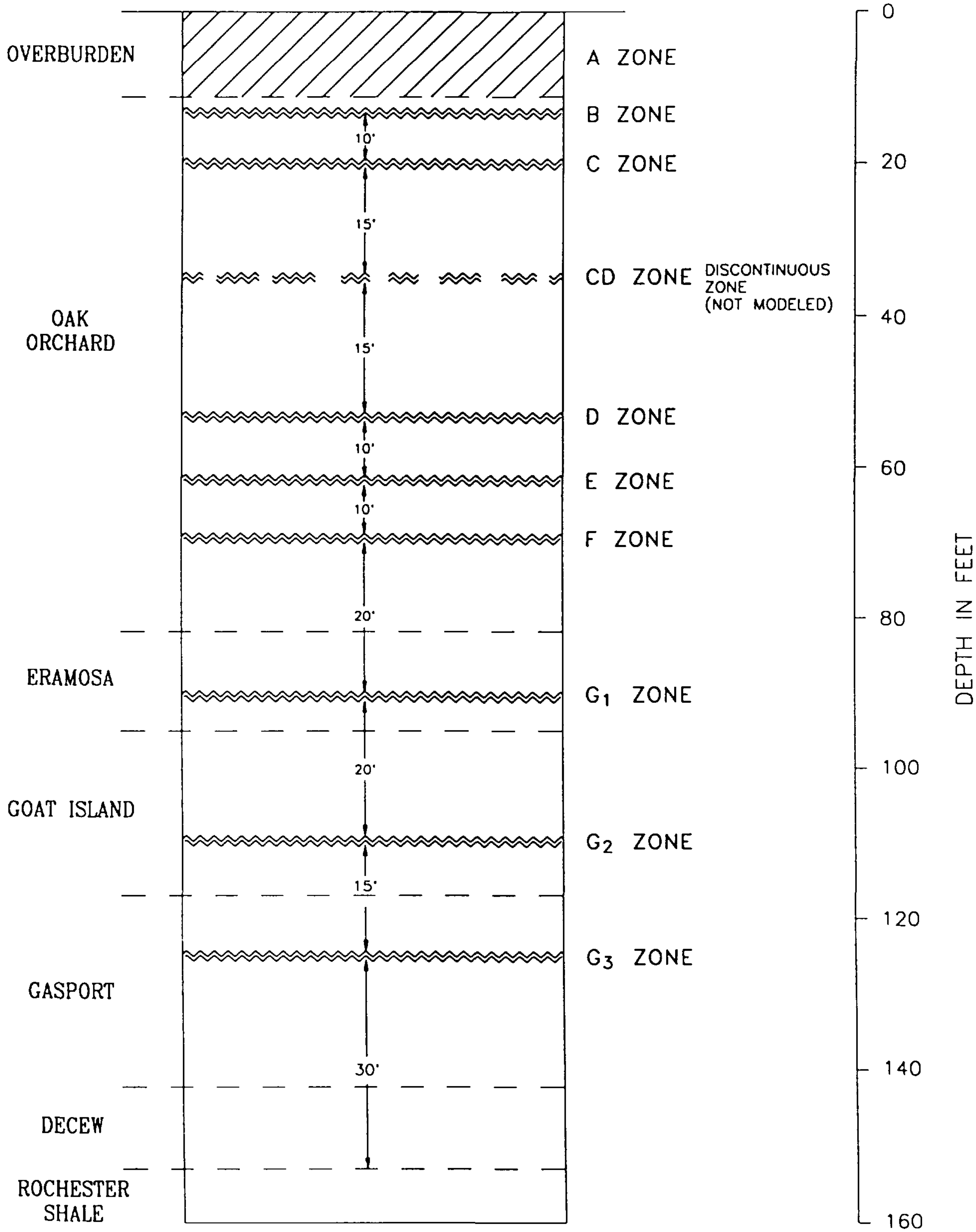
400446



NOTE: WATER LEVEL MEASUREMENTS AND UPPER LOCKPORT POTENTIOMETRIC SURFACE CONTOURS FOR OCTOBER 30 – NOVEMBER 3, 1990.
UNPUBLISHED DATA FROM U.S.G.S. REGIONAL FLOW STUDIES (KAPPEL, 1995b)

FIGURE 1-10	REGIONAL MAN-MADE PASSAGEWAYS & UPPER LOCKPORT POTENTIOMETRIC SURFACE CONTOURS			
DUPONT	SCALE 1"=1800'	DESIGNED BY	DRAWN BY SAG	CAD DRAWING NO 3293-5
	DATE 10/10/95	CHECKED PFM	APPROVED	PROJECT NO 3293
	DuPont Necco Park Niagara Falls, NY			
	DuPont Environmental Remediation Services			

400447

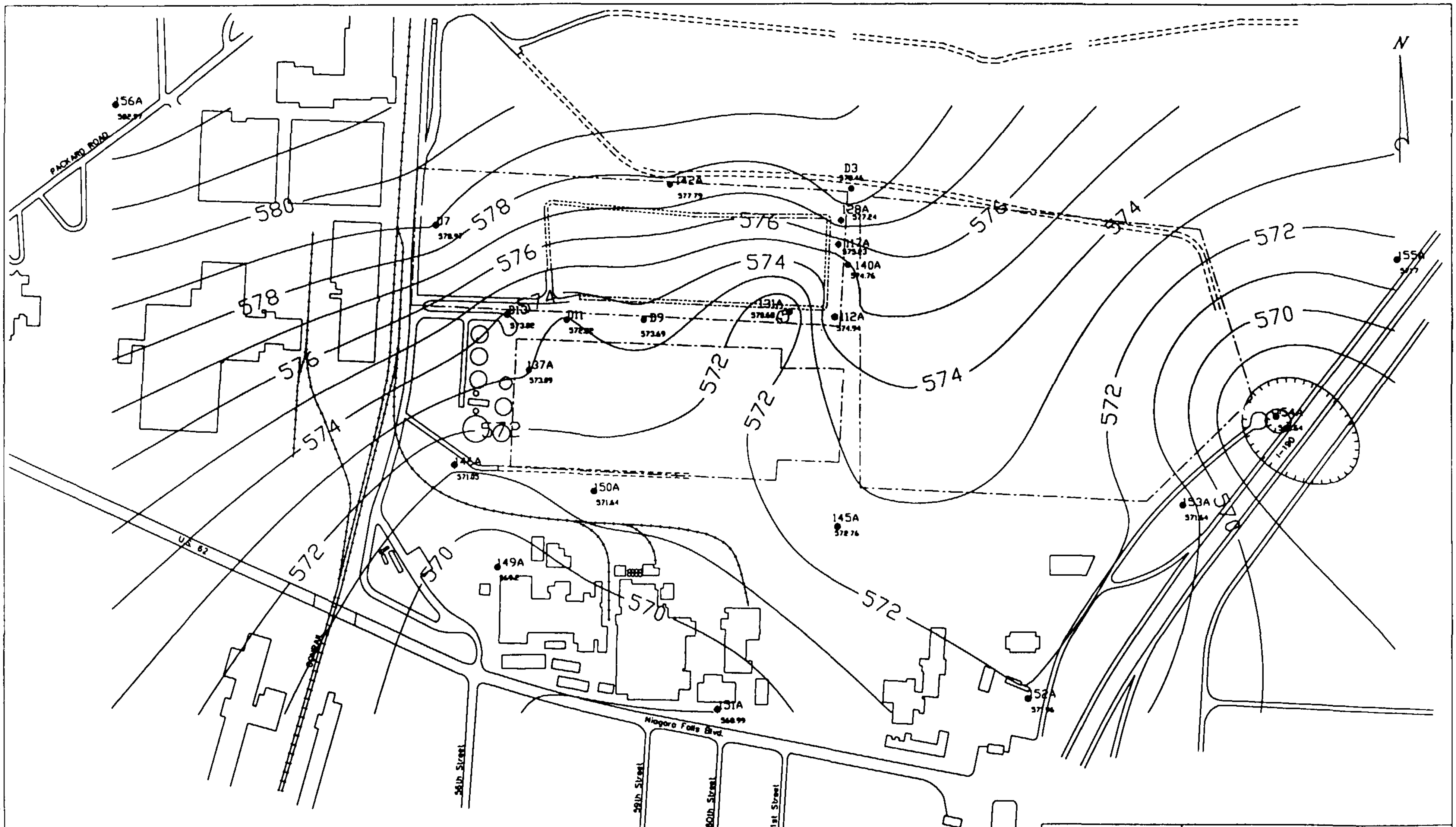


LEGEND

— — STRATIGRAPHIC CONTACT

〰〰 BEDDING PLANE FRACTURE ZONE

FIGURE 1-11	GEOLOGIC CROSS SECTION			
DUPONT	SCALE AS SHOWN	DESIGNED BY PFM	DRAWN BY SMF	CAD DRAWING NO 3293-3
	DATE 4/24/95	CHECKED CLB	APPROVED RGB	PROJECT NO 3293
	DuPont Necco Park Niagara Falls, New York			
	DuPont Environmental Remediation Services			



LEGEND

• MONITORING WELL LOCATION

RECOVERY WELL	PUMPING RATE [1]
RW-1 (D-12)	9.6 gpm
RW-2 (52)	9.8 gpm
RW-3	NOT RUNNING

MEASUREMENT DATE: 3/14/91

1: AVERAGE PUMPING RATE DURING WEEK.

0 200 400 600

SCALE IN FEET

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

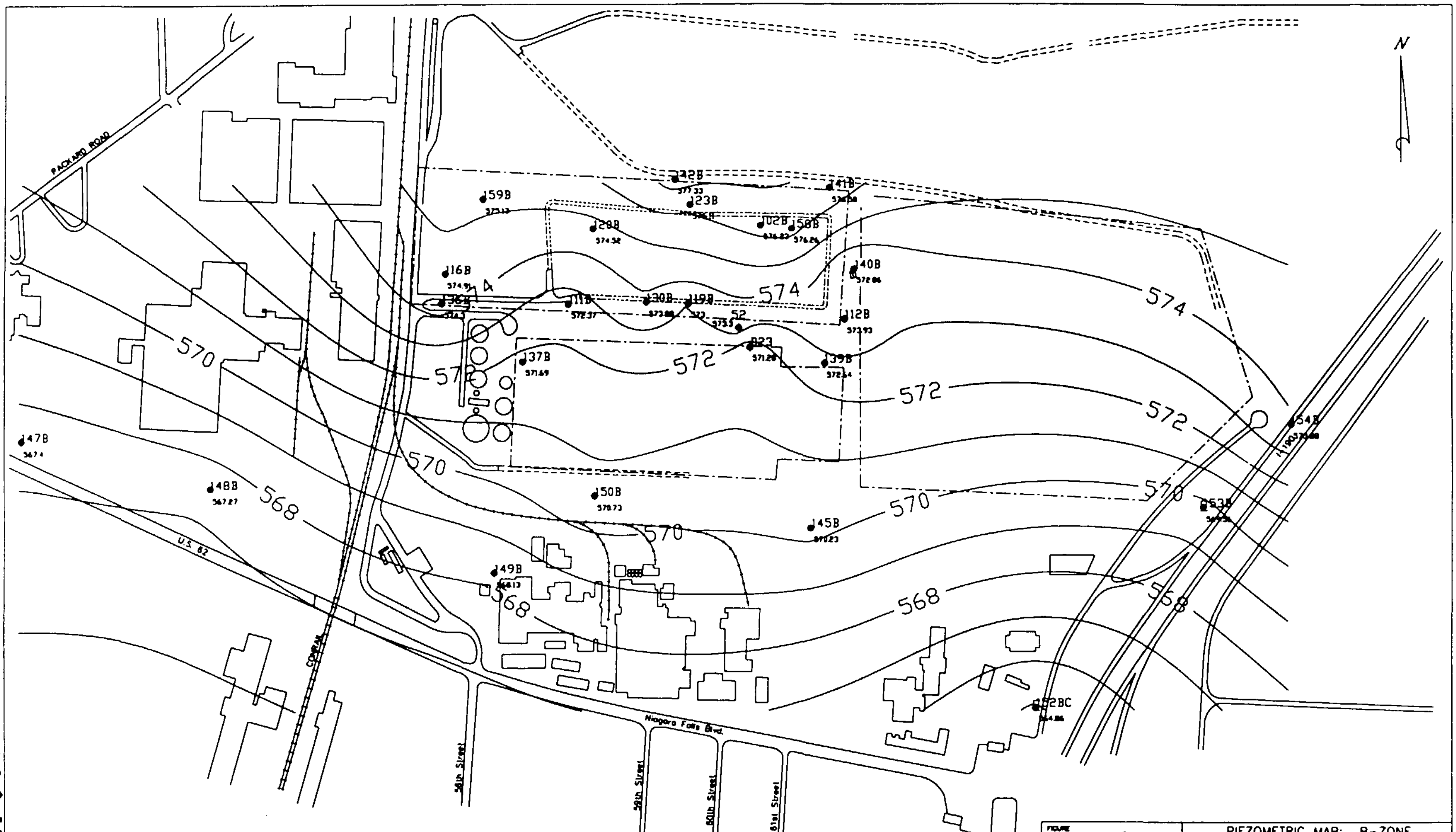
FIGURE	PIEZOMETRIC MAP: A-ZONE		
1-12	SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
	DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281

DUPONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400449



LEGEND

• MONITORING WELL LOCATION

RECOVERY WELL	PUMPING RATE[1]
RW-1 (D-12)	NOT RUNNING
RW-2 (52)	NOT RUNNING
RW-3	NOT RUNNING

MEASUREMENT DATE: 2/13/92

1: AVERAGE PUMPING RATE DURING WEEK.

0 200 400 600
SCALE IN FEET

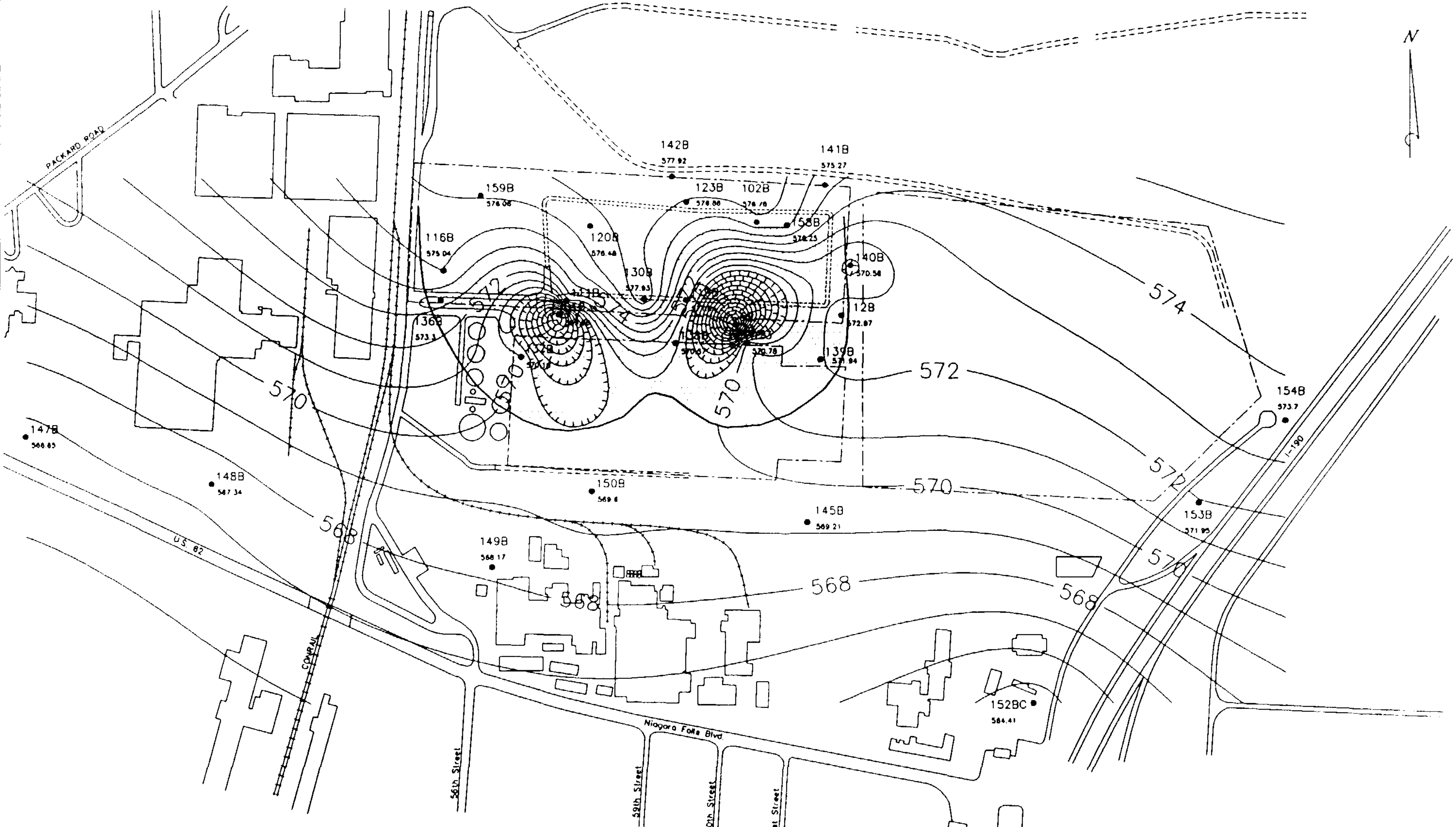
TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-13	PIEZOMETRIC MAP: B-ZONE UNSTRESSED CONDITIONS		
SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO. 1281-1C
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO. 1281

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400450



LEGEND

- • MONITORING WELL LOCATION
- EXTENT OF CAPTURE ZONE

0 200 400 600
SCALE IN FEET

RECOVERY WELL	PUMPING RATE [1]
RW-1 (D-12)	8 gpm
RW-2 (52)	6.1 gpm
RW-3	3.2 gpm

MEASUREMENT DATE: 6/1/92

1: AVERAGE PUMPING RATE DURING WEEK

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-14

POST-GROUT CURTAIN
CONCEPTUAL CAPTURE ZONE: B-ZONE

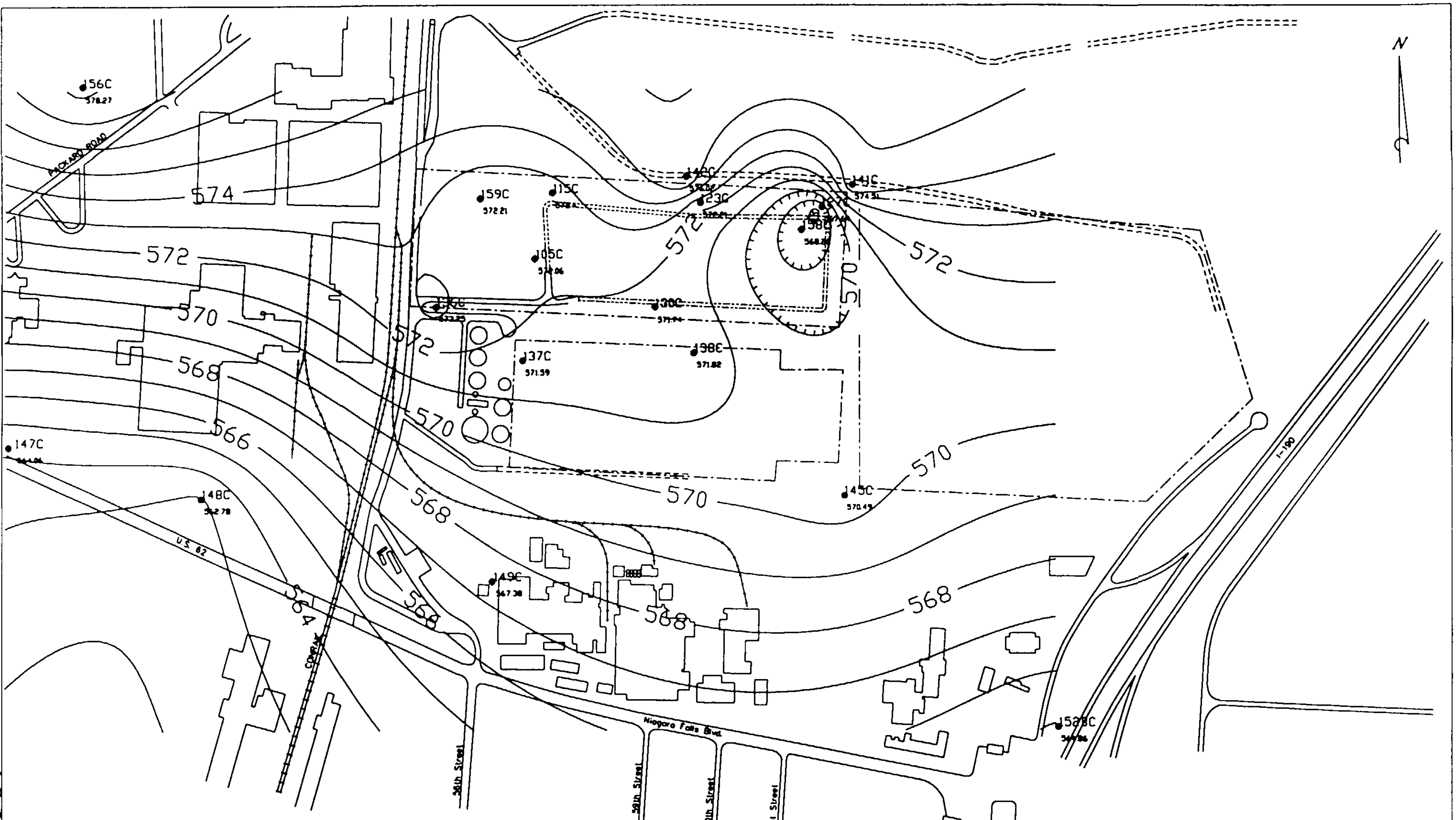
SCALE	DESIGNED BY	DRAWN BY	CAD DRAWING NO
1" = 600'		SMF	1281-1C
DATE	CHECKED	APPROVED	PROJECT NO
4/24/95	PFM	CLB	1281

DUPONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400451



LEGEND

• MONITORING WELL LOCATION

RECOVERY WELL	PUMPING RATE [1]
RW-1 (D-12)	NOT RUNNING
RW-2 (52)	NOT RUNNING
RW-3	NOT RUNNING

MEASUREMENT DATE: 2/13/92

1: AVERAGE PUMPING RATE DURING WEEK.

0 200 400 600
SCALE IN FEET

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-15

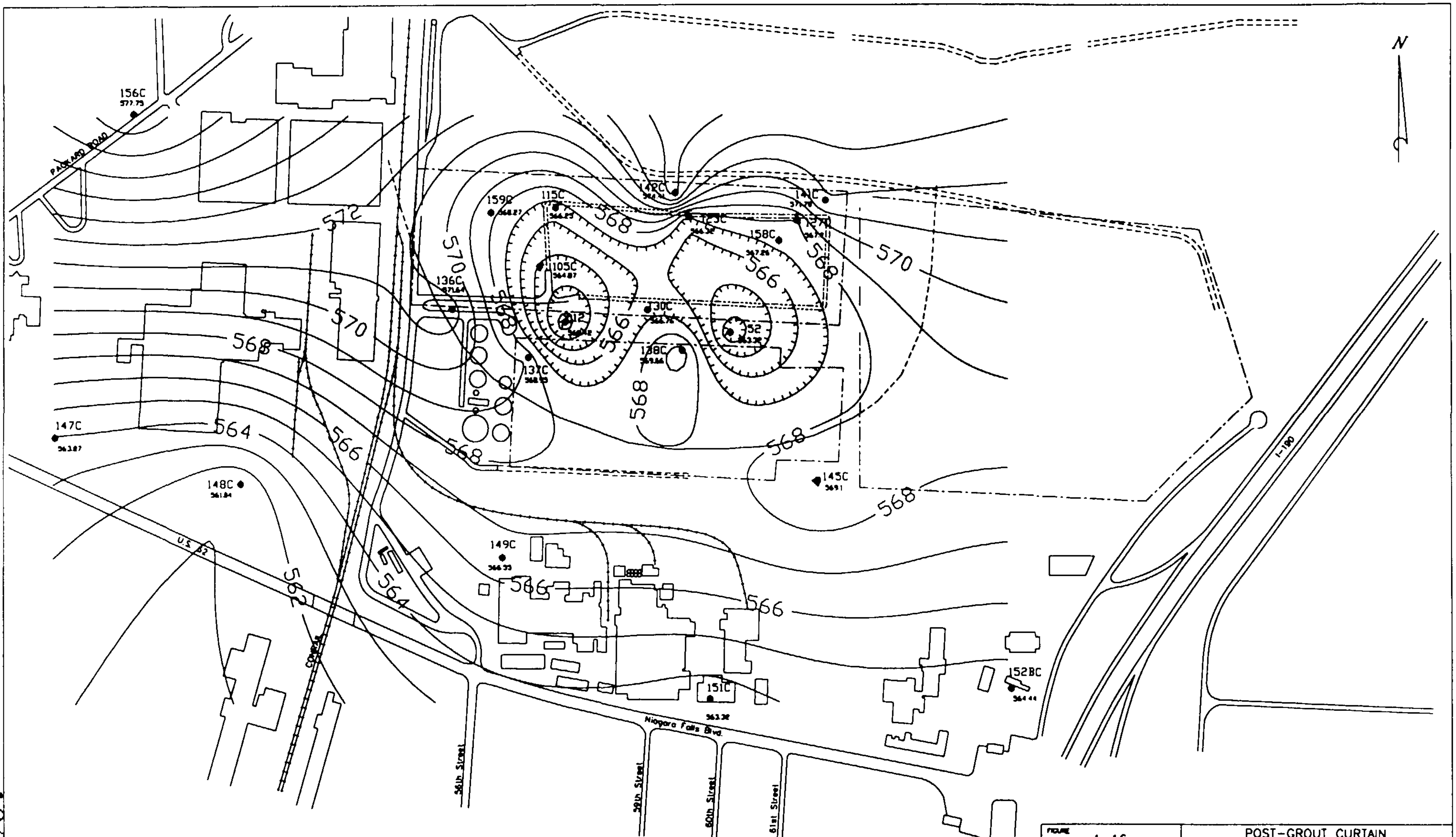
PIEZOMETRIC MAP: C-ZONE UNSTRESSED CONDITIONS

SCALE	DESIGNED BY	DRAWN BY	CAD DRAWING NO
1" = 600'		SMF	1281-1C
DATE	CHECKED	APPROVED	PROJECT NO
4/24/95	PFM	CLB	1281

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400452



LEGEND
- MONITORING WELL LOCATION

EXTENT OF CAPTURE ZONE

0 200 400 600
SCALE IN FEET

RECOVERY WELL	PUMPING RATE[1]
RW-1 (0-12)	9.5 gpm
RW-2 (52)	6.7 gpm
RW-3	NOT RUNNING

MEASUREMENT DATE: 10/1/91

1: AVERAGE PUMPING RATE DURING WEEK.

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

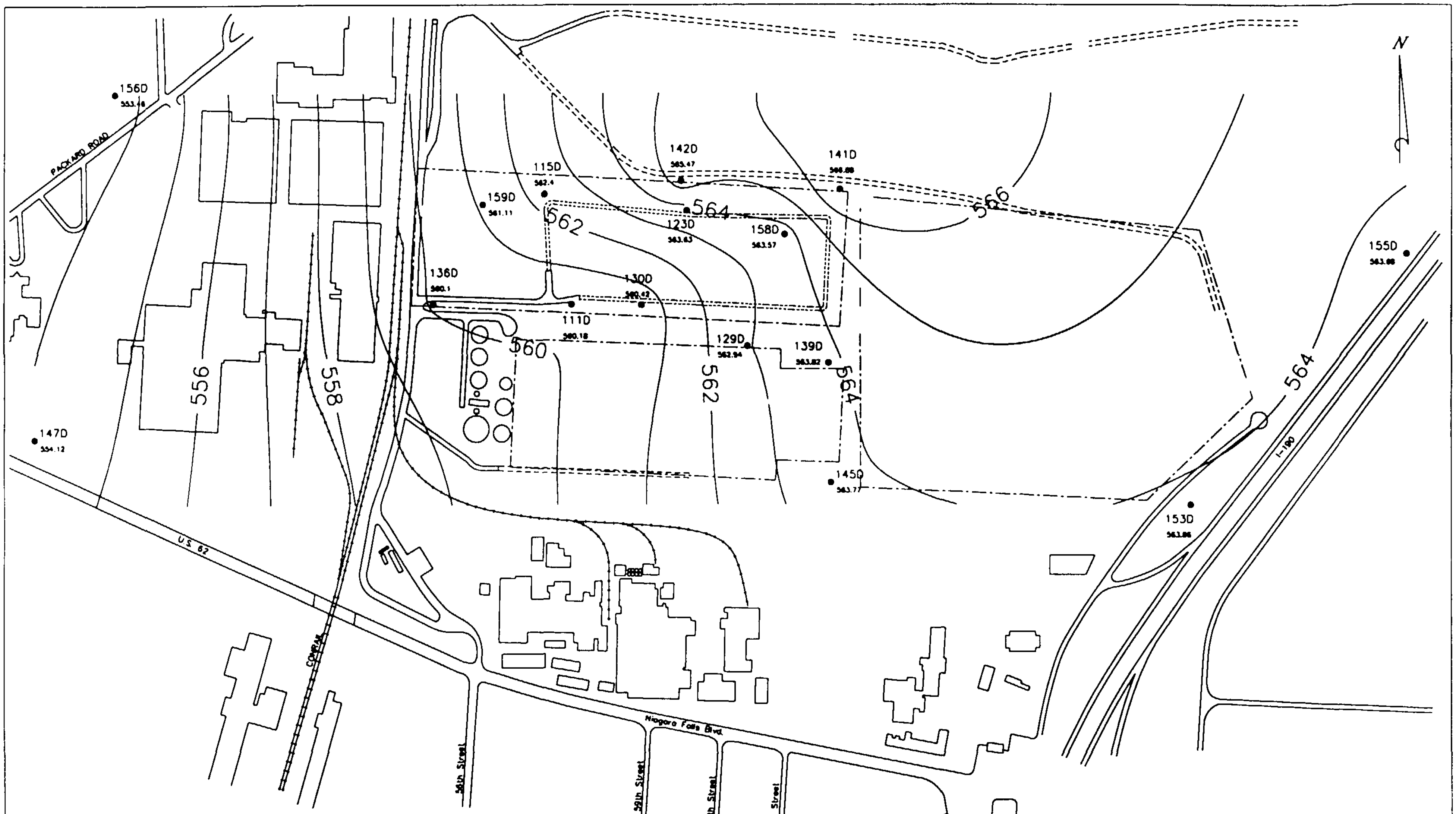
FIGURE 1-16	POST-GROUT CURTAIN CONCEPTUAL CAPTURE ZONE: C-ZONE		
SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281

DU PONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400453



LEGEND

- MONITORING WELL LOCATION

RECOVERY WELL	PUMPING RATE [1]
RW-1 (D-12)	NOT RUNNING
RW-2 (52)	NOT RUNNING
RW-3	NOT RUNNING

MEASUREMENT DATE: 2/13/92

1: AVERAGE PUMPING RATE DURING WEEK.

