Final

Remedial Investigation/Feasibility Study Report for Parcel E-2

Hunters Point Shipyard
San Francisco, California

May 2011

Prepared for:
Base Realignment and Closure
Program Management Office West
San Diego, California 92108

Prepared by:
Engineering/Remediation Resources Group, Inc.
115 Sansome Street, Suite 200
San Francisco, California 94104

and

Shaw Environmental, Inc.
4005 Port Chicago Highway
Concord, California 94520

Prepared under:
Naval Facilities Engineering Command Southwest
Contract Number N68711-05-C-6011
DCN: ERRG-6011-0000-0004

Final

Remedial Investigation/Feasibility Study Report for Parcel E-2 Hunters Point Shipyard, San Francisco, California May 2011

Contract No.: N68711-05-C-6011
DCN: ERRG-6011-0000-0004

Submitted by:

Engineering/Remediation Resources Group, Inc. and Shaw Environmental, Inc.

Signature	May 5, 2011 Date
Doug Bielskis, P.E.	ERRG Project Manager
Signature	May 5, 2011 Date
Dan McCullar, P.G., C.E.G.	Shaw Project Manager

CERTIFICATION

This document was prepared under the direction and supervision of a qualified Professional Engineer

REGISTERED PROFESSIONAL ENGINEER
DOUGLAS A. BIELSKIS
No. C 63113
Exp. 6/30/12
CIVIL
STATE OF CALIFORNIA

Doug Bielskis, P.E.
California Professional Engineer C63113

Table of Contents

EXECUTIVE SUMMARY ES-1
ES.1. Site History and Planned Reuse ES-2
ES.1.1. Operational History ES-2
ES.1.2. Investigation Activities ES-3
ES.1.3. Interim Removal Actions ES-3
ES.1.4. Ongoing Monitoring Programs ES-4
ES.2. Nature and Extent of Contamination ES-4
ES.2.1. Solid Waste and Soil in the Landfill Area ES-5
ES.2.2. Landfill Gas ES-6
ES.2.3. Soil and Isolated Solid Waste in the Panhandle and East Adjacent Areas ES-6
ES.2.4. Groundwater ES-7
ES.2.5. Surface Water ES-8
ES.2.6. Shoreline Sediment ES-8
ES.3. Risk Assessments ES-8
ES.3.1. Soil ES-9
ES.3.2. Landfill Gas ES-10
ES.3.3. Groundwater ES-11
ES.4. Remedial Investigation Conclusions ES-12
ES.5. Feasibility Study ES-12
ES.5.1. Remediation Goals ES-12
ES.5.2. Remedial Action Objectives ES-13
ES.5.3. General Response Actions, Remedial Technologies, and Process Options ES-15
ES.5.4. Development of Remedial Alternatives ES-15
ES.5.5. Detailed Evaluation of Remedial Alternatives ES-17
ES.5.6. Comparative Analysis of Remedial Alternatives ES-17

SECTION 1. INTRODUCTION 1-1
1.1. Parcel E-2 CERCLA Progress 1-2
1.1.1. Previous Investigations 1-2
1.1.2. Ongoing Monitoring Programs 1-3
1.1.3. Removal Actions in Parcel E-2 1-4
1.1.4. Parcel E-2 RI/FS 1-4
1.2. Study Areas in Parcel E-2 1-5
1.3. Report Framework 1-5

Table of Contents *(continued)*

1.4. Report Purpose and Goals 1-6
1.4.1. Evaluation Process for Landfill Area 1-6
1.4.2. Evaluation Process for Panhandle, East Adjacent, and Shoreline Areas 1-7
1.4.3. Goal of Parcel E-2 RI/FS Report 1-8
1.5. Report Organization 1-9
1.6. Site Description 1-10
1.6.1. Location 1-10
1.6.2. Topography and Site Features 1-10
1.6.3. Climate 1-11
1.6.4. Study Areas 1-11
1.7. Site History 1-13
1.7.1. General Site History 1-13
1.7.2. Parcel E-2 History 1-14
1.7.3. Parcel E-2 Radiological History 1-16
1.8. Future Site Reuse 1-17

SECTION 2. SITE DESCRIPTION AND PHYSICAL CHARACTERISTICS 2-1
2.1. Site Features 2-1
2.1.1. Landfill Area 2-1
2.1.2. Panhandle Area 2-3
2.1.3. East Adjacent Area 2-3
2.1.4. Shoreline Area 2-3
2.2. Geology and Hydrogeology 2-4
2.2.1. Geologic and Hydrogeologic Units 2-4
2.2.2. Groundwater Flow 2-9
2.2.3. Hydraulic Characteristics 2-12
2.2.4. Tidal Effects 2-13
2.2.5. Total Dissolved Solids 2-14
2.2.6. Groundwater Beneficial Reuse 2-15
2.3. Hydrology 2-17
2.4. Ecology 2-18
2.4.1. Terrestrial Habitat 2-19
2.4.2. Wetland Habitat 2-21
2.4.3. Intertidal Habitat 2-24

SECTION 3. REMEDIAL INVESTIGATION ACTIVITIES AND REMOVAL ACTIONS 3-1
3.1. Pre-Remedial Investigation Activities 3-2
3.1.1. Geotechnical Investigation, Waste Disposal Sites (1973) 3-3
3.1.2. As-Built Drawings for Storm Sewer Interceptor Project (1974) 3-3
3.1.3. Initial Assessment Study (1984) 3-4
3.1.4. Confirmation Study, Verification Step (1987) 3-4

Table of Contents *(continued)*

3.1.5. Area Study for Asbestos-Containing Material and Organic and Inorganic Soil Contamination (1987) ... 3-4
3.1.6. Triple A Investigation, Remedial Action Order, and RI/FS Scoping Document (1986 to 1988) ... 3-4
3.2. Landfill Investigations ... 3-5
3.2.1. Remedial Investigation (1988 to 1996) ... 3-5
3.2.2. Landfill Gas Characterization (2002) ... 3-6
3.2.3. Landfill Lateral Extent Evaluation (2002) ... 3-6
3.2.4. Landfill Liquefaction Potential Evaluation (2002) ... 3-6
3.3. Soil Investigations in Non-Landfill Areas ... 3-7
3.3.1. Remedial Investigation (1988 to 1996) ... 3-8
3.3.2. Standard Data Gaps Investigation (2002) ... 3-9
3.3.3. Characterization of Metal Slag Area (2004) ... 3-10
3.4. Groundwater Investigations ... 3-10
3.4.1. Remedial Investigation (1988 to 1996) ... 3-10
3.4.2. Groundwater Data Gaps Investigation (2000 to 2002) ... 3-11
3.4.3. Groundwater Data Gaps Investigation (2007 to 2008) ... 3-12
3.5. Ecological Assessments ... 3-13
3.5.1. Intertidal Sediment Studies (1991 to 1992) ... 3-13
3.5.2. Phase 1A and Phase 1B ERA (1994 to 1996) ... 3-14
3.5.3. BERA (1997) ... 3-14
3.5.4. ERA Validation Study and Protective Soil Concentration Technical Memorandum (1999) ... 3-14
3.5.5. Parcel F Validation Study (2000 to 2002) ... 3-15
3.5.6. Wetlands Delineation and Functions and Values Assessment (2002) ... 3-15
3.5.7. SDGI (2002) and Shoreline Characterization Technical Memorandum (2005) ... 3-15
3.6. Radiological Assessments ... 3-16
3.6.1. Site Reconnaissance (1988 to 1989) ... 3-17
3.6.2. Phase I Radiological Investigation (1991) ... 3-17
3.6.3. Phase II Radiological Investigation (1993) ... 3-18
3.6.4. Interim Parcel E Radiation Risk Assessment (1997) ... 3-19
3.6.5. Interim Investigation between Phase IV and Phase V Radiological Investigations (2001) ... 3-19
3.6.6. Phase V Radiological Investigation (2002 to 2003) ... 3-19
3.6.7. Radionuclides in Groundwater Evaluation (2002) ... 3-21
3.6.8. Radionuclides in Groundwater Evaluation (2008) ... 3-22
3.7. Outdoor Air Monitoring ... 3-23
3.7.1. Solid Waste Air Quality Assessment Test (1988 to 1989) ... 3-24
3.7.2. Outdoor Air Monitoring (1992 to 1996) ... 3-24

3.7.3. Perimeter Air Monitoring Program, Landfill Cap Construction (2000 to 2001).....3-25
3.7.4. Landfill Gas Characterization (2002)....................3-26
3.8. Previous Removal Actions....................3-27
3.8.1. Sandblast Waste Fixation (1991 to 1995)....................3-27
3.8.2. Storm Drain Sediment Removal Action (1996 to 1997)....................3-28
3.8.3. Groundwater Extraction System and Containment Barrier (1997 to 1998)....................3-28
3.8.4. Landfill Cap Construction (2000 to 2001)....................3-29
3.8.5. Landfill Gas Removal Action (2002 to 2003)....................3-29
3.8.6. Shoreline Cleanup (2003 to 2004)....................3-30
3.8.7. Metal Slag Area Removal Action (2005 to 2007)....................3-31
3.8.8. PCB Hot Spot Area Removal Action (2005 to 2007)....................3-32
3.9. Ongoing Monitoring Programs....................3-34
3.9.1. Groundwater Monitoring (2004 to present)....................3-34
3.9.2. Gas Monitoring and Control (2004 to present)....................3-35
3.9.3. Stormwater Discharge Management (2003 to present)....................3-36
3.9.4. Landfill Cap Inspection and Maintenance (2003 to present)....................3-36

SECTION 4. NATURE AND EXTENT OF SOLID WASTE, LANDFILL GAS, AND CHEMICALS IN SOIL....................4-1
4.1. Evaluation Methods....................4-1
4.1.1. Solid Waste Extent Evaluation....................4-2
4.1.2. Landfill Gas Evaluation....................4-4
4.1.3. Soil Evaluation....................4-7
4.2. Landfill Area....................4-12
4.2.1. Fill and Solid Waste Characteristics....................4-13
4.2.2. Landfill Solid Waste Extent....................4-14
4.2.3. Landfill Gas....................4-16
4.2.4. Chemicals Detected in Soil....................4-22
4.3. Panhandle Area....................4-36
4.3.1. Characteristics and Extent of Fill and Isolated Solid Waste Locations....................4-37
4.3.2. Chemicals Detected in Panhandle Area Soil....................4-38
4.4. East Adjacent Area....................4-51
4.4.1. Characteristics and Extent of Fill and Isolated Solid Waste Locations....................4-52
4.4.2. Chemicals Detected in East Adjacent Area Soil....................4-54
4.5. Summary of Findings....................4-67
4.5.1. Nature and Extent of Solid Waste....................4-67
4.5.2. Nature and Extent of Landfill Gas....................4-69
4.5.3. Nature and Extent of Soil Contamination....................4-70
4.5.4. Data Gaps....................4-74

Table of Contents *(continued)*

SECTION 5. NATURE AND EXTENT OF CHEMICALS IN GROUNDWATER 5-1
5.1. Data Evaluation Methodology 5-2
5.2. Groundwater Beneficial Use 5-4
5.3. Identification of Chemicals Detected in Groundwater 5-4
5.3.1. Summary of Results from Past Evaluations 5-5
5.3.2. Dense Nonaqueous-Phase Liquid and Light Nonaqueous-Phase Liquid in Parcel E-2 Groundwater 5-8
5.3.3. Comprehensive List of Chemical Detections 5-10
5.4. Hunters Point Groundwater Ambient Levels 5-14
5.5. Chemical Concentration Limits and Standards 5-14
5.5.1. A-Aquifer 5-15
5.5.2. B-Aquifer 5-16
5.6. Selection of Groundwater Evaluation Criteria 5-16
5.7. Focused Evaluation 5-17
5.7.1. Graphical Presentation of Groundwater Data 5-17
5.7.2. Graphical Data Analysis Results 5-18
5.8. Summary of Findings 5-38
5.8.1. Summary of Lateral and Vertical Extent 5-38
5.8.2. Resolution of Data Quality Objectives 5-40
5.8.3. Laboratory Reporting Limits Exceeding Remedial Investigation Evaluation Criteria 5-42
5.8.4. Data Gaps 5-45

SECTION 6. CONCEPTUAL SITE MODEL 6-1
6.1. Potential Sources of Contamination 6-1
6.2. Potentially Affected Media and Migration Pathways 6-3
6.2.1. Soil 6-3
6.2.2. Subsurface Air (Gas from the Landfill) 6-4
6.2.3. Outdoor Air 6-5
6.2.4. Groundwater 6-5
6.2.5. Surface Water 6-7
6.2.6. Sediment 6-7
6.2.7. Wetlands 6-7
6.3. Exposure Points, Exposure Routes, and Receptors 6-8
6.3.1. Soil 6-8
6.3.2. Subsurface Air 6-8
6.3.3. Groundwater 6-9
6.3.4. Surface Water and Sediment 6-9
6.3.5. Wetlands 6-9

SECTION 7. RISK ASSESSMENT 7-1
7.1. Human Health Risk Assessment 7-2
7.1.1. Human Health Risk Assessment Methodology 7-2
7.1.2. Human Health Risk Assessment Results 7-5
7.1.3. Remediation Goals 7-10
7.1.4. Sample Locations with Chemical Concentrations Exceeding Remediation Goals . 7-11
7.2. Screening-Level Ecological Risk Assessments 7-11
7.2.1. Onshore Screening-Level Ecological Risk Assessment 7-11
7.2.2. Shoreline Screening-Level Ecological Risk Assessment 7-13
7.3. Ecological Risk Assessment for Exposure to Groundwater 7-15

SECTION 8. REMEDIAL INVESTIGATION SUMMARY AND CONCLUSIONS 8-1
8.1. Remedial Investigation Approach 8-1
8.1.1. Site Characterization 8-1
8.1.2. Conceptual Site Model 8-2
8.1.3. Site Risks 8-3
8.2. Solid Waste and Soil in the Landfill Area 8-4
8.2.1. Nature and Extent of Solid Waste and Chemicals in Soil 8-5
8.2.2. Risk Assessments for Landfill Area 8-10
8.2.3. Conclusions for Solid Waste and Soil in Landfill Area 8-13
8.3. Landfill Gas 8-19
8.3.1. Landfill Gas Characterization 8-19
8.3.2. Landfill Gas Monitoring and Control Activities 8-20
8.3.3. Landfill Gas Risk Evaluations 8-20
8.3.4. Conclusions for Landfill Gas 8-21
8.4. Soil and Isolated Solid Waste in the Panhandle and East Adjacent Areas 8-22
8.4.1. Nature and Extent of Isolated Solid Waste Locations 8-22
8.4.2. Nature and Extent of Chemicals in Soil 8-24
8.4.3. Risk Assessment for the Panhandle and East Adjacent Areas 8-26
8.4.4. Conclusions for Isolated Solid Waste, Soil, and Sediment in Panhandle and East Adjacent Areas 8-29
8.5. Groundwater 8-30
8.5.1. Nature and Extent of Chemicals in Groundwater 8-30
8.5.2. Quantitative Human Health Risk Assessment for Groundwater 8-33
8.5.3. Conclusions for Groundwater 8-35
8.6. Surface Water 8-36
8.7. Shoreline Sediment 8-37
8.8. Summary of Conclusions 8-37

Table of Contents *(continued)*

SECTION 9. REMEDIAL ACTION OBJECTIVES 9-1

9.1. Remedial Action Objectives for Solid Waste, Soil, and Sediment 9-2

9.1.1. Chemicals of Concern and Chemicals of Ecological Concern in Solid Waste, Soil, and Sediment 9-2

9.1.2. Solid Waste, Soil, and Sediment Remedial Action Objectives for the Protection of Human Health and the Environment 9-3

9.2. Landfill Gas Remedial Action Objectives 9-3

9.3. Groundwater Remedial Action Objectives 9-4

9.3.1. Chemicals of Concern and Chemicals of Ecological Concern in Groundwater 9-5

9.3.2. Groundwater Remedial Action Objectives for the Protection of Human Health 9-6

9.3.3. Groundwater Remedial Action Objectives for the Protection of Wildlife 9-6

9.4. Surface Water Remedial Action Objectives 9-6

9.5. Summary of Remedial Action Objectives 9-7

SECTION 10. POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS 10-1

10.1. Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements 10-2

10.1.1. Groundwater 10-2

10.1.2. Surface Water 10-4

10.1.3. Soil 10-4

10.2. Potential Location-Specific Applicable or Relevant and Appropriate Requirements 10-5

10.2.1. Coastal Resources 10-5

10.2.2. Wetlands Protection 10-5

10.2.3. Biological Resources 10-6

10.2.4. Cultural Resources 10-6

10.3. Potential Action-Specific Applicable or Relevant and Appropriate Requirements 10-6

10.3.1. Action-Specific Applicable or Relevant and Appropriate Requirements for Containment 10-7

10.3.2. Action-Specific Applicable or Relevant and Appropriate Requirements for Construction and Grading 10-9

10.3.3. Action-Specific Applicable or Relevant and Appropriate Requirements for Shoreline Construction 10-9

10.3.4. Action-Specific Applicable or Relevant and Appropriate Requirements for Landfill Gas Monitoring and Control 10-11

10.3.5. Action-Specific Applicable or Relevant and Appropriate Requirements for Groundwater Monitoring 10-11

10.3.6. Action-Specific Applicable or Relevant and Appropriate Requirements for Surface Water Monitoring and Management 10-12

10.3.7. Action-Specific Applicable or Relevant and Appropriate Requirements for Institutional Controls 10-12

10.3.8. Action-Specific Applicable or Relevant and Appropriate Requirements for Leachate Collection and Control 10-13
10.3.9. Action-Specific Applicable or Relevant and Appropriate Requirements for Excavation and Off-Site Disposal 10-13

SECTION 11. IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS 11-1
11.1. Applicable General Response Actions 11-3
11.1.1. No Action 11-4
11.1.2. Institutional Actions 11-4
11.1.3. Containment Actions (With or Without Collection, Treatment, and Disposal) 11-5
11.1.4. Removal Actions 11-5
11.2. Evaluation Criteria for Technologies and Process Options 11-6
11.3. No Action 11-6
11.4. Institutional Actions 11-7
11.4.1. Institutional Controls 11-7
11.4.2. Engineering Controls 11-14
11.4.3. Site Monitoring 11-15
11.5. Containment (With or Without Removal, Treatment, and Disposal) 11-17
11.5.1. Solid Waste, Soil, and Sediment Containment 11-18
11.5.2. Shoreline Protection 11-28
11.5.3. Landfill Gas Collection 11-32
11.5.4. Landfill Gas Treatment 11-35
11.5.5. Groundwater Containment and Leachate Collection (With or Without Treatment and Discharge) 11-41
11.6. Removal by Excavation (With Off-Site Disposal or On-Site Consolidation) 11-50
11.6.1. Excavation with Off-Site Disposal of Solid Waste, Soil, and Sediment throughout Parcel E-2 11-50
11.6.2. Excavation and Off-Site Disposal of Hot Spots in the Panhandle, East Adjacent, and Shoreline Areas 11-54
11.6.3. Excavation of Hot Spots in the Panhandle, East Adjacent, and Shoreline Areas with On-Site Consolidation and Off-Site Disposal 11-57
11.6.4. Excavation of Solid Waste, Soil, and Sediment in the Panhandle, East Adjacent, and Shoreline Areas with On-Site Consolidation and Off-Site Disposal 11-58
11.7. Summary of Screening of Technologies and Process Options 11-59
11.8. Wetlands Mitigation Alternatives 11-60

SECTION 12. DEVELOPMENT OF REMEDIAL ALTERNATIVES 12-1
12.1. Common Components for Remedial Alternatives 2, 3, 4, and 5 12-3
12.1.1. Institutional Controls 12-3
12.1.2. Groundwater Monitoring 12-4

12.1.3. Completion of the Shoreline Protection (with Removal of Solid Waste, Soil, and Sediment) 12-5
12.1.4. Stormwater Discharge Management and Monitoring 12-7
12.1.5. Integration with Ongoing Wetlands Restoration, Property Development, and Offshore Feasibility Study 12-8
12.1.6. Hot Spot Removal in the Panhandle, East Adjacent, and Shoreline Areas 12-10
12.2. Remedial Alternatives Developed For Parcel E-2 12-13
12.2.1. Alternative 1: No Action 12-13
12.2.2. Alternative 2: Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, institutional controls, and unlined freshwater wetlands) 12-14
12.2.3. Alternative 3: Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands) 12-20
12.2.4. Alternative 4: Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands) 12-31
12.2.5. Alternative 5: Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and unlined freshwater wetlands) 12-34

SECTION 13. DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES 13-1
13.1. Alternative 1: No Action 13-3
13.1.1. Overall Protection of Human Health and the Environment 13-3
13.1.2. Compliance with ARARs 13-3
13.1.3. Long-Term Effectiveness and Permanence 13-4
13.1.4. Reduction in Toxicity, Mobility, or Volume 13-4
13.1.5. Short-Term Effectiveness 13-4
13.1.6. Implementability 13-4
13.1.7. Cost 13-4
13.1.8. State and Community Acceptance 13-4
13.1.9. Summary of Detailed Analysis for Remedial Alternative 1 13-5
13.2. Alternative 2: Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, institutional controls, and unlined freshwater wetlands) 13-5
13.2.1. Overall Protection of Human Health and the Environment 13-5
13.2.2. Compliance with ARARs 13-5
13.2.3. Long-Term Effectiveness and Permanence 13-6
13.2.4. Reduction in Toxicity, Mobility, or Volume 13-6
13.2.5. Short-Term Effectiveness 13-7
13.2.6. Implementability 13-8
13.2.7. Cost 13-9
13.2.8. State and Community Acceptance 13-10
13.2.9. Summary of Detailed Analysis for Remedial Alternative 2 13-10

13.3. Alternative 3: Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands) 13-10
13.3.1. Overall Protection of Human Health and the Environment 13-12
13.3.2. Compliance with ARARs 13-12
13.3.3. Long-Term Effectiveness and Permanence 13-13
13.3.4. Reduction in Toxicity, Mobility, or Volume 13-14
13.3.5. Short-Term Effectiveness 13-14
13.3.6. Implementability 13-14
13.3.7. Cost 13-15
13.3.8. State and Community Acceptance 13-15
13.3.9. Summary of Detailed Analysis for Remedial Alternative 3 13-15
13.4. Alternative 4: Contain Solid Waste, Soil, Sediment and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands) 13-16
13.4.1. Overall Protection of Human Health and the Environment 13-17
13.4.2. Compliance with ARARs 13-17
13.4.3. Long-Term Effectiveness and Permanence 13-17
13.4.4. Reduction in Toxicity, Mobility, or Volume 13-18
13.4.5. Short-Term Effectiveness 13-18
13.4.6. Implementability 13-18
13.4.7. Cost 13-19
13.4.8. State and Community Acceptance 13-19
13.4.9. Summary of Detailed Analysis for Remedial Alternative 4 13-19
13.5. Alternative 5: Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and unlined freshwater wetlands) 13-19
13.5.1. Overall Protection of Human Health and the Environment 13-20
13.5.2. Compliance with ARARs 13-21
13.5.3. Long-Term Effectiveness and Permanence 13-21
13.5.4. Reduction in Toxicity, Mobility, or Volume 13-21
13.5.5. Short-Term Effectiveness 13-21
13.5.6. Implementability 13-22
13.5.7. Cost 13-22
13.5.8. State and Community Acceptance 13-22
13.5.9. Summary of Detailed Analysis for Remedial Alternative 5 13-22

SECTION 14. COMPARATIVE EVALUATION OF REMEDIAL ALTERNATIVES 14-1
14.1. Long-Term Effectiveness and Permanence 14-2
14.2. Reduction in Toxicity, Mobility, and Volume 14-3
14.3. Short-Term Effectiveness 14-4
14.4. Implementability 14-5

14.5. Cost..14-6
14.6. State and Community Acceptance...14-7
14.7. Summary of Comparative Analysis...14-7

SECTION 15. REFERENCES..15-1

List of Figures

Figure ES-1. Parcel E-2 Locations and Removal Action Areas
Figure ES-2. Results of Remedial Technologies and Process Options Evaluation

Figure 1-1. Site Vicinity Map
Figure 1-2. Landfill/Parcel E-2 Locations
Figure 1-3. Removal Action Areas
Figure 1-4. Surface Topography and Site Features
Figure 1-5. Wind Speed and Direction Map
Figure 1-6. 1946 Aerial Photograph
Figure 1-7. 1955 Aerial Photograph
Figure 1-8. 1965 Aerial Photograph
Figure 1-9. 1969 Aerial Photograph with IR Site Boundaries
Figure 1-10. 1975 Aerial Photograph
Figure 1-11. 1985 Aerial Photograph with Triple A Site Boundaries
Figure 1-12. Site History Timeline
Figure 1-13. Sampling Locations
Figure 1-14. Parcel E-2 Radiologically Impacted Sites
Figure 1-15. Designated Reuse Zones at Parcel E-2

Figure 2-1. Hunters Point Surficial Geology
Figure 2-2. Location of Parcel E-2 Cross Sections
Figure 2-3. Cross Section A-A’
Figure 2-4. Cross Section B-B’
Figure 2-5. Cross Section C-C’
Figure 2-6. Cross Section D-D’
Figure 2-7. Cross Section E-E’
Figure 2-8. Cross Section F-F’
Figure 2-9. Cross Section G-G’
Figure 2-10. Cross Section H-H’ and I-I’
Figure 2-11. Cross Section J-J’
Figure 2-12. Bedrock Surface Elevations
Figure 2-13. Bay Mud Thickness Map
Figure 2-14. A-Aquifer Groundwater Elevations, March 2007
Figure 2-15. A-Aquifer Groundwater Elevations, August 2007
Figure 2-16. B-Aquifer Groundwater Elevations, August 2007
Figure 2-17. Vertical Groundwater Flow Potential
Figure 2-18. Aquifer and Slug Test Locations

Figure 2-19. Tidal Influence Study Wells and Parameters
Figure 2-20. Maximum Total Dissolved Solids Concentrations in the A-Aquifer
Figure 2-21. Monthly Precipitation at Hunters Point Shipyard, 2002 to 2008
Figure 2-22. Drainage Patterns and BMPs
Figure 2-23. Parcel E-2 Terrestrial, Wetland, and Intertidal Habitats

Figure 3-1. Landfill Characterization Sampling Locations
Figure 3-2. Soil and Groundwater Sampling Locations
Figure 3-3. Ecological Sampling Locations
Figure 3-4. Outdoor Air Monitoring Locations
Figure 3-5. Conceptual Cross Section of Landfill Gas System
Figure 3-6. Landfill Gas Monitoring System Locations
Figure 3-7. Groundwater Monitoring Network for Parcel E-2 Landfill

Figure 4-1. Isolated Waste Locations in Adjacent Areas
Figure 4-2. Outdoor Air Survey Results for Methane
Figure 4-3. Extent of Subsurface Methane Prior to Removal Action
Figure 4-4. Lead in 0-2' Soil
Figure 4-5. Heptachlor Epoxide in 0-2' Soil
Figure 4-6. Total PCBs (High Risk) in 0-2' Soil
Figure 4-7. Total PCBs (High Risk) PCB Hot Spot Area in 0-2' Soil
Figure 4-8. Benzo(a)anthracene in 0-2' Soil
Figure 4-9. Benzo(a)pyrene in 0-2' Soil
Figure 4-10. Benzo(b)fluoranthene in 0-2' Soil
Figure 4-11. Indeno(1,2,3-cd)pyrene in 0-2' Soil
Figure 4-12. Naphthalene in 0-2' Soil
Figure 4-13. Antimony in 2-10' Soil
Figure 4-14. Arsenic in 2-10' Soil
Figure 4-15. Cadmium in 2-10' Soil
Figure 4-16. Chromium (total) in 2-10' Soil
Figure 4-17. Copper in 2-10' Soil
Figure 4-18. Iron in 2-10' Soil
Figure 4-19. Lead in 2-10' Soil
Figure 4-20. Vanadium in 2-10' Soil
Figure 4-21. Dieldrin in 2-10' Soil
Figure 4-22. Heptachlor Epoxide in 2-10' Soil
Figure 4-23. Total PCBs (High Risk) in 2-10' Soil
Figure 4-24. Total PCBs (High Risk) PCB Hot Spot Area in 2-10' Soil
Figure 4-25. Total PCBs (Low Risk) in 2-10' Soil

Figure 4-26. 1,4-Dichlorobenzene in 2-10’ Soil
Figure 4-27. 2-Methylnaphthalene in 2-10’ Soil
Figure 4-28. Anthracene in 2-10’ Soil
Figure 4-29. Benzo(a)anthracene in 2-10’ Soil
Figure 4-30. Benzo(a)pyrene in 2-10’ Soil
Figure 4-31. Benzo(b)fluoranthene in 2-10’ Soil
Figure 4-32. Benzo(k)fluoranthene in 2-10’ Soil
Figure 4-33. Chrysene in 2-10’ Soil
Figure 4-34. Dibenz(a,h)anthracene in 2-10’ Soil
Figure 4-35. Indeno(1,2,3-cd)pyrene in 2-10’ Soil
Figure 4-36. Naphthalene in 2-10’ Soil
Figure 4-37. Ethylbenzene in 2-10’ Soil
Figure 4-38. Total TPH in 2-10’ Soil
Figure 4-39. Arsenic in >10’ Soil
Figure 4-40. Cadmium in >10’ Soil
Figure 4-41. Chromium (total) in >10’ Soil
Figure 4-42. Iron in >10’ Soil
Figure 4-43. Lead in >10’ Soil
Figure 4-44. Total PCBs (High Risk) in >10’ Soil
Figure 4-45. Total PCBs (Low Risk) in >10’ Soil
Figure 4-46. 1,4-Dichlorobenzene in >10’ Soil
Figure 4-47. Benzo(a)anthracene in >10’ Soil
Figure 4-48. Benzo(a)pyrene in >10’ Soil
Figure 4-49. Benzo(b)fluoranthene in >10’ Soil
Figure 4-50. Naphthalene in >10’ Soil
Figure 4-51. n-Nitroso-di-n-propylamine in >10’ Soil
Figure 4-52. Carbon Tetrachloride in >10’ Soil
Figure 4-53. Ethylbenzene in >10’ Soil
Figure 4-54. Tetrachloroethene in >10’ Soil
Figure 4-55. Xylene (total) in >10’ Soil
Figure 4-56. Total TPH in >10’ Soil
Figure 4-57. Antimony in 0-2’ Soil
Figure 4-58. Arsenic in 0-2’ Soil
Figure 4-59. Cadmium in 0-2’ Soil
Figure 4-60. Iron in 0-2’ Soil
Figure 4-61. Mercury in 0-2’ Soil
Figure 4-62. Vanadium in 0-2’ Soil
Figure 4-63. 4,4’-DDE in 0-2’ Soil
Figure 4-64. Dieldrin in 0-2’ Soil
Figure 4-65. Benzo(k)fluoranthene in 0-2’ Soil

List of Figures *(continued)*

Figure 4-66. Bis(2-ethylhexyl)phthalate in 0-2' Soil
Figure 4-67. Chrysene in 0-2' Soil
Figure 4-68. Dibenz(a,h)anthracene in 0-2' Soil
Figure 4-69. Total TPH in 0-2' Soil
Figure 4-70. Zinc in 2-10' Soil
Figure 4-71. Dioxins and Furans in 2-10' Soil
Figure 4-72. Dioxins and Furans in >10' Soil
Figure 4-73. Indeno(1,2,3-cd)pyrene in >10' Soil
Figure 4-74. Chromium (total) in 0-2' Soil
Figure 4-75. 1,1,2,2-Tetrachloroethane in 0-2' Soil
Figure 4-76. 4,4'-DDE in 2-10' Soil
Figure 4-77. 4,4'-DDT in 2-10' Soil
Figure 4-78. 1,2,4-Trichlorobenzene in 2-10' Soil
Figure 4-79. 1,1,2,2-Tetrachloroethane in 2-10' Soil

Figure 5-1. Cyanide in Groundwater
Figure 5-2. Fluoride in Groundwater
Figure 5-3. Nitrate (as nitrogen) in Groundwater
Figure 5-4. Nitrite (as nitrogen) in Groundwater
Figure 5-5. Sulfide in Groundwater
Figure 5-6. Un-ionized Ammonia in Groundwater
Figure 5-7. Aluminum in Groundwater
Figure 5-8. Antimony in Groundwater
Figure 5-9. Arsenic in Groundwater
Figure 5-10. Barium in Groundwater
Figure 5-11. Beryllium in Groundwater
Figure 5-12. Cadmium in Groundwater
Figure 5-13. Chromium (total) in Groundwater
Figure 5-14. Chromium VI in Groundwater
Figure 5-15. Cobalt in Groundwater
Figure 5-16. Copper in Groundwater
Figure 5-17. Lead in Groundwater
Figure 5-18. Manganese in Groundwater
Figure 5-19. Mercury in Groundwater
Figure 5-20. Nickel in Groundwater
Figure 5-21. Selenium in Groundwater
Figure 5-22. Silver in Groundwater
Figure 5-23. Vanadium in Groundwater
Figure 5-24. Zinc in Groundwater

List of Figures *(continued)*

Figure 5-25. 4,4'-DDD in Groundwater
Figure 5-26. 4,4'-DDE in Groundwater
Figure 5-27. 4,4'-DDT in Groundwater
Figure 5-28. Alpha-chlordane in Groundwater
Figure 5-29. Total PCBs in Groundwater
Figure 5-30. Dieldrin in Groundwater
Figure 5-31. Endosulfan I in Groundwater
Figure 5-32. Endosulfan II in Groundwater
Figure 5-33. Endrin in Groundwater
Figure 5-34. Gamma-BHC (lindane) in Groundwater
Figure 5-35. Gamma-chlordane in Groundwater
Figure 5-36. Heptachlor in Groundwater
Figure 5-37. Heptachlor Epoxide in Groundwater
Figure 5-38. 2-Chlorophenol in Groundwater
Figure 5-39. Benzo(a)pyrene in Groundwater
Figure 5-40. Benzo(k)fluoranthene in Groundwater
Figure 5-41. Bis(2-ethylhexyl)phthalate in Groundwater
Figure 5-42. Butylbenzylphthalate in Groundwater
Figure 5-43. Dibenz(a,h)anthracene in Groundwater
Figure 5-44. Diethylphthalate in Groundwater
Figure 5-45. Di-n-butylphthalate in Groundwater
Figure 5-46. Hexachlorocyclopentadiene in Groundwater
Figure 5-47. Naphthalene in Groundwater
Figure 5-48. 1,2-Dichloroethane in Groundwater
Figure 5-49. Benzene in Groundwater
Figure 5-50. Carbon tetrachloride in Groundwater
Figure 5-51. Trichloroethene in Groundwater
Figure 5-52. Vinyl Chloride in Groundwater
Figure 5-53. Total TPH in Groundwater

Figure 6-1. Conceptual Site Model
Figure 6-2. Schematic of Potential Migration Pathways
Figure 6-3. Conceptual Site Model Flow Chart

Figure 7-1. Total Risk - Surface Soil (0 to 2 feet bgs), Recreational Exposure Scenario
Figure 7-2. Incremental Risk - Surface Soil (0 to 2 feet bgs), Recreational Exposure Scenario
Figure 7-3. Total Risk - Subsurface Soil (0 to 10 feet bgs), Construction Worker Exposure Scenario
Figure 7-4. Incremental Risk - Subsurface Soil (0 to 10 feet bgs), Construction Worker Exposure Scenario
Figure 7-5. Locations with Chemical Concentrations Exceeding the Protective Soil Concentration in 0-3' Soil

List of Figures *(continued)*

Figure 7-6. Screening- and Trigger-Level Groundwater Evaluation for Aquatic Life

Figure 8-1. Application of Containment Presumptive Remedy
Figure 8-2. Soil Areas of Concern
Figure 8-3. Groundwater Areas of Concern

Figure 11-1. Results of Remedial Technologies and Process Options Evaluation
Figure 11-2. Area Requiring Institutional Controls
Figure 11-3. Low-permeability Soil Cap
Figure 11-4. Geosynthetic Cap
Figure 11-5. Multilayer Geosynthetic Cap
Figure 11-6. Evapotranspiration Cap
Figure 11-7. Conceptual Landfill Gas Vent, Extraction Well and Wind Turbine
Figure 11-8. Conceptual Landfill Gas Flare
Figure 11-9. Alternate Flare

Figure 12-1. Conceptual Grading Plan, Alternatives 3, 4, and 5
Figure 12-2. Cross Sections A, B, and C, Alternatives 3, 4, and 5
Figure 12-3. Cross Section D and Cross Section E, Alternatives 3, 4, and 5
Figure 12-4. South Perimeter Cap Termination with Rock Riprap Protection, Alternatives 3, 4, and 5
Figure 12-5. Panhandle Cap Termination (West Boundary), Alternatives 3, 4, and 5
Figure 12-6. East Adjacent Area Cap Termination (East Boundary), Alternatives 3, 4, and 5
Figure 12-7. Soil Hot Spot Evaluation
Figure 12-8. Proposed Soil Hot Spot Excavations in East Adjacent Area
Figure 12-9. Proposed Soil Hot Spot Excavations in Panhandle Area
Figure 12-10. Conceptual Construction Plan, Alternative 2
Figure 12-11. Proposed Excavation Depths, Alternative 2
Figure 12-12. Conceptual Grading Plan, Alternative 2
Figure 12-13. Alternatives 3 and 4 Cover and Excavation Plan
Figure 12-14. Alternatives 3, 4, and 5 Cover Schematic
Figure 12-15. Cross Section F, Alternatives 3, 4, and 5
Figure 12-16. Soil Hot Spot Excavations and Groundwater Diversion, Alternative 3
Figure 12-17. Landfill Cap Tie-In, Alternatives 3, 4, and 5
Figure 12-18. Multilayer Geosynthetic Cap Tie-In, Alternatives 3, 4, and 5
Figure 12-19. Conceptual Landfill Gas Collection Plan, Alternatives 3, 4, and 5
Figure 12-20. Soil Hot Spot Excavations and Groundwater Containment, Alternatives 4 and 5
Figure 12-21. Alternative 5 Cover and Excavation Plan

List of Tables

Table ES-1. Comparative Analysis of Parcel E-2 Remedial Alternatives

Table 1-1. RI/FS Organization Summary
Table 1-2. Buildings Within 1,000 Feet of Parcel E-2 Landfill
Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2

Table 2-1. Summary of Slug Test Results
Table 2-2. Summary of Constant Rate Pumping Test Results in Parcel E-2

Table 3-1. Summary of Characterization Activities
Table 3-2. Chronology of Landfill Characterization Activities
Table 3-3. Chronology of Soil Characterization Activities
Table 3-4. Chronology of Groundwater Characterization Activities

Table 4-1. Summary of Human Health Evaluation Criteria for Soil
Table 4-2. Landfill Gas Characterization Monitoring Probes Result Summary
Table 4-3. Summary of Analyses and Detections in the Landfill Area (0-2 feet bgs)
Table 4-4. Summary of Detected Exceedances of Evaluation Criteria in the Landfill Area (0-2 feet bgs)
Table 4-5. Summary of Analyses and Detections in the Landfill Area (2-10 feet bgs)
Table 4-6. Summary of Detected Exceedances of Evaluation Criteria in the Landfill Area (2-10 feet bgs)
Table 4-7. Summary of Analyses and Detections in the Landfill Area (greater than 10 feet bgs)
Table 4-8. Summary of Detected Exceedances of Evaluation Criteria in the Landfill Area (greater than 10 feet bgs)
Table 4-9. Summary of Analyses and Detections in the Panhandle Area (0-2 feet bgs)
Table 4-10. Summary of Detected Exceedances of Evaluation Criteria in the Panhandle Area (0-2 feet bgs)
Table 4-11. Summary of Analyses and Detections in the Panhandle Area (2-10 feet bgs)
Table 4-12. Summary of Detected Exceedances of Evaluation Criteria in the Panhandle Area (2-10 feet bgs)
Table 4-13. Summary of Analyses and Detections in the Panhandle Area (greater than 10 feet bgs)
Table 4-14. Summary of Detected Exceedances of Evaluation Criteria in the Panhandle Area (greater than 10 feet bgs)
Table 4-15. Summary of Analyses and Detections in the East Adjacent Area (0-2 feet bgs)
Table 4-16. Summary of Detected Exceedances of Evaluation Criteria in the East Adjacent Area (0-2 feet bgs)

List of Tables *(continued)*

Table 4-17.	Summary of Analyses and Detections in the East Adjacent Area (2-10 feet bgs)
Table 4-18.	Summary of Detected Exceedances of Evaluation Criteria in the East Adjacent Area (2-10 feet bgs)
Table 4-19.	Summary of Analyses and Detections in the East Adjacent Area (greater than 10 feet bgs)
Table 4-20.	Summary of Detected Exceedances of Evaluation Criteria in the East Adjacent Area (greater than 10 feet bgs)
Table 4-21.	Resolution of Data Quality Objectives, Lateral Extent of Landfill Waste
Table 4-22.	Resolution of Data Quality Objectives, Landfill Gas Characterization
Table 4-23.	Resolution of Data Quality Objectives, Landfill Gas Monitoring and Control System Operation
Table 4-24.	Exceedance Frequency of Soil Evaluation Criteria
Table 4-25.	Resolution of Data Quality Objectives, Parcel E-2 Soil and Sediment
Table 4-26.	Exceedances of Soil Evaluation Criteria Adjacent to Parcel Boundary
Table 5-1.	Data Summary - Anions Detected in Parcel E-2 Groundwater
Table 5-2.	Data Summary - Metals Detected in Parcel E-2 Groundwater and HGAL Information
Table 5-3.	Data Summary – Pesticides and PCBs Detected in Parcel E-2 Groundwater
Table 5-4.	Data Summary - SVOCs Detected in Parcel E-2 Groundwater
Table 5-5.	Data Summary - VOCs Detected in Parcel E-2 Groundwater
Table 5-6.	Data Summary – Petroleum Hydrocarbons Detected in Parcel E-2 Groundwater
Table 5-7.	Limits and Standards for Parcel E-2 Aquifers – Anions
Table 5-8.	Limits and Standards for Parcel E-2 Aquifers – Metals
Table 5-9.	Limits and Standards for Parcel E-2 Aquifers – Pesticides and PCBs
Table 5-10.	Limits and Standards for Parcel E-2 Aquifers – SVOCs
Table 5-11.	Limits and Standards for Parcel E-2 Aquifers – VOCs
Table 5-12.	Limits and Standards for Parcel E-2 Aquifers – Petroleum Hydrocarbons
Table 5-13.	List of All RIECs that Apply to Parcel E-2 Aquifers
Table 5-14.	Perimeter Monitoring Wells at Parcel E-2
Table 5-15.	List of All Possible Areas of Concern in Parcel E-2 Aquifers
Table 7-1.	Human Health Risk Assessment Potentially Complete Pathways
Table 7-2.	Total Risk – Summary of Cancer Risks and Hazard Indices for Recreational Exposure Scenario, Surface Soil (0 to 2 feet bgs)
Table 7-3.	Incremental Risk – Summary of Cancer Risks and Hazard Indices for Recreational Exposure Scenario, Surface Soil (0 to 2 feet bgs)
Table 7-4.	Total Risk – Risk Characterization Analysis for Surface Soil (0 to 2 feet bgs) for Recreational Exposure Scenario
Table 7-5.	Incremental Risk – Risk Characterization Analysis for Surface Soil (0 to 2 feet bgs) for Recreational Exposure Scenario

List of Tables *(continued)*

Table 7-6. Total Risk – Summary of Cancer Risks and Hazard Indices by Planned Reuse, Subsurface Soil (0 to 10 feet bgs), Construction Worker Scenario

Table 7-7. Incremental Risk – Summary of Cancer Risks and Hazard Indices by Planned Reuse, Subsurface Soil (0 to 10 feet bgs), Construction Worker Scenario

Table 7-8. Risk Characterization Summary for A-Aquifer Groundwater, Construction Worker Scenario

Table 7-9. Total Risk: Risk Characterization Analysis for Subsurface Soil (0 to 10 feet bgs), Construction Worker Scenario

Table 7-10. Incremental Risk: Risk Characterization Analysis for Subsurface Soil (0 to 10 feet bgs), Construction Worker Scenario

Table 7-11. Risk Characterization Analysis for B-Aquifer Groundwater Based on Domestic Use

Table 7-12. Lead Evaluation for Groundwater

Table 7-13. Remediation Goals for Chemicals of Concern in Soil

Table 7-14. Remediation Goals for Chemicals of Concern in A-Aquifer Groundwater

Table 7-15. Remediation Goals for Chemicals of Concern in B-Aquifer Groundwater

Table 7-16. Risk and Hazard Drivers and Associated Sampling Locations Exceeding Remediation Goals for Recreational Receptor Scenario, Surface Soil (0 to 2 feet bgs)

Table 7-17. Summary Statistics for Parcel E-2 Onshore SLERA

Table 7-18. Groundwater COPECs for Aquatic Wildlife

Table 11-1. Containment Technology Evaluation

Table 12-1. Summary of Remedial Alternatives for the Parcel E-2 Feasibility Study

Table 12-2. Hot Spot Goals for Soil and Sediment

Table 12-3. Actions to be Addressed in Remedial Design for Parcel E-2

Table 13-1. Cost Estimate Summaries

Table 14-1. Comparative Analysis of Parcel E-2 Remedial Alternatives

List of Appendices

Appendix A	Final Parcel E Nonstandard Data Gaps Investigation Landfill Gas Characterization (provided on compact disc only)
Appendix B	Final Parcel E Nonstandard Data Gaps Investigation Landfill Lateral Extent Evaluation (provided on compact disc only)
Appendix C	Final Parcel E Nonstandard Data Gaps Investigation Landfill Liquefaction Potential (provided on compact disc only)
Appendix D	Final Parcel E Nonstandard Data Gaps Investigation Wetlands Delineation and Function and Values Assessment Parcel B and E (provided on compact disc only)
Appendix E	Final Removal Action Landfill Cap Closeout Report (provided on compact disc only)
Appendix F	Draft Removal Action Closeout Report, Landfill Gas Removal Action (provided on compact disc only)
Appendix G	Draft Parcels E and E-2 Shoreline Characterization Technical Memorandum (provided on compact disc only)
Appendix H	EPA Presumptive Remedy Guidance (provided on compact disc only)
Appendix I	Groundwater Beneficial Use Evaluation
Appendix J	Analytical Results, Boring Logs, and Well Construction/Water Level Data (provided on compact disc only)
Appendix K	Baseline Human Health Risk Assessment
Appendix L	Screening-Level Ecological Risk Assessment for Onshore Areas
Appendix M	Evaluation of Groundwater Chemical Migration to the Aquatic Environment
Appendix N	Applicable or Relevant and Appropriate Requirements
Appendix O	Regulatory Analysis of Shoreline Area and Adjacent Wetlands
Appendix P	Preliminary Evaluations for Landfill Containment System
Appendix Q	Qualitative Slope Stability Evaluation
Appendix R	Detailed Cost Estimates and Assumptions
Appendix S	Responses to Regulatory Agency Comments on the Draft and Draft Final RI/FS Report for Parcel E-2

Acronyms and Abbreviations

§	Section
µg/L	micrograms per liter
AFA	AFA Construction Group
AFCEE	Air Force Center for Environmental Excellence
ARAR	applicable or relevant and appropriate requirement
ARIC	area requiring institutional controls
ATSDR	Agency for Toxic Substances and Disease Registry
ATT	Aqua Terra Technologies
BAAQMD	Bay Area Air Quality Management District
Basin Plan	Comprehensive Water Quality Control Plan for the San Francisco Bay Basin
Bay	San Francisco Bay
BCDC	San Francisco Bay Conservation and Development Commission
BCT	Base Realignment and Closure Cleanup Team
BERA	baseline ecological risk assessment
BGMP	Basewide Groundwater Monitoring Program
bgs	below ground surface
BHC	benzene hexachloride
BMPs	best management practices
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylenes
Cal/EPA	California Environmental Protection Agency
CCR	California Code of Regulations
CCSF	City and County of San Francisco
CDM	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIWMB	California Integrated Waste Management Board
cm/sec	centimeters per second
COCs	chemicals of concern
COECs	chemicals of ecological concern
COPCs	chemicals of potential concern
COPECs	chemicals of potential ecological concern

cpm	counts per minute
CPT	cone penetrometer test
CSC	California species of special concern
CTR	California Toxics Rule
DCA	dichloroethane
DCB	dichlorobenzene
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DHS	Department of Health Services
DNAPL	dense nonaqueous-phase liquid
DoD	U.S. Department of Defense
DQO	data quality objective
DTSC	Department of Toxic Substance Control
EE/CA	engineering evaluation/cost analysis
EEC	Eagle Environmental Construction
ELCRs	excess lifetime cancer risks
EMCON	EMCON Associates
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
ER-M	effects range-median
ERRG	Engineering/Remediation Resources Group, Inc.
ESAP	environmental sampling and analysis plan
ESL	environmental screening level
FFA	Federal Facilities Agreement
FS	Feasibility Study
FSP	field sampling plan
GAC	granular activated carbon
GCL	geosynthetic clay liner
GDGI	groundwater data gaps investigation
GES	groundwater extraction system
GMP	gas monitoring probe

gpd	gallons per day
GRA	general response action
GRI	Geosynthetic Research Institute
HELP-3	Hydrogeologic Evaluation of Landfill Performance, Version 3
HDPE	high-density polyethylene
HGAL	Hunters Point groundwater ambient levels
HHRA	human health risk assessment
HI	hazard index
HLA	Harding Lawson Associates
HPALs	Hunters Point ambient levels
HPS	Hunters Point Shipyard
HQs	hazard quotients
HRA	Historical Radiological Assessment
IAS	Initial Assessment Study
IDW	investigation-derived waste
IPCC	Intergovernmental Panel on Climate Change
IR	Installation Restoration
IT	International Technology Corporation
ITSI	Innovative Technical Solutions, Inc
Kleinfelder	Kleinfelder, Inc.
LEL	lower explosive limit
LFR	Levine-Fricke-Recon
LLRW	low-level radioactive waste
LNAPL	light nonaqueous-phase liquid
LRLs	laboratory reporting limits
LUC	land use control
MACTEC	MACTEC Engineering and Consulting
MARRS	MARRS Services, Inc.
MCLs	maximum contaminant levels
MD	munitions debris
MDAS	material documented as safe
MDLs	method detection limits
mg/kg	milligrams per kilogram
mg/L	milligrams per liter

MOA	Memorandum of Agreement
MPE	maximum probable earthquake
MPPEH	material potential presenting an explosive hazard
msl	mean sea level
NACIP	Navy Assessment and Control of Installation Pollutants
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
Navy	Department of the Navy
NAWQC	National Ambient Water Quality Criteria
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDGIs	nonstandard data gaps investigations
NEESA	Naval Energy and Environmental Support Activity
NMOC	nonmethane organic compound
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRDL	Naval Radiological Defense Laboratory
NTCRA	non-time-critical removal action
O&M	operation and maintenance
OMP	Operation and Maintenance Plan
PAHs	polycyclic aromatic hydrocarbons
PAMP	perimeter air monitoring program
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
PeCDF	pentachlorodibenzofuran
PMO	Program Management Office
ppm	parts per million
ppmv	parts per million by volume
PQL	practical quantitation limit
PRB	permeable reactive barrier
PRC	PRC Environmental Management
PRG	preliminary remediation goal

PSC	protective soil concentration
PV	present value
PVC	polyvinyl chloride
QAPP	quality assurance project plan
QCSR	quality control summary report
R&D	research and development
RAOs	remedial action objectives
RASO	Radiological Affairs Support Office
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RI	Remedial Investigation
RIEC	remedial investigation evaluation criteria
RME	reasonable maximum exposure
RMP	Risk Management Plan
ROCs	radionuclides of concern
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SCRS	surface confirmation radiation survey
SDGI	standard data gap investigation
SFDA	San Francisco District Attorney
SFRA	San Francisco Redevelopment Agency
Shaw	Shaw Environmental, Inc.
SLERA	screening-level ecological risk assessment
SPT	standard penetration test
SSF	site specific factors
SVOCs	semivolatile organic compounds
SWAQAT	Solid Waste Air Quality Assessment Test
SWDMP	Stormwater Discharge Management Plan
SWRCB	State Water Resources Control Board
TCA	trichloroethane
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCE	trichloroethene

Acronyms and Abbreviations *(continued)*

TCRA	time-critical removal action
TDS	total dissolved solids
TEQ	toxicity equivalent quotient
TIZ	tidal influenced zone
TMZ	tidal mixing zone
TOG	total oil and grease
TPH	total petroleum hydrocarbons
TPH-d	TPH as diesel
TPH-g	TPH as gasoline
TPH-mo	TPH as motor oil
Triple A	Triple A Machine Shop, Inc.
TRVs	toxicity reference values
TtECI	Tetra Tech EC, Inc.
TtEMI	Tetra Tech EM Inc.
TtFW	Tetra Tech FW, Inc.
U&A	Uribe and Associates, Inc.
UCL	upper confidence limit
UCSF	University of California, San Francisco
USACE	U.S. Army Corps of Engineers
UXO	unexploded ordnance
VOCs	volatile organic compounds
WBZ	water-bearing zone
WMMP	wetlands mitigation and monitoring plan
WQOs	water quality objectives

Executive Summary

The Department of the Navy (Navy) has prepared this combined Remedial Investigation (RI)/Feasibility Study (FS) Report for the area consisting of the closed industrial landfill (hereafter identified as the "Parcel E-2 Landfill") and the surrounding areas that contain isolated or noncontiguous pockets of buried solid waste within Parcel E-2 at Hunters Point Shipyard (HPS) in San Francisco, California. This RI/FS Report is part of ongoing efforts by the Navy to address contamination at Parcel E-2 in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Title 42 United States Code [USC] Sections [§§] 9601-9675).

Because past shipyard operations left hazardous materials on site, HPS property was placed on the National Priorities List in 1989 as a Superfund site pursuant to CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986. In 1991, HPS was designated for closure pursuant to the Defense Base Closure and Realignment Act of 1990. Closure activities at HPS involve conducting environmental remediation and making the property available for nondefense use. As a management tool to accelerate site investigation, cleanup, and reuse, HPS was divided into parcels. Sites within each parcel are evaluated concurrently. In September 2004, the Navy divided Parcel E into two parcels (Parcels E and E-2) to facilitate closure of the Parcel E-2 Landfill and its adjacent areas.

This RI/FS Report summarizes and evaluates the nature and extent of contamination using all available data, including information from removal actions that have removed potential contamination sources at Parcel E-2. The data were used to update risk assessments for humans and wildlife at Parcel E-2. Results from the nature and extent evaluation and risk assessments were used to identify remedial action objectives (RAOs), and to develop remedial alternatives consistent with U.S. Environmental Protection Agency (EPA) RI/FS guidance for landfills (EPA, 1991a). Each remedial alternative was evaluated in accordance with criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40 Code of Federal Regulations [CFR] Part 300). This RI/FS Report addresses CERCLA hazardous substances except for radionuclides. Radionuclides in soil and groundwater are evaluated in the radiological addendum to this RI/FS Report. Both chemical and radiological contaminants will then be addressed together in the proposed plan and the Record of Decision (ROD).

ES.1. SITE HISTORY AND PLANNED REUSE

Parcel E-2 consists of 47.4 acres of shoreline and lowland coast along the southwestern portion of HPS, and contains four distinct areas, which were designated to streamline the information presented in this RI/FS Report (Figure ES-1):

- The "Landfill Area," which comprises the entire Parcel E-2 Landfill and its immediate perimeter
- The "Panhandle Area," located west and southwest of the Landfill Area
- The "East Adjacent Area," located to the east of the Landfill Area
- The "Shoreline Area" located at the interface with San Francisco Bay

Based on the City and County of San Francisco's Redevelopment Plan for HPS, Parcel E-2 is designated for open space reuse except for a small area in the East Adjacent Area, which is designated as part of the "Shipyard South Multi-Use District." The potential land uses envisioned for the Shipyard South Multi-Use District include recreational, industrial, and residential (San Francisco Redevelopment Agency, 2010).

ES.1.1. Operational History

Parcel E-2 is part of an area created in the 1940s, 1950s, and 1960s by filling in the bay margin with various materials, including soil, crushed bedrock, dredged sediments, and debris. The overall composition of the fill material, on which the Parcel E-2 Landfill was created, is primarily sand and clay with intermixed construction debris (Tetra Tech EM Inc. [TtEMI], 2004f). Almost all of the land at HPS was created by filling activities conducted between the early 1940s and the late 1960s.

Between 1958 and 1974, the Navy created the Parcel E-2 Landfill by placing various shipyard wastes, including construction debris, municipal-type solid waste, and industrial waste (including sandblast waste, paint sludge, solvents, and waste oils) (Naval Energy and Environmental Support Activity [NEESA], 1984). As a result, the landfill has a heterogeneous composition and includes solid waste intermixed with soil fill. The physical extent of solid waste covers approximately 22 acres (TtEMI, 2004f). Shortly after landfill operations ceased in 1974, the Navy implemented several preliminary landfill closure measures, including placing a minimum of 2 feet of compacted, imported fill on top of the landfill.

Between 1976 and 1986, industrial operations conducted by a lessee of the property (Triple A Machine Shop, Inc.) allegedly resulted in the disposal of industrial debris, sandblast waste, oily industrial sand, and asphalt over an area of approximately 5 acres along the shoreline in Parcel E-2 and in a portion of the Landfill Area. The lessee also allegedly stored unlabeled, deteriorating, uncovered drums with their contents exposed to the elements in the southeast portion of Parcel E-2 (San Francisco District Attorney, 1986).

ES.1.2. Investigation Activities

Environmental investigations performed from 1984 to 1996 were evaluated in RI and FS reports for Parcel E, which encompassed the area later subdivided as Parcel E-2. During preparation of these reports, the Navy and regulatory agencies decided that additional data gaps investigations were needed to better define the nature and extent of chemicals in soil and groundwater at Parcel E-2, and to better evaluate site conditions in and around the Parcel E-2 Landfill. Previous environmental investigations at Parcel E-2 are listed below.