0 200 400 600

SCALE IN FEET

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-17

PIEZOMETRIC MAP: D-ZONE
UNSTRESSED CONDITIONS

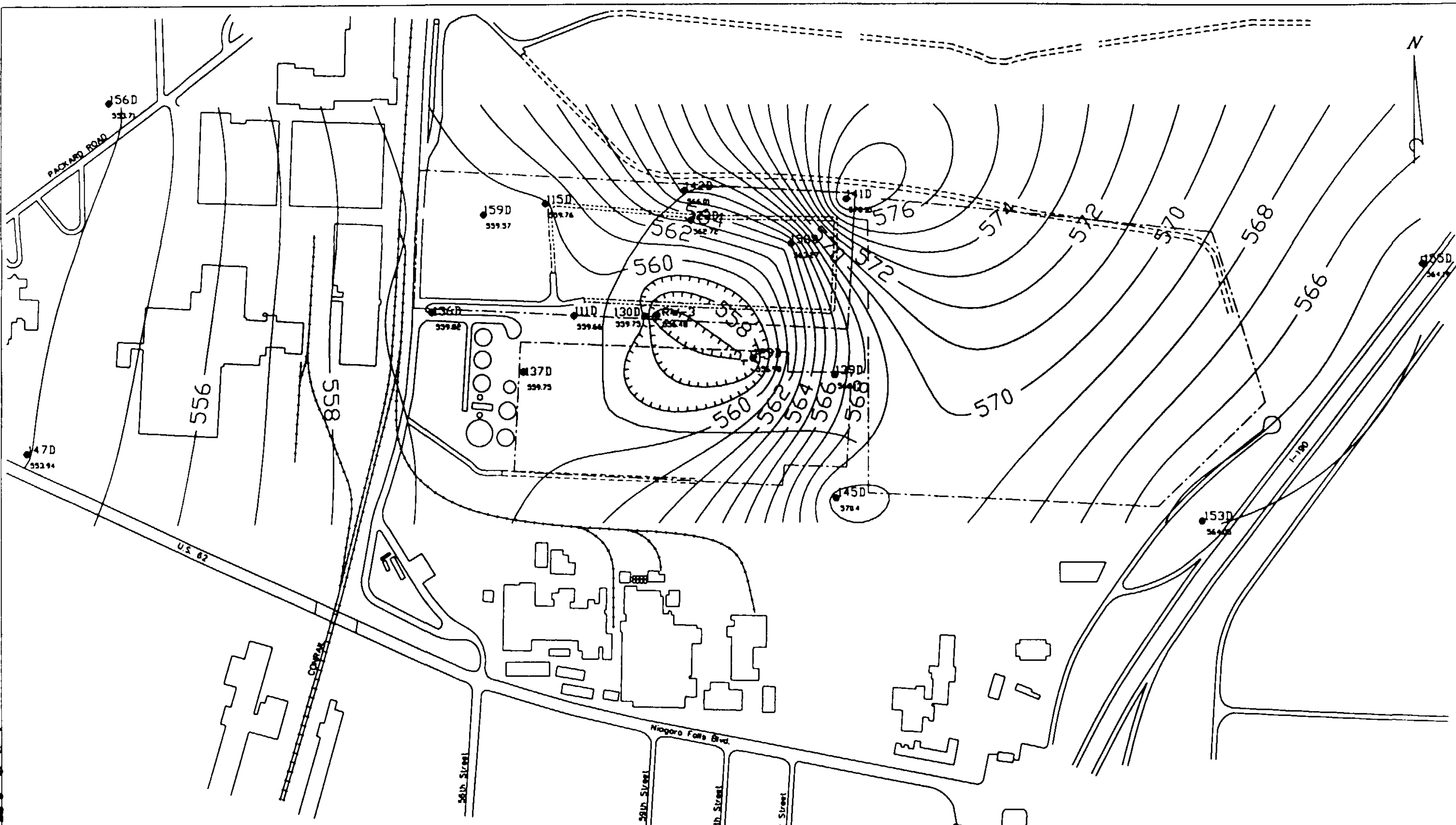
SCALE	DESIGNED BY	DRAWN BY	CAD DRAWING NO
1" = 600'		SMF	1281-1C
DATE	CHECKED	APPROVED	PROJECT NO
4/24/95	PFM	CLB	1281

DUPONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400454



LEGEND
- MONITORING WELL LOCATION
- EXTENT OF CAPTURE ZONE

0 200 400 600
SCALE IN FEET

RECOVERY WELL	PUMPING RATE [1]
RW-1 (D-12)	NOT MEASURED
RW-2 (52)	NOT RUNNING
RW-3	3 gpm

MEASUREMENT DATE: 8/14/92

1: AVERAGE PUMPING RATE DURING WEEK.

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-18

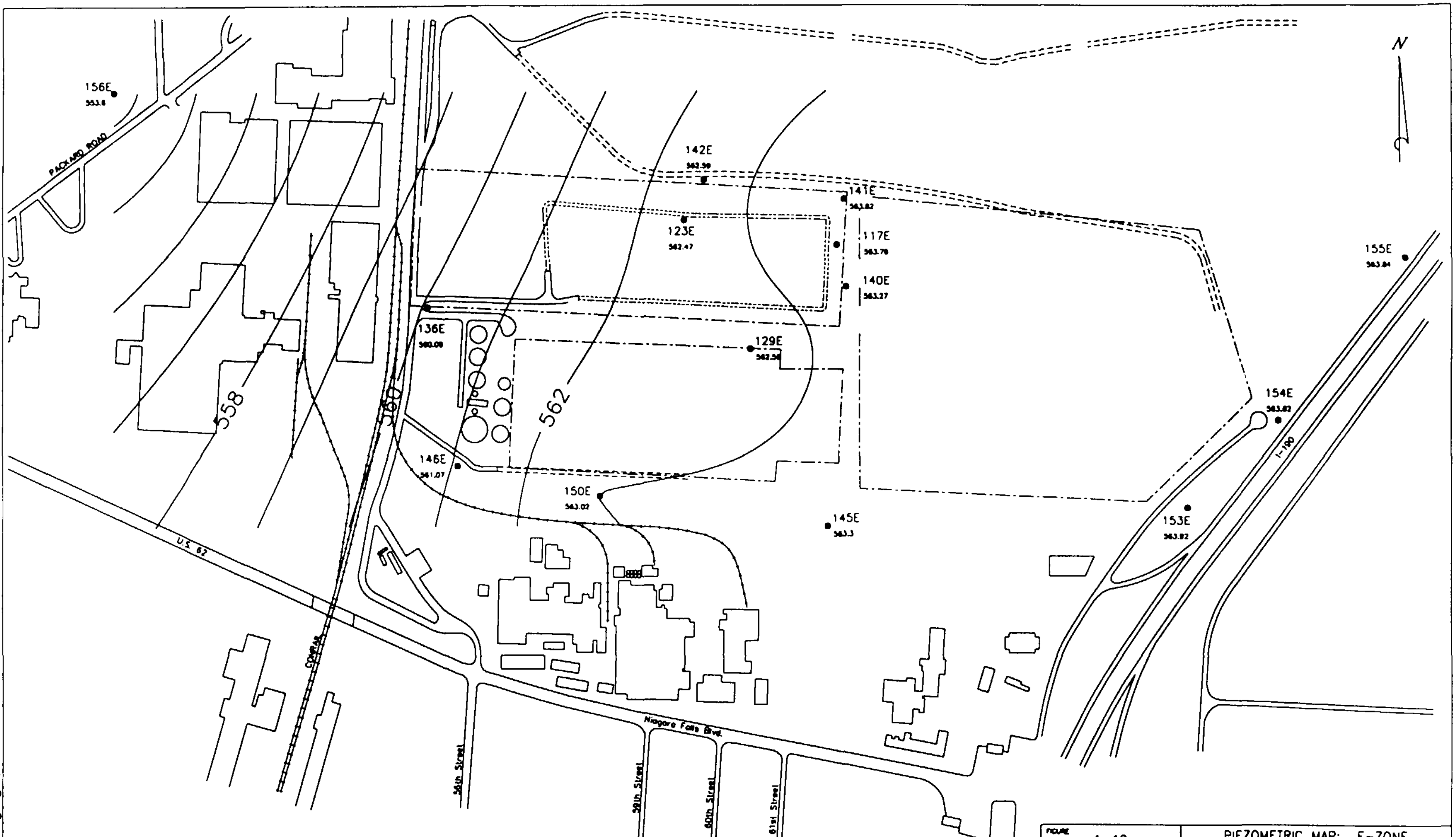
D-ZONE CONCEPTUAL CAPTURE ZONE

SCALE	DESIGNED BY	DRAWN BY	CAD DRAWING NO
1" = 600'		SMF	1281-1C
DATE	CHECKED	APPROVED	PROJECT NO
4/24/95	PFM	CLB	1281

DUPONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services



LEGEND

• MONITORING WELL LOCATION

RECOVERY WELL	PUMPING RATE [1]
RW-1 (D-12)	NOT RUNNING
RW-2 (52)	NOT RUNNING
RW-3	NOT RUNNING

MEASUREMENT DATE: 2/13/92

1: AVERAGE PUMPING RATE DURING WEEK.

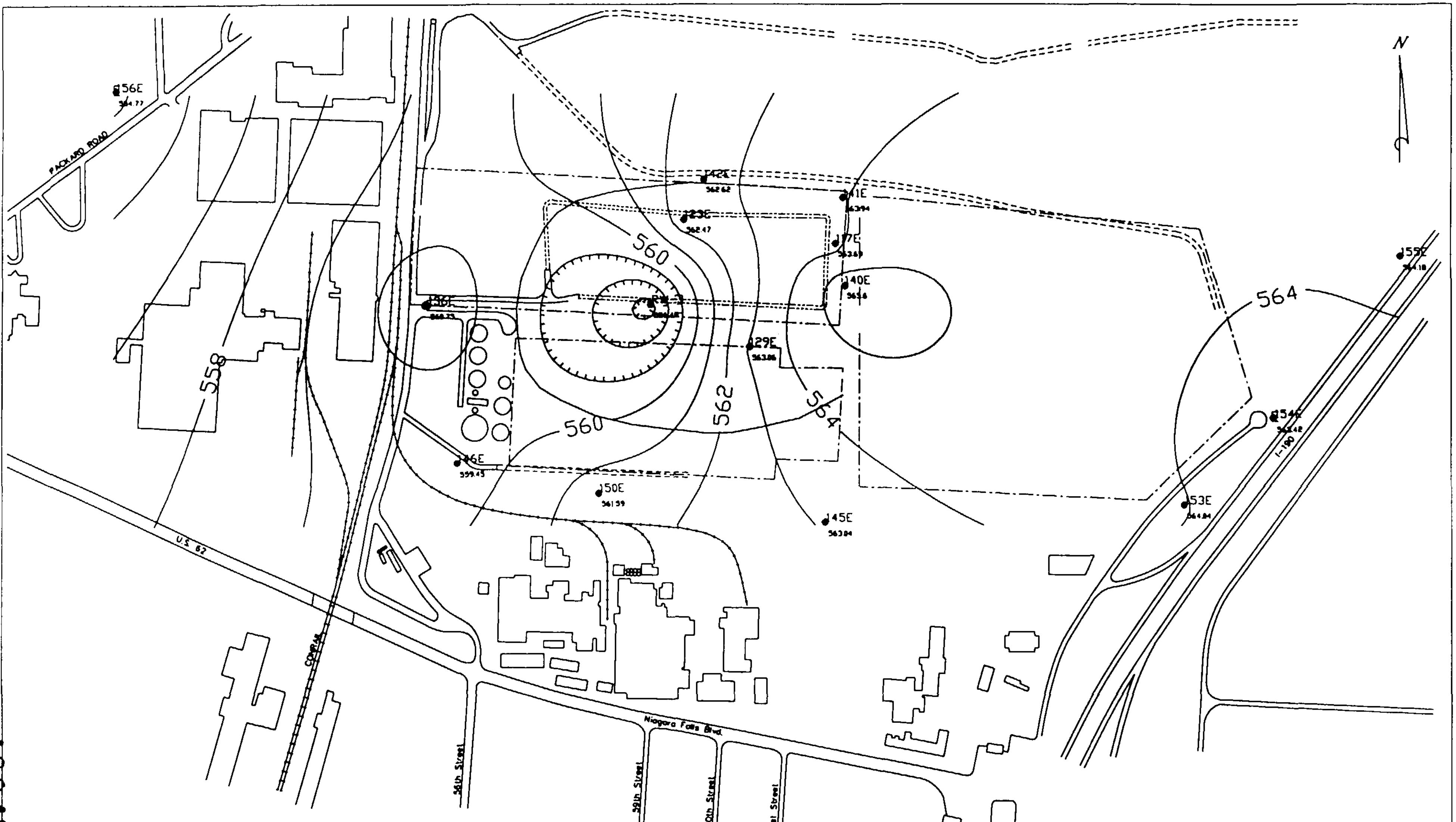
0 200 400 600

SCALE IN FEET

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-19	PIEZOMETRIC MAP: E-ZONE UNSTRESSED CONDITIONS			
DU PONT	SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
	DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281
	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Services			

400456



LEGEND

- MONITORING WELL LOCATION

EXTENT OF CAPTURE ZONE

0 200 400 600
SCALE IN FEET

RECOVERY WELL	PUMPING RATE [1]
RW-1 (D-12)	NOT MEASURED
RW-2 (52)	NOT RUNNING
RW-3	3 gpm

MEASUREMENT DATE: 8/14/92

1: AVERAGE PUMPING RATE DURING WEEK.

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

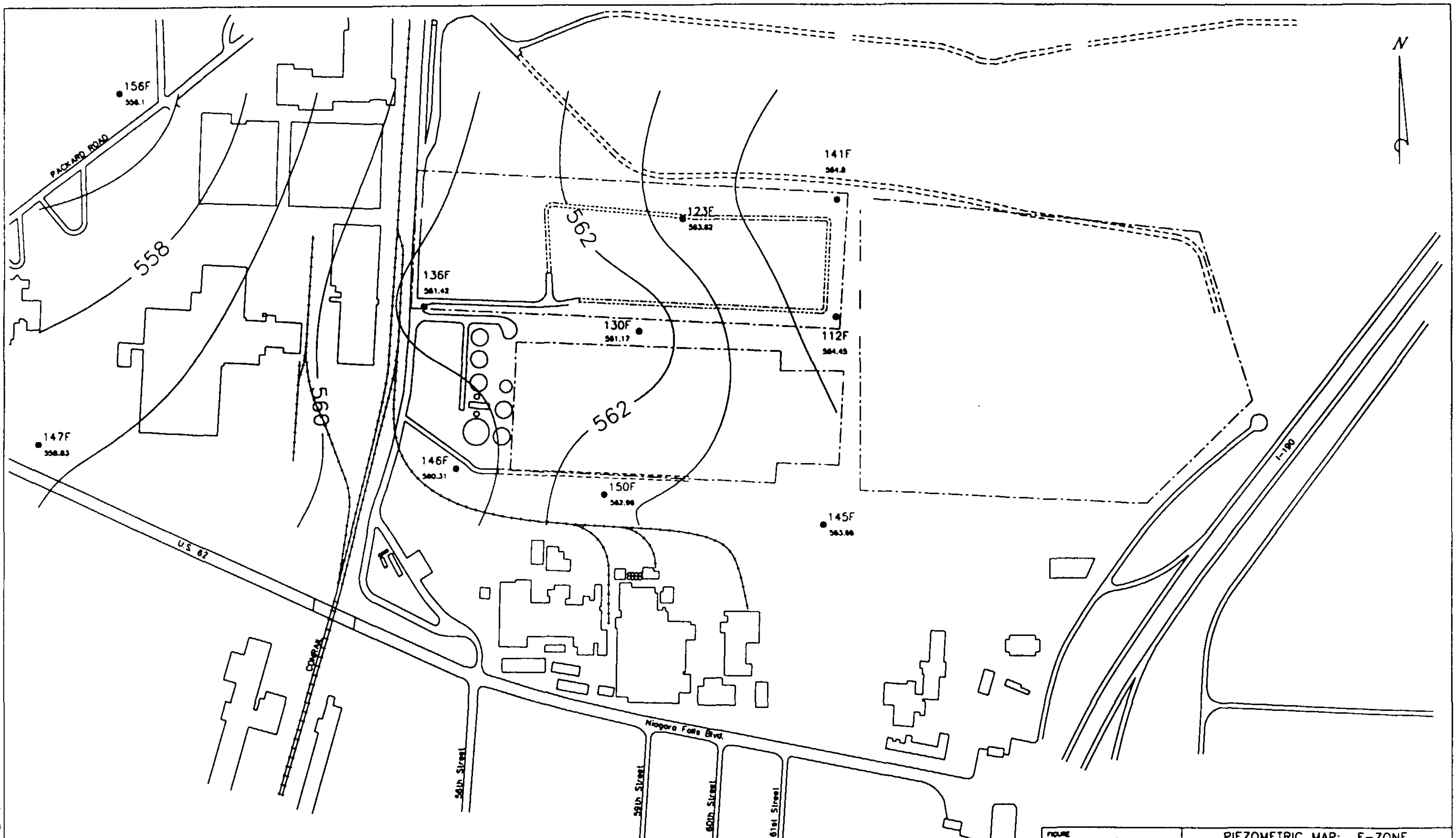
FIGURE 1-20	E-ZONE CONCEPTUAL CAPTURE ZONE		
SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281

DU PONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400457



LEGEND
• MONITORING WELL LOCATION

RECOVERY WELL	PUMPING RATE [1]
RW-1 (0-12)	22.8 gpm
RW-2 (52)	NOT RUNNING
RW-3	NOT RUNNING

MEASUREMENT DATE: 1/30/92

1: AVERAGE PUMPING RATE DURING WEEK.

0 200 400 600
SCALE IN FEET

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-21

PIEZOMETRIC MAP: F-ZONE
UNSTRESSED CONDITIONS

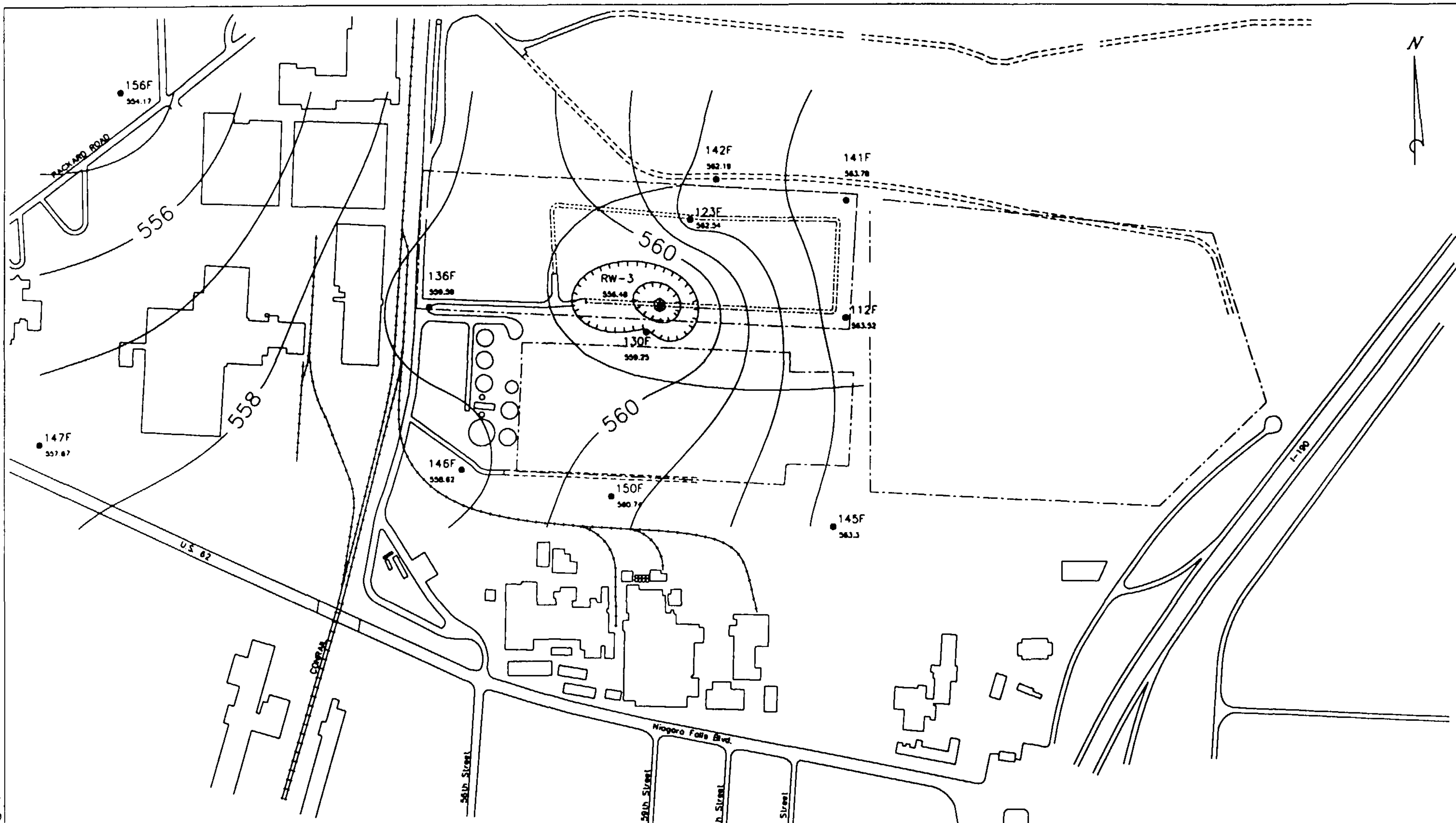
SCALE	DESIGNED BY	DRAWN BY	CAD DRAWING NO
1" = 600'		SMF	1281-1C
DATE	CHECKED	APPROVED	PROJECT NO
4/24/95	PFM	CLB	1281

DUPONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400458



LEGEND

- MONITORING WELL LOCATION

EXTENT OF CAPTURE ZONE

0 200 400 600

SCALE IN FEET

RECOVERY WELL	PUMPING RATE [1]
RW-1 (0-12)	NOT MEASURED
RW-2 (52)	NOT RUNNING
RW-3	3 gpm

MEASUREMENT DATE: 8/14/92

1: AVERAGE PUMPING RATE DURING WEEK.

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

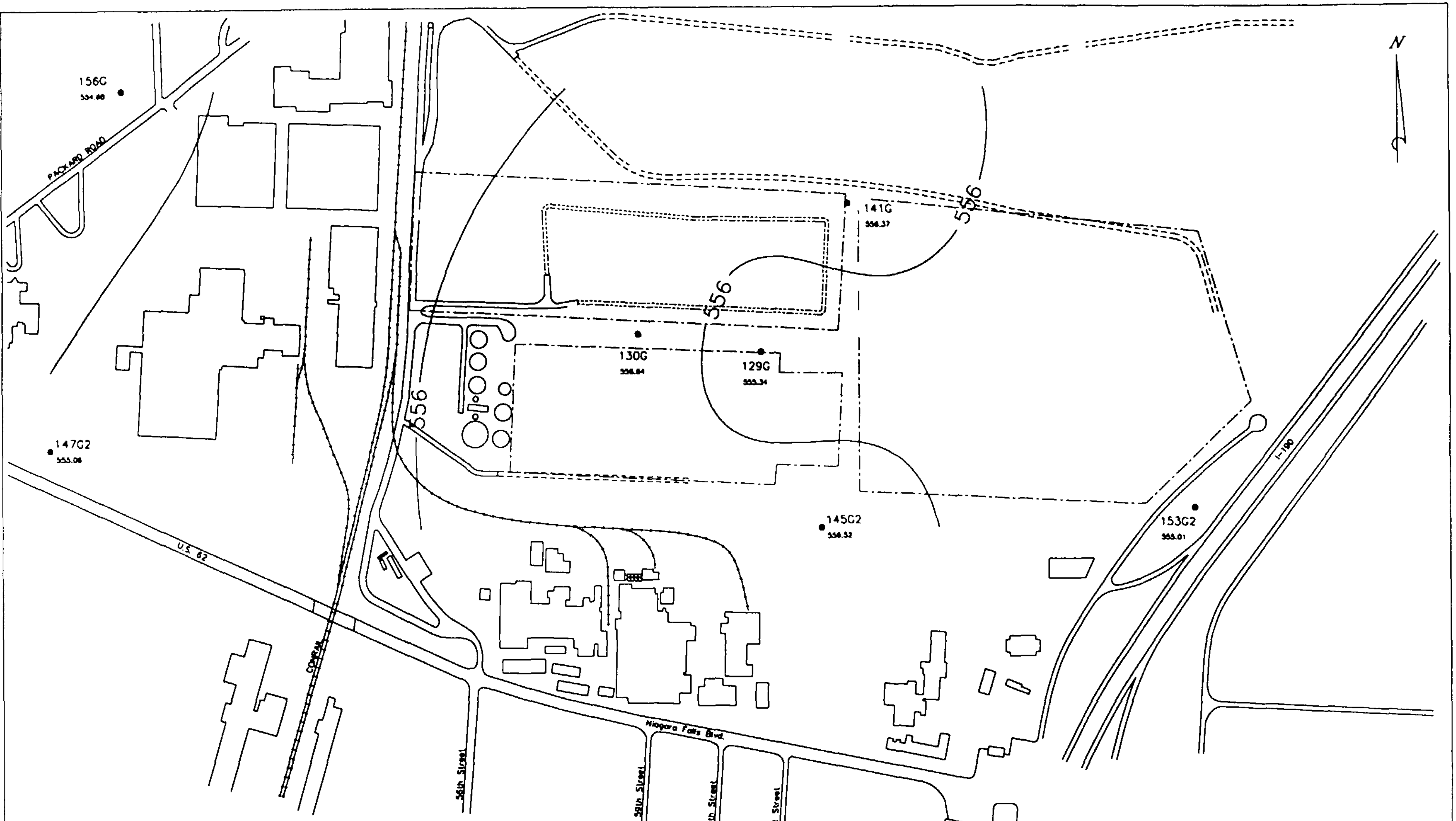
FIGURE 1-22	F-ZONE CONCEPTUAL CAPTURE ZONE		
SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281

DUPONT

DUPONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400459



LEGEND

• MONITORING WELL LOCATION

MEASUREMENT DATE: 8/14/92

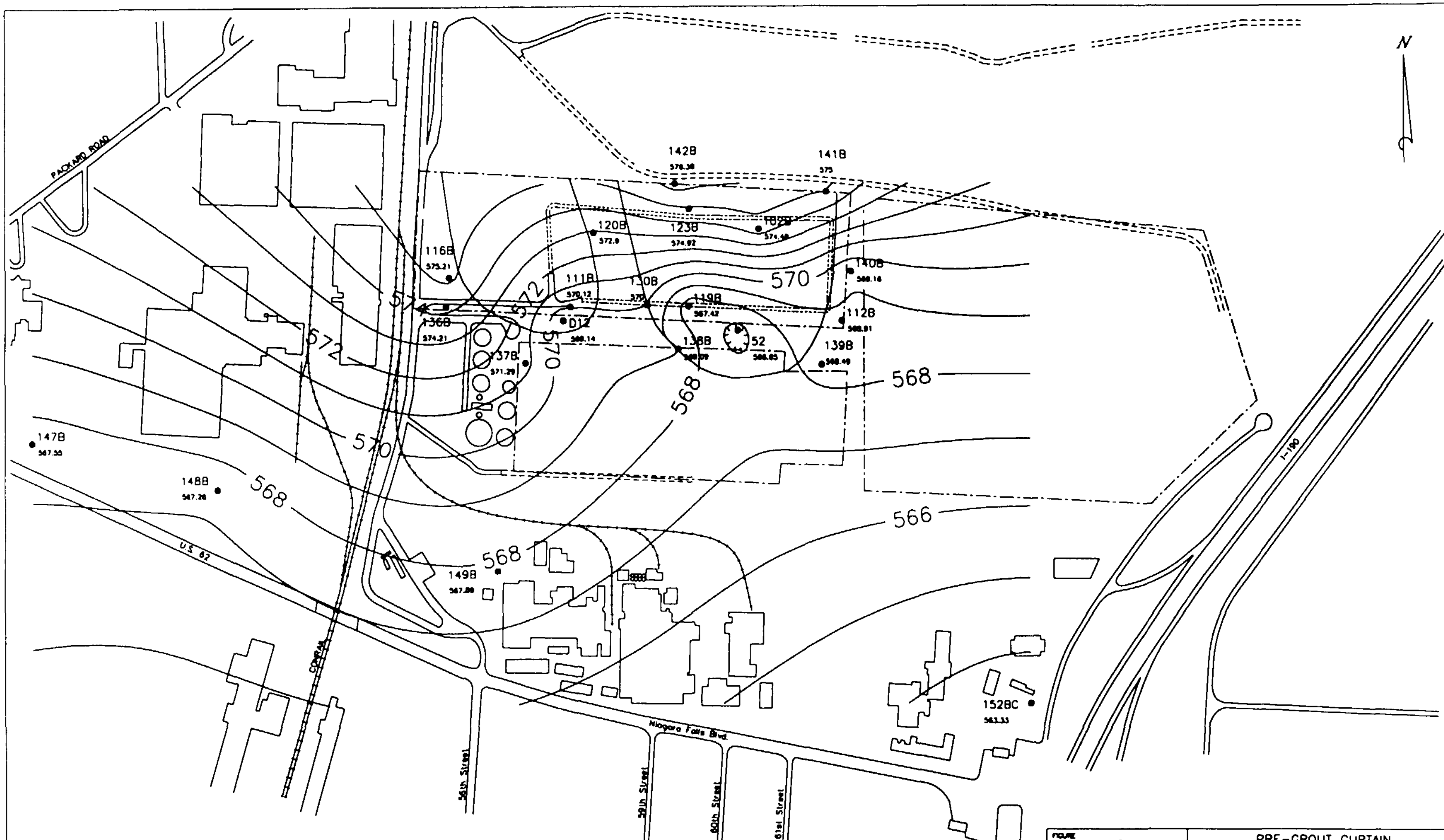
0 200 400 600

SCALE IN FEET

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE	1-23	PIEZOMETRIC MAP: G-ZONE			
		SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
		DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281
DU PONT		DUPONT NECCO PARK NIAGARA FALLS, NY			
		DuPont Environmental Remediation Services			

400460



LEGEND

- MONITORING WELL LOCATION

EXTENT OF CAPTURE ZONE

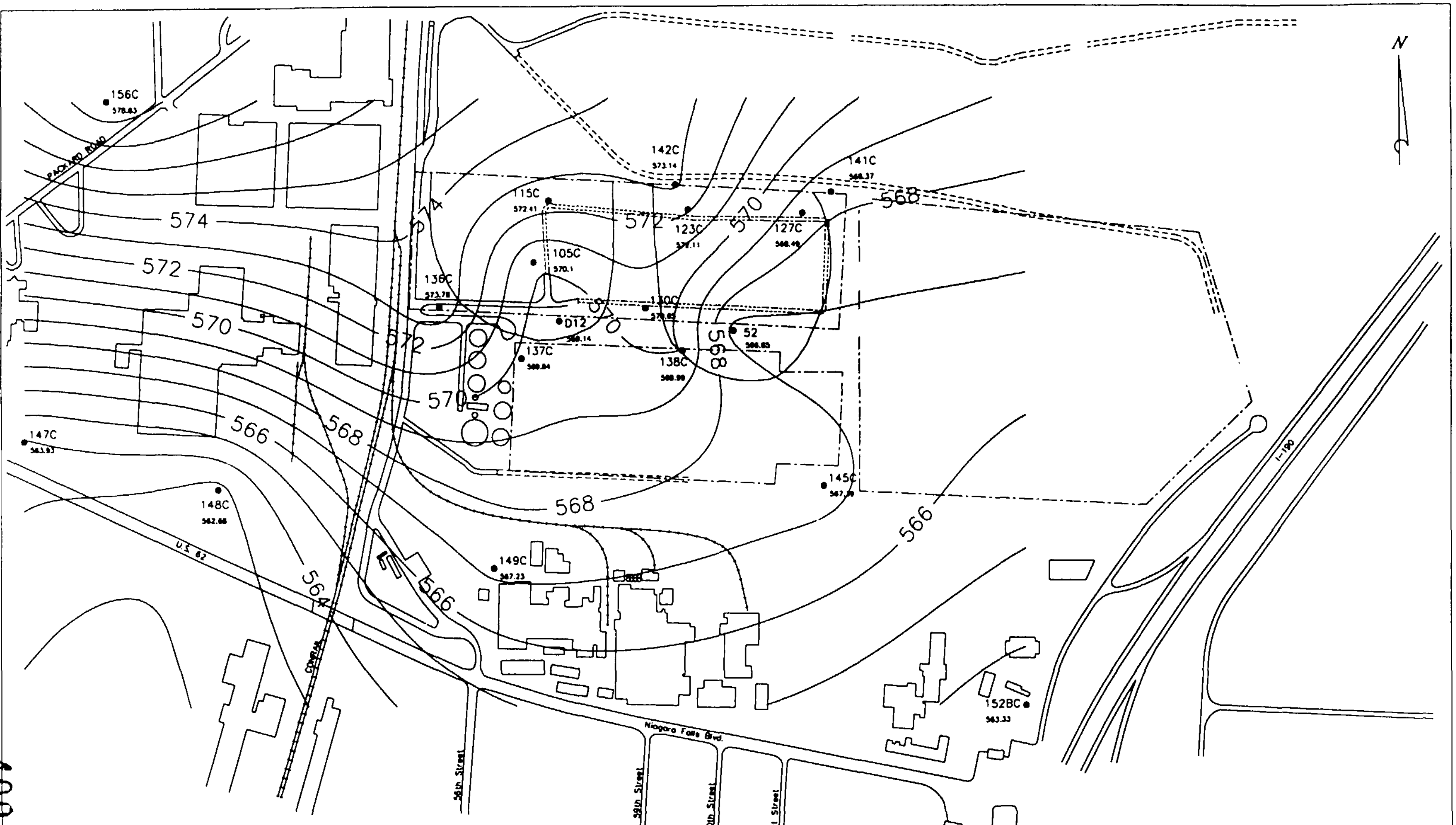
0 200 400 600
SCALE IN FEET

MEASUREMENT DATE: OCTOBER, 1987
SEE FIGURE 26, SFR INTERIM
PERFORMANCE REPORT (WCC 1990).