Environmental Investigation Activities at Parcel E-2

- 1984 — Initial Assessment Study
- 1987 — Confirmation Study/Verification Step, Area Study for Asbestos-Containing Material and Organic and Inorganic Soil Contamination
- 1986–1988 — Triple A Investigation, Remedial Action Order and RI/FS Scoping Document
- 1988–1989 — Solid Waste Air Quality Assessment Test
- 1988–1992 — Operable Unit I Remedial Investigation
- 1991–1992 — Intertidal Sediment Study
- 1991 and 1993 — Radiological Investigation (Phases I and II)
- 1994–1996 — Ecological Risk Assessment (Phases 1A and 1B)
- 1995–1998 — Parcel E Remedial Investigation and Feasibility Study
- 1999–2000 — Ecological Risk Assessment Validation Study
- 2000–2002 — Groundwater Data Gaps Investigations (Phases I, II, and III)
- 2001–2002 — Landfill and Soil Data Gaps Investigations, Wetlands Delineation
- 2001–2003 — Radiological Investigations, Phase V (and other interim investigations)
- 2002–2005 — Shoreline Sediment Characterization
- 2007–2008 — Parcel E-2 Groundwater Investigation

ES.1.3. Interim Removal Actions

The Navy has performed several interim removal actions at Parcel E-2 to minimize potential exposure of hazardous substances and to expedite the cleanup process. Removal actions conducted to date are listed below.

Removal Actions at Parcel E-2 (Figure ES-1)

- Groundwater Extraction System, 1997–1998: a groundwater containment and extraction system was installed at the southeast portion of Parcel E-2 to reduce the potential for release of landfill constituents into San Francisco Bay.
- Landfill Cap Construction, 2000–2001: a multilayer interim cap was constructed on a portion of the Parcel E-2 Landfill to prevent oxygen intrusion and extinguish smoldering subsurface areas following a brush fire.
- Landfill Gas Removal Action, 2002–2003: a landfill gas control and monitoring system was installed along the northern Parcel E-2 boundary to control gas migration from the landfill.
- Metal Slag Area Removal Action, 2005–2007: 8,200 cubic yards of contaminated soil and sediment, including 119 cubic yards of radiologically impacted soil and debris, was excavated and disposed of off site from this area in the southwest portion of Parcel E-2.
- Polychlorinated Biphenyl Hot Spot Area Removal Action, 2005–2007: 44,500 cubic yards of contaminated soil, including 611 cubic yards of radiologically impacted soil and debris, was excavated from this area and disposed of off site in the southeast portion of Parcel E-2.

ES.1.4. Ongoing Monitoring Programs

The Navy has implemented several environmental monitoring programs to satisfy regulatory requirements for Parcel E-2 until a final remedy is selected. The ongoing monitoring programs at Parcel E-2 are summarized below.

Ongoing Monitoring Programs Implemented at Parcel E-2

- 2003–Present Stormwater Discharge Management Program
- 2003–Present Landfill Cover Inspection and Maintenance Program
- 2004–Present Basewide Groundwater Monitoring Program
- 2004–Present Landfill Gas Control and Monitoring Program

ES.2. NATURE AND EXTENT OF CONTAMINATION

The nature and extent evaluation was performed for the following potentially contaminated media: (1) solid waste and soil in the Landfill Area; (2) landfill gas; (3) soil and isolated solid waste in the adjacent areas (Panhandle, East Adjacent, and Shoreline Areas); (4) groundwater; (5) surface water; and (6) shoreline sediment. Data were initially evaluated to identify chemicals whose presence may be attributed to the Navy's past site operations. The evaluation was then focused by comparing the site data against remedial investigation evaluation criteria (RIEC). The RIEC were selected based on regulatory criteria and are adequately conservative to show the extent of chemicals that may pose a risk to human health or the environment. As discussed on Page ES-1, this RI/FS Report addresses CERCLA hazardous substances except for radionuclides. Radionuclides in soil and groundwater are evaluated in the radiological addendum to this RI/FS Report.

ES.2.1. Solid Waste and Soil in the Landfill Area

The contiguous solid waste in the Landfill Area is composed primarily of municipal-type waste and construction debris. The waste was observed in 28 soil borings, 18 monitoring wells, and 25 test pits extended within the Landfill Area. The solid waste includes wood, paper, plastic, metal, glass, asphalt, concrete, and bricks that are mixed with sand, clay, and gravel fill. Construction debris (such as asphalt, concrete, and brick) is typically inert and is not expected to generate leachate that would create potential risks to human health or the environment.

In addition to municipal-type waste and construction debris, historic information indicates that industrial wastes were also disposed of in or around the Landfill Area, including sandblast waste, radioluminescent devices, asbestos-containing debris, paint sludge, solvents, and waste oils (NEESA, 1984; Naval Sea Systems Command, 2004). The presence of some of these industrial wastes was confirmed during cleanup activities within the Polychlorinated Biphenyl (PCB) Hot Spot Area, which extended into a small portion the Landfill Area (Navy, 2005b through 2005f; Tetra Tech EC, Inc. [TtECI], 2007a). The characterization data suggest that the quantity of industrial waste within the Landfill Area is less than the quantity of municipal-type waste and construction debris.

The areal extent of solid waste covers approximately 22 acres, and the estimated volume of the solid waste is 473,000 cubic yards. Waste across the Landfill Area varies from less than 10 feet thick to greater than 25 feet thick (with an average of about 13 feet thick). In most areas of the Parcel E-2 Landfill, waste is in direct contact with groundwater.

The soil data set within the Landfill Area was derived from 333 soil samples collected from the intermittent soil fill mixed within the solid waste. Metals, semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), PCBs, pesticides, and petroleum hydrocarbons were detected at concentrations exceeding the RIEC in soil samples collected at the Landfill Area. Soil characterization data within the Landfill Area are used to assess the general extent of RIEC exceedances relative to the landfill waste volume. This assessment provides a basis for determining whether lesser quantities of hazardous wastes are present in the landfill as compared with municipal wastes, which is one evaluation factor outlined in EPA presumptive remedy guidance (provided in Appendix H of this report). Nearly all of the chemicals detected in Landfill Area soil at concentrations above RIECs were of a limited extent relative to the overall waste volume. These results indicate that lesser quantities of potentially hazardous industrial wastes are present in the landfill as compared with municipal-type waste and construction debris.

The nature and extent of solid waste and chemicals in soil within the Landfill Area is adequately characterized to evaluate a focused set of remedial alternatives in the FS. This determination is based in large part on EPA presumptive remedy guidance for CERCLA landfills (EPA, 1993a, 1993b, 1994, and 1996). Consistent with EPA guidance, characterization of the solid waste is not necessary or appropriate for selecting a response action for the Landfill Area.

ES.2.2. Landfill Gas

Landfill gas characterization, consisted of installation of temporary soil gas borings and 21 permanent gas monitoring probes (GMPs). It was determined that methane was present at concentrations exceeding 25 percent of the lower explosive limit (LEL), equivalent to 1.25 percent methane by volume, north of the Parcel E-2 Landfill (including property owned by the University of California San Francisco [UCSF]). Methane was not detected at concentrations exceeding 25 percent of the LEL in locations along Crisp Avenue (approximately 200 feet north of the landfill) or to the east, south, and west of the landfill. Nonmethane organic compounds (NMOCs) were detected in both the temporary soil gas borings and the permanent GMPs, with the highest concentrations immediately north of the landfill.

Upon completion of the landfill gas characterization, the Navy conducted a removal action to (1) remove landfill gas and reduce subsurface methane concentrations at the UCSF compound to below the LEL (5 percent methane by volume in air); and (2) control future migration of landfill gas to off-site areas. The removal action involved installation and operation of a gas control, extraction, and treatment system. Monitoring is performed on a regular basis and includes notification and response procedures if hazardous concentrations of landfill gas (either methane or NMOCs) are detected beyond the fence line of the landfill and beneath the UCSF compound. Data collected as part of the landfill gas characterization study, the removal action, and ongoing landfill gas monitoring have adequately defined the nature and extent of landfill gas at Parcel E-2. Additional studies are planned, in conjunction with the remedial design, to more thoroughly evaluate soil gas concentrations in the Panhandle Area and East Adjacent Area and to assess whether methane or NMOCs are present in the areas at concentrations that may be hazardous to human health.

ES.2.3. Soil and Isolated Solid Waste in the Panhandle and East Adjacent Areas

The nature and extent of solid waste in the Panhandle and East Adjacent Areas are distinct from the solid waste defined in the Landfill Area. Specifically, fill material in the Panhandle and East Adjacent Areas consists primarily of soil and rock with isolated solid waste locations that are not contiguous with solid waste in the Landfill Area. Solid waste within the Panhandle and East Adjacent Areas consists of a heterogeneous distribution of construction debris (primarily concrete, brick, wood, and asphalt) and isolated locations of industrial wastes (such as, sandblast waste, metal slag, radioluminescent devices, and oily waste). Industrial wastes have been encountered in the two Parcel E-2 areas where removal actions were recently completed. Industrial wastes encountered within the Metal Slag Area (in the Panhandle Area) and the PCB Hot Spot Area (in the East Adjacent Area) were removed and disposed of off site; however, chemical concentrations in soil remain at both areas and warrant further analysis in the FS portion of this report.

The soil data set was derived from 754 soil samples (113 soil borings, 113 excavation grids within the PCB Hot Spot Area and Metal Slag Area, and 14 test pits) collected within the Panhandle and East Adjacent Areas. Metals, SVOCs, VOCs, pesticides, PCBs, dioxins and furans, and petroleum hydrocarbons were detected at concentrations exceeding RIECs in soil samples collected in the Panhandle and East Adjacent Areas. Soil contamination is more widely distributed in the Panhandle Area and the shallow zones (0 to 10 feet below ground surface [bgs]) of the East Adjacent Area. Soil contamination is less extensive within East Adjacent Area soil at depths greater than 10 feet bgs. This finding is attributed to the fact that deep soil within the East Adjacent Area consists of either natural sediments or fill material placed during expansion of the shipyard in the early 1940s.

The heterogeneous distribution of solid waste and soil contamination makes delineation of potential areas of concern problematic; however, past characterization efforts have provided sufficient data to evaluate potential risks to humans and wildlife at Parcel E-2 because past sampling locations have focused, to the extent practical, on the most likely contaminant sources (based on a comprehensive review of historic aerial photographs and any visual evidence of contamination).

ES.2.4. Groundwater

Groundwater contamination has been confirmed through sampling across Parcel E-2 in both the A-aquifer and uppermost B-aquifer. The lateral and vertical extent of chemicals in groundwater has been defined across most of Parcel E-2 through a series of investigations and the ongoing groundwater monitoring program. The extent of chemicals in groundwater, however, is not completely defined along the Parcel E-2 shoreline. In 2008, a focused data gaps investigation was performed along the Parcel E-2 shoreline, and results of the investigation helped to identify areas requiring further evaluation in the FS portion of this report. Primary potential migration pathways for contaminated groundwater include migration and discharge of A-aquifer groundwater into San Francisco Bay and wetlands and migration of A-aquifer groundwater (including the saturated waste layer) into the uppermost B-aquifer.

The primary groundwater analytical groups at Parcel E-2 include metals, SVOCs, VOCs, pesticides, PCBs, petroleum hydrocarbons, and anions (such as ammonia and cyanide). Groundwater sampling results indicate that the concentrations and extent of contamination in the uppermost B-aquifer are less than observed in the A-aquifer due to the hydrogeologic and geologic characteristics (presence of Bay Mud) across most of Parcel E-2. Overall, the number of detected chemicals and the magnitude of the concentrations detected in both aquifers have declined between 1990 and 2007.

ES.2.5. Surface Water

Potential exposure of wildlife to unacceptable chemical concentrations in surface water runoff is monitored in accordance with a Stormwater Discharge Management Program (MARRS Services, Inc. [MARRS] and MACTEC Engineering and Consulting [MACTEC], 2009b). Results to date indicate no incidents of noncompliance at Parcel E-2 except in isolated locations where best management practices (BMPs) require modification to better control erosion and sediment transport from neighboring properties (TtEMI, 2004d; AFA Construction Group and Eagle Environmental Construction [EEC], 2005a; EEC, 2006 and 2007; MARRS and MACTEC, 2008a, 2009a, and 2010). The ongoing maintenance of the interim cap and implementation of BMPs serves to minimize erosion from surface water runoff and potential exposure to wildlife. Continued management (through implementation of BMPs) and monitoring of surface water runoff should be evaluated as part of any remedial alternative that leaves contaminated soil in place.

ES.2.6. Shoreline Sediment

Potential risks to wildlife, specifically benthic invertebrates, birds, and mammals, exposed to intertidal sediments at Parcel E-2 were evaluated in a screening-level ecological risk assessment (SLERA) prepared in conjunction with the Shoreline Characterization Technical Memorandum (included as Appendix G in this RI/FS Report). Concentrations of chemicals in surface and subsurface sediment samples collected from the Shoreline Area were screened against toxicological benchmarks for invertebrates, birds, and mammals.

The shoreline SLERA concluded that concentrations of copper and lead in sediment along the Parcel E-2 shoreline are a potential source of contamination to Parcel F. In addition, benthic invertebrates, birds, and mammals are at risk from exposure to PCBs in surface sediments along the Parcel E-2 shoreline.

Source control measures are warranted along the Parcel E-2 shoreline, particularly in the Metal Slag Area of the Panhandle Area and the Landfill Area, to control potential releases of copper and lead to Parcel F. In addition, ecological risk to benthic invertebrates, birds, and mammals in the shoreline warrants the evaluation of remedial alternatives for intertidal sediments along the entire Parcel E-2 shoreline.

ES.3. RISK ASSESSMENTS

Potential risks to humans and wildlife were evaluated for the following contaminated media: (1) soil; (2) landfill gas; (3) groundwater; and (4) shoreline sediment. The human health risk assessment (HHRA) was performed in accordance with the protocols and procedures for conducting HHRAs at HPS established by the Base Realignment and Closure Cleanup Team. SLERAs for soil and sediment were performed in accordance with Navy policy and EPA guidance (Navy, 1999; EPA, 1997).

ES.3.1. Soil

Human Health Risk Assessment

The HHRA calculated cancer risks and noncancer hazards from exposure to chemicals of potential concern (COPCs) in soil for recreational users and construction workers. The recreational use evaluated in the HHRA is consistent with the planned open space reuse at Parcel E-2. As discussed in Section ES.1, land uses other than open space are incompatible with the landfill area, and institutional controls such as restrictive covenants will address this incompatibility. Both total and incremental risks were evaluated for exposure to soil at Parcel E-2. The total risk evaluation provides an estimate of the risks posed by all chemicals at the site, including those present at concentrations at or below Hunters Point ambient levels (HPALs). The incremental risk evaluation provides an estimate of risks posed by all chemicals at the site, except those that do not exceed HPALs. A risk characterization analysis, of both total and incremental risk, identified the following chemicals of concern (COCs) that contribute to cancer risks exceeding 1×10^{-6} or noncancer hazard indices exceeding 1.0:

Chemicals of Concern		
Construction Worker Exposure [a] to Subsurface Soil (0 to 10 feet bgs)	Recreational User Exposure [b] to Surface Soil (0 to 2 feet bgs)	
4,4-DDT	Antimony	Indeno(1,2,3-cd)pyrene
Antimony	Aroclor-1242	Lead
Aroclor-1016	Aroclor-1248	Total PCBs (non-dioxin)
Aroclor-1242	Aroclor-1254	
Aroclor-1248	Aroclor-1260	
Aroclor-1254	Arsenic	
Aroclor-1260	Benzo(a)anthracene	
Arsenic	Benzo(a)pyrene	
Benzo(a)anthracene	Benzo(b)fluoranthene	
Benzo(a)pyrene	Benzo(k)fluoranthene	
Benzo(b)fluoranthene	Dieldrin	
Benzo(k)fluoranthene	Heptachlor epoxide	

Notes: COCs for total risk and incremental risk are identical

a The construction worker exposure scenario is not associated with a specific planned reuse for Parcel E-2.

b COCs identified for this exposure scenario are based on the planned reuse for Parcel E-2 as open space.

DDT Dichlorodiphenyltrichloroethane

The highest cancer and noncancer risks were at grid cells where the western and southwestern sidewall of the PCB Hot Spot Area excavation is located. Risk in these grid cells was reduced slightly following the removal action; however, remaining chemical concentrations along the western and southwestern sidewall of the PCB Hot Spot Area excavation continue to drive risk.

Screening-Level Ecological Risk Assessment

The Navy implemented the following steps to update previous ecological assessments with recent data collected during the soil data gaps investigation and following removal actions at the Metal Slag Area and the PCB Hot Spot Area: (1) evaluated the new data set to validate the list of chemicals of potential ecological concern (COPECs) used in the previous baseline ecological risk assessment for terrestrial receptors; (2) identified additional chemicals as COPECs and calculated protective soil concentrations (PSCs) for these additional chemicals; and (3) updated the previous ecological assessments by performing a SLERA for onshore ecological receptors using the updated PSCs and surface soil data set. The onshore SLERA evaluated all soil data within the Landfill Area, Panhandle Area, and East Adjacent Area, including data collected within wetland areas. Concentrations of cadmium, copper, lead, manganese, mercury, nickel, vanadium, zinc, polycyclic aromatic hydrocarbons, total DDT, and total PCBs exceeded PSCs (adjusted by HPALs, as appropriate) and are chemicals of ecological concern (COECs) that pose a potential threat to birds and mammals exposed to soil in Parcel E-2.

ES.3.2. Landfill Gas

Human exposure to subsurface air emanating from the landfill (referred to as landfill gas) can pose a potential risk in two ways: (1) explosive conditions due to concentrations of methane at or above the LEL; and (2) inhalation of NMOCs that, above certain concentrations, have associated cancer and noncancer health effects. Evaluation of these potential risks was performed consistent with regulations outlined in Title 27 California Code of Regulations (CCR).

For the landfill gas characterization, the evaluation methodology for methane data involved comparing field and laboratory data collected from the monitoring network against the numeric 27 CCR limits. The evaluation methodology for NMOCs involved performing risk assessments on soil gas data using the Johnson and Ettinger vapor intrusion model (EPA, 2003a). Cancer risk calculations for GMPs along Crisp Avenue and within the UCSF compound were less than the NCP point of departure of 1×10^{-6}; therefore, soil gas along Crisp Avenue and within the UCSF compound does not pose an unacceptable risk to human health.

Based on evaluation of available data from January 2004 through June 2010, the gas control system is controlling the migration of hazardous levels of methane gas beyond the northern fence line of the Parcel E-2 Landfill. In January and February 2006, hazardous levels of methane were detected at the fence line of the landfill. The Navy promptly performed active extraction to control the migration of hazardous levels of methane beyond the fence line of the landfill. The potential exists for methane, if not properly controlled, to migrate beyond the Parcel E-2 Landfill boundary at concentrations that may be hazardous to human health. Therefore, continued monitoring and control (through either passive or active methods) of methane should be included as part of any remedial alternative that leaves solid wastes in place in the Landfill Area.

ES.3.3. Groundwater

Human Health Risk Assessment

For the evaluation of human exposure to groundwater, the HHRA used groundwater monitoring data from the 12 most recent sampling events (through October 2007) from all Parcel E-2 wells to develop a conservative exposure concentration for each potentially complete pathway (based on the 95 percent upper confidence limit). The HHRA evaluated B-aquifer groundwater for domestic use; the evaluation used both B-aquifer and A-aquifer data because of the potential for vertical hydraulic communication between the A- and B-aquifers in some areas at Parcel E-2. In addition, construction workers were also assumed to be exposed to groundwater in the A-aquifer during trenching activities. For groundwater exposures, risks are the same for the total risk and incremental risk evaluations because a comparison to ambient levels was not conducted for groundwater.

The primary risk drivers for the construction worker trench exposure scenario are SVOCs, primarily benzo(a)pyrene and dibenz(a,h)anthracene, which account for more than 95 percent of the total cancer risk exceeding 1×10^{-6}. However, benzo(a)pyrene and dibenz(a,h)anthracene have not been detected in Parcel E-2 groundwater since August 2002. In addition, the extent of most SVOCs in Parcel E-2 groundwater has been localized, with maximum concentrations detected at former well IR01MWI-3 in the PCB Hot Spot Area excavation.

The primary risk drivers for the domestic use of the groundwater exposure scenario are arsenic and PCBs, accounting for over 70 percent of the total cancer risk exceeding 1×10^{-6}. Another risk driver that contributes significantly to the total cancer risk is benzo(a)pyrene, which accounts for approximately 13 percent of the total cancer risk exceeding 1×10^{-6}. The risk evaluation also indicated that the primary noncancer risk drivers include metals (arsenic, iron, hexavalent chromium, and thallium), 4-nitrophenol, and PCBs, which account for over 85 percent of the noncancer risk exceeding a hazard index of 1.0.

Ecological Risk Assessment

A screening-level assessment of ecological risk to aquatic wildlife exposed to potentially contaminated groundwater at Parcel E-2 is provided in Appendix M. Chemical concentrations in groundwater were screened against the assigned aquatic evaluation criteria, mainly comprising saltwater aquatic criteria, to identify COPECs for surface water quality. Site-specific data for select COPECs were then evaluated against trigger levels, consistent with the methods used in recent FS reports at other HPS parcels, to further confirm if the COPECs needed to be addressed in remedial alternatives. Based on concentrations exceeding trigger levels (as adjusted based on HGALs), the following chemicals (or groups of chemicals) pose a potential threat to aquatic wildlife exposed to potentially contaminated groundwater at Parcel E-2:

- Copper
- Lead
- Zinc
- Un-ionized Ammonia
- Sulfide
- Cyanide
- PCBs (Total)
- Total petroleum hydrocarbons (TPH)

ES.4. REMEDIAL INVESTIGATION CONCLUSIONS

Parcel E-2 has been adequately characterized to support the development of a focused set of remedial alternatives. The conclusion that adequate data exist, despite the areas where chemicals in soil and groundwater are not completed delineated, is consistent with EPA RI/FS guidance. Specifically, EPA RI/FS guidance states that "the objective of the RI/FS process is not the unattainable goal of removing all uncertainty, but rather to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site" (EPA, 1988a).

Based on the nature and extent evaluation, the identified exposure pathways based on the conceptual site model, and the risk assessment results, the following media and affected areas pose potential threats to human health and the environment and will undergo remedial option analysis in the FS: (1) solid waste and soil in the Landfill Area; (2) landfill gas; (3) soil and isolated solid waste in the Panhandle and East Adjacent Areas; (4) A-aquifer and B-aquifer groundwater; (5) surface water runoff; and (6) shoreline sediment.

ES.5. FEASIBILITY STUDY

The approach used to conduct the FS consisted of the following steps: develop remediation goals, develop RAOs, identify general response actions (GRAs), identify areas requiring remediation, and evaluate alternatives based on the nine NCP evaluation criteria. Each of these steps is discussed in the following paragraphs.

ES.5.1. Remediation Goals

Humans

Remediation goals for humans were derived for each COC identified in the risk assessments by comparing the highest concentrations of acceptable incremental risk with both the laboratory's reporting limit and the ambient level for the COC, if one was established. The greatest value from this comparison was selected as the remediation goal for that COC. For landfill gas, remediation goals were derived using the numeric 27 CCR limits for methane and by identifying screening levels for NMOCs that are considered protective of human health.

Wildlife

Remediation goals for wildlife were derived for COECs identified from the nature and extent evaluation and the risk assessments. For surface soil and shoreline sediment, remediation goals were derived using the corresponding PSCs (for soil) and effects range-median values (for shoreline sediment) developed as part of the risk assessment process. For surface water runoff, remediation goals were derived using promulgated criteria for saltwater aquatic life. Saltwater aquatic criteria were used in a screening-level evaluation of groundwater discharges; however, the identified chemicals in groundwater that may pose a risk to aquatic wildlife in San Francisco Bay are considered COPECs (that is, of chemicals of potential ecological concern) given the conservative nature of the risk analysis performed for that pathway. As such, groundwater remediation goals have not been developed for these COPECs. The remedial alternatives evaluate areas affected by these COPECs, the remediation technologies to be evaluated (include source removal, containment, and monitoring) are considered adequate to address the potential risk to aquatic wildlife in the bay.

In addition, remediation goals were established for TPH that are commingled with CERCLA-regulated chemicals. The TPH remediation goals were based on criteria established for Hunters Point petroleum program and were developed for protection of aquatic wildlife in the bay. The TPH criteria sum all TPH categories (gasoline-range, diesel-range, and motor-oil range). The total TPH groundwater criterion ranges from 1,400 to 20,000 micrograms per liter, depending on the distance from the shoreline (Shaw Environmental, Inc. [Shaw], 2007). The total TPH soil source criterion is 3,500 milligrams per kilogram, and is applied to potential soil sources between 0 and 10 feet bgs (Shaw, 2007).

ES.5.2. Remedial Action Objectives

RAOs for Parcel E are medium-specific goals that were developed to protect human health and the environment. Each RAO specifies: (1) the COCs; (2) the exposure route and receptor(s); and (3) an acceptable chemical concentration or range of concentrations for medium of concern. The following table summarizes the RAOs developed for Parcel E-2.

Media / Receptor	Remedial Action Objective
Waste, Soil, and Sediment / Humans	Prevent exposure to organic and inorganic chemicals at concentrations greater than remediation goals in (1) solid waste, soil, or sediment from 0 to 2 feet bgs by recreational users; or (2) solid waste, soil, or sediment from 0 to 10 feet bgs by construction workers.
Waste, Soil, and Sediment / Wildlife	Prevent exposure of wildlife to organic and inorganic chemicals in solid waste or soil at concentrations greater than remediation goals from 0 to 3 feet bgs throughout Parcel E-2.
	Prevent exposure of wildlife to organic and inorganic chemicals in intertidal sediment at concentrations greater than remediation goals from 0 to 2.5 feet bgs throughout the Shoreline Area.
Landfill Gas	Control methane concentrations to (1) 5 percent (by volume in air) or less at subsurface points of compliance; and (2) 1.25 percent (by volume in air) or less in on-site structures.
	Prevent exposure to NMOCs at concentrations (1) greater than 500 parts per million by volume (ppmv) at the subsurface points of compliance; and (2) greater than 5 ppmv above background levels in the breathing zone of on-site workers and visitors.
Groundwater / Humans	Prevent exposure to groundwater that may contain COCs at concentrations greater than remediation goals through the domestic use pathway.
	Prevent or minimize migration of B-aquifer groundwater that may contain COCs at concentrations greater than remediation goals beyond the compliance boundary.
	Prevent or minimize dermal contact to and vapor inhalation from A-aquifer groundwater containing COCs at concentrations greater than remediation goals by construction workers.
Groundwater / Wildlife	Prevent or minimize migration of COPECs to prevent discharge that would result in concentrations greater than the corresponding water quality criteria for aquatic wildlife.
	Prevent or minimize migration of A-aquifer and B-aquifer groundwater containing total TPH concentrations greater than the remediation goal (where commingled with CERCLA substances) into San Francisco Bay.
Surface Water / Wildlife	Prevent or minimize migration of surface water that may contain COECs at concentrations greater than water quality criteria for aquatic wildlife into San Francisco Bay.

ES.5.3. General Response Actions, Remedial Technologies, and Process Options

GRAs are responses or remedies intended to meet RAOs. The following GRAs were selected for Parcel E-2:

- No action—which is required by the NCP and is used as a baseline for comparison
- Institutional actions—includes institutional controls, engineering controls, and site monitoring
- Containment actions (with or without collection, treatment, and disposal)—includes technologies that isolate media to reduce or eliminate exposure to, and off-site migration of, surface and subsurface contaminants
- Removal actions—includes removal of contaminated media for treatment and disposal on or off site; exposure risk and migration potential are diminished by eliminating or reducing the contaminant source

The technologies and associated process options identified for each GRA were screened using three criteria: (1) effectiveness; (2) implementability; and (3) cost. Screening of the technologies and process options for each GRA is summarized in Figure ES-2. The Landfill Area meets all of the criteria specified in EPA guidance for application of the containment presumptive remedy. However, based on feedback from members of the local community, the Navy has agreed to fully evaluate excavation of the landfill as part of the FS to provide information to support the community's review of potential remedial alternatives for Parcel E-2. Therefore, removal by excavation and off-site disposal was retained as a potentially viable process option for the Landfill Area. For the Panhandle, East Adjacent, and Shoreline Areas, process options related to both containment and removal were retained for development of remedial alternatives.

Implementation of any containment or removal action that would alter existing site conditions will affect Parcel E-2 wetlands. Compliance with regulations for wetlands protection (in accordance with the Clean Water Act [§ 404] and the San Francisco Bay Plan [14 CCR, §§ 10110 through 11990]) will require that such effects be addressed through the established wetlands mitigation process. The following mitigation approaches have been identified: (1) wetlands banking; (2) wetlands restoration within HPS at areas not affected by COCs or COECs; and (3) wetlands restoration in the Panhandle Area of Parcel E-2.

ES.5.4. Development of Remedial Alternatives

The following remedial alternatives were developed for Parcel E-2 from the technologies and process options retained for each GRA:

- **Alternative 1 – No Action:** For this alternative, no remedial action would take place. Solid waste, soil, sediment, groundwater, and surface water would be left in place without any response actions (such as, institutional controls, monitoring, containment, removal, and treatment). The no action alternative is retained throughout the FS process as required by the NCP to provide a baseline for comparison with and evaluation of other alternatives.
- **Alternative 2 – Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, institutional controls, and unlined freshwater wetlands):** This alternative would involve excavation and off-site disposal of all solid waste, debris, and soil in the Landfill Area. Isolated solid waste locations, soil, and sediment in the adjacent areas (which consist of the Panhandle Area, East Adjacent Area, and Shoreline Area) would also be excavated and disposed of off site. The proposed excavation in the Panhandle Area, East Adjacent Area, and Shoreline Area would eliminate exposure to radioactive and nonradioactive contamination, in accordance with the exposure depths in the risk assessments, and would extend deeper in areas with known hot spots of nonradioactive chemicals. Groundwater monitoring would be included under this alternative to evaluate chemical concentrations in groundwater while the aquifers naturally recover. Additionally, groundwater monitoring would be used to confirm site conditions and to ensure that, over time, the potential exposure pathways would remain incomplete. This alternative would also include institutional controls (consisting of land use and activity restrictions) that would be implemented across the entire parcel to prevent exposure to COCs and COECs in soil and groundwater. Wetlands disturbed during excavation activities would be restored on top of the clean fill in the Panhandle Area.
- **Alternative 3 – Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands):** This alternative would involve (1) excavation and off-site disposal of all radiological surface anomalies and Tier 1 and Tier 2 hot spots in the Panhandle Area, East Adjacent Area, and Shoreline Area; and (2) excavation and on-site consolidation of soil in portions of the Panhandle Area planned for wetlands restoration (both tidal and freshwater) and sediment throughout the Shoreline Area. Excavation activities would be followed by containment of solid waste and soil in the Landfill, Panhandle, East Adjacent, and Shoreline Areas. The portions of the Landfill Area not already covered by the existing multilayer cap would be covered with a similarly designed multilayer cap. The isolated solid waste locations and soil in the East Adjacent Area, as well as portions of the Panhandle and Shoreline Areas not planned for tidal wetlands restoration, would be covered with a geosynthetic cap. The cap termination within the Shoreline Area would be protected with a shoreline protection system and, where the Landfill Area abuts the Shoreline Area, would also be underlain by a subsurface drainage system (in the event that groundwater monitoring results prompt extraction and treatment of leachate and contaminated groundwater). In addition, this alternative would include (1) construction of a groundwater diversion system (consisting of an upgradient slurry wall and subsurface drain) along the west side of the landfill to divert upgradient groundwater and reduce leachate generation; (2) installation, operation, and maintenance of an active landfill gas control system; (3) monitoring of landfill gas, stormwater, and groundwater; and (4) institutional controls (consisting of land use and activity restrictions) that would be implemented across the entire parcel to prevent exposure to COCs and COECs in soil, landfill gas, and groundwater. Also, freshwater wetlands disturbed during construction of the containment systems would be restored on top of the cap in the Panhandle Area, while tidal wetlands disturbed during construction would be restored without a cap.

- **Alternative 4 – Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and lined freshwater wetlands):** This alternative would have the same components as Alternative 3, but would include (1) excavation and off-site disposal of Tier 3, 4, and 5 hot spots (in addition to Tier 1 and 2 hot spots; (2) containment of contaminated groundwater with a slurry wall in the nearshore areas where landfill waste is within 100 feet of San Francisco Bay (referred to as the "nearshore slurry wall"); and (3) a contingency to extend the nearshore slurry wall south into the PCB Hot Spot Area. The need for this extension will be assessed in the remedial design using updated groundwater monitoring data from wells in and around the excavated portion of the PCB Hot Spot Area, which is being collected under the Basewide Groundwater Monitoring Program. The groundwater diversion system along the west side of the landfill, as proposed under Alternative 3, would minimize hydraulic head buildup behind the nearshore slurry wall.
- **Alternative 5 – Contain Solid Waste, Soil, Sediment, and Groundwater with Hot Spot Removal (including monitoring, institutional controls, and unlined freshwater wetlands):** This alternative would have the same components as Alternative 4, but would include restoration of freshwater wetlands without a liner. Alternative 5 was developed to evaluate the relative advantages of unlined freshwater wetlands compared with the lined freshwater wetlands proposed under Alternatives 3 and 4.

ES.5.5. Detailed Evaluation of Remedial Alternatives

Each remedial alternative was evaluated in comparison to the two threshold and five balancing evaluation criteria established in the NCP. The two modifying criteria, state and community acceptance, will be assessed in the ROD following comment on the RI/FS Report and the proposed plan. A comparative analysis was then conducted to evaluate the relative performance of the three remedial alternatives developed for Parcel E-2.

NCP EVALUATION CRITERIA

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements

Balancing Criteria

- Long-term effectiveness and permanence
- Reduction of mobility, toxicity, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

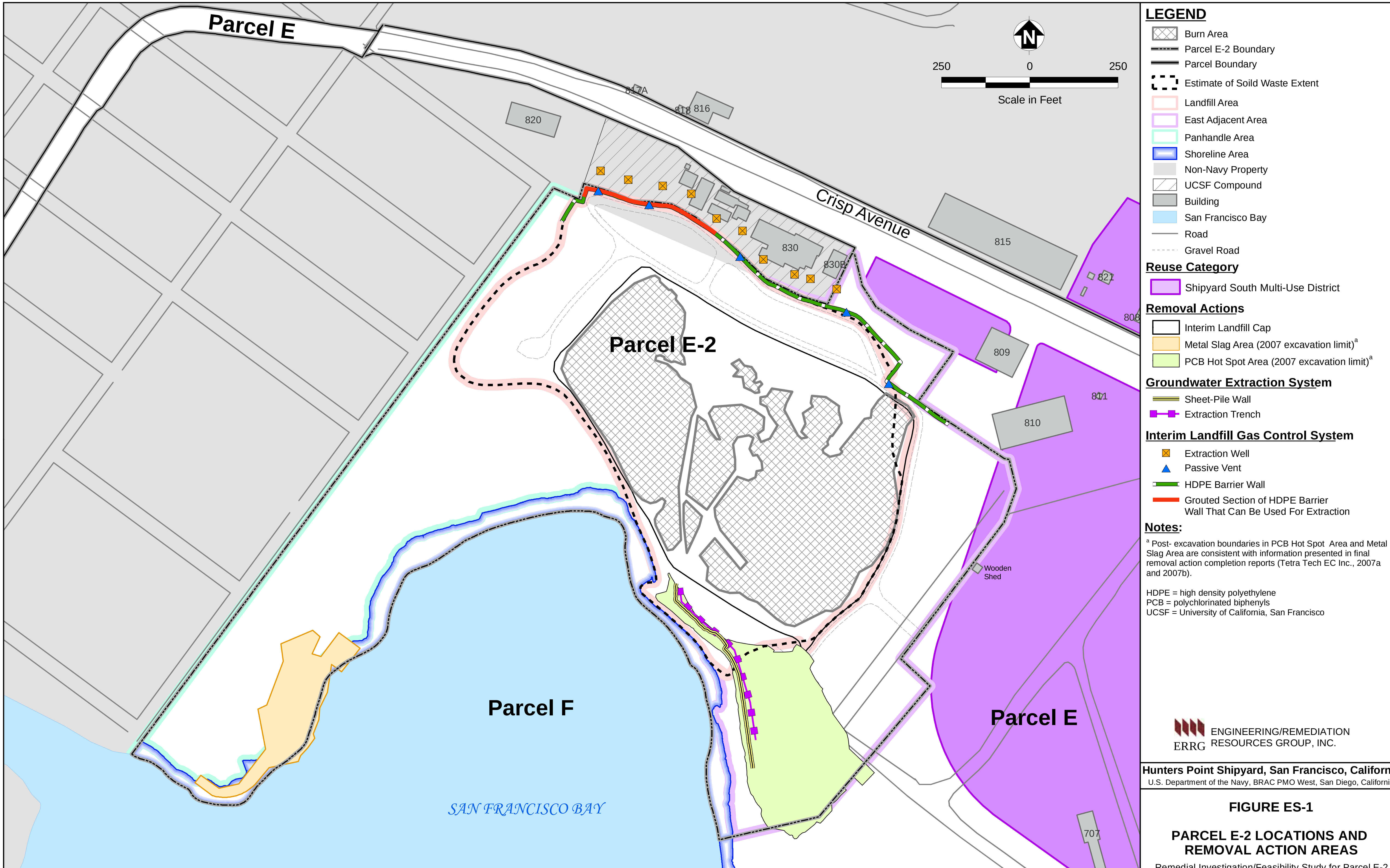
Modifying Criteria

- State acceptance
- Community acceptance

ES.5.6. Comparative Analysis of Remedial Alternatives

Table ES-1 summarizes the comparative analysis; showing each alternative's rating under the three threshold criteria and five balancing criteria. The no action alternative (Alternative 1) would not be effective in protecting human health and the environment. Alternatives 2, 3, 4, and 5 would be effective remedial alternatives for Parcel E-2. Alternatives 3, 4, and 5 appear to be significantly more feasible, predictable, cost-effective, time-effective, and implementable remedies, when compared with Alternative 2. Alternatives 4 and 5 offer improved long-term effectiveness but have a higher cost relative to Alternative 3. The remedy for Parcel E-2 will be selected in the ROD following comment on the RI/FS Report and the proposed plan.

Figures



Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE ES-1

PARCEL E-2 LOCATIONS AND REMOVAL ACTION AREAS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Site Features Map2.mxd

Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Solid Waste and Soil in Landfill, Panhandle, and East Adjacent Areas; Sediment in Shoreline Area	No Action	None	None	No additional action would be taken to address solid waste and soil in the Landfill Area, Panhandle Area or East Adjacent Area, or sediment in the Shoreline Area.	Required by the NCP and is used as a baseline against which other response actions are compared - would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications); Administrative Mechanisms (Land Use Plans, Soil and Groundwater Procedures and Policies, Construction Permitting, Public Notices and Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Restrict the use of the parcel to open space • Require maintenance of control systems • Maintain the integrity of covers (or access restrictions where covers are not present) • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as, subsurface construction)	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e., to limit and restrict access)	Signs (Warning and No Trespassing); Traffic Barriers and Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
		Site Monitoring	Short-Term Monitoring; Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction that may disturb contaminated solid waste, soil, or sediment. Long-term monitoring includes operation and maintenance of control systems (such as, inspection and maintenance of caps/covers).	Although monitoring alone would not achieve RAOs, short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	Low	High	Low	Yes
	Containment	Caps/Covers	Low-Permeability Soil Cap	The low-permeability soil cap system (Title 27 cover, prescriptive standard) includes a low-permeability soil layer (such as clay) at least 12 inches thick with a maximum permeability of $1x10^{-6}$ cm/sec or equal to the hydraulic conductivity of the base liner system.	Limited local sources of low-permeability soil; costly to purchase and import large volumes of suitable low-permeability soil.	High	Moderate-High	Moderate-High	Yes (for potential focused application at freshwater wetlands)
			Geosynthetic Cap	The geosynthetic cap system (Title 27 cover, engineered alternative) would include a 60-mil-thick HDPE geomembrane in place of the low-permeability soil layer (typical permeability is $1x10^{-13}$ cm/sec)	Highly effective and implementable with proper QA/QC, skilled labor, and appropriate supplies and equipment.	High	High	Moderate	Yes
			Multilayer Geosynthetic Cap	The multilayer geosynthetic cap system includes a composite low-permeability layer consisting of an HDPE geomembrane at least 60 mils thick over a GCL (typical permeability of GCL is $5x10^{-9}$ cm/sec)	Already installed over a portion of the waste area; highly effective and implementable with proper QA/QC, skilled labor, and appropriate supplies and equipment.	High	High	Moderate-High	Yes
			Evapotranspiration Cap	An evapotranspiration cap is typically a 4- to 6-foot-thick soil layer over a soil foundation layer; it acts to store moisture within the cap thickness, while minimizing infiltration, until the moisture is removed through vegetative uptake or evaporation.	Diminished effectiveness in temperate climates; ideal in arid or semi-arid climates; would require importation of a significant amount of cover soil and may encroach on neighboring property.	Moderate	Low	Moderate to High	No (not implementable given limited space and temperate climate)
		Shoreline Protection *	Armoring	Armoring includes seawalls, bulkheads, and protective revetments.	Armoring would protect the containment systems from erosion, and allow freshwater wetlands to be established in the Panhandle Area.	High	High	High	Yes
			Shoreline Stabilization	Shoreline stabilization includes man-made structures (such as nearshore breakwaters and reefs) or natural material (such as vegetation or sand fill) used to moderate the coastal sediment transport processes and reduce the local erosion rate.	Shoreline stabilization would be effective In areas planned for tidal wetlands restoration.	Moderate	High	Moderate to High	Yes
			Shoreline Nourishment	Shoreline nourishment can include berms, dunes, feeder beach, nearshore berm, dune stabilization, or structural stabilization.	Inadequate area for proper implementation; would not prevent erosion.	Low	Low	Moderate	No (not implementable within narrow Shoreline Area)
	Removal	Excavation	Excavation/Off-Site Disposal 1. Landfill Area 2. Soil in adjacent areas	Excavation and off-site disposal of all solid waste and contaminated soil in the Landfill Area, and contaminated soil/sediment in Panhandle, East Adjacent, and Shoreline Areas that may pose a risk to human health and the environment	Multiple issues associated with excavation and transport of such a large volume of landfill solid waste and soil.	Moderate-High	Low-Moderate	Very High	Yes (to support community review of potential remedies)
			Excavation/Off-Site Disposal 1. Hot spots in adjacent areas 2. Incidental LLRW	Excavation and off-site disposal of hot spots in Panhandle, East Adjacent, and Shoreline Areas (including LLRW encountered during hot spot excavation activities)	Primary hot spots consist of liquid and highly toxic wastes in the PCB Hot Spot shoreline; additional removal at other locations in the Panhandle and East Adjacent Areas to enhance performance of remedy.	High	High	Moderate to High	Yes
			Excavation/On-Site Consolidation of hot spots in adjacent areas (with off-site disposal of incidental LLRW)	Excavation of hot spots in Panhandle, East Adjacent, and Shoreline Areas with off-site disposal of LLRW and on-site consolidation of non-radiological hot spot material	Hot spots are not mobile, and planned leachate collection/treatment system is considered adequate but not as robust as off-site disposal facilities.	Moderate	Moderate	Moderate	No (potential issues with administrative implementability)
			Excavation/On-Site Consolidation of contaminated material in adjacent areas (with off-site disposal of incidental LLRW)	Excavation of solid waste and contaminated soil/sediment in Panhandle, East Adjacent, and Shoreline Areas, as needed to meet design requirements of a containment process option (for example, stable slopes along shoreline and altered topography to support wetlands restoration), with off-site disposal of LLRW and on-site consolidation of non-radiological material	Specific hot spot removal areas include surface soil in the Metal Slag Area, soil along the PCB Hot Spot shoreline, soil along the Landfill Area Shoreline, and soil from various inland locations in the Panhandle and East Adjacent Areas.	High	High	Moderate	Yes

Legend

- Green: Retained for use in Remedial Alternatives
- Yellow: Retained for possible future incorporation (based on future site data)
- Orange: Eliminated from consideration

Notes:
* Required in Shoreline Area
Acronyms defined on page 4

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE ES-2
RESULTS OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS EVALUATION

Remedial Investigation/Feasibility Study for Parcel E-2

N:\Projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\Graphics\ES-2 Remedial Technology Screening Table_03-25-10.vsd

Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Landfill Gas in Parcel E-2	No Action	None	None	No additional action would be taken to remove or treat landfill gas.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil and Groundwater Procedures and Policies, Construction Permitting, Public Notices and Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Require maintenance of control systems • Ensure compliance with 27 CCR requirements for construction within 1,000 feet of a landfill, such as the requirement for gas control systems on any installed subsurface structures or other areas in which landfill gas may accumulate	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e., to limit and restrict access)	Signs (Warning and No Trespassing) Traffic Barriers and Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction that may affect landfill gas migration. Long-term monitoring includes monitoring of gas monitoring probes, subsurface structures, and site structures; also includes operation and maintenance of gas control systems.	Although monitoring alone would not achieve RAOs, short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	Low	High	Low	Yes
	Containment	Landfill Gas Collection	Passive Venting	A passive system at Parcel E-2 would include a series of venting wells extending from below the historic low water table elevation through the cap and discharging to the atmosphere above the surface of the cap.	Diminished effectiveness at landfills with no bottom and sidewall liner system, or landfills with insufficient buffer space between the edge of waste and the compliance points; if NMOC treatment is required at the discharge points, the required treatment systems could restrict landfill gas venting, rendering venting less effective.	Moderate	High	Low	Yes
			Active Collection	Active landfill gas collection uses vacuum blowers to extract landfill gas through vertical extraction wells installed and plumbed together; gases are drawn to a central collection point to create an inward pressure gradient to prevent outward landfill gas migration.	More effective with geosynthetic caps in shallow landfills because geosynthetic materials offer a better barrier against vacuum short-circuiting to the surface.	High	High	Moderate	Yes
	Treatment (gas treatment and/or destruction) *	Adsorption (via GAC and Hydrosil®)	GAC Hydrosil® (permanganate-impregnated zeolite medium)	GAC would remove SVOCs and most VOCs; could be used with either passive or active collection systems. Hydrosil® would remove lighter VOCs such as vinyl chloride; could be used with either passive or active collection systems.	Treatment units could restrict the airflow of passive venting systems, rendering them less effective.	High	High	Low (if NMOC concentrations are low) High (if NMOC concentrations are high, following capping of the entire landfill)	Yes
		Destruction (via combustion)	Enclosed Flare	An enclosed flare would destroy landfill gas, including NMOCs and methane, through combustion; primary chemical byproducts from flares are carbon dioxide and nitrogen oxide compounds.	Operating conditions would reduce the possibility of dioxin formation by promoting the destruction of organics, operating at temperatures above those that would allow dioxin formation followed by rapid quenching, and extending the combustion residence time.	High	Moderate to High	Low to Moderate	Yes
			Open Flare	Eliminated from consideration due to poor system controls (relative to enclosed flares).		N/A	N/A	N/A	N/A
			Internal Combustion Engine	Eliminated from consideration because volume of gas generated by the Parcel E-2 Landfill is not anticipated to be sufficient to support the cost-effective implementation of internal combustion engines.		N/A	N/A	N/A	N/A
		Destruction (via non-combustion processes)	Energy Recovery Gas-to-Product	Energy recovery technologies, such as fuel cells, use landfill gas to produce energy directly. Gas-to-product conversion technologies focus on converting landfill gas into commercial products, such as compressed natural gas, methanol, purified carbon dioxide and methane, or liquefied natural gas.	Effectiveness of energy recovery and gas-to-product systems at Parcel E-2 is unknown because of the lack of information on gas concentration generation rates (assumed moderate to high, depending on implementability).	Likely Low (assumed moderate to high, if implementable at Parcel E-2)	Likely Low (site-specific conditions need to be better defined)	High	Yes

Legend

- Retained for use in Remedial Alternatives (green)
- Retained for possible future incorporation (based on future site data) (yellow)
- Eliminated from consideration (orange)

Notes:
* Additional data are needed to determine the type(s) of treatment required for landfill gas at Parcel E-2.
Acronyms defined on page 4

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE ES-2 (cont.) RESULTS OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS EVALUATION

Remedial Investigation/Feasibility Study for Parcel E-2

Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Groundwater in Parcel E-2	No Action	None	None	No action would be taken to remove, contain or treat groundwater; no institutional controls would be established to prevent exposure, and no monitoring would be required.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil and Groundwater Procedures and Policies, Construction Permitting, Public Notices and Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as subsurface construction • Restrict the use of groundwater within the Parcel E-2 boundaries • Prohibit the installation of wells that have the potential to affect the migration of contaminated groundwater within Parcel E-2.	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and would be required to prevent exposure to groundwater within the Parcel E-2 boundaries.	High	High	Low	Yes
		Engineering Controls (i.e., to limit and restrict access)	Signs (Warning & No Trespassing) Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction of groundwater control systems. Long-term monitoring includes groundwater monitoring and operation and maintenance of groundwater control systems.	Although monitoring alone would not achieve RAOs, short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	Low	High	Low	Yes
	Containment	Physical Barrier	Slurry Wall	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Physical barrier may need to be complemented with hydraulic barrier to prevent excessive groundwater mounding.	Moderate to High	Moderate to High	Moderate to High	Yes
			Grout Curtain Vertical Geomembrane	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Site-specific conditions limit the implementability of these options.	Moderate to High	Low to Moderate	Moderate to High	No (not implementable given site-specific conditions)
			Sheet-Pile Wall	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Physical barrier may need to be complemented with a hydraulic barrier to prevent excessive groundwater mounding. Corrosion potential limits effectiveness and presence of large debris limits implementability.	Moderate	Moderate	Moderate to High	No (issues regarding effectiveness and implementability)
		Hydraulic Barrier	Flow Diversion Drain	Flow diversion drain coupled with a physical barrier would be installed on the upgradient side of the landfill to reduce groundwater flow through the waste. Drain would divert flow to reduce groundwater mounding behind the physical barrier.	Flow diversion drain is a passive technology requiring no operation, and minimal maintenance after installation.	Moderate to High	High	Low	Yes
			Extraction from Wells and Off-Site Discharge	System would extract groundwater through pumping wells to contain groundwater and achieve RAOs at compliance points; extracted groundwater could be discharged to the sanitary sewer system, treated and reinjected, or treated and discharged to the bay.	Groundwater modeling would be required to optimize extraction well placement and pumping rates, and to minimize the volume of water pumped from the Parcel E-2 aquifers; the required level of treatment would greatly influence cost.	Moderate to High	High	High	Yes
			Phytoremediation / Phytohydraulics	Phytohydraulics would use of plants to control rainfall infiltration and groundwater levels and movement; plants would remove water through evapotranspiration. In addition to hydraulic control, phytoremediation could potentially help reduce chemical concentrations in subsurface soil and groundwater.	Further studies would be required to identify plant species that could tolerate brackish groundwater, determine required planting area size and plant density. Space requirements may be incompatible with site conditions.	Moderate to High	Low	Low to Moderate	No (issues regarding implementability)
	Treatment	Reactive Barrier	Permeable Reactive Barrier	Permeable reactive barrier would be installed along the shoreline to breakdown contaminants in groundwater flowing off site.	Permeable reactive barrier is a passive technology that may require periodic reinjection of reagent to maintain effectiveness. Technology is unproven for treatment of landfill leachate in a tidal environment.	Undetermined in the short term; Low in the long term	Low	High	No (issues regarding effectiveness, implementability, and cost)

Legend

- Retained for use in Remedial Alternatives (green)
- Retained for possible future incorporation (based on future site data) (yellow)
- Eliminated from consideration (orange)

Notes:
Acronyms defined on page 4

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE ES-2 (cont.) RESULTS OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS EVALUATION

Remedial Investigation/Feasibility Study for Parcel E-2

N:\Projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\Graphics\ES-2 Remedial Technology Screening Table_03-25-10.vsd

Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Surface Water in Parcel E-2	No Action	None	None	No action would be taken to monitor or manage stormwater runoff and groundwater discharges to wetlands and the Bay at Parcel E-2; no institutional controls would be established to prevent exposure to surface water.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil and Groundwater Procedures and Policies, Construction Permitting, Public Notices and Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Restrict the use of the parcel to open space • Require maintenance of stormwater BMPs • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as, subsurface construction)	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e., to limit and restrict access)	Signs (Warning and No Trespassing) Traffic Barriers and Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (not effective as part of permanent remedy; conflicts with planned open space reuse)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring Stormwater BMPs	Short-term monitoring involves stormwater monitoring during construction. Long-term monitoring includes surface water monitoring and inspection and maintenance of stormwater BMPs. Monitoring of surface water is used to demonstrate compliance with RAOs designed to prevent unacceptable exposures to aquatic receptors in the bay.	Although monitoring alone would not achieve RAOs, a stormwater monitoring program, including stormwater BMPs, would be implemented in conjunction with an inspection and maintenance for any containment systems.	Low	High	Low	Yes

Legend

- Retained for use in Remedial Alternatives (green)
- Retained for possible future incorporation (based on future site data) (yellow)
- Eliminated from consideration (orange)

Acronyms

BMPs = best management practices
CCR = California Code of Regulations
cm/sec = centimeters per second
GAC = granular activated carbon
GCL = geosynthetic clay liner
GRA = general response action
HDPE = high-density polyethylene
LLRW = low-level radioactive waste
NCP = National Oil and Hazardous Substances Pollution Contingency Plan
NMOC = nonmethane organic compound
PCB = polychlorinated biphenyl
QA = quality assurance
QC = quality control
RAOs = remedial action objectives
RCRA = Resource Conservation and Recovery Act
SVOCs = semivolatile organic compounds
VOC = volatile organic compounds

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE ES-2 (cont.)
RESULTS OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS EVALUATION
Remedial Investigation/Feasibility Study for Parcel E-2

N:\Projects\2005 Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\Graphics\ES-2 Remedial Technology Screening Table_03-25-10.vsd

Tables

Table ES-1. Comparative Analysis of Parcel E-2 Remedial Alternatives

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard, San Francisco, California

ALTERNATIVES	Overall Protection of Human Health and the Environment [a]	Compliance with ARARs [a]	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost ($ Million)	Overall Rating by Alternative
Alternative 1: No Action	No	No	○	○	●	●	$0	NA
Alternative 2: Excavate and Dispose of Solid Waste, Soil, and Sediment (including monitoring, ICs, and unlined freshwater wetlands)	Yes	Meets ARARs	●	◑	○	○	$351.5	○
Alternative 3: Contain Solid Waste, Soil, and Sediment with Hot Spot Removal (including monitoring, ICs, and lined freshwater wetlands)	Yes	Meets ARARs	◑	◑	◕	◑	$77.7 (A) $78.4 (B)	◑
Alternative 4: Contain Solid Waste, Soil, Sediment and Groundwater with Hot Spot Removal (including monitoring, ICs, and lined freshwater wetlands)	Yes	Meets ARARs	◕	◑	◕	◑	$85.4 (A) $86.6 (B)	◕
Alternative 5: Contain Solid Waste, Soil, Sediment and Groundwater with Hot Spot Removal (including monitoring, ICs, and unlined freshwater wetlands)	Yes	Meets ARARs	◕	◑	◕	◕	$85.5 (A) $86.7 (B)	◕

Legend:

- ○ Low
- ◑ Moderate
- ◕ Moderate to High
- ● High

Notes:

a Overall protection of human health and the environment and compliance with ARARs are threshold criteria and alternatives are judged as either meeting or not meeting the criteria.

ARARs applicable or relevant and appropriate requirements
ICs institutional controls
NA not acceptable

Section 1. Introduction

This report presents a combined Remedial Investigation (RI)/Feasibility Study (FS) for the contiguous area consisting of the closed industrial landfill (hereafter referred to as the "Parcel E-2 Landfill") and the surrounding adjacent areas that contain isolated or noncontiguous pockets of buried solid waste at Parcel E-2, Hunters Point Shipyard (HPS) in San Francisco, California (Figure 1-1). HPS was identified as a National Priorities List (NPL) site by the U.S. Environmental Protection Agency (EPA) in 1989. As a result, the Department of the Navy (Navy) is conducting investigations and response actions in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (Title 42 United States Code [42 USC] Sections [§§] 9601-9675) at a number of sites at HPS where a release of a CERCLA hazardous substance has occurred. As a management tool to accelerate site investigation, cleanup, and reuse, HPS was divided into parcels, and sites within each parcel are evaluated concurrently.

HPS is currently divided into 10 parcels, as shown on Figure 1-1. In 1992, the Navy divided HPS into five contiguous parcels (A through E). In 1996, the Navy added a sixth parcel (Parcel F), which encompasses immediately adjacent areas of San Francisco Bay; Parcel F is referred to as the "offshore area." In September 2004, the Navy divided Parcel E into two parcels (Parcels E and E-2) to facilitate closure of the Parcel E-2 Landfill and its adjacent areas (Figure 1-2). In December 2004, the Navy transferred Parcel A to the San Francisco Redevelopment Agency (SFRA). In July 2008, the Navy subdivided Parcel D into four separate parcels (Parcels D-1, D-2, G, and UC-1), and separated the western edge of Parcel C to create Parcel UC-2; these changes were made to expedite the closure and transfer of these new parcels.

This RI/FS is part of ongoing efforts by the Navy to address contamination at HPS Parcel E-2 in accordance with CERCLA. The RI/FS is a mechanism for characterizing the nature and extent of site contamination and associated human health and ecological risks and evaluating potential remedial options to address those risks. As the lead response agency, the Navy has authority over evaluation of risk, selection of the remedial alternative, and overall public participation at HPS. The Navy is coordinating with the EPA Region 9, the Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (RWQCB) in accordance with a Federal Facility Agreement (FFA) that provides a procedural framework and schedule for the CERCLA cleanup process at HPS (Navy, EPA, DTSC, and RWQCB, 1991). The Navy, EPA, DTSC, and RWQCB representatives are collectively referred to as the Base Realignment and Closure (BRAC) Cleanup Team (BCT) for HPS.

Engineering/Remediation Resources Group, Inc. (ERRG) and Shaw Environmental, Inc. (Shaw) jointly produced this combined RI/FS Report for Parcel E-2, with support from Tetra Tech EM Inc. (TtEMI). Shaw was retained by the Navy to develop remedial alternatives 3, 4, and 5. TtEMI was subcontracted by ERRG to provide FS support and to perform the baseline human health risk assessment (HHRA).