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE	PRE-GROUT CURTAIN CONCEPTUAL CAPTURE ZONE: B-ZONE			
1-24	SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
	DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281
DU PONT	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Services			

400461



LEGEND

- • MONITORING WELL LOCATION
- EXTENT OF CAPTURE ZONE

0 200 400 600

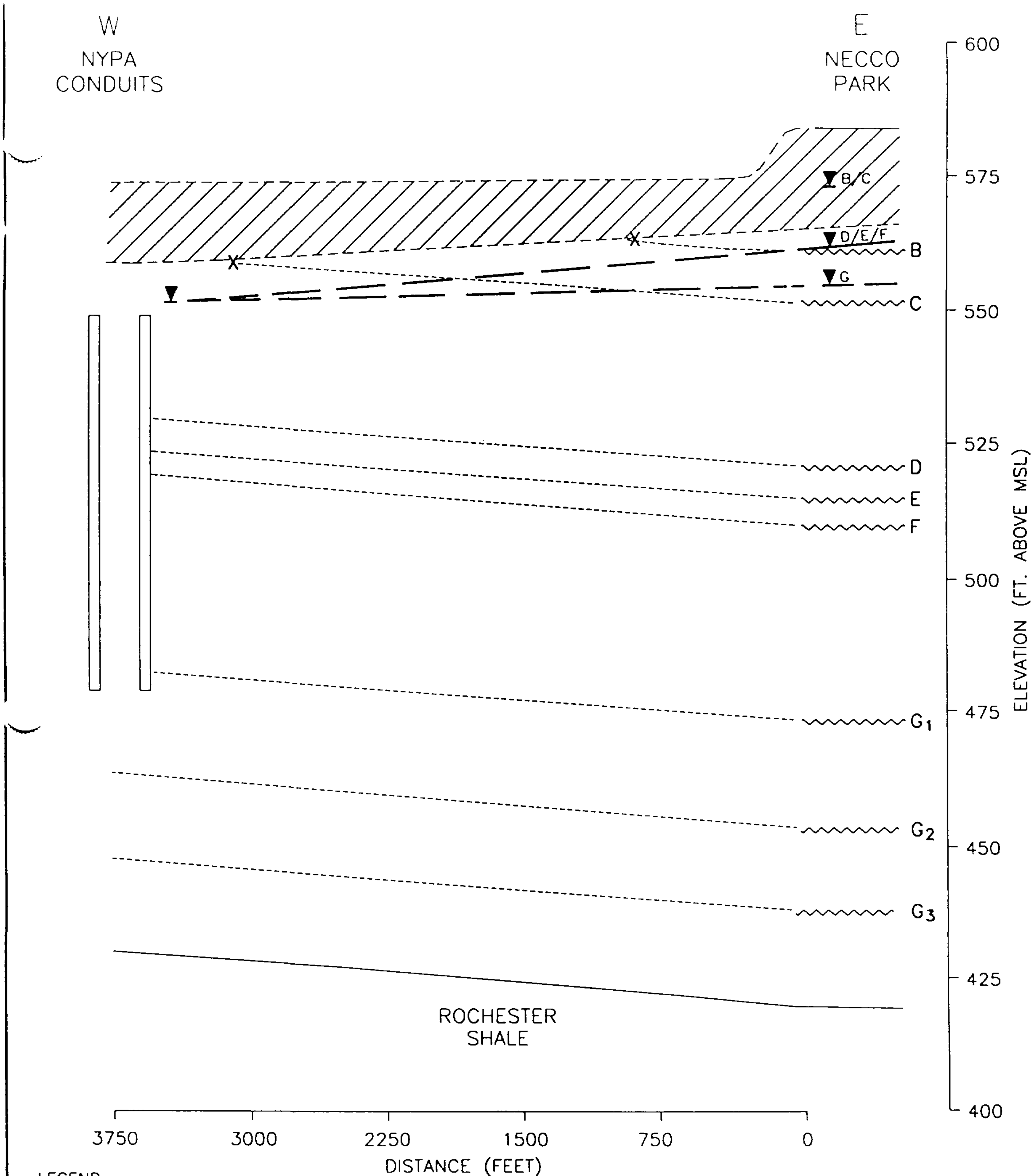
SCALE IN FEET

MEASUREMENT DATE: OCTOBER, 1987
SEE FIGURE 58, SFR INTERIM
PERFORMANCE REPORT (WCC 1990).

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-25	PRE-GROUT CURTAIN CONCEPTUAL CAPTURE ZONE: C-ZONE			
	SCALE 1" = 600'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1C
	DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 1281
	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Services			

400462

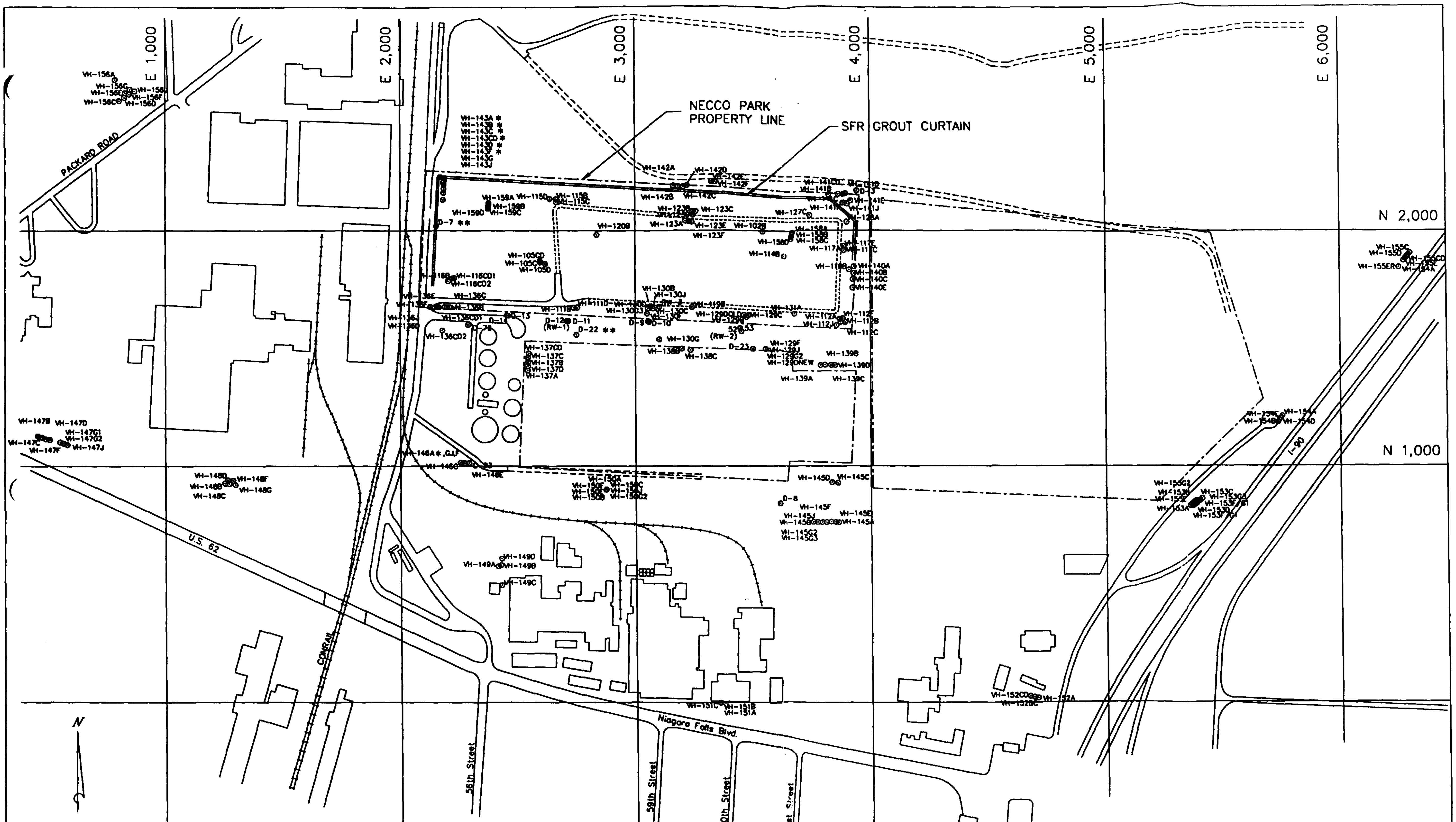


LEGEND

- OVERBURDEN
- BEDROCK FRACTURE ZONE
- EXTRAPOLATION OF FRACTURE ZONES
- X FRACTURE ZONE SUBCROP
- EXTRAPOLATED WATER LEVELS
- WATER LEVEL

FIGURE 1-26	GEOLOGICAL CROSS SECTION TO THE NYPA CONDUITS			
	SCALE AS SHOWN	DESIGNED BY PFM	DRAWN BY SMF	CAD DRAWING NO 3293-4
	DATE 4/24/95	CHECKED CLB	APPROVED RGB	PROJECT NO 3293
DUPONT	DuPont Necco Park Niagara Falls, New York			
	DuPont Environmental Remediation Services			

400463



LEGEND:

- ⊙ MONITORING WELL
- * GROUTED DURING SFR GROUT CURTAIN INSTALLATION
- ** WELL ABANDONED

0 400
Scale in feet

TAKEN FROM WOODWARD-CLYDE DWG. No. 81370160

FIGURE 1-27	MONITORING WELL LOCATION MAP		
SCALE 1" =400'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1A
DATE 4/24/95	CHECKED PFM	APPROVED JMM	PROJECT NO 1281

DU PONT NECCO PARK
NIAGARA FALLS, NY

DuPont Environmental Remediation Services

400464

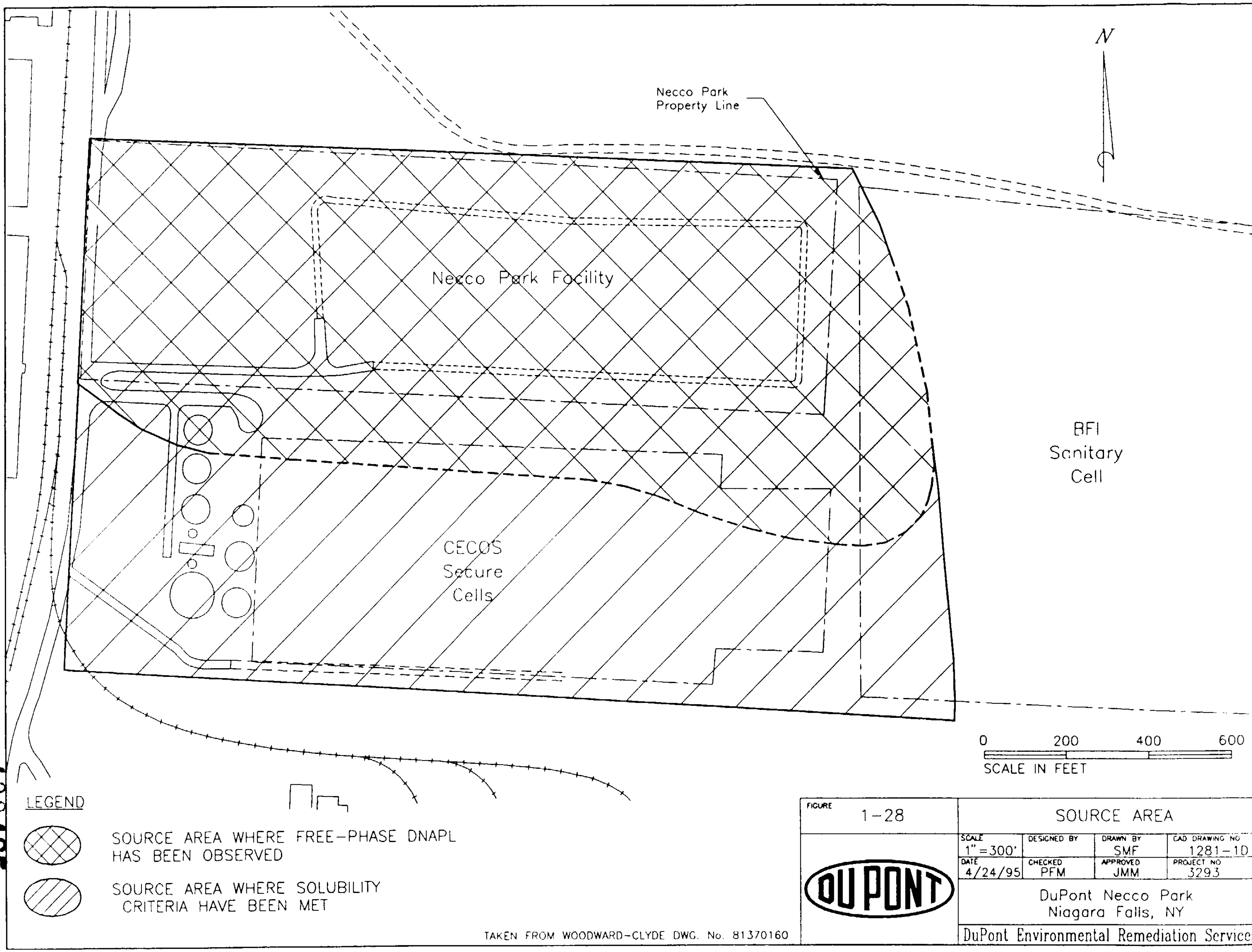
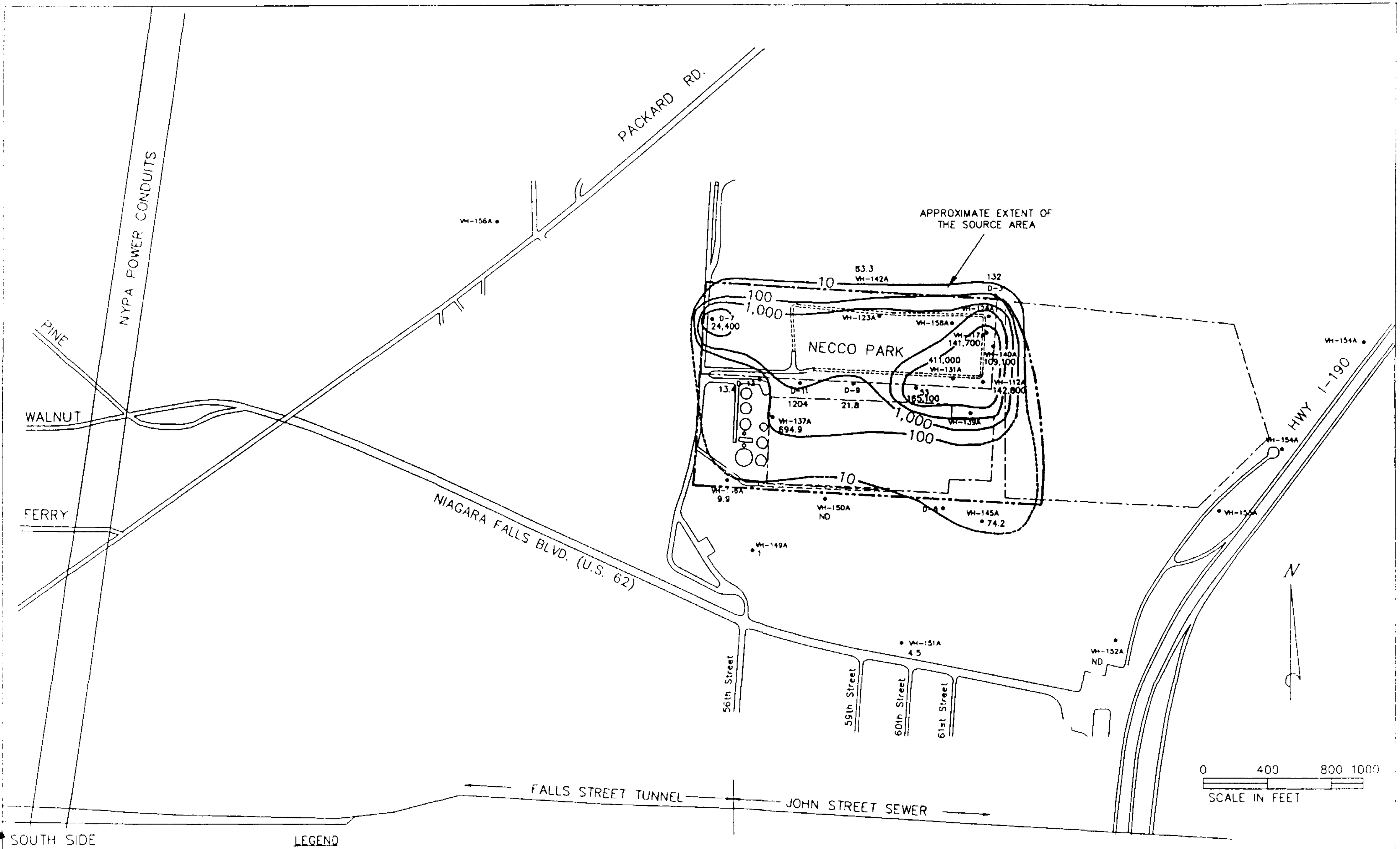


FIGURE 1-28	SOURCE AREA			
	SCALE 1" = 300'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 1281-1D
DUPONT	DATE 4/24/95	CHECKED PFM	APPROVED JMM	PROJECT NO 3293
	DuPont Necco Park Niagara Falls, NY			
	DuPont Environmental Remediation Services			



400466

LEGEND

VH-143B 347.5 • MONITORING WELL LOCATION AND TOTAL VOLATILE ORGANICS CONCENTRATION (ug/l)

—— ISOCONCENTRATION CONTOUR

.... ESTIMATED CONCENTRATION BASED ON FIELD DATA

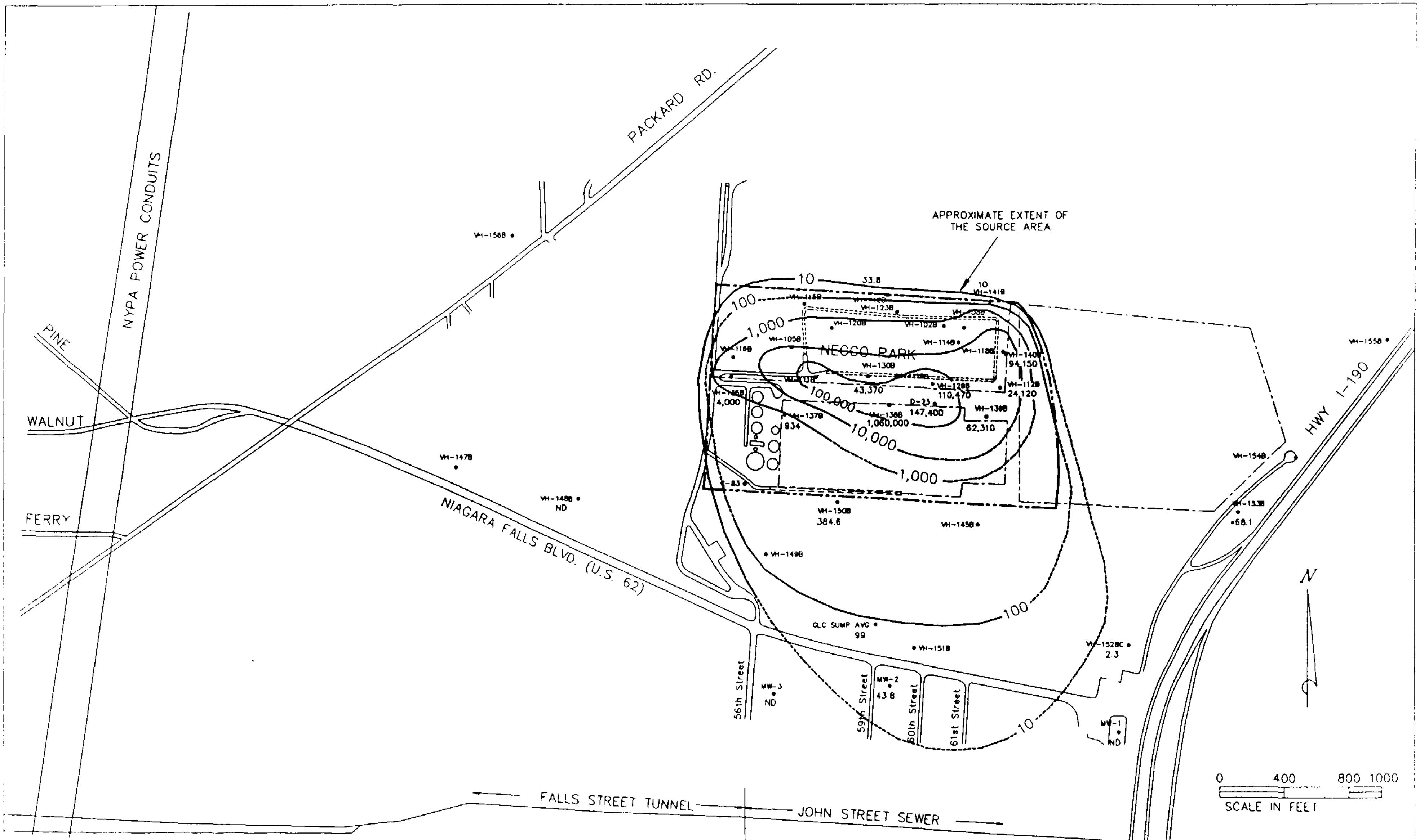
- - - - - ESTIMATED CONCENTRATION BASED ON TRANSPORT MODEL

FIGURE 1-29	A-ZONE FAR FIELD EXTENT		
SCALE 1"=850'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 3293-2
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 3293

DUPONT

DuPont Necco Park
Niagara Falls, New York

DuPont Environmental Remediation Services



LEGEND

VH-143B • 347.5 — MONITORING WELL LOCATION AND TOTAL VOLATILE ORGANICS CONCENTRATION (ug/l)

———— ISOCONCENTRATION CONTOUR

-·-·-·-· ESTIMATED CONCENTRATION BASED ON FIELD DATA

- - - - - ESTIMATED CONCENTRATION BASED ON TRANSPORT MODEL

NOTE:

* ANOMALOUS TOTAL VOC CONCENTRATION, CONSISTENTLY NO VOC DETECTIONS PRIOR TO AND FOLLOWING SECOND SEMI-ANNUAL, 1992 SAMPLING EVENT

1994 DATA USED FOR WELLS VH-150B & VH-152BC

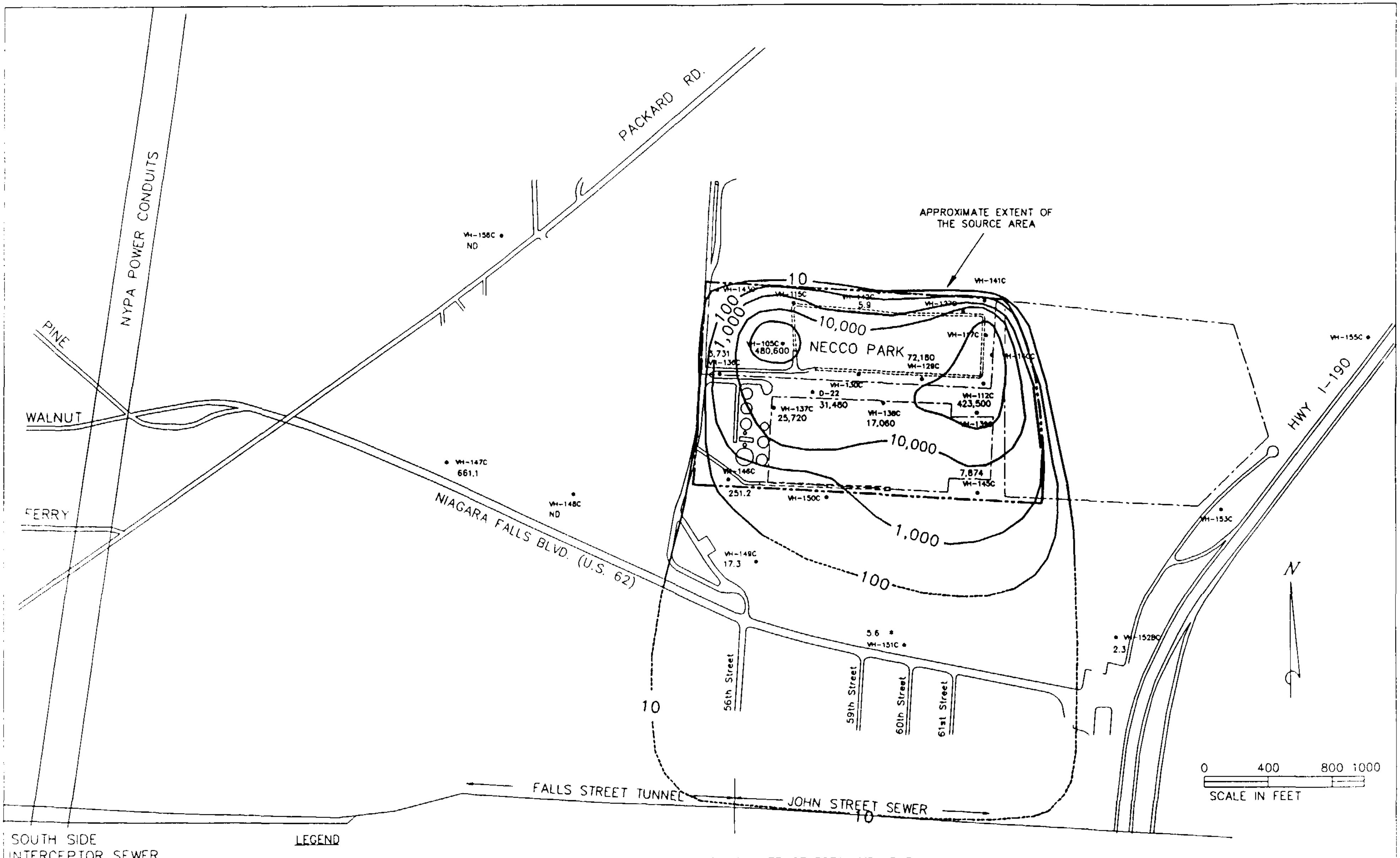
FIGURE 1-30	B-ZONE FAR FIELD EXTENT		
SCALE 1" = 850'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 3293-2
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 3293

DUPONT

DuPont Necco Park
Niagara Falls, New York

DuPont Environmental Remediation Services

400467



LEGEND

VH-143B • 347.5 — MONITORING WELL LOCATION AND TOTAL VOLATILE ORGANICS CONCENTRATION (ug/l)

ISOCONCENTRATION CONTOUR

ESTIMATED CONCENTRATION BASED ON FIELD DATA

ESTIMATED CONCENTRATION BASED ON TRANSPORT MODEL

(143.4) AVERAGE TOTAL VOLATILE ORGANICS CONCENTRATION USED IN TRANSPORT MODELING

• VH-151C AVERAGE IS GREATER THAN 10 ug/l

1994 DATA USED FOR WELLS VH-145C, VH-146C, VH-149C, VH-151C & VH-152BC

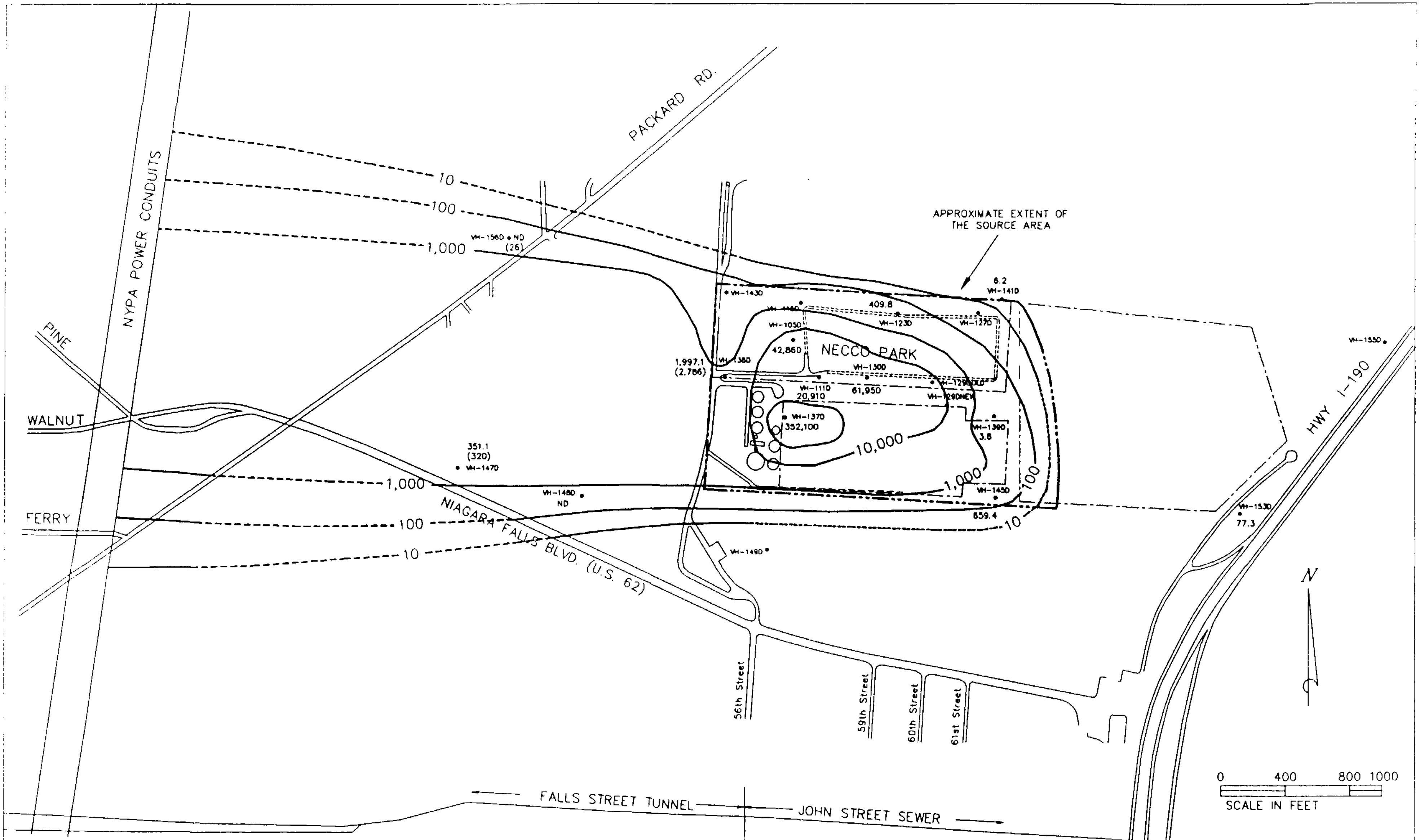
FIGURE 1-31	C-ZONE FAR FIELD EXTENT		
SCALE 1" = 850'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 3293-2
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 3293

DUPONT

DuPont Necco Park
Niagara Falls, New York

DuPont Environmental Remediation Services

400468



LEGEND

VH-143D • 347.5 MONITORING WELL LOCATION AND TOTAL VOLATILE ORGANICS CONCENTRATION (ug/l)

———— ISOCONCENTRATION CONTOUR

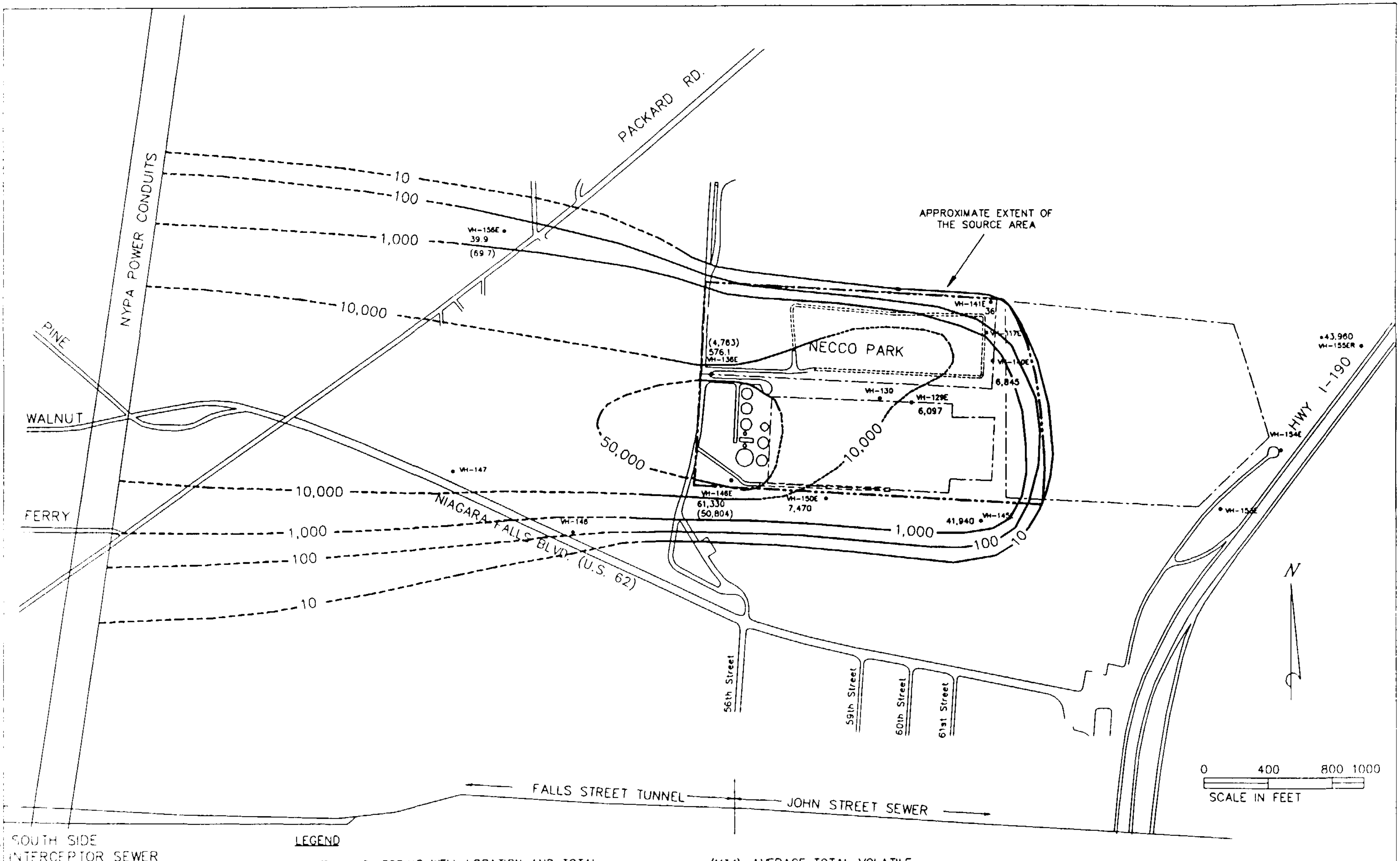
-·-·-·-· ESTIMATED CONCENTRATION BASED ON FIELD DATA

- - - - - ESTIMATED CONCENTRATION BASED ON TRANSPORT MODEL

(143.4) AVERAGE TOTAL VOLATILE ORGANICS CONCENTRATION USED IN TRANSPORT MODELING

FIGURE 1-32	D-ZONE FAR FIELD EXTENT			
	SCALE 1" =850'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 3293-2
	DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 3293
DUPONT	DuPont Necco Park Niagara Falls, New York			
	DuPont Environmental Remediation Services			

400469



LEGEND

VH-143B • 347.5 — MONITORING WELL LOCATION AND TOTAL VOLATILE ORGANICS CONCENTRATION (ug/l)

——— ISOCONCENTRATION CONTOUR

-·-·-·- ESTIMATED CONCENTRATION BASED ON FIELD DATA

- - - - ESTIMATED CONCENTRATION BASED ON TRANSPORT MODEL

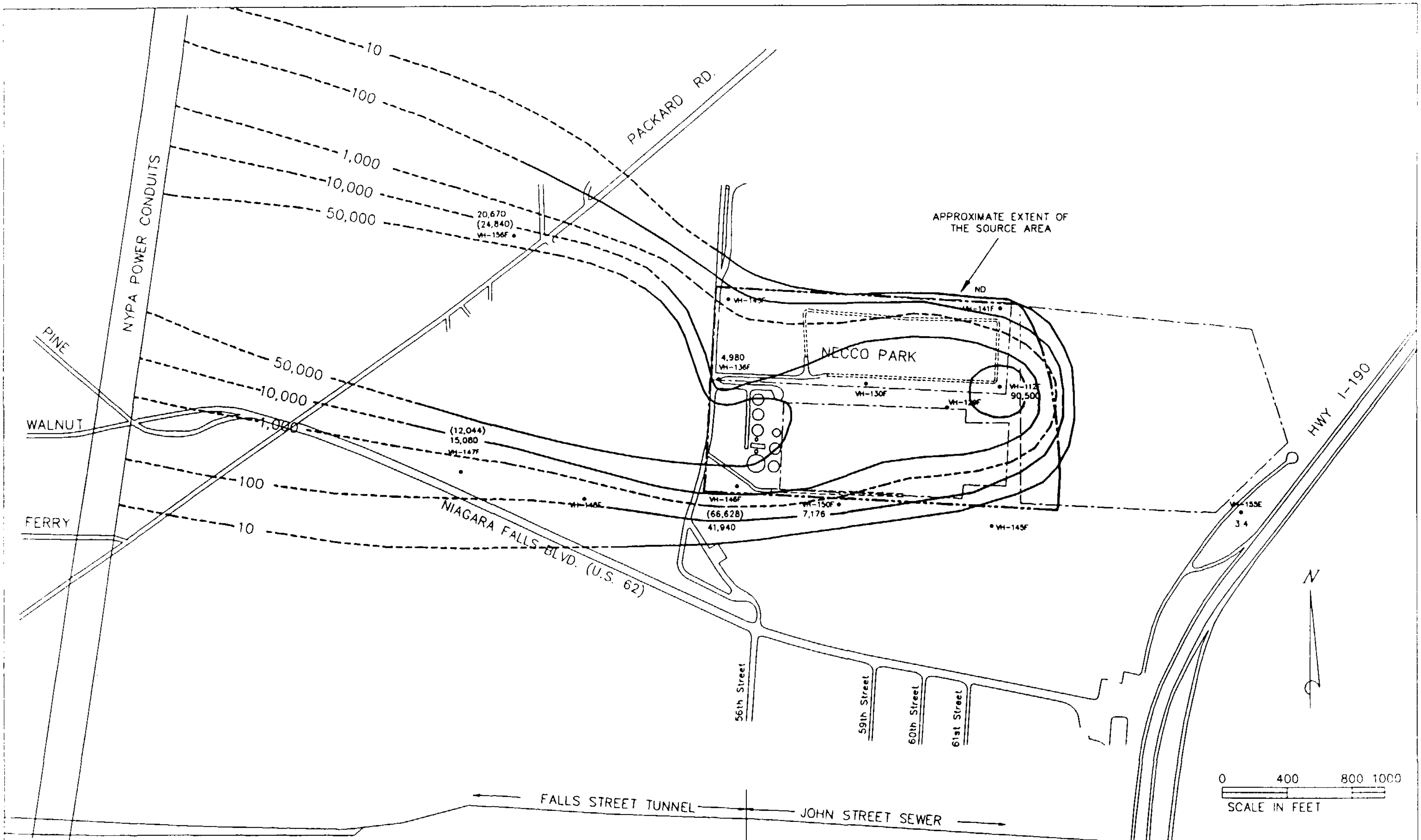
(143.4) AVERAGE TOTAL VOLATILE ORGANICS CONCENTRATION USED IN TRANSPORT MODELING

NOTE:

* ANOMALOUS TOTAL VOC CONCENTRATION, CONSISTENTLY VOC CONCENTRATIONS <10 ug/l PRIOR TO AND FOLLOWING SECOND SEMI-ANNUAL 1992 SAMPLING EVENT

FIGURE 1-33	E-ZONE FAR FIELD EXTENT			
	SCALE 1"=850'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 3293-2
	DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 3293
DUPONT	DuPont Necco Park, Niagara Falls, New York			
	DuPont Environmental Remediation Services			

400470



SOUTH SIDE
INTERCEPTOR SEWER

LEGEND

VH-143B • 347.5 MONITORING WELL LOCATION AND TOTAL VOLATILE ORGANICS CONCENTRATION (ug/l)

(143.4) AVERAGE TOTAL VOLATILE ORGANICS CONCENTRATION USED IN TRANSPORT MODELING

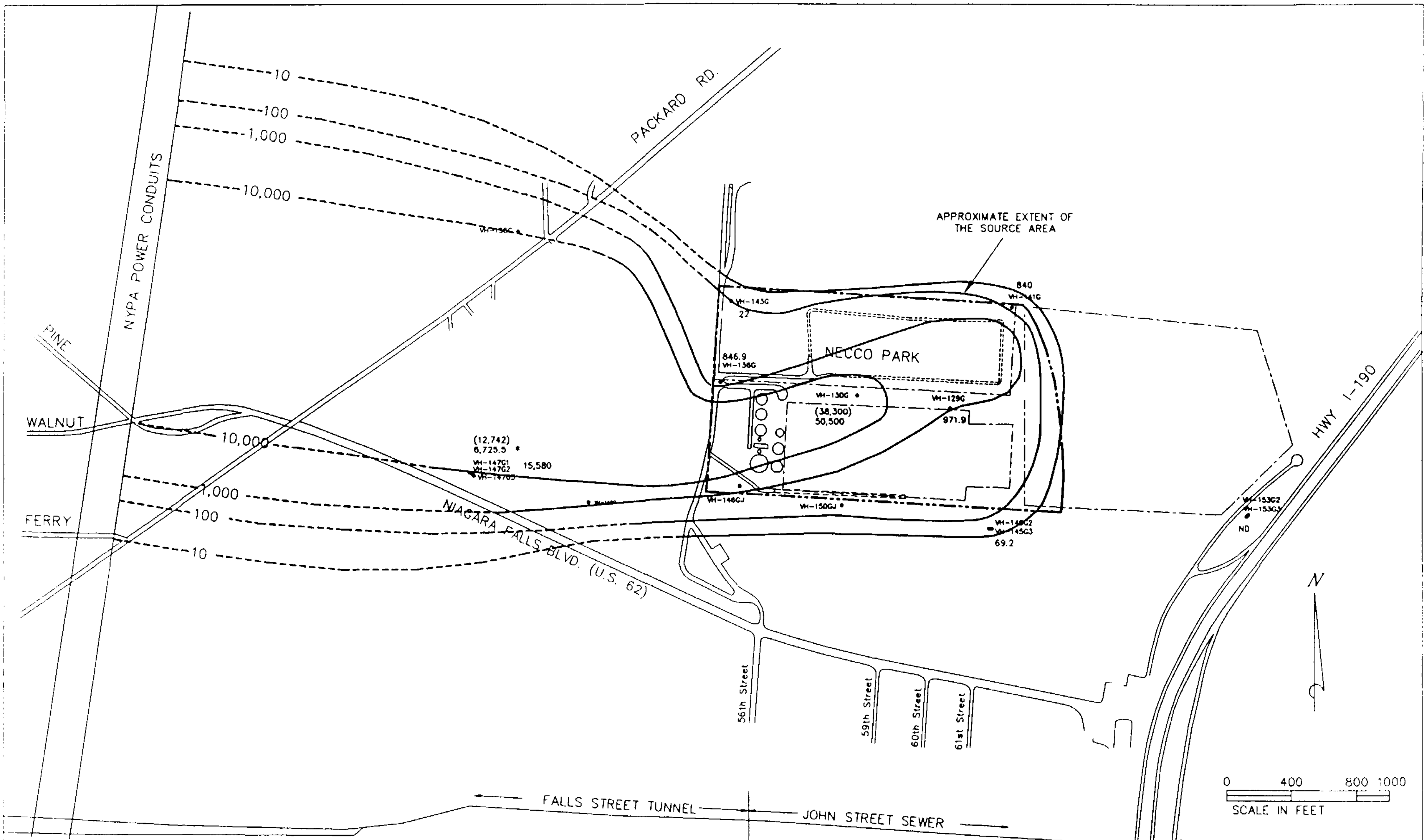
——— ISOCONCENTRATION CONTOUR

-·-·-·- ESTIMATED CONCENTRATION BASED ON FIELD DATA

- - - - ESTIMATED CONCENTRATION BASED ON TRANSPORT MODEL

FIGURE 1-34	F-ZONE FAR FIELD EXTENT			
	SCALE 1"=850'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 3293-2
	DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 3293
DUPONT	DuPont Necco Park Niagara Falls, New York			
	DuPont Environmental Remediation Services			

400471



SOUTH SIDE
INTERCEPTOR SEWER

LEGEND

VH-143B 347.5 • MONITORING WELL LOCATION AND TOTAL VOLATILE ORGANICS CONCENTRATION (ug/l)

ISOCONCENTRATION CONTOUR

ESTIMATED CONCENTRATION BASED ON FIELD DATA

ESTIMATED CONCENTRATION BASED ON TRANSPORT MODEL

(143.4) AVERAGE TOTAL VOLATILE ORGANICS CONCENTRATION USED IN TRANSPORT MODELING

* AVERAGE OF G1, G2 & G3

FIGURE 1-35	G-ZONE FAR FIELD EXTENT		
SCALE 1" =850'	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO 3293-2
DATE 4/24/95	CHECKED PFM	APPROVED CLB	PROJECT NO 3293

DuPont Necco Park
Niagara Falls, New York

DuPont Environmental Remediation Services

400472

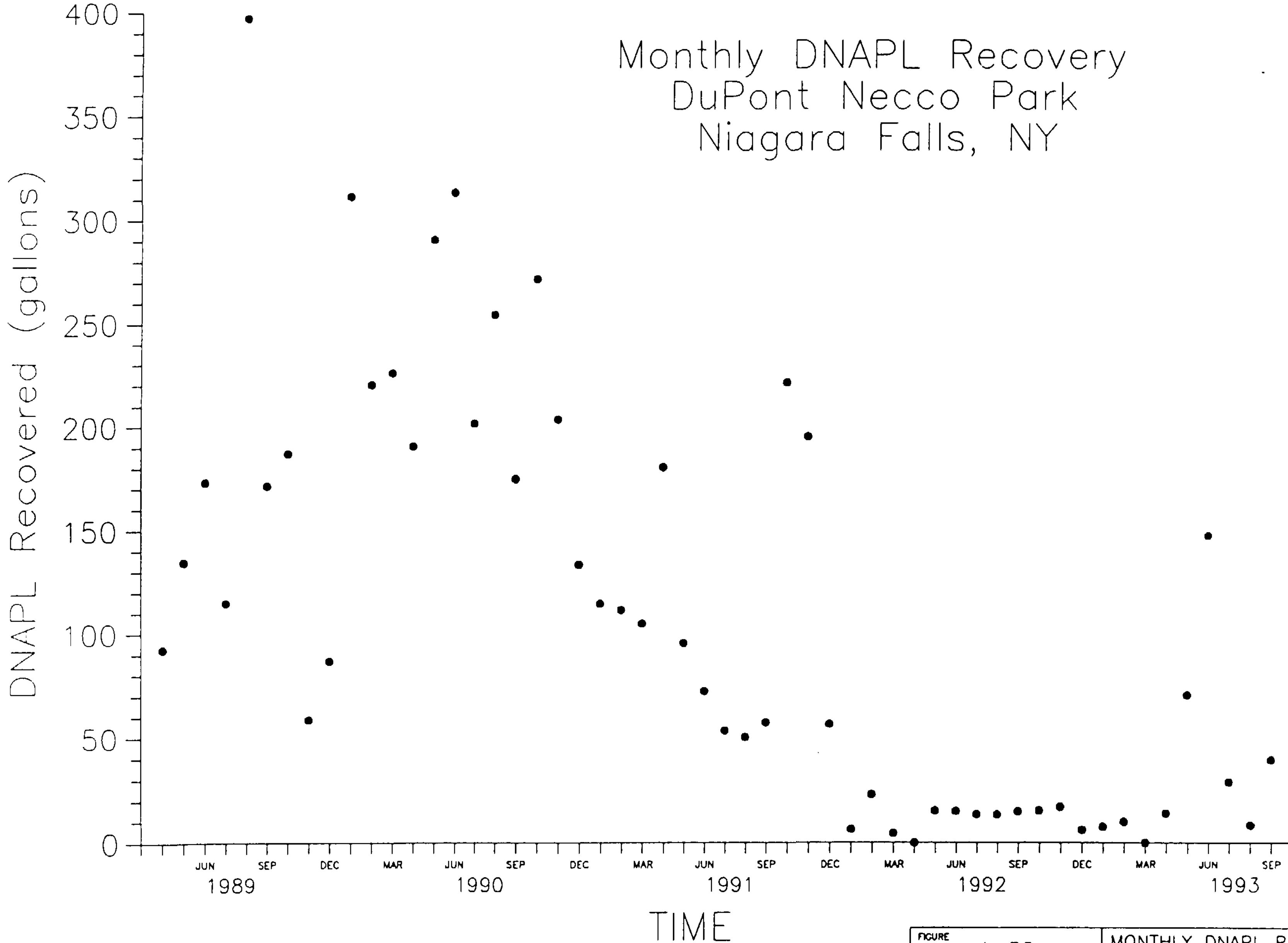


FIGURE 1-36	MONTHLY DNAPL RECOVERY VOLUME 1989-1993 NECCO PARK			
	SCALE AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING NO 1-72
	DATE 4/25/95	CHECKED PFM	APPROVED JMM	PROJECT NO 1281
	DUPONT NECCO PARK NIAGARA FALLS, NY			
	DuPont Environmental Remediation Servic			

400473

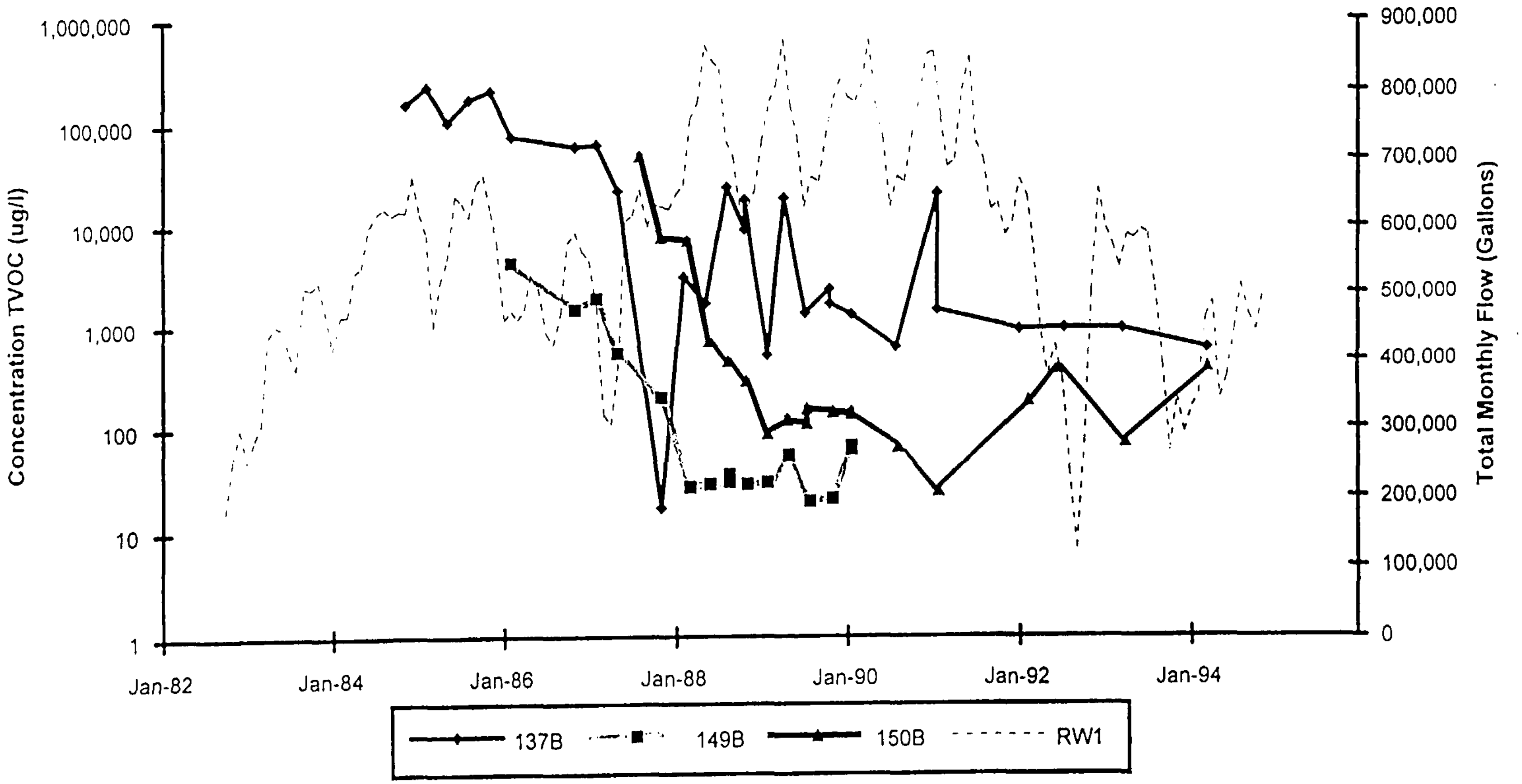


FIGURE	RW-1 Pumping vs. Monitor Well Concentrations			
1-37	SCALE	DESIGNED BY PFM	DRAWN BY CDW	CAD DRAWING NO
DUPONT	DATE 4/21/95	CHECKED CLB	APPROVED RGB	PROJECT NO 3293
	DuPont Necco Park Analysis of Alternatives			
	DuPont Environmental Remediation Services			

400474

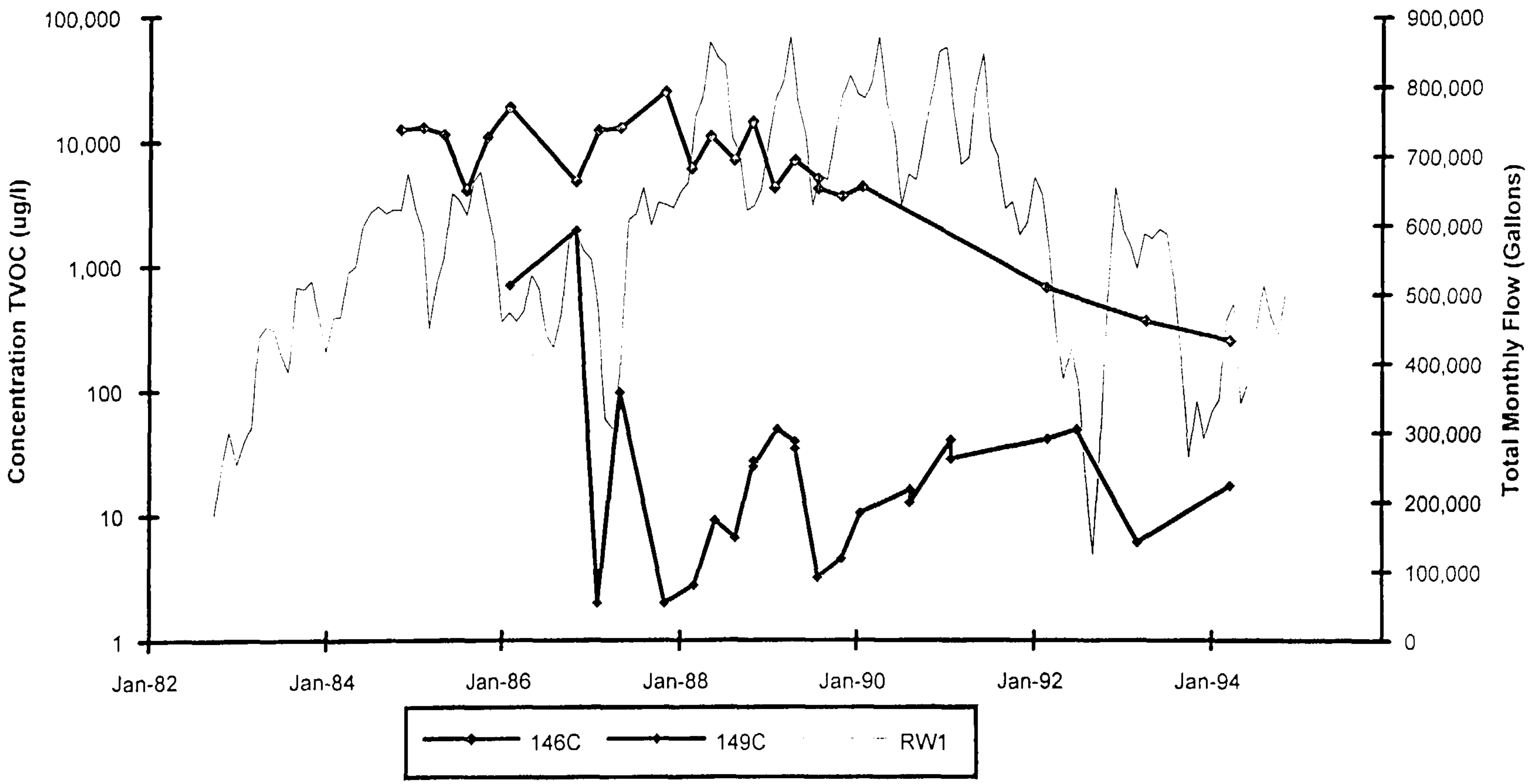


FIGURE 1-38	RW-1 Pumping vs. Monitor Well Concentrations			
	SCALE	DESIGNED BY PFM	DRAWN BY CDW	CAD DRAWING NO
DUPONT	DATE 4/21/95	CHECKED CLB	APPROVED RGB	PROJECT NO 3293
	DuPont Necco Park Analysis of Alternatives			
	DuPont Environmental Remediation Servic			