1.1. PARCEL E-2 CERCLA PROGRESS

EPA guidance describes the CERCLA remedial process as a series of progressive steps for achieving cleanup and release of environmental issues at a site for future reuse (EPA, 1988a). The typical sequence includes a preliminary assessment and site inspection, RI, FS, proposed plan, public comment period, record of decision (ROD), remedial design (RD), remedial action, and post-construction reporting. Removal actions are also used at times to expedite the cleanup process.

1.1.1. Previous Investigations

The Navy previously completed parcel-wide RI and FS reports (TtEMI, Levine-Fricke-Recon [LFR], and Uribe & Associates [U&A], 1997; TtEMI, 1998) for Parcel E, which encompassed the area later subdivided as Parcel E-2. During preparation of the Parcel E RI and FS reports, the Navy and regulatory agencies identified additional tasks to support the RD for Parcel E, most of which were specific to the Parcel E-2 Landfill. These tasks included defining the nature and extent of landfill gas, refining the lateral extent of solid waste, evaluating liquefaction potential, and delineating wetlands areas adjacent to the landfill. In addition, the Navy and regulatory agencies decided that additional data for Parcel E were needed, including data from the area now referred to as Parcel E-2, to better define the nature and extent of chemicals in soil and groundwater.

Groundwater data gap investigations (GDGIs) were conducted in three phases, from July 2000 through October 2002, to better define the extent of groundwater contamination at Parcels C, D, and E (TtEMI, 2001a, 2002c, and 2004c). From 2007 to 2008, a focused GDGI was performed to evaluate chemical concentrations along the Parcel E-2 shoreline (CE2-Kleinfelder Joint Venture, 2009a). In addition, a soil and sediment data gaps investigation was conducted in 2002 to further delineate the nature and extent of soil and sediment contamination in Parcel E (TtEMI, 2005c), including areas within Parcel E-2. This soil and sediment data gap investigation was referred to as the "standard data gaps investigation" (SDGI), to differentiate it from a series of data gap investigations conducted in 2002 to evaluate various landfill and wetland characteristics at Parcel E-2 (TtEMI, 2002a). These landfill and wetland data gap investigations were referred to as "nonstandard data gaps investigations" (NDGIs), and included:

- A characterization of the nature and extent of landfill gas (TtEMI, 2003e; Appendix A to this report)
- An evaluation of the lateral extent of the solid waste within the Parcel E-2 Landfill (TtEMI, 2004f; Appendix B to this report)
- An evaluation of landfill liquefaction potential (TtEMI and Innovative Technical Solutions, Inc. [ITSI], 2004b; Appendix C to this report)
- A delineation and functions and values assessment of the wetland areas within and adjacent to the Parcel E-2 Landfill (TtEMI, 2003d; Appendix D to this report)

Parcel E-2 was evaluated as Installation Restoration (IR) Site 01/21 in the previous RI and FS reports and subsequent data gaps investigations; however, small portions of IR Sites 02 and 76 are located within Parcel E-2. In addition, numerous sampling locations from adjoining IR Sites 04, 12, 56, and 72 are located within Parcel E-2.

1.1.2. Ongoing Monitoring Programs

The Navy has implemented several environmental monitoring programs to satisfy regulatory requirements for Parcel E-2[1] until a final remedy is selected. In accordance with the monitoring requirements for waste disposal facilities (Title 27 California Code of Regulations [27 CCR], Chapter 2), the following monitoring programs have been established and are currently being conducted at Parcel E-2:

- Landfill gas control and monitoring program (TtEMI and ITSI, 2004c): Program includes operation and maintenance (O&M) of the gas control system and perimeter gas monitoring to document compliance with 27 CCR requirements for control of off-site gas migration.
- Basewide groundwater monitoring program (BGMP) (CE2-Kleinfelder Joint Venture, 2009c): Program involves regular monitoring of groundwater wells throughout Parcel E-2 for various chemicals specified in 27 CCR, including volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), metals and other inorganic compounds, petroleum hydrocarbons, polychlorinated biphenyls (PCBs), and pesticides.
- Landfill cover integrity monitoring and maintenance program (TtEMI, 2003b): Program includes irrigation of the vegetative cover, periodic inspections of the interim cap, and necessary maintenance actions based on inspection results.
- Stormwater management and monitoring program (MARRS Services, Inc. [MARRS] and MACTEC Engineering and Consulting [MACTEC], 2009b): Program involves inspecting and maintaining best management practices (BMPs) currently in place to control erosion, and monitoring surface water runoff at discharge points.

[1] In September 2004, the Navy divided Parcel E into two parcels (E and E-2). Discussions within this report that reference documents published prior to September 2004 refer to the portion of Parcel E that became Parcel E-2.

These monitoring programs are discussed in more detail in Section 3.9. The landfill gas and groundwater data produced from these ongoing monitoring programs helped define the nature and extent of contamination at Parcel E-2 and are presented in Sections 4 and 5, along with data from previous investigations.

1.1.3. Removal Actions in Parcel E-2

The Navy also conducted several removal actions in Parcel E-2 after completion of the Parcel E RI and FS reports. These removal actions consisted of:

- Installation of a groundwater containment and extraction system to reduce the potential for release of landfill constituents into the San Francisco Bay (International Technology Corporation [IT], 1999)
- Installation of a multilayer interim cap on a portion of the Parcel E-2 Landfill to prevent oxygen intrusion and extinguish smoldering subsurface areas following a brush fire (TtEMI, 2005b; Appendix E to this report)
- Installation of a landfill gas control and monitoring system along the northern Parcel E-2 boundary to control gas migration from the landfill (TtEMI, 2004a; Appendix F to this report)
- Collection, characterization, and disposal of debris along the shoreline of Parcels E and E-2 (Tetra Tech FW, Inc. [TtFW], 2004c)

In 2006, the Navy completed removal actions to excavate and dispose of PCB-contaminated soil (referred to as a “hot spot”) and a metal slag area at Parcel E-2 (Tetra Tech EC, Inc. [TtECI], 2007a and 2007b). The location of the removal actions are shown on Figure 1-3. As discussed in Section 3.8.8, the shoreline portion of the PCB Hot Spot Area was not excavated because of its proximity to San Francisco Bay. The FS portions of this report include an assessment of the removal of the remaining portions of the PCB Hot Spot Area.

1.1.4. Parcel E-2 RI/FS

This RI/FS Report was prepared to summarize and evaluate the current site conditions following the data gaps investigations and removal actions. The data gaps investigations and ongoing monitoring programs significantly expanded the set of environmental data at Parcel E-2, with more than 1,070 additional soil and groundwater samples being collected to date. In addition, removal actions have removed potential contamination sources in Parcel E-2. To address these changes, this RI/FS Report includes: (1) an update to the site characterization; (2) a revised HHRA and an evaluation of potential environmental effects on the San Francisco Bay; (3) updated remedial action objectives (RAOs); and (4) development and evaluation of revised remedial alternatives based on these updates.

This report addresses CERCLA hazardous substances except for radionuclides. Radionuclides in soil and groundwater are evaluated in the radiological addendum to this RI/FS Report. Both chemical and radiological contaminants will then be addressed together in the proposed plan and the ROD.

1.2. STUDY AREAS IN PARCEL E-2

Figure 1-2 shows the location of the four distinct but contiguous areas contained within Parcel E-2:

- The "Landfill Area," which comprises the entire Parcel E-2 Landfill and its immediate perimeter
- The "East Adjacent Area," located to the east of the Landfill Area
- The "Panhandle Area," located west and southwest of the Landfill Area
- The "Shoreline Area," located at the interface with San Francisco Bay

These four areas were defined for the RI/FS to facilitate referencing to each throughout the narrative, figures, and tables. Each study area is further described in Section 1.6.4.

Although part of Parcel E-2, the Shoreline Area is located in a narrow intertidal zone that is being evaluated in conjunction with Parcel F, the offshore area at HPS. This report briefly summarizes studies conducted in the Shoreline Area and discusses the tidal wetlands located in the Shoreline Area. The intertidal sediments were evaluated in the Shoreline Characterization Technical Memorandum that included a screening-level ecological risk assessment (SLERA) for the Parcels E and E-2 shoreline (SulTech, 2007; Appendix G to this report). The results of the shoreline SLERA were incorporated into the FS portion of this report. The remedial alternatives evaluated in this report are intended to control unacceptable exposures to humans and wildlife from contaminated soil, sediment, and groundwater, throughout Parcel E-2, including the Shoreline Area.

1.3. REPORT FRAMEWORK

In 2004, the Navy decided to conduct the RI/FS for Parcel E-2 separately from the other Parcel E sites to increase efficiency of the CERCLA process. Creation of Parcel E-2 to separate the Landfill, Panhandle, East Adjacent, and Shoreline Areas from the rest of Parcel E allows for a more streamlined remedy evaluation process that will help accelerate the final remedy for Parcel E-2. This report was prepared in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (Title 40 of the *Code of Federal Regulations* [40 CFR], Part 300) and used the following guidance documents:

- "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA, 1988a)
- "Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites" (EPA, 1991a)
- "A Guide to Principal Threat and Low Level Threat Wastes" (EPA, 1991b)

- "Presumptive Remedy for CERCLA Municipal Landfill Sites" (EPA, 1993a; Appendix H to this report)
- "Presumptive Remedy: Policy and Procedures" (EPA, 1993b; Appendix H to this report)
- "Feasibility Study Analysis for CERCLA Municipal Landfill Sites" (EPA, 1994; Appendix H to this report)
- "Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills" (EPA, 1996; Appendix H to this report)
- "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (EPA, 2000b)

1.4. REPORT PURPOSE AND GOALS

As discussed in the NCP, the purpose of the RI/FS process is to assess site conditions and evaluate alternatives to the extent necessary to select a remedy, and the goal of the remedy selection process is to select remedies that (1) are protective of human health and the environment; (2) maintain this protection over time; and (3) minimize untreated waste (55 Federal Register 8846, March 8, 1990). For this report, the Navy followed separate remedy evaluation processes for the Landfill Area and the adjacent areas (Panhandle Area, East Adjacent Area, and Shoreline Area). Each evaluation process is discussed below.

1.4.1. Evaluation Process for Landfill Area

The EPA has developed a specialized RI/FS process for landfill sites (EPA, 1991a, 1993a, 1993b, 1994, and 1996) that, provided certain conditions are met, supports selection of a containment presumptive remedy. Use of the specialized process is intended to improve and accelerate the site characterization and remedy evaluation process and to ensure consistent evaluation of remedial alternatives at similar sites. This process is based on the rationale that the unique characteristics of landfills (such as the presence of extensive heterogeneous waste intervals) limit the selection of practicable remedial alternatives.

EPA's specialized RI/FS process includes an evaluation methodology specific to military landfills (EPA, 1996) that is applicable to the Landfill Area. The approach allows the process to focus on containment technologies for use in remedial alternative evaluations and allows for qualitative risk evaluations instead of more detailed quantitative evaluations, provided there is a clear need for remedial action based on exceedance of risk-based criterion established to protect human health and the environment or applicable or relevant and appropriate requirement (ARAR) criterion.

The containment presumptive remedy typically involves:

- A landfill cap
- Source area groundwater control and leachate control, if groundwater contamination is an issue

- Landfill gas control, if landfill gas is migrating beyond the site boundary above action levels
- Institutional controls to prevent any direct contact with contamination in waste material, groundwater, and landfill gas, if any of these are present

The containment presumptive remedy has typically been used for wastes that pose a relatively low long-term threat and where treatment is impracticable. An example is a large landfill (approximately 100,000 cubic yards or larger) with heterogeneous wastes impracticable for treatment (EPA, 1996).

The Parcel E-2 Landfill can be considered for application of the presumptive remedy because it is large (estimated volume of 473,000 cubic yards) and its contents are more similar to municipal landfills than to hazardous waste landfills. However, some members of the local community have expressed a strong desire for the Navy to thoroughly evaluate excavation of the landfill. The Navy has agreed to evaluate excavation of the landfill as part of this report to provide information to support the community's review of potential remedial alternatives for Parcel E-2.

EPA guidance for military landfills (EPA, 1996) advises that the presumptive remedy should not be used where excavation is considered; however, the Navy believes that, based on site-specific considerations, excavation should also be evaluated to address community concerns although this goes beyond the requirements of the presumptive remedy policy. This approach is consistent with EPA's directive titled "Presumptive Remedies: Policy and Procedures" (pp. 1-2, EPA 1993b), which states that "there may be unusual circumstances (such as, complex contaminant mixtures, soil conditions, or extraordinary State and community concerns) that may require the site manager to look beyond the presumptive remedies for additional (perhaps more innovative) technologies or remedial approaches." In addition, this approach was applied in the Remedial Action Plan and ROD prepared for the landfill within Investigation Area H1 at the former Mare Island Naval Shipyard (Weston Solutions, Inc, 2006).

1.4.2. Evaluation Process for Panhandle, East Adjacent, and Shoreline Areas

The areas adjacent to the Parcel E-2 Landfill (the Panhandle Area, East Adjacent Area, and Shoreline Area) contain waste deposits that, while similar in content to the Landfill Area, are intermittent and separated by other fill soil. This intermittence is largely because the areas adjacent to the Parcel E-2 Landfill were reclaimed from San Francisco Bay using a combination of fill soil and waste materials. The intermittent waste distribution in the Panhandle Area, East Adjacent Area, and Shoreline Area makes evaluation of these areas under the presumptive remedy guidance inappropriate. As a result, these areas require consideration more typical of a standard RI/FS (i.e., quantitative risk assessments and evaluation of remedial alternatives other than containment).

Although the containment presumptive remedy does not apply to the Panhandle Area, East Adjacent Area, and Shoreline Area, the Navy recognizes that site conditions at these areas and their proximity to the Landfill Area present opportunities to streamline the remedy evaluation process by focusing on remediation technologies that can be closely aligned with actions at the Landfill Area. For example, sediment within the Shoreline Area will require removal during implementation of a containment remedy at the Landfill Area to provide a stable base for future shoreline protection features. Previous studies have determined that concentrations of copper and lead in Shoreline Area sediment are a potential source of contamination to San Francisco Bay. The contaminated sediment, once excavated from the Shoreline Area and screened to segregate any potential radiological materials, can be placed at an upland location in the Landfill Area prior to capping, thereby minimizing the risk to San Francisco Bay. This type of focused remedy evaluation process for the Panhandle Area, East Adjacent Area, and Shoreline Area is consistent with the streamlining approach outlined in pages 8704-8705 of the 1990 NCP Preamble (55 Federal Register 8704-8705, March 8, 1990) and in Section 4.1.3.1 of EPA's RI/FS guidance (EPA, 1988a).

1.4.3. Goal of Parcel E-2 RI/FS Report

The overall goal of this report is to integrate a presumptive remedy RI/FS for the Landfill Area with a standard RI/FS for the areas adjacent to the Landfill Area. To achieve this goal, the RI uses characterization data collected through March 2008, and presents quantitative risk assessments for soil and groundwater to (1) determine whether the containment presumption, as outlined in EPA guidance (EPA, 1993a, 1993b, and 1996) is appropriate for the Landfill Area; and (2) provide a strong basis for the RAOs established for contamination in the Panhandle Area, East Adjacent Area, and Shoreline Area. For the Landfill Area, the FS focuses on containment technologies (consistent with EPA RI/FS presumptive remedy guidance for landfills) and includes excavation and disposal technologies for comparison purposes. For the Panhandle Area, East Adjacent Area, and Shoreline Area, the FS focuses on (1) excavation and disposal technologies to address isolated areas that pose a significant risk to future site occupants and wildlife; and (2) containment technologies to address areas of more widespread but low-level contamination.

Based on this approach, the specific goals of the RI/FS are:

- Characterize the nature and extent of contamination in Parcel E-2 by compiling and evaluating data from previous investigations.
- Develop a conceptual site model that describes contaminant sources, transport routes, exposure pathways, and potential receptors.
- Conduct a quantitative risk assessment that uses the conceptual site model and data from previous investigations to identify areas that require remedial action to protect human health and the environment.
- Develop RAOs that specify the contaminants and media of interest, exposure pathways, and remediation goals.
- Develop general response actions (GRAs) for each medium that will satisfy the RAOs.

- Identify and screen remedial technologies and process options for each GRA to retain those that can be technically and cost-effectively implemented at Parcel E-2, with a focus on containment and excavation and disposal technologies.
- Develop focused remedial alternatives from the retained remedial technologies and process options, screen the alternatives against EPA criteria, and perform a comparative analysis of retained alternatives to identify those that most effectively meet the RAOs.

This RI/FS Report is meant to provide the necessary information to support an informed risk management decision on which remedy appears to be most appropriate for Parcel E-2. Following the RI/FS, a preferred alternative will be presented by the Navy in a proposed plan. Following public review and comment, a final remedy will be selected by the Navy and documented in a ROD.

1.5. REPORT ORGANIZATION

The primary report sections and appendices are summarized in Table 1-1. The RI sections of the report, which include an evaluation of the nature and extent of the contamination, development of a conceptual site model, and evaluations of human health and ecological risks, are provided in Sections 1 through 8. Sections 9 through 14 constitute the FS portion of the document and include development of RAOs, identification of ARARs, specification of GRAs, identification and screening of technologies and process options, and development and evaluation of remedial alternatives.

Appendices A through D include summary reports for previous phases of the NDGI. Appendices E and F present the closure reports for the interim landfill cap and the landfill gas control system, respectively. Appendix G presents the characterization information (including a SLERA) for the Shoreline Area. Appendix H includes EPA presumptive remedy guidance documents for incorporation into the CERCLA administrative record for Parcel E-2. Appendix I presents an evaluation of groundwater beneficial uses for the A- and B-aquifers at Parcel E-2. Appendix J summarizes analytical data and boring logs from previous Parcel E-2 investigations. Appendix K presents the HHRA. Appendix L presents the SLERA for the Landfill Area, Panhandle Area, and East Adjacent Area. Appendix M presents an evaluation of groundwater chemical migration to the aquatic environment offshore of Parcel E-2. Appendix N includes an ARARs analysis for the remedial alternatives. Appendix O provides a regulatory analysis of the Shoreline Area and the adjacent wetlands that may be affected by the proposed remedial alternatives. Appendix P includes three preliminary evaluations associated with the proposed containment alternatives (i.e., landfill cap infiltration, landfill gas generation, and groundwater modeling). Appendix Q evaluates slope stability for the proposed containment alternatives. Appendix R details the cost estimates for each remedial alternative. Appendix S presents the responses to regulatory agency comments on the Draft and Draft Final RI/FS Report for Parcel E-2.

1.6. SITE DESCRIPTION

This subsection presents a general description of the location, topography and site features, and climate of HPS. A brief description of Parcel E-2, including the Landfill Area and other adjacent areas (the Panhandle Area, East Adjacent Area, and Shoreline Area), is also provided. More specific descriptions of site features and physical characteristics (i.e., geology, hydrology, and ecology) of Parcel E-2 are provided in Section 2.

1.6.1. Location

HPS is located in southeast San Francisco on a peninsula that extends east into San Francisco Bay. Parcel E-2 consists of 47.4 acres of shoreline and lowland coast along the southwestern portion of HPS (Figure 1-1). Parcel E-2 is bounded by:

- Property owned by the University of California, San Francisco (UCSF) and a portion of Parcel E to the north
- The bay to the south
- Portions of Parcel E to the east
- Non-Navy off-base property to the west

The Landfill Area is located in Parcel E-2, with a small portion extending north onto the UCSF property, which is a formerly used defense site investigated during the Parcel E RI as IR Site 76 (TtEMI, LFR, and U&A, 1997). Although the Parcel E-2 Landfill extends slightly north beyond the property line, this small portion of land is not being used by UCSF. The Navy has negotiated an easement with UCSF to perform the necessary environmental restoration activities within this small portion of land. Figure 1-2 shows the small portion of the Landfill Area that extends onto UCSF property.

1.6.2. Topography and Site Features

The ground surface elevation at Parcel E-2 varies from approximately 30 feet above mean sea level (msl) in the northern portion of the parcel to a few feet above msl along the southwestern portion of the parcel. The Parcel E-2 Landfill is covered with either several feet of soil or a multilayer landfill cap composed of geosynthetic materials with a soil vegetative cover. Surface runoff from most of Parcel E-2 flows directly into the bay, but runoff in the northern portion of Parcel E-2 (including portions of the UCSF property) flows into catch basins, which discharge into the HPS storm sewer system and then the bay. Surface water runoff at point source discharge locations is monitored in accordance with the Stormwater Discharge Management Plan (SWDMP) (MARRS and MACTEC, 2009b).

Limited underground utilities are located in the northeastern portion of Parcel E-2 and include water and storm sewer lines. Historical records show that these utility lines may extend into the landfill waste; however, no subsurface utilities were encountered during construction of the gas control system, which extended through an area where a water line was shown to exist on historic records. Figure 1-4 shows the surface topography, surface water discharge locations (including an underdrain channel that bisects the landfill cap), and underground utility lines present at Parcel E-2.

Seasonal vegetation is present in the Panhandle Area and East Adjacent Area, and portions of the Shoreline Area are covered with concrete riprap (TtEMI, LFR, and U&A, 1997). Saline emergent wetlands (approximately 2.38 acres) are located along the Parcel E-2 shoreline and extend into the Panhandle Area, Landfill Area, and East Adjacent Area. In addition, a 1.3-acre seasonally ponded area is located in the Panhandle Area of Parcel E-2 (TtEMI, 2003d). Wetland areas in Parcel E-2 are shown on Figure 1-4 and are discussed in Section 2.4.2.

No buildings are present in Parcel E-2. Table 1-2 lists buildings located within 1,000 feet of the Parcel E-2 Landfill, which, in accordance with the requirements of 27 CCR, are not being threatened by landfill gas migration based on the results of previous and ongoing gas monitoring (TtEMI, 2003e and 2004a; ITSI, 2004a through 2004g, 2005a through 2005n, 2006a through 2006g, 2006i through 2006m, 2007a through 2007c, 2007e through 2007g, 2008a through 2008c, 2008e, 2009a through 2009d, and 2010a through 2010c).

1.6.3. Climate

The climate in the HPS area is characterized by partly cloudy, cool summers with little precipitation and mostly clear, mild winters with moderate precipitation. Average temperatures typically vary between 50 and 60 degrees Fahrenheit, with an average humidity range of 70 to 75 percent.

The prevailing winds at HPS are out of the west, west-northwest, and west-southwest. Figure 1-5 shows a wind rose plot generated from wind data collected at the meteorological station at HPS over a 6-year period. Seasonal variations occur in wind strength and direction. Generally, wind at HPS is strongest in the mid- to late afternoon hours, when higher velocity wind tends to blow in from the Pacific Ocean. The average wind speed is approximately 8 miles per hour, although gusts may exceed 25 miles per hour (TtEMI, LFR, and U&A, 1997).

1.6.4. Study Areas

For the purposes of this report, Parcel E-2 comprises four distinct but contiguous areas, as described in Section 1.2. These areas are shown on Figure 1-2 and are described in the following subsections.

Parcel E-2 was created by filling in the bay margin with various materials, including native soil, rock, and sediments, as well as construction and industrial debris. Figures 1-6 through 1-11 are aerial photographs of Parcel E-2 that document the expansion of Parcel E-2 into the bay at various stages of filling history.

Specific observations from these aerial photographs are discussed below; however, the overall filling history is discussed in Section 1.7.2.

1.6.4.1. The Landfill Area

Between 1958 and 1974, the Navy created the Parcel E-2 Landfill by placing various shipyard wastes, including construction debris, municipal-type solid waste, and industrial waste (including sandblast waste, paint sludge, solvents, and waste oils) (Naval Energy and Environmental Support Activity [NEESA], 1984). As a result, the landfill has a heterogeneous composition and includes solid waste intermixed with soil fill. Intervals containing the solid waste are usually brown to black. In some areas, the waste can be sludge-like with an oily sheen. Historic records indicate that an oily waste area was located along the western perimeter of the Landfill Area (Navy, 1974) (Figure 1-8). The physical extent of solid waste covers approximately 22 acres (TtEMI, 2004f). Figure 1-10 shows the approximate extent of solid waste within the Landfill Area superimposed over an aerial photograph from 1975.

1.6.4.2. The East Adjacent Area

The East Adjacent Area extends from the Landfill Area to the eastern Parcel E-2 boundary, which abuts portions of Parcel E (IR Sites 02, 04, 12, 56, and 72). During previous investigations, the Navy concluded the East Adjacent Area contained isolated solid waste locations and soil contamination. The East Adjacent Area includes an area with PCB contamination that was addressed under an interim removal action; however, portions of the PCB-contaminated soil remain unexcavated (TtECI, 2007a). Parcel E-2 encompasses a small portion of IR Site 02 (known as the "Bay Fill Area"); the Parcel E-2 boundary was created so the initial PCB Hot Spot Area would be contained entirely within the Parcel E-2.

Aerial photographs from 1946 through 1969 (Figures 1-6 through 1-9) show that the Navy historically used the East Adjacent Area for storage of equipment and material. During the RI, these uses were distinguished from the industrial uses of the adjacent Parcel E IR sites, which are shown on Figure 1-9. Navy operations at these sites included a former scrap yard (IR Site 04); a former salvage yard (IR Site 12); a railroad yard and former lumber storage yard (IR Site 56); and a former paint and oil store house (IR Site 72). From 1976 to 1986, the adjacent Parcel E IR sites were also used by a private ship repair company, Triple A Machine Shop, Inc. (Triple A), for operations that reportedly included the disposal of hazardous substances and wastes at various locations (California Department of Health Services [DHS], 1988). Triple A sites within Parcel E-2 and the adjoining Parcel E IR sites are identified on Figure 1-11. The adjacent Parcel E IR sites are being evaluated under a separate RI report.

1.6.4.3. The Panhandle Area

The Panhandle Area is located west and southwest of the Landfill Area and has a relatively flat topography. A drainage channel is located along the western perimeter of Parcel E-2, and runs south into the low-lying inland seasonal wetlands southwest of the Landfill Area. During previous investigations, the Navy concluded the Panhandle Area contains isolated solid waste locations and soil contamination. The Panhandle Area also contains areas of potential low-level radioactivity, including an experimental ship-shielding area (Figure 1-8) and a metal slag area (Figure 1-3). A removal action was conducted to remove the metal slag and prevent potential contaminant migration to San Francisco Bay (TtFW, 2005b). The radiological history at Parcel E-2 is discussed briefly in Section 1.7.3 and is presented in detail in Volume II of the Historical Radiological Assessment (HRA) (Naval Sea Systems Command [NAVSEA], 2004).

1.6.4.4. The Shoreline Area

The Shoreline Area is the intertidal zone that contains areas covered with concrete riprap and other exposed shoreline containing intertidal sediments and emergent saline wetlands. The inland boundary of the Shoreline Area is defined by the break in slope (in areas covered with concrete riprap) or presence of drift material (in beach and wetland areas). The outboard boundary of the Shoreline Area shown on Figure 1-3 was defined in the aerial photograph used to generate the HPS base map. The intertidal sediments present in the Shoreline Area were characterized during the RI and SDGI, and the results are summarized in a Shoreline Characterization Technical Memorandum (SulTech, 2007; see Appendix G). The metal slag area, discussed in the subsection above, also extends into the Shoreline Area.

1.7. SITE HISTORY

The site history described in this subsection is presented as a graphical timeline on Figure 1-12. The following subsections summarize the history of activities that led to contaminant releases at HPS and the subsequent cleanup efforts that have been conducted to reduce those releases.

1.7.1. General Site History

HPS was owned and operated as a commercial dry dock facility until 1939, when the Navy purchased the property from Bethlehem Steel. Upon entry of the U.S. into World War II in 1941, the Navy immediately began to expand HPS into a naval shipyard. The Navy began excavation of the hills surrounding the shipyard, using the resulting spoils to expand the shoreline into San Francisco Bay. Quays, docks, and support buildings were built on an expedited wartime schedule to support the shipyard's mission of fleet repair and maintenance (NAVSEA, 2004).

As shipyard operations expanded, the need for skilled workers grew. HPS, known then as San Francisco Naval Shipyard, established apprenticeship programs for most of the shipyard trades and recruited personnel from all over the U.S. to fill jobs created by the shipyard expansion. This influx of personnel greatly affected growth of the surrounding area (NAVSEA, 2004).

Immediately after the end of World War II, the Navy used the expansive berthing facilities at HPS for reserve fleet ships returning from the Pacific. By 1951, HPS shifted from operating as a general repair facility to specializing in submarine maintenance and repair. However, the Navy continued to operate Pacific Fleet carrier overhaul and ship maintenance repair facilities at HPS through the 1960s. Use of the shipyard began to decline steadily in the late 1960s and early 1970s, and the shipyard was disestablished as an active Naval facility in 1974 (NAVSEA, 2004).

From 1976 to 1986, the Navy leased 98 percent of HPS to Triple A. During this period, Triple A used dry docks, berths, machine shops, power plants, offices, and warehouses to repair commercial and naval vessels. During its occupancy, Triple A allegedly generated and disposed of hazardous substances and wastes at various locations throughout HPS, including Parcel E-2 (DHS, 1988).

The Navy resumed operation of the shipyard in 1986, when HPS was assigned as an annex to Naval Station Treasure Island. Shipyard operations were permanently terminated in 1989 (NAVSEA, 2004). In 1991, HPS was slated for closure under the Defense Base Closure and Realignment Act of 1990. Oversight of the base closure activities was performed by the Navy's Naval Facility Engineering Command (NAVFAC), Engineering Field Activity West, in San Bruno, California, until 2000, when oversight of HPS was transferred to NAVFAC Southwest, in San Diego, California. Ongoing base closure work at HPS is overseen by the Navy's BRAC Program Management Office (PMO) West, in San Diego, California.

The first environmental investigation at HPS was the 1984 Initial Assessment Study (IAS), conducted under the Navy Assessment and Control of Installation Pollutants (NACIP) program. The IAS consisted primarily of a records review and visual inspection of the site. The IAS recommended confirmation studies at numerous HPS sites, including the Parcel E-2 Landfill (NEESA, 1984). Following completion of the confirmation studies, a RI/FS process was developed for a number of HPS sites (including the Parcel E-2 Landfill) and RI field activities were initiated in 1988 (TtEMI, LFR, and U&A, 1997).

In 1989, HPS was placed on the NPL as a Superfund site pursuant to CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. HPS was designated as a "B" site by the Agency for Toxic Substances and Disease Registry (ATSDR) in 1991; this designation is for sites that pose no imminent threats to human health but have the potential to pose long-term threats to human health (ATSDR, 1991). In 1992, HPS was divided into five parcels (Parcels A through E) to aid in environmental investigation and cleanup activities. In 2004, Parcel E was divided into two parcels (Parcels E and E-2) to facilitate the closure of the Parcel E-2 Landfill and its adjacent areas.

1.7.2. Parcel E-2 History

Parcel E-2 is part of an area created in the 1940s, 1950s, and 1960s by filling in the bay margin with various materials, including soil, crushed bedrock, dredged sediments, and debris. The overall composition of the fill material, on which the Parcel E-2 Landfill was created, is primarily sand and clay with intermixed construction debris (TtEMI, 2004f). Most land at HPS was created in the early 1940s; however, these filling activities only extended into the eastern edge of Parcel E-2, as evidenced in the 1946 aerial photograph (Figure 1-6). In 1955 (Figure 1-7), additional filling had occurred at the western boundary of Parcel E-2. By 1965 (Figure 1-8), most of Parcel E-2 had been filled and industrial activities throughout the parcel were evident. By 1969 (Figure 1-9), filling activities at Parcel E-2 were largely complete except for a channel that extended from near the bay to the northwestern corner of Parcel E-2. This channel was filled in by 1975, at which time the landfill was closed by placing and compacting a soil cover (Figure 1-10). Triple A's industrial operations at Parcel E-2 are evidenced in the 1985 aerial photograph (Figure 1-11).

During Triple A's occupancy of the site from 1976 to 1986, the company allegedly disposed of industrial debris, sandblast waste, oily industrial sand, and asphalt over an area of approximately 5 acres along the shoreline in Parcel E-2, Triple A Site 16 (Figure 1-11) (San Francisco District Attorney [SFDA], 1986). A portion of the Landfill Area was also included as part of Triple A Site 16 (TtEMI, LFR, and U&A, 1997). In addition, Triple A allegedly stored unlabeled, deteriorating, uncovered drums with their contents exposed to the elements in the southeast portion of Parcel E-2 known as Triple A Site 1 (Figure 1-11; SFDA, 1986).

Since landfill operations ceased, the Navy implemented several preliminary landfill closure measures (Navy, 1974), including:

- Installing a stormwater interceptor line to divert runoff from the hill area north of the Parcel E-2 Landfill to an outfall
- Attempting to construct a clay dike to minimize groundwater flow into the bay; the construction was terminated due to extensive large debris present within the landfill
- Placing a minimum of 2 feet of compacted, imported fill on top of the landfill
- Grading the entire site to facilitate stormwater drainage

The Parcel E-2 Landfill was initially identified as an area of potential concern during the IAS, which concluded that it was highly probable that chemicals from waste disposed of in the landfill had reached the groundwater and were migrating toward San Francisco Bay. This conclusion revealed a potential threat to the bay environment, and a confirmation study was recommended for the site (NEESA, 1984). As a result, the landfill was included in several subsequent investigations, eventually progressing to the RI stage as IR Site 01/21. The IR Site 01/21 boundary encompasses most of Parcel E-2; however, a small portion of IR Site 2 (Bay Fill Area) is included within Parcel E-2. Figure 1-13 shows the air, soil, soil gas, and groundwater locations where samples were collected during previous investigations at Parcel E-2. Figure 1-13 also shows the boundaries of IR Site 01/21 and various Triple A sites identified in Parcel E-2.

As discussed in Section 1.1.3, the Navy has performed several removal actions at Parcel E-2 to control potential releases of hazardous substances. These actions included construction of an interim landfill cap in response to an August 2000 brush fire at the Parcel E-2 Landfill. The landfill cap was constructed to inhibit oxygen migration into the waste to prevent more fires from occurring under the capped area (TtEMI, 2005b; provided as Appendix E to this report). The cap consists of a multilayer system of sub-base soil, high-density polyethylene (HDPE) membrane, synthetic drainage layer, and topsoil. The cap encompasses approximately 14.5 acres (Figure 1-10).

Table 1-3 summarizes environmental investigations and interim actions conducted at Parcel E-2 from 1984 to March 2008. These activities are discussed in more detail in Section 3.

1.7.3. Parcel E-2 Radiological History

A history of Navy radiological operations at HPS is provided in Volume II of the HRA (NAVSEA, 2004). The HRA concluded that low levels of radiological contamination exist within the confines of HPS. The review of previous radiological activities, cleanup actions, and release surveys identified no imminent threat or substantial risk to tenants or the environment of HPS or the local community (NAVSEA, 2004).

Historical radiological operations at Parcel E-2 included:

- Disposal of radioluminescent commodity items (such as dials, gauges, and deck markers)
- Potential disposal of wastes from decontamination of ships used in atomic weapons testing (i.e., sandblast waste)
- Potential disposal of building debris from demolition of radiologically impacted buildings used by the Naval Radiological Defense Laboratory (NRDL)
- Potential disposal of materials used in radiological experiments by NRDL
- Use of an Experimental Shielding Range – located in the Panhandle Area; the range was used for ship shielding experiments and included a fan-shaped, post-exposure reflection and refraction field, and two other support areas bordered on the west side by a soil berm (Figure 1-8)

Numerous investigations of potential radiological contamination have been performed throughout HPS, including Parcel E-2. The results of the radiological investigations at Parcel E-2 are discussed briefly in Section 3.6, and are presented in more detail in Volume II of the HRA. The HRA identified most of the land area within Parcel E-2 as radiologically impacted. These radiologically impacted sites are shown on Figure 1-14.

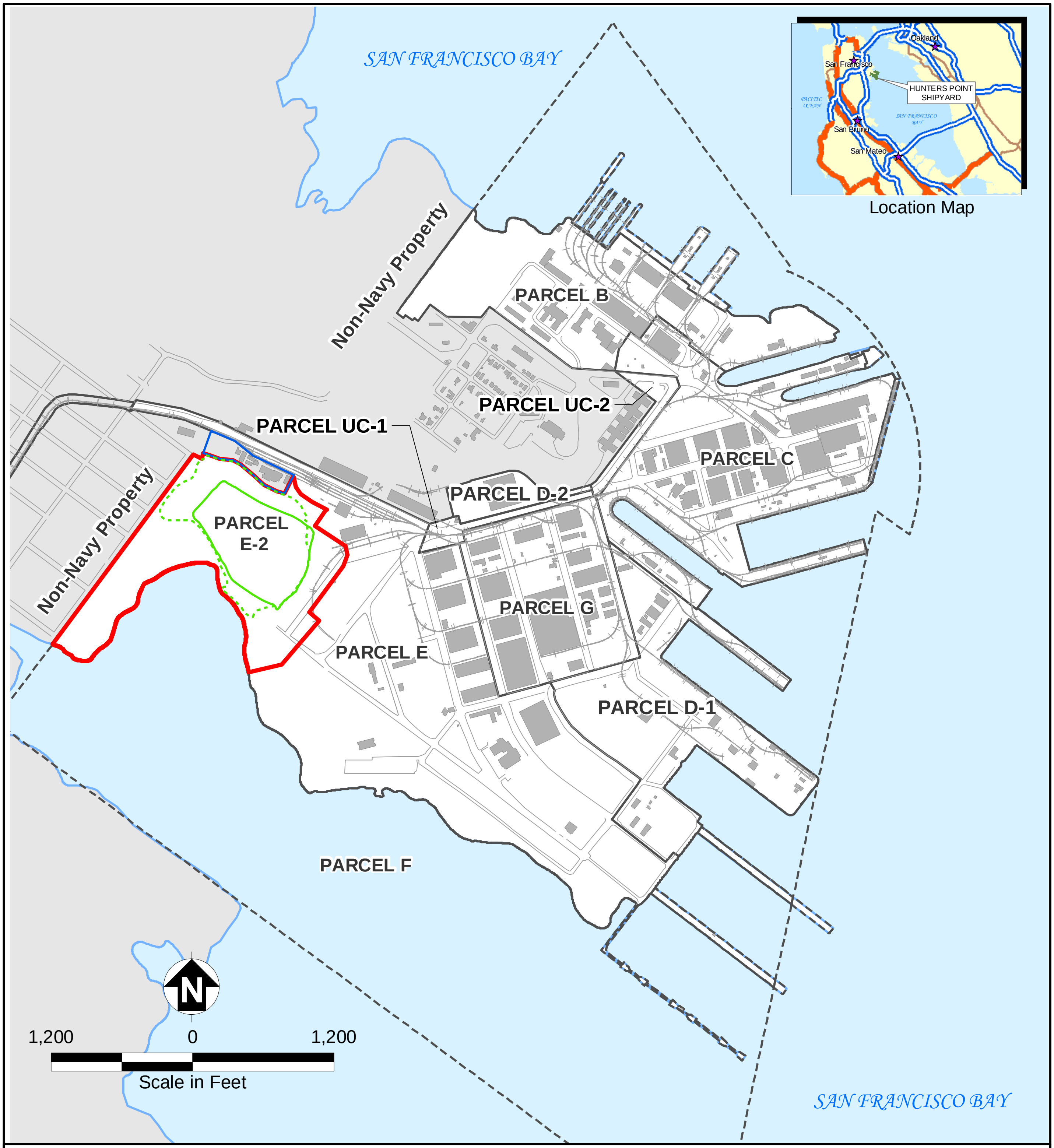
The results of radiological characterization performed to date are summarized in the radiological addendum to this RI/FS Report. Based on the potential radiological impacts at Parcel E-2, the remedial alternatives evaluated in this report include provisions for the proper screening, handling, and disposal of radiological materials.

1.8. FUTURE SITE REUSE

The data analysis, risk evaluations, and remedial alternatives presented in this RI/FS Report assume that the future reuse of Parcel E-2 will be open space. This assumption was developed in consultation with the City and County of San Francisco (CCSF) based on the 1997 “Hunters Point Shipyard Redevelopment Plan,” and was documented in the previous versions of the RI/FS Report published in 2007 and 2009. Pursuant to the CCSF’s 2010 amended “Hunters Point Shipyard Redevelopment Plan,” a small area (about 0.42 acres) in the East Adjacent Area is part of the “Shipyard South Multi-Use District,” and may be used for recreational, industrial, and residential purposes (SFRA, 2010). The proposed remedial alternatives will allow for potential residential use in this 0.42-acre area if it is demonstrated that soil contaminants do not exceed levels established elsewhere at HPS for residential reuse, or if any contaminants that exceed those established levels are addressed by the remedial alternatives.

Figure 1-15 shows the designated reuse of Parcel E-2 according to the SFRA Redevelopment Plan (SFRA, 2010).

Figures



- Parcel Boundary
- University of California, San Francisco Compound
- Non-Navy Property
- Parcel E-2 Boundary
- Parcel F Boundary
- Road
- Rail Line
- Building
- Estimate of Solid Waste Extent
- Interim Landfill Cap Extent

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

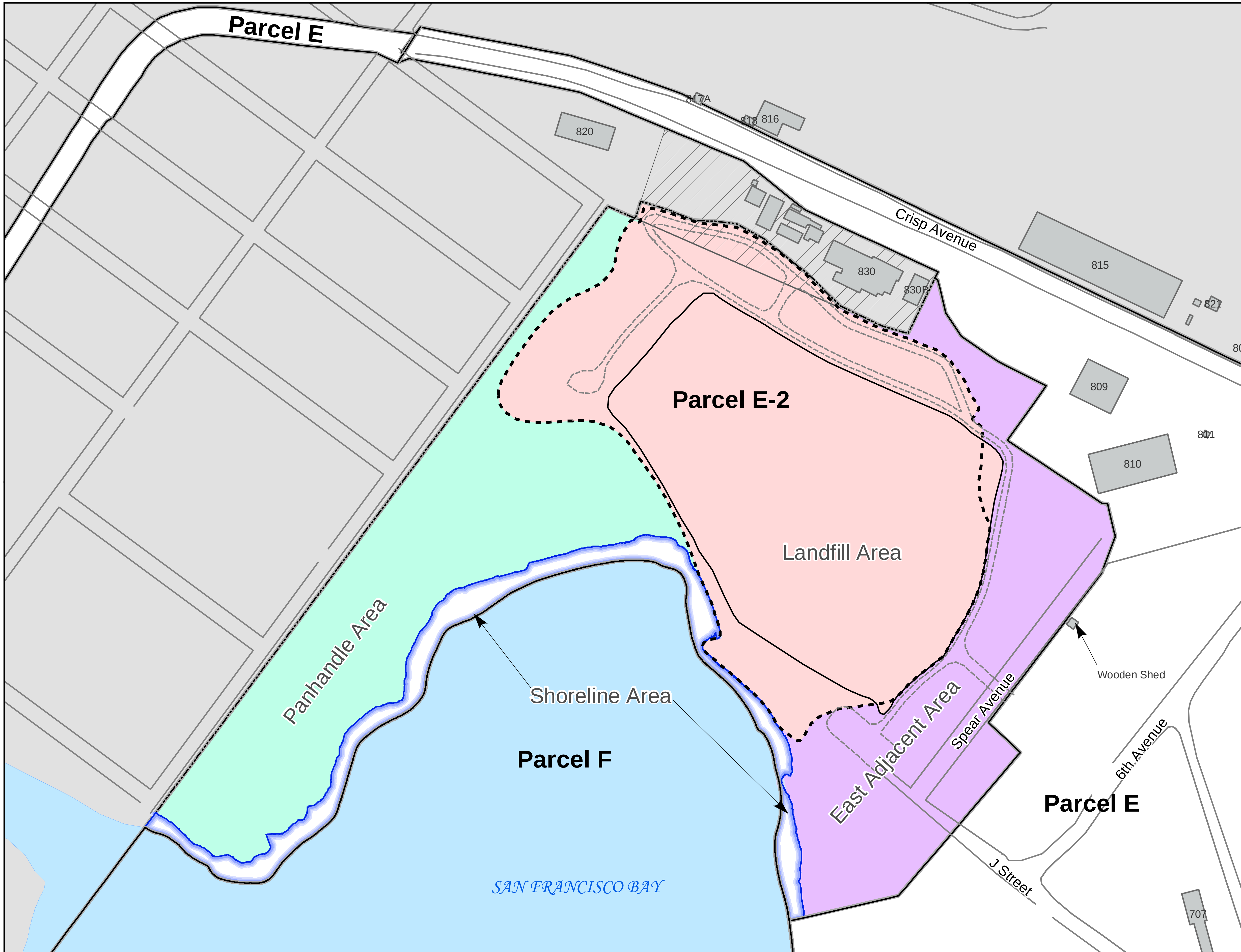
Department of the Navy, BRAC PMO West, San Diego, California

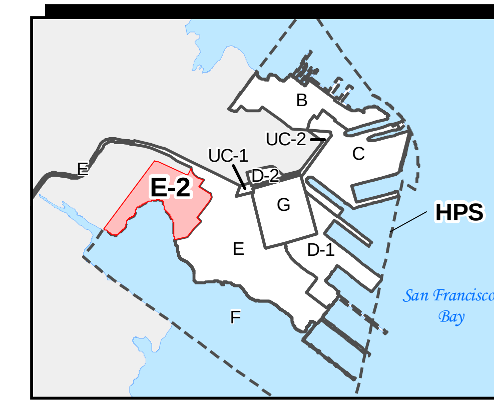
FIGURE 1-1

SITE VICINITY MAP

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\B_originals\GIS\Projects\Landfill\Landfill_RI\Facility Location Map.mxd





Location Map

Legend

- Parcel Boundary
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Shoreline Area
- Estimate of Solid Waste Extent
- Interim Landfill Cap Extent
- Non-Navy Property
- UCSF Compound
- UCSF Property within Landfill Area*
- Building (with building number)
- Road
- Gravel Road

Notes:

*Remediation work in area to be performed under easement (granted by UCSF.)

UCSF = University of California, San Francisco

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

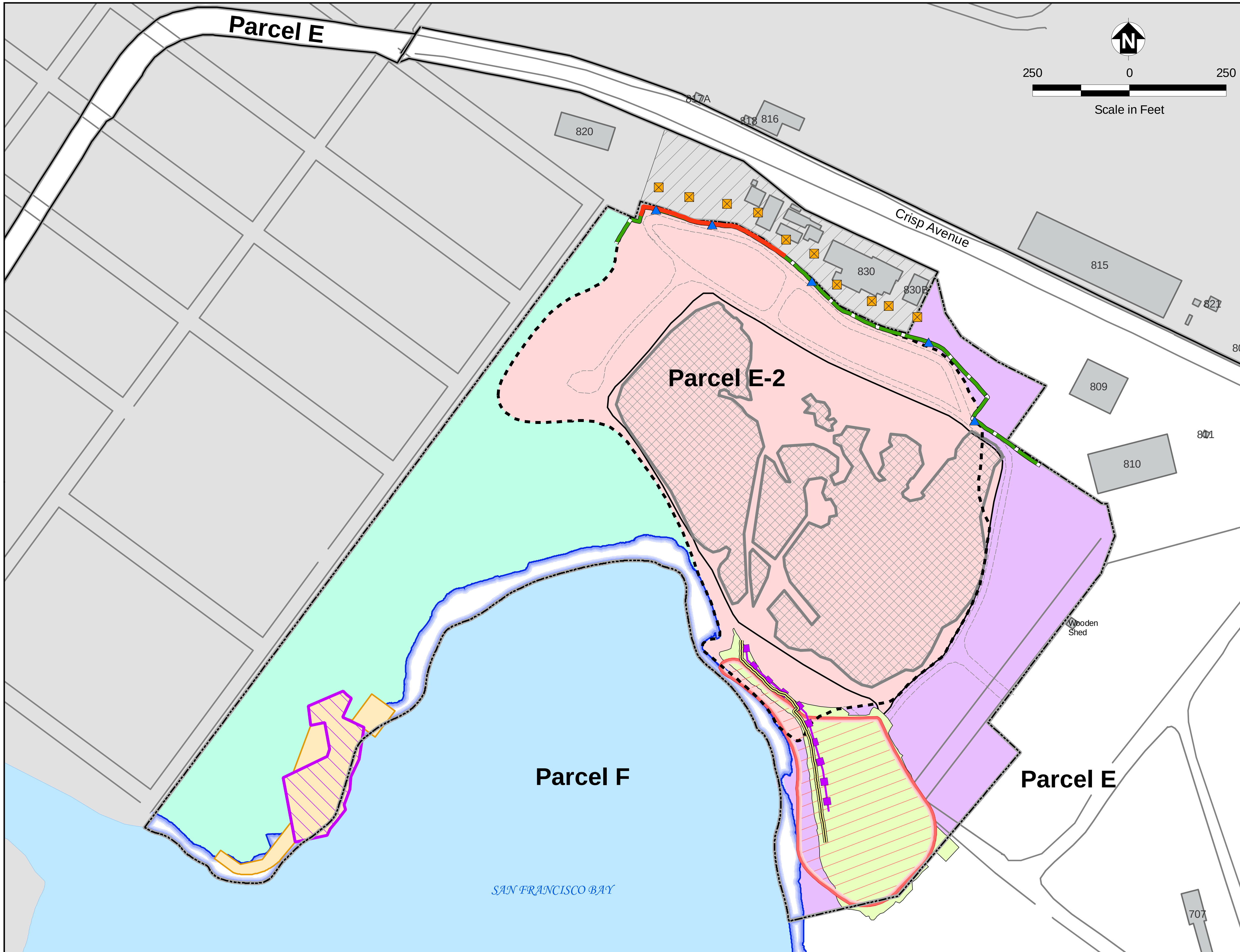
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-2

LANDFILL/PARCEL E-2 LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\B_originals\GIS\Projects\Landfill\Landfill_RI\Landfill-Parcel_E-2_Location.mxd



LEGEND

- Burn Area
- Parcel E-2 Boundary
- Parcel Boundary
- Estimate of Soild Waste Extent
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Shoreline Area
- Non-Navy Property
- UCSF Compound
- Building
- Road
- Gravel Road

Removal Actions

- Interim Landfill Cap
- Metal Slag Area (proposed boundary)
- Metal Slag Area (2007 excavation limit)[a]
- PCB Hot Spot Area (proposed boundary)
- PCB Hot Spot Area (2007 excavation limit)[a]

Groundwater Extraction System

- Sheet-Pile Wall
- Extraction Trench

Interim Landfill Gas Control System

- Extraction Well
- Passive Vent
- HDPE Barrier Wall
- Grouted Section of HDPE Barrier Wall That Can Be Used For Extraction

Notes:

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

HDPE = high-density polyethylene
PCB = polychlorinated biphenyl
UCSF = University of California, San Francisco

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

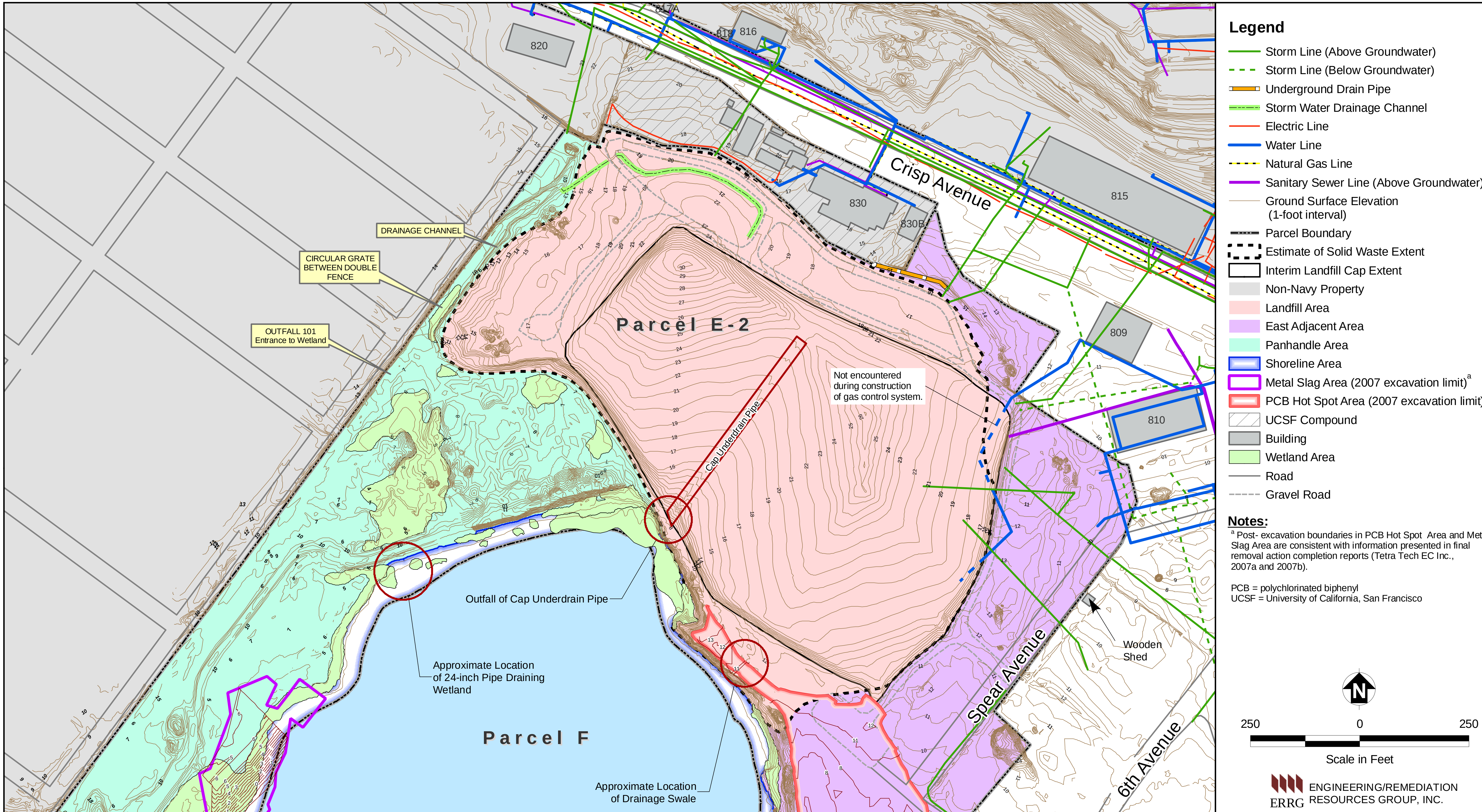
Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-3

REMOVAL ACTION AREAS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Site Features Map3.mxd



Hunters Point Shipyard, San Francisco, California

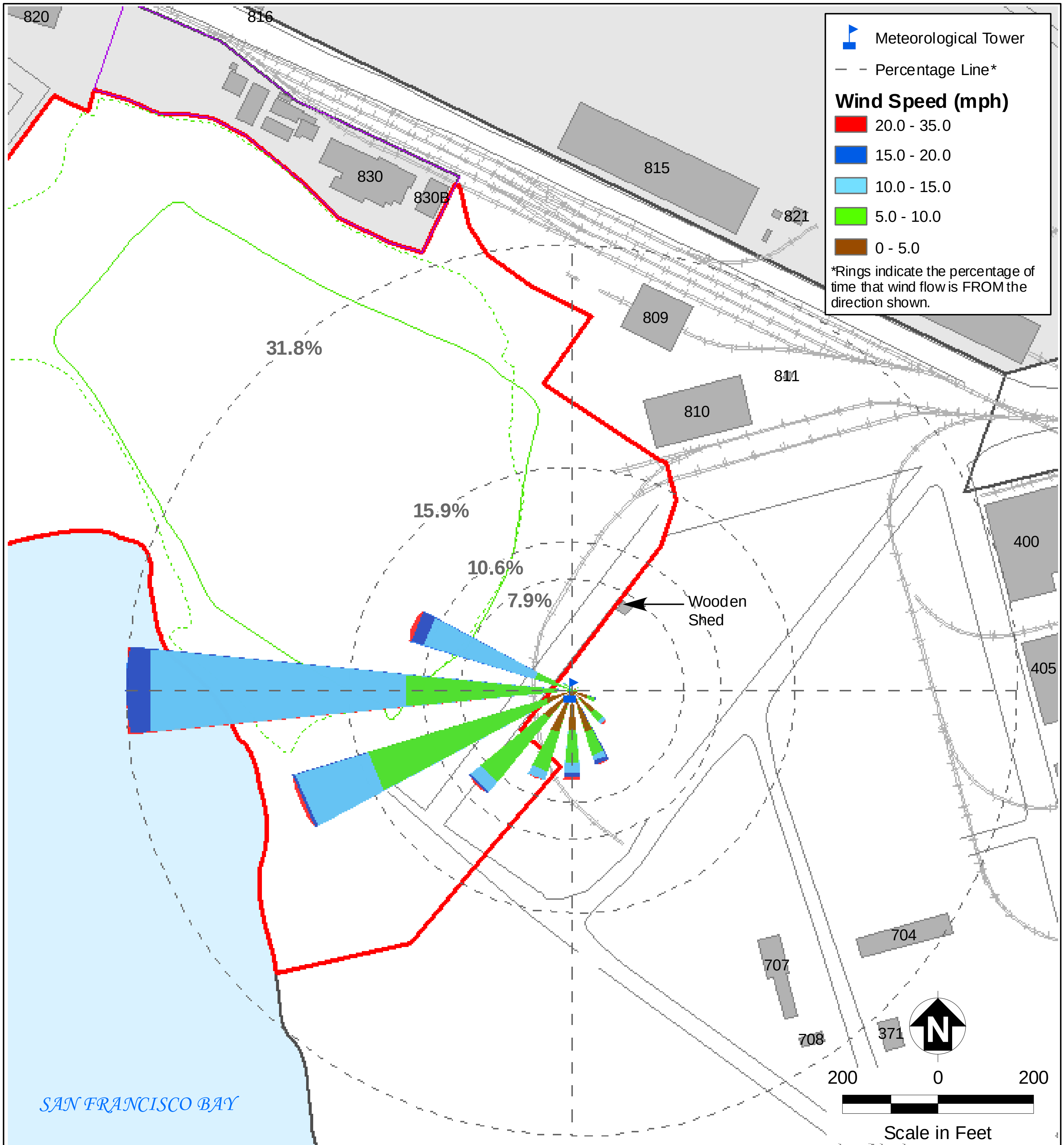
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-4

SURFACE TOPOGRAPHY AND SITE FEATURES

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\E-2_Utilities Map_rev.mxd



University of California, San Francisco Compound
Non-Navy Property
Parcel E-2 Boundary
Road
Rail Line
Building
Parcel F Boundary
Estimate of Solid Waste Extent
Interim Landfill Cap Extent

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

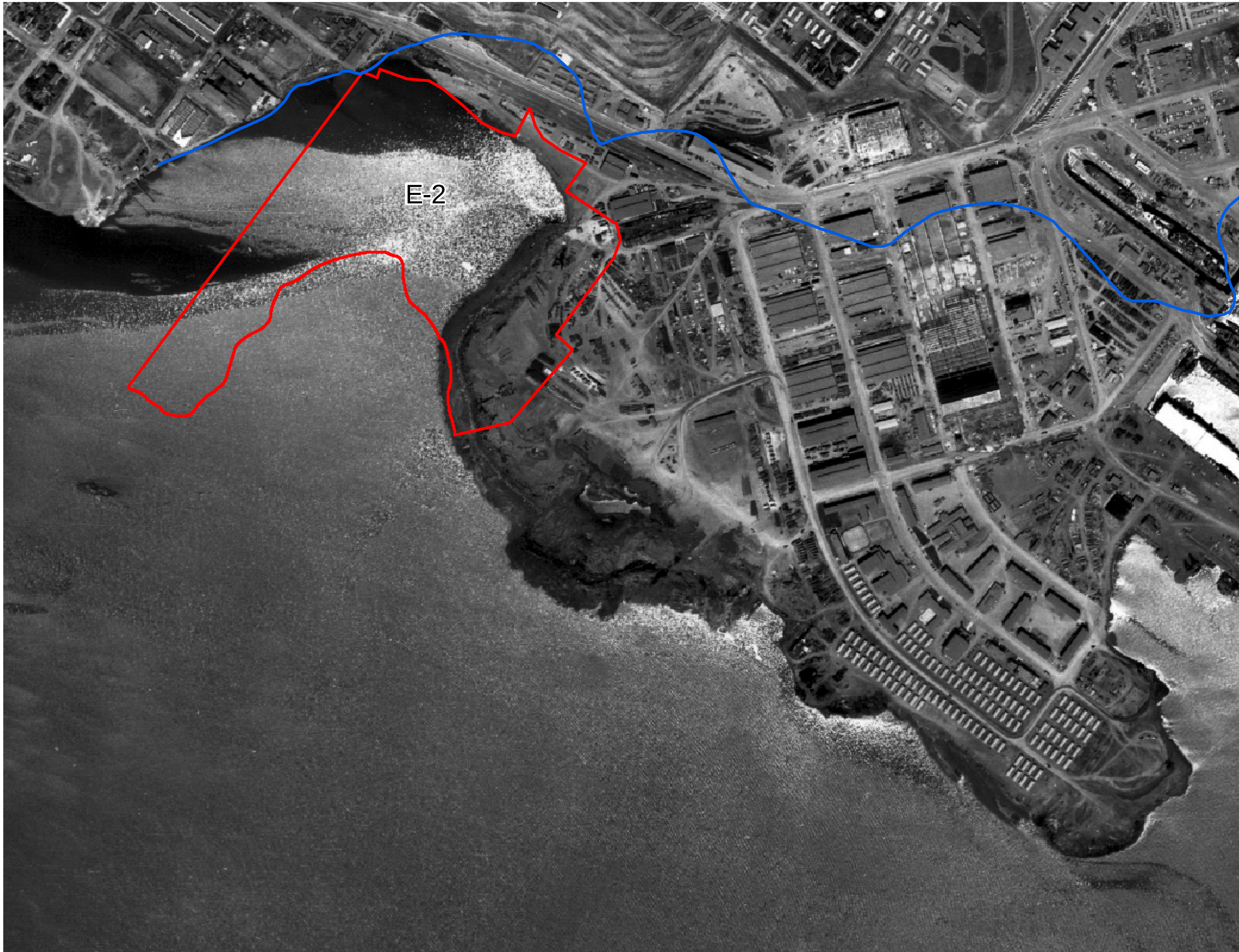
Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-5

WIND SPEED AND DIRECTION MAP

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\B_originals\GIS\Projects\Landfill\Landfill_RI\Windrose Map.mxd



Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-6
1946 AERIAL PHOTOGRAPH
Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Aerial_Photos\1946_new.mxd

Legend

- Parcel E-2 Boundary
- 1935 Shoreline

500 0 500
Scale in Feet

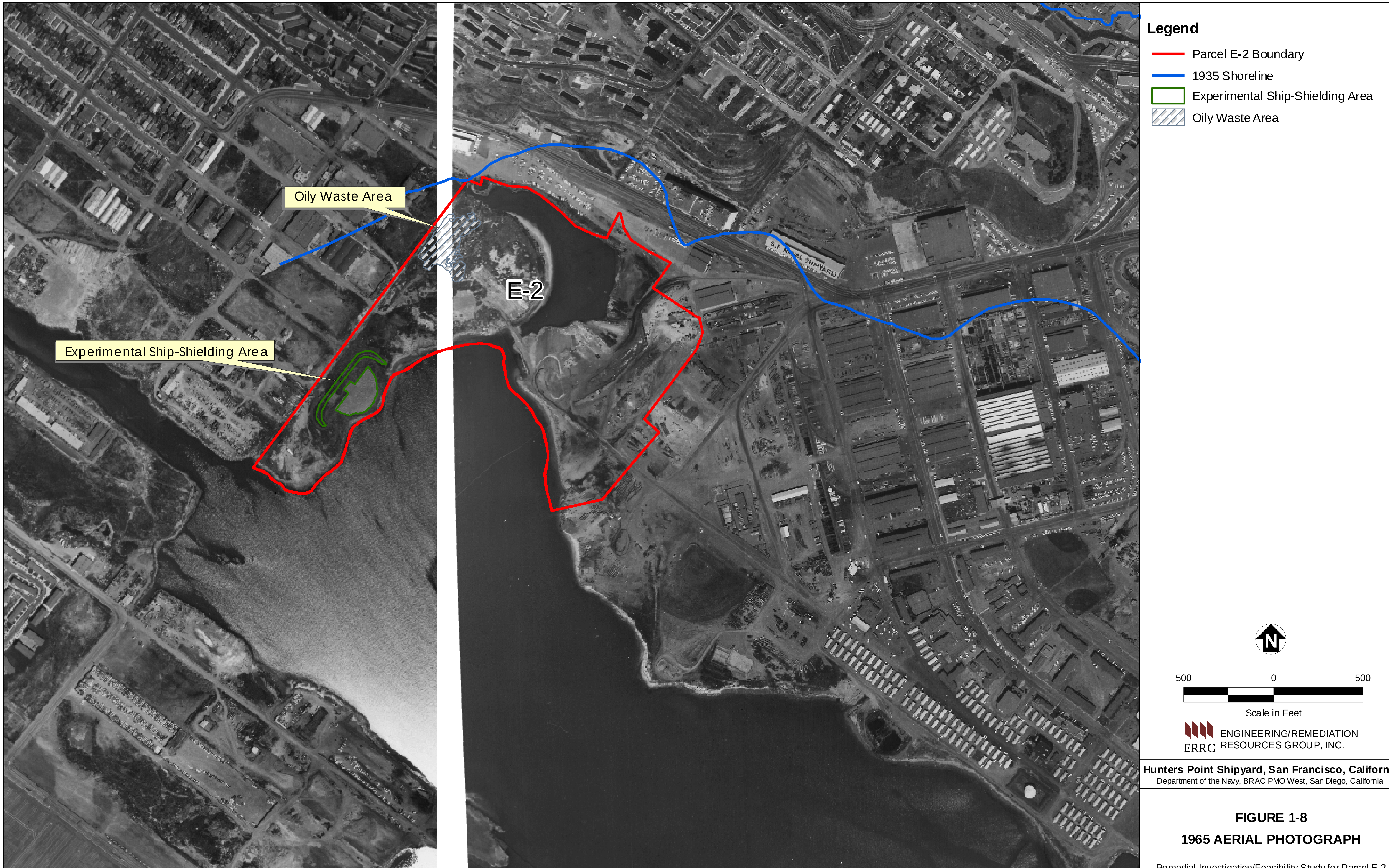
ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-7
1955 AERIAL PHOTOGRAPH

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Aerial_Photos\1955_new.mxd

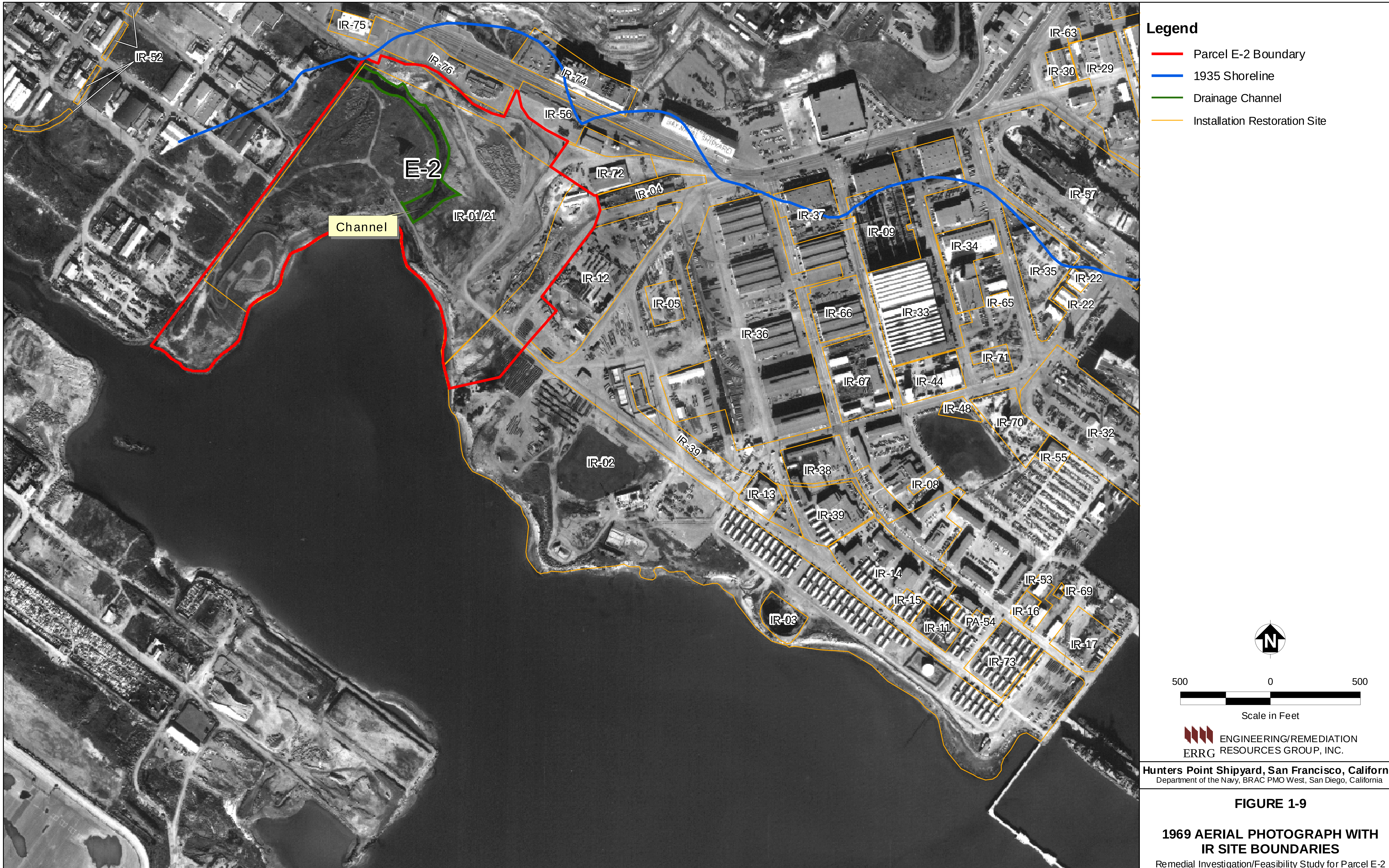


Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-8
1965 AERIAL PHOTOGRAPH

Remedial Investigation/Feasibility Study for Parcel E-2

\\con-fs01\projects\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Aerial_Photos\1965_new.mxd



Hunters Point Shipyard, San Francisco, California

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-9

1969 AERIAL PHOTOGRAPH WITH IR SITE BOUNDARIES

Remedial Investigation/Feasibility Study for Parcel E-2

\\con-fs01\projects\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Aerial_Photos\1969_newv_2.mxd

Legend

- Parcel E-2 Boundary
- 1935 Shoreline
- Estimated Extent of Waste

N

500 0 500

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

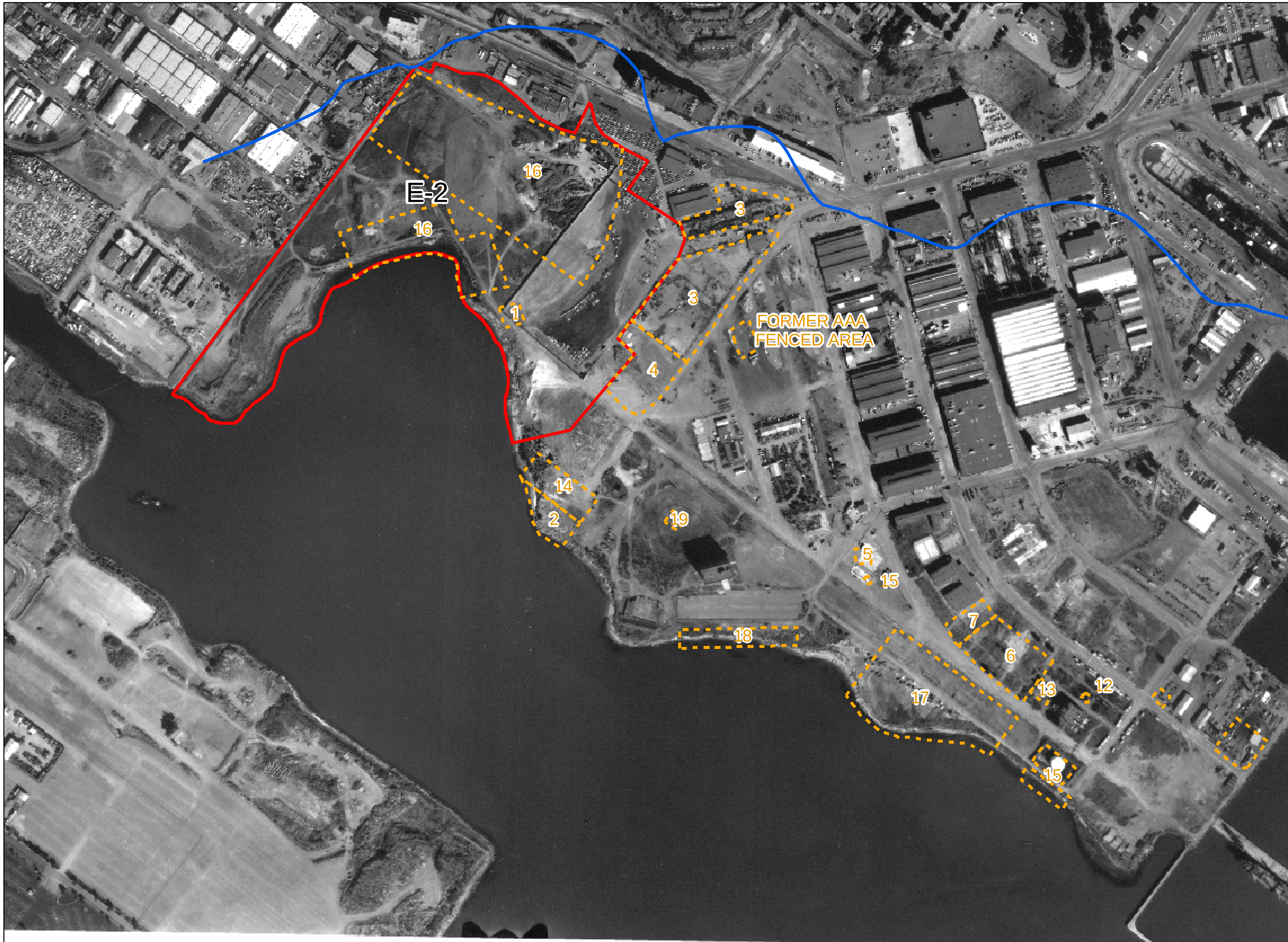
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-10

1975 AERIAL PHOTOGRAPH

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Aerial_Photos\1975_new.mxd



Legend

- Parcel E-2 Boundary
- 1935 Shoreline
- Triple A Sites

500 0 500

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

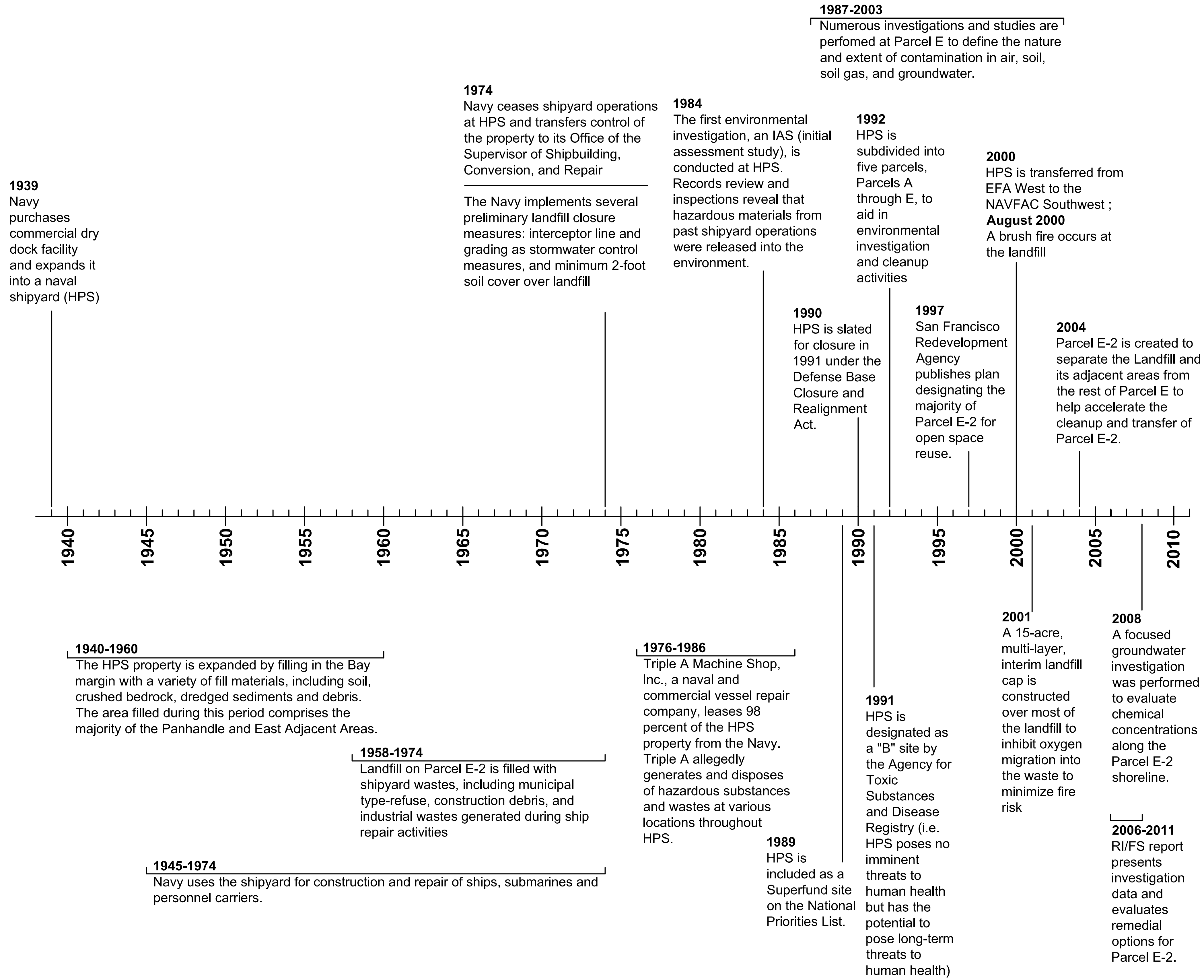
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-11

1985 AERIAL PHOTOGRAPH WITH TRIPLE A SITE BOUNDARIES

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Aerial_Photos\1985_new.mxd



Navy = U.S. Department of the Navy

BRAC = Base Realignment and Closure

HPS = Hunters Point Shipyard

IAS = Initial Assesment Study

NAVFAC = Naval Facilities Engineering Command

EFA = Engineering Field Activity

PMO = Project Management Office

RI/FS = Remedial Investigation/Feasibility Study

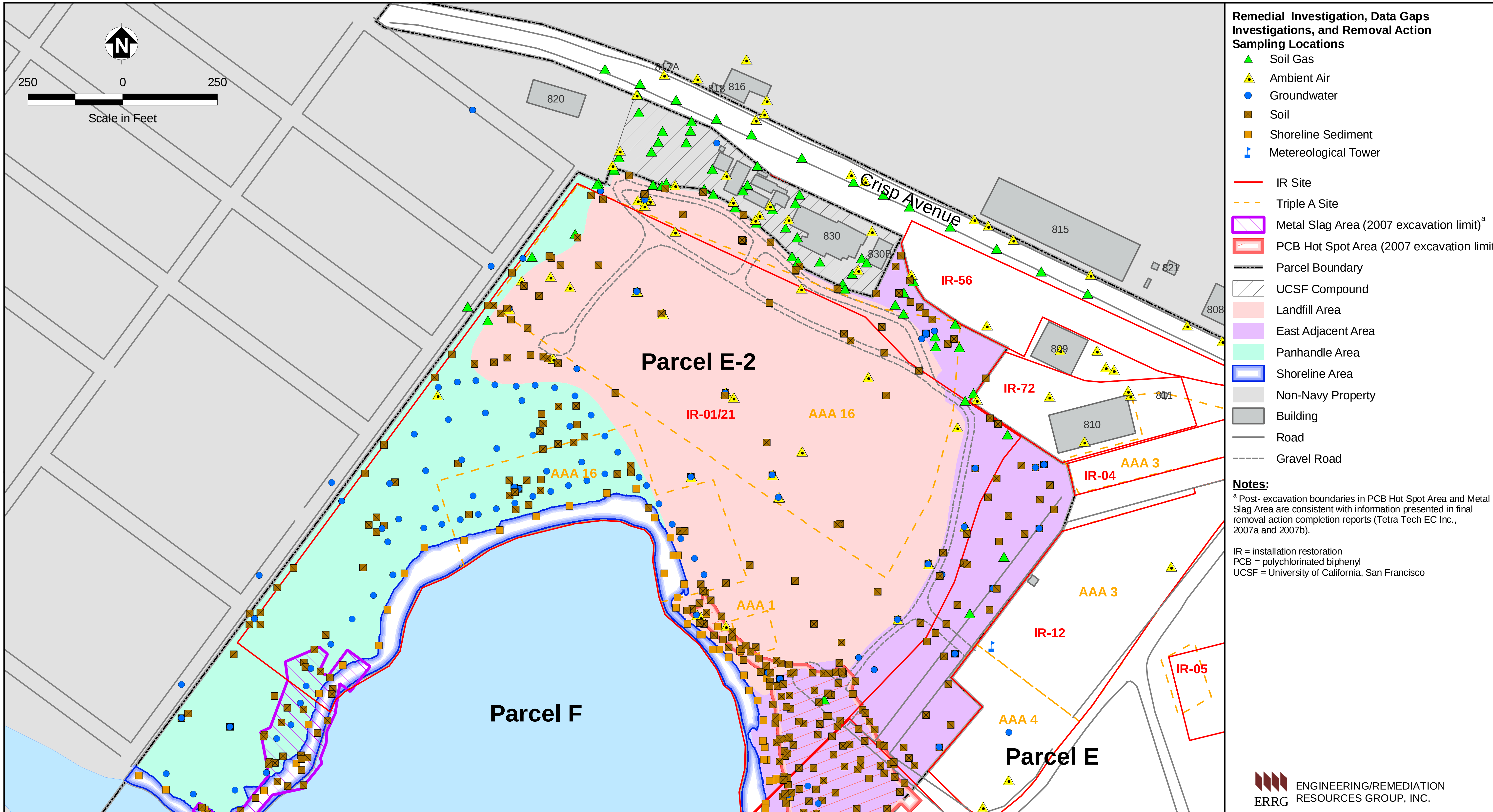
ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-12
SITE HISTORY TIMELINE

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Section 3\1_1-HPS-timeline.dwg



Hunters Point Shipyard, San Francisco, California

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-13

SAMPLING LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Sample Locations.mxd

Area Radiological Status

- Radiologically Impacted Site
- Impacted Storm Drain System (Above Groundwater)
- Impacted Storm Drain System (Below Groundwater)
- Impacted Sanitary Sewer System
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Shoreline Area
- Interim Landfill Cap Extent
- Experimental Ship-Shielding Area
- IR Site Boundary
- Parcel Boundary
- Non-Navy Property
- Building
- Demolished Building
- Road
- Rail Line

Notes:

Impacted sites are sites that have known radiological contamination or where site history indicates that radiological contamination may be present.

Impacted sites based on Historical Radiological Assessment (Naval Sea Systems Command, 2004).

For planning purposes, all storm drains and sanitary sewers should be considered impacted.

Storm drain and sanitary sewer line locations are based on data from the Navy's Caretaker Site Office and the Historical Radiological Assessment; locations will be verified in the field. Construction documentation for septic sewer lines does not exist. Potential septic sewer lines, if found to originate from radiologically impacted buildings near Parcel E-2 (Building 810), would be considered impacted.

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

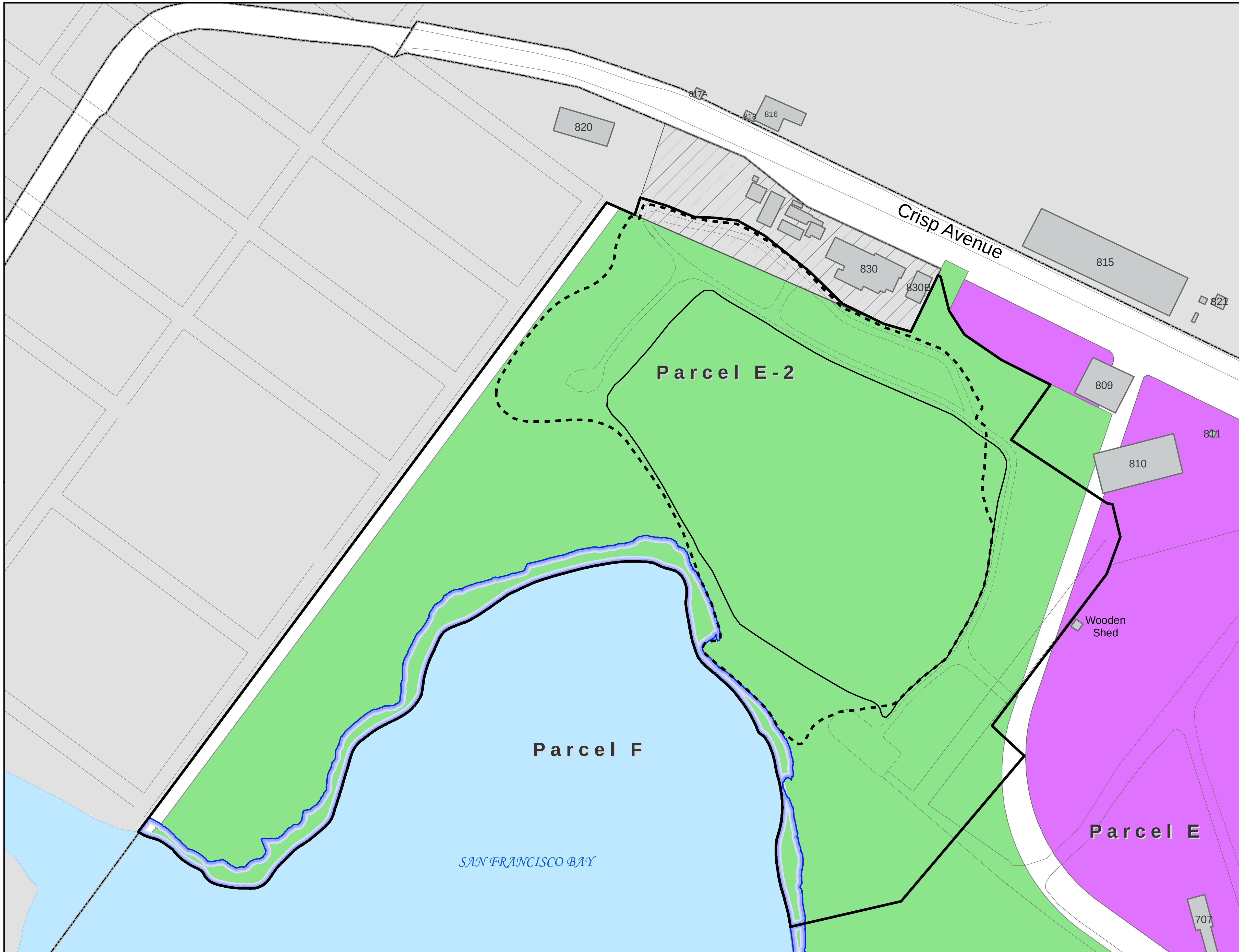
Hunters Point Shipyard, San Francisco, California
Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-14

PARCEL E-2 RADIOLOGICALLY IMPACTED SITES

Remedial Investigation/Feasibility Study for Parcel E-2

N:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Radiological Status_Parcel E.mxd



Legend

- Estimate of Solid Waste Extent
- Shoreline Area
- Road
- Gravel Road
- Interim Landfill Cap Extent
- Non-Navy Property within Landfill Area*
- Parcel E-2 Boundary
- Other Parcel Boundary
- Building
- UCSF Compound
- San Francisco Bay
- Non-Navy Property

Reuse Category

- Shipyard South Multi-Use District
- Shoreline Open Space

Notes:

*Remediation work in area to be performed under easement (granted by UCSF.)

UCSF = University of California, San Francisco

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-15

DESIGNATED REUSE ZONES AT PARCEL E-2

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Designated Reuse.mxd

Tables

Table 1-1. RI/FS Organization Summary
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Section	Description
1. Introduction	Presents the CERCLA Progress and study areas at Parcel E-2; report framework, purpose, and goals; report organization; site description; site history; and planned reuse.
2. Site Description and Physical Characteristics	Describes the site features and geology, hydrogeology, hydrology, and ecology of Parcel E-2. Characteristics of the four study areas at Parcel E-2 are also described.
3. Remedial Investigation Activities and Removal Actions	Summarizes investigations and evaluations conducted at Parcel E-2 (including removal actions and ongoing monitoring).
4. Nature and Extent of Solid Waste, Landfill Gas, and Chemicals in Soil	Evaluates data collected during previous investigations conducted at Parcel E-2 (as discussed in Section 3 and subsections) to define the nature and extent of solid waste, landfill gas, and chemicals in soil. Information presented in this section could affect the remedial alternatives evaluated in the FS portion of this report.
5. Nature and Extent of Chemicals in Groundwater	Evaluates data collected during previous investigations conducted at Parcel E-2 (as discussed in Section 3 and subsections) to define the nature and extent of chemicals in groundwater. Information presented in this section could affect the remedial alternatives evaluated in the FS portion of this report.
6. Conceptual Site Model	Describes the Parcel E-2 contaminant sources, potentially affected media and migration pathways, and potential receptors.
7. Risk Assessment	Describes the baseline HHRA and SLERA conducted to quantify the potential risks to human health and wildlife from the Landfill Area, East Adjacent Area, and Panhandle Area.
8. Remedial Investigation Summary and Conclusions	Summarizes the results of the RI and the conclusions based on the RI data.
9. Remedial Action Objectives	Describes media, exposure routes, and human and ecological receptors to be addressed in the remedial alternatives and defines contaminant concentrations that are protective of receptors in Parcel E-2.
10. Potential Applicable or Relevant and Appropriate Requirements	Identifies potential chemical-, location-, and action-specific ARARs as required by CERCLA.
11. Identification and Screening of Technologies and Process Options	Describes the GRAs appropriate for Parcel E-2 and evaluates remedial technologies and processes that are applicable to Parcel E-2.
12. Development of Remedial Alternatives	Describes each alternative developed from the remedial technologies and process options retained after the evaluation in Section 10.
13. Detailed Analysis of Remedial Alternatives	Evaluates each remedial alternative against the nine criteria defined in EPA guidance (EPA, 1988a).
14. Comparative Analysis of Remedial Alternatives	Compares retained remedial alternatives to evaluate which alternative most effectively meets the RAOs.
15. References	Presents the documents, publications, and reports used to prepare this RI/FS Report.

Table 1-1. RI/FS Organization Summary *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Appendices	
A	Final Parcel E Nonstandard Data Gaps Investigation Landfill Gas Characterization (provided on compact disc only)
B	Final Parcel E Nonstandard Data Gaps Investigation Landfill Lateral Extent Evaluation (provided on compact disc only)
C	Final Parcel E Nonstandard Data Gaps Investigation Landfill Liquefaction Potential (provided on compact disc only)
D	Final Parcel E Nonstandard Data Gaps Investigation Wetlands Delineation and Function and Values Assessment Parcel B and E (provided on compact disc only)
E	Final Removal Action Landfill Cap Closeout Report (provided on compact disc only)
F	Removal Action Closeout Report, Landfill Gas Removal Action (provided on compact disc only)
G	Parcels E and E-2 Shoreline Characterization Technical Memorandum (provided on compact disc only)
H	EPA Presumptive Remedy Guidance (provided on compact disc only)
I	Groundwater Beneficial Use Evaluation
J	Analytical Results, Boring Logs, and Well Construction/Water Level Data (provided on compact disc only)
K	Baseline Human Health Risk Assessment
L	Screening-Level Ecological Risk Assessment for Onshore Areas
M	Evaluation of Groundwater Chemical Migration to the Aquatic Environment
N	Applicable or Relevant and Appropriate Requirements
O	Regulatory Analysis of Shoreline Area and Adjacent Wetlands
P	Preliminary Evaluations for Landfill Containment Systems
Q	Qualitative Slope Stability Evaluation
R	Detailed Cost Estimates and Assumptions
S	Responses to Regulatory Agency Comments on the Draft and Draft Final RI/FS Report for Parcel E-2

Notes:

ARARs applicable or relevant and appropriate requirements
CERCLA Comprehensive Environmental Response, Compensation and Liability Act
EPA U.S. Environmental Protection Agency
FS Feasibility Study
GRAs general response actions
HHRA human health risk assessment
RAOs remedial action objectives
RI Remedial Investigation
SLERA screening-level ecological risk assessment

Sources:

EPA. 1988a. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA." Office of Solid Waste and Emergency Response Directive 9355-3.01 and -02. EPA/540G-89/004. Available Online at: <http://epa.gov/superfund/policy/remedy/sfremedy/rifs/overview.htm>.

Table 1-2. Buildings Within 1,000 Feet of Parcel E-2 Landfill
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Building	IR Site	Parcel	Former Use	Current Use	Planned Reuse[a]	Approximate Distance from Landfill
400	IR-36 North	E	Storehouse	Vacant	Mixed Use	950 feet east
704	IR-36 West	E	Automotive repair shop	Vacant	Mixed Use	950 feet southeast
707	IR-39	E	NRDL animal colony	Vacant	Mixed Use	875 feet southeast
808	NA	Former A	Industrial Storehouse	Leased to Precision Transport	Mixed Use	700 feet northeast
809	IR-56	E	Lumber storehouse	Vacant	Mixed Use	250 feet northeast
810	IR-72	E	Paint and oil storehouse	Vacant	Mixed Use	250 feet northeast
811	IR-72	E	Diesel fueling station	Vacant	Mixed Use	575 feet northeast
815	IR-74	FUDS	NRDL main laboratory	Leased to Filesafe Company	NA[b]	325 feet northeast
816	NA	Former A	NRDL high-voltage accelerator laboratory	Vacant	Open Space	250 feet north
817A	NA	Former A	Sentry House	Vacant	Open Space	250 feet north
818	NA	Former A	Chlorination plant	Vacant	Open Space	250 feet north
820	IR-75	FUDS	NRDL cyclotron laboratory	Wood moulding shop	NA[b]	175 feet northwest
821	NA	Former A	X-ray shield facility	Vacant	Mixed Use	625 feet northeast
830	IR-76	FUDS	NRDL animal kennels	UCSF animal kennels	NA[c]	Less than 00 feet north
830B	IR-76	FUDS	UCSF animal kennels	UCSF animal kennels	NA[c]	Less than 100 feet north
831	IR-76	FUDS	NRDL animal kennels	UCSF animal kennels	NA[c]	Less than 100 feet north

Table 1-2. Buildings Within 1,000 Feet of Parcel E-2 Landfill *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Building	IR Site	Parcel	Former Use	Current Use	Planned Reuse[a]	Approximate Distance from Landfill
Shed	IR-12	E	Storage shed (unnamed)	Vacant	Mixed Use	250 feet east

Notes: Current and former Navy buildings are identified in the table above; additional structures are located within 1,000 feet of the western boundary of the Parcel E-2 landfill.
a Hunters Point Shipyard Redevelopment Plan (SFRA, 2010)
b FUDS property owned by Ted Lowpensky
c FUDS property owned by UCSF

FUDS formerly used defense site
IR Installation Restoration
NA not applicable
NRDL Naval Radiological Defense Laboratory
R&D research and development
SFRA San Francisco Redevelopment Agency
UCSF University of California, San Francisco

Source:
SFRA. 2010. “Hunters Point Shipyard Redevelopment Plan.” August 3 (amendment to July 14, 1997, redevelopment plan).

Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Date(s)	Activity	Summary of Activities
1984	Initial Assessment Survey	The purpose of the IAS was to identify sites posing a potential threat to human health or the environment from contamination from past hazardous material operations. Records reviews and a visual inspection of the landfill (IAS Site 3, later renamed IR Site 01/21) were conducted. The IAS concluded that it was highly probable that chemicals from waste disposed of in the Parcel E-2 Landfill had reached groundwater and were migrating toward San Francisco Bay. This migration constituted a potential threat to the bay environment, and a confirmation study was recommended for the site (NEESA, 1984).
1987	Confirmation Study / Verification Step	The study was conducted in response to the IAS to verify the presence of hazardous waste contamination. Activities conducted in the area of the landfill included a geophysical survey, subsurface exploration using exploratory borings, and soil and groundwater sampling. The study concluded that soil at the Parcel E-2 Landfill contained a variety of VOCs and SVOCs that appeared to be associated with petroleum products and some chlorinated organic solvents. The report recommended further environmental investigations based on the detection of contaminants beyond the reported landfill boundaries (EMCON, 1987a).
1987	Area Study	The study was conducted throughout HPS to evaluate whether a release of hazardous substances to soil had occurred at construction sites outside the boundaries of previously identified investigation sites. The area study primarily concluded that soils within Study Area A, including Parcels E and E-2, contained naturally occurring asbestos derived from serpentine bedrock (EMCON, 1987b).
1988	Solid Waste Air Quality Assessment Test	The study included evaluation of meteorological conditions, ambient air quality, landfill gas compositions, surface gas emissions, and subsurface gas migration. The analysis of gases covered a wide range of organic chemicals, including VOCs and methane. Surface gas emissions were not detected during this investigation. The only chemicals detected were in ambient air and detected upwind from possible sources off site in the surrounding industrial areas. Methane was detected in isolated pockets at IR Site 01/21 and at the northern edge of the IR Site 01/21 boundary (near the UCSF compound but within the solid waste footprint) (HLA, 1989).
1986 to 1988	Triple A Investigation, Remedial Action Order and Remedial Investigation/ Feasibility Study Scoping Document	The Navy identified 19 sites that Triple A had allegedly used to store and dispose of hazardous and other wastes during its occupancy of the site. Two of these sites, Triple A Sites 1 and 16, are located within Parcel E-2 (SFDA, 1986). DHS issued a Remedial Action Order to the Navy and its tenant, Triple A (DHS, 1988). The Remedial Action Order listed numerous sites, including IR Site 01/21 and Triple A Sites 1 and 16. In response to the Remedial Action Order, the Navy completed a scoping document for the RI/FSs to be conducted at HPS. The scoping document grouped the sites into OUs and described the field investigations to be conducted under the RI (HLA, 1988).

Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2 *(continued)*

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Date(s)	Activity	Summary of Activities
1988 – 1992	Operable Unit I Remedial Investigation	The Parcel E-2 Landfill progressed to the RI stage as IR Site 01/21 and was grouped (along with IR Sites 02 and 03 in Parcel E) into OU-I. The first phase of the OU-I RI (from 1988 to 1989) consisted of reconnaissance activities, including a geophysical survey and test pit excavation to delineate the extent of landfill waste, a soil gas survey to evaluate the presence of VOCs in soil and groundwater, and the installation of deep soil borings to define subsurface stratigraphy. Subsequent phases of the OU-I RI involved primary and contingency sampling of soil and groundwater performed from October 1990 to June 1992 (TtEMI, LFR, and U&A, 1997).
1991 to 1992	Intertidal Sediment Study	As part of the intertidal sediment study, sediment samples were collected in the intertidal zone of HPS, including along the Parcel E-2 shoreline, to evaluate if chemicals had migrated from Parcels E and E-2 to the bay (ATT, 1991). The ESAP whole sediment study measured concentrations of chemicals in sediments, stormwater, and bay water near stormwater outfalls and other potential source areas within the boundaries of HPS.
1991 and 1993	Radiological Investigations (Phases I and II)	The Phase I investigation was initiated to evaluate and confirm the nature and surficial extent of radium-bearing devices in several disposal areas at HPS, including Parcel E-2. Nine radioactive point source anomalies associated with radium-containing devices were observed in the southwestern and northeastern areas. The Phase II investigation was conducted to delineate the subsurface distribution of radium-containing devices at several locations, including Parcel E-2. No elevated gamma count rates were measured in the test pits or trenches installed within IR Site 01/21; however, test pits and trenches installed at IR Site 02, in close proximity to Parcel E-2, contained gamma-emitting anomalies associated with radium-containing devices and firebrick (NAVSEA, 2004).
1991 to 1995	Sandblast Waste Fixation	A field treatment demonstration was performed to determine if sandblast waste could be stabilized and recycled into asphalt (Battelle, 1989). Between 1991 and 1995, 4,665 tons of sandblast waste from throughout HPS was collected and consolidated in Parcel E-2. The waste was sent to an asphalt plant, where it was successfully reused in the manufacture of asphalt (Battelle, 1996).
1992, 1994, and 1996	Facility-wide Ambient Air Monitoring (Phases I, II, and III)	Ambient air sampling was conducted at select locations, including the Parcel E-2 Landfill. Low levels of VOCs and asbestos were detected at IR Site 01/21 during Phase I. During Phase II, air samples near a sandblast waste pile at IR Site 01/21 contained elevated concentrations of asbestos, metals, and PCBs. During Phase III, detected concentrations of asbestos, metals, and VOCs were similar to regional background concentrations, and concentrations of PCBs were two orders of magnitude lower than concentrations detected during Phase II. The Phase III study concluded that the removal of the sandblast waste pile in 1994 most likely contributed to the elevated concentrations of asbestos, metals, and PCBs detected during Phase II (TtEMI, LFR, and U&A, 1997).

Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2 *(continued)*

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Date(s)	Activity	Summary of Activities
1994 to 1996	Phase 1A and 1B Ecological Risk Assessment	The Phase 1A ERA was a qualitative analysis that developed a preliminary characterization of HPS based on existing data, biotic surveys, and contaminant migration pathways and exposure routes. Both terrestrial and aquatic environments were considered in the Phase 1A ERA. Following the Phase 1A analysis, the quantitative Phase 1B ERA was performed to delineate potential gradients of contamination from onshore sources to offshore sediments, and to characterize the risk to aquatic wildlife (PRC, 1994, 1996c, and 1996d).
1995 to 1998	Parcel E Remedial Investigation and Feasibility Study	Following the 1992 decision to align the HPS IR sites into parcels, the RI at the landfill was completed in conjunction with other Parcel E IR sites, and involved additional field investigation performed from October 1995 to June 1996 (TtEMI, LFR, and U&A, 1997). In 1993, IR Site 01 was combined with IR Site 21. IR Site 21 was initially identified as a separate site during the RI/FS scoping process, but was later determined to be part of the landfill and thus was combined with IR Site 01. The Parcel E RI also included a baseline ERA and HHRA. During preparation of the Parcel E RI and FS reports in 1997 and 1998, the Navy and regulatory agencies identified additional tasks to support the remedial design for Parcel E. These tasks were performed as part of data gaps investigations from 2000 through 2003.
1996 to 1997	Storm Drain Sediment Removal Action	The Navy removed accumulated sediments from the storm drain system at HPS to reduce potential transport of contaminated sediments to the bay. The storm drain system at HPS consists of approximately 107,000 linear feet of piping, less than 1,000 feet of which are present in Parcel E-2. Most storm drain lines within Parcel E-2 were inaccessible during the removal action, except for a short section of storm drain (less than 200 feet) present southwest of Building 810 (IT, 1997).
1997 to 1998	Groundwater Extraction System and Containment Barrier	Previous investigations identified high PCB concentrations in groundwater in the southeast portion of Parcel E-2. To prevent the potential transport of PCBs to the bay, the Navy (1) constructed a 614-foot-long, sheet-pile wall between the landfill and the Bay and (2) installed a groundwater extraction system behind the sheet-pile wall to reduce groundwater mounding behind the wall (IT, 1999). These components are shown on Figure 1-3.
1999 to 2000	ERA Validation Study and Protective Soil Concentration Technical Memorandum	The validation study addressed some of the uncertainties associated with dose calculations (from the baseline ERA) and developed site-specific soil concentrations that would be protective of terrestrial receptors (referred to as PSCs). Based on the results of the validation study, cadmium, copper, lead, nickel, selenium, and zinc were determined to be of potential risk to wildlife and PSCs were derived for these chemicals (TtEMI and LFR, 2000a and 2000b).
2000 to 2001	Interim Landfill Cap Construction	In August 2000, a brush fire burned about 37 percent of the landfill surface area. An interim cap was constructed to extinguish the fire and prevent the occurrence of future fires under the capped areas (TtEMI, 2005b) (Appendix E of this RI/FS report). In addition, the cap reduces the potential for hazardous substances to leach from landfill waste by preventing stormwater from flowing through materials in the landfill. The cap encompasses about 14.5 acres (Figure 1-3). An extensive air monitoring program was performed during the cap construction to identify any conditions requiring corrective measures necessary to ensure that public health and the environment of the nearby community were not compromised by air emissions from the subsurface smoldering and landfill capping activities.

Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2 *(continued)*

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Date(s)	Activity	Summary of Activities
July 2000 to October 2002	Groundwater Data Gaps Investigation	The GDGI was conducted in three phases between 2000 and 2002 to update previous assessments of groundwater conditions at HPS, supplement information gathered during the Parcel E RI, and better define the extent of groundwater contamination at HPS (TtEMI, 2001a and 2004c). Water level measurements and a tidal study were used to refine the Parcel E-2 hydrogeological conceptual model, and three rounds of groundwater monitoring were used to develop a basewide groundwater monitoring program and to refine the nature and extent evaluation presented in this RI/FS.
2001 to 2005	Radiological Investigations, Phase V (and other interim investigations)	As part of an interim 2001 investigation, a characterization survey of the Parcels E and E-2 shoreline was performed. Several areas were noted during the survey that exceeded background gamma radiation levels, most significantly the area known as the “metal reef” within Parcel E. The Phase V investigation was performed from 2002 to 2003 at the radiologically impacted sites within Parcel E-2. Several areas with elevated levels of radioactivity were reported. The Historical Radiological Assessment recommended further characterization, followed by remediation and a final status survey (NAVSEA, 2004).
October 2001 to November 2002	Nonstandard Data Gaps Investigation	An NDGI was conducted to collect supplemental information required to support the remedial design for Parcel E. Four separate investigations were conducted and are described below. ▪ <u>Wetlands Delineation and Functions and Values Assessment (October 2001 to April 2002)</u>. The Navy conducted the wetland delineation and wetland functions and values assessment as part of the NDGI (TtEMI, 2003d) (Appendix D of this RI/FS Report). Two wetland areas were identified at Parcel E: (1) about 3.2 acres of tidal wetlands along the shoreline and (2) about 1.3 acres of inland seasonal freshwater wetland that partially overlaps with the Parcel E-2 Landfill. The functions and values assessment found that the value of these wetlands is low, and the most significant function of these wetlands to be seasonal wildlife use for wintering and migrating birds. ▪ <u>Landfill Lateral Extent Evaluation (March to April 2002)</u>. The Navy evaluated the lateral extent of solid waste as part of the NDGI of Parcel E (TtEMI, 2004f) (Appendix B of this RI/FS Report). After a review of the existing information, test pits and soil borings were installed to determine the edge of physical waste. The lateral extent of landfill waste was found to encompass about 22 acres (Figure 1-2), and the vertical extent varies from 5 to 25 feet thick, with the bottom of waste being located between 12 and 30 feet bgs.

Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2 *(continued)*

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Date(s)	Activity	Summary of Activities
October 2001 to November 2002	Nonstandard Data Gaps Investigation *(continued)*	▪ Landfill Liquefaction Potential (April 2002). The Navy evaluated the potential for soil liquefaction during an earthquake in areas surrounding the Parcel E-2 Landfill as part of the NDGI (TtEMI and ITSI, 2004b) (Appendix C of this RI/FS Report). The evaluation indicated that most of the cohesionless soil layers (66 to 67 percent) would not liquefy during the MPE. The evaluation determined that, for the remaining soil layers that could liquefy during the MPE, lateral movement of soil below the waste would be less than 4 to 5 feet. The evaluation also concluded that, if containment were selected as the final remediation measure, further analysis would be required on response of the landfill cap, overall stability of the landfill site, slope stability, and other closure features. ▪ Landfill Gas Characterization (April to November 2002). As part of the NDGI, the Navy conducted an evaluation to characterize and delineate landfill gas as part of the NDGI (TtEMI, 2003e) (Appendix A of this RI/FS Report). As part of the investigation, ambient air and soil gas surveys were conducted and GMP01 through GMP21 were installed and monitored on a weekly basis. Results from GMP monitoring indicated that methane, the main component of landfill gas, was present at levels that exceeded the LEL (5 percent by volume in air) in subsurface areas in the northern part of the landfill and aboveground at four areas on the UCSF compound. Trace concentrations of NMOCs were also detected in this area; however, a screening evaluation concluded that the detected levels of NMOCs did not pose an unacceptable risk to human health.
August 2002 to May 2003	Landfill Gas Time-Critical Removal Action	The Navy conducted a TCRA to remove combustible levels of methane on the UCSF compound. The landfill gas TCRA had the following goals: (1) to reduce methane levels on the UCSF compound to less than the LEL of 5 percent for methane and (2) to prevent future landfill gas migration onto the UCSF compound. The TCRA completed the following actions to achieve these goals: ▪ An active gas extraction system, consisting of 2 mobile extraction units, 10 extraction wells, and 5 GMPs on the UCSF compound was operated beginning in October 2002 to reduce methane levels. By January 20, 2003, the TCRA goals were met and gas extraction within the UCSF compound was discontinued. ▪ The Navy installed a landfill gas control system along the northern boundary of the landfill; the landfill gas control system consists of an HDPE barrier wall, gas collection trench, gas collection piping, and four gas vents. ▪ Removed NMOCs from the vented and extracted gas streams using mobile treatment systems within the UCSF compound and permanent treatment units attached to each of the four landfill gas control system vents; after goals within the UCSF compound were achieved, extraction within the UCSF compound was discontinued.

Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2 *(continued)*

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Date(s)	Activity	Summary of Activities
August 2002 to May 2003	Landfill Gas Time-Critical Removal Action *(continued)*	▪ From January 29 to February 19, 2003, the gas extraction phase within the UCSF compound was followed by four rounds of weekly confirmation monitoring and then from February through May 2003, four rounds of monthly confirmation monitoring were conducted. These monitoring events showed that methane concentrations across the UCSF property remained below the methane LEL. ▪ In February 2003 and May 2003, two rounds of sampling were conducted to verify NMOC concentrations. Gas samples were collected from all GMPs within the UCSF compound and submitted for laboratory analyses. Sampling results confirmed that methane concentrations were less than 5 percent and NMOCs were below the action level of 5 ppmv above background. Based on the confirmation field monitoring and laboratory sample data, the landfill gas TCRA goals were successfully met (TtEMI, 2004a) (Appendix F of this RI/FS report).
September 2002 to February 2003	Standard Data Gaps Investigation	The Navy conducted the onshore SDGI to further define the nature and extent of chemicals in soil within the non-landfill areas. The Navy reviewed aerial photographs and logs from test pits, soil borings, monitoring wells, and GMPs from various investigations at Parcel E-2 to identify known and potential contaminant sources that required additional delineation. The results from the SDGI (TtEMI, 2005c) were also used to delineate the PCB Hot Spot, which was partially removed under an interim removal action. In addition to the onshore sampling, the SDGI characterized the nature and extent of chemicals in sediment within, or in close proximity to, the Shoreline Area. The intertidal sediments were evaluated in a Shoreline Characterization Technical Memorandum that included a SLERA for the Parcels E and E-2 shoreline (SulTech, 2005) (Appendix G to this report).
September 2003 to June 2004	Shoreline Cleanup	As part of a waste consolidation effort throughout HPS, hazardous and nonhazardous debris (consisting primarily of brick, metal scrap, concrete, and wood) along the Parcels E and E-2 shoreline (including portions of the Panhandle Area) was characterized and disposed of off site (TtFW, 2004c).
May 2003 to Present	Landfill Gas Monitoring and Control	Landfill gas is being monitored on a regular basis under the Interim Landfill Gas MCP (TtEMI and ITSI, 2004c) to verify that hazardous levels of landfill gas are not migrating beyond the fence line of the landfill and onto the UCSF compound. The landfill gas control system is operated using both passive venting and active extraction. During monitoring performed since January 2004, all concentrations of NMOCs were below action levels and regulatory requirements identified in the MCP. Methane concentrations have, in nearly all cases, remained below specified action levels; however, methane concentrations exceeding specified action levels were detected in occasionally. In these instances, the Navy notified the appropriate parties and implemented response measures to control methane at the fence line of the landfill.

Date(s)	Activity	Summary of Activities
July 2003 to Present	Interim Cap Inspection and Maintenance	Inspection and maintenance of the interim landfill cap is performed in accordance with a site-specific operation and maintenance plan (TtEMI, 2003b). The irrigation system, along with other components of the interim cap, is inspected on a quarterly basis to ensure that it is functioning properly and providing adequate water to the vegetative cover. Inspection and mowing of the vegetative cover is performed twice per year.
July 2003 to Present	Storm Water Management and Monitoring	Stormwater discharge in Parcel E-2 is managed in accordance with a SWDMP that was originally published in 2003 (TtEMI, 2003c). The Parcel E-2 stormwater program involves quarterly visual observations of non-stormwater discharge, storm water sampling and analysis, monthly visual observations of stormwater discharge, and an annual comprehensive site compliance evaluation. Results to date indicate no incidents of noncompliance at Parcel E-2 except in isolated locations where BMPs require modification to better control erosion and sediment transport from neighboring properties. In 2007, the Parcel E-2 SWDMP was integrated with the basewide SWDMP to streamline the stormwater program (MARRS and MACTEC, 2007). The SWDMP is revised on an annual basis to reflect current site conditions, clarify or change the discharge locations, and update the list of BMPs (MARRS and MACTEC, 2009b).
June 2004 to Present	Basewide Groundwater Monitoring Program	The Navy monitors groundwater on a regular basis under the BGMP (TtEMI, 2004e). Since June 2004, the BGMP has been updated several times to optimize the monitoring network within Parcel E-2 and other HPS parcels (CE2-Kleinfelder Joint Venture, 2007c, 2007g, 2008b, 2008c, and 2009c). Analyses of samples from wells in and around the landfill are performed based on 27 CCR requirements. Additionally, four A-aquifer wells in southern end of the Panhandle Area are sampled to monitor chemicals previously detected at concentrations that may pose a potential risk to human health and the environment (CE2-Kleinfelder Joint Venture, 2009c).
June 2005 to May 2006	Metal Slag Area Removal Action	The TCRA at the Metal Slag Area was performed in conjunction with removal of the Metal Debris Reef in the southeast portion of Parcel E. The TCRA was designed to remove metal slag and debris containing low-level radiological material, as well as non-radiological chemical contamination incidental to the removal of both areas. A detailed description of this removal action is included in the Final Removal Action Completion Report (TtECI, 2007b).
June 2005 to September 2006	PCB Hot Spot Removal Action	The TCRA at the PCB Hot Spot was designed to remove PCB- and petroleum hydrocarbon-contaminated soil and debris, possibly containing low-level radiological material. The excavation involved the removal of soils that contained PCBs at concentrations greater than 1 mg/kg (from the surface to 3 feet bgs) and 100 mg/kg (deeper than 3 feet bgs), TPH at concentrations greater than 3,500 mg/kg, and radiological contaminants above the radiological removal action goals. The removal action goals also included removal of, to a practical extent, free-phase petroleum hydrocarbons. A detailed description of this removal action is included in the Final Removal Action Completion Report (TtECI, 2007a). The shoreline portion of the PCB Hot Spot was not excavated because of its proximity to San Francisco Bay; however, the Navy initiated a follow-on removal action in this area in March 2010; the follow-on removal action is scheduled for completion in 2011).

Table 1-3. Summary of Previous Environmental Investigations and Remedial Activities in Parcel E-2 *(continued)*

Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Date(s)	Activity	Summary of Activities
September 2007 to June 2008	Groundwater Investigation	A focused groundwater investigation was performed to evaluate chemical concentrations (dissolved metals, PCBs, petroleum hydrocarbons, and ammonia) along the Parcel E-2 shoreline. Study areas included areas adjacent to the Parcel E-2 Landfill, the PCB Hot Spot, and Metal Slag Area (CE2-Kleinfelder Joint Venture, 2009a). The scope of the investigation was expanded to include supplemental sampling for specific radionuclides.