400475

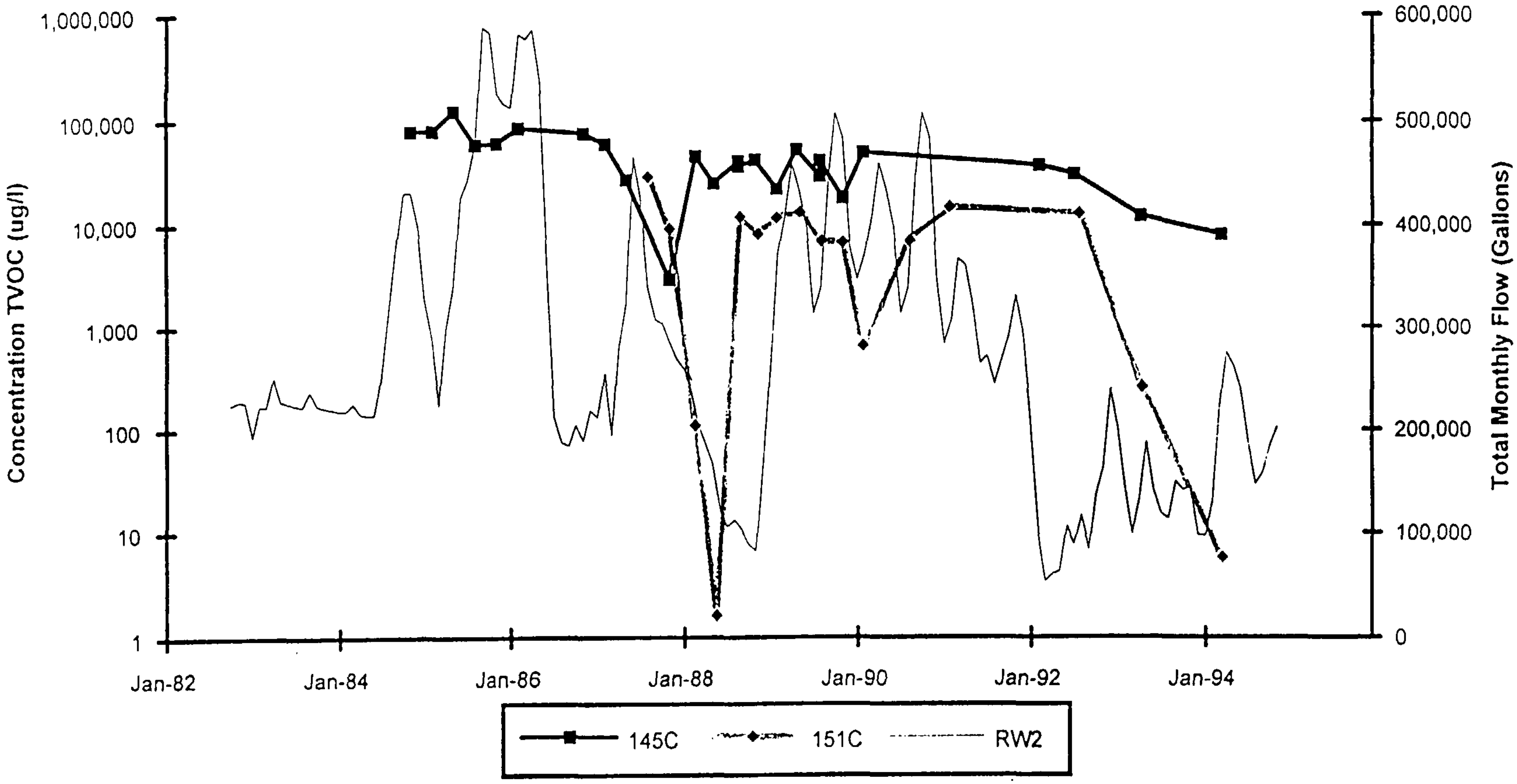
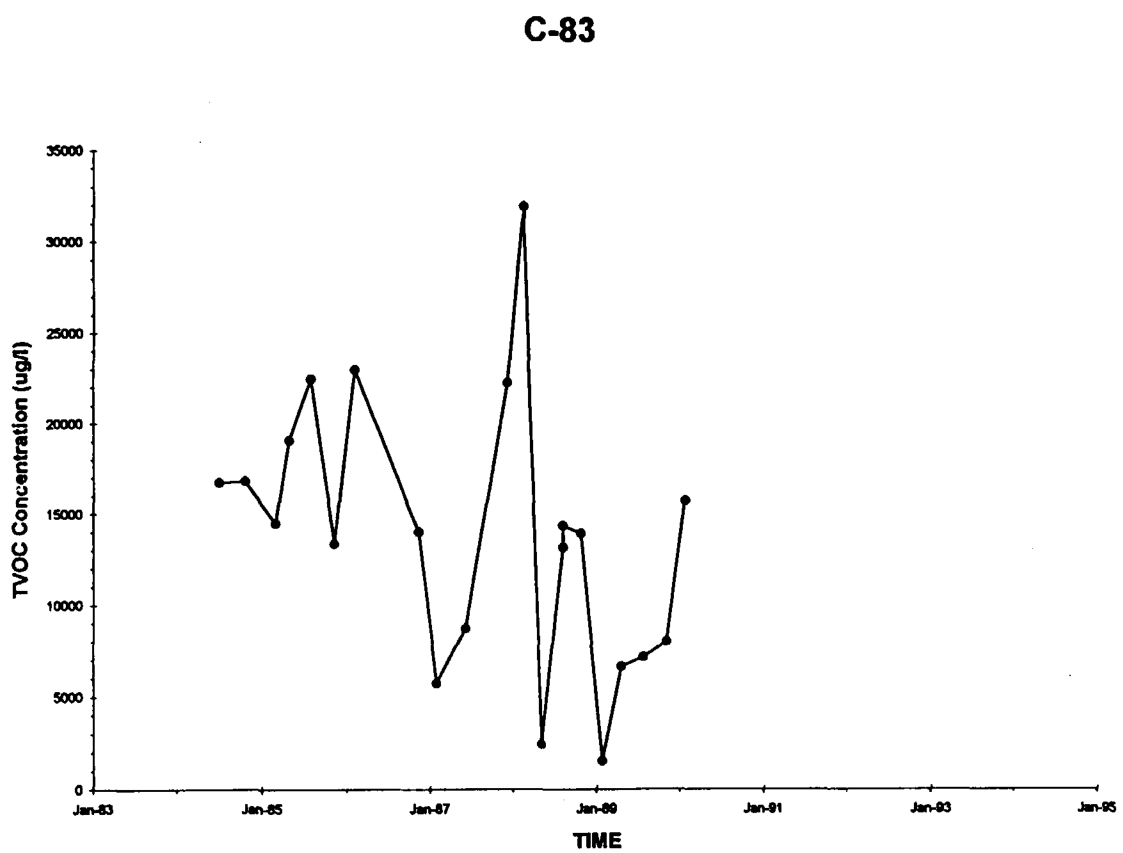
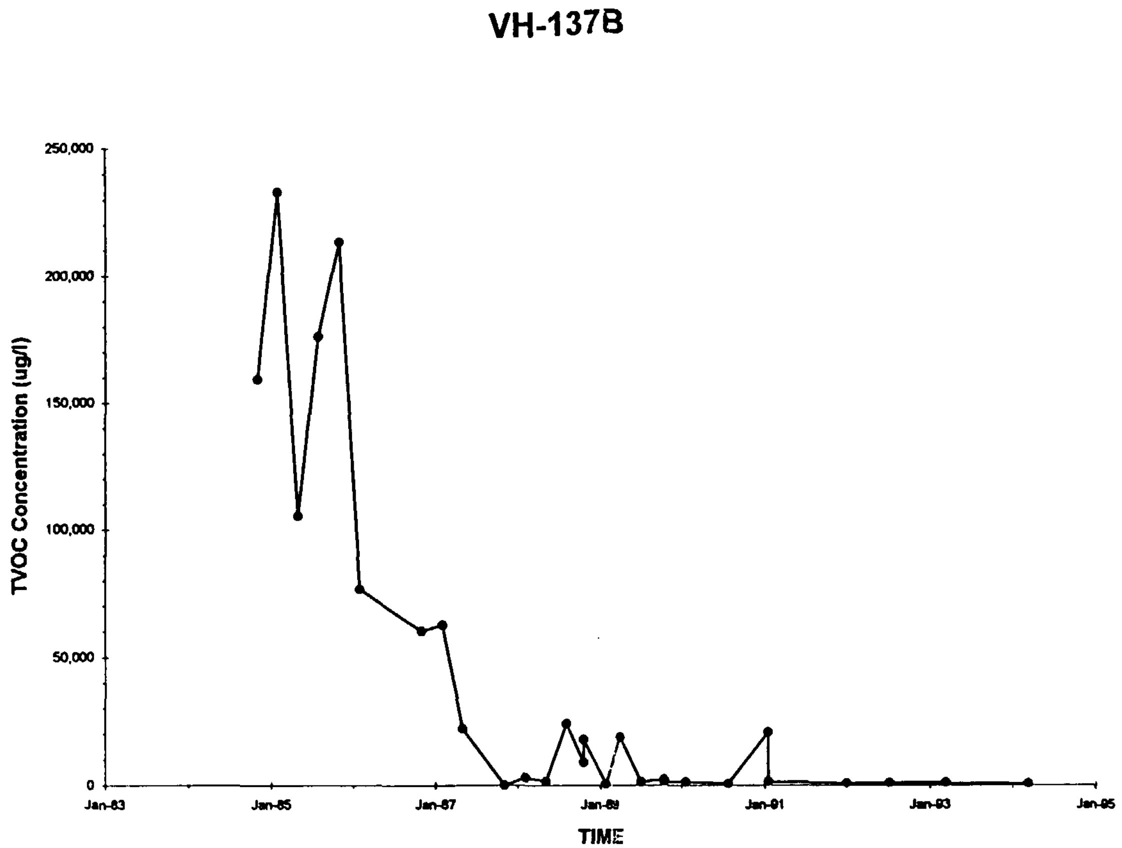
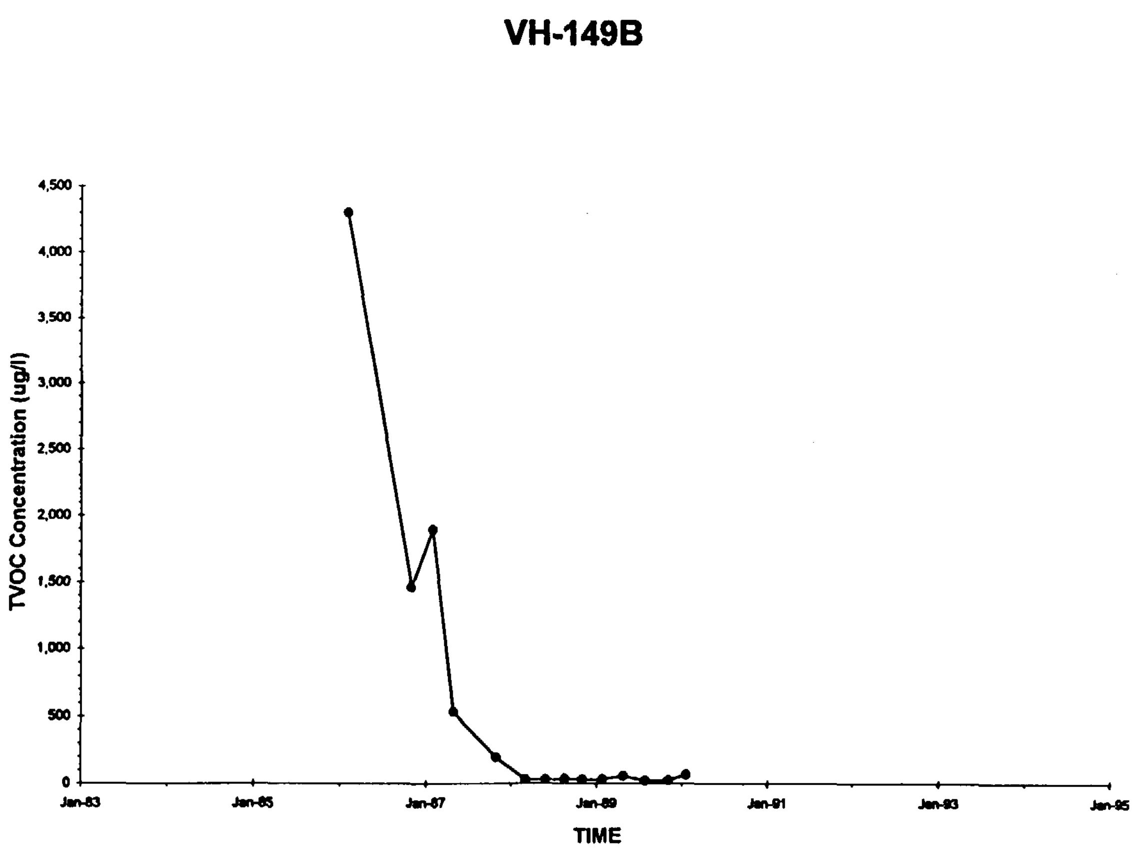


FIGURE 1-39	RW-2 Pumping vs. Monitor Well Concentrations			
	SCALE	DESIGNED BY PFM	DRAWN BY CDW	CAD DRAWING NO
	DATE 4/21/95	CHECKED CLB	APPROVED RGB	PROJECT NO 3293
	DuPont Necco Park Analysis of Alternatives			
	DuPont Environmental Remediation Services			

400476







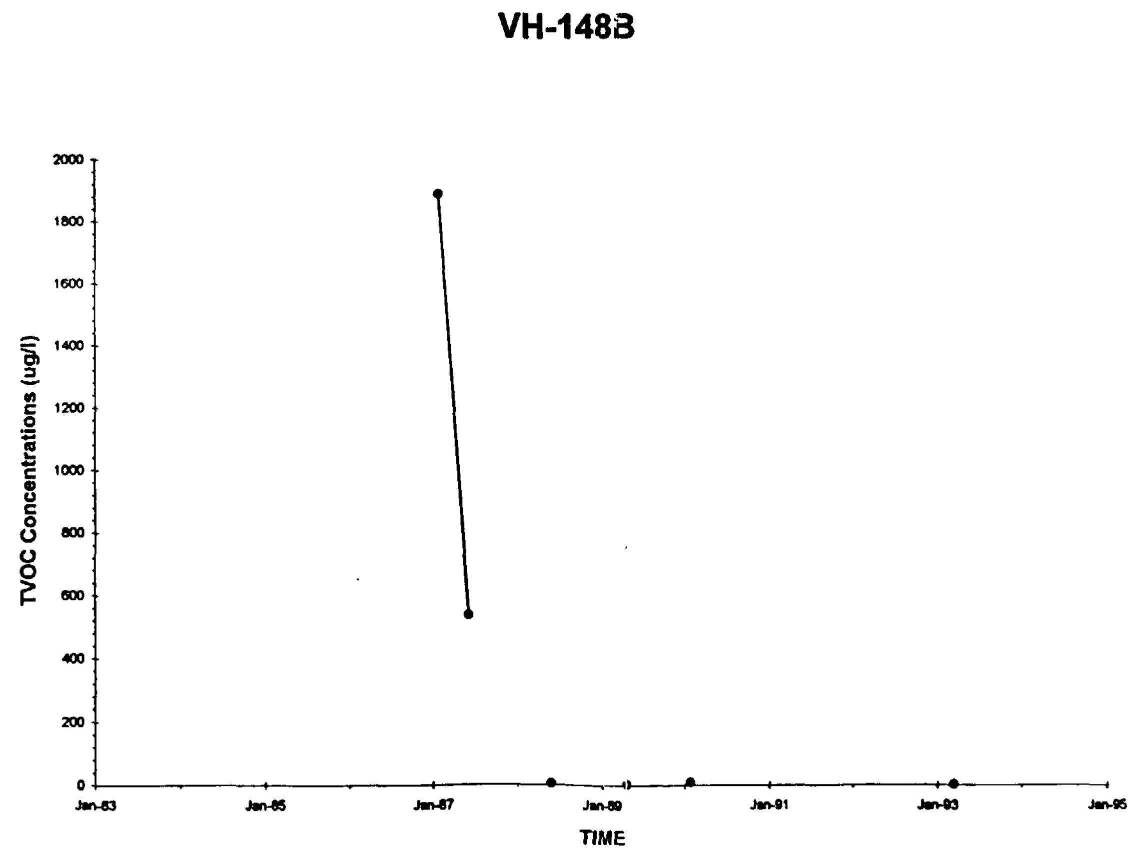
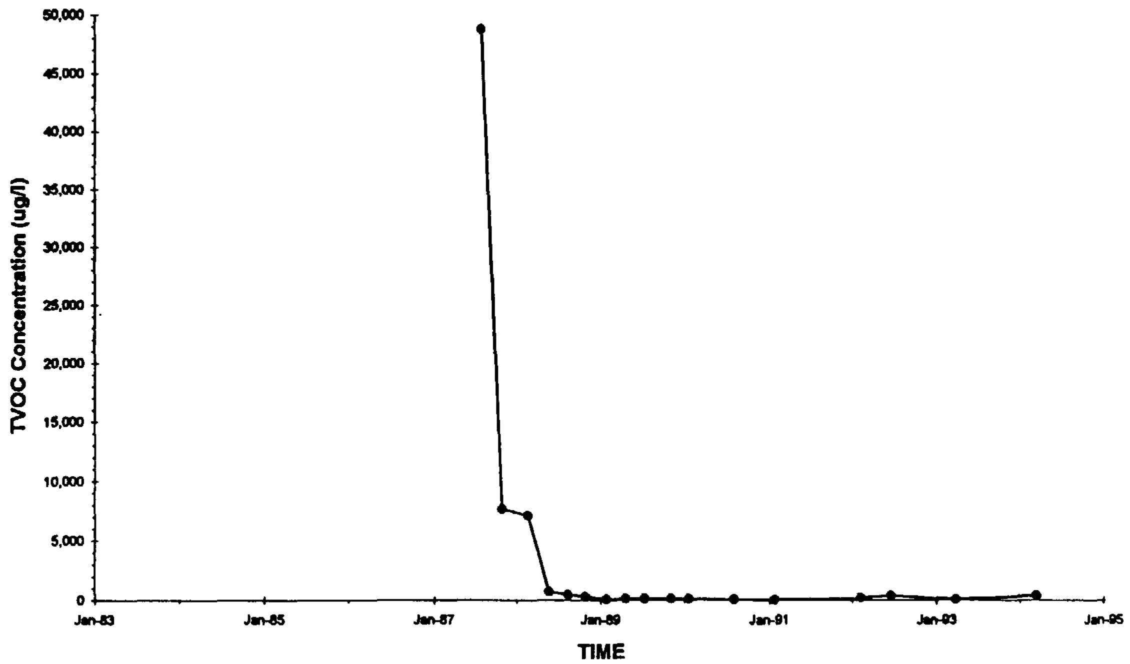


FIGURE 1-40	TVOC Concentrations Through Time: B Zone Wells			
	SCALE NO SCALE	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO
	DATE 9/20/95	CHECKED PFM	APPROVED	PROJECT NO 3293
DUPONT	DuPont Necco Park Niagara Falls, NY			
	DuPont Environmental Remediation Services			

400477

VH-150B



VH-152BC

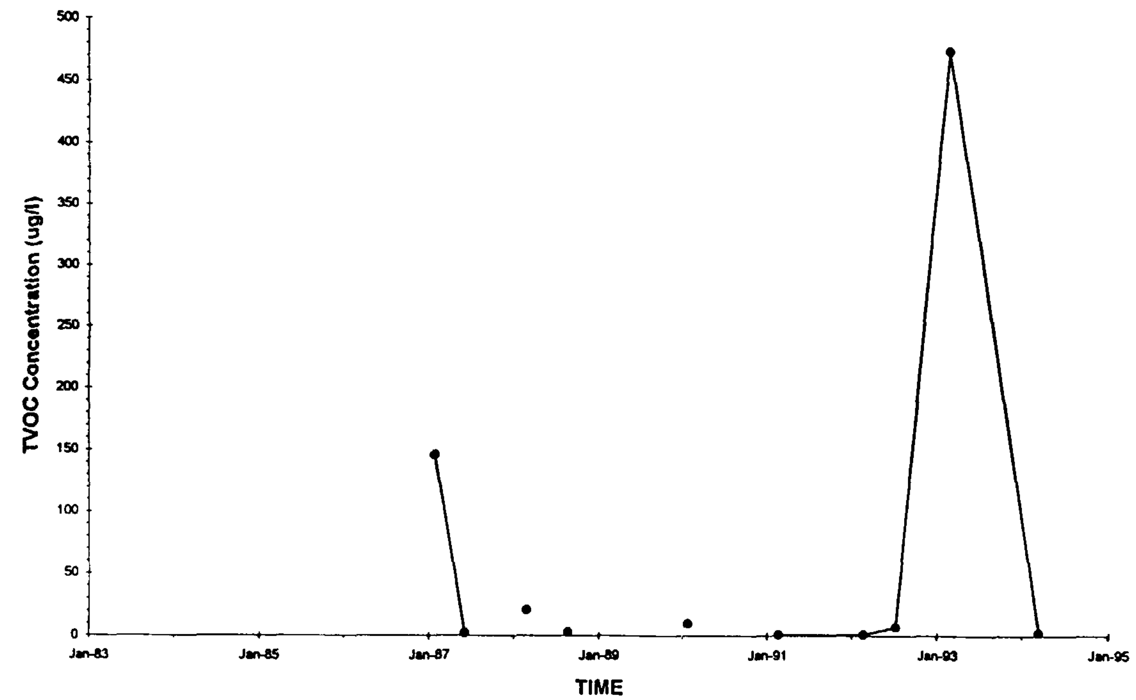
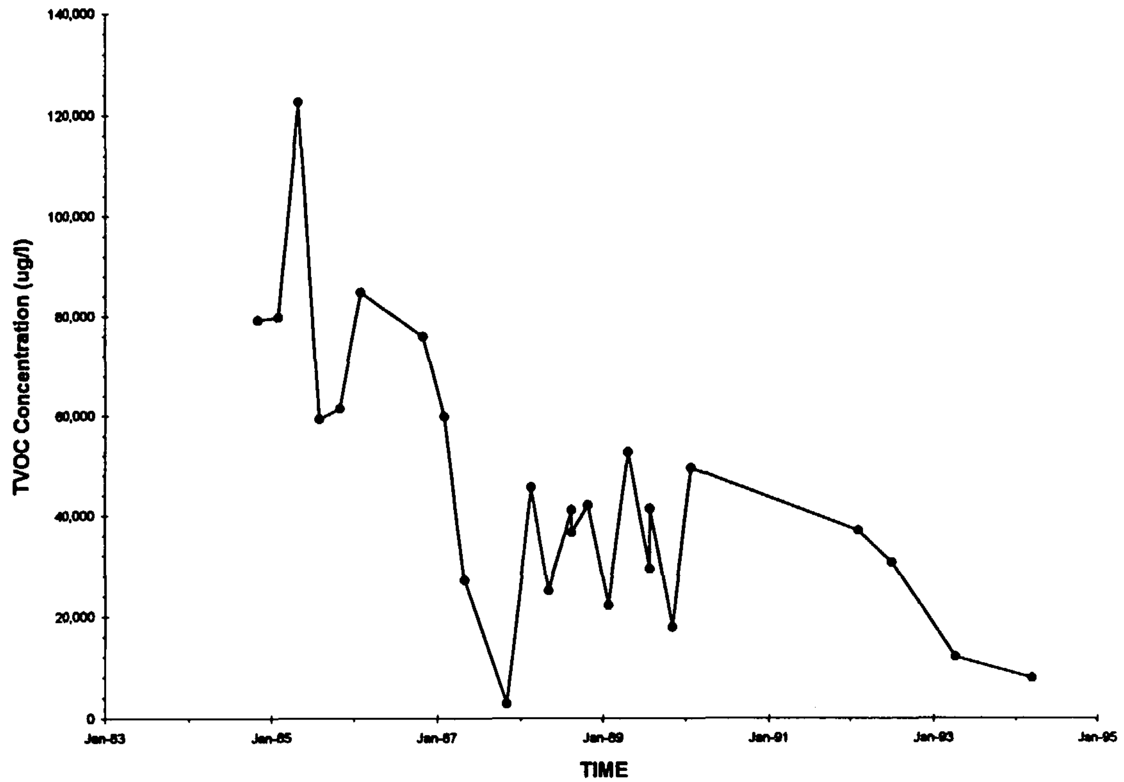


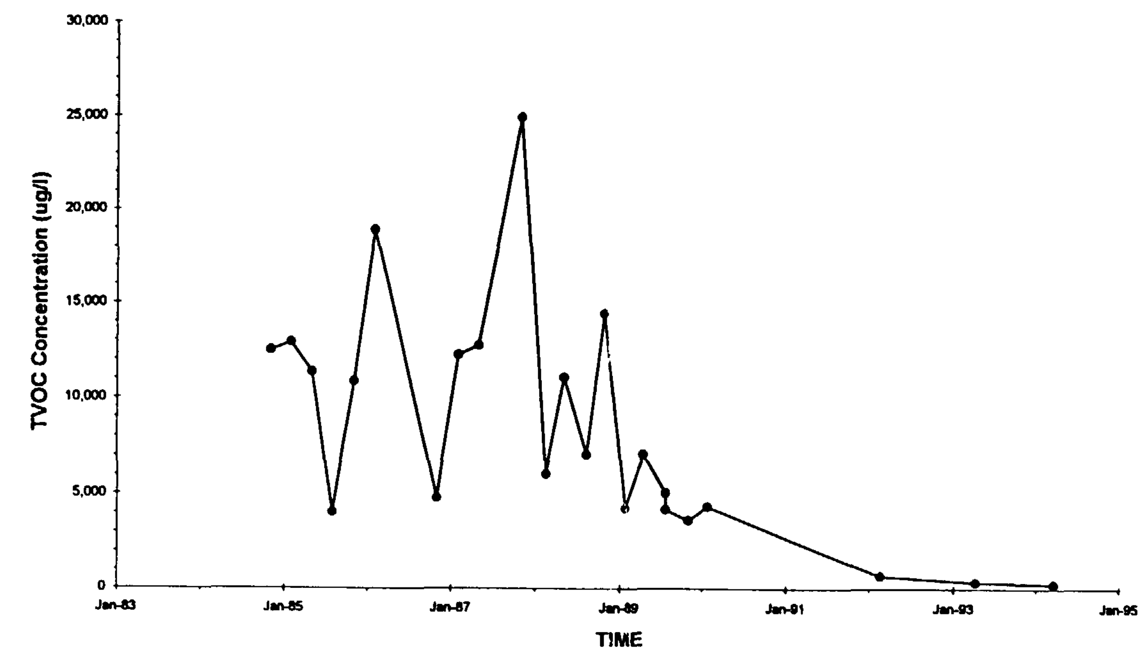
FIGURE 1-41	TVOC Concentrations Through Time: B Zone Wells			
	SCALE NO SCALE	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO
	DATE 9/20/95	CHECKED PFM	APPROVED	PROJECT NO 3293
DUPONT	DuPont Necco Park Niagara Falls, NY			
	DuPont Environmental Remediation Services			

400478

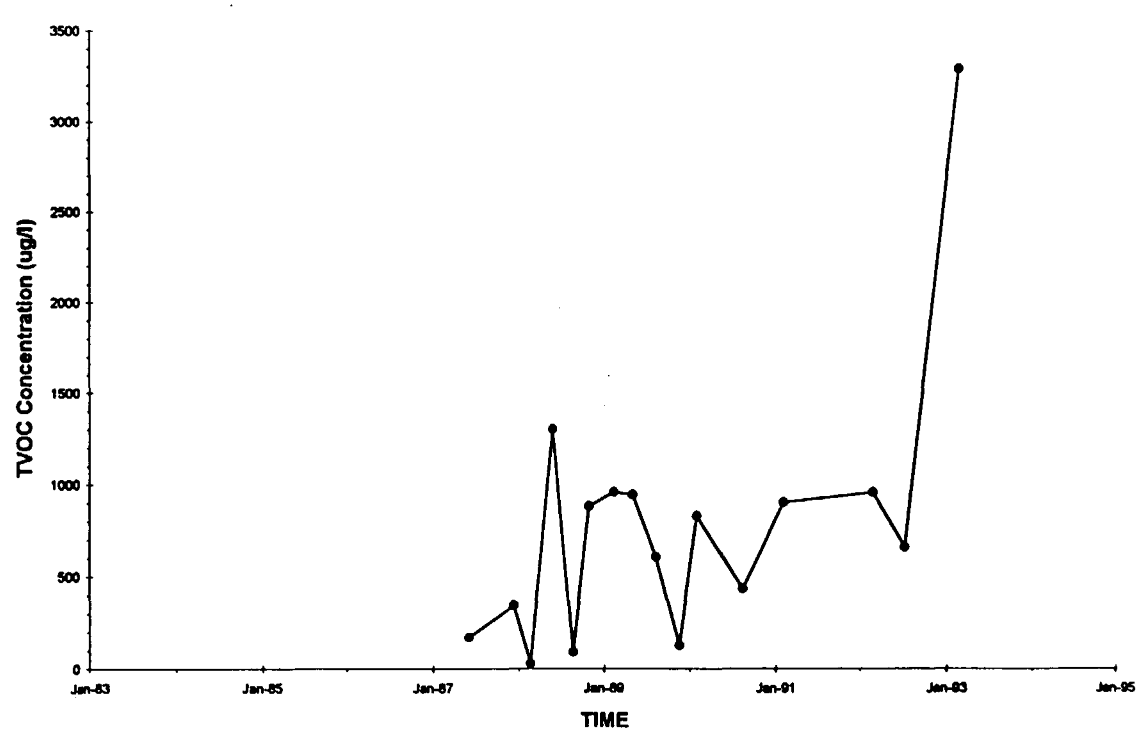
VH-145C



VH-146C



VH-147C



VH-148C

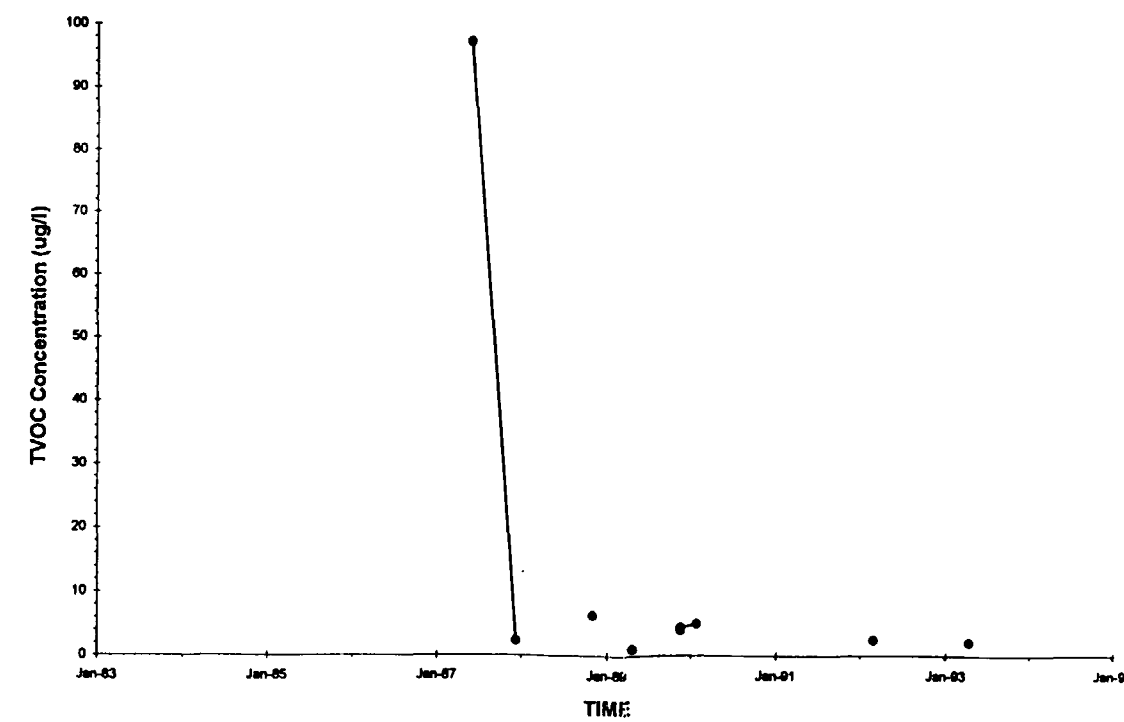
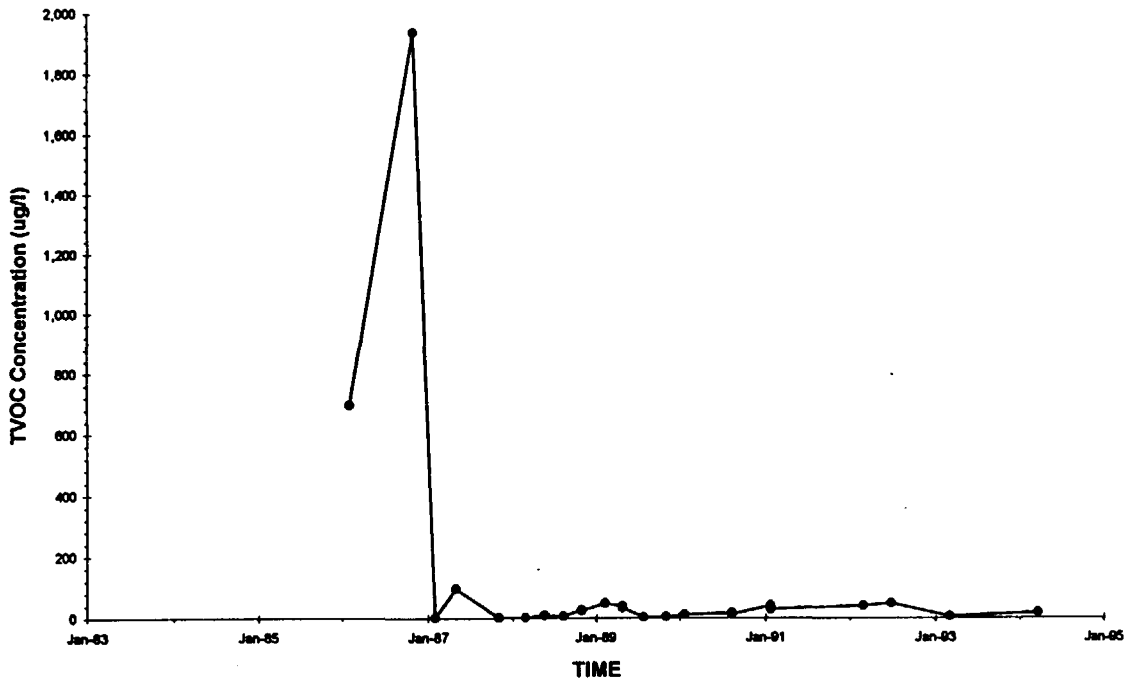
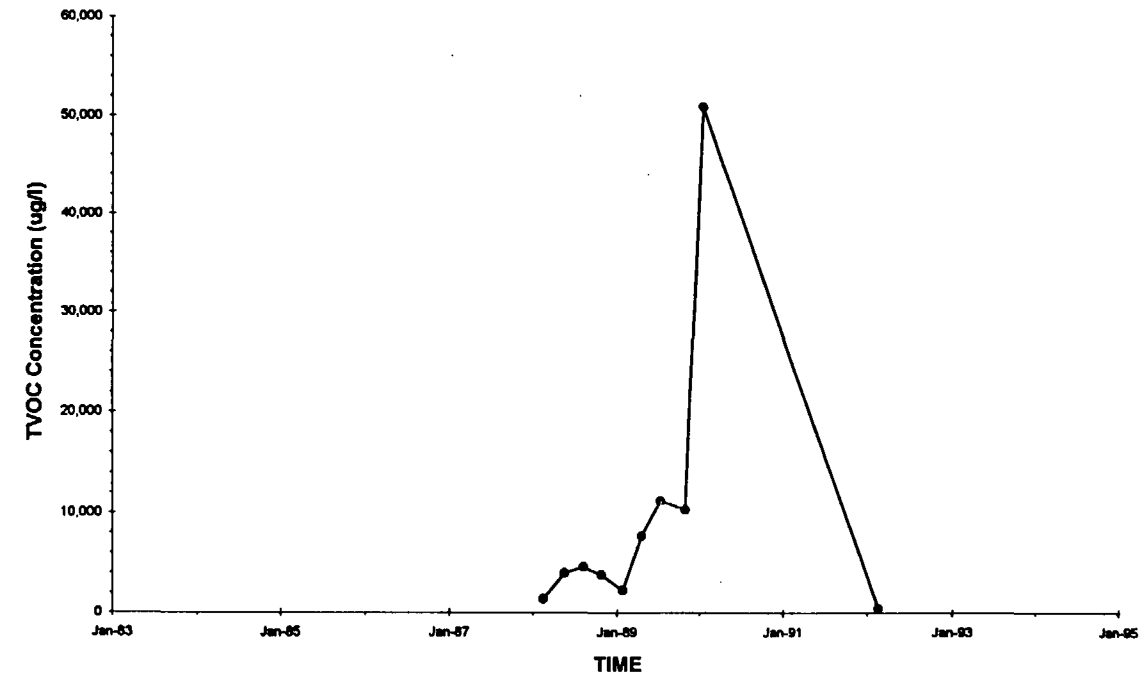


FIGURE	TVOC Concentrations Through Time: C Zone Wells			
1-42	SCALE: NO SCALE	DESIGNED BY	DRAWN BY: SMF	CAD DRAWING NO
DUPONT	DATE: 9/20/95	CHECKED: PFM	APPROVED	PROJECT NO: 3293
	DuPont Necco Park Niagara Falls, NY			
	DuPont Environmental Remediation Services			

VH-149C



VH-150C



VH-151C

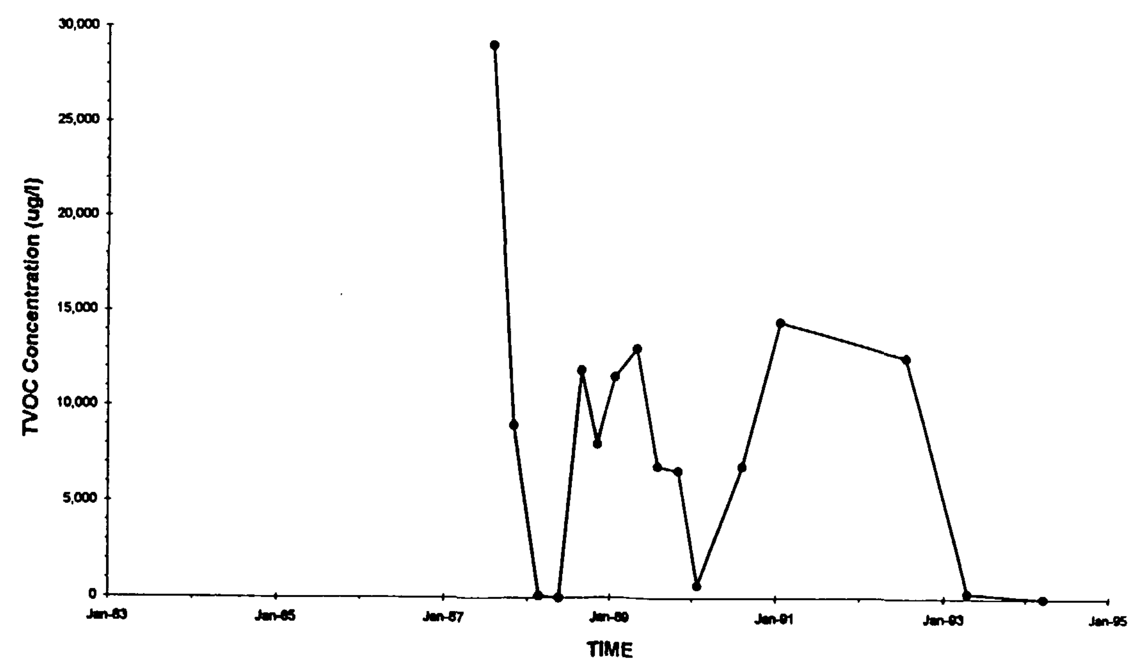
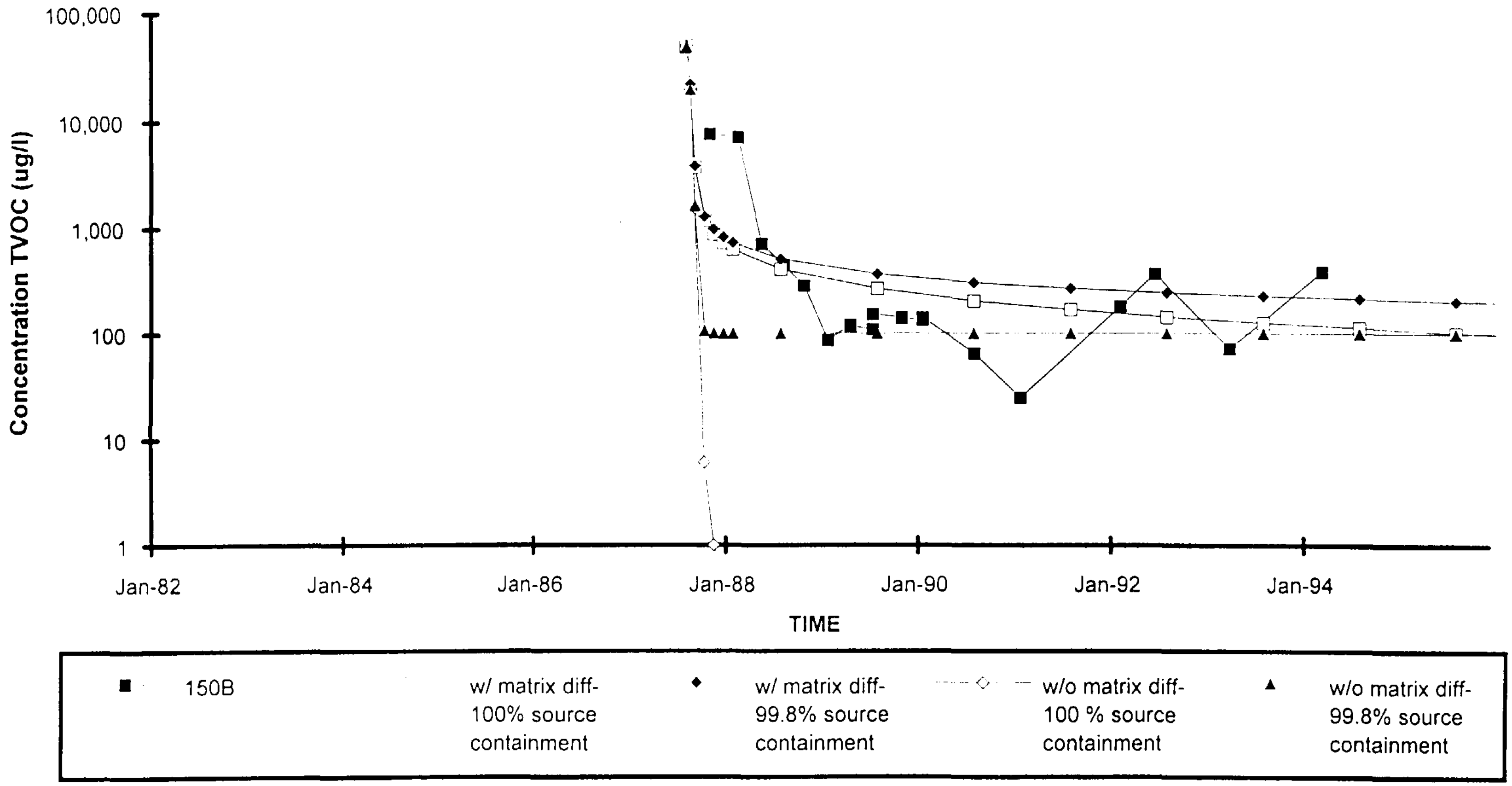


FIGURE 1-43	TVOC Concentrations Through Time: C Zone Wells			
	SCALE NO SCALE	DESIGNED BY	DRAWN BY SMF	CAD DRAWING NO
DUPONT	DATE 9/20/95	CHECKED PFM	APPROVED	PROJECT NO 3293
	DuPont Necco Park Niagara Falls, NY			
	DuPont Environmental Remediation Services			

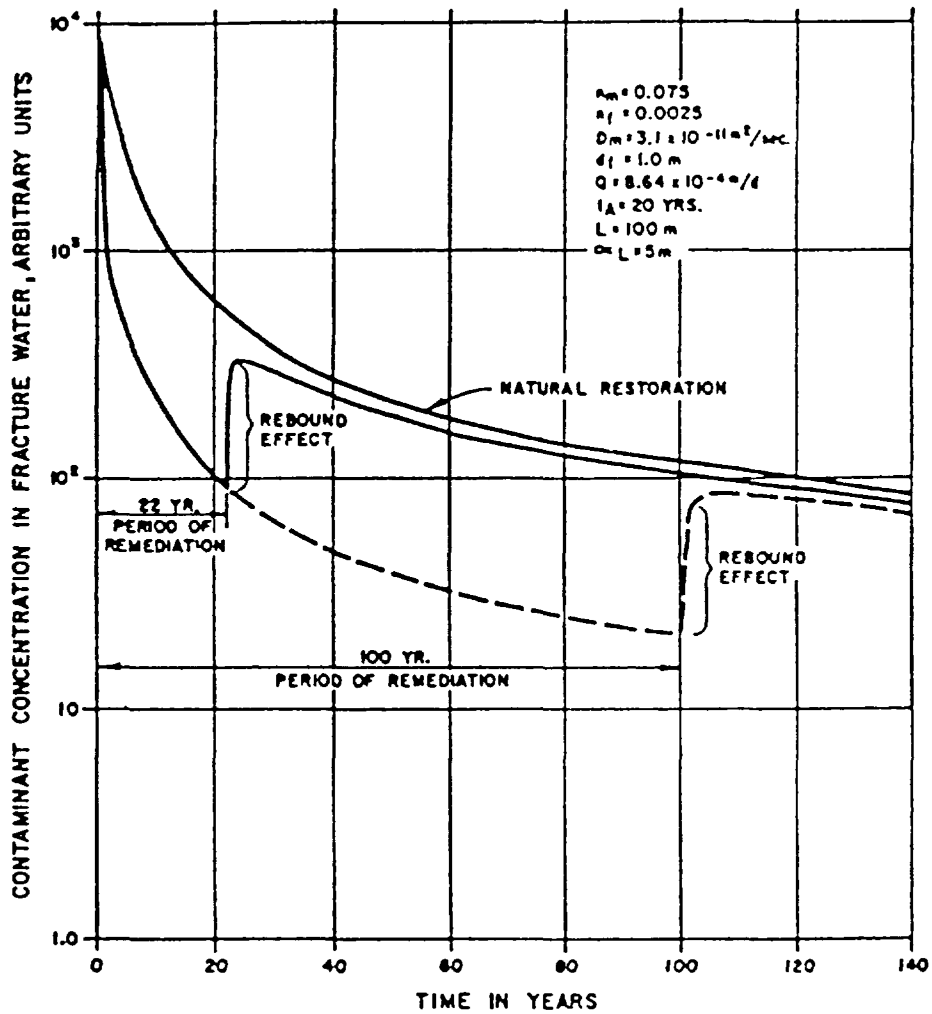
400480



4004481

FIGURE 1-44	Actual vs. Modeled Downgradient Concentrations			
	SCALE	DESIGNED BY PFM	DRAWN BY CDW	CAD DRAWING NO
	DATE 4/21/95	CHECKED CLB	APPROVED RGB	PROJECT NO 3293
DU PONT	DuPont Necco Park Analysis of Alternatives			
	DuPont Environmental Remediation Services			

Note: Source contained at 50 years



Source: Mutch et al. 1993

FIGURE 1-45	COMPARISON OF AQUIFER CLEAN-UP TIMES FOR NATURAL RESTORATION & ACTIVE REMEDIATION			
DUPONT	SCALE: AS SHOWN	DESIGNED BY	DRAWN BY	CAD DRAWING NO
	DATE: 3/15/95	CHECKED: PFM	APPROVED: CLB	PROJECT NO: 3293
	DuPont Necco Park Niagara Falls, New York			
	DuPont Environmental Remediation Services			

400482

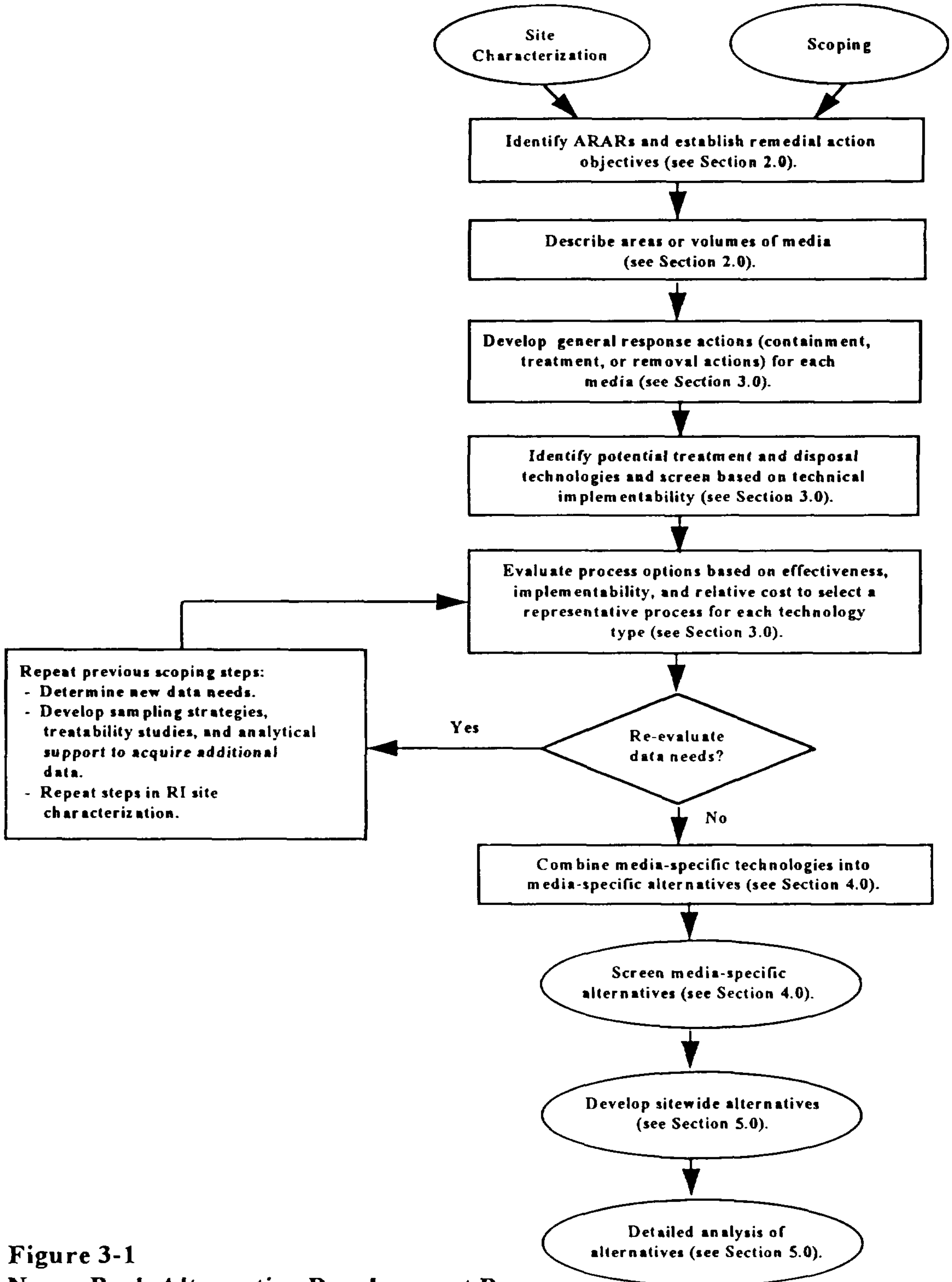


Figure 3-1
Necco Park Alternative Development Process

Source: Adapted from EPA's Guidance for Controlling Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988)

TABLES

Table 1-1

PRODUCTION AND EXTRACTION WELLS IN THE NIAGARA FALLS AREA

Location	Distance (Feet) from Necco Park	Well Type	Number of Wells	Zone Monitored
Olin Chemical	9,500 (southwest)	Production	2***	Lockport (C through F zones)
DuPont				
Niagara	10,000 (southwest)	Extraction	17	Lockport (A zone bedrock)
			5	Overburden (A zone overburden)
Necco Park Landfill		Extraction	2	Lockport (B and C zones)
			1	Lockport (D through F zones)
Occidental Chemical				
Durez Niagara Plant	2,500 (northwest)	Extraction	3	Lockport (B and C zones)
Hyde Park Landfill*	17,000 (northwest)	Extraction	6	Lockport
S-Area Landfill*	6,000 (south/ southwest)	Extraction	16	Lockport
BFI/CECOS Landfill**	1,800 (northeast)	Extraction	8	Lockport
			12	Overburden (A zone)

Note:

Data derived from the *Niagara Falls Regional Groundwater Assessment* (WCC and CRA 1992)

* These wells are currently being installed or tested.
** Only 10 of these wells are pumped during the winter months.
*** Only one well is operational at any given time.

Table 1-2

NECCO PARK AQUEOUS INDICATOR PARAMETER LIST

Inorganic and General Water-Quality Parameter	Volatile Organic Compounds	Semivolatile Organic Compounds
pH	Vinyl chloride	Hexachloroethane
Specific conductivity	1,1-dichloroethene	Hexachlorobutadiene
Temperature	Trans-1,2-dichloroethene	Phenol
Chloride	Cis-1,2-dichloroethene	4-methylphenol
Ammonia nitrogen	Chloroform	2,4,6-trichlorophenol
Soluble barium	Carbon tetrachloride	2,4,5-trichlorophenol
Cyanide	1,2-dichloroethane	Pentachlorophenol
Total organic halogens	Trichloroethene	Hexachlorobenzene
Total organic carbons	1,1,2-trichloroethane	TIC-1
Total dissolved solids	Tetrachloroethene	
Total suspended solids	1,1,2,2-tetrachloroethane	
Rhodamine		

Table 1-3

DNAPL COMPONENTS

Contaminant	Mole Fraction in DNAPL (%)
Hexachlorobutadiene	59
Hexachloroethane	9
Hexachlorobenzene	2
Carbon tetrachloride	5
Chloroform	1
Tetrachloroethene	3
1,1,2,2-tetrachloroethane	5
Trichloroethene	4

Note:

The data was derived from the following sources:

WCC. 1986. *NAPL Investigation, Necco Park.*
WCC. 1987. *NAPL Sampling and Analytical Plan.*
WCC. 1987. *Results of NAPL Sampling and Analytical Program, Necco Park.*

Table 1-4

ZONE-SPECIFIC OFF-SITE LOADINGS

Zone	Loading (lbs/day)	
	Nonpumping Conditions*	Existing Conditions
B	4.97	0.01
C	3.86	<0.01
D	0.55	0.53
E	4.82	4.61
F	7.43	7.14
G	0.99	0.98
Total	22.6	13.3

*Based on alternative 1

Table 2-1

POTENTIAL CHEMICAL-SPECIFIC ARARs

Standards, Requirements, Criteria, or Limits	Citation or Reference	Description
New York Safe Drinking-Water Act Standards	10 NYCRR Chapter I, Part 5-1	State maximum contaminant level (MCL) standards for public water systems based on public health and feasible technology
New York Surface-Water and Groundwater Quality Standards and Effluent Standards	6 NYCRR Parts 700-705	State surface-water and groundwater quality and receiving water discharge standards
New York State Pollutant Discharge Elimination System	6 NYCRR Chapter X, Parts 750-758	Permitting procedures and discharge limitations for discharges of effluent to surface water
Federal Safe Drinking-Water Act	42 USC s300f	The act that provides the EPA with the authority to develop and implement drinking-water standards
National Primary Drinking-Water Standards	40 CFR 141	Standards (MCLs and MCLGs) for public water systems based on public health and feasible technology
National Secondary Drinking-Water Standards	40 CFR 143	Numerical criteria-based (secondary MCLs—SMCLs) aesthetics
Niagara County Drinking-Water Standards	Niagara County Sanitary Code Chapter IV	Niagara County drinking-water standards (MCLs) for public water systems based on public health and feasible technology
Standards for Owners and Operators of Hazardous Waste TSDs	40 CFR 264.94	Groundwater protection standards for toxic metals and pesticides
Federal Water-Quality Criteria	33 USC SS 1251-1376 40 CFR 131	Criteria for water quality based on toxicity to aquatic organisms and public health
New York Water Pollution Control Regulations	6 NYCRR Parts 608, 610-614	Permit requirements for protected stream disturbance, petroleum cleanup, and petroleum storage
New York Rules for Inactive Hazardous Waste Disposal Sites	6 NYCRR Part 375	Regulation for inactive hazardous waste sites
Toxic Substances Control Act	40 CFR 761	Regulation of PCBs, dioxins, and commercial chemicals

Table 2-2

POTENTIAL LOCATION-SPECIFIC ARARs

Standards, Requirements, Criteria, or Limits	Citation or Reference	Description
Coastal Zone Management Act	16 USC 1451 15 CFR 923/930	Preserves, protects, develops, restores, and enhances the resources of the coastal zone
Endangered Species Act	16 USC 153	Protects endangered species threatened to become extinct
New York Wetlands Regulations	6 NYCRR Part-661	Protects wetlands in the state of New York from adverse environmental impact caused by development activities
Executive Order on Floodplain Management	E.O. No. 11988	Requires federal agencies to evaluate the potential effects of actions in a floodplain to avoid, to the maximum extent possible, the adverse impact associated with direct and indirect development of a floodplain

Table 2-3

POTENTIAL ACTION-SPECIFIC ARARs AND TBCs

Standards, Requirements, Criteria, or Limits	Citation or Reference	Description
New York Safe Drinking-Water Act Standards	10 NYCRR Chapter I, Part 5-1	State standards (MCLs) for public water systems based on public health and feasible technology
New York Surface-Water and Groundwater Quality Standards and Effluent Standards	6 NYCRR Parts 700-705	State surface-water and groundwater quality and receiving-waters discharge standards
New York State Pollutant Discharge Elimination System	6 NYCRR Chapter X, Parts 750-758	Requirements for discharges of effluent to surface water
Federal Safe Drinking-Water Act	42USC s300f	The act that provides the EPA with the authority to develop and implement drinking-water standards
National Primary Drinking-Water Standards	40 CFR 141	Standards (MCLs and MCLGs) for public water systems based on public health and feasible technology
National Secondary Drinking-Water Standards	40 CFR 143	Numerical criteria-based (SMCLs) aesthetics
Standards for Owners and Operators of Hazardous Waste TSDs	40 CFR 264.94	Groundwater protection standards for toxic metals and pesticides
Toxic Substances Control Act	40 CFR 761	Regulation of the management of PCBs and dioxins and commercial chemicals
Clean Water Act Section 404	40 CFR 300	Prohibits discharge of dredged or fill material into wetlands without a permit; preserves and enhances wetlands
New York Hazardous Waste Regulations	6 NYCRR Parts 370-375	Establishes regulations for hazardous waste treatment, storage, transportation, and disposal in the state of New York
Water Allocation Permit	Article 15, Environmental Conservation Law, Title 16	Laws implementing requirements of the Great Lakes compact; applicable to facilities with a minimum well pumping rate of 100,000 gallons per day and other facilities that divert water from the Great Lakes drainage basin
New York State Solid and Hazardous Waste Regulations	6 NYCRR Part 364	Waste Transporter Permit
New York State Solid and Hazardous Waste Regulations	6 NYCRR Part 376	LDRs
New York State Solid and Hazardous Waste Regulations	6 NYCRR Part 257	Air Quality Standards
New York Solid Waste Regulations	6 NYCRR 360	Establishes regulations for nonhazardous waste disposal
New York Air Emissions Limits Regulations	6 NYCRR Parts 200-254	Sets limits for air emissions for specific processes and permit requirements
Well Permitting Procedures	10 NYCRR Chapter I, Part 5	Establishes procedures for permitting installation of a well
City of Niagara Falls Sewer Discharge Permit	City of Niagara Falls Sewer Use Ordinance Chapter 250	Limits contaminant concentration and discharges to POTWs

Table 2-3

POTENTIAL ACTION-SPECIFIC ARARs AND TBCs

Standards, Requirements, Criteria, or Limits	Citation or Reference	Description
Niagara County Drinking Water Standards	Niagara County Sanitary Code Chapter IV	Niagara County drinking-water standards (MCLs) for public water systems based on public health and feasible technology
Resource Conservation and Recovery Act	40 CFR 260 - 270 42 USC 6901 et seq.	Regulates the generation, transport, treatment, storage, and disposal of hazardous wastes
New York Occupational Safety and Health	6 NYCRR 662-666	Worker health and safety
Federal Occupational Safety and Health	29 CFR	Worker health and safety
Federal Air Emissions Regulations	40 CFR Part 50-80	Regulation of the construction, operation, and emissions from stationary and mobile sources of air pollutants identified by the EPA
Hazardous Materials Transportation Act	49 USC 55 1801-1813 49 CFR 100-180	Regulation of the packaging, marking, labeling, manifesting, and mode of transportation of materials identified as hazardous materials by the Department of Transportation
NYSDEC Technical and Administrative Guidance Memorandum	N/A	Determination of soil cleanup objectives and cleanup levels
New York State Air Guide 1	N/A	Toxic Ambient Air Contaminants Guidelines
Four-Party Agreement	N/A	