Notes:

27 CCR	Title 27 California Code of Regulations
ATT	Aqua Terra Technologies, Inc.
Battelle	Battelle Memorial Institute
BGMP	Basewide Groundwater Monitoring Program
BMPs	best management practices
bgs	below ground surface
DHS	Department of Health Services
EMCON	EMCON Associates, Inc.
ERA	ecological risk assessment
ESAP	Environmental Sampling and Analysis Plan
FS	Feasibility Study
GDGI	groundwater data gaps investigation
GMP	gas monitoring probe
HDPE	high-density polyethylene
HHRA	human health risk assessment
HLA	Harding Lawson Associates, Inc.
HPS	Hunters Point Shipyard
IAS	Initial Assessment Study
IR	Installation Restoration
IT	International Technology Corporation
ITSI	Innovative Technical Solutions, Inc.
LEL	lower explosive limit
LFR	Levine-Fricke-Recon
MCP	Monitoring and Control Plan
mg/kg	milligrams per kilogram
MPE	maximum probable earthquake
NAVSEA	Naval Sea Systems Command
Navy	Department of the Navy
NEESA	Naval Energy and Environmental Support Activity
NDGI	nonstandard data gaps investigation
NMOC	non-methane organic compound
OU	Operable Unit
PCBs	polychlorinated biphenyls
ppmv	parts per million by volume
PRC	PRC Environmental Management, Inc.
PSC	protective soil concentration
RI	Remedial Investigation
SDGI	standard data gaps investigation
SFDA	San Francisco District Attorney
SLERA	Screening level ecological risk assessment
SVOCs	semivolatile organic compounds
SWDMP	Stormwater Discharge Management Plan
TCRA	time-critical removal action
TPH	total petroleum hydrocarbons
Triple A	Triple A Machine Shop
TtECI	Tetra Tech EC, Inc.
TtEMI	Tetra Tech EM Inc.
TtFW	Tetra Tech Foster Wheeler, Inc.
U&A	Uribe and Associates, Inc.
UCSF	University of California, San Francisco
VOCs	volatile organic compounds

Section 2. Site Description and Physical Characteristics

This section describes the site characteristics associated with Parcel E-2, including the site features; geologic, hydrogeologic, and hydrologic conditions; and ecologic conditions, such as terrestrial, wetland, and intertidal habitats[2]. According to EPA guidance, characterization of a landfill's contents is not necessary or generally appropriate for selecting a response action for these sites when applying the presumptive remedy methodology for remedial alternatives evaluation (EPA, 1993a; Appendix H to this report). However, because Parcel E-2 is composed of a landfill, as well as adjacent areas (the Panhandle Area, East Adjacent Area, and Shoreline Area) containing noncontiguous waste deposits outside the primary landfill area, characterization data collected through March 2008 were used in the remedy evaluation process.

2.1. SITE FEATURES

Parcel E-2 encompasses approximately 47.4 acres at HPS. As described in Section 1, the parcel was divided into the following four areas:

- The "Landfill Area," which comprises the entire Parcel E-2 Landfill and its immediate perimeter
- The "Panhandle Area," located west and southwest of the Landfill Area
- The "East Adjacent Area," located to the east of the Landfill Area
- The "Shoreline Area," located at the interface with San Francisco Bay

The following subsections describe the surface features for each of the four areas listed above, including information about the types of solid waste believed to be present at each area. Numerous areas within Parcel E-2 are considered "radiologically impacted," which is discussed in further detail in Section 3.6.

2.1.1. Landfill Area

The 22-acre Landfill Area consists of two subareas: (1) a 14.5-acre interim landfill cap and (2) a 7.5-acre area that is covered with a 2-foot-thick soil layer. The interim cap, originally constructed to smother remnants of a waste layer fire that occurred in August 2000, consists of a multilayer system of sub-base soil, an HDPE membrane, a synthetic drainage layer, and topsoil (TtEMI, 2005b; Appendix E to this

[2] In September 2004, the Navy divided Parcel E into two parcels (E and E-2). Discussions within this report that reference documents published prior to September 2004 refer to the portion of Parcel E that became Parcel E-2.

report). The remaining 7.5 acres that were unaffected by the fire are covered by a 2-foot-thick soil layer that was placed in 1974 during a preliminary closure action.

Based on data from 26 soil borings, 12 monitoring wells, and 25 test pits extended within the Landfill Area, solid waste in the landfill is primarily municipal-type waste and construction debris. The solid waste includes wood, paper, plastic, metal, glass, asphalt, concrete, and bricks that are mixed with sand, clay, and gravel fill. Historic information indicates that industrial wastes, including sandblast waste, radioluminescent devices, asbestos-containing debris, paint sludge, solvents, and waste oils, were also disposed of in or around the Landfill Area (NEESA, 1984; NAVSEA, 2004). For simplicity, the debris and waste that make up the landfill are referred to as "solid waste" throughout the remainder of this report. The lateral and vertical extents of solid waste within the landfill were evaluated during previous investigations, as discussed in Section 3.2 of this RI/FS Report. The types of solid waste within the Landfill Area are discussed in more detail in Section 4.2.1.

The 14.5-acre interim landfill cap limits precipitation from percolating into portions of the solid waste, and the entire Landfill Area is sloped sufficiently for surface drainage that avoids ponding (drainage patterns are discussed in Section 2.3). The Navy performs inspection and maintenance of the interim landfill cap in accordance with a site-specific operation and maintenance (O&M) plan (TtEMI, 2003b).

In 2002, a landfill gas characterization study revealed that landfill gas had migrated north of the solid waste extent and onto the adjacent Navy and UCSF property. In response to this finding, a time-critical removal action (TCRA) was conducted to (1) reduce concentrations of subsurface methane north of the Parcel E-2 Landfill (under both Navy and UCSF property) to below 5 percent, and (2) prevent future landfill gas migration. The TCRA included installation and operation of a gas control, extraction, and treatment system; the TCRA is discussed in more detail in Section 3.8.5 of this RI/FS Report.

From 1997 to 1998, a 614-foot-long sheet-pile wall was constructed along the southern portion of the Landfill Area, to a depth ranging from 12 to 55 feet bgs, to reduce the potential for release of chemicals from the landfill into the bay. To reduce groundwater mounding behind the sheet-pile wall, a groundwater extraction system (GES) was installed at the same time to intercept, treat, and discharge groundwater to the municipal sewer system (IT, 1999); both features are shown on Figure 1-3 and are discussed in more detail in Section 3.8.3 of this RI/FS Report. These features targeted A-aquifer groundwater. The GES was deactivated in April 2005 to excavate contaminated soil adjacent to the sheet-pile wall and remains offline following implementation of the removal action in the PCB Hot Spot Area (TtFW, 2005a) (discussed in Section 3.8.8).

2.1.2. Panhandle Area

The Panhandle Area has a relatively flat topography and is covered by fill soil that contains noncontiguous pockets of solid waste. Waste at these locations is not contiguous with the Landfill Area and consists primarily of construction debris, with lesser quantities of industrial waste (discussed further in Section 4.3.1). The presence of isolated solid waste locations is largely because the Panhandle Area was reclaimed from the bay by filling using a combination of fill soil and waste materials (with larger proportions of fill soil as compared to the fill material within the Landfill Area). The interim landfill cap, that covers much of the Landfill Area, does not extend onto the Panhandle Area.

The Panhandle Area includes a drainage channel just outside the extent of landfill waste along the western perimeter of Parcel E-2 (see Figure 1-4). The drainage channel directs runoff south and discharges indirectly to the bay through low-lying seasonal wetlands southwest of the Parcel E-2 Landfill. The wetland areas are discussed in more detail in Section 2.4.2.

The Panhandle Area contains areas of potential low-level radioactivity, including a former experimental ship-shielding area and the metal slag area. The metal slag area, which is in the southern peninsula of the Panhandle Area and extends into the Shoreline Area, was excavated under an interim removal action (see Figure 1-3; TtECI, 2007b).

2.1.3. East Adjacent Area

Like the Panhandle Area, the East Adjacent Area has a relatively flat topography and includes solid waste locations intermixed with fill soil that are not contiguous with the Parcel E-2 Landfill. Waste at these locations is not contiguous with the Landfill Area and consists primarily of construction debris, with lesser quantities of industrial waste (discussed further in Section 4.4.1). The East Adjacent Area also includes an area containing potential low-level radioactive debris. The East Adjacent Area contains an area with PCB contamination, a portion of which was excavated under an interim removal action (see Figure 1-3; TtECI, 2007a). The sheet-pile wall and associated GES extends from the Landfill Area into the East Adjacent Area (Figure 1-3). The interim gas control system also extends into the East Adjacent Area.

2.1.4. Shoreline Area

The Shoreline Area is the intertidal zone that contains areas covered with concrete riprap and other exposed shoreline containing sediments and emergent saline wetlands. The intertidal sediments present in the Shoreline Area were characterized during the SDGI, and the results are summarized in the Shoreline Characterization Technical Memorandum (SulTech, 2007; Appendix G to this report). The metal slag area, discussed in the subsection above, also extends into the Shoreline Area and was previously excavated under an interim removal action (Figure 1-3; TtECI, 2007b).

2.2. GEOLOGY AND HYDROGEOLOGY

Numerous field investigations have been performed to characterize and define the geology and hydrogeology at HPS. This subsection discusses the geologic and hydrogeologic conditions at Parcel E-2 based on the information derived from those investigations. The geologic descriptions presented in this subsection are interpreted from lithologic cross sections presented in the Landfill Lateral Extent Evaluation Report (TtEMI, 2004f). Hydrogeologic descriptions related to hydrostratigraphy, groundwater flow patterns, hydraulic characteristics, tidal effects, and total dissolved solids (TDS) are also presented in this subsection and are based primarily on information included in the Parcel E Groundwater Summary Report prepared following the Phase III GDGI (TtEMI, 2004c). This subsection also summarizes the evaluation of potential beneficial uses of groundwater at Parcel E-2.

2.2.1. Geologic and Hydrogeologic Units

The peninsula forming HPS is within a northwest-trending belt of the Franciscan Complex bedrock known as the Hunters Point Shear zone. The natural geology at HPS consists of unconsolidated Holocene sediments of estuarine and alluvial origin (Quaternary age) deposited on an uneven, eroded bedrock surface composed primarily of serpentinite (Jurassic-Cretaceous age). Artificial fill was deposited extensively over the natural sediments and bedrock during expansion of the shipyard in the early 1940s. Six individual geologic units have been identified at HPS. In general, the stratigraphic sequence of these geologic units, from youngest (shallowest) to oldest (deepest), is as follows: (1) Artificial Fill; (2) Slope Debris and Ravine Fill; (3) Undifferentiated Upper Sand Deposits; (4) Bay Mud; (5) Undifferentiated Sedimentary Deposits; and (6) Franciscan Complex Bedrock (TtEMI, 2004c). Figure 2-1 shows the surficial geologic units present at HPS, including the various subdivisions within the Franciscan Complex Bedrock. With the exception of Slope Debris and Ravine Fill, all other geologic units are present at Parcel E-2.

The hydrostratigraphy of Parcel E-2 consists of four distinct units, including three water-bearing units and one aquitard. The shallowest water-bearing unit is referred to as the A-aquifer. The A-aquifer is essentially manmade and consists primarily of Artificial Fill material, but also includes Undifferentiated Upper Sand Deposits. The A-aquifer is separated from the deeper water-bearing unit, referred to as the B-aquifer, by the Bay Mud in most locations across HPS. The B-aquifer consists of Undifferentiated Sedimentary Deposits underlying the Bay Mud. The upper weathered portions of the Franciscan Complex bedrock that directly underlie permeable Artificial Fill, Undifferentiated Upper Sand, and Undifferentiated Sedimentary deposits are considered part of the overlying aquifer (TtEMI, 2004c). The portions of saturated bedrock that are not in direct contact with the A- or B-aquifers are hydrostratigraphically classified as the bedrock water-bearing zone (WBZ) (TtEMI, 2004c). Flow in the bedrock WBZ generally occurs in localized, discontinuous fractures located below the upper portions of bedrock (TtEMI, LFR, and U&A, 1997). The relationships between the stratigraphic and hydrostratigraphic units at Parcel E-2 are presented below.

Stratigraphic Unit	Corresponding Hydrostratigraphic Unit
Artificial Fill (Qaf)	A-aquifer [a]
Undifferentiated Upper Sand Deposits (Quus)	A-aquifer [a]
Bay Mud (Qbm)	Aquitard [b]
Undifferentiated Sedimentary Deposits (Qu)	B-aquifer [c]
Franciscan Complex Bedrock (KJfm)	Bedrock WBZ [d]

Notes:

a Hydrostratigraphic unit comprises permeable portions of the Artificial Fill and Undifferentiated Upper Sand deposits, and includes weathered portions of the bedrock that directly underlie saturated Artificial Fill or Undifferentiated Upper Sand deposits and localized areas where Undifferentiated Upper Sand deposits are interbedded with Bay Mud deposits.

b Hydrostratigraphic unit also includes low-permeability Artificial Fill deposits.

c Unit comprises the permeable portions of the Undifferentiated Sedimentary deposits.

d Unit consists of portions of saturated bedrock that are not in direct contact with the A- or B-aquifers.

Numerous field investigations at Parcel E-2 have provided geologic information that was used to define the subsurface stratigraphy and depth to bedrock at Parcel E-2. Figure 2-2 is a map showing cross-section locations across Parcel E-2. Figures 2-3 through 2-8 are the geologic cross-section diagrams of the Landfill Area that were presented in the Landfill Lateral Extent Evaluation Report (TtEMI, 2004f). Figures 2-9, 2-10, and 2-11 are hydrogeologic cross-section diagrams that were originally presented in the Parcel E Groundwater Summary Report (TtEMI, 2004c). The hydrogeologic cross sections cover the Landfill Area, Panhandle Area, and East Adjacent Area, and depict the lithologic units and the relative permeabilities of these sediments to portray the hydrostratigraphy at Parcel E-2.

Because of the different purposes for each set of cross sections, the data set used to construct the hydrogeologic cross sections does not provide the same level of detail for the heterogeneous artificial fill as compared to the geologic cross sections. The geologic cross sections were originally prepared to depict the subsurface conditions in and immediately surrounding the landfill waste and, as such, focused on providing the greatest level of detail within the heterogeneous artificial fill. In contrast, the hydrogeologic cross sections were prepared to depict the overall hydrostratigraphy at Parcel E-2, with a focus on identifying permeable zones within the A- and B-aquifers.

An important geologic feature at Parcel E-2 is the bedrock surface that declines steeply from the northern portion to the southern portion of Parcel E-2 (cross section G-G’, Figure 2-9). The bedrock within the Hunters Point Shear Zone has been subjected to intense tectonic activity resulting in a high degree of folding, faulting, and metamorphism. As a result, the top surface of the bedrock ranges from approximately 55 feet below ground surface (bgs) in the northern part of Parcel E-2 to greater than 280 feet bgs in the southern part of Parcel E-2. This is a decline of approximately 225 feet over the length of the site, which corresponds to a horizontal distance of approximately 1,100 feet. Based on the bedrock depths reported above, overburden sediments and fill above the bedrock at Parcel E-2 vary from about 55 feet thick in the northeast portion of Parcel E-2 to greater than 280 feet thick in the southern portion. Figure 2-12 shows the bedrock surface elevations at and adjacent to Parcel E-2.

Another important geologic feature at Parcel E-2 is the distribution of the Bay Mud Aquitard. The Bay Mud is present over most of Parcel E-2, except in the northwest corner. In this location, saturated Artificial Fill material and Undifferentiated Upper Sand Deposits (the A-aquifer) directly overlie the Undifferentiated Sediments (the B-aquifer); as a result, the A- and B-aquifers are in hydraulic communication at this location. However, as discussed in Section 2.2.2.2, where the Bay Mud aquitard is present, potentiometric data indicate an upward flow potential between the A- and B-aquifers. Further, as shown in cross section G-G' (Figure 2-9), the presence of laterally continuous layers of silt and clay within the B-aquifer sediments serves to hydraulically isolate the uppermost portions of the B-aquifer (that are interconnected with the A-aquifer) from the lower portions of the B-aquifer. The Bay Mud Aquitard thickens away from upland areas in the northern portion of Parcel E-2, as shown on Figure 2-13.

As part of the subsurface investigations that were conducted to gather the geologic and hydrogeologic data for Parcel E-2, monitoring wells were installed across the parcel in the A-aquifer and uppermost B-aquifer zones, and the well identifications are designated by "A" and "B" suffixes, respectively. These well identifications are consistent with the hydrostratigraphic interpretations made on Figures 2-9, 2-10, and 2-11 (TtEMI, 2004c). The Navy is monitoring groundwater in the A-aquifer and uppermost B-aquifer under the BGMP. Groundwater monitoring has not been required in the lower B-aquifer zone because (1) the degree of contamination in the uppermost B-aquifer is much lower than that in the A-aquifer (see Section 5); (2) the uppermost portions of the B-aquifer (that are interconnected with the A-aquifer) are hydraulically isolated from the lower portions of the B-aquifer; and (3) there is an upward vertical flow potential from the uppermost B-aquifer to the A-aquifer (see Section 2.2.2.2). Groundwater monitoring has not been required in the Parcel E-2 bedrock WBZ because the bedrock is relatively deep (greater than 55 feet bgs in the northern portion of Parcel E-2 to greater than 200 feet bgs in the southeast portion of Parcel E-2). In addition, the potential for downward migration of contamination into the bedrock WBZ is low because site stratigraphy within the B-aquifer limits hydraulic communication between the uppermost B-aquifer zone and the lower B-aquifer zone.

The following subsections provide more detail on each of the geologic units at Parcel E-2 and their relationships to their corresponding hydrogeologic units.

2.2.1.1. Artificial Fill and Undifferentiated Upper Sand Deposits – The A-Aquifer

Cross-sections A-A' through J-J' (Figures 2-3 through 2-11) show varying thickness of heterogeneous Artificial Fill material at Parcel E-2 and adjacent portions of Parcel E and the UCSF compound. The Artificial Fill ranges from 17 feet thick at the southern and northern edges of the Parcel E-2 Landfill (cross sections A-A' and B-B') (Figures 2-3 and 2-4) to 34 feet thick in the eastern portion of the landfill (cross section E-E') (Figure 2-7). The fill material consists primarily of soil and construction debris used for land reclamation, as well as a range of solid waste, construction, and demolition debris deposited in the landfill. The soil portion of the fill varies in composition from fine-grained clay deposits to coarse gravel and larger boulders and has an irregular contact with the underlying units. The irregular contact may be attributed to both natural causes (such as former stream channels) and manmade causes (such as dredging or placement of heavier bedrock-derived fill and debris on softer Bay Mud and sand deposits).

Construction and demolition debris, consisting mainly of broken concrete, asphalt, and bricks used as riprap, is visible along the edge of the Landfill Area, where it meets the Shoreline Area. Much of this shoreline debris was removed in 2004 as part of shoreline cleanup (TtFW, 2004c). Ballast sand and fill soil are mixed with the construction debris in some areas (TtEMI, 2004f). In addition to construction and demolition debris, the landfill contains industrial wastes, sandblast waste, and domestic refuse.

Based on the geologic cross sections (Figures 2-3 through 2-8), the vertical extent of solid waste in the Parcel E-2 Landfill ranges from approximately 10 to 25 feet thick and has an overlying cover of 1 to 15 feet thick. The top elevation of solid waste in the landfill is estimated to vary between 2 to 18 feet above msl, and in most locations is present above the water table. The bottom of the solid waste in the landfill extends beneath the water table, and is estimated to vary in elevation between 3 feet above msl and 13 feet below msl (cross section D-D') (Figure 2-6). The extent of the contiguous solid waste in the landfill is described in detail in Section 4.2.2.

Cross sections B-B', D-D', and E-E' (Figures 2-4, 2-6, and 2-7) show a discontinuous, undifferentiated sand unit present beneath the Artificial Fill in the northern portion of Parcel E-2. This Undifferentiated Upper Sand unit consists mostly of fine sand with occasional silty and clayey sands with marine shells. It ranges from 0 to 14 feet thick and generally overlies the Undifferentiated Sediments unit or Bay Mud, but in localized areas is interbedded with the Bay Mud (TtEMI, 2003e and 2004c).

The A-aquifer primarily consists of the heterogeneous, unconsolidated Artificial Fill material, with portions of the Undifferentiated Upper Sand Deposits and localized areas of the Bay Mud interbedded with Undifferentiated Upper Sand deposits. Cross sections H-H' (Figure 2-10) and J-J' (Figure 2-11) show that the lateral continuity of the A-aquifer is disrupted by numerous low-permeability zones because of the heterogeneous nature of the Artificial Fill (TtEMI, 2004c). The A-aquifer directly overlies the B-aquifer in the northwest corner of Parcel E-2, where the Bay Mud aquitard is absent (Figures 2-9, 2-10, and 2-13). Cross section C-C' (Figure 2-5) shows that, north of Parcel E-2, along Crisp Avenue, the A-aquifer lies directly on the bedrock and the weathered bedrock beneath the water table is considered to belong to the A-aquifer.

The A-aquifer is approximately 5 to 15 feet thick from north to south across Parcel E-2 and is generally unconfined (TtEMI, 2004c); however, semiconfined conditions exist in areas where fine-grained fill material overlies coarser-grained fill material or Undifferentiated Upper Sand deposits (cross sections H-H' and J-J') (Figures 2-10 and 2-11). Groundwater flow directions in the A-aquifer are discussed in Section 2.2.2.

2.2.1.2. Bay Mud – The Aquitard

Bay Mud is present across most of Parcel E-2 and consists of Holocene, estuarine, grayish-green sediments that are almost exclusively composed of silt and clay (TtEMI, 2004c). The aquitard has an irregular upper surface, as discussed in Section 2.2.1.1. The Bay Mud thickens to the south and is over 45 feet thick near the shoreline at the southern end of Parcel E-2 (TtEMI, 2003e). As Figure 2-13 shows, the Bay Mud is absent in the northwest corner of Parcel E-2 and thickens to greater than 10 feet across most of Parcel E-2 (to a maximum of 39 feet thick in the southeast portion of Parcel E-2). The Bay Mud acts as an aquitard between the A- and B-aquifers where it is sufficiently thick (typically 1 to 2 feet). Fine-grained fill material that underlies the A-aquifer may also act as an aquitard (TtEMI, 2004c).

As discussed in Section 2.2.1, the Bay Mud aquitard is absent in the northwest corner of Parcel E-2; as a result, the A- and B-aquifers are interconnected. However, the vertical flow potential is upward in this area, and the presence of laterally continuous layers of silt and clay within the B-aquifer sediments throughout Parcel E-2 serves to hydraulically isolate the uppermost portions of the B-aquifer (that are interconnected with the A-aquifer) from the lower portions of the B-aquifer.

2.2.1.3. Undifferentiated Sediments – The B-Aquifer

The Undifferentiated Sediments consist of interbedded clay, silt, and sand and are the oldest unconsolidated sedimentary unit in Parcel E-2. The Undifferentiated Sediments unconformably overlie the Franciscan Complex Bedrock, and range from 45 feet thick in the northern part of Parcel E-2 to over 235 feet thick in the southern portion of Parcel E-2 (TtEMI, 2003e). Cross sections G-G' and J-J' (Figures 2-9 and 2-11) show that the Undifferentiated Sediments consist of two to three relatively thick (approximately 30- to 40-foot), laterally continuous layers of sand and silty or clayey sand, which are separated by laterally continuous layers of silt or clay that range from 8 to 120 feet thick (TtEMI, 2004c).

The B-aquifer is present in the permeable portions of the Undifferentiated Sediments, which, as described above, consists of two to three permeable layers separated by thick silt or clay layers. The uppermost

B-aquifer is semiconfined and separated from the A-aquifer by an aquitard, except in the northwest corner of Parcel E-2 (TtEMI, 2004c).

2.2.1.4. Franciscan Complex Bedrock – The Bedrock Water-Bearing Zone

Bedrock in Parcel E-2 consists of the Franciscan Complex, with serpentinite as the most common component. Serpentine bedrock is often associated with metamorphic basalt called "greenstone," which has a distinctive green color. Pockets of greywacke sandstones occur in some areas (TtEMI, 2004c). Figure 2-12 shows where serpentinite bedrock outcrops north of Parcel E-2. From the northern part of Parcel E-2, the bedrock plunges to the west and south. The depth to bedrock ranges from approximately 55 feet bgs in the northern part of Parcel E-2 to greater than 280 feet bgs in the southern part of Parcel E-2.

As discussed in Section 2.2.1, the upper weathered portions of the bedrock that directly underlie A- or B-aquifer sediments are considered part of the overlying aquifer. The highly weathered bedrock has low hardness, and has been described as both crumbling easily to sand-sized grains and as having weathered to clay (TtEMI, LFR, and U&A 1997; TtEMI, 2004c). Borings logs for gas monitoring probes (GMPs) installed in the upper weathered bedrock underlying Crisp Avenue (located approximately 150 feet north of Parcel E-2) demonstrate this variability. The portions of saturated bedrock that are not in direct contact with the A- or B-aquifers are hydrostratigraphically classified as the bedrock WBZ (TtEMI, 2004c). Flow in the bedrock WBZ generally occurs in localized, discontinuous fractures located below the upper portions of bedrock (TtEMI, LFR, and U&A, 1997).

2.2.2. Groundwater Flow

Groundwater flow patterns in the A-aquifer are regularly evaluated by collecting water level measurements at monitoring wells installed throughout Parcel E-2 and generating groundwater elevation maps as part of the BGMP. Construction details for the Parcel E-2 monitoring wells are summarized in Appendix J3. Historic groundwater elevations are presented in Appendix J4. A-aquifer groundwater elevations are measured using a methodology designed to reduce the influence of tidal effects on the general definition of the potentiometric surface; the methodology is described in the sampling and analysis plan for the BGMP (CE2-Kleinfelder Joint Venture, 2009c). Additionally, groundwater flow patterns within the uppermost B-aquifer and tidal influenced zone (TIZ) of the A-aquifer have been evaluated during previous investigations at the parcel. The following subsections discuss the groundwater flow patterns of these aquifers, as well as groundwater recharge and discharge for the A-aquifer and uppermost B-aquifer.

2.2.2.1. Horizontal Groundwater Flow

Across most of Parcel E-2, groundwater in the A-aquifer flows south toward the bay; however, flow in the northeast portion of Parcel E-2 flows east toward a groundwater depression that is east of the landfill, near the boundary between Parcels G and E (CE2-Kleinfelder Joint Venture, 2007f, 2008a, and 2008d). This groundwater depression is most likely the residual effect of groundwater infiltrating damaged sanitary sewer lines during pumping at a nearby lift station. The sanitary sewer lift station, located at the former Parcel A, ceased operation in May 2007. The lateral extent of the groundwater depression had decreased from approximately 73 acres in May 2007 to less than 0.1 acre in March 2009 (CE2-Kleinfelder Joint Venture, 2009d). The potentiometric surfaces shown on Figures 2-14 and 2-15 (CE2-Kleinfelder Joint Venture, 2007f and 2008a) do not incorporate removal of tidal effects; however, past tidal studies have shown that the general geometry of the potentiometric surface within the TIZ can be accurately represented without filtering out tidal effects (TtEMI, 2004c). Section 2.2.4 presents a more thorough discussion of tidal effects.

Other buried utility lines located below the groundwater table may also act as preferential groundwater flow pathways. As shown on Figures 2-14 and 2-15, sections of the storm drain system in adjacent Parcel E are submerged below the groundwater table and appear to be affecting A-aquifer flow patterns south of Building 810. The Navy is in the process of removing the existing sanitary sewer and storm drain lines across HPS. The potentiometric surface of the A-aquifer continues to be monitored quarterly under the BGMP to track possible changes in flow patterns of the A-aquifer.

Groundwater elevations in the uppermost B-aquifer, as measured in August 2007, are presented on Figure 2-16 (CE2-Kleinfelder Joint Venture, 2008a). Based on the groundwater elevations in the limited number of wells shown on Figure 2-16, groundwater in the uppermost B-aquifer flows to the southeast across most of Parcel E-2. B-aquifer groundwater elevations are monitored under the BGMP on a quarterly basis (CE2-Kleinfelder Joint Venture, 2008a and 2008d).

2.2.2.2. Vertical Groundwater Flow Potential

Figure 2-17 illustrates vertical flow potential by presenting hydrographs for well pairs screened in the A-aquifer and uppermost B-aquifer. Based on available water level data from 2004 to 2008, the vertical component of groundwater flow potential between the A-aquifer and the uppermost B-aquifer is upward at these well pairs (Figure 2-17). The available data suggest that, in addition to the presence of the Bay Mud aquitard, potential downward migration of contaminated groundwater from the A- to B-aquifer is limited by the upward groundwater flow potential (from the B- to A-aquifer).

2.2.2.3. Groundwater Recharge and Discharge

Groundwater recharge to the A-aquifer at Parcel E-2 is affected by vertical and lateral infiltration from within Parcel E-2, as well as groundwater flow from land upgradient of Parcel E-2. Recharge may also be contributed by leaking utility lines. Higher groundwater levels exist during the rainy season. Groundwater elevations measured in Parcel E-2 wells in March 2007 were on average 0.9 foot higher than in August 2007. A-aquifer groundwater discharge over the northeast portion of Parcel E-2 is directed eastward across Parcel E toward a groundwater depression near the Parcel E and Parcel G boundary. As discussed in Section 2.2.2.1, deactivation of the sanitary sewer lift station has decreased the lateral extent of the groundwater depression from approximately 73 acres to 0.1 acre over a 21-month period (CE2-Kleinfelder Joint Venture, 2009d). The Navy continues to remove the existing sanitary sewer and storm drain lines across HPS, and the effect of this activity is being evaluated as part of the BGMP quarterly water level measurements. Groundwater near the Parcel E-2 shoreline discharges toward the bay.

The area hydraulically upgradient of Parcel E-2 is the primary source of recharge to the B-aquifer. This area consists of non-Navy industrial property to the west and northwest. The recharge source is groundwater flowing horizontally into the B-aquifer. The B-aquifer is hydraulically connected to and discharges to permeable zones underlying the bay.

2.2.2.4. Seasonal Groundwater Effects

Recent groundwater data for Parcel E-2 (four quarters from 2007 and the first quarter 2008) were evaluated as part of this RI/FS Report to assess seasonal effects in groundwater flow patterns or gradients (CE2-Kleinfelder Joint Venture, 2007f, 2008a, and 2008d). A-aquifer groundwater levels were highest in March 2007 (Figure 2-14), following the wet winter season, and lowest in August 2007, representing dry season conditions (Figure 2-15). Groundwater gradients measured across Parcel E-2 were somewhat lower in March 2007 (average of 0.014) than they were in August 2007 (average of 0.021). The overall direction of groundwater flow was consistent from season to season, with the primary seasonal difference being the somewhat shallower gradients across the landfill mass, with steeper gradients along the boundaries of the landfill area during the dry season (June and August) than during the wet season (March). Groundwater gradients are steepest on the south side of the landfill mass (toward the bay) and shallowest on the eastern side (toward Parcel E). Groundwater levels in the B-aquifer are slightly higher during the wet season as compared with the dry season (Figure 2-17); however, B-aquifer groundwater flow patterns and gradients do not appear to be significantly affected by the wet and dry seasons.

2.2.3. Hydraulic Characteristics

Constant rate aquifer tests were performed at various A- and B-aquifer wells during the Parcel E RI (TtEMI, LFR, and U&A, 1997). Additionally, slug tests were performed in Parcel E-2 during the Parcel E RI, and in conjunction with an evaluation of the groundwater extraction system (IT, 2001). Figure 2-18 shows the constant rate and slug test locations in Parcel E-2. Based on the slug test results shown in Table 2-1, hydraulic conductivity within the A-aquifer varies significantly across the site, ranging from 0.14 to 130 feet per day. The highly variable hydraulic conductivity is likely because slug tests were primarily conducted on wells screened within the heterogeneous artificial fill material.

In addition, existing data from constant-rate aquifer pumping tests (TtEMI, LFR, and U&A, 1997; TtEMI, 2004c) were evaluated. Because they occur over a longer time period, constant-rate tests stress a much larger volume of the water-bearing units than do slug tests; therefore, they represent a larger volume of the aquifer. Table 2-2 presents the results of constant rate aquifer tests performed at Parcel E-2; hydraulic conductivities using this method ranged from 3.4 to 1,440 feet per day.

For this project, hydraulic conductivity values estimated from constant-rate aquifer tests are considered most representative of site conditions. Hydraulic conductivity values obtained from the constant rate aquifer tests were used, in conjunction with the representative hydraulic gradient calculated using data from the June 2002 tidal study, to estimate A-aquifer groundwater flow velocities using the following equation:

$$V = Ki / \eta_e \qquad (2\text{-}1)$$

where:

v	=	Groundwater flow velocity (feet per day)
K	=	Hydraulic conductivity (feet per day)
i	=	Hydraulic gradient (dimensionless)
η_e	=	Effective porosity (dimensionless)

Using the range of hydraulic conductivity values from constant-rate aquifer tests of 3.4 to 1,440 feet per day (Table 2-2), a hydraulic gradient of 0.002 (Figure 3-12 of Parcel E Groundwater Summary Report; TtEMI, 2004c), and an assumed A-aquifer effective porosity of 0.25[3], the groundwater flow velocity in the A-aquifer ranges from 0.03 to 12 feet per day (TtEMI, 2004c). Using the same parameters, but substituting a hydraulic gradient of 0.014 (based on representative gradients measured in March 2007), the groundwater flow velocity in the A-aquifer ranges from 0.2 to 81 feet per day.

[3] Two soil samples were collected for effective porosity analysis during the drilling of IR03MW372A (TtEMI, 2004c). An effective porosity of 0.25 is considered "typical" of the A-aquifer (TtEMI, 2004c).

2.2.4. Tidal Effects

Tidal studies performed during the Parcel E RI and the Phase III GDGI have characterized the extent of the A-aquifer TIZ, which is defined as the area where the maximum tidal fluctuation exceeds 0.10 foot in the A-aquifer (TtEMI, 2004c). The A-aquifer TIZ in Parcel E-2 extends approximately 100 to 300 feet inland from the Bay. The data are insufficient to estimate the boundary of the uppermost B-aquifer TIZ, but B-aquifer well IR01MW17B (in the northwest corner of Parcel E-2 about 555 feet from the bay) exhibited stronger tidal responses than nearby A-aquifer well IR01MW16A. This stronger tidal response is expected in the semiconfined uppermost B-aquifer compared with the generally unconfined A-aquifer, because pressure changes in the aquifer associated with the tidal water level changes in the bay are more readily transmitted through confined aquifers than unconfined aquifers (TtEMI, 2004c).

Additional tidal influence parameters, including tidal efficiency and time lag, were quantified during the Phase III GDGI and are presented on Figure 2-19 (TtEMI, 2004c). Tidal efficiency was estimated using the following equation:

$$eff = h_w / h_o \qquad (2\text{-}2)$$

where:

eff	=	Tidal efficiency (dimensionless)
h_w	=	Difference between groundwater elevation in a monitoring well observed over a period in time, usually between subsequent low and high tides (feet)
h_o	=	Difference between water elevation in the bay observed over the same tidal cycle as h_w (feet)

Tidal efficiency ranges from 0.3 to 6 percent in A-aquifer wells in Parcel E-2. Tidal efficiency is generally higher near the bay and decreases with distance inland. This conclusion is generally supported by the observation of the maximum tidal efficiency at A-aquifer well IR01MWI-8 (located 70 feet from the bay) and the minimum tidal efficiency at A-aquifer well IR01MW16A (located 605 feet from the bay). However, A-aquifer tidal efficiency data from elsewhere at Parcel E-2 indicate no clear correlation between distance from the bay and tidal efficiency. Variations in tidal efficiency are most likely a result of the heterogeneous nature of the A-aquifer.

The Phase III GDGI tidal influence study also evaluated the potential for ruptured utility lines to affect the groundwater level response to the tide. The study did not reveal any potential preferential pathways within the A-aquifer TIZ at Parcel E-2. This finding is not surprising due to the low number of submerged utility lines present in Parcel E-2.

The Phase III GDGI also evaluated the extent of the tidal mixing zone (TMZ) in the A-aquifer. The TMZ is the portion of the A-aquifer within which the bay water flows in and out during a tidal cycle so that groundwater physically mixes with the bay water. The TMZ is not the same as the TIZ, which is defined by groundwater level (pressure) responses to tidal fluctuations in the bay. The tidal mixing study involved collection of specific conductance (a temperature-independent surrogate for salinity derived from continuous conductivity and temperature measurements) data over time from wells located in IR Site 02 and IR Site 15 at Parcel E. The study found that tidal mixing extended inland greater than 70 feet, but less than 335 feet from the bay. The extent of tidal mixing was greater than predicted using a simple hydraulic model, and could be attributed to a submerged storm drain line that possibly provided a direct connection to saline bay water (TtEMI, 2004c).

2.2.5. Total Dissolved Solids

TDS concentrations in groundwater are an important measure of groundwater quality and are a primary criterion in determining the beneficial uses of groundwater (Section 2.2.6). As presented in the Parcel E Groundwater Summary Report for the Phase III GDGI (TtEMI, 2004c), TDS concentrations typically exceed 3,000 milligrams per liter (mg/L) in the A-aquifer across most of Parcel E-2, and the highest TDS concentrations (greater than 10,000 mg/L) in the A-aquifer are encountered along the Parcel E-2 shoreline. In the southeast corner of Parcel E-2, an area where TDS concentrations are less than 3,000 mg/L is surrounded by TDS concentrations exceeding 3,000 mg/L. This area coincides with a large groundwater mound believed to be caused by leaking water lines in the south-central portion of the Parcel E shoreline (TtEMI, 2004c).

Limited TDS data are available for the uppermost B-aquifer across Parcel E-2. In June 2002, maximum B-aquifer TDS concentrations in Parcel E-2 ranged from 1,700 to 4,610 mg/L (TtEMI, 2004c).

Earlier definitions of the TIZ, such as those in the Parcel E RI Report (TtEMI, LFR, and U&A, 1997), included high TDS concentrations (greater than 10,000 mg/L) in groundwater. Inclusion of the TDS concentration in the TIZ definition appears to have given the impression that high TDS concentrations up to 400 feet inland from the bay are caused by tidal mixing. As discussed in Section 2.2.4, tidal mixing appears to occur at some inland locations and is believed to be attributable to preferential pathways such as ruptured and submerged storm drain lines. High TDS concentrations inland could also be the result of a wedge of saline water that normally lies beneath the freshwater portion of an aquifer that is near a body of seawater. A saline wedge does not move laterally hundreds of feet with the tide; it is a stable feature in equilibrium with the fresh water above (TtEMI, 2004c).

2.2.6. Groundwater Beneficial Reuse

According to the RWQCB Basin Plan, groundwater at Parcel E-2 has the following potential beneficial uses (RWQCB, 2007a):

- Agricultural water supply
- Industrial service and process water supply
- Municipal and domestic drinking water supply

Groundwater at Parcel E-2 is unlikely to be used for agricultural and industrial purposes due to generally high TDS, chloride, salinity, specific conductance, and hardness values in the A-aquifer and uppermost B-aquifer (see data in Appendix G of TtEMI, 2004c). According to the Basin Plan, site-by-site determinations of the freshwater replenishment beneficial use will be made. Freshwater replenishment has been determined to be a beneficial use of the groundwater at Parcel E-2; Appendix M evaluates the potential for chemicals in groundwater to pose a risk to aquatic life in the bay. Appendix I evaluates the beneficial uses of groundwater at Parcel E-2, with a specific focus on evaluating use of the A- and B-aquifers at Parcel E-2 as potential drinking water sources. The following subsections summarize the findings of this evaluation.

2.2.6.1. A-Aquifer Evaluation for Federal Criteria

Federal groundwater classification criteria identify three classes of groundwater (EPA, 1986). Class I groundwater is an irreplaceable source of drinking water or is ecologically vital. Class II groundwater is a current or potential source of drinking water that has other beneficial uses. Class III groundwater is not a potential source of drinking water and is of limited beneficial use. EPA considers groundwater to be Class I or Class II if the following criteria are met:

- The TDS concentration is less than 10,000 mg/L
- A minimum well yield of 150 gallons per day (gpd) or 0.104 gallon per minute is achievable

Transmissivities measured at Parcel E-2 during the RI (Table 2-2) suggest that the minimum well yield of 150 gpd would be met for the A-aquifer. Therefore, the classification of the A-aquifer relative to federal criteria focuses on measured TDS concentrations. Figure 2-20 presents the maximum historical TDS concentrations (from data collected through October 2002) detected in A-aquifer groundwater monitoring wells at Parcel E-2, along with contours for the federal TDS criteria. As shown on Figure 2-20, Class II groundwater exists throughout most of Parcel E-2 A-aquifer.

Appendix I evaluates various site-specific factors (SSF) to determine if conditions other than TDS concentrations affect the potential for Class II A-aquifer groundwater at Parcel E-2 to be used as a drinking water source. The NCP preamble allows for the application of SSFs to determine appropriate remediation goals for Class I and II groundwater. As outlined in Appendix I, a range of other SSFs make use of A-aquifer groundwater for water supply extremely unlikely. Principal among these are:

- Insufficient aquifer thickness to provide adequate supply
- Depth to groundwater too shallow to support a sanitary seal and adequate screened interval
- Lack of historical and current precedents for use of HPS groundwater for public water supply
- Existence of local and state institutional controls that prohibit or severely restrict locations where new potable wells can be installed
- Poor quality of underlying B-aquifer relative to drinking water standards

Considering these factors together, the weight of evidence indicates that the Class II A-aquifer at Parcel E-2 is not a potential source of water for municipal or domestic water supply.

2.2.6.2. A-Aquifer Evaluation for State Criteria

Under State Water Resources Control Board (SWRCB) Resolution No. 88-63, all groundwater is considered potentially suitable for municipal or domestic supply unless at least one of the following conditions applies (SWRCB, 1988):

- The TDS concentration exceeds 3,000 mg/L and the groundwater is not reasonably expected by RWQCB to supply a public water system
- The groundwater is contaminated, either by natural processes or by human activity, to the degree that it cannot reasonably be treated for domestic use
- The water source does not provide sufficient water to supply a single well capable of producing an average, sustained yield of 200 gpd

In response to a request by the Navy (2003), the RWQCB determined that the A-aquifer at HPS is not suitable or potentially suitable as a municipal or domestic water supply, and meets exemption criteria in SWRCB Resolution 88-63 and RWQCB Resolution 89-39 (RWQCB, 2003c). This determination is based on the following factors:

- TDS concentrations in A-aquifer groundwater exceed 3,000 mg/L
- Artificial fill composes most of the A-aquifer
- Naturally occurring dissolved metals concentrations have been estimated (Hunters Point groundwater ambient levels [HGAL]), and some of these metals concentrations exceed maximum contaminant levels (MCLs) for drinking water when the metal is at or below its HGAL
- There is no historical, present, or planned future use of groundwater at HPS
- Well construction requirements prohibit water supply wells in most parts of HPS
- Pumping would cause saltwater intrusion in areas where potable wells could conceivably be installed

2.2.6.3. B-Aquifer Evaluation

TDS data are available for the six wells installed in the uppermost B-aquifer in Parcel E-2, and maximum TDS concentrations in these wells ranged from 1,600 to 5,120 mg/L. Based on available TDS data, the B-aquifer at Parcel E-2 would be considered suitable as a potential drinking water source, and the evaluation of SSFs in Appendix I reveals that the B-aquifer in Parcel E-2 has moderate potential to be used as a drinking water source. Considering this conclusion and past agreements with the BCT on the HHRA, the groundwater ingestion pathway is included in the risk assessment for the B-aquifer. This assumption provides an additional layer of conservatism with respect to the protection of human health at Parcel E-2.

2.2.6.4. Bedrock Water-Bearing Zone Evaluation

As discussed in Section 2.2.1, groundwater monitoring has not been required in the Parcel E-2 bedrock WBZ because the bedrock is relatively deep (greater than 55 feet bgs in the northern portion of Parcel E-2 to greater than 200 feet bgs in the southeast portion of Parcel E-2). Therefore, no direct data are available to assess the water quality or yield of the bedrock WBZ underlying Parcel E-2 relative to federal and state criteria.

2.3. HYDROLOGY

Precipitation is the main source of surface water runoff at HPS. Surface water runoff at HPS is greatest in the winter months (November through April), when rainfall often exceeds 4 inches per month. Precipitation is less than 0.1 inch per month from June through September, resulting in minimal runoff. Precipitation data from an on-site meteorological station are shown on Figure 2-21. In addition to rainfall, the irrigation system for the interim landfill cap at Parcel E-2 is another potential source of surface water runoff. The irrigation system could potentially generate runoff if used excessively during dry months to maintain vegetation; however, the system is operated and maintained so that excessive watering does not occur (ITSI, 2006h, 2007d, 2008d, 2010d, and 2010e).

As discussed in Section 1.6.2, surface water runoff at the landfill is managed in accordance with the SWDMP (MARRS and MACTEC, 2009b), which complies with the General Permit of the National Pollutant Discharge Elimination System (NPDES), as administered by the SWRCB. Monitoring is performed in accordance with the SWDMP, and various BMPs described in the SWDMP are used to limit erosion or unwanted discharges from the site (MARRS and MACTEC, 2009b). Surface water drainage patterns at Parcel E-2 and engineered BMPs are shown on Figure 2-22 and described below.

In the western and northwestern portion of Parcel E-2, runoff is controlled by drainage channels constructed along the western perimeter of Parcel E-2. The channels direct runoff south and discharge indirectly to the bay through low-lying seasonal wetlands in the Panhandle Area southwest of the landfill.

Stormwater discharge is monitored at the point where the western perimeter channel discharges into the Panhandle Area (MARRS and MACTEC, 2009b).

In the northeastern portion of Parcel E-2 (and portions of the UCSF property), runoff is controlled by drainage channels that direct runoff into one of two catch basins (Figure 2-22). Stormwater then flows east through a 12-inch-diameter polyvinyl chloride (PVC) pipe and discharges into the HPS storm sewer system, which ultimately discharges into the bay. Stormwater discharge is monitored at both catch basins (MARRS and MACTEC, 2009b).

In the eastern portion of Parcel E-2 (including the eastern portion of the interim landfill cap), runoff flows south into a low-lying area south of the interim landfill cap (Figure 2-22). This area was excavated and revegetated following the removal action at the PCB Hot Spot Area (TtECI, 2007a), as discussed in Section 3.8.8. The vegetation helps limit sediment runoff. In addition, the drainage swale at the southeast portion of the landfill, which diverts runoff from the eastern portion of the cap to the bay, was restored following the removal action (Figure 2-22).

In the central portion of Parcel E-2, most runoff flows to a riprap-lined swale in the center of the interim landfill cap and then discharges into the bay at the southern edge of the interim cap. The drainage structures in Parcel E-2 are presently capable of handling runoff from the 100-year, 24-hour storm event (estimated at 4 inches). To limit erosion, vegetation and other BMPs (such as silt fences, hay bales, fiber rolls, gravel or sandbags, and berms) have been established at Parcel E-2. Surface water runoff from Parcel E-2 will be controlled and monitored in accordance with the existing SWDMP until implementation of the final remedy for Parcel E-2 (MARRS and MACTEC, 2009b).

2.4. ECOLOGY

The ecology of Parcel E includes terrestrial habitat, aquatic environments, and transitional wetlands. All of these ecological areas have been disturbed by human activities such as excavation, filling, and development (Harding Lawson Associates [HLA], 1991). Habitat data from the Phase 1A ecological risk assessment (ERA) were used with data from a resurvey of Parcels E and E-2 in February 1997. The field survey results delineated the terrestrial habitats (industrial, ruderal, and non-native annual grassland) and the wetland and intertidal habitats (TtEMI, LFR, and U&A, 1997). In 2001 and 2002, ecological surveys were performed in the wetland and intertidal habitats at Parcel E-2 (TtEMI, 2003d; SulTech, 2007, Appendix G to this report), and are discussed in Sections 2.4.2 and 2.4.3 below. In 2004, a biological assessment was performed to support the removal actions at the Metal Slag Area and PCB Hot Spot Area (TtFW, 2004a).

2.4.1. Terrestrial Habitat

The onshore environment at Parcels E and E-2 is significantly less developed than other areas at HPS and consists primarily of industrial and ruderal (disturbed) habitat. These habitats are typified by paved and fenced areas, abandoned lots, and other disturbed areas. Poorly developed soil horizons, low organic soil content, soil contamination, and shallow saline groundwater limit the composition and abundance of the terrestrial vegetation community (TtEMI, LFR, and U&A, 1997). Plant species present in Parcel E-2 are opportunistic weeds and herbaceous species adapted to arid conditions and poor soil quality (HLA, 1991). Although the onshore environment at Parcel E-2 supports few plant species, birds, mammals, and reptiles have been observed in this parcel. The habitat in Parcel E-2 provides food for granivorous, omnivorous, and scavenging birds observed at HPS (HLA, 1991). Burrows have been observed in Parcel E-2 and are suspected to have been created by small mammals (PRC Environmental Management, Inc. [PRC], 1994). The terrestrial habitats at Parcel E-2 are summarized in the following sections. Figure 2-23 presents the terrestrial ecological habitat at Parcel E-2.

2.4.1.1. Industrial Habitat

Industrial areas present within the East Adjacent Area consist of artificial structures, including paved areas (such as roadways, parking lots, and old foundations), packed earth, and other similar areas. Industrial areas may provide shelter for wildlife species but lack the vegetative component essential to support most wildlife. Common bird species such as barn swallows (*Hirundo rustica*), mourning doves (*Zenaida macroura*), song sparrows (*Melospiza melodia*), and barn owls (*Tyto alba*) are known to use abandoned industrial structures adjacent to Parcel E-2 for nesting. Raptors such as the red-tailed hawk (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*) may also use these areas to perch. Small mammals such as the house mouse (*Mus musculus*), deer mouse (*Peromyscus maniculatus*), and Norway rat (*Rattus norvegicus*) may shelter in abandoned structures adjacent to Parcel E-2. Although industrial structures may provide shelter, they do not provide a food source. Therefore, animals are expected to forage in other less disturbed habitat types in Parcel E-2 where food sources are present (TtEMI, LFR, and U&A, 1997).

2.4.1.2. Ruderal Habitat

The ruderal habitat present within the Panhandle Area and East Adjacent Area (and a small portion of the Landfill Area) consists of areas that have been "altered" and is typified by abandoned lots, eroding pavement, and other marginal zones. Most of the habitat is undeveloped and often cluttered with debris such as concrete, scrap iron, and other discarded materials. Ruderal areas are dominated by aggressive non-native plants. Common plant species found in the ruderal habitat at Parcel E-2 include a predominance of fennel (*Foeniculum vulgare*), black mustard (*Brassica nigra*), barley (*Hordeum murinum*), cultivated oat (*Avena sativa*), plantain (*Plantago sp.*), and perennial ryegrass (*Lolium perenne*) (TtFW, 2005b). In addition, native shrub species such as coyote brush (*Baccharis pilularis*) and non-native ornamental tree species such as Peruvian pepper tree (*Schinus molle*) and green wattle (*Acacia decurrens*) occur in disturbed areas (TtEMI, LFR, and U&A, 1997).

The ruderal areas throughout Parcel E-2 provide habitat for a variety of bird species, including the mourning dove, rock dove (*Columba livia*), house finch (*Carpodacus mexicanus*), savannah sparrow (*Passerculus sandwichensis*), song sparrow, western meadowlark (*Sturnella neglecta*), and northern mockingbird (*Mimus polyglottos*). These bird species were observed during the February 1997 field survey. Birds of prey such as the red-tailed hawk and American kestrel were also observed at Parcel E-2 during the 1997 survey (TtEMI, LFR, and U&A, 1997).

Small mammals observed within the ruderal habitat include the black-tailed jackrabbit (*Lepus californicus*) and California ground squirrel (*Spermophilus beecheyi*). Other mammals that may occur within this habitat include the deer mouse, Botta's pocket gopher (*Thomomys bottae*), raccoon (*Procyon lotor*), and red fox (*Vulpes vulpes*). Ruderal habitat at Parcel E-2 may provide a home for the western fence lizard (*Sceloporus occidentalis*), gopher snake (*Pituophis melanoleucus*), and garter snake (*Thamnophis sirtalis*) (HLA, 1991; PRC, 1994). The bird, mammal, and reptile species noted above are a potential prey base for predatory birds observed over Parcel E-2, such as the red-tailed hawk and American kestrel.

2.4.1.3. Non-Native Annual Grassland Habitat

Non-native annual grasslands, present within the Landfill Area and Panhandle Area, are dominated by annual grass species such as ripgut brome, perennial ryegrass, wild oat *(Avena fatua*), and barley. Although these grasses may occur in the other habitat types, non-native annual grassland is characterized by approximately 100 percent grass coverage with little or no shrub component (TtEMI, LFR, and U&A, 1997).

The vegetative cover on the interim landfill cap and surrounding areas within the Landfill Area consists of Zorro annual fescue *(Vulpia myuros)*, Blando brome *(Bromus hordeaceus)*, Rose clover *(Trifolium hirtum)*, Gulf annual ryegrass *(Lolium multiflorum)*,and mixed California wildflowers (TtEMI, 2005b). The vegetative cover is inspected on a regular basis to ensure that proper vegetation growth prevents soil erosion and does not damage the geosynthetic membrane. Inspection for and removal of deep-rooted, invasive species is also performed on a regular basis (TtEMI, 2003b).

The herbaceous vegetation of grassland habitat provides refuge, as well as foraging and nesting habitat, for many wildlife species. Grassland habitats likely support fauna similar to ruderal areas, including bird species such as the meadowlark, song sparrow, red-tailed hawk, northern harrier (*Circus cyaneus*, a California species of special concern [CSC]), and the American kestrel. Additionally, the burrowing owl (*Athene cunicularia*), also a CSC, has been sighted in the past at HPS and may use grassland habitat at Parcel E-2 for nesting and foraging. Small mammals commonly found in grassland habitat include the black-tailed jackrabbit, California ground squirrel, Botta's pocket gopher, and the deer mouse. Other mammals, such as the black-tailed deer (*Odocoileus hemionus*) and red fox, likely forage in the grassland habitat (TtEMI, LFR, and U&A, 1997).

2.4.2. Wetland Habitat

Wetlands studies performed at HPS, including Parcel E-2, are summarized in the Delineation and Functions and Values Assessment (TtEMI, 2003d; Appendix D to this report). This subsection summarizes information provided in that report.

In October 2001, the Navy delineated wetland areas in Parcels B, E, and E-2. Figure 2-23 presents the wetland habitat at Parcel E-2. The wetlands delineation was conducted using technical guidelines and methods described in the U.S. Army Corps of Engineers' (USACE) Wetland Delineation Manual (USACE, 1987b). The methodology consisted of visually observing soil, vegetation, and hydrology characteristics along a transect line perpendicular to site contours and across potential wetlands and uplands. Soil was characterized for each transect by digging 1-foot-diameter test pits and inspecting the upper 1.5 feet of soil for hydric soil indicators. Vegetation was characterized according to the "National List of Plant Species that Occur in Wetlands: 1996 National Summary" (U.S. Fish and Wildlife Service, 1996). Hydrology was assessed by observing wetland hydrologic indicators such as watermarks, drift lines, sediment deposits, and drainage patterns. The Delineation and Functions and Values Assessment was submitted to the USACE for review to ensure technical adequacy and compliance with all substantive requirements. The USACE responded on July 30, 2003, that it had no comments.

The two wetland areas identified at Parcel E-2 are summarized below.

Intertidal wetlands along the shoreline: Approximately 3.2 acres of intertidal and saline emergent wetlands along the Parcels E and E-2 shoreline were identified. Of the 3.2 acres, 2.38 acres are in Parcel E-2. The wetlands are bounded by a riprap wall and San Francisco Bay. The riprap wall ranges from 10 to 30 feet wide and 3 to 15 feet high. The ground surface in the intertidal wetlands areas slopes gently downward from the base of the riprap wall to the shore of the bay. Most of the intertidal wetlands are part of the Shoreline Area, the intertidal zone that is being evaluated in conjunction with Parcel F. A portion of the intertidal wetlands is collocated with the Parcel E-2 Landfill and will be affected by remedial activities.

An inland seasonal freshwater wetland in the Panhandle Area: A 1.3-acre seasonally ponded area was identified in the Panhandle Area of Parcel E-2. The wetland consists of a stormwater drainage ditch and a low-lying area where stormwater runoff ponds during the wet season. The wetland is bordered by the Landfill Area to the northeast, the Bayview/Hunters Point district to the west and northwest, and the riprap wall to the south. The wetland receives runoff from the north through a drainage ditch. During storm events, some tidal influx may occur through a culvert in the south berm. The bay-side opening of the drainage culvert has a flap to prevent tidal inflow, but the flap has been rusted open for some time.

The following subsections generally describe the functions and values characteristics of the wetlands at Parcel E-2, as well as potential mitigation measures that could be implemented to mitigate damage caused to these wetlands as part of ongoing or future remedial actions.

2.4.2.1. Functions and Values of Wetland Areas

A functions and values assessment of the wetlands was conducted in December 2001, in conjunction with the wetlands delineation, and was followed by a confirmatory assessment in April 2002. The functions and values assessment followed the methods and guidance in USACE's wetland evaluation technique (USACE, 1987a).

The primary features of the *tidal wetlands* that contribute to the overall function of the system include the presence of known contaminants, vegetation cover, and location along the Pacific Flyway. The prime function of these wetlands consists of a low ability to retain sediments and toxicants and to produce nutrients. The tidal system and substrate type reduce the groundwater recharge and discharge ability of this wetland.

The features of the *seasonal freshwater wetland* that contribute to the overall function of the system include a stormwater ditch that drains to the wetland, a drainage culvert that drains the wetland, the watershed, infrequent tidal influences, presence of known contaminants, vegetative cover, and location along the Pacific Flyway. The prime functions of this wetland consist of the ability to retain sediments and toxicants and to produce nutrients. Because of the restricted outlet, export of nutrients is minimal. The combined estuarine and freshwater system and substrate type reduce the groundwater recharge and discharge ability of this wetland.

All wetlands identified at Parcel E-2 (tidal and seasonal freshwater) are situated along the Pacific Flyway; therefore, an abundance and diversity of wintering and migrating waterfowl species is a potentially significant feature; however, only red-winged blackbirds were observed to nest in the seasonal freshwater wetland. The diversity and abundance of aquatic organisms are moderate in the tidal wetlands and low in the seasonal freshwater wetland. This lack of aquatic organisms is presumably due to the toxicity of the soil and water in both types of wetlands and due to the seasonal nature of the freshwater wetland.

Both the tidal and seasonal freshwater wetlands identified at Parcel E-2 have no recreational value. Access to the wetlands is restricted because the site is located within a naval base. The wetlands are not unique and have no cultural value because they are manmade and situated on artificial fill.

In general, the most significant function of these wetlands is seasonal use for wintering and migrating wildlife. Because the wetlands are located on a known hazardous waste disposal site on manmade land, value in terms of social significance, effectiveness, and opportunity is low.

2.4.2.2. Presence of Special-Status Species

Species present in the Parcel E-2 wetland areas were assessed during the Phase 1A ERA (PRC, 1994) and a field survey conducted in 1997 in conjunction with the RI (TtEMI, LFR, and U&A, 1997). The only special-status species observed was the American peregrine falcon (*Falco peregrinus anatum*), which has been sighted feeding in the area (PRC, 1994). The American peregrine falcon is currently identified as a candidate for delisting from the state of California endangered and threatened species list; this species was delisted as a federal endangered species in 1999 (California Department of Fish and Game, 2008).

Non-special-status species observed in the wetland areas include plants (such as salt grass and sedge) and migratory shorebirds (such as the black turnstone [*Arenaria melanocephala*], killdeer [*Charadrius vociferous*], and willet [*Tringa semipalmata*]). During high tides, additional species may be present, including the osprey [*Pandion haliaetus*], great blue heron (*Ardea herodias*), great egret (*Ardea alba*), and belted kingfisher (*Megaceryle alcyon*). In addition, the Panhandle Area potentially contains raccoons, mallard ducks (*Anas plathyrhynchos*), California ground squirrels, and burrowing owls (PRC, 1994; TtEMI, LFR, and U&A, 1997). In 2004, the Navy conducted a bird survey of Parcels E and E-2 to identify potential special-status species in advance of several interim removal actions. The primary conclusion of that survey was that no suitable habitat exists at Parcels E or E-2 for any of the rail species (TtFW, 2004a). Protection of all plant and animal species in the Parcel E-2 wetland areas will be considered during the evaluation of potential remedies and during the RD. The RD will consider appropriate measures to protect the American peregrine falcon, which is the only special-status species identified at Parcel E-2.

2.4.2.3. Surface Water Drainage Effects to Seasonal Freshwater Wetlands

Seasonal freshwater wetlands in the Panhandle Area currently receive surface water runoff from the landfill cap area and function to remove suspended solids from the runoff before it enters San Francisco Bay. Parcel E-2 remediation may involve installation of a larger landfill cap, thereby resulting in additional surface water runoff from the cap to the wetlands. As stated above, the area of seasonal freshwater wetlands in the Panhandle Area can be enhanced to add new wetlands areas. Enhancing the wetland would serve two purposes: (1) the wetland would be capable of handling larger volumes of surface water runoff from any additional landfill cap area created as part of the Parcel E-2 remedy; and (2) it would compensate for wetlands lost during the removal actions occurring at other parts of Parcel E-2. Enlarging the seasonal freshwater wetlands in the Panhandle Area is discussed in the subsection below, as well as in Section 12.1.5.

2.4.2.4. Wetlands Restoration and Mitigation

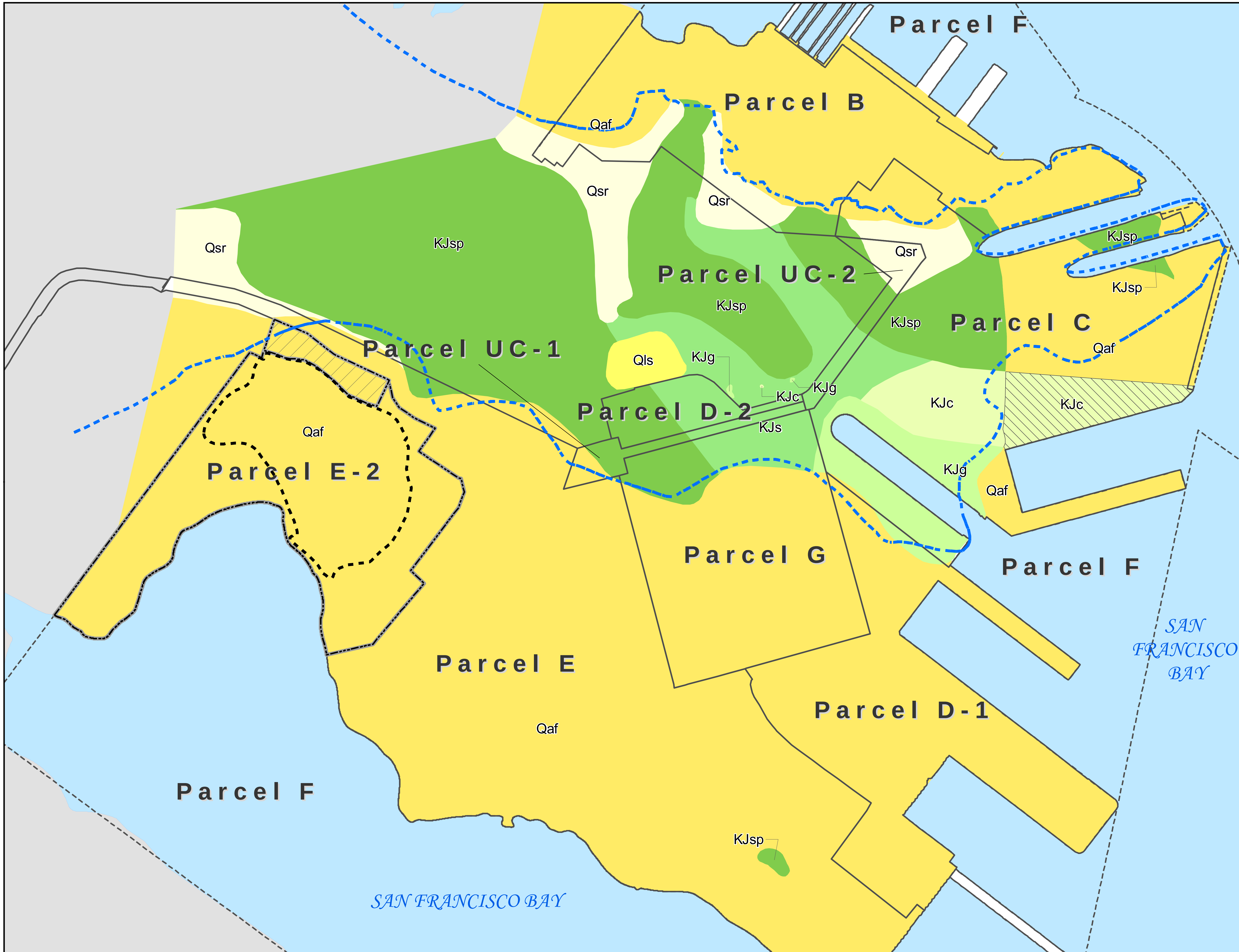
Because wetlands are collocated with the Landfill Area and other solid waste disposal areas at Parcel E-2, they will likely be disturbed or destroyed during ongoing and future (if any) remedial actions. The exact acreage of wetlands affected depends on the remedial alternative that is selected; specific acreages affected by remediation under each alternative are discussed in the FS portion of this report.

The Panhandle Area west of the Landfill Area was identified as a potential location where damage to wetlands could be mitigated. For every acre (or fraction thereof) of wetland destroyed in Parcel E-2, the Navy intends to use an area of non-wetland property of the same size in the Panhandle Area for creation of new wetlands. Current estimates indicated that enough non-wetland property is located within the Panhandle Area that the area can be used as a mitigation area to compensate (typically on a one-to-one basis) for the permanent destruction of wetland areas in other parcels at HPS, if necessary. Future development plans for the Panhandle Area will need to address potential incompatibilities between recreation and pedestrian facilities and wetland areas. Further details on wetland restoration and mitigation are provided in Sections 11.8 and 12.1.5.

2.4.3. Intertidal Habitat

Habitat within the Shoreline Area consists of intertidal and saline emergent wetlands, unvegetated shoreline areas, and riprap covered areas. Figure 2-23 presents the intertidal habitat at Parcel E-2. Riprap consists of large pieces of concrete, metal rebar, and wood to prevent erosion. Wetland habitats are discussed in Section 2.4.2. Plant and animal species identified in the intertidal Shoreline Area are discussed in Section 1.3.1 of the Shoreline Characterization Technical Memorandum (SulTech, 2007; Appendix G of this report), and include California ground squirrels and the house mouse.

Figures



Geologic Characterization

- KJc-Chert Interbedded with Shale
- KJg-Predominantly Greenstone Volcanic Rock
- KJs-Undifferentiated Sandstone and Shale
- KJsp-Serpentinite
- Qls-Landslide Debris Zone
- Qaf-Artificial Fill
- Qsr-Slope Debris and Ravine Fill
- Geologic Contact (TtEMI, 2001a)
- Parcel Boundary
- Parcel E-2 Boundary
- Estimate of Solid Waste Extent
- UCSF Compound
- Non-Navy Property
- San Francisco Bay
- 1935 Shoreline

Notes:
UCSF = University of California, San Francisco

Reference:

Bonilla, M.G. 1971. "Preliminary Geologic Map of the San Francisco South Quadrangle and Part of the Hunters Point Quadrangle." *U.S. Geological Survey Miscellaneous Field Studies Map.* MG-311. 1:24,000.

TtEMI. 2001a. "Parcel E Information Package Phase II Groundwater Data Gaps Investigation, Hunters Point Shipyard, San Francisco, California." August 10.

N

600 0 600

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

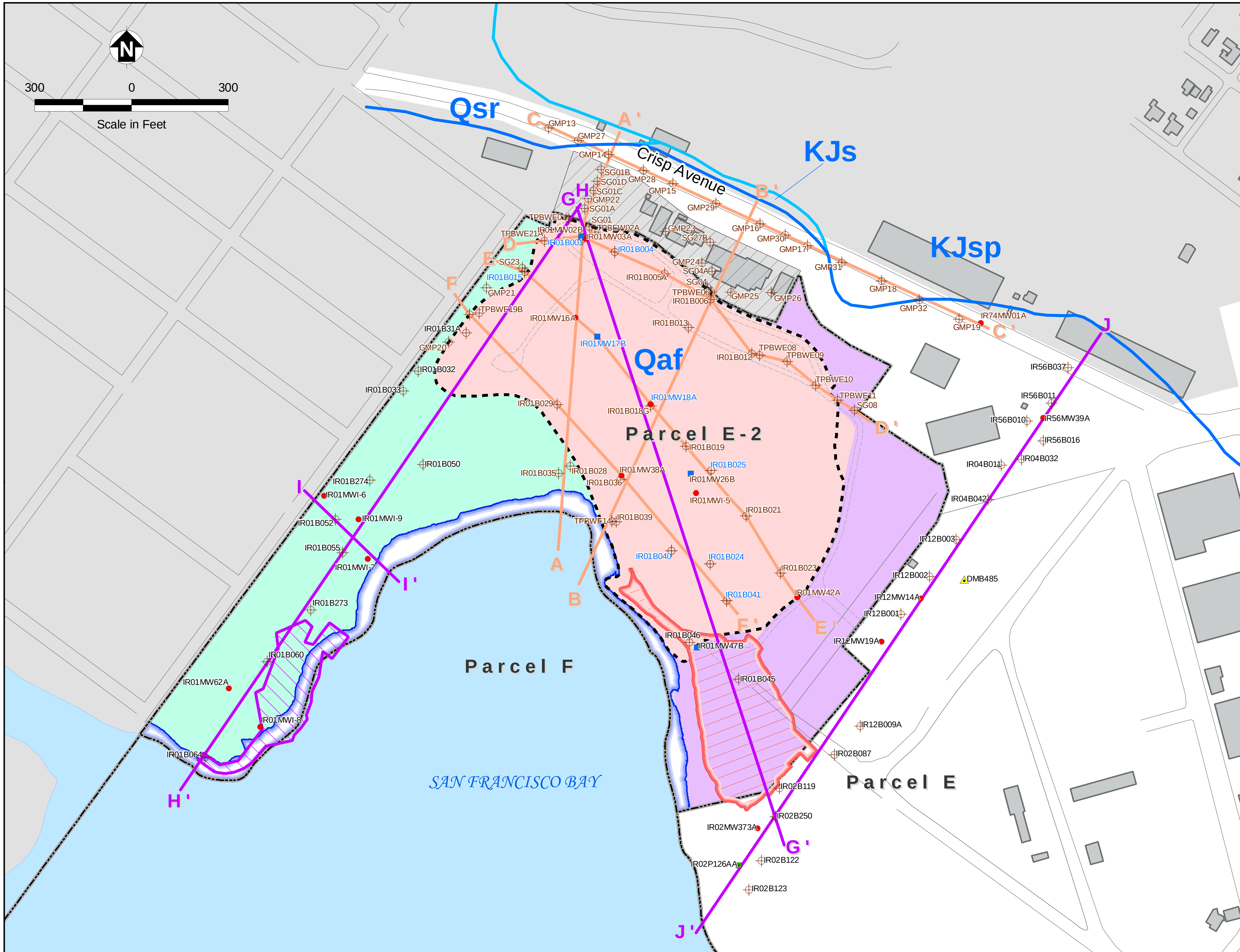
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-1

HUNTERS POINT SURFICIAL GEOLOGY

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\HPS_geologic_characterization.mxd



Piezometer
Historical Geotechnical Boring
A-Aquifer Monitoring Well
B-Aquifer Monitoring Well
Boring Location
Geologic Cross Section Location
Hydrogeologic Cross Section Location
Geologic Contact
Bedrock-Artificial Fill Geologic Contact*
Road
Gravel Road
Metal Slag Area (2007 excavation limit)[a]
PCB Hot Spot Area (2007 excavation limit)[a]
Limit of Landfill Cap
Estimate of Solid Waste Extent
Parcel Boundary
Building
UCSF Compound
Landfill Area
Adjacent Area
Panhandle Area
Shoreline Area
San Francisco Bay
Non-Navy Property

Notes:

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

KJs = Sandstone and Shale Bedrock
KJsp = Serpentinite Bedrock
Qaf = Artificial Fill
Qsr = Slope Debris and Ravine Fill
UCSF = University of California, San Francisco

Black Text = Borings used in Hydrogeologic Cross-Sections
Brown Text = Borings used in Geologic Cross-Sections
Blue Text = Borings used in both Geologic and Hydrogeologic Cross-Sections

References:

Bonilla, M.G. 1971. "Preliminary Geologic Map of the San Francisco South Quadrangle and Part of the Hunters Point Quadrangle." U.S. Geological Survey Miscellaneous Field Studies Map. MG-311. 1:24,000.
*Geologic Conact based on Bonilla (1971)

TtEMI 2001a. "Parcel E Information Package Phase II Groundwater Data Gaps Investigation, Hunters Point Shipyard, San Francisco, California." August 10

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

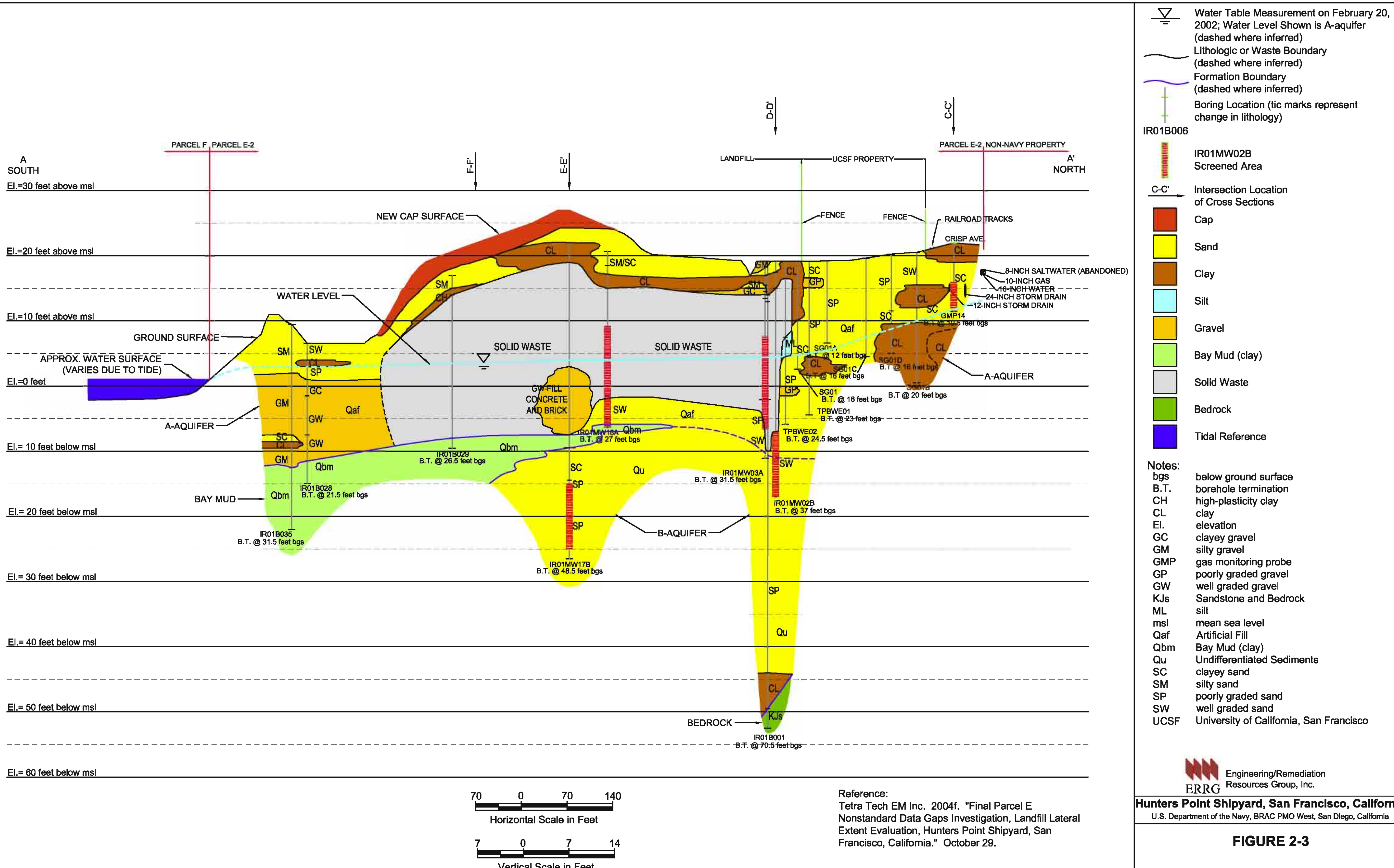
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-2

LOCATION OF PARCEL E-2 CROSS SECTIONS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\Location of E-2 Cross Sections1.mxd



Notes:

bgs	below ground surface
B.T.	borehole termination
CH	high-plasticity clay
CL	clay
El.	elevation
GC	clayey gravel
GM	silty gravel
GMP	gas monitoring probe
GP	poorly graded gravel
GW	well graded gravel
KJs	Sandstone and Bedrock
ML	silt
msl	mean sea level
Qaf	Artificial Fill
Qbm	Bay Mud (clay)
Qu	Undifferentiated Sediments
SC	clayey sand
SM	silty sand
SP	poorly graded sand
SW	well graded sand
UCSF	University of California, San Francisco

Reference:
Tetra Tech EM Inc. 2004f. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California

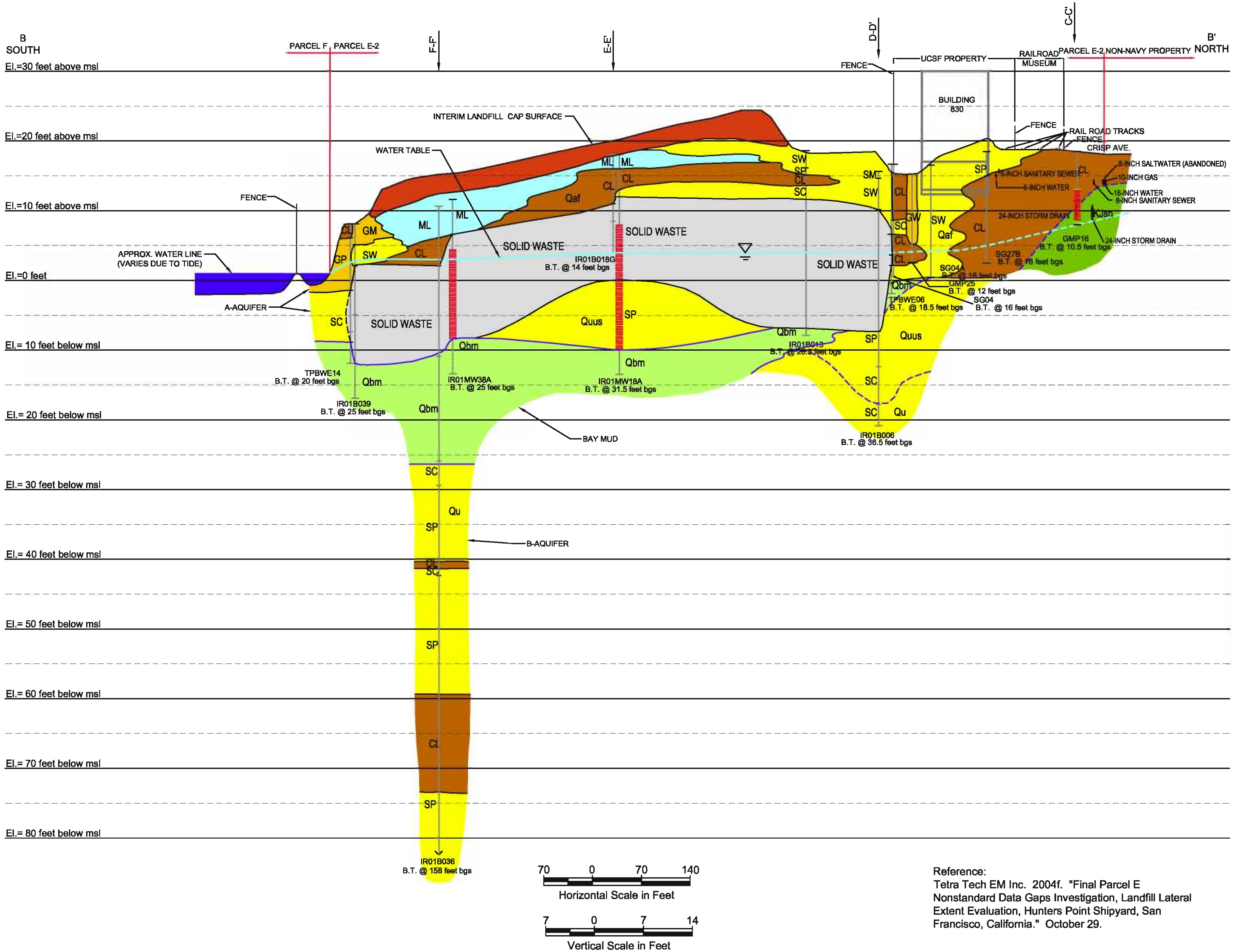
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-3

CROSS SECTION A-A'

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\HPCross Sections\Figure 2-3.dwg



Water Table Measurement on February 20, 2002; Water Level Shown is A-aquifer (dashed where inferred)

Lithologic or Waste Boundary (dashed where inferred)

Formation Boundary (dashed where inferred)

IR01B006 — Boring Location (tic marks represent change in lithology)

GMP16 Screened Area

C-C' — Intersection Location of Cross Sections

- Cap
- Sand
- Clay
- Silt
- Gravel
- Bay Mud (clay)
- Solid Waste
- Bedrock
- Tidal Reference

Notes:

bgs	below ground surface
B.T.	borehole termination
CL	clay
El.	elevation
GM	silty gravel
GMP	gas monitoring probe
GP	poorly graded gravel
GW	well graded gravel
KJsp	Serpentine Bedrock
ML	silt
msl	mean sea level
Qaf	Artificial Fill
Qbm	Bay Mud (clay)
Qu	Undifferentiated Sediments
Quus	Undifferentiated Upper Sand Deposits
SC	clayey sand
SM	silty sand
SP	poorly graded sand
SW	well graded sand
UCSF	University of California, San Francisco

Reference:
Tetra Tech EM Inc. 2004f. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California

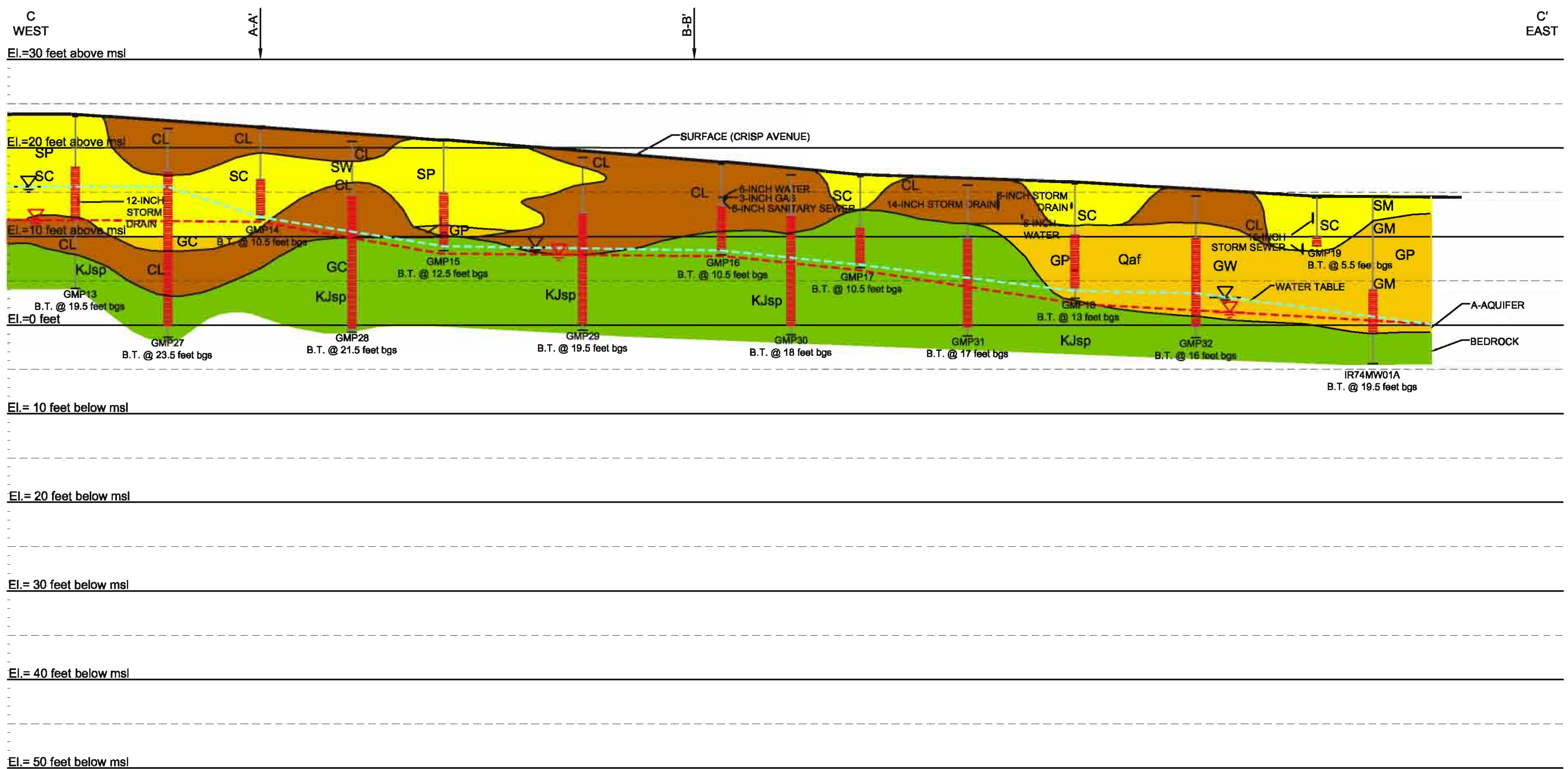
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-4

CROSS SECTION B-B'

Remedial Investigation/Feasibility Study for Parcel E-2

2005-09-22 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\W_Maps&Drawings\GIS\Projects\HP Cross Sections\Figure 2-4.dwg ERRG-Concord Jeremy Miller



70 0 70 140
Horizontal Scale in Feet

7 0 7 14
Vertical Scale in Feet

Water Table Measurements at GMPs on February 20, 2002; Water Level Shown is A-aquifer (dashed where inferred)

Water Table Represents the Estimated Low Groundwater Level Based on the Measurements at GMPs on May 31, 2002, that were adjusted approximately 2 feet downward to account for the maximum historic-level fluctuation (dashed where inferred)

Stormwater Sewer Utility Line

Lithologic or Waste Boundary (dashed where inferred)

IR01B006 Boring Location (tic marks represent change in lithology)

IR74MW01A Screened Area

A-A' Intersection Location of Cross Sections

Sand

Clay

Gravel

Bedrock

Notes:

bgs	below ground surface
B.T.	borehole termination
CL	clay
El.	elevation
GC	clayey gravel
GM	silty gravel
GMP	gas monitoring probe
GP	poorly graded gravel
GW	well graded gravel
KJsp	Serpentine Bedrock
msl	mean sea level
Qaf	Artificial Fill
SC	clayey sand
SM	silty sand
SP	poorly graded sand
SW	well graded sand

Reference:

Tetra Tech EM Inc. 2004f. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

ERRG Engineering/Remediation Resources Group, Inc.

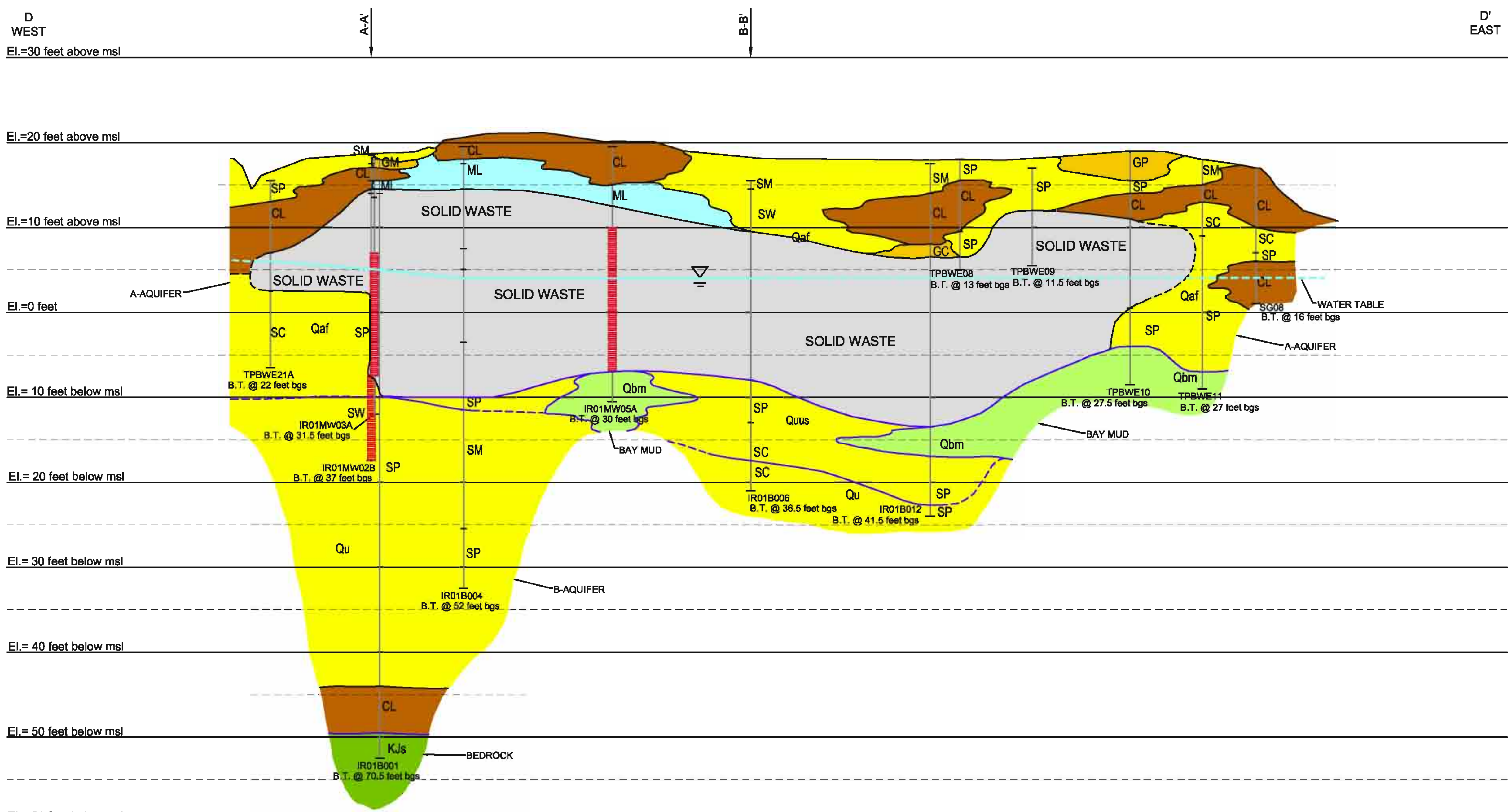
Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-5

CROSS SECTION C-C'

Remedial Investigation/Feasibility Study for Parcel E-2



Water Table Measurement on February 20, 2002; Water Level Shown is A-aquifer (dashed where inferred)

Lithologic or Waste Boundary (dashed where inferred)

Formation Boundary (dashed where inferred)

IR01B006 Boring Location (tic marks represent change in lithology)

IR01MW02B Screened Area

A-A' Intersection Location of Cross Sections

Sand

Clay

Silt

Gravel

Bay Mud (clay)

Solid Waste

Bedrock

Notes:

bgs	below ground surface
B.T.	borehole termination
CL	clay
El.	elevation
GC	clayey gravel
GM	silty gravel
GP	poorly graded gravel
KJs	Sandstone and Shale Bedrock
ML	silt
msl	mean sea level
Qaf	Artificial Fill
Qbm	Bay Mud (clay)
Qu	Undifferentiated Sediments
Quus	Undifferentiated Upper Sand Deposits
SC	clayey sand
SM	silty sand
SP	poorly graded sand
SW	well graded sand

70 0 70 140

Horizontal Scale in Feet

7 0 7 14

Vertical Scale in Feet

Reference:
Tetra Tech EM Inc. 2004f. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

ERRG Engineering/Remediation Resources Group, Inc.

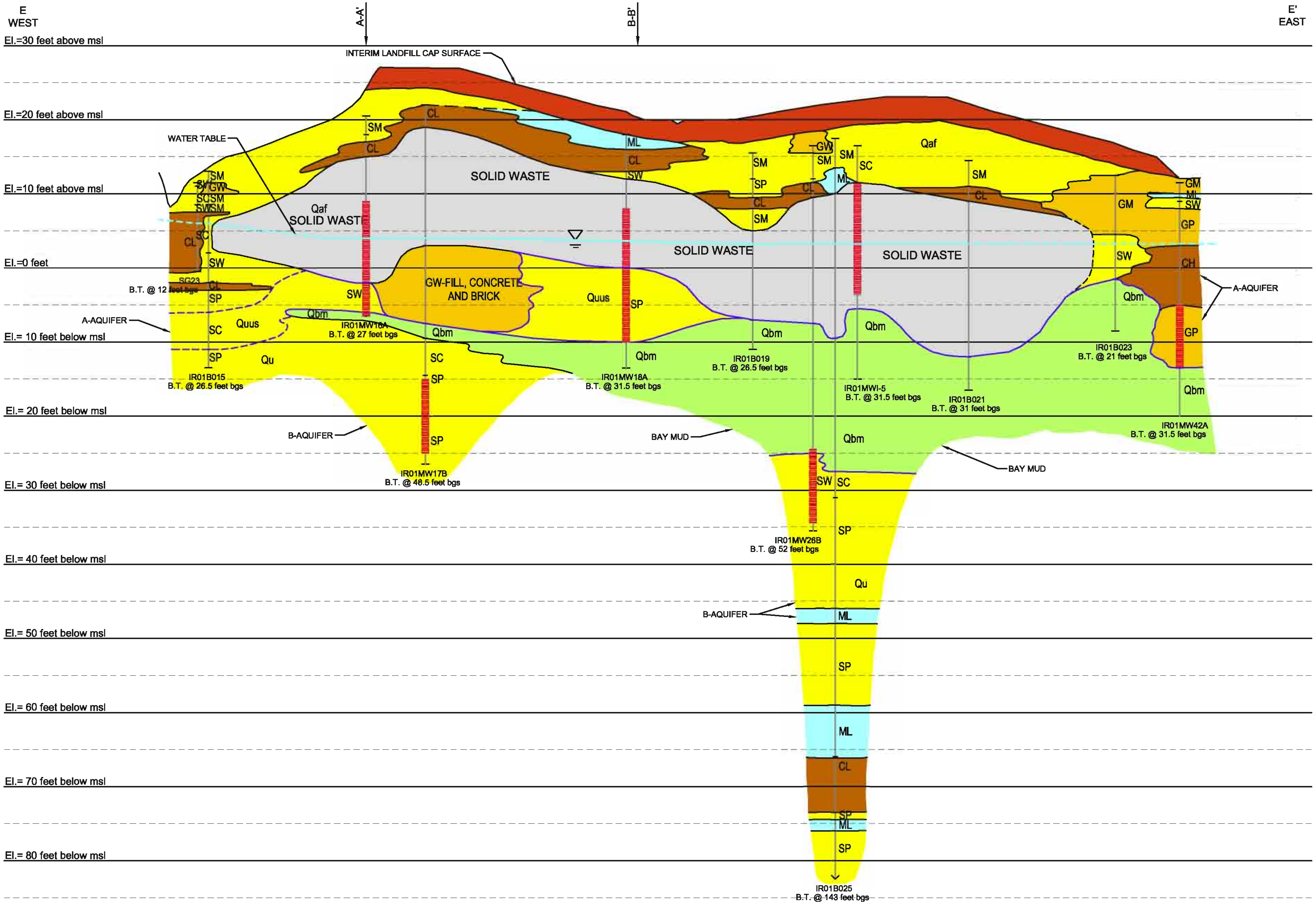
Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-6

CROSS SECTION D-D'

Remedial Investigation/Feasibility Study for Parcel E-2



70 0 70 140
Horizontal Scale in Feet

7 0 7 14
Vertical Scale in Feet

Reference:
Tetra Tech EM Inc. 2004f. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

Water Table Measurement on February 20, 2002; Water Level Shown is A-aquifer (dashed where inferred)
Lithologic or Waste Boundary (dashed where inferred)
Formation Boundary (dashed where inferred)
IR01B006 Boring Location (tic marks represent change in lithology)
IR01MW17B Screened Area
A-A' Intersection Location of Cross Sections
Cap
Sand
Clay
Silt
Gravel
Bay Mud (clay)
Solid Waste

Notes:

bgs	below ground surface
B.T.	borehole termination
CH	high-plasticity clay
CL	clay
El.	elevation
GM	silty gravel
GP	poorly graded gravel
GW	well graded gravel
ML	silt
msl	mean sea level
Qaf	Artificial Fill
Qbm	Bay Mud (clay)
Qu	Undifferentiated Sediments
Quus	Undifferentiated Upper Sand Deposits
SC	clayey sand
SM	silty sand
SP	poorly graded sand
SW	well graded sand

ERRG Engineering/Remediation Resources Group, Inc.

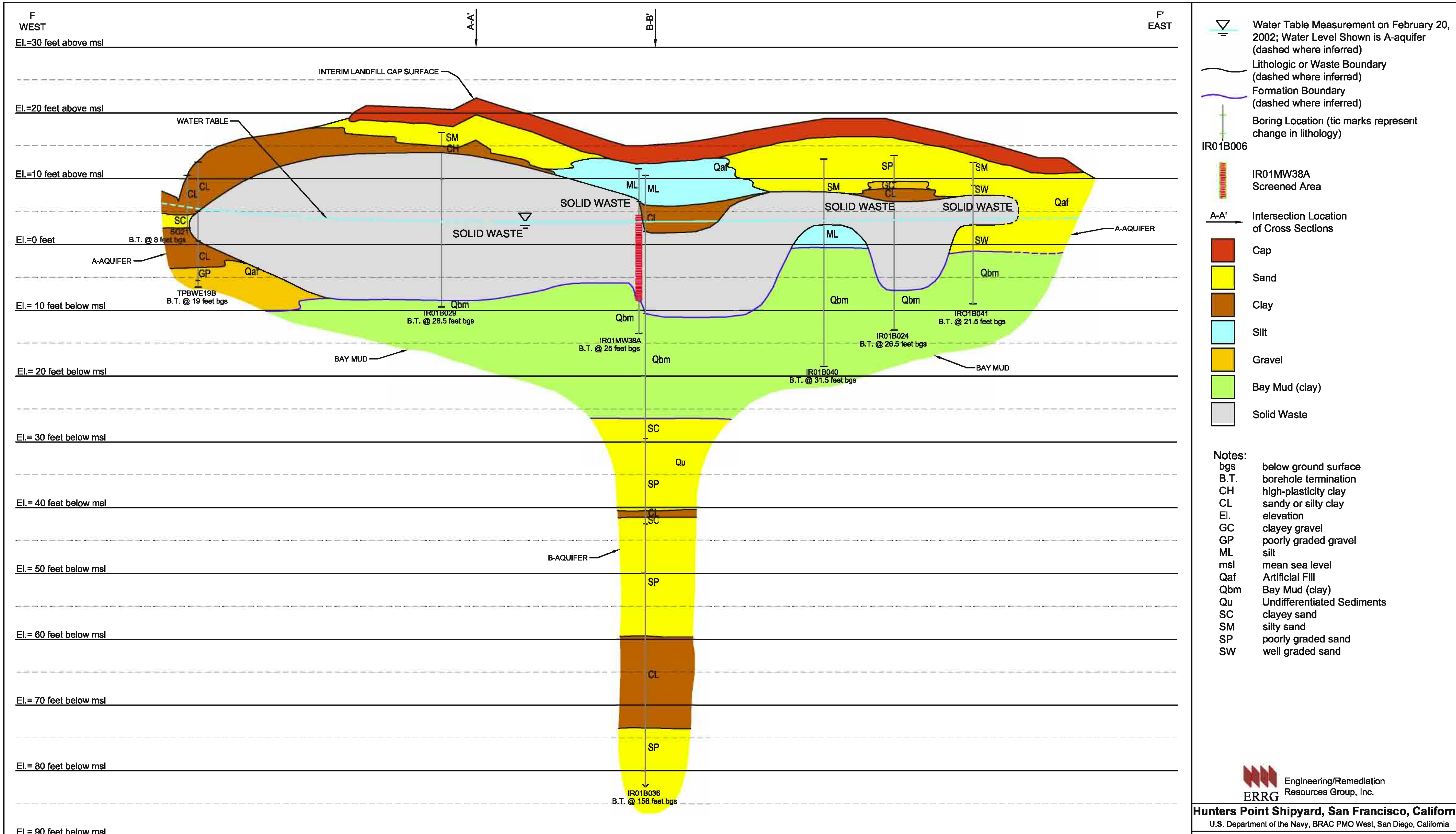
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-7

CROSS SECTION E-E'

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\HP Cross Sections\Figure 2-7.dwg



Notes:

bgs	below ground surface
B.T.	borehole termination
CH	high-plasticity clay
CL	sandy or silty clay
El.	elevation
GC	clayey gravel
GP	poorly graded gravel
ML	silt
msl	mean sea level
Qaf	Artificial Fill
Qbm	Bay Mud (clay)
Qu	Undifferentiated Sediments
SC	clayey sand
SM	silty sand
SP	poorly graded sand
SW	well graded sand

Reference:
Tetra Tech EM Inc. 2004f. "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation, Hunters Point Shipyard, San Francisco, California." October 29.

ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California

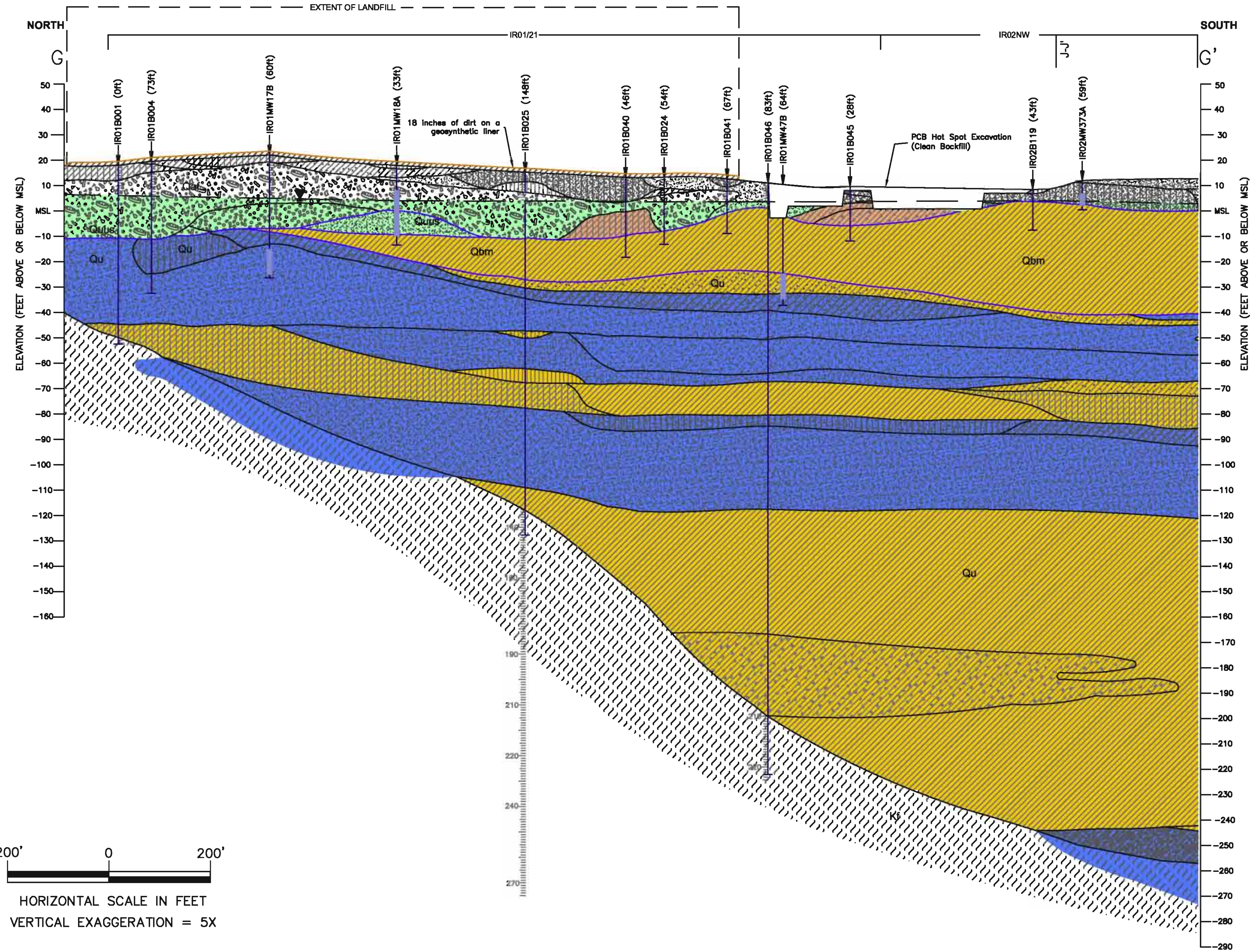
U.S. Department of the Navy, BRAC PMO West, San Diego, California

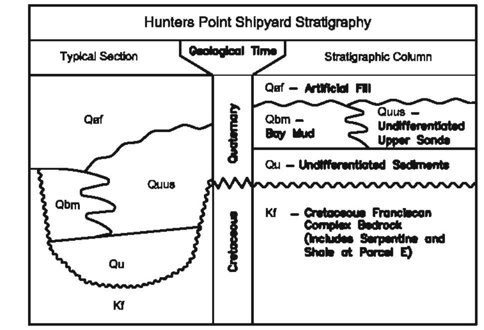
FIGURE 2-8

CROSS SECTION F-F'

Remedial Investigation/Feasibility Study for Parcel E-2

2006-10-05 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\HP Cross Sections\Figure 2-8.dwg





Legend

- Formation Contact (dashed where inferred)
- Lithological Contact (dashed where inferred)
- Ground Surface
- Landfill Cap
- MSL Mean Sea Level
- (Distance Projected to Cross Section) Monitoring Well/Soil Boring Location.
- Well Screen
- A-Aquifer Zone Water Table February 2002
- IR Boundary
- Intersection location of cross sections
- A-Aquifer Zone
- B-Aquifer Zone
- Aquitard Zone
- Qaf Low Permeable Zone based on Lithology
- Gravel
- Clayey Gravel
- Silty Gravel
- Sandy Gravel
- Sand
- Clayey Sand
- Silty Sand
- Gravelly Sand
- Silt
- Clayey Silt
- Sandy Silt
- Gravelly Silt
- Clay
- Silty Clay
- Sandy Clay
- Gravelly Clay
- Sand/Gravel/Clay Mixture
- Boulder Fill
- Weathered Bedrock
- Bedrock
- Concrete
- Debris

Notes:

1. These cross-sections represent one interpretation of the shallow subsurface along the corresponding line: alternate interpretations are possible.

2. Borings have been projected onto the lines of section. The projection of borings' lithologies may cause graphical distortions of geological features.

3. Bedrock and sediment contact is based on lithological logs and a bedrock surface map.

Reference:

Tetra Tech EM, Inc. 2004 Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation, Hunters Point Shipyard. May

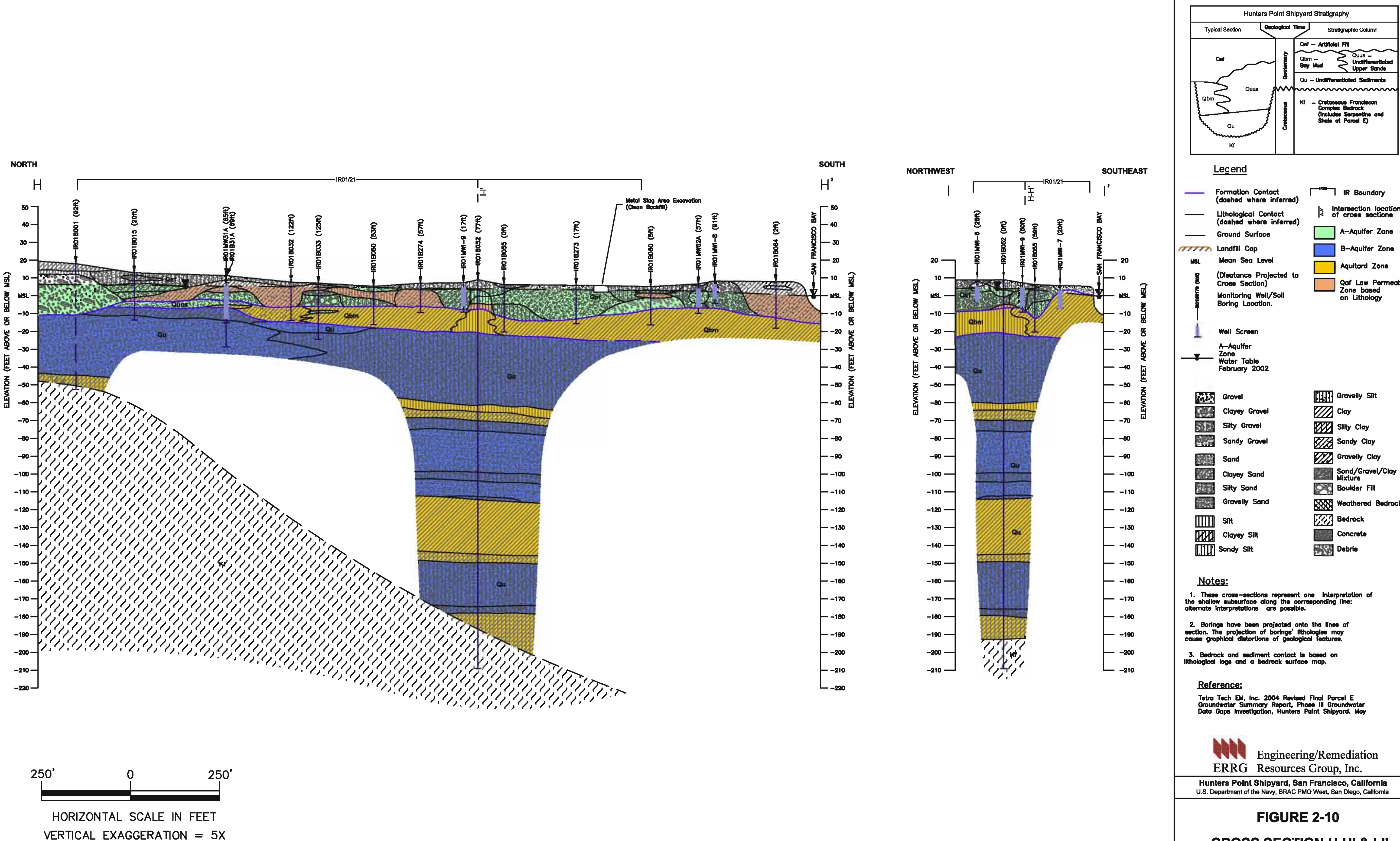
Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-9

CROSS SECTION G-G'

Remedial Investigation/Feasibility Study for Parcel E-2



ERRG Engineering/Remediation Resources Group, Inc.

Hunters Point Shipyard, San Francisco, California

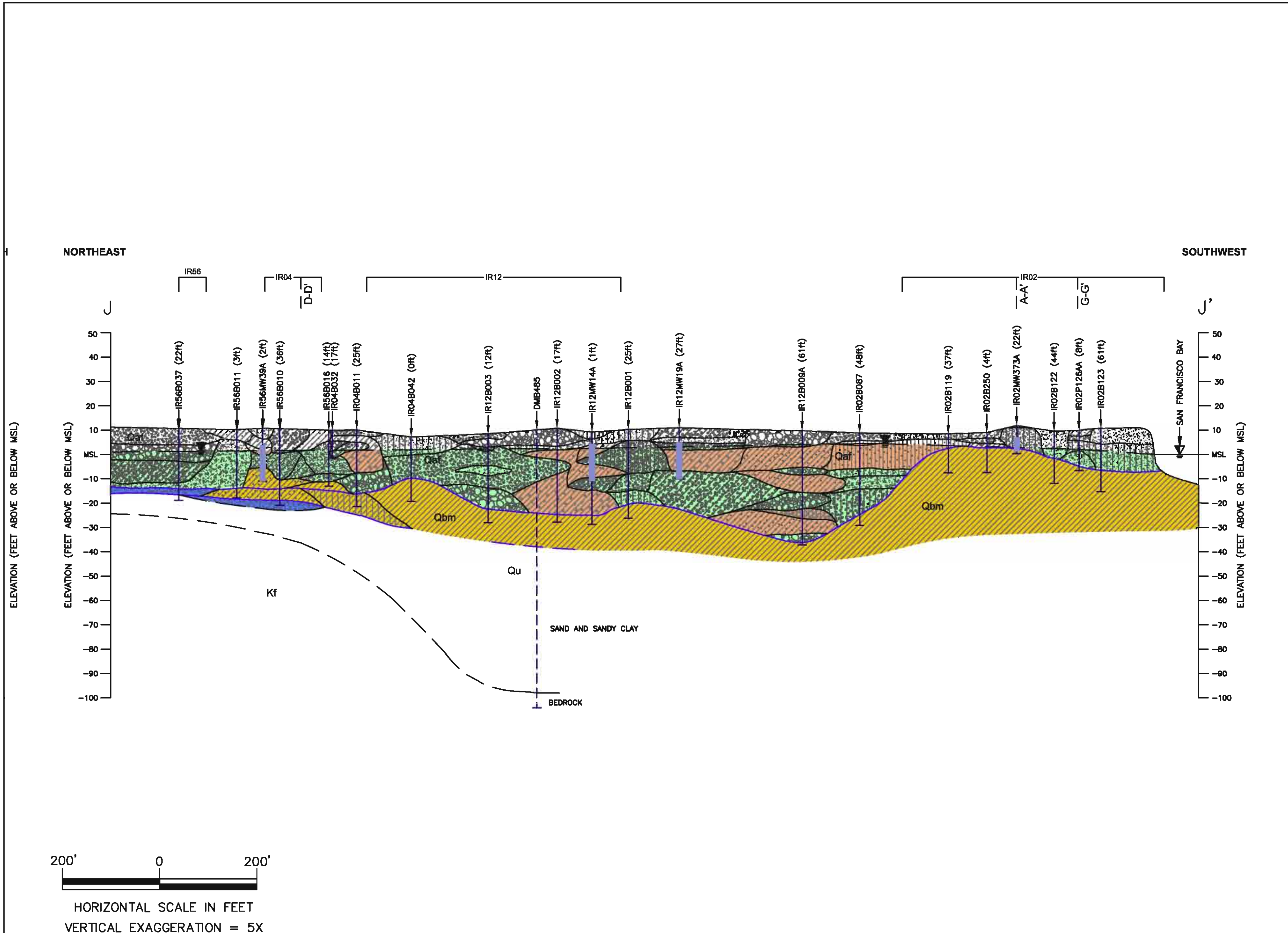
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-10

CROSS SECTION H-H' & I-I'

Remedial Investigation/Feasibility Study for Parcel E-2

2006-10-05 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\HP Cross Sections\Figure 2-9,2-10,2-11.dwg



Notes:

1. These cross-sections represent one interpretation of the shallow subsurface along the corresponding line: alternate interpretations are possible.
2. Borings have been projected onto the lines of section. The projection of borings' lithologies may cause graphical distortions of geological features.
3. Bedrock and sediment contact is based on lithological logs and a bedrock surface map.

Reference:

Tetra Tech EM, Inc. 2004 Revised Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation, Hunters Point Shipyard. May

ERRG Engineering/Remediation Resources Group, Inc.