Table 2-4

CHEMICAL-SPECIFIC ARARs AND ACCEPTABLE RISK-BASED CONCENTRATIONS FOR GROUNDWATER

Contaminant	New York Public Water Supply Regulations (µg/l)	New York Groundwater Quality Standards (µg/l)	Maximum Contaminant Level (µg/l)	Maximum Contaminant Level Goal (µg/l)	Noncarcinogenic Risk Based Concentration[7] (µg/l)	Carcinogenic Risk Based Concentration[1] (µg/l)	Practical Quantitation Limit (µg/l)
1,1,2,2-tetrachloroethane	5[4,6]	5[4]				0.3	10
Carbon tetrachloride	5[4,6]	5	5	0	15	0.46	10
Vinyl chloride	2	2	2	0		0.04	10
1,1,2-trichloroethane	5[4,6]	5[4]	5	3	98	1.0	10
1,1-dichloroethene	5[4,6]	5[4]	7	7	200	0.07	10
Hexachlorobutadiene	5[4,6]	5[4]			18	0.3	10
1,2-dichloroethane	5[4,6]	5[4]	5	0	7,387	0.63	10
Chloroform	100[2]	7	100[2]		238	1.9	10
Tetrachloroethene	5[4,6]	5[4]	5	0	183	1.0	10
Trichloroethene	5[4,6]	5[4]	5	0	136	5.5	10
2,4,6-trichlorophenol	50[5]	1[3]				4.5	10
Hexachlorobenzene	5[4,6]	0.35	1	0	4	0.008	10
Hexachloroethane	5[4,6]	5[4]			17	2.8	10
Pentachlorophenol	1	1[3]	1	0	67	0.04	50
Barium, soluble	2,000	1,000	2,000	2,000	2,555		
Cyanide, total		100	200		730		
Phenol	50[5,6]	1[3]			21,054		10
4-methylphenol	50[5,6]	1[3]			169		10
2,4,5-trichlorophenol	50[5,6]	1[3]			1,839		50
cis-1,2-dichloroethene	5[4,6]	5[4]	70	70	229		10
trans-1,2-dichloroethene	5[4,6]	5[4]	100	100	459		10

[1]Concentrations were calculated for a cancer risk level of 10^{-6} assuming residential exposures via ingestion, inhalation, and dermal adsorption while showering.
[2]Based on total trihalomethanes.
[3]Total phenolics.
[4]Based on classification as a principal organic contaminant (POC).
[5]Based on classification as an unspecified organic contaminant (UOC).
[6]Total combined POC and UOC has a maximum limit of 100 µg/l.
[7]Concentrations were calculated for a hazard index of 1 assuming residential exposures via ingestion, inhalation, and dermal adsorption while showering.
µg/l = micrograms per liter

400493

Table 2-5

TARGET REMEDIATION GOALS FOR GROUNDWATER

Contaminant	Target Goal (µG/L)
1,1,2,2-tetrachloroethane	5
Carbon tetrachloride	5
Vinyl chloride	2
1,1,2-trichloroethane	5
1,1-dichloroethene	7
Hexachlorobutadiene	5
1,2-dichloroethane	5
Chloroform	7
Tetrachloroethene	5
Trichloroethene	5
2,4,6-trichlorophenol	1
Hexachlorobenzene	0.35
Hexachloroethane	5
Pentachlorophenol	1
Barium, soluble	1,000
Cyanide, total	100
Phenol	1
4-methylphenol	1
2,4,5-trichlorophenol	1
cis-1,2-dichloroethene	5
trans-1,2-dichloroethene	5

µg/l = micrograms per liter

Table 3-1

OVERBURDEN TECHNOLOGY IDENTIFICATION AND SCREENING

General Response Action	Technology	Process Options	Description	Screening Comments
No action	None	Not Applicable	No Action -- all current activities discontinued	Required for consideration
Institutional action	Access Restrictions	Deed Restrictions	Deeds for property to restrict future use	Potentially applicable
		Fencing	Fencing to restrict access	Potentially applicable
		Security Personnel	Guards to restrict access	Potentially applicable
	Monitoring	Air Monitoring	Air monitoring for potential vapors	Potentially applicable
Containment	Capping	Clay Cap	Compacted clay covered with soil and vegetation over area	Potentially applicable
		NYS 360 Cap	Low permeability layer, protective layer and vegetative layer over area	Potentially applicable
		Asphalt Cap	Asphaltic material over area	Potentially applicable
		NYS 373 Cap	Compacted clay and low permeability geomembrane system over area	Potentially applicable
	Vertical Barriers	Slurry Wall	Trench around area is filled with a soil (or cement) bentonite slurry	Potentially applicable
		Grout Curtain	Low permeability grout wall installed by injection or mixing	Potentially applicable
		Sheet Piles	Steel or plastic interlocking panels driven through soils to form wall	Potentially applicable
	Horizontal Barrier	Bottom Barriers	Horizontal layer of low permeability material	Potentially applicable
Excavation	Excavation	Excavation	Removal of soil/waste with standard excavation equipment	Potentially applicable
Treatment	Thermal	Incineration	Combustion in rotary kiln or fluidizied bed	Potentially applicable for organics
		Radio Frequency Heat.	Electromagnetic energy for subsurface heating	Potentially applicable for organics
		Thermal Desorption	Low temp. (<1,200F) desorption and destruction of constituents	Potentially applicable for organics
		In Situ Vitrification	High temp. treatment to form glass-like matrix and destroy organics	Potentially applicable for organics
		Commercial Incineration	Commercial incinerator for high temperature destruction	Potentially applicable
	Biological	In Situ	In place bacterial degradation of constituents	Potentially applicable for organics
		Ex Situ	Treatment in on-site treatment cells or bioreactors	Potentially applicable for some organics
	Physical/Chemical	Soil Vapor Extraction	Vapor phase constituents removed with low vacuum	Potentially applicable for organics
		Soil Flushing	Constituents solubilized with solvent/surfactant and extracted	Potentially applicable
		Soil Washing	Excavated material mixed w/solvents, surfactant to remove constituents	Potentially applicable
		Dual Phase Extraction	Vapor and liquid phase constituents removed with high vacuum	Potentially applicable for organics
		In Situ Stabilization	Material mixed with agent in place to reduce mobility	Potentially applicable
		Ex Situ Stabilization	Excavated material mixed with agent to reduce mobility	Potentially applicable
		Vapor phase treatment	Vapor phase carbon, thermal oxidation or condensing	Potentially applicable

400495

Table 3-1
(Continued)

General Response Action	Technology	Process Options	Description	Screening Comments
Disposal	Disposal	On-Site Landfill	On-site area prepared for disposal of treated material	Potentially applicable
		Off-Site Landfill	Commercial landfill	Potentially applicable

400496

Table 3-2

DNAPL TECHNOLOGY IDENTIFICATION AND SCREENING

General Response Action	Technology	Process Options	Description	Screening Comments
No action	None	Not Applicable	No Action -- all current activities discontinued	Required for consideration
Institutional action	Access Restrictions	Deed Restrictions	Future use restrictions	Potentially applicable
		GW Use Controls	Local ordinance controlling groundwater use	Potentially applicable
	Monitoring	DNAPL Monitoring	Tracking DNAPL through visual observation or solubility	Potentially applicable
Containment	Vertical Barriers	Slurry Wall	Trench around area is filled with soil (or cement) bentonite slurry	Potentially applicable
		Grout Curtain	Low permeability grout wall installed by injection or mixing	Potentially applicable
		Sheet Piles	Steel or plastic interlocking panels driven through soils to form wall	Potentially applicable
	Horizontal Barrier	Low Permeability Floor	Horizontal layer of low permeability material	Potentially applicable
Collection	Extraction	Extraction Wells	Liquid extracted through vertical or horizontal wells	Potentially applicable
		Trenches	Liquid extracted through trench	Potentially applicable
Treatment	Electrolytic Processes	Electro-Osmosis	Constituent removal enhanced by electrical potential gradients	Not applicable, DNAPL is not sufficiently polar
		Electroacoustic	Constituent removal enhanced by electrical and pressure gradients	Not applicable, DNAPL is not sufficiently polar
	Thermal	Radio Frequency Heating	Electromagnetic energy to accomplish subsurface heating	Potentially applicable
		In Situ Vitrification	High temperature treatment to destroy organics	Potentially applicable
		Commercial Incineration	Commercial incinerator for high temperature destruction	Potentially applicable
	Biological	In Situ Aerobic	Microbial degradation with oxygen	Not applicable due to biotoxicity
		In Situ Anaerobic	Microbial degradation without oxygen	Not applicable due to biotoxicity
		Ex Situ Aerobic	Treatment in cells or bioreactors w/oxygen	Not applicable due to biotoxicity
		Ex Situ Anaerobic	Treatment in cells or bioreactors w/o oxygen	Not applicable due to biotoxicity
		Passive Treatment Wall	Vertical wall with reactive granular backfill and additives	Not applicable due to biotoxicity
		Natural Attenuation	Natural degradation of constituents	Not applicable due to biotoxicity
	Physical/Chemical	Vapor Extraction	Vapor phase constituents removed with low vacuum	Potentially applicable
		Surfactant Flushing	Constituents solubilized with solvent/surfactant and extracted	Potentially applicable
		Dual Phase Extraction	Vapor phase constituents removed with high vacuum	Potentially applicable
		In Situ Stabilization	Material mixed with agent in place to reduce mobility	Potentially applicable
		Vapor phase treatment	Vapor phase carbon adsorption, thermal oxidation or condensing	Potentially applicable

Highlighted technologies are screened from further evaluation.

400497

Table 3-3

SOURCE AREA GROUNDWATER TECHNOLOGY IDENTIFICATION AND SCREENING

General Response Action	Technology	Process Options	Description	Screening Comments
No action	None	Not Applicable	No Action -- all current activities discontinued	Required for consideration
Institutional action	Monitoring	GW Monitoring	Groundwater monitored	Potentially applicable
	Access Restrictions	Deed Restrictions	Future use restrictions	Potentially applicable
		GW Use Controls	Local ordinance controlling groundwater use	Potentially applicable
Containment	Vertical Barriers	Slurry Wall	Trench around area is filled with soil (or cement) bentonite slurry	Potentially applicable for overburden
		Grout Curtain	Low permeability grout wall installed by injection or mixing	Potentially applicable for bedrock
		Sheet Piles	Steel or plastic interlocking panels driven through soils to form wall	Potentially applicable for overburden
	Hydraulic Controls	Extraction Wells	Liquid extracted by vertical or horizontal wells	Potentially applicable
		Trenches	Liquid extracted by horizontal trench	Potentially applicable
Treatment	Biological	In Situ Aerobic	Microbial degradation with oxygen	Potentially applicable
		Ex Situ Aerobic	Treatment in bioreactor with oxygen	Potentially applicable
		In Situ Anaerobic	Microbial degradation without oxygen	Potentially applicable
		Ex Situ Anaerobic	Treatment in bioreactor without oxygen	Potentially applicable
		Passive Treatment Walls	Vertical wall with reactive granular backfill and additives	Potentially applicable
		Natural Attenuation	Natural degradation of constituents	Potentially applicable
	Electrolytic Processes	Electro-Osmosis	Constituent removal enhanced by electrical potential gradients	Not applicable, constituents not sufficiently polar
		Electroacoustic	Constituent removal enhanced by electrical and pressure gradients	Not applicable, constituents not sufficiently polar
	Physical/Chemical	Air Sparging	Air injected in groundwater and vapors extracted through wells	Potentially applicable for organics
		Dual Phase Extraction	Vapor and liquid phase removed with high vacuum	Potentially applicable
		Precipitation	Constituents precipitated by shifting equilibrium	Potentially applicable
		Air Stripping	Volatile compounds transferred to air phase	Potentially applicable for organics
		Steam Stripping	Constituents volatilized to steam phase	Potentially applicable for organics
		Carbon Adsorption	Adsorption of constituents onto activated carbon	Potentially applicable
		Chemical Oxidation	Oxidation through chemical addition and UV exposure	Potentially applicable for organics
		Reverse Osmosis	Constituents removed by forcing through a semi-permeable membrane	Potentially applicable
		Ion Exchange	Synthetic compounds used to remove ions	Potentially applicable for inorganics
		Filtration	Constituents removed by forcing through a porous media	Potentially applicable for solids
		Microfiltration	Constituents removed by forcing through a membrane	Potentially applicable for solids
		Vapor phase treatment	Vapor phase carbon adsorption, thermal oxidation, or condensing	Potentially applicable for vapor

Highlighted technologies are screened from further evaluation.

400498

Table 3-3
(Continued)

General Response Action	Technology	Process Options	Description	Screening Comments
Treatment	Thermal	Incineration	Organics destroyed at high temperatures	Potentially applicable
	Off-Site Treatment	Commercial Treatment	Treatment at CECOS WWTP	Potentially applicable
		POTW	Treatment at Niagara Falls WWTP	Potentially applicable
Discharge	On-Site Discharge	Injection Wells	Discharge to aquifer through deep wells	Potentially applicable
		Injection Trenches	Discharge to overburden trenches	Potentially applicable
	Off-Site Discharge	POTW	Discharge to Niagara Falls WWTP	Potentially applicable
		Surface Water	Discharge to Niagara River through pipes or drainage ditch	Potentially applicable
		Injection Wells	Discharge to aquifer through deep wells	Potentially applicable

Highlighted technologies are screened from further evaluation.

400499

Table 3-4

FAR FIELD GROUNDWATER TECHNOLOGY IDENTIFICATION AND SCREENING

General Response Action	Technology	Process Options	Description	Screening Comments
No action	None	Not Applicable	No Action -- all current activities discontinued	Required for consideration
Institutional action	Monitoring	GW Monitoring	Groundwater monitored	Potentially applicable
	Access Restrictions	GW Use Controls	Local ordinance controlling groundwater use	Potentially applicable
Containment	Vertical Barriers	Slurry Wall	Trench filled with soil (or cement) bentonite slurry	Not applicable in bedrock
		Grout Curtain	Low permeability grout wall installed by injection	Not applicable due to large area
		Sheet Piles	Steel or interlocking panels driven through soils to form wall	Not applicable in bedrock
	Hydraulic Controls	Extraction Wells	Groundwater extracted by vertical or horizontal wells	Potentially applicable
		Utility Drains	Groundwater extracted by utility drains and tunnels	Potentially applicable
Treatment	Biological	Natural Attenuation	Natural degradation of constituents	Potentially applicable
		Ex Situ Aerobic	Treatment in bioreactor with oxygen	Potentially applicable
		In Situ Anaerobic	Microbial degradation without oxygen	Potentially applicable
		Ex Situ Anaerobic	Treatment in bioreactor without oxygen	Potentially applicable
		In Situ Aerobic	Microbial degradation with oxygen	Potentially applicable
	Electrolytic Processes	Electro-Osmosis	Constituent removal enhanced by electrical potential gradients	Not applicable, constituents not sufficiently polar
		Electroacoustic	Constituent removal enhanced by electrical potential gradients	Not applicable, constituents not sufficiently polar
	Physical/Chemical	Precipitation	Constituents precipitated by shifting equilibrium	Potentially applicable
		Air Stripping	Volatile compounds transferred to air phase	Potentially applicable for organics
		Steam Stripping	Constituents volatilized into steam phase	Potentially applicable for organics
		Carbon Adsorption	Adsorption of constituents onto activated carbon	Potentially applicable for organics
		Chemical Oxidation	Oxidation through chemical addition and UV exposure	Potentially applicable for organics
		Reverse Osmosis	Constituents removed by forcing through a semi-permeable membrane	Potentially applicable
		Ion Exchange	Synthetic compounds used to remove ions	Potentially applicable for inorganics
		Filtration	Constituents removed by forcing through a porous media	Potentially applicable for solids
		Microfiltration	Constituents removed by forcing through a membrane	Potentially applicable for solids
		Vapor phase treatment	Vapor phase carbon adsorption, thermal oxidation or condensing	Potentially applicable for vapor
	Thermal	Incineration	Organics destroyed at high temperatures	Potentially applicable

Highlighted technologies are screened from further evaluation.

400500

Table 3-4
(Continued)

General Response Action	Technology	Process Options	Description	Screening Comments
Treatment	Off-Site Treatment	Commercial	Treatment at CECOS WWTP	Potentially applicable
		POTW	Treatment at Niagara Falls WWTP	Potentially applicable
Discharge	On-Site Discharge	Injection Wells	Discharge to aquifer through deep wells	Potentially applicable
		Injection Trenches	Discharge to overburden trenches	Potentially applicable
	Off-Site Discharge	POTW	Discharge to Niagara Falls WWTP	Potentially applicable
		Surface Water	Discharge to Niagara River through pipes or drainage ditch	Potentially applicable
		Injection Wells	Discharge to aquifer through deep wells	Potentially applicable

Highlighted technologies are screened from further evaluation.

400501

Table 3-5

SUMMARY OF TECHNOLOGIES RETAINED

MEDIA	GRA	TECHNOLOGY
Overburden	No Action	None
	Institutional Action	Access Restrictions Monitoring
	Containment	Capping Vertical Barriers Horizontal Barriers
	Excavation	Excavation
	Treatment	Thermal Biological Physical/Chemical
	Disposal	Disposal
DNAPL	No Action	None
	Institutional Action	Access Restrictions Monitoring
	Containment	Vertical Barriers Horizontal Barriers
	Collection	Extraction
	Treatment	Thermal Physical/Chemical
Source Area Groundwater	No Action	None
	Institutional Action	Monitoring Access Restrictions
	Containment	Vertical Barriers Hydraulic Control
	Treatment	Biological Physical/Chemical Thermal Off-Site Treatment
	Discharge	On-Site Discharge Off-Site Discharge
Far Field Groundwater	No Action	None
	Institutional Action	Monitoring Access Restrictions
	Containment	Hydraulic Controls
	Treatment	Biological Physical/Chemical Thermal Off-Site Treatment
	Discharge	On-Site Discharge Off-Site Discharge

Table 3-6

PHYSICAL CHARACTERISTICS OF NECCO PARK ORGANIC CONSTITUENTS

Constituent	Henry's Law Constant (atm-m3/mol)	Boiling Point (centigrade)
volatiles		
vinyl chloride	8.19E-02	-13.9
1,1-dichloroethene	3.40E-02	32
trans-1,2-dichloroethene	6.56E-03	45-60
cis-1,2-dichloroethene	7.58E-03	45-60
chloroform	2.87E-03	61
carbon tetrachloride	2.41E-02	77
1,2-dichloroethane	9.78E-04	83
trichloroethene	9.10E-03	87
1,1,2-trichlorethane	1.17E-03	114
tetrachloroethene	2.59E-02	121
1,1,2,2-tetrachloroethane	3.81E-04	146
semivolatiles		
hexachloroethane	2.49E-03	189
hexachlorobutadiene	4.57E+00	215
phenol	4.54E-07	182
4-methylphenol	9.60E-07	202
2,4,6-trichlorophenol	3.90E-06	246
2.4,5-trichlorophenol	2.18E-04	sublimes
pentachlorophenol	2.75E-06	311
hexachlorobenzene	6.81E-04	325

Table 3-7

OVERBURDEN PROCESS OPTION EVALUATION

General Response Action	Technology	Process Options	Effectiveness	Implementability	Cost
No action	None	Not Applicable	Does not meet RAOs	Implementable	Low
Institutional action	Access Restrictions	Deed Restrictions	Does not meet RAOs	Implementable	Low
		Fencing	Does not meet RAOs	Implementable	Moderate
		Security Personnel	Does not meet RAOs	Implementable	High
	Monitoring	Air Monitoring	Does not meet RAOs	Implementable	Moderate
Containment	Capping	Clay Cap	Effective in limiting mobility of constituents	Existing	Low
		NYS 360 Cap	Effective in limiting mobility of constituents	Implementable	Moderate
		Asphalt Cap	Not effective in limiting percolation	Implementable	Moderate
		NYS 373 Cap	Effective in limiting mobility of constituents	Implementable	High
	Vertical Barriers	Slurry Wall	Effective in containing constituents in overburden	Implementable	Low
		Grout Curtain	Effective in containing constituents in overburden	Implementable	High
		Sheet Piles	May be effective in containing constituents in overburden	May be difficult to construct	High
	Horizontal Barrier	Bottom Barriers	Questionable effectiveness	Difficult to construct	High
Excavation	Excavation	Excavation	Effective in removing overburden/waste	Implementable	Low
Treatment	Thermal	Incineration	Effective for organics	Community concerns, high vapors	High
		Radio Frequency Heat.	Unproven	Limited availability	High
		Thermal Desorption	Ineffective for high boiling point organics	Implementable	Moderate
		In Situ Vitrification	Ineffective in saturated zone	Limited availability	High
		Commercial Incineration	Effective for organics	Limited capacity	High
	Biological	In Situ	Ineffective due to DNAPL presence in overburden	Difficult to implement	Moderate
		Ex Situ	Limited effectiveness for high concentrations	Difficult to implement	High

Cost evaluation is relative to other process options of the same technology.
Highlighted process options are screened from further evaluation.

400504

Table 3-7
(Continued)

General Response Action	Technology	Process Options	Effectiveness	Implementability	Cost
Treatment	Physical/Chemical	Soil Vapor Extraction	Ineffective due to low permeability of soils	Difficult to implement	Moderate
		Soil Flushing	May cause contaminants to migrate	Difficult to implement	Moderate
		Soil Washing	Ineffective due to particle size/organics	Significant modifications for organics	High
		Dual Phase Extraction	Potentially applicable	Implementable	High
		In Situ Stabilization	Limited effectiveness on organics	Difficult because of debris	Moderate
		Ex Situ Stabilization	Effective for inorganics/ash	Implementable	High
		Vapor phase treatment	Effective for organics	Implementable	Moderate
Disposal	Disposal	On-Site Landfill	Effective in containing treated material	Implementable	Moderate
		Off-Site Landfill	Effective in containing treated material	Implementable	High

Cost evaluation is relative to other process options of the same technology.
Highlighted process options are screened from further evaluation.

400505

Table 3-8

DNAPL PROCESS OPTION EVALUATION

General Response Action	Technology	Process Options	Effectiveness	Implementability	Cost
No action	None	Not Applicable	Does not meet RAOs	Implementable	Low
Institutional action	Access Restrictions	Deed Restrictions	Does not meet RAOs	Implementable	Low
		GW Use Controls	Does not meet RAOs	Implementable	Low
	Monitoring	DNAPL Monitoring	Does not meet RAOs	Implementable	Low
Containment	Vertical Barriers	Slurry Wall	Effective for containing DNAPL in overburden	Implementable	Low
		Grout Curtain	Effective in bedrock, may mobilize DNAPL	Implementable	High
		Sheet Piles	May be effective for containing DNAPL in overburden	Difficult to implement	High
Collection	Extraction	Extraction Wells	Removes small volumes of DNAPL	Implementable	Moderate
		Trenches	Potentially effective	Implementable	Moderate
Treatment	Thermal	Radio Frequency Heating	Unproven	Limited availability	High
		In Situ Vitrification	Ineffective in saturated zone	Limited availability	High
		Commercial Incineration	Effective in destroying organics	Implementable	Moderate
	Physical/Chemical	Soil Vapor Extraction	Ineffective due to low permeability	Difficult to implement	Moderate
		Surfactant Flushing	May cause contaminants to migrate	Difficult to implement	Moderate
		Dual Phase Extraction	Potentially effective on some DNAPL	Implementable	High
		In Situ Stabilization	Limited effectiveness on organics	Difficult because of debris	Moderate
		Vapor phase treatment	Effective for organics	Implementable	Moderate

Cost evaluation is relative to other process options of the same technology.
Highlighted process options are screened from further evaluation.

4000506

Table 3-9

SOURCE AREA GROUNDWATER PROCESS OPTION EVALUATION

General Response Action	Technology	Process Options	Effectiveness	Implementability	Cost
No action	None	Not Applicable	Does not meet RAOs	Implementable	Low
Institutional action	Monitoring	GW Monitoring	Does not meet RAOs	Implementable	Low
	Access Restrictions	Deed Restrictions	Does not meet RAOs	Implementable	Low
		GW Use Controls	Does not meet RAOs	Implementable	Low
Containment	Vertical Barriers	Slurry Wall	Effective for containing GW in overburden	Implementable	Low
		Grout Curtain	Effective for containing GW in bedrock	Implementable	High
		Sheet Piles	May be effective containing GW in overburden	Installation difficulties	High
	Hydraulic Controls	Extraction Wells	Effective	Implementable	Low
		Trenches	Effective for overburden	Implementable	Moderate
Treatment	Biological	In Situ Aerobic	Ineffective due to presence of DNAPL	Difficult to implement	Moderate
		Ex Situ Aerobic	Effective on some organics	Implementable	Moderate
		In Situ Anaerobic	Ineffective due to presence of DNAPL	Difficult to implement	Moderate
		Ex Situ Anaerobic	Effective on some organics	Implementable	HIgh
		Passive Treatment Walls	Not effective in bedrock	Implementable in overburden	Moderate
		Natural Attenuation	Ineffective in reasonable time frames	Implementable	Low
	Physical/Chemical	Air Sparging	Ineffective due to low permeability soils	Implementable	Moderate
		Dual Phase Extraction	Potentially Effective	Implementable	High
		Precipitation	Effective for inorganics	Implementable	Low
		Air Stripping	Effective for volatile organics	Implementable	Moderate
		Steam Stripping	Effective for most organics	Implementable	High
		Carbon Adsorption	Effective for low solubility organics	Implementable	Moderate
		Chemical Oxidation	Effective on organics	Implementable	High
		Reverse Osmosis	Effective on inorganics and some organics	Implementable	High
		Ion Exchange	Effective on inorganics	Implementable	High
		Filtration	Effective for solids removal	Implementable	Moderate
		Microfiltration	Effective for solids removal	Implementable	High
		Vapor phase treatment	Effective for organics	Implementable	Moderate
	Thermal	Incineration	Effective for organics	Difficult to operate/maintain	High

Cost evaluation is relative to other process options of the same technology.
Highlighted process options are screened from further evaluation.

400507

Table 3-9
(Continued)

General Response Action	Technology	Process Options	Effectiveness	Implementability	Cost
Treatment	Off-Site Treatment	Commercial	Effective	Implementable	High
		POTW	Effective	Need POTW approval	Moderate
Discharge	On-Site Discharge	Injection Wells	Effective	High maintenance/plugging	High
		Injection Trenches	Effective	May impact adjacent landfill cells	Moderate
	Off-Site Discharge	POTW	Effective	Implementable	High
		Surface Water	Effective	Stringent discharge requirements	Moderate
		Injection Wells	Effective	High maintenance/plugging	High

Cost evaluation is relative to other process options of the same technology.
Highlighted process options are screened from further evaluation.

400508

Table 3-10

FAR FIELD GROUNDWATER PROCESS OPTION EVALUATION

General Response Action	Technology	Process Options	Effectiveness	Implementability	Cost
No action	None	Not Applicable	Does not meet RAOs	Implementable	Low
Institutional action	Monitoring	GW Monitoring	Does not meet RAOs	Implementable	Low
	Access Restrictions	GW Use Controls	Does not meet RAOs	Implementable	Low
Containment	Hydraulic Controls	Extraction Wells	Effective	Property access required	High
		Utility Drains	Effective	Existing	Low
Treatment	Biological	Natural Attenuation	Potentially effective	Implementable	Low
		Ex Situ Aerobic	Potentially effective	Difficult to operate/maintain	High
		In Situ Anaerobic	Potentially effective	Difficult to implement	Moderate
		Ex Situ Anaerobic	Potentially effective	Difficult to operate/maintain	Moderate
		In Situ Aerobic	Not proven in bedrock	Difficult to implement	Moderate
	Physical/Chemical	Precipitation	Effective for inorganics	Implementable	Low
		Air Stripping	Effective for volatile organics	Implementable	Moderate
		Steam Stripping	Effective for most organics	Implementable	High
		Carbon Adsorption	Effective on low solubility organics	Implementable	Moderate
		Chemical Oxidation	Effective on organics	Implementable	High
		Reverse Osmosis	Effective on inorganics and some organics	Implementable	High
		Ion Exchange	Effective on inorganics	Implementable	High
		Filtration	Effective for solids removal	Implementable	Moderate
		Microfiltration	Effective for solids removal	Implementable	High
		Vapor phase treatment	Effective for organics	Implementable	Moderate
	Thermal	Incineration	Effective for organics	Difficult to operate/maintain	High
	Off-Site Treatment	Commercial	Effective	Capacity limitations	High
		POTW	Effective	Pretreatment may be required	Moderate
Discharge	On-Site Discharge	Injection Wells	Effective	High maintenance/plugging	High
		Injection Trenches	Effective	Area limitations	Moderate
	Off-Site Discharge	POTW	Effective	Implementable	High
		Surface Water	Effective	High pretreatment requirements	Moderate
		Injection Wells	Effective	High maintenance/plugging	High

Cost evaluation is relative to other process options of the same technology.
Highlighted process options are screened from further evaluation.