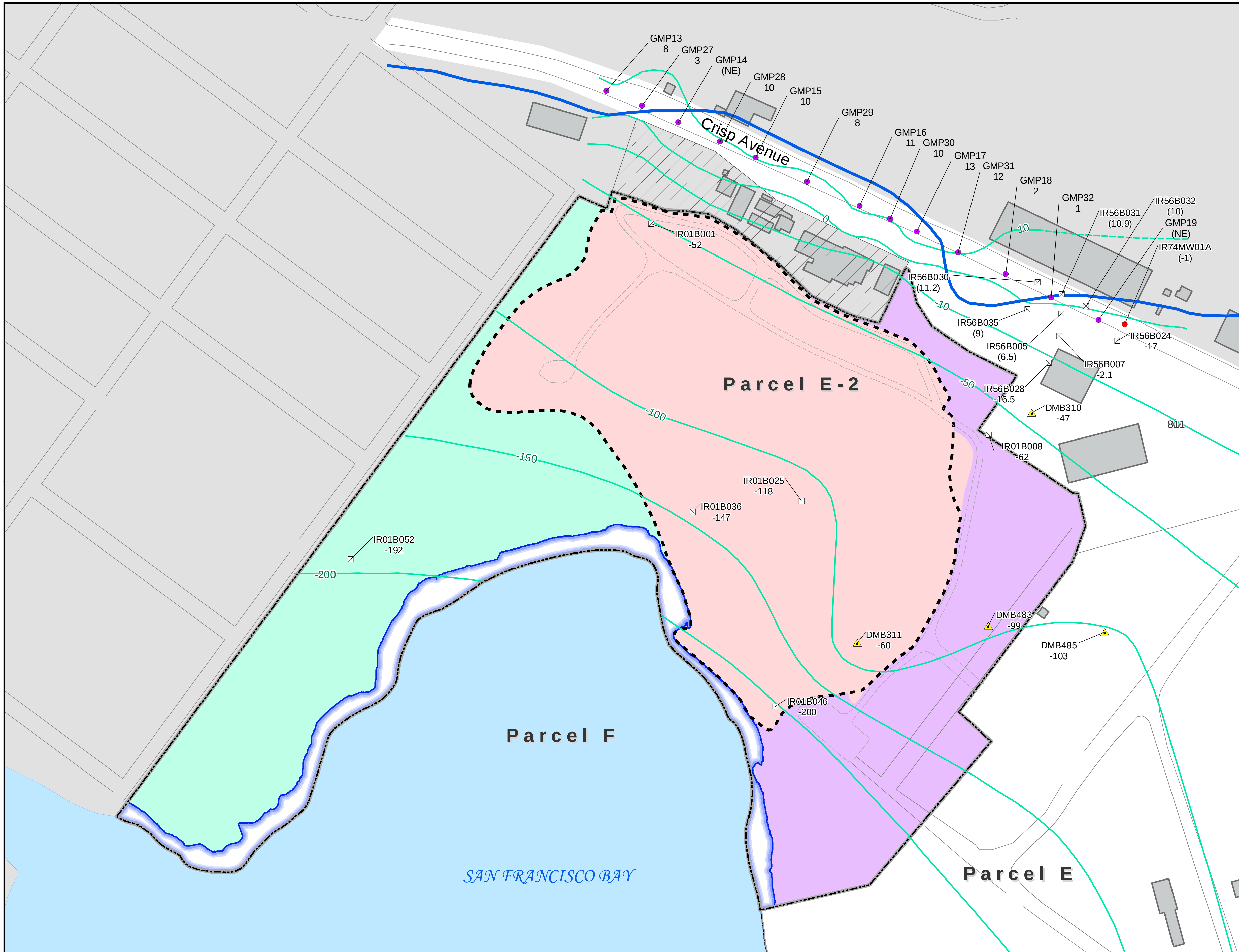
Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-11
CROSS SECTION J-J'

Remedial Investigation/Feasibility Study of Parcel E-2

2006-10-05 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\HP Cross Sections\Figure 2-9,2-10,2-11.dwg



Soil Boring
Dames and Moore Boring
A-Aquifer Monitoring Well
Existing Gas Monitoring Probe
Bedrock Elevation Contours (dashed lines are inferred)
Bedrock-Artificial Fill Geologic Contact*
IR01B036 -147 Well Boring Label with Bedrock Surface Elevations (in feet above msl)
Parcel Boundary
Landfill Area
East Adjacent Area
Panhandle Area
Shoreline Area
Estimate of Solid Waste Extent
Interim Landfill Cap Extent
Non-Navy Property
UCSF Compound
Building
Road
Gravel Road

Notes:

* Geologic Conact based on Bonilla (1971)

( ) Data shown but not used in evaluation of bedrock surface contour.

NE = Bedrock Not Encountered
UCSF = University of California, San Francisco

Reference:

Bonilla, M.G. 1971. "Preliminary Geologic Map of the San Francisco South Quadrangle and Part of the Hunters Point Quadrangle." *U.S. Geological Survey Miscellaneous Field Studies Map.* MG-311. 1:24,000.

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

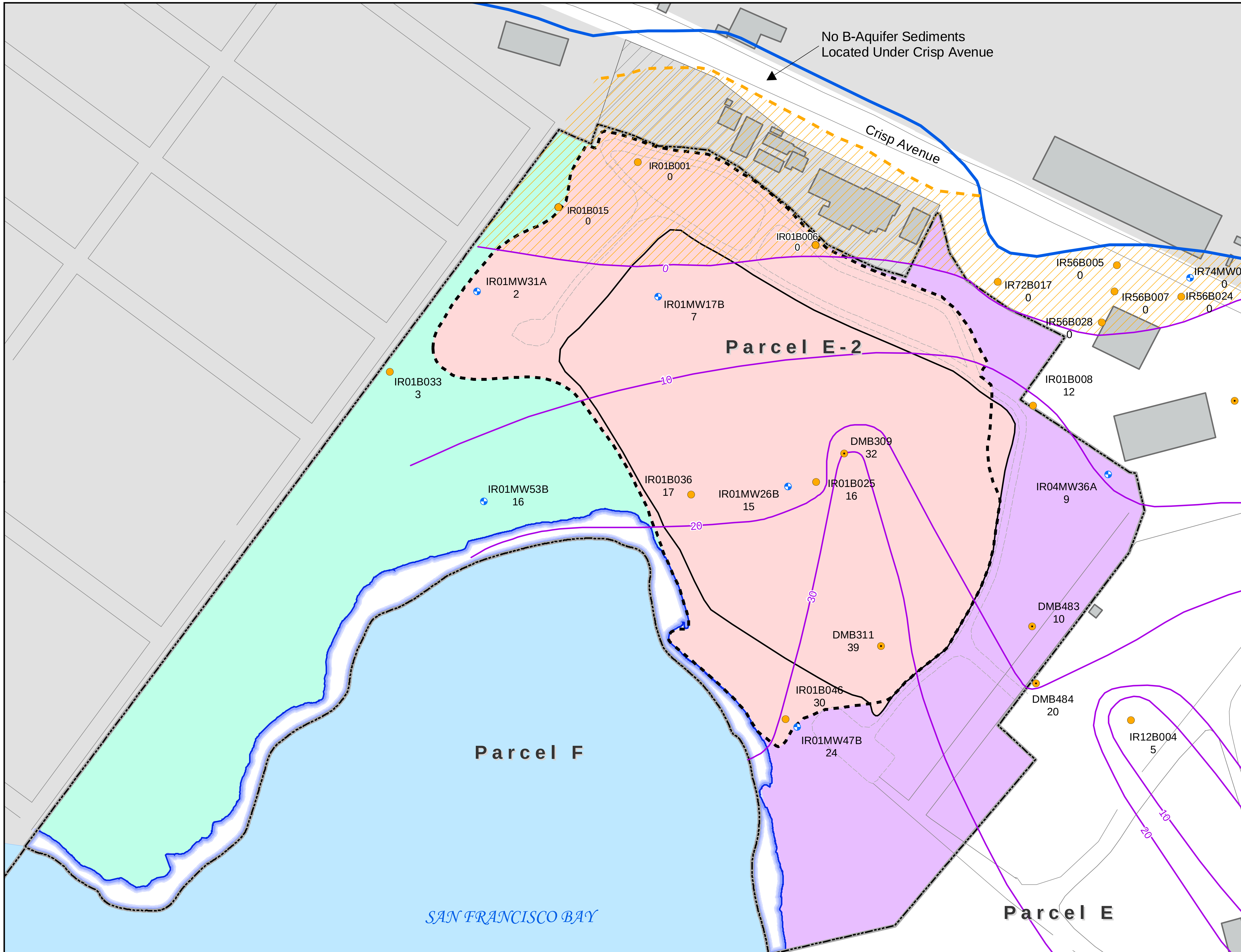
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-12

BEDROCK SURFACE ELEVATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\Bedrock Surface Elevations\Bedrock Surface Elevations.mxd



Monitoring Well
Piezometer
Soil Boring
Dames and Moore Boring
DMB484 20 — Well or Soil Boring Identification with Bay Mud Thickness (in feet)
—20— Bay Mud Thickness Contour Line (10-foot interval)
Bedrock-Artificial Fill Geologic Contact
Area Where A- and B-Aquifer are not Hydraulically Separated by an Aquitard (Dashed where Inferred)
Parcel Boundary
Landfill Area
East Adjacent Area
Panhandle Area
Shoreline Area
Estimate of Solid Waste Extent
Interim Landfill Cap Extent
Non-Navy Property
UCSF Compound
Building
Road
Gravel Road

Notes:

Mean bay water level elevation: 0.33 feet above mean sea level

UCSF = University of California, San Francisco

References:

Tetra Tech EM Inc. 2004c. "Revised Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation, Hunters Point Shipyard, San Francisco, California." May 11.

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

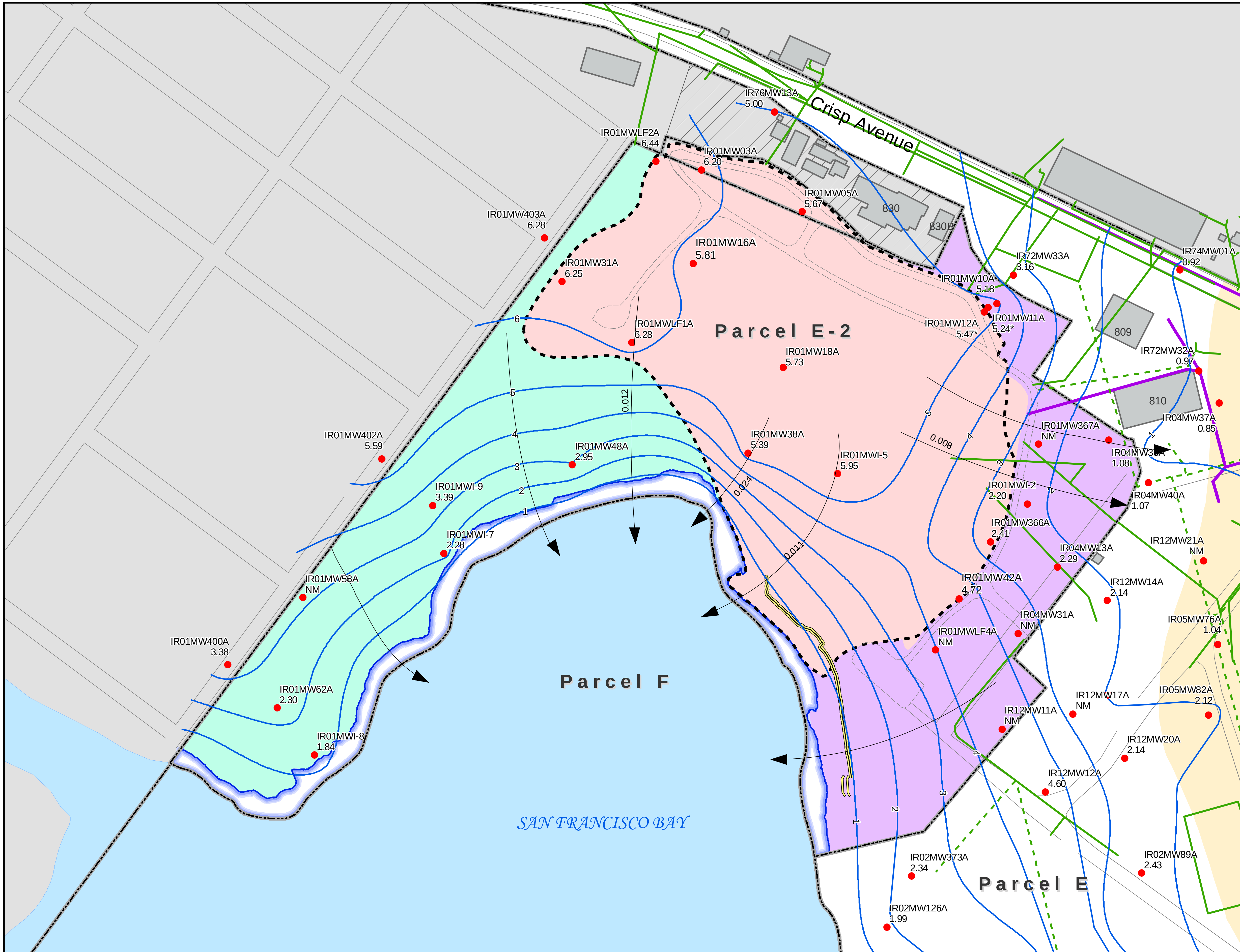
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-13

BAY MUD THICKNESS MAP

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\Bay Mud Thickness\Bay Mud Thickness.mxd



IR01MW38A
- A-Aquifer Monitoring Well and Identification
- A-Aquifer Groundwater Elevation Contour Line (feet above msl)
- 0.008 A-Aquifer Flow Direction and Flow Gradient
- Storm Line (Above Groundwater)
- Storm Line (Below Groundwater)
- Sanitary Sewer Line (Above Groundwater)
- Sheet-Pile Wall
- Road
- Gravel Road
- Solid Waste Extent
- Parcel Boundary
- Building
- UCSF Compound
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Shoreline Area
- San Francisco Bay
- Non-Navy Property

Notes:

Water Table Measurement in March 2007.
Water Level shown is A-Aquifer.
* Redundant, not contoured

msl = mean sea level
NM = not measured
UCSF = University of California, San Francisco

References:

CE2-Kleinfelder Joint Venture. 2007. Parcels C, D, E, and E-2 Quarterly Groundwater Monitoring Report (January to March 2007) and Annual Report. Hunters Point Shipyard, California. November.

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

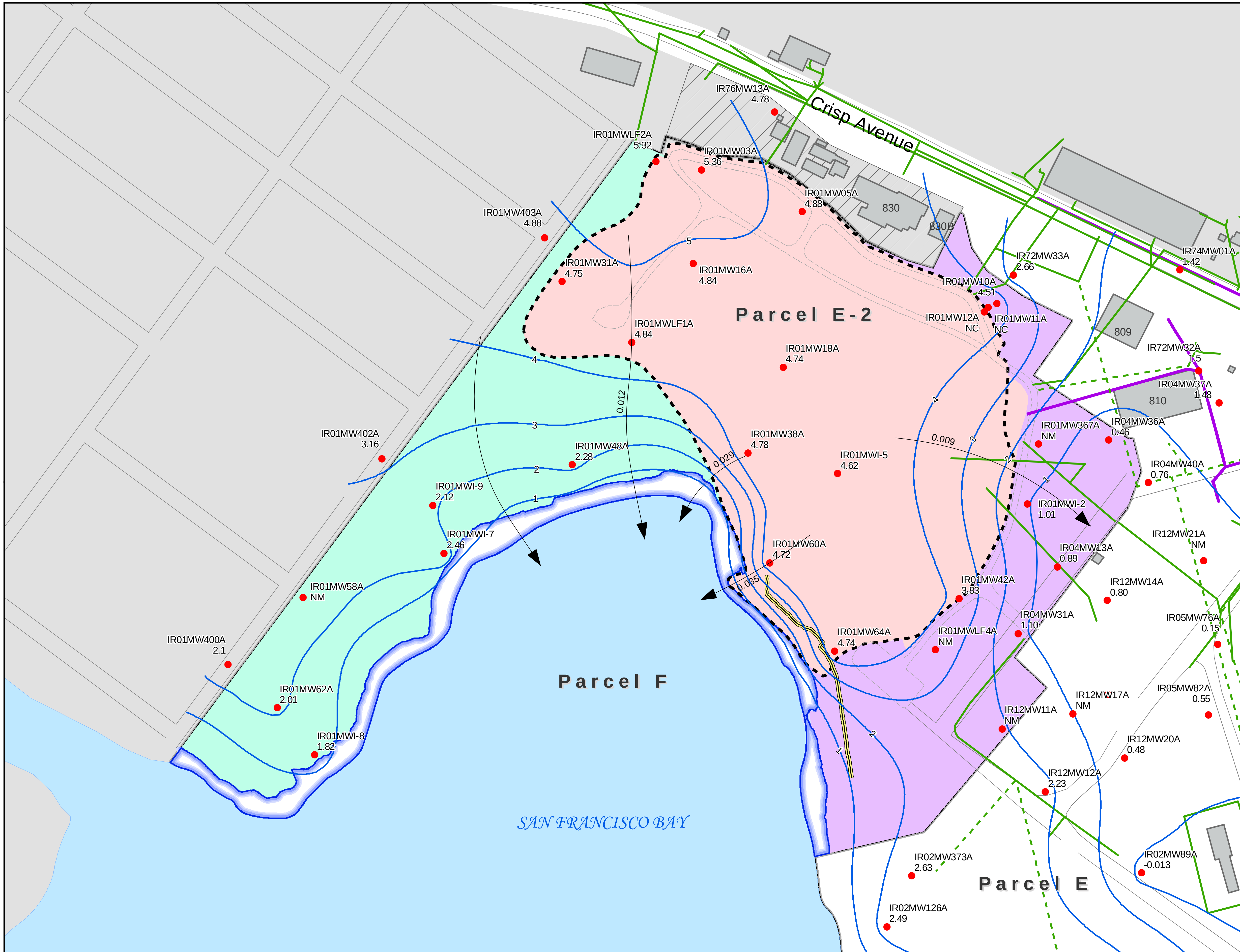
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-14

A-AQUIFER GROUNDWATER ELEVATIONS MARCH 2007

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\A-aquifer Elevations\A-Aquifer_2007_1Qtr.mxd



IR01MW38A

- A-Aquifer Monitoring Well and Identification
- A-Aquifer Groundwater Elevation Contour Line (feet above msl)
- 0.008 A-Aquifer Flow Direction and Flow Gradient
- Storm Line (Above Groundwater)
- Storm Line (Below Groundwater)
- Sanitary Sewer Line (Above Groundwater)
- Sheet-Pile Wall
- Road
- Gravel Road
- Solid Waste Extent
- Parcel Boundary
- Building
- UCSF Compound
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Shoreline Area
- San Francisco Bay
- Non-Navy Property

Notes:

Water Table Measurement in August 2007.
Water Level shown is A-Aquifer.
* Redundant, not contoured

msl = mean sea level
NC = not calculated
NM = not measured
UCSF = University of California, San Francisco

References:

CE2-Kleinfelder Joint Venture. 2008. Semi-Annual Groundwater Monitoring Report April to September 2007). Hunters Point Shipyard, California. January.

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

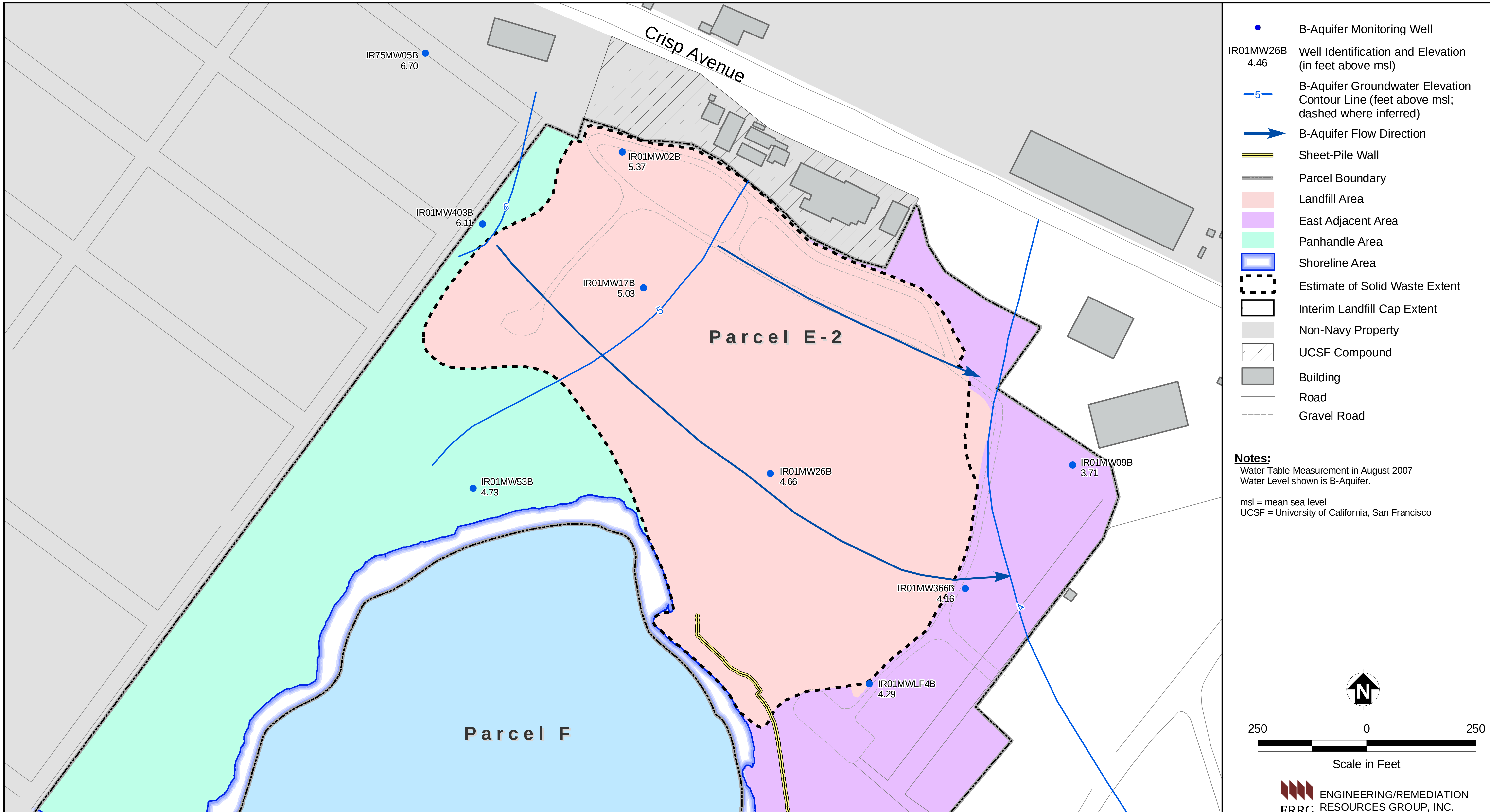
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-15

A-AQUIFER GROUNDWATER ELEVATIONS AUGUST 2007

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\A-aquifer Elevations\A-Aquifer_2007_3Qtr.mxd



Notes:

Water Table Measurement in August 2007
Water Level shown is B-Aquifer.

msl = mean sea level
UCSF = University of California, San Francisco

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

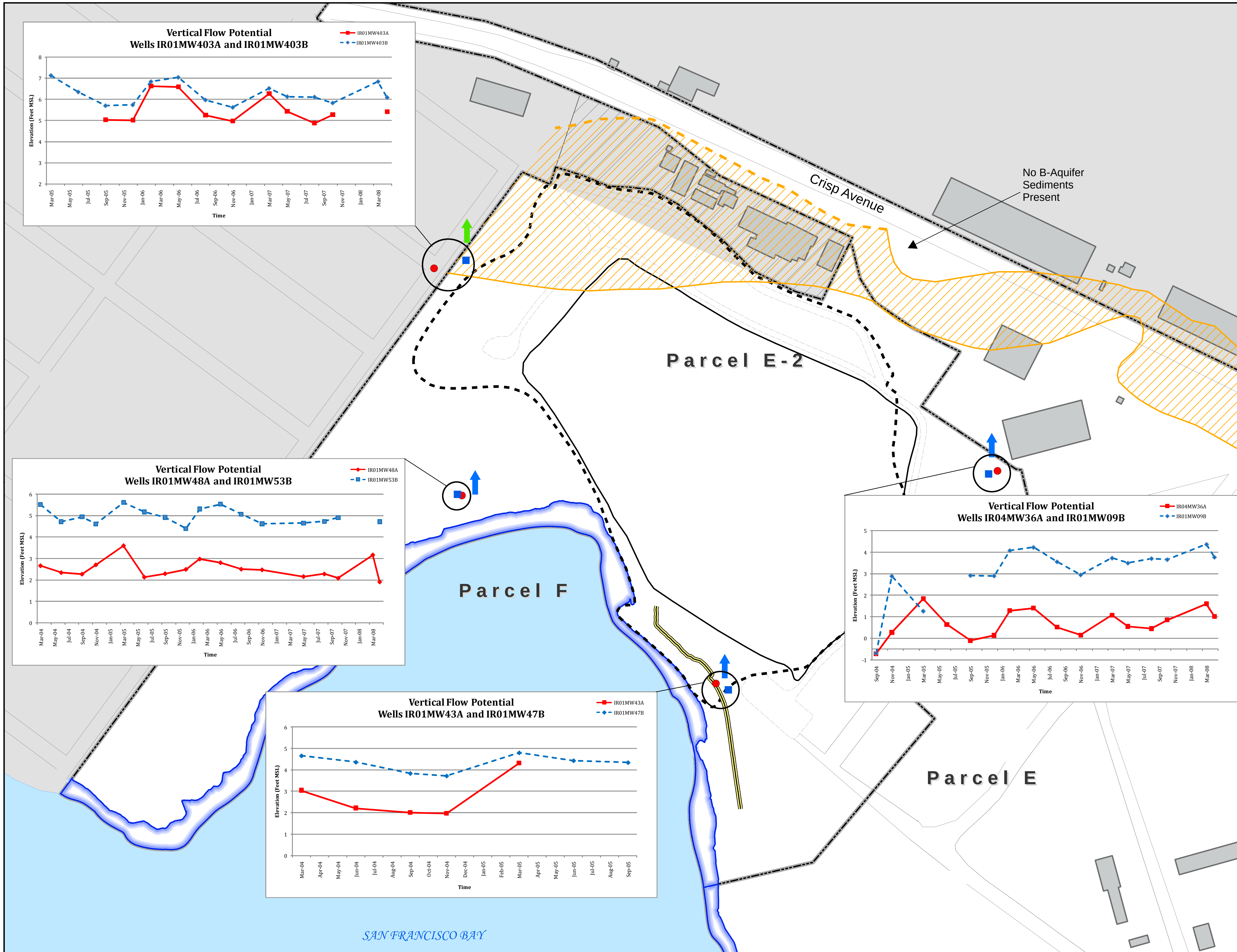
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-16

B-AQUIFER GROUNDWATER ELEVATIONS, AUGUST 2007

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\B-aquifer Elevations\B-Aquifer Groundwater Elevations.mxd



A-Aquifer Monitoring Well with Well Number

B-Aquifer Monitoring Well with Well Number

Vertical Groundwater Flow Potential (up or down) between A- and B-aquifer, Separated by Aquitard

Vertical Groundwater Flow Potential (up or down) between A- and B-aquifer, Not Separated by Aquitard

Area Where A- and B-Aquifer are not Hydraulically Separated by an Aquitard (Dashed where Inferred)

Sheet-Pile Wall

Parcel Boundary

Shoreline Area

Estimate of Solid Waste Extent

Interim Landfill Cap Extent

Non-Navy Property

UCSF Compound

Building

Road

Gravel Road

Notes:

Field conditions prevented measurements in certain wells over consecutive quarters; all available data during the period are plotted but trends between non-consecutive measurements are shown but not interpolated.

Wells IR01MW43A and IR01MW47B were decommissioned in June and October 2005, respectively, in conjunction with the PCB Hot Spot removal action. Available data for these wells from March 2004 to September 2005 are shown.

PCB = polychlorinated biphenyl
UCSF = University of California, San Francisco

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

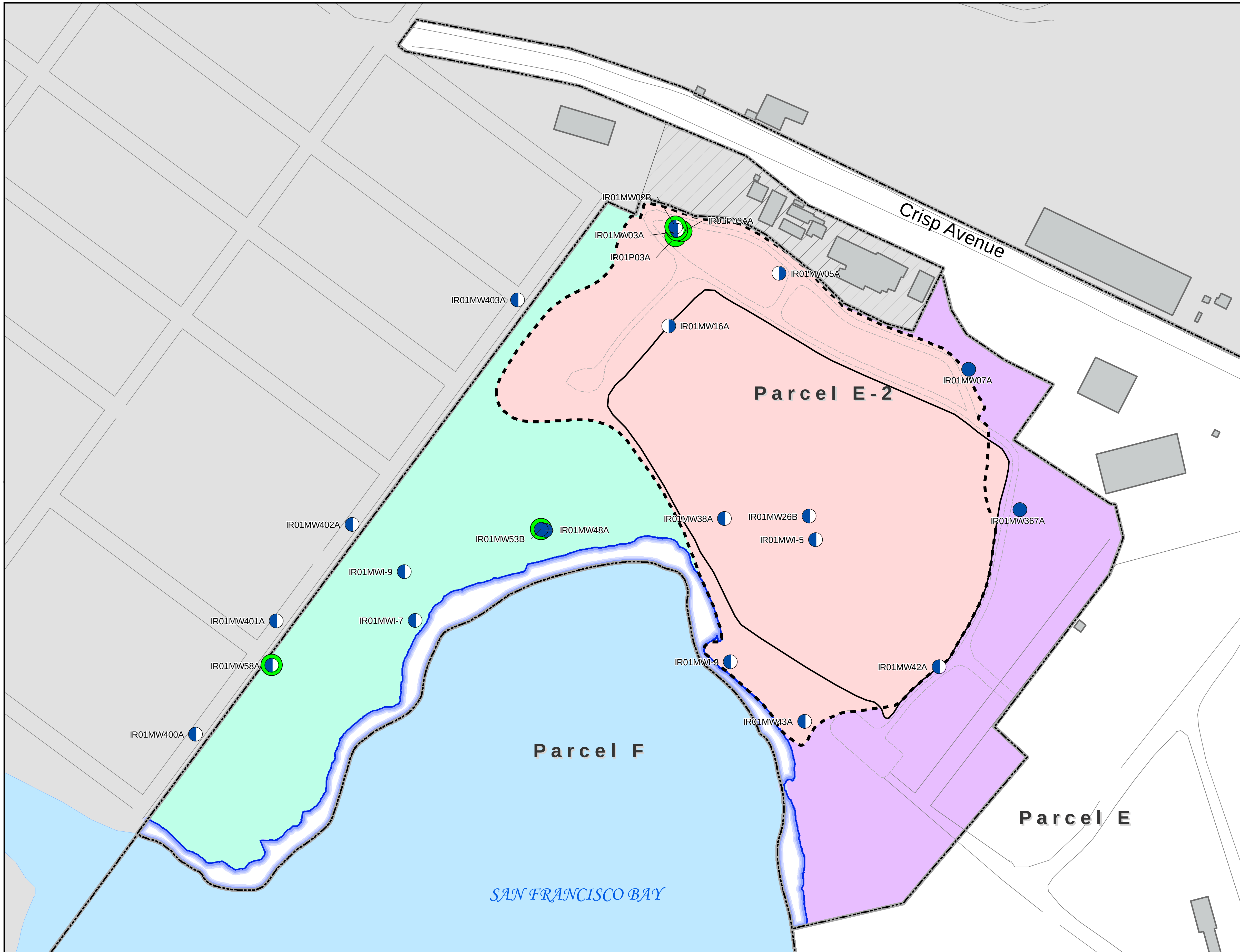
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-17

VERTICAL GROUNDWATER FLOW POTENTIAL

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\Vertical Groundwater Flow Direction\Vertical Groundwater Flow.mxd



1996 Constant Rate Pumping Test Location
1996 Slug Test Location
2001 Slug Test Location
1996 & 2001 Slug Test Location

Parcel Boundary
Landfill Area
East Adjacent Area
Panhandle Area
Shoreline Area
Estimate of Solid Waste Extent
Interim Landfill Cap Extent
Non-Navy Property
UCSF Compound
Building
Road
Gravel Road

Notes:
UCSF = University of California, San Francisco

N

250 0 250
Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

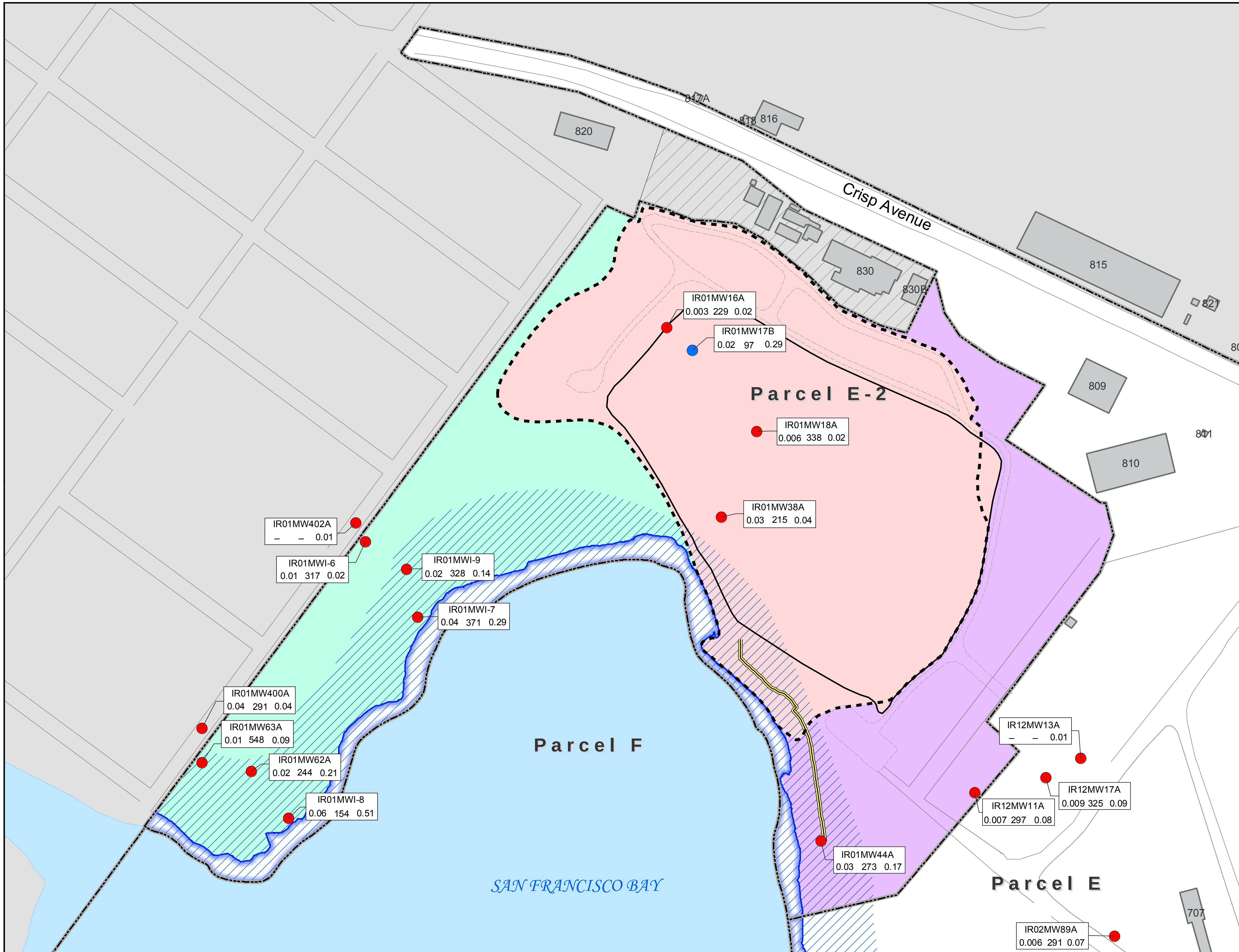
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-18

AQUIFER AND SLUG TEST LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Aquifer_Test_Locations.mxd



A-Aquifer Monitoring Well
B-Aquifer Monitoring Well
Landfill Area
East Adjacent Area
Panhandle Area
Shoreline Area
Estimate of Solid Waste Extent
Interim Landfill Cap Extent
Non-Navy Property
UCSF Compound
Building
Parcel Boundary
Sheet-Pile Wall
Tidal Influence Zone (Maximum Tidal Fluctuation ≥ 0.10 foot)
Road
Gravel Road

Notes:
The tidal influence study was conducted May 20 to June 3, 2002.

– Not available
UCSF = University of California, San Francisco

IR15MW10F ← Well Identification
0.05 160 0.70
Maximum Tidal Fluctation (Feet)
Time Lag (Minutes)
Tidal Efficiency

Referenes:
Tetra Tech EM Inc. 2004c. "Revised Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation, Hunters Point Shipyard, San Francisco, California." May 11.

N

250 0 250
Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

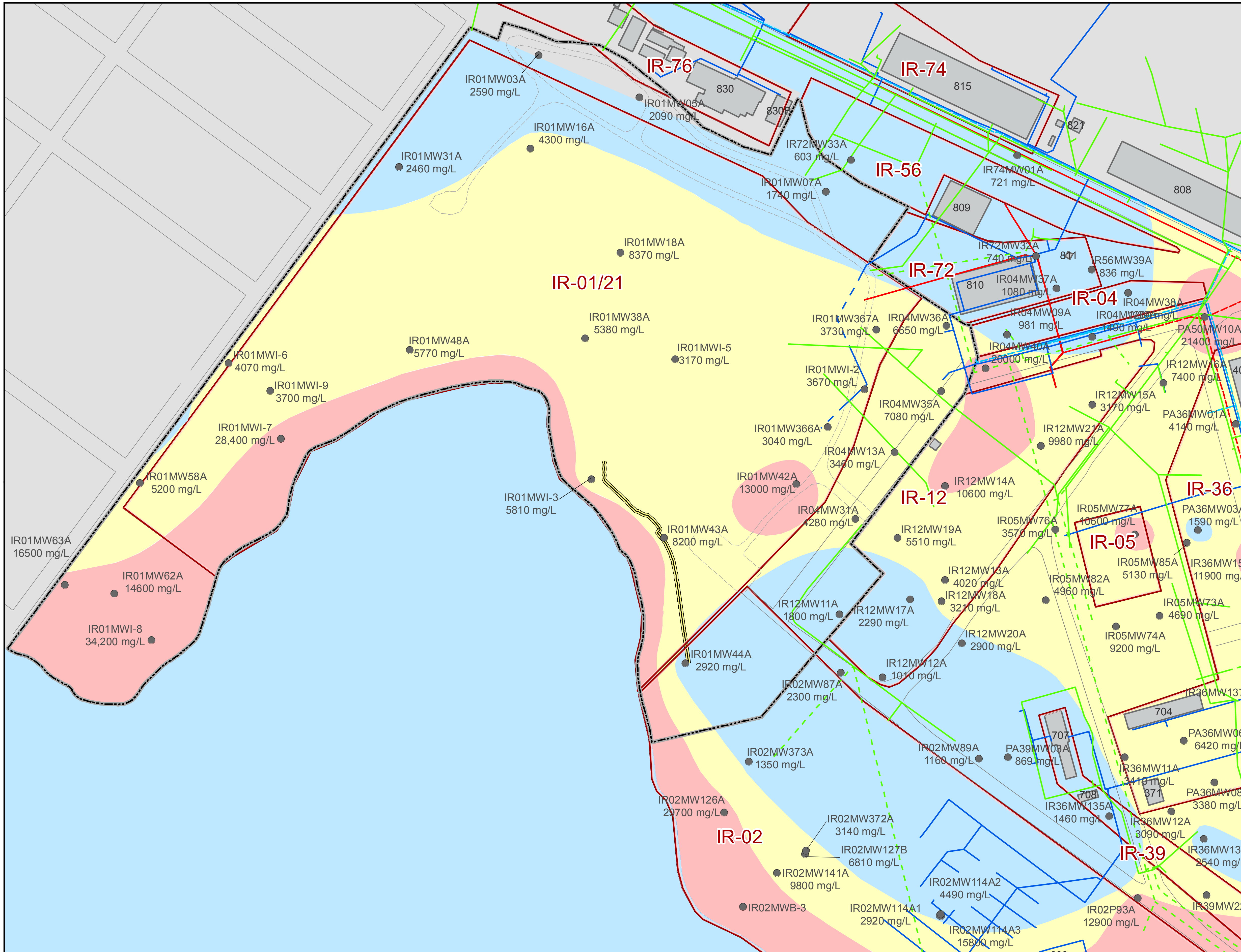
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-19

TIDAL INFLUENCE STUDY WELLS AND PARAMETERS

Remedial Investigation/Feasibility Study for Parcel E-2

2005-12-19 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\GW_figures\Tidal Influence Study\Tidal-Influence_Study.mxd



A-Aquifer Monitoring Well With Well Identification and Maximum TDS Result

A-Aquifer Maximum TDS Zones

- ≥10,000 mg/L
- ≥3,000 mg/L and <10,000 mg/L
- <3,000 mg/L

- Parcel E-2 Boundary
- IR Site Boundary
- Building
- Non-Navy Property
- Storm Line-Below Groundwater
- Storm Line-Above Ground
- Sanitary Sewer Line -Below Groundwater
- Sanitary Sewer Line-Above Groundwater
- Water Line
- Saltwater Line
- Sheet-Pile Wall
- Road

Notes:

IR = Installation Restoration
mg/L = milligrams per liter
TDS = total dissolved solids

References:

Adapted from Tetra Tech EM Inc. 2004c. "Revised Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation, Hunters Point Shipyard, San Francisco, California." May 11.

N

200 0 200

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

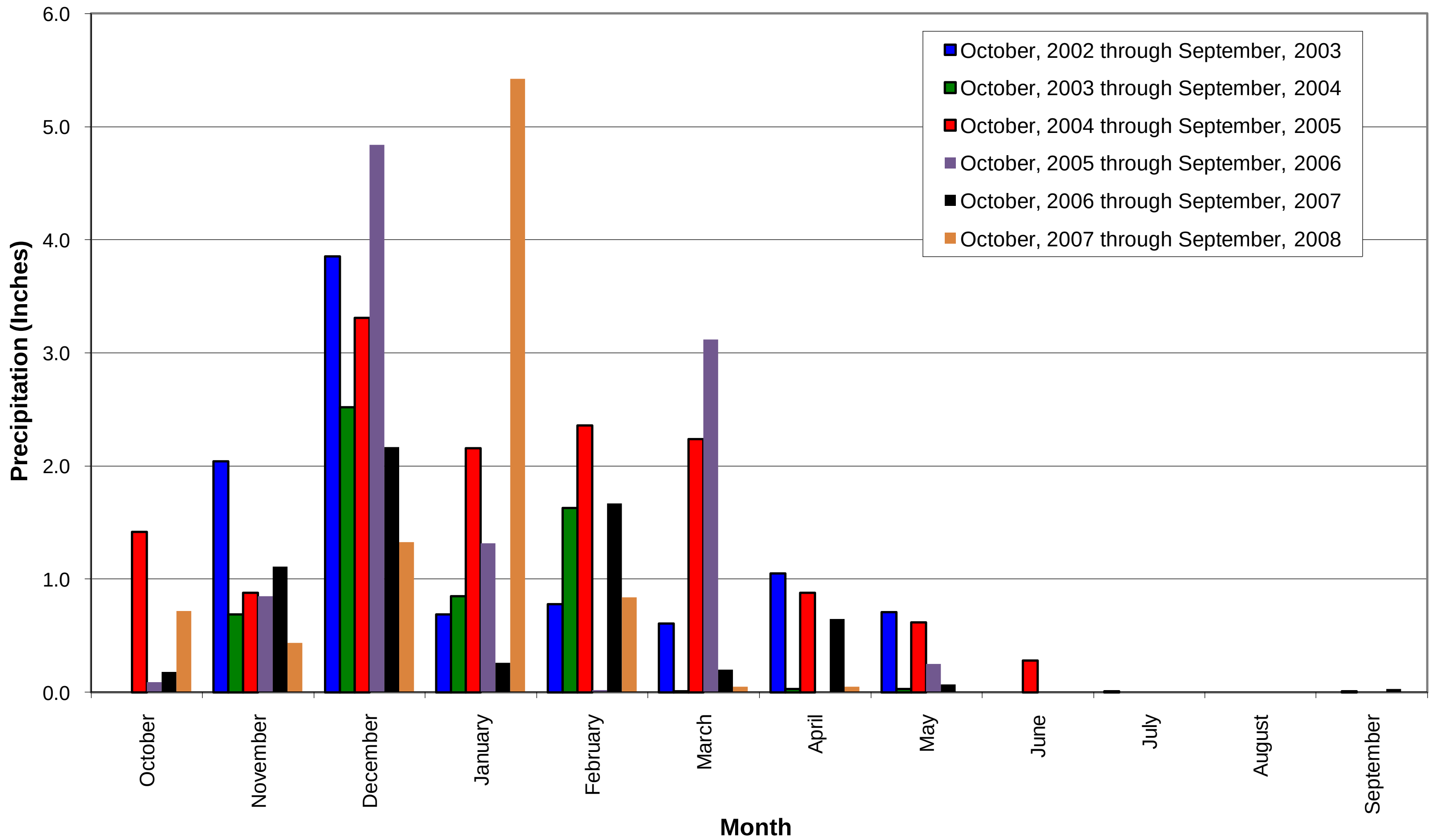
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-20

MAXIMUM TOTAL DISSOLVED SOLIDS CONCENTRATIONS IN THE A-AQUIFER

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\BeneficialLUse\Maximum Total Dissolved Solids in the A-Aquifer.mxd



Notes: Precipitation data collected at Hunters Point Shipyard meteorological tower located on Parcel E. The meteorological tower began operation on September 17, 2002.

Values plotted are the total precipitation per month from October, 2002 through September, 2008.

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

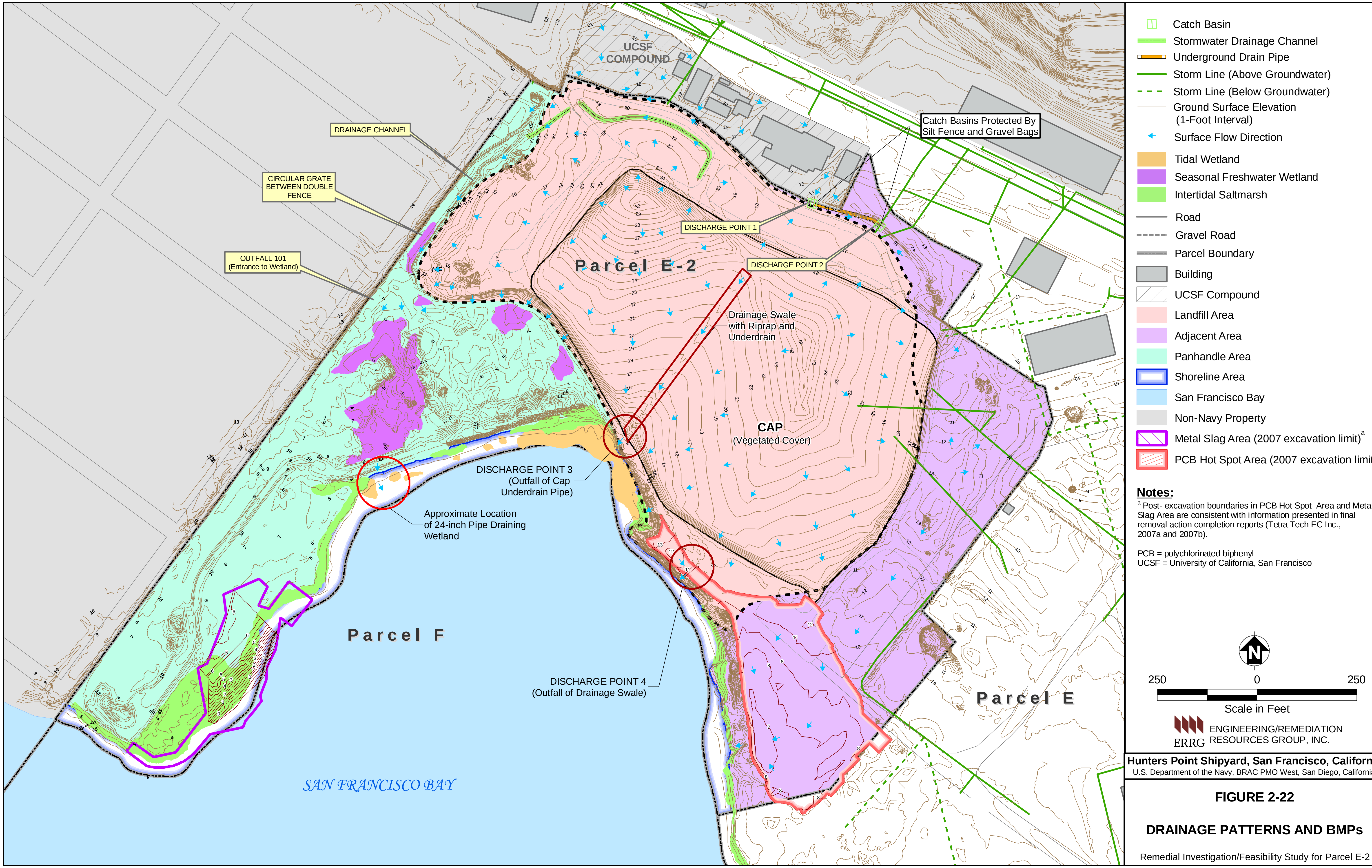
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-21

MONTHLY PRECIPITATION AT HUNTERS POINT SHIPYARD, 2002 TO 2008

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\Graphics\Precip_figure_Oct02-Sept08



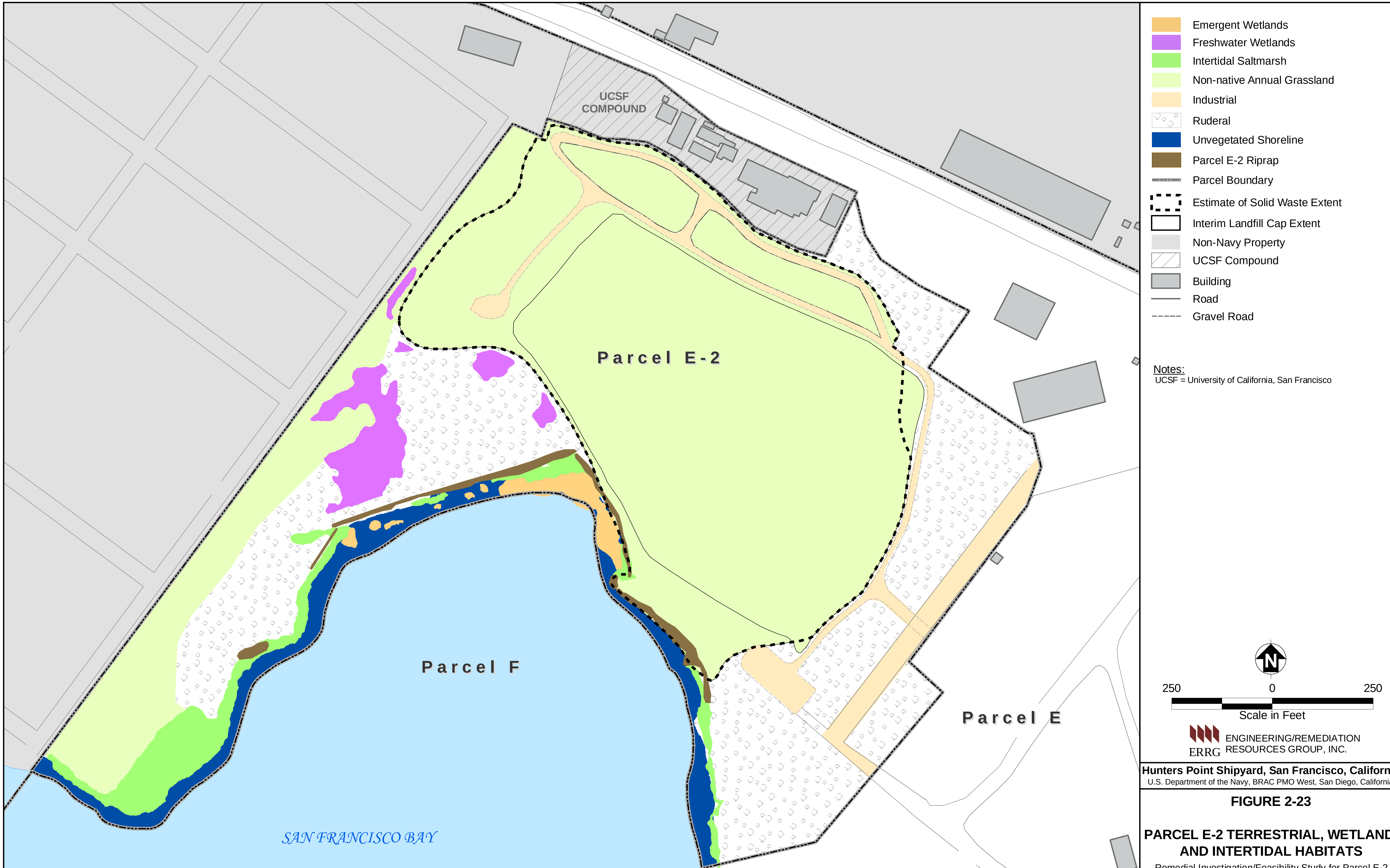
Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-22

DRAINAGE PATTERNS AND BMPs

Remedial Investigation/Feasibility Study for Parcel E-2



ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-23

PARCEL E-2 TERRESTRIAL, WETLAND, AND INTERTIDAL HABITATS

Remedial Investigation/Feasibility Study for Parcel E-2

N:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Terrestrial-habitats.mxd

Tables

Table 2-1. Summary of Slug Test Results
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

IR Site No.	Well No	Area	Aquifer	T (ft^2/day)	K (ft/day)	Hydrostratigraphic Unit	Data Source
01/21	IR01MW02B	Landfill	B	65	1.3	Artificial Fill (well-graded sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW03A	Landfill	A	246	20	Artificial Fill (poorly graded sand with clay and landfill debris)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW05A	Landfill	A	--	0.15	Artificial Fill (landfill debris with silt and clay)	Groundwater Control System Evaluation Report (IT, 2001)
	IR01MW07A	Landfill	A	178	24	Artificial Fill (sandy clay with gravel)	Draft Final Parcel E RI (TtEMI, LFR, and U&A, 1997)
	IR01MW16A	Landfill	A	--	2.4	Artificial Fill (landfill debris zone, well-graded sand with gravel)	GW Control System Evaluation Report (IT, 2001)
	IR01MW26B	Landfill	B	97	0.9	Undifferentiated Upper Sand Deposits (well-graded sand with silt)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW38A	Landfill	A	16	1.2	Artificial Fill (sandy silt, well-graded gravel, and landfill debris)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW42A	Landfill	A	506	59	Artificial Fill (serpentinite gravel)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW43A	East Adjacent Area	A	77	5.4	Artificial Fill (sandy silt and well-graded sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW48A	Landfill	A	190	16	Artificial Fill (silty sand with gravel	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW53B	Landfill	B	701	4.43	Undifferentiated Sedimentary Deposits (silty and poorly graded sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)

Table 2-1. Summary of Slug Test Results *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

IR Site No.	Well No	Area	Aquifer	T (ft^2/day)	K (ft/day)	Hydrostratigraphic Unit	Data Source
01/21	IR01MW58A	Landfill	A	32	3.4	Artificial Fill (sand, silt, and gravel)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW367A	Landfill	A	92	6.27	Artificial Fill and Undifferentiated Upper Sand Deposits (silty and poorly graded sand and gravel)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW400A	Landfill	A	187	14.83	Artificial Fill (silty sand and poorly graded gravel)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW401A	Landfill	A	182	13.71	Artificial Fill and Undifferentiated Upper Sand Deposits (silty poorly and well-graded sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW402A	Landfill	A	147	14.05	Artificial Fill (silty sand and well-graded gravel)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW403A	Landfill	A	1,734	30.76	Artificial Fill and Undifferentiated Upper Sand Deposits (silty and poorly graded sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MWI-3	Landfill	A	5	0.71	Artificial Fill (sand to gravelly sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MWI-5	Landfill	A	115	11	Artificial Fill (clayey sand and landfill debris)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW-7	Landfill	A	500	50	Bay Mud Deposits (silty clay)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW-9	Landfill	A	10	1.2	Artificial Fill (clayey sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)

Table 2-1. Summary of Slug Test Results *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

IR Site No.	Well No	Area	Aquifer	T (ft^2/day)	K (ft/day)	Hydrostratigraphic Unit	Data Source
01/21	IR01P03AA	Landfill	A	688	12.29	Artificial Fill (landfill debris)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MW366A	Landfill	A	2	0.14	Artificial Fill (silty sand with gravel)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR01MWI-2	East Adjacent Area	A	625	69	Artificial Fill (clayey sand and sandy gravel)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
04	IR04MW31A	East Adjacent Area	A	181	11	Artificial Fill (clayey gravel with sand and gravel with silt)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR04MW35A	East Adjacent Area	A	523	29.42	Artificial Fill (gravelly silt)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
	IR04MW36A	East Adjacent Area	A	209	130	Artificial Fill (gravelly silt and gravelly clay with sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)
12	IR12MW11A	East Adjacent Area	A	113	12	Artificial Fill (gravelly silt, clayey gravel, and poorly graded gravel with sand)	Draft Final Parcel E RI Report (TtEMI, LFR, and U&A, 1997)

Notes:

--	not applicable
ft/day	feet per day
ft^2day	square feet per day
IR	Installation Restoration
IT	International Technology Corporation
K	hydraulic conductivity
LFR	Levine-Fricke-Recon
RI	Remedial Investigation
T	transmissivity
TtEMI	Tetra Tech EM Inc.
U&A	Uribe and Associates, Inc.