400509

Table 3-11

SUMMARY OF PROCESS OPTIONS RETAINED

MEDIA	GRA	TECHNOLOGY	PROCESS OPTION
Overburden	No Action	None	Not Applicable
	Institutional Action	Access Restrictions	Deed Restrictions Fencing Security Personnel
		Monitoring	Air Monitoring
	Containment	Capping	Clay Cap NYS 360 Cap NYS 373 Cap
		Vertical Barriers	Slurry Wall
	Excavation	Excavation	Excavation
	Treatment	Thermal	Thermal Desorption
		Physical/Chemical	Dual Phase Extraction Ex Situ Stabilization Vapor Phase Treatment
	Disposal	Disposal	On-Site Landfill
DNAPL	No Action	None	Not Applicable
	Institutional Action	Access Restrictions	Deed Restrictions Groundwater Use Restrictions
		Monitoring	DNAPL Monitoring
	Containment	Vertical Barriers	Slurry Wall (overburden) Grout Curtain (bedrock)
	Collection	Extraction	Extraction Wells Trenches
	Treatment	Thermal	Commercial Incineration
		Physical/Chemical	Dual Phase Extraction Vapor Phase Treatment
Source Area Groundwater	No Action	None	Not Applicable
	Institutional Action	Monitoring	Groundwater Monitoring
		Access Restrictions	Deed Restrictions Groundwater Use Restrictions
	Containment	Vertical Barriers	Slurry Wall (overburden) Grout Curtain (bedrock)
		Hydraulic Control	Extraction Wells Trenches
	Treatment	Biological	Ex Situ Anaerobic Ex Situ Aerobic
		Physical/Chemical	Precipitation Air Stripping Carbon Adsorption Filtration Vapor Phase Treatment
		Off-Site Treatment	Commercial POTW
	Discharge	Off-Site Discharge	Surface Water Injection Wells
Far Field Groundwater	No Action	None	Not Applicable
	Institutional Action	Monitoring	Groundwater Monitoring
		Access Restrictions	Groundwater Use Restrictions
	Containment	Hydraulic Controls	Extraction Wells Utility Drains
	Treatment	Biological	Natural Attenuation
		Physical/Chemical	Precipitation Air Stripping Carbon Adsorption Filtration Vapor Phase Treatment
		Off-Site Treatment	POTW
	Discharge	Off-Site Discharge	Surface Water Injection Wells

Table 4-1

OVERBURDEN ALTERNATIVES

Alternative	Process Options	
OB1	Not Applicable	
OB2	Deed Restrictions Security Personnel	Fencing Clay Cap
OB3	Deed Restrictions Security Personnel	Fencing Cap Upgrade (protective layer, grading)
OB4	Deed Restrictions Security Personnel	Fencing Cap Replacement (low permeability liner)
OB5	Deed Restrictions Security Personnel Downgradient Slurry Wall	Fencing Cap Upgrade
OB6	Deed Restrictions Security Personnel Complete Slurry Wall	Fencing Cap Upgrade
OB7	Deed Restrictions Security Personnel Dual Phase Extraction	Fencing Cap Upgrade Dual Phase Extraction
OB8	Deed Restrictions Fencing Security Personnel Cap Upgrade Limited Excavation	Thermal Desorption Vapor-phase Treatment Stabilization On-Site Disposal Downgradient Slurry Wall
OB9	Deed Restrictions Fencing Security Personnel Complete Excavation	Thermal Desorption Vapor-phase Treatment Stabilization On-Site Disposal

Table 4-2

DNAPL ALTERNATIVES

Alternative	Process Options	
D1	Not Applicable	
D2	Deed Restrictions DNAPL Monitoring	DNAPL Extraction through existing wells Incineration
D3	Deed Restrictions DNAPL Monitoring	Enhanced DNAPL Extraction Incineration
D4	Deed Restrictions DNAPL Monitoring Downgradient Slurry Wall	Enhanced DNAPL Extraction Incineration
D5	Deed Restrictions DNAPL Monitoring Grout Curtain (A-F)	Enhanced DNAPL Extraction Incineration Downgradient Slurry Wall
D6	Deed Restrictions DNAPL Monitoring Grout Curtain (A-G)	Enhanced DNAPL Extraction Incineration Downgradient Slurry Wall
D7	Deed Restrictions DNAPL Monitoring Vapor-phase Treatment	Dual Phase Extraction

Table 4-3

SOURCE AREA GROUNDWATER ALTERNATIVES

Alternative	Process Options	
SGW1	Not Applicable	
SGW2	Deed Restrictions Groundwater Monitoring	Hydraulic Controls (B-F zones) Commercial Treatment
SGW3	Deed Restrictions Groundwater Monitoring Downgradient Slurry Wall	Hydraulic Controls (A-F zones) Commercial Treatment
SGW4	Deed Restrictions Groundwater Monitoring	Hydraulic Controls (B-F zones) Commercial Treatment
SGW5	Deed Restrictions Groundwater Monitoring Downgradient Slurry Wall	Hydraulic Controls (A-F zones) Commercial Treatment
SGW6	Deed Restrictions Groundwater Monitoring	Total Hydraulic Control (B-F zones) Commercial Treatment
SGW7	Deed Restrictions Groundwater Monitoring	Total Hydraulic Control (B-F zones) POTW Treatment
SGW8	Deed Restrictions Groundwater Monitoring	Total Hydraulic Control (B-F zones) On-Site Treatment
SGW9	Deed Restrictions Groundwater Monitoring Downgradient Slurry Wall	Total Hydraulic Control (A-F zones) Groundwater Treatment
SGW10	Deed Restrictions Groundwater Monitoring	Total Hydraulic Control (B-G zones) Groundwater Treatment
SGW11	Deed Restrictions Groundwater Monitoring Grout Curtain (B-F zones)	Total Hydraulic Control (B-F zones) Groundwater Treatment
SGW12	Deed Restrictions Groundwater Monitoring Grout Curtain (B-F zones)	Total Hydraulic Control (A-F zones) Groundwater Treatment Downgradient Slurry Wall
SGW13	Deed Restrictions Groundwater Monitoring Grout Curtain (B-G zones)	Total Hydraulic Control (B-G zones) Groundwater Treatment
SGW14	Deed Restrictions Groundwater Monitoring Grout Curtain (B-F zones)	Total Hydraulic Control (B-G zones) Groundwater Treatment

Table 4-4

FAR FIELD GROUNDWATER ALTERNATIVES

Alternative	Process Options	
FGW1	Groundwater use controls Hydraulic Containment (Utility Drains)	Natural attenuation
FGW2	Groundwater use controls Hydraulic Containment (Utility Drains)	Natural attenuation Groundwater Monitoring
FGW3	Groundwater use controls Hydraulic Containment (Utility Drains) Natural attenuation POTW Treatment	Groundwater Monitoring Active Hydraulic Containment (50%)
FGW4	Groundwater use controls Hydraulic Containment (Utility Drains) Natural attenuation POTW Treatment	Groundwater Monitoring Active Hydraulic Containment (75%)
FGW5	Groundwater use controls Hydraulic Containment (Utility Drains) Natural attenuation POTW Treatment	Groundwater Monitoring Active Hydraulic Containment (100%)
FGW6	Groundwater use controls Hydraulic Containment (Utility Drains) Natural attenuation On-Site Treatment	Groundwater Monitoring Active Hydraulic Containment (100%)

Table 4-5

SUMMARY OF MEDIA-SPECIFIC ALTERNATIVE SCREENING

ALTERNATIVE	COMPONENTS	RETAINED	DESCRIPTION
OB1	Discontinue cap maintenance	YES	
OB2	Fencing Security personnel Clay cap	YES	
OB3	Deed restrictions Fencing Permeability testing Additional clay (if necessary) Protective layer Air monitoring	YES	
OB4	Deed restrictions Fencing Security personnel Low permeability liner Air monitoring	NO	Equally as effective as OB3, with higher cost
OB5	Deed restrictions Fencing Security personnel Cap upgrade Downgradient slurry wall Air monitoring	YES	
OB6	Deed restrictions Fencing Security personnel Cap upgrade Complete slurry wall Air monitoring	NO	Equally as effective as OB5, with higher cost
OB7	Deed restrictions Fencing Security personnel Cap upgrade DPE Vapor phase treatment incineration Aqueous phase treatment Air monitoring	YES	
OB8	Excavation (300,000 CY) Thermal desorption Vapor phase treatment Stabilization On-site disposal Cap upgrade Air monitoring	NO	Possible short term impacts, potential public concern regarding thermal desorption, high cost

Shaded alternatives are screened from further evaluation

Table 4-5

SUMMARY OF MEDIA-SPECIFIC ALTERNATIVE SCREENING

ALTERNATIVE	COMPONENTS	RETAINED	DESCRIPTION
OB9	Excavation (1,000,000 CY) Thermal desorption Vapor phase treatment Stabilization On-site disposal Cap upgrade Air monitoring	NO	Possible short term impacts, potential public concern regarding thermal desorption, high cost
D1	Discontinue DNAPL monitoring Discontinue DNAPL extraction	YES	
D2	DNAPL monitoring DNAPL extraction Incineration	YES	
D3	Deed restrictions DNAPL monitoring Additional DNAPL extraction Incineration	YES	
D4	Deed restrictions DNAPL monitoring Additional DNAPL extraction Incineration Downgradient slurry wall	YES	
D5	Deed restrictions DNAPL monitoring Additional DNAPL extraction Incineration Downgradient slurry wall Grout curtain (B-F)	YES	
D6	Deed restrictions DNAPL monitoring Additional DNAPL extraction Incineration Downgradient slurry wall Grout curtain (B-G)	YES	DNAPL not observed in G zone, high cost
D7	Deed restrictions DNAPL monitoring DPE Vapor phase treatment Incineration Aqueous phase treatment	YES	

Shaded alternatives are screened from further evaluation

Table 4-5

SUMMARY OF MEDIA-SPECIFIC ALTERNATIVE SCREENING

ALTERNATIVE	COMPONENTS	RETAINED	DESCRIPTION
SGWI	Discontinue groundwater monitoring and hydraulic controls	YES	
SGW2	Groundwater monitoring Hydraulic controls (B-F zones) Commercial treatment	YES	
SGW3	Deed restrictions Groundwater monitoring Downgradient slurry wall Hydraulic controls (A-F zones) Commercial treatment	YES	
SGW4	Deed restrictions Groundwater monitoring Hydraulic controls (B-F zones) Commercial treatment	YES	
SGW5	Deed restrictions Groundwater monitoring Hydraulic controls (A-F zones) Commercial treatment Downgradient slurry wall	YES	
SGW6	Deed restrictions Groundwater monitoring Total hydraulic control (B-F zones) Commercial treatment	YES	
SGW7	Deed restrictions Groundwater monitoring Total hydraulic control (B-F zones) POTW treatment	NO	POTW may not accept groundwater without pretreatment
SGW8	Deed restrictions Groundwater monitoring Total hydraulic control (B-F zones) On-site treatment	NO	Equally as effective as SGW6, more difficult to implement
SGW9	Deed restrictions Groundwater monitoring Total hydraulic control (B-F zones) Commercial treatment Grout curtain (B-F)	YES	
SGW10	Deed restrictions Groundwater monitoring Total hydraulic control (B-G zones) Commercial treatment	NO	Not significantly more effective than SGW6, higher cost

Shaded alternatives are screened from further evaluation

Table 4-5

SUMMARY OF MEDIA-SPECIFIC ALTERNATIVE SCREENING

ALTERNATIVE	COMPONENTS	RETAINED	DESCRIPTION
SGW11	Deed restrictions Groundwater monitoring Total hydraulic control (A-F zones) Commercial treatment Grout curtain (B-F)	YES	
SGW12	Deed restrictions Groundwater monitoring Total hydraulic control (A-F zones) Grout curtain (B-F) Downgradient slurry wall Commercial treatment	YES	
SGW13	Dead restrictions Groundwater monitoring Total hydraulic control (B-G zones) Grout curtain (B-G) Commercial treatment	YES	
SGW14	Dead restrictions Groundwater monitoring Total hydraulic control (B-G zones) Grout curtain (B-F) Commercial treatment	NO	Not significantly more effective than SGW12, higher cost

Shaded alternatives are screened from further evaluation

Table 4-5

SUMMARY OF MEDIA-SPECIFIC ALTERNATIVE SCREENING

ALTERNATIVE	COMPONENTS	RETAINED	DESCRIPTION
FGW1	Groundwater use controls Hydraulic containment (utility drains) Natural attenuation	YES	
FGW2	Groundwater use controls Hydraulic containment (utility drains) Natural attenuation Groundwater monitoring	YES	
FGW3	Groundwater use controls Hydraulic containment (utility drains) Natural attenuation Groundwater monitoring Active hydraulic containment (50%) POTW treatment	NO	Not significantly more effective than FGW2, high cost
FGW4	Groundwater use controls Hydraulic containment (utility drains) Natural attenuation Groundwater monitoring Active hydraulic containment (75%) POTW treatment	NO	Not significantly more effective than FGW2, high cost
FGW5	Groundwater use controls Hydraulic containment (utility drains) Natural attenuation Groundwater monitoring Active hydraulic containment (100%) POTW treatment	YES	
FGW6	Groundwater use controls Hydraulic containment (utility drains) Natural attenuation Groundwater monitoring Active hydraulic containment (100%) On-site treatment Injection	NO	Equally as effective as FGW5, more difficult to implement, high cost

Shaded alternatives are screened from further evaluation

Table 5-1

Alternative Components

Alternative	Description	
1	No Action	
2	EXISTING SYSTEMS = Partial Source Area Hydraulic Control (B-F) Upgradient Grout Curtain DNAPL Extraction Groundwater Monitoring	Utility drains Fencing/Security Personnel Natural Attenuation Clay Cap
3	EXISTING SYSTEMS +	Cap Upgrade Additional DNAPL Extraction
4	EXISTING SYSTEMS +	Cap Upgrade Additional DNAPL Extraction Downgradient Slurry Wall A Zone Hydraulic Control (Source Area)
5	EXISTING SYSTEMS +	Cap Upgrade DPE (DNAPL extraction & hydraulic control) A Zone Hydraulic Control (Source Area)
6	EXISTING SYSTEMS +	Cap Upgrade Additional DNAPL Extraction Additional Source Area Hydraulic Control (B-F)
7	EXISTING SYSTEMS +	Cap Upgrade Additional DNAPL Extraction Downgradient Slurry Wall Additional Source Area Hydraulic Control (A-F)
8	EXISTING SYSTEMS +	Cap Upgrade DPE (DNAPL extraction & hydraulic control) Additional Source Area Hydraulic Control (A-F)
9	EXISTING SYSTEMS +	Cap Upgrade Additional DNAPL Extraction Downgradient Slurry Wall Total Source Area Hydraulic Control (A-F) Grout Curtain (B-F)
10	EXISTING SYSTEMS +	Cap Upgrade Additional DNAPL Extraction Downgradient Slurry Wall Total Source Area Hydraulic Control (A-F)
11	EXISTING SYSTEMS +	Cap Upgrade DPE (DNAPL extraction & hydraulic control) Total Source Area Hydraulic Control (A-F)
12	EXISTING SYSTEMS +	Cap Upgrade Additional DNAPL Extraction Downgradient Slurry Wall Total Source Area Hydraulic Control (A-G) Grout Curtain (B-G)
13	EXISTING SYSTEMS +	Cap Upgrade Enhanced DNAPL Extraction Downgradient Slurry Wall Total Source Area Hydraulic Control (A-F) Grout Curtain (B-F) Far Field Pump & Treat (100%)

Table 5-2

EVALUATION OF POTENTIAL ARARs

Standards, Requirements, Criteria, or Limits	Alternatives													Comments
	1	2	3	4	5	6	7	8	9	10	11	12	13	
New York Safe Drinking-Water Act Standards—10 NYCRR Chapter I, Part 5-1	N	N	N	N	N	N	N	N	N	N	N	N	N	None of these alternatives will meet all of the MCLs in the source area and may not meet all of the MCLs in the far field.
New York Surface-Water and Groundwater Quality Standards and Effluent Standards—6 NYCRR Parts 700, 705	N	N	N	N	N	N	N	N	N	N	N	N	N	Alternatives will not meet all of the groundwater quality standards in the source area and may not meet all of the groundwater quality standards in the far field.
New York State Pollutant Discharge Elimination System—6 NYCRR Chapter X, Parts 750-758	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Compliance with the permitting procedures and discharge limits will be achieved by commercial WWTP or POTW.
Federal Safe Drinking-Water Act—42 USC 300f	N	N	N	N	N	N	N	N	N	N	N	N	N	Alternatives will not meet all of the groundwater quality standards in the source area and may not meet all of the groundwater quality standards in the far field.
National Primary Drinking-Water Standards—40 CFR 141	N	N	N	N	N	N	N	N	N	N	N	N	N	Alternatives will not meet all of the groundwater MCLs or MCLGs in the source area and may not meet all of the groundwater MCLs or MCLGs in the far field.
National Secondary Drinking-Water Standards—40 CFR 143	N	N	N	N	N	N	N	N	N	N	N	N	N	Alternatives will not meet all of the groundwater MCLs or MCLGs in the source area and may not meet all of the groundwater MCLs or MCLGs in the far field.

Y = Meets ARAR
N = Does not meet ARAR
NA = ARAR not applicable

400521

Table 5-2

EVALUATION OF POTENTIAL ARARs

Standards, Requirements, Criteria, or Limits	Alternatives													Comments
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Niagara County Drinking-Water Standards—Niagara County, Sanitary Code Chapter IV	N	N	N	N	N	N	N	N	N	N	N	N	N	Alternatives will not meet the groundwater MCLs in the source area and may not meet groundwater MCLs in the far field.
Standards for Owners and Operators of Hazardous Waste TSDs—40 CFR 264.94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	This landfill was closed prior to RCRA and therefore is not subject to these groundwater protection standards.
Federal Water-Quality Criteria—33 USC SS 1251-1376 40 CFR 131	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	No anticipated impacts to surface water bodies with any alternatives.
New York Water Pollution Control Regulations—6 NYCRR Part 608	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Compliance with permitting requirements, if applicable, will be achieved by commercial WWTP or POTW.
New York Water Pollution Control Regulations—6 NYCRR Parts 610-614	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Because these rules apply to petroleum storage and petroleum spill cleanup, they are not applicable to these alternatives.
New York Rules for Inactive Hazardous Waste Disposal Sites—6 NYCRR Part 375	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Development and execution of remedial actions under NYSDEC approval would constitute compliance with this regulation.
Toxic Substances Control Act—40 CFR 761	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Management of PCBs, dioxins, or other regulated commercial chemicals will be conducted in compliance with TSCA, as necessary.

Y = Meets ARAR
N = Does not meet ARAR
NA = ARAR not applicable

400522

Table 5-2

EVALUATION OF POTENTIAL ARARs

Standards, Requirements, Criteria, or Limits	Alternatives													Comments
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Coastal Zone Management Act—16 USC 1451, 15 CFR 923/930	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	These alternatives will have no significant impact on the coastal zone air quality and resources; flood and erosion control; scenic resources; sensitive habitats and species; historic, cultural, architectural, and archeological resources; sitting and development of energy facilities; recreational resources; sanitary waste disposal; public access; agricultural resources; or economic development provisions of the act.
Coastal Zone Management Act—16 USC 1451, 15 CFR 923/930	N	N	N	N	N	N	N	N	N	N	N	N	N	Groundwater quality standards will not be met in the source area and may not be met in the far field.
Coastal Zone Management Act—16 USC 1451, 15 CFR 923/930	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Materials management would be consistent with the act.
Endangered Species Act—16 USC 153	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Alternatives will not have a direct or significant impact on endangered species.
New York Wetlands Regulations—6 NYCRR Part 661	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Alternatives will not be conducted in wetlands.
Executive Order on Floodplain Management—E.O. No. 11988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Alternatives will not be conducted in a floodplain.
Clean Water Act Section 404—33 USC 1344	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Dredge or fill material will not be deposited in wetlands.
New York Hazardous Waste Regulations—6 NYCRR Parts 370-375	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Any hazardous waste generated as a result of these activities will be accumulated, transported, and treated or disposed of in compliance with New York Hazardous Waste Regulations. Any permits required for the treatment of groundwater will be obtained by the commercial WWTP or the POTW.

Y = Meets ARAR
N = Does not meet ARAR
NA = ARAR not applicable

400523

Table 5-2

EVALUATION OF POTENTIAL ARARs

Standards, Requirements, Criteria, or Limits	Alternatives													Comments
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Water Allocation Permit Article 15, Environmental Conservation Law, Title 16	NA	NA	NA	NA	NA	Y	Y	Y	NA	Y	Y	Y	Y	Alternatives 6, 7, 8, 10, 11 and 12 will result in a pumping rate in excess of 100,000 gallons per day and would comply with the substantive requirements of the law.
New York Solid Waste Regulations—6 NYCRR 360	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	This landfill was closed under an approved closure plan.
New York Air Emission Limits Regulations—6 NYCRR Parts 200-254	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Compliance with these regulations, if necessary, will be achieved by the commercial WWTP or POTW for any new or modified facilities.
Well Permiting Procedures—10 NYCRR Chapter I, Part 5	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Any new well that will be installed will be permitted as required by this regulation.
City of Niagara Falls Sewer Discharge Permit—City of Niagara Falls Sewer Use Ordinance Chapter 250	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Compliance with these regulations will be achieved by the commercial WWTP or POTW.
Resource Conservation and Recovery Act—40 CFR 260-270 42 USC 6901 et seq.	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Any hazardous waste generated as a result of these activities will be accumulated, transported, and treated or disposed in accordance with RCRA. Any permits required for the treatment of groundwater will be obtained by commercial WWTP or POTW.
New York Occupational Safety and Health—6 NYCRR 662-666	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	All remedial activities will be conducted in accordance with New York OSHA requirements.
Federal Occupational Safety and Health—29 CFR	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	All remedial activities will be conducted in accordance with federal OSHA requirements.
Federal Air Emissions Regulations—40 CFR Parts 50-59, 62-67, and 69-80	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Alternatives will be conducted in accordance with these regulations.

Y = Meets ARAR
N = Does not meet ARAR
NA = ARAR not applicable

400524

Table 5-2

EVALUATION OF POTENTIAL ARARs

Standards, Requirements, Criteria, or Limits	Alternatives													Comments
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Federal Air Emissions Regulations—40 CFR Part 60	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Compliance with these provisions will be accomplished by commercial WWTP, POTW, or on-site DPE system as necessary.
Federal Air Emissions Regulations—40 CFR Part 61	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Compliance with these provisions will be accomplished by commercial WWTP POTW, or on-site DPE system as necessary.
Federal Air Emissions Regulations—40 CFR Part 68	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Chemical accident prevention and reporting requirements will be met by all alternatives.
Hazardous Materials Transportation Act—49 USC 55 1801-1813 49 CFR 100-180	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	All DOT-regulated hazardous materials will be transported in compliance with these regulations.
New York Waste Transporters Permits—6 NYCRR Part 364	NA	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	All DOT-regulated hazardous materials will be transported in compliance with these regulations.

Y = Meets ARAR
N = Does not meet ARAR
NA = ARAR not applicable

Table 5-3

CECOS POTW DISCHARGE LIMITS

Parameter	Discharge Limitations		
	Annual Average	Daily Maximum	Units
Flow	0.10	0.25	MGD
Total Suspended Solids	310	2,000	lbs/day
Soluble Organic Carbon	1,000	1,500	lbs/day
Total Phenols	1.0	5.0	lbs/day
Total Cyanide	1.20	3.0	lbs/day
Total Cadmium	0.10	0.47	lbs/day
Total Chromium	0.088	0.67	lbs/day
Total Copper	0.766	5.75	lbs/day
Total Lead	0.289	2.17	lbs/day
Total Mercury	0.007	0.05	lbs/day
Total Nickel	2.05	5.06	lbs/day
Total Zinc	0.696	5.23	lbs/day
Trichloroethane	0.05	0.15	lbs/day
Chloroform	0.316	0.790	lbs/day
Methylene Chloride	1.930	4.813	lbs/day
Volatile Priority Pollutants	Monitor*	Monitor	lbs/day
Aci Priority Pollutants	Monitor*	Monitor	lbs/day
Base/Neutral Priority Pollutants	Monitor*	Monitor	lbs/day
Pesticides and PCBs Priority Pollutants	Monitor*	Monitor	lbs/day
Total Phosphorous	7.0	15.0	lbs/day

*Although no permit limits are listed, ordinance limitations apply to the following parameters.

Parameter	Ordinance Limit (µg/l)
Volatile Organics	
Benzene	25
Carbon Tetrachloride	50
Chlorodibromomethane	10
Monochlorobenzene	25
Dichlorobromomethane	10
Chloroform	45

Table 5-3

CECOS POTW DISCHARGE LIMITS

Parameter	Ordinance Limit (µg/l)
Dichloroethylene	37.5
Bromoform	10
Dichloropropylene	25
Ethyl Benzene	25
Tetrachloroethane	25
Tetrachloroethylene	25
Toluene	25
Trichloroethane	25
Trichloroethylene	25
Methylene Chloride	187.25
Vinyl Chloride	37.5
Acid Extractable Organics	
Monochlorophenol	10
Dichlorophenol	10
Monochlorocresol	10
Trichlorophenol	10
Pentachlorophenol	10
Base/Neutral Extractable Organics	
Dimethyl Phthalate	47
Butyl Benzyl Phthalate	100
Dibutyl Phthalate	100
Diethyl Phthalate	47
Dioctyl Phthalate	47
Monochlorotoluene	10
Nitrosodiphenylamine	10
Dichlorobenzene	3
Dichlorotoluene	10
Acenaphthane	10
Fluoranthene	3
Chrysene	3
Naphthalene	10
Benz(a)Anthracene	3
Pyrene	10
Phenanthrene	3

Table 5-3

CECOS POTW DISCHARGE LIMITS

Parameter	Ordinance Limit (µg/l)
Trichlorobenzene	3
Trichlorotoluene	10
Hexachlorobutadiene	3
Tetrachlorobenzene	3
Hexachlorocyclopentadiene	10
Hexachlorobenzene	3
Monochlorobenzotrifluoride	10
Dichlorobenzotrifluoride	10
PCBs and Pesticides	
Hexachlorocyclohexane	1.0
PCB	0.25
Endosulfan	0.7
Endosulfan Sulfate	1.0
Mirex	1.0
Dechlorane Plus	1.0
Heptachlor	1.0

µg/l = Micrograms per liter
lbs/day = Pounds per day

Table 5-4

SUMMARY OF ALTERNATIVE EVALUATION

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	NPV*
Alternative 1	Potential exposure due to cap deterioration. Total loading to far field 22.6 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals, NY Rules for Inactive Hazardous Waste Disposal Sites. NY Solid Waste Regulations or CZM Policy 38. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Increase in loading to far field. Possible contact with waste material.	No effects during implementation.	Implementable.	$0.0 million
Alternative 2	Currently no exposure; therefore, no risk. Total loading to far field 13.3 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap. Volume reduced by GW and DNAPL extraction.	Minimal effects during implementation.	Implementable	$20.9 million
Alternative 3	Currently no exposure; therefore, no risk. Total loading to far field 13.3 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap. Volume reduced by GW and DNAPL extraction.	Minimal effects during implementation. May create temporary route for DNAPL migration.	Implementable	$23.5 million
Alternative 4	Currently no exposure; therefore, no risk. Total loading to far field 13.3 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap and slurry wall. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during slurry wall construction. May create temporary route for DNAPL migration.	May need bentonite substitute. Trench materials may not be appropriate for slurry wall.	$29.1 million

NPV = net present value and does not include $40 million spent to date.

Table 5-4

SUMMARY OF ALTERNATIVE EVALUATION

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	NPV*
Alternative 5	Currently no exposure; therefore, no risk. Total loading to far field 13.3 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap and DPE. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during system installation. May create temporary route for DNAPL migration.	Requires bench and pilot treatability studies. Requires utility installation.	$32.2 million
Alternative 6	Currently no exposure; therefore, no risk. Total loading to far field 3.9 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap. Volume reduced by GW and DNAPL extraction.	Minimal effects during implementation. May create temporary route for DNAPL migration.	Implementable	$39.7 million
Alternative 7	Currently no exposure; therefore, no risk. Total loading to far field 3.9 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap and slurry wall. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during slurry wall construction. May create temporary route for DNAPL migration.	May need bentonite substitute. Trench materials may not be appropriate for slurry wall.	$45.3 million
Alternative 8	Currently no exposure; therefore, no risk. Total loading to far field 3.9 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap and DPE. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during system installation. May create temporary route for DNAPL migration.	Requires bench and pilot treatability studies. Requires utility installation.	$46.8 million

400530

**NPV = net present value and does not include $40 million spent to date.*

Table 5-4

SUMMARY OF ALTERNATIVE EVALUATION

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	NPV*
Alternative 9	Currently no exposure; therefore, no risk. Total loading to far field 1.7 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap, slurry wall, and grout curtain. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during curtain installation. May create temporary route for DNAPL migration.	Limited working area to install grout curtain.	$53.8 million
Alternative 10	Currently no exposure; therefore, no risk. Total loading to far field 1.0 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap and slurry wall. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during slurry wall construction. May create temporary route for DNAPL migration.	Requires CECOS expansion. May require bentonite substitute.	$65.1 million
Alternative 11	Currently no exposure; therefore, no risk. Total loading to far field 1.0 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap and DPE. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during system installation. May create temporary route for DNAPL migration.	Requires bench and pilot treatability studies. Requires utility installation. Requires CECOS expansion.	$67.4 million
Alternative 12	Currently no exposure; therefore, no risk. Total loading to far field 0.8 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap, slurry wall and grout curtain. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during curtain installation. May create temporary route for DNAPL migration.	Limited working area to install grout curtain.	$79.0 million

NPV = net present value and does not include $40 million spent to date.

Table 5-4

SUMMARY OF ALTERNATIVE EVALUATION

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	NPV*
Alternative 13	Currently no exposure; therefore, no risk. Total loading to far field 1.5 lbs./day. Potential future risk if groundwater used for drinking water.	Does not meet target goals or CZM Policy 38. Meets all other ARARs. Not effective in attaining RAOs.	Continued use of Niagara River as a drinking water source will maintain protection of human health. Future use of groundwater as a drinking water source would pose risk to human health.	Toxicity reduced by GW treatment and incineration. Mobility reduced by cap, slurry wall and grout curtain. Volume reduced by GW and DNAPL extraction.	Possible volatile emissions during slurry wall construction. May create temporary route for DNAPL migration.	Extensive work in industrial/residential area. Limited working area for grout curtain construction. May need bentonite substitute.	$96.5 million

**NPV = net present value and does not include $40 million spent to date.*

Table 5-5

SUMMARY OF ALTERNATIVES COMPARISON

Overall Protection of Human Health and Environment	Compliance with ARARs	Long-term Effectiveness	Reduction of Toxicity, Mobility and Volume	Short-term Effectiveness	Implementability	NPV* (millions)
All alternatives are protective of human health under the current groundwater use because there are no human receptors. Contaminant loadings to the Niagara River are not expected to present a risk to the environment. However, future potential human receptors consuming groundwater would be above acceptable risk levels.	All ARARs are met by alternatives 2 through 13 except for chemical-specific groundwater standards and CZM (policy 38). Achievement of first RAO in source area not technically feasible due to presence of DNAPL. Alternatives with source control in B-F zones achieve significant reduction in constituent loading to far field (alternatives 9, 10, 11 and 13). Alternative 12 provides a slight decrease in loading to far field compared to alternatives 9, 10, and 11. However, first RAO is not achieved by any alternative in the far field. The second RAO is not achieved by any alternative due to the presence of DNAPL.	All alternatives except for no action, permanently destroy aqueous contamination through treatment at CECOS or POTW and permanently destroy DNAPL through thermal treatment. All alternatives leave residual DNAPL in source area. All alternatives leave residual dissolved constituents in far field.	Alternatives 2 through 13 reduce toxicity through GW treatment and DNAPL incineration. Alternatives 2 through 12 reduce mobility through capping. Slurry wall reduces mobility in alternative 4, 7, 9, 10, 12, and 13. Grout curtain reduces mobility in alternatives 9, 12, and 13. Volume of aqueous contamination reduced in alternatives 2 through 13. DNAPL extraction reduces DNAPL volume in alternatives 2 through 13.	Alternatives which excavate through overburden may be source of volatiles. All alternatives, except for alternatives 1 and 2 create temporary route for DNAPL migration.	Alternative 13 is most difficult to implement due to grout curtain and far field pump and treat system. Alternatives 10 and 11 require CECOS expansion. DPE alternatives require treatability studies (alternative 5, 8 and 11).	1 - \$0.0 2 - \$20.9 3 - \$23.5 4 - \$29.1 5 - \$32.2 6 - \$39.7 7 - \$45.3 8 - \$46.8 9 - \$53.8 10 - \$65.1 11 - \$67.4 12 - \$79.0 13 - \$96.5

400533

**NPV = net present value and does not include \$40 million spent to date.*