Table 2-2. **Summary of Constant Rate Pumping Test Results in Parcel E-2,**
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

IR Site No.	Pumping Test No.	Well No. [a]	Pumping Test Type	Type of Analysis	Method	Q [b] (gpm)	T [c] (ft^2/day)	S [d]	K [e] (ft/day)	Hydrostratigraphic Unit
01/21	1	IR01MW03A (P)	Drawdown	C-J	AQTESOLV[f]	4.25	48.6	NA	3.4	Clay to gravel fill and boulder
			Drawdown	Theis	AQTESOLV[f]		44.2	NA	3.7	
			Recovery	Theis	AQTESOLV[f]		328	NA	25.2	
		IR01MW02B (O)	Drawdown	C-J	AQTESOLV[f]		251	0.012	14.8	Undifferentiated Sedimentary Deposits
			Drawdown	Theis	AQTESOLV[f]		199	0.017	11.7	
			Recovery	Theis	AQTESOLV[f]		354	NA	20.8	
		IR01P03A (O)	Drawdown	C-J	AQTESOLV[f]		2,290	0.07	179	Landfill debris
			Drawdown	Theis	AQTESOLV[f]		2,290	0.07	179	
			Recovery	Theis	AQTESOLV[f]		2,460	NA	192	
		IR01P03AA (O)	Drawdown	C-J	AQTESOLV[f]		6,880	0.17	623	Clay to gravel fill
			Drawdown	Theis	AQTESOLV[f]		6,880	0.17	623	
			Recovery	Theis	AQTESOLV[f]		15,900	NA	1,440	
		IR01P03AB (O)	Drawdown	C-J	AQTESOLV[f]		6,410	0.14	526	Clay to gravel fill
			Drawdown	Theis	AQTESOLV[f]		6,410	0.14	526	
			Recovery	Theis	AQTESOLV[f]		9,560	NA	785	
	2	IR01MW53B (P)	Recovery	Theis	GWAP	10.5	150	NA	14	Undifferentiated Sedimentary Deposits
	3	IR01MW58A (P)	Recovery	Theis	GWAP	5.5	970	NA	80	Silt to gravel fill

Table 2-2. Summary of Constant Rate Pumping Test Results in Parcel E-2 *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Notes:	Table from Appendix C of Parcel E Remedial Investigation Report (Tetra Tech EM Inc., Levine-Fricke-Recon, and Uribe and Associates, Inc., 1997)
a	Wells with designation ending with "B" are screened in the B-aquifer; remaining monitoring wells are screened in the A-aquifer
b	Average pumping rate
c	Transmissivity
d	Storativity
e	Hydraulic conductivity
f	Aquifer test solver (AQTESOLV), Geraghty and Miller Modeling Group (1994)
C-J	Cooper-Jacob method (1946)
ft/day	feet per day
ft^2/day	square feet per day
gpm	gallons per minute
GWAP	Graphical Well Analysis Package
IR	Installation Restoration
NA	not applicable
O	observation well
P	pumping well
Theis	Theis method (1935)

Section 3. Remedial Investigation Activities and Removal Actions

Multiple environmental investigations have been conducted at Parcel E-2[4], beginning in 1984. These investigations included basewide investigations (such as the IAS), investigations performed throughout Parcel E (which was later subdivided into Parcels E and E-2), and landfill-specific investigations within Parcel E-2. The environmental investigations can be categorized into the following time frames:

Pre-Remedial Investigation Activities (1984 to 1988): The Parcel E-2 Landfill was initially identified as IAS Site 3 during the IAS conducted in 1984 under the NACIP program (NEESA, 1984). Additional investigations performed following the IAS included installation of nine monitoring wells (IR01MWI-1 through IR01MW-9) during the 1987 confirmation study and verification step.

Remedial Investigation Activities (1988 to 1996): The Parcel E-2 Landfill progressed to the RI stage as IR Site 1 and was grouped (along with IR Sites 02 and 03 in Parcel E) into Operable Unit (OU)-I. The first phase of the OU-I RI (from 1988 to 1989) consisted of reconnaissance activities, including a geophysical survey and test pit excavation to delineate the extent of landfill waste, a soil gas survey to evaluate the presence of VOCs in soil and groundwater, and installation of deep soil borings to define subsurface stratigraphy. Subsequent phases of the OU-I RI involved primary and contingency sampling of soil and groundwater from October 1990 to June 1992. Following the 1992 decision to align the HPS IR sites into parcels, the RI at the landfill was completed in conjunction with other Parcel E IR sites and involved additional field investigations performed from October 1995 to June 1996 (TtEMI, LFR, and U&A, 1997). In 1993, IR Site 1 was combined with IR Site 21. IR Site 21 was initially identified as a separate site during the RI/FS scoping process, but was later determined to be part of the landfill and thus was combined with IR Site 1.

Data Gaps Investigations (2000 to 2003): During preparation of the Parcel E RI and FS reports in 1997 and 1998, the Navy and regulatory agencies identified additional tasks to support the RD for Parcel E, most of which were specific to the Parcel E-2 Landfill. These tasks were performed during the NDGI, from October 2001 to September 2002, and included defining the nature and extent of landfill gas, refining the lateral extent of solid waste, evaluating liquefaction potential of the landfill, and delineating wetlands areas adjacent to the landfill. In addition, the Navy and the regulatory agencies decided that

[4] In September 2004, the Navy divided Parcel E into two parcels (E and E-2). Discussions within this report that reference documents published prior to September 2004 refer to the portion of Parcel E that became Parcel E-2.

additional data for Parcel E were needed, including data from the area now referred to as Parcel E-2, to better define the nature and extent of chemicals in soil and groundwater. As discussed in Section 1, these investigations included the GDGI, performed from July 2000 to October 2002, and the SDGI, performed from September 2002 to February 2003.

Landfill Compliance Monitoring (2003 to present): The Navy has implemented several environmental monitoring programs to help satisfy regulatory requirements (as outlined in 27 CCR) for Parcel E-2 until a final remedy is selected. As discussed in Section 1.1.2, these programs include landfill gas control and monitoring, groundwater monitoring, landfill cover integrity monitoring and maintenance, and stormwater management and monitoring. Data from the ongoing monitoring provides information on current site conditions that is helpful in verifying the nature and extent conclusions from previous site investigations.

This RI/FS Report is based on information compiled from these past investigations and ongoing monitoring, rather than from a single RI field investigation. Analytical data from pre-RI investigations are not included in the RI data set; however, the results of these investigations were incorporated into the RI field program (TtEMI, LFR, and U&A, 1997). Table 3-1 summarizes the field activities performed during the RI and subsequent data gaps investigations and compliance monitoring.

In addition, this RI/FS Report also includes information from several interim removal actions that were performed in Parcel E-2. This section includes brief summaries of the methods, actions performed, and relevant results of the investigations and removal actions conducted at Parcel E-2.

Many of the previous investigations were summarized in reports that are drawn upon and either referenced or included as appendices to this report. Previous investigations and other IR Program activities were divided into the following categories to simplify their presentation in this section: pre-RI activities (Section 3.1); landfill investigations (Section 3.2); soil investigations in non-landfill areas, including the East Adjacent Area and the Panhandle Area (Section 3.3); groundwater investigations (Section 3.4); ecological assessments (Section 3.5); radiological assessments (Section 3.6); outdoor air monitoring (Section 3.7); previous removal actions (Section 3.8); and ongoing monitoring programs (Section 3.9). Table 1-3 presents a chronology of all previous environmental investigations, as well as previous and ongoing remedial actions conducted at Parcel E-2.

3.1. PRE-REMEDIAL INVESTIGATION ACTIVITIES

The pre-RI activities are summarized in the following documents:

- "Geotechnical Investigation, Waste Disposal Sites" (Lowney-Kaldveer Associates, 1973)
- "As-Built Drawings for Storm Sewer Interceptor Phase II, MILCON Project P-261B" (Navy, 1974)

- "Initial Assessment Study of Hunters Point Naval Shipyard" (Disestablished) (NEESA, 1984)
- "Confirmation Study, Verification Step, Hunters Point Naval Shipyard (Disestablished)" (EMCON Associates [EMCON], 1987a)
- "Area Study for Asbestos-Containing Material and Organic and Inorganic Soil Contamination, Hunters Point Naval Shipyard (Disestablished)" (EMCON, 1987b)
- "Parcel E Remedial Investigation, Draft Final Report" (TtEMI, LFR, and U&A, 1997)

The following subsections are brief summaries of the findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding document listed above.

3.1.1. Geotechnical Investigation, Waste Disposal Sites (1973)

In 1973, Lowney-Kaldveer Associates performed a geotechnical investigation as part of closing the Parcel E-2 Landfill. The field investigation consisted of a surface reconnaissance and a subsurface exploration, including 12 soil borings to depths ranging from 12 to 47 feet bgs. Existing topography and the soil conditions derived from soil samples collected from the borings indicated that the east and west margins of the landfill were raised with sand and clay fill prior to using the area as a landfill. These fill activities left an inlet of San Francisco Bay open that extended through the middle of the waste disposal area.

3.1.2. As-Built Drawings for Storm Sewer Interceptor Project (1974)

Following the disestablishment of HPS as an active naval facility in 1974, several preliminary closure actions were performed at the Parcel E-2 Landfill. A stormwater interceptor line was constructed to divert stormwater runoff from the hill area north of the landfill to an outfall near Berth 36. This action prevented runoff from inundating the landfill and increasing leachate production. In addition, the landfill was covered with a minimum of 2 feet of compacted imported fill. The fill was placed in two lifts: the first lift varied in thickness but was a minimum of 1 foot thick, and the second lift was 1 foot thick (TtEMI, LFR, and U&A, 1997).

An oily waste area was also identified on the Navy's drawings along the western perimeter of the site (Figure 1-8). Ponded liquid was removed, and the top 6 inches of soil at the oily waste area was scarified before placing the soil cover. The soil cover was also graded to facilitate surface water drainage. Drawings also indicate attempts to construct a 1,000-foot-long clay dike along the southern edge of the landfill; however, it did not succeed in attaining an effective seal because of reported difficulty in excavating bulky underground debris (NEESA, 1984).

3.1.3. Initial Assessment Study (1984)

In 1984, WESTEC Services, Inc. conducted the IAS at IR-01. The IAS consisted primarily of a review of records and a visual inspection of the site. The study concluded that it was highly probable that chemicals from waste disposed of in the Parcel E-2 Landfill had reached groundwater and were migrating toward San Francisco Bay. This migration constituted a potential threat to the bay environment and a confirmation study was recommended for the site.

3.1.4. Confirmation Study, Verification Step (1987)

In 1987, the verification step of the confirmation study was conducted at IR Site 01. This study consisted of a geophysical survey, the drilling of nine soil borings, and the completion of these borings as monitoring wells (IR01MWI-1 through IR01MW-9). The verification step report concluded that soil at the Parcel E-2 Landfill contained a variety of VOCs and SVOCs that appeared to be associated with petroleum products and some chlorinated organic solvents. The report recommended further environmental investigations because contaminants were detected beyond the reported landfill boundaries. It also recommended that, because the results of the gross alpha and beta radiation scans were inconclusive, groundwater should be analyzed for radium and a gamma radiation screening should be performed.

3.1.5. Area Study for Asbestos-Containing Material and Organic and Inorganic Soil Contamination (1987)

In 1987, the Area Study for asbestos-containing material and organic and inorganic soil contamination was conducted throughout HPS to evaluate whether a release of hazardous substances to soil had occurred at construction sites outside the boundaries of previously identified investigation sites. The area study primarily concluded that soil within Study Area A, including Parcels E and E-2, contained naturally occurring asbestos derived from the serpentine bedrock.

3.1.6. Triple A Investigation, Remedial Action Order, and RI/FS Scoping Document (1986 to 1988)

The Navy leased portions of HPS to Triple A from July 1, 1976, through June 30, 1986. During this period, Triple A used dry docks, berths, machine shops, power plants, offices, and warehouses to repair commercial and naval vessels. The Navy identified 19 sites that Triple A had allegedly used to store and dispose of hazardous and other wastes during its occupancy of the site. Two of these sites, Triple A Sites 1 and 16, are located within Parcel E-2 (see Figure 1-11). At Site 16, Triple A allegedly disposed of industrial debris, sandblast waste, oily industrial sand, and asphalt over an area of approximately 5 acres along the shoreline of Parcel E-2 (SFDA, 1986). A portion of the Landfill Area was also included as part of Triple A Site 16. At Site 1, Triple A allegedly stored unlabeled, deteriorating, uncovered drums with their contents exposed to the elements in the southeast corner of Parcel E-2 (SFDA, 1986).

On January 7, 1988, the DHS issued a Remedial Action Order to the Navy and its tenant, Triple A (DHS, 1988). The Remedial Action Order listed numerous sites, including IR Site 01 and Triple A Sites 1 and 16. In response to the Remedial Action Order, the Navy completed a scoping document for the RI/FSs to be conducted at HPS. The scoping document grouped the sites into OUs and described the field investigations to be conducted under the RI (HLA, 1988).

3.2. LANDFILL INVESTIGATIONS

The results of the Parcel E-2 landfill investigations are summarized in the following documents:

- "Parcel E Remedial Investigation, Draft Final Report" (TtEMI, LFR, and U&A, 1997)
- "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Gas Characterization" (TtEMI, 2003e; provided as Appendix A to this report)
- "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Lateral Extent Evaluation" (TtEMI, 2004f; provided as Appendix B to this report)
- "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Liquefaction Potential" (TtEMI and ITSI, 2004b; provided as Appendix C to this report)

The following subsections are brief summaries of the findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding document listed above. The nature and extent of solid waste and subsurface gas in the Landfill Area is discussed in more detail in Section 4.2.

3.2.1. Remedial Investigation (1988 to 1996)

The Landfill Area was investigated during the OU-I RI from 1988 to 1992. During the RI, the Navy performed geophysical surveys and excavated test pits to characterize the lateral extent of the landfill waste layer. Figure 3-1 shows the locations of landfill characterization activities, including those performed during the RI. Table 3-2 summarizes the chronology of landfill characterization activities from the RI through the NDGI. In addition, soil borings were installed within the Landfill Area to define the vertical extent of landfill waste, assess the chemical condition of soil fill within the landfill, and evaluate the general composition of the landfill waste. Some of these soil borings were converted into groundwater monitoring wells to assess the chemical conditions of groundwater both within and underneath the landfill waste. Soil and groundwater sampling locations are shown on Figure 3-2. Tables 3-3 and 3-4 summarize the chronology of soil and groundwater sampling activities, respectively.

Data collected during the RI was adequate to define the vertical extent of landfill waste, assess the chemical condition of soil fill within the landfill, and evaluate the general composition of the landfill waste. Following evaluation of the RI results, several data gaps remained within the Landfill Area. The Navy and the regulatory agencies decided to conduct a data gaps investigation (referred to as the NDGI) in 2002 to gather more information to characterize the nature and extent of landfill gas, better delineate the lateral extent of waste, and estimate the potential for sand layers near the landfill to liquefy during an earthquake.

3.2.2. Landfill Gas Characterization (2002)

In 2002, as part of the NDGI, the Navy conducted an evaluation to delineate and characterize landfill gas. This evaluation included outdoor air monitoring and building atmosphere surveys, a subsurface soil gas survey, and GMP installation and monitoring. Figure 3-1 shows these monitoring locations, and Table 3-2 summarizes the chronology of landfill characterization activities. Results from GMP monitoring indicated that methane, the main component of landfill gas, was present at levels that exceeded the LEL of 5 percent by volume in air in subsurface areas in the northern part of the landfill and aboveground at four areas on the UCSF compound. Trace concentrations of NMOCs were also detected in this area; however, a screening evaluation concluded that the detected concentrations of NMOCs did not pose an unacceptable risk to human health. The landfill gas characterization report is included as Appendix A to this report.

3.2.3. Landfill Lateral Extent Evaluation (2002)

In 2002, as part of the NDGI, an evaluation of the lateral extent of solid waste was conducted. After a review of the existing historical information, test pits were excavated and soil borings were drilled (Figure 3-1) to determine the edge of the continuous physical waste in the Parcel E-2 Landfill. When solid waste was encountered in a test pit, "step-out" test pits were excavated up to 50 feet from the previous location outward from the center of the landfill. The evaluation determined that the lateral extent of landfill waste encompasses approximately 22 acres (Figure 3-1), and is bounded in most areas by fill composed of soil (mainly sand and gravel) and noncontiguous waste (mainly construction debris and nonhazardous refuse). Along the northern perimeter, the landfill boundary extends to within a few feet of the fence line that separates the landfill and the UCSF compound. The landfill lateral extent evaluation report is included as Appendix B to this report.

3.2.4. Landfill Liquefaction Potential Evaluation (2002)

In 2002, as part of the NDGI, an evaluation was conducted to determine the potential for subsurface layers in the vicinity of the Parcel E-2 Landfill to liquefy during an earthquake. Data collected included visual soil classification from soil borings, standard penetration test (SPT) borings to estimate the relative stiffness and strength (bearing capacity) of soil, cone penetrometer test (CPT) borings to obtain information on soil density and lithology, seismic wave velocity, and laboratory analyses of soil geotechnical characteristics. CPTs and SPTs were performed along the perimeter of the landfill and within the landfill waste (Figure 3-1). The information was used to model the effects of soil liquefaction caused by an earthquake to determine if the integrity of the landfill cover would be compromised.

According to 27 CCR, landfill closure systems must be designed to withstand shaking from the maximum probable earthquake (MPE). The following characteristics apply to the MPE defined based on a deterministic evaluation:

- Location: San Andreas Fault Peninsula Segment
- Magnitude: 7.9
- Distance from site: 12 kilometers
- Peak ground acceleration: 0.5 and 0.6 times the acceleration of gravity

Only certain types of soil (referred to as cohesionless soil) will potentially liquefy under dynamic loading from an earthquake. These types include loosely consolidated soil classified as sand, silty sand, and sandy silt. The Artificial Fill surrounding and underlying the Parcel E-2 Landfill is heterogeneous and consists of discontinuous layers of cohesionless soil intermixed with cohesive soil (e.g., clay) and landfill waste, and is underlain by the Bay Mud, which consists predominantly of clay with discontinuous layers of sand and silt.

The liquefaction potential of cohesionless soil layers identified within the SPT and CPT borings was evaluated using standard geotechnical methods (Youd and others, 2001; Seed and others, 2001). The evaluation indicated that most of these soil layers (66 to 67 percent) would not liquefy during the MPE. The evaluation concluded that, for the remaining soil layers that could liquefy during the MPE, lateral movement of soil below the waste may be approximately 4 to 5 feet. This estimate is conservative because of the discontinuous layers and resistance from nonliquefiable soil at the boundaries, which would likely reduce the amount of lateral movement to less than the estimated 4 to 5 feet. Settlement of liquefiable soil below the waste may be up to 10 inches.

The evaluation also concluded that, if containment were selected as the final remediation measure, further analysis would be required on response of the landfill cap, overall stability of the landfill site, slope stability, and other closure features. The landfill liquefaction potential evaluation is included as Appendix C to this report. Additional slope stability analyses are discussed in Section 11.5.1.1.

3.3. SOIL INVESTIGATIONS IN NON-LANDFILL AREAS

The non-landfill areas are those beyond the landfill extent but within the Parcel E-2 boundary; these areas are the East Adjacent Area and the Panhandle Area (Figure 1-2). Investigations performed in the intertidal Shoreline Area are discussed in Section 3.5. The results of investigations in the East Adjacent Area and the Panhandle Area are summarized in the following documents:

- "Parcel E Remedial Investigation, Draft Final Report" (TtEMI, LFR, and U&A, 1997)
- "Parcels E and E-2 Standard Data Gaps Investigation, Data Summary Report (Revision 01)" (TtEMI, 2005c)
- "Draft Final Removal Action Design and Implementation Work Plan, Metal Debris Reef and Metal Slag Areas, Parcels E and E-2" (TtFW, 2005b)

The following subsections are brief summaries of the findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding document listed above. The nature and extent of chemicals in soil within the East Adjacent Area and Panhandle Area are discussed in more detail in Sections 4.3 and 4.4, respectively.

3.3.1. Remedial Investigation (1988 to 1996)

From 1988 to 1992, soil within the non-landfill areas was investigated during the OU-I RI. These areas, which lie outside the Landfill and Shoreline Area boundaries but within Parcel E-2, are mainly composed of fill material, including soil mixed with noncontiguous solid waste deposits. The Navy collected soil samples from surface locations, excavated shallow test pits, and drilled deeper soil and monitoring well borings to evaluate whether hazardous substances and petroleum hydrocarbons had been released at Parcel E-2. Figure 3-2 shows the soil sampling locations, and Table 3-3 summarizes the chronology of soil characterization activities.

Reconnaissance activities, performed from 1988 to 1989, consisted of drilling deep soil borings to define subsurface stratigraphy and performing a soil gas survey to evaluate the potential presence of VOCs in soil and groundwater. During the soil gas survey at Parcel E-2, concentrations of total petroleum hydrocarbons (TPH), excluding methane and other aliphatic hydrocarbons, were detected in the northern portion of the landfill. In addition, concentrations of less than 1 part per billion of trichloroethane (TCA); trichloroethene (TCE); tetrachloroethene (PCE); and benzene, toluene, ethylbenzene, and xylenes were detected (HLA, 1990a). From 1990 to 1992, soil sampling was performed at numerous soil borings and test pits to characterize the nature and extent of chemicals in soil within the East Adjacent Area and Panhandle Area. From 1995 to 1996, additional investigation was performed, as part of the Parcel E RI, to better define the nature and extent of chemicals in soil within the East Adjacent Area.

The RI fieldwork produced sufficient data to identify areas of potential soil contamination in most of Parcel E-2. However, following evaluation of the RI results, several data gaps remained within the East Adjacent Area and Panhandle Area. The Navy and regulatory agencies decided to conduct a data gaps investigation (referred to as the SDGI) in 2002 to characterize the landfill and shoreline interface, further delineate known source areas or chemical detections from single points, and to bound potential sources identified in aerial photographs.

3.3.2. Standard Data Gaps Investigation (2002)

The Navy conducted the onshore SDGI in 2002 to further define the nature and extent of chemicals in soil within the non-landfill areas. The Navy reviewed aerial photographs and logs from test pits, soil borings, monitoring wells, and GMPs from various investigations at Parcel E-2. The Navy then conducted an evaluation that compared soil data with human health and ecological screening criteria and evaluated the visual presence of putrescible solid waste (waste that contains significant quantities of biodegradable material such as wood) beyond the landfill extent. The evaluation identified a number of chemical detections above the SDGI screening criteria, several potential source areas identified in aerial photographs, and several known source areas. In addition, wood debris was identified at several locations outside the Landfill Area that had the potential to generate levels of methane gas above the LEL; however, none of these waste locations were contiguous with the Landfill Area and none of the locations warranted designation as hot spots because they do not contain highly toxic or mobile chemicals.

Onshore sampling locations were selected to bound known or potential source areas and chemical detections from single points. Soil samples collected from non-landfill areas were analyzed for metals (including hexavalent chromium), pesticides, PCBs, SVOCs, and TPH (in select locations). The results were used to delineate the PCB Hot Spot Area, a portion of which was removed under an interim removal action (see Section 3.8.8). Confirmation sampling results from the PCB Hot Spot Area are presented in this Draft Final RI/FS Report in Sections 4.2.4 and 4.4.2. Waste types encountered during the removal action are summarized in Sections 4.2.1 and 4.4.1. The SDGI onshore sampling adequately delineated the extent of chemicals in soil at some areas; however, the SDGI samples had detected concentrations of chemicals above both human health and ecological criteria. This finding is attributed to the heterogeneous nature of the fill material within the Panhandle Area and East Adjacent Area. The nature and extent of chemicals in soil within the Panhandle Area and East Adjacent Area are discussed in more detail in Sections 4.3 and 4.4, respectively.

In addition to the onshore sampling, the SDGI characterized the nature and extent of chemicals in sediment within, or in close proximity to, the Shoreline Area. The Parcel E-2 shoreline consists mainly of intertidal sediments between the mean tide line and a riprap wall placed along portions of the shoreline for erosion control. Results of sediment sampling in the Shoreline Area were evaluated in the Shoreline Characterization Technical Memorandum (SulTech, 2007; Appendix G to this report) and are briefly discussed in Section 3.5. In addition to the SDGI sediment sampling, soil samples were collected along the bayward side of the sheet-pile wall during the SDGI to define the extent of chemicals in soil at the interface of the landfill and shoreline. Although these soil sampling locations were considered "shoreline" locations in the SDGI, the locations fall outside of the Shoreline Area as defined for this RI/FS (Figure 3-2) and are considered part of the Landfill Area in this report. Data from these sampling locations were used to delineate the PCB hot spot and were subsequently excavated as part of the removal action (TtECI, 2007a).

3.3.3. Characterization of Metal Slag Area (2004)

The Metal Slag Area contains wastes suspected to have originated from the metal foundry (Building 241 in Parcel C) and the smelter (Building 408 in Parcel D) when the shipyard was active. Waste in the Metal Slag Area includes industrial debris and metal slag with radioactive anomalies. In support of a removal action at the Metal Slag Area, site characterization was performed to further define the vertical and horizontal extent of metal slag. The characterization activities were conducted from June through September 2004 and included (1) topographic and bathymetric surveys, (2) marine geophysics surveys, (3) landside geophysics surveys, (4) environmental resources surveys, (5) vibracoring and sonic drilling, and (6) sampling activities. The metal slag layer was found to range from 1.5 to 6 feet thick over an area of approximately 0.9 acre. Site characterization activities involved collecting samples from offshore and onshore borings and analyzing the samples for radiological and nonradiological chemicals. Elevated concentrations of cesium-137, metals, PCBs, and pesticides were identified at the Metal Slag Area. The metal slag and debris within the area were removed in 2005 and 2006 (see Section 3.8.7). Confirmation sampling results are included in Section 4.3.2 of this RI/FS Report. Waste types encountered during the removal action are summarized in Sections 4.3.1 and 4.4.1.

3.4. GROUNDWATER INVESTIGATIONS

The groundwater data presented in this report were either originally summarized in the four documents listed below, or have been collected as part of the BGMP (Section 3.9):

- "Parcel E Remedial Investigation, Draft Final Report" (TtEMI, LFR, and U&A, 1997)
- "Parcel E Information Package, Phase II Groundwater Data Gaps Investigation" (TtEMI, 2001a)
- "Revised Final Parcel E Groundwater Summary Report, Phase III Groundwater Data Gaps Investigation" (TtEMI, 2004c)
- "Draft Final Technical Memorandum for Groundwater Investigation at Parcel E-2" (CE2-Kleinfelder Joint Venture, 2009a)

The following subsections are brief summaries of the findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding document listed above. The nature and extent of chemicals in groundwater is discussed in more detail in Section 5.

3.4.1. Remedial Investigation (1988 to 1996)

During the RI, the Navy installed monitoring wells and collected groundwater samples to evaluate whether hazardous substances and petroleum hydrocarbons had migrated to groundwater at Parcel E-2. Figure 3-2 shows the groundwater sampling locations, and Table 3-4 summarizes the chronology of groundwater characterization activities. In addition to groundwater sampling, the Navy installed piezometers and performed slug, step-drawdown, and constant-rate pumping tests to characterize the aquifers. Lastly, the Navy conducted a 72-hour tidal influence study within the nearshore areas of Parcel E-2. The results of the aquifer characterization and tidal influence study are discussed in Sections 2.2.3 and 2.2.4, respectively.

The first monitoring wells in Parcel E-2 (IR01MWI-1 through IR01MW-9) were installed in 1986 as part of the confirmation study and verification step. Two of these nine wells (IR01MWI-1 and IR01MW-4; Figure 3-2) were subsequently decommissioned; however, no records are available on the dates or procedures used in the decommissioning. From 1990 to 1992, the Navy performed primary and contingency sampling activities as part of the OU-I RI. Activities involved collecting samples from existing A-aquifer monitoring wells and installing and collecting samples from additional A-aquifer and B-aquifer monitoring wells throughout Parcel E-2. RI activities during this period also included collecting grab groundwater samples from soil borings to assist in the location of future monitoring wells. From 1995 to 1996, additional samples were collected at existing monitoring wells and several additional monitoring wells were installed to better define the groundwater conditions in the East Adjacent Area and evaluate groundwater flow patterns west and northwest of Parcel E-2 (in non-Navy property).

The RI activities produced sufficient data to identify areas of potential groundwater contamination and assess their migration potential. Following evaluation of the RI results, it was concluded that additional data collection from existing monitoring wells was needed to assess current groundwater flow patterns and chemical conditions. The Navy and the regulatory agencies decided to conduct a multi-phase GDGI at Parcels C, D, E, and E-2.

3.4.2. Groundwater Data Gaps Investigation (2000 to 2002)

The GDGI was conducted in three phases between 2000 and 2002 to update previous assessments of groundwater conditions at HPS, supplement information gathered during the Parcel E RI, and better define the extent of groundwater contamination at HPS. The Phase I GDGI involved collection of water level data at Parcels C, D, E, and E-2 and groundwater samples at Parcels C and D. The groundwater sampling program was expanded during the Phase II and Phase III GDGI to include Parcels E and E-2. An evaluation of the condition of the monitoring wells throughout HPS was conducted during Phase II (January through April 2001), and subsequent repairs and new well installation were conducted during Phase III (February through October 2002). Three new A-aquifer wells (IR01MW10A through IR01MW12A) and one piezometer (IR01P-04A) were installed at Parcel E-2 to replace wells that were decommissioned during construction of the landfill gas control system and to monitor groundwater conditions in the vicinity of the landfill gas barrier wall. Wells IR01MW10A through IR01MW12A were installed to replace well IR01MW07A, and piezometer IR01P-04A was installed to replace piezometer IR01P03A. The well decommissioning and replacement activities are discussed in Section 2.3.4 of the Landfill Gas Removal Action Closeout Report (TtEMI, 2004a; Appendix F to the RI/FS Report).

The most prevalent chemicals with groundwater concentrations exceeding GDGI evaluation criteria in Parcel E-2 were VOCs, ammonia, and cyanide. Of the VOCs detected, benzene and 1,4-dichlorobenzene were detected over a relatively extensive area at concentrations just above the MCLs. Although other metals, SVOCs, PCBs, and pesticides were detected at concentrations exceeding GDGI evaluation criteria, the extent of these chemicals in groundwater was not widespread. The Phase III GDGI also collected groundwater samples for analysis of radionuclides at Parcel E-2; the findings of this portion of the GDGI are discussed in Section 3.6. The GDGI concluded that groundwater characterization at the Parcel E-2 Landfill is incomplete and recommended that additional groundwater samples be collected. Following evaluation of the GDGI results, the Navy and the regulatory agencies decided to implement a BGMP to regularly monitor groundwater conditions at HPS. The Parcel E-2 monitoring program was designed to comply with 27 CCR requirements and is discussed in Section 3.9.

3.4.3. Groundwater Data Gaps Investigation (2007 to 2008)

In August 2007, the Navy and the regulatory agencies decided to conduct a focused GDGI along the Parcel E-2 shoreline. The purpose of this GDGI was to provide supplemental data for this RI/FS Report to (1) evaluate chemical concentrations in A-aquifer groundwater adjacent to the Shoreline Area and within the northeast portion of the Panhandle Area (near existing freshwater wetlands); (2) evaluate the effectiveness of the PCB Hot Spot Area removal action in reducing PCBs and petroleum hydrocarbons in A-aquifer groundwater; and (3) evaluate whether A-aquifer groundwater beneath the Metal Slag Area has been affected by dissolved metals. The GDGI consisted of the following fieldwork elements:

- A geophysical survey was performed in September and November 2007 to identify potential subsurface obstructions in the planned work areas.
- Sixty-one A-aquifer temporary wells (TW01 through TW61) were installed in February and March 2008 using direct-push technology (Figure 3-2).
- Grab groundwater samples were collected in March 2008 from the 61 A-aquifer temporary wells and 7 previously installed A-aquifer piezometers (PZ131F, PZ138E, PZ138F, PZ144E, PZ150D, PZ150E, and PZ161D).

Grab groundwater samples were analyzed for one or more of the following chemical groups: (1) TPH, (2) PCBs, (3) ammonia as nitrogen, and (4) dissolved metals. These data are presented in Section 5 of this RI/FS Report. At the request of the regulatory agencies, the scope of the investigation was expanded to include collection and analysis of supplemental grab groundwater samples for specific radionuclides (cesium-137, cobalt-60, radium-226, and strontium-90). The supplemental samples were collected in June 2008, and the associated data will be presented in a separate technical memorandum.

3.5. ECOLOGICAL ASSESSMENTS

Several ecological assessments were performed at Parcels E and E-2. These assessments evaluated exposures to terrestrial wildlife within the onshore areas of Parcels E and E-2 and to aquatic wildlife in San Francisco Bay. The evaluation of aquatic wildlife was performed in conjunction with the CERCLA process at Parcel F. The results of previous ecological assessments are summarized in the following documents:

- "Intertidal Sediment Study and Environmental Sampling and Analyses Plan" (Aqua Terra Technologies [ATT], 1991)
- "Phase 1A Ecological Risk Assessment, Volumes 1 to 3" (PRC, 1994)
- "Phase 1B Ecological Risk Assessment, Parts I and II" (PRC, 1996c and 1996d)
- Baseline Ecological Risk Assessment (BERA) presented as Appendix F to the "Parcel E Remedial Investigation, Draft Final Report" (TtEMI, LFR, and U&A, 1997)
- "Draft Final Ecological Risk Assessment Validation Study" (TtEMI and LFR, 2000a)
- "Protective Soil Concentrations [PSC] Technical Memorandum" (TtEMI and LFR, 2000b)
- "Draft Parcel F Validation Study Report" (Battelle, Entrix, Inc., and Neptune and Company, 2002)
- "Final Parcel E Nonstandard Data Gaps Investigation, Wetlands Delineation and Functions and Values Assessment" (TtEMI, 2003d)
- "Parcels E and E-2 Standard Data Gaps Investigation, Data Summary Report (Revision 01)" (TtEMI, 2005c)
- Draft Parcels E and E-2 Shoreline Characterization Technical Memorandum (SulTech, 2007; Appendix G of this report)

The following subsections are brief summaries of the findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding document listed above.

3.5.1. Intertidal Sediment Studies (1991 to 1992)

In 1991 and 1992, as part of the intertidal sediment study, sediment samples were collected in the intertidal zone of HPS, including along the Parcel E-2 shoreline, to evaluate if chemicals had migrated from Parcels E and E-2 to San Francisco Bay. The Environmental Sampling and Analyses Plan's (ESAP) whole sediment study was implemented in 1991 to measure concentrations of chemicals in sediments, stormwater, and bay water near stormwater outfalls and other potential source areas within the boundaries of HPS. Mussel tissue was also collected and analyzed.

3.5.2. Phase 1A and Phase 1B ERA (1994 to 1996)

The intertidal and ESAP data were used to identify chemicals of potential ecological concern (COPECs) in the Phase 1A ERA. The Phase 1A ERA was a qualitative analysis that developed a preliminary characterization of HPS based on existing data, biotic surveys, and contaminant migration pathways and exposure routes. Both terrestrial and aquatic environments were considered in the Phase 1A ERA. Following the Phase 1A analysis, the quantitative Phase 1B ERA was performed to delineate potential gradients of contamination from onshore sources to offshore sediments and to characterize the risk to aquatic wildlife. Offshore sediment samples were collected and the sediment data were reassessed as part of the Parcel F validation study.

3.5.3. BERA (1997)

During the Parcel E RI, the terrestrial COPECs identified during the Phase 1A ERA were adopted and refined for a BERA. Habitat data from the Phase 1A ERA were also used with data from a resurvey of Parcels E and E-2 in February 1997 (see Section 2.4). The main purpose of the BERA was to evaluate whether site chemical adversely affected the terrestrial environment of Parcels E and E-2. The BERA process consisted of the following activities: (1) identifying COPECs and ecological receptors; (2) analyzing exposure of each ecological receptor; (3) researching ecotoxicological literature to develop toxicity reference values (TRVs) for use in the risk assessment; and (4) characterizing the risk to terrestrial wildlife at Parcel E IR sites.

Lead and total PCBs were identified as Category 2 COPECs, and further evaluation of these COPECs was recommended to identify whether they were likely to pose a potential risk to terrestrial vertebrates at Parcel E-2. In addition, high-molecular-weight polycyclic aromatic hydrocarbons (PAHs), total chlordane, and total dichlorodiphenyltrichloroethane (DDT) were identified as Category 2 COPECs for one ecological receptor (the American kestrel), and further evaluation of these COPECs was recommended to identify whether they were likely to pose a risk to raptors at Parcel E-2. Also, rodent and bird toxicity data were not available for several chemicals, and a recommendation was made to reevaluate potential risk for these chemicals if toxicity data were identified in the near future. Overall, the BERA classified Parcel E-2 as a site posing uncertain risks, but not one posing significant immediate ecological risks.

3.5.4. ERA Validation Study and Protective Soil Concentration Technical Memorandum (1999)

In response to regulatory agency comments on the Parcel E BERA, the Navy conducted the ERA Validation Study to address some of the uncertainties associated with dose calculations and to develop site-specific soil concentrations (referred to as protective soil concentrations [PSCs]) that would be protective of terrestrial receptors. Twelve collocated samples of soil, plant tissue, invertebrate tissue, lizard tissue, and small mammal tissue were collected during the study (including three samples from the Panhandle Area of Parcel E-2). The analytical results were used to calculate exposure doses and hazard quotients (HQs) (by comparing these doses to the low and high TRVs used in the BERA). The results of these evaluations were used to develop PSCs for the representative receptor species: the American kestrel, the house mouse, and the red-tailed hawk. Based on the results of the validation study, cadmium, copper, lead, nickel, selenium, and zinc were determined to be of potential risk to ecological receptors and PSCs were derived for these chemicals. Figure 3-3 shows the soil, sediment, and tissue sampling locations from the ERA Validation Study.

3.5.5. Parcel F Validation Study (2000 to 2002)

The Parcel F Validation Study was conducted to more accurately define the offshore areas that required evaluation in an FS. One collocated sediment and tissue sample was collected from within the Parcel E-2 shoreline (Figure 3-3). The validation study identified copper, lead, and PCBs as the primary ecological risk drivers in South Basin (the offshore area from Parcels E and E-2). The validation study hypothesized that metals and PCBs along the shoreline were a source of contamination to Parcel F sediments. Due to these results, the Navy decided to evaluate the shoreline as a potential source of copper, lead, and PCBs to Parcel F.

3.5.6. Wetlands Delineation and Functions and Values Assessment (2002)

As discussed in Section 2.4, the wetlands delineation identified two wetland areas within Parcel E-2: (1) approximately 3.2 acres of tidal wetlands along the shoreline south of the landfill; and (2) approximately 1.3 acres of inland seasonal freshwater wetland in the Panhandle Area (Figure 1-4). The function and values assessment concluded that the wetland areas have a low ability to retain sediments and toxicants and to produce nutrients. In general, the most significant function of these wetlands is seasonal use for wintering and migrating birds. The value of these wetlands was concluded to be low because they are situated within a known hazardous waste site on manmade land. The wetlands delineation and functions and values report is discussed in more detail in Section 2.4 and is included as Appendix D to this report.

3.5.7. SDGI (2002) and Shoreline Characterization Technical Memorandum (2005)

The shoreline investigation, performed as part of the SDGI, involved the collection of additional data from intertidal sediment to evaluate whether contamination in the Parcels E and E-2 shoreline had migrated, or had the potential to migrate, to sediments in adjacent Parcel F (offshore), and to identify areas within the shoreline that posed an unacceptable ecological risk. Systematic sediment samples were collected every 100 feet at two depths (0 and 2 feet bgs) from the shoreline to identify potential sources to Parcel F. All systematic samples were analyzed for copper, lead, and PCBs. In addition, biased shoreline sediment samples were collected in suspected source areas to define the extent of known hot spots within close proximity to the Parcel E-2 shoreline (the Landfill Area and an area containing sandblast waste within the East Adjacent Area). All biased sediment samples and 10 percent of the systematic samples were analyzed for metals, hexavalent chromium, pesticides, PCBs, and SVOCs. Figure 3-3 shows the sediment sampling locations from the SDGI.

Copper and lead in shoreline sediments, adjacent to the Landfill Area and the East Adjacent Area, were identified as a potential source of contamination to Parcel F. PCBs in shoreline sediments, adjacent to the Landfill Area, were identified as a potential source of contamination to Parcel F. Groundwater discharge was determined to be a potential pathway for migration of metals and PCBs to Parcel F. However, due to the limited solubility of metals and PCBs in site groundwater, it is unlikely to contribute to contamination in offshore sediments. The nature and extent of chemicals in shoreline sediment is discussed in more detail in the Shoreline Characterization Technical Memorandum (Appendix G of this RI Report). A SLERA for the shoreline sediment is also included in Appendix G.

Soil data collected during the onshore portion of the SDGI was also evaluated to validate the COPEC list used in the previous BERA for terrestrial receptors. Surface soil (less than 3 feet bgs) concentrations previously used in calculating PSCs, referred to as "pre-2000 data," were compared with surface soil concentrations representative of current soil in Parcel E-2, referred to as "all" data. Based on a comparison of these two data sets, additional chemicals were identified as COPECs. PSCs were calculated for these additional COPECs using the methodology established during the ERA Validation Study. A SLERA for the Parcel E-2 onshore area was performed to evaluate the new PSCs (along with the existing PSCs, which did not change) against the updated surface soil data set. The results of the SLERA are discussed in Section 7 and presented in Appendix L of this RI Report.

3.6. RADIOLOGICAL ASSESSMENTS

As discussed in Section 1.4.2, the HRA presented a comprehensive history of radiological operations conducted by the Navy and Navy contractors at HPS. The overall conclusion of the HRA is that low levels of radioactive contamination exist within the confines of HPS. The HRA identified numerous locations within Parcel E-2 as radiologically impacted, including IR Site 01/21 (which comprises most of Parcel E-2), the ship shielding area at the southwest corner of Parcel E-2, and the Parcel E-2 shoreline (NAVSEA, 2004).

Numerous investigations of potential radiological contamination have been performed throughout HPS, including Parcel E-2. Radiological investigations performed at Parcel E-2 include:

- Site Reconnaissance (1988 to 1989)
- Phase I Radiological Investigation (1991)
- Phase II Radiological Investigation (1993)

- Interim Parcel E Radiation Risk Assessment (1997)
- Interim Investigation between Phase IV and Phase V Radiological Investigations (2001)
- Phase V Radiological Investigation (2002 to 2003)
- Radiological Groundwater Investigation (2002)
- Characterization of the Metal Slag Area (2004; discussed in Section 3.3.3)
- Radiological Groundwater Investigation (2008)

A brief summary of radiological investigations performed at Parcel E-2 is provided in the following paragraphs. For each investigation, the methods used to evaluate the radionuclides of concern (ROCs) and associated release limits were current at the time of the survey. Unless otherwise indicated, the information presented in each subsection is derived from the HRA (NAVSEA, 2004).

3.6.1. Site Reconnaissance (1988 to 1989)

In 1988, HLA conducted a preliminary surface radiation survey to evaluate whether radioactivity levels at HPS posed unacceptable exposure risks to RI field workers. Project activities included a scintillation survey for radiation at surface locations at Parcel E-2. The surface gamma survey at the Parcel E-2 Landfill was conducted at grid points over the entire landfill. The average gamma count rate was determined to be significantly below the mean of the background values measured at HPS. Surface gamma counts at one location in the landfill exceeded the average level at the landfill, but were close to the mean of the HPS background values (HLA, 1990a).

3.6.2. Phase I Radiological Investigation (1991)

In 1991, the Navy began radiation investigations at HPS in four main phases as part of the RI program. Phases I and II involved field investigations at several HPS locations including Parcel E-2, while Phases III and IV were performed elsewhere at HPS (outside of Parcel E-2). Also during this period, an interim radiation risk assessment and a shoreline characterization survey were performed at Parcels E and E-2.

The portion of the Phase I radiological investigation at Parcel E-2 was conducted in two stages: (1) air monitoring and (2) the surface confirmation radiation survey (SCRS). Phase I particulate air monitoring was conducted in 1991 to evaluate the background airborne particulate alpha and beta radioactivity levels at several locations, including Parcel E-2. The gross alpha and gross beta airborne particulate concentrations were well within safety standards for airborne concentrations of general radioactive materials in outdoor air (PRC, 1992a).

The Phase I SCRS was initiated in 1992 to evaluate and confirm the nature and surficial extent of radium-bearing devices in several disposal areas at HPS, including Parcel E-2. A local grid coordinate system was developed for the Phase I SCRS to map and relocate radioactive material detected during the surface walkover survey. Each grid section was 300 feet by 300 feet square, with each section further subdivided into 30-foot by 30-foot subgrids. During the Phase I SCRS, gamma readings exceeding two times the background level were considered potential radioactive point source anomalies associated with buried radium-containing devices (PRC, 1992a).

When elevated gamma readings were observed, the location, gamma measurements, and exposure measurements were recorded and a biased soil sample was collected to identify the present radioisotopes (PRC, 1992a). To provide additional characterization information, systematic soil samples were also collected at random, unbiased locations at a frequency of one sample per 2 acres. All soil samples were analyzed at an off-site laboratory using gamma spectroscopy to identify and quantitate gamma-emitting radioisotopes. During the surface walkover survey in Parcel E-2, a cluster of seven radioactive point source anomalies associated with radium-containing devices were observed in the vicinity of the Metal Slag Area; two additional anomalies were observed in the Panhandle Area northeast of the Metal Slag Area (PRC, 1992a). Based on the results of the Phase I SCRS, a recommendation was made for further investigation.

3.6.3. Phase II Radiological Investigation (1993)

The Phase II radiological investigation was conducted in 1993, in an attempt to delineate the subsurface distribution of radium-containing devices at several locations, including Parcel E-2 (PRC, 1996a). Six 15-foot-long test pits were excavated in the Panhandle Area at locations where point source anomalies were found during the Phase I SCRS. The test pits were excavated until Bay Mud or groundwater was encountered, or until the walls of the excavation became unstable. Trench and test pit depths ranged from 2.5 to 10.5 feet bgs, with an average depth of about 8 feet bgs.

The walls of each test pit, as well as excavated soil, were scanned for gamma-emitting radioactive material. If elevated gamma readings were observed, the location, gamma measurements, and exposure measurements were recorded. During the Phase II investigation, gamma count rates exceeding one and one-half times the background level were considered radioactive point source anomalies associated with buried radium-containing devices (PRC, 1996a). If radioactive point source anomalies were found, they were further investigated by excavation and soil samples were collected for analysis at an off-site laboratory using gamma spectroscopy to identify the present radioisotopes (PRC, 1996a).

No elevated gamma count rates were measured in the test pits or trenches installed within Parcel E-2; as a result, no additional soil samples were collected at Parcel E-2 for gamma spectroscopy analysis. However, test pits and trenches installed at IR Site 02, in close proximity to Parcel E-2, contained gamma-emitting anomalies associated with radium-containing devices and firebrick. Results of soil samples collected within IR Site 02 were used to delineate an area containing radium-containing devices, which were subsequently removed during an interim removal action (TtECI, 2007c); this area is located entirely within the current boundary of Parcel E.

3.6.4. Interim Parcel E Radiation Risk Assessment (1997)

As part of the Parcel E RI, TtEMI performed a radiation risk assessment to evaluate potential risks associated with human exposure (for residential and industrial scenarios) to radionuclides detected in Parcels E and E-2. Radium-226 and its radioactive daughter products (lead-210 and radon-222) were identified as radionuclides of potential concern. Risks were quantified for exposure to radium-226 in soil and to radon-222 in indoor air, since risk from radon-222 occurs only if buildings are constructed in a radiologically contaminated area. As discussed in Section 1.8, the reasonably anticipated reuse for Parcel E-2 is open space. Therefore, an industrial exposure scenario was considered a more conservative risk assessment that likely over-estimated the risk to future site occupants. For exposure to radium-226 under the industrial exposure scenario, several exposure areas identified in the risk assessment had calculated excess lifetime cancer risks (ELCRs) between 1×10^{-6} and 1×10^{-5} for the reasonable maximum exposure case. Risks to radon-222 were not considered relevant for Parcel E-2 because no buildings were constructed in the parcel. The assessment report concluded that health risks for exposure to radium-226 in soil were not considered significant.

3.6.5. Interim Investigation between Phase IV and Phase V Radiological Investigations (2001)

A characterization survey of the shoreline of Parcels E and E-2 was performed in 2001. Gamma scans were conducted over pre-positioned grids within approximately 50 feet of the mean tide line. Gamma radiation levels in several areas exceeded background gamma radiation levels, most significantly the area known as the “metal reef” within Parcel E. Analysis of samples collected from those locations identified radium-226 as the contaminant.

3.6.6. Phase V Radiological Investigation (2002 to 2003)

The Phase V radiological investigation began in January 2002 prior to issuance of the HRA. The purpose of the investigation was to support the release of buildings or areas that were identified as areas where radioactive materials had been used or areas where remedial actions to remove known contamination had occurred. The Phase V investigation of what is now Parcel E-2 was performed in 2002 and 2003, and the results were not available for inclusion in the HPS HRA (NAVSEA, 2004); therefore, the Phase V investigation results were presented for the first time in the Radiological Addendum to this RI/FS Report (ERRG and Radiological Survey and Remedial Services, LLC, 2011). The Phase V investigation at Parcel E-2 consisted of a surface survey and was designed to meet the requirements of a Multi-Agency Radiation Survey and Site Investigation Manual Class 1 Final Status Survey if contamination was not found (U.S. Department of Defense et al., 2000). The objective of the Phase V investigation at Parcel E-2 was to demonstrate whether residual radioactivity on the surface met the predetermined release criteria as summarized below.

- Radium-226: 1 picocurie per gram (pCi/g) greater than background not to exceed 2 pCi/g[5]
- Stronium-90: 10.8 pCi/g
- Cesium-137: 0.13 pCi/g[6]
- Cobalt-60: 0.060 pCi/g

The release criteria were considered equivalent to EPA preliminary remediation goals (PRGs) (now called regional screening levels) for outdoor worker exposure to soil, based on agreements with EPA.

The investigation area was divided into 73 Class 1 survey units measuring 40 by 50 meters (2,000 square meters, or 21,528 square feet) each. Each survey unit was assigned an alphabetic designation. Sixteen systematic sample locations were established approximately 11 meters apart in each grid. Reference (background) readings consisted of 16 1-minute static gamma readings taken on the hillside of Parcel A and 16 samples collected at various areas within Parcels B, C, D, and E.

The Phase V investigation consisted of the following steps:

1. Perform gamma scans of 100 percent of the surface area
2. Take 16 systematic static gamma measurements in each survey unit
3. Take biased static measurements in areas where high gamma readings were measured
4. Take exposure rate measurements from the systematic static measurement locations
5. Collect soil samples at static and biased measurement locations
6. Analyze the soil samples by gamma spectroscopy at the on-site laboratory to quantify activities of a suite of 17 radionuclides, including cesium-137 and radium-226, the primary ROCs at Parcel E-2

A total of 1,168 systematic and 23 biased soil samples were collected during the Phase V investigation. Gamma scan measurements typically ranged from 4,500 to 8,000 counts per minute (cpm), with occasional scan measurements identified as being in excess of 10,000 cpm. Sample results identified residual radioactivity exceeding the release criteria for cesium-137 and radium-226 in each survey unit. The elevated levels appeared to be consistent over the surface of the area, including the landfill cap, and there was a direct correlation between gamma static readings and gamma spectroscopy results. Results for samples from the reference areas indicated mean background activity of 0.049 pCi/g for cesium-137

[5] The radium-226 release limit was 5 pCi/g when the Phase V investigation was started but was subsequently reduced to 1 pCi/g above background.

[6] The cesium-137 release limit applied to this survey when conducted in 2002 is slightly higher than the one used today (0.113 pCi/g); however, this change does not directly impact the results of this survey.

and 0.82 pCi/g for radium-226, which were consistent with the background activity levels used for the interim removal actions at Parcels E and E-2 (TtECI, 2007a, 2007b, and 2007c).

Based on the sample results, every survey unit had activity levels of radium-226 exceeding the release criterion and 46 of the survey units had activity levels of cesium-137 exceeding the release criterion. All of the eight survey units within the vicinity of the Experimental Ship-Shielding Area had activity levels of cobalt-60 exceeding the release criterion. Ten percent of the samples were sent to an off-site laboratory for quality assurance and strontium-90 analysis because the on-site laboratory did not analyze directly for strontium-90. Results from the quality assurance laboratory were within the range of results from the on-site laboratory (based on a normal distribution of results). The average ratio (3.626) of strontium-90 to cesium-137 results from the off-site laboratory was used to estimate strontium-90 activity levels. The estimated strontium-90 activity levels for each sample were calculated by multiplying the corresponding cesium-137 activity by 3.626. This methodology was considered a conservative approach to estimate potential strontium-90 activity levels at Parcel E-2. None of the survey units had elevated activity levels of strontium-90. The remedial alternatives evaluated in this report address provisions for the proper screening, handling, and disposal of radioactive materials in Parcel E-2.

3.6.7. Radionuclides in Groundwater Evaluation (2002)

The radiological groundwater investigation for the Phase III GDGI at HPS was conducted to assess the levels of specific radionuclides in site groundwater. The general approach in designing the radiological investigation for groundwater in Parcels E and E-2 was to collect isotope-specific data for “radionuclides of interest,” defined as species that may be site related or may be present in the environment as natural or anthropogenic background as known at the time (prior to issuance of the HRA). The investigation was intended to supplement data collected during previous investigations for radiological indicator parameters (gross alpha and gross beta) because the nonspecific results for gross alpha and gross beta did not allow the Navy to distinguish between natural and potentially site-related components of radioactivity in A-aquifer groundwater. Radium-226 and radium-228 were considered primary radionuclides of potential concern at Parcel E-2 because debris disposed of at the landfill may have contained radium dials; however, groundwater samples collected from seven A-aquifer monitoring wells within and immediately adjacent to the Landfill Area were analyzed for 47 specific isotopes. The analytical data were evaluated by simple (nonstatistical) threshold comparisons with a fixed standard and by statistical tests comparing the site data with background data (two-sample statistical tests) and with fixed standards (one-sample statistical tests) (TtEMI, 2004c). The statistical test results for the Landfill Area are summarized as follows:

- Statistical testing comparing groundwater data from the Landfill Area for radionuclides with drinking water or other standards (one-sample t-test) showed that no standards were statistically exceeded at the 95 percent confidence level (Appendix I, Table I-9 of Parcel E Groundwater Summary Report [TtEMI, 2004c]).
- Statistical testing comparing groundwater data from the Landfill Area and background areas (parametric and nonparametric two-sample tests) indicated that differences between background and site data sets for potassium-40, radium-226, and strontium-90 are statistically significant in at least one of the tests (Appendix I, Tables I-14 and I-15 of Parcel E Groundwater Summary Report [TtEMI, 2004c]).
- The site mean activities of 0.472 picoCuries per liter (pCi/L) for radium-226 and 0.879 pCi/L for radium-228 are far below the drinking water standard of 5 pCi/L for the sum of radium-226 plus radium-228.
- Beta emissions from naturally occurring potassium-40 exceeded the screening standard of 50 pCi/L for gross beta activity (all beta-emitting isotopes, combined). Potassium-40 occurs naturally in seawater, at about 300 pCi/L, as beta emissions. Bay water samples collected for this investigation produced an average of 280 pCi/L for potassium-40.
- Other radionuclides that were detected infrequently in groundwater samples from the Landfill Area did not exceed background levels. These detections included two results for actinium-228 (a naturally occurring radioisotope) near the detection limit, one qualified result at the detection limit for americium-241 (alpha scan result), one result for lead-214 (naturally occurring) near the detection limit, four detections of uranium-234, and three detections of uranium-238.

The investigation concluded that naturally occurring potassium-40 in seawater is the main contributor to beta emissions measured in groundwater samples from nearshore monitoring wells. The gross beta values historically reported for samples collected from nearshore wells were dominated by beta emissions from natural potassium-40 in seawater, not beta emissions from radium isotopes. Background seawater contains the highest average activity of potassium-40 (280 pCi/L, beta) of all data groups, followed by nearshore IR sites where saltwater intrusion has resulted in brackish groundwater conditions. This intrusion has altered the composition of nearshore groundwater, with corresponding changes in the radiological quality (especially gross beta emissions). The results of the radiological groundwater investigation are detailed in the Parcel E Groundwater Summary Report (TtEMI, 2004c).

3.6.8. Radionuclides in Groundwater Evaluation (2008)

As part of a groundwater investigation at Parcel E-2, groundwater samples were collected in June 2008 from 61 temporary wells and 7 existing piezometers and submitted to an off-site laboratory for analysis of radionuclides. The samples provided data to evaluate whether A-Aquifer groundwater within and hydraulically downgradient of radiologically impacted sites at Parcel E-2 contained elevated concentrations of ROCs. All groundwater samples were analyzed for the primary ROCs at Parcel E-2 (cesium-137, radium-226, and strontium-90). In addition, 11 groundwater samples collected near the Experimental Ship-Shielding Area were also analyzed for cobalt-60. Sampling information from the groundwater investigation is presented in Appendix J of the Final Technical Memorandum for Groundwater Investigation at Parcel E-2 (CE2-Kleinfelder Joint Venture, 2009a).

Also in June 2008, groundwater samples were collected from six existing monitoring wells (five in the A-aquifer and one in the B-aquifer; all wells were within or in close proximity to the Landfill Area) and submitted to an off-site laboratory for radionuclide analyses. Samples are regularly collected from the wells and analyzed for nonradioactive chemicals under the BGMP. The analyses for radioactive chemicals (cesium-137, radium-226, and strontium-90) at these wells was performed as a one-time supplement to the BGMP, to provide additional data to evaluate whether groundwater within and hydraulically downgradient of the Landfill Area contained elevated concentrations of ROCs. Sampling information from the supplemental BGMP monitoring is presented in the Semiannual Groundwater Monitoring Report for April to September 2008 (CE2-Kleinfelder Joint Venture, 2009b).

The radionuclide groundwater data collected in June 2008 were compiled as part of the radiological addendum and were evaluated, similar to the 2002 investigation, by simple (non-statistical) threshold comparisons to a fixed standard (such as drinking water standards) and by statistical tests comparing the site data to fixed standards (one-sample statistical tests). The simple threshold comparison to drinking water standards revealed no exceedances for cobalt-60, cesium-137, and strontium-90 out of 74 samples analyzed. For radium-226, the drinking water standard (5 pCi/L, combined for radium-226 and radium-228) was exceeded in 2 out of 74 samples analyzed. The two radium-226 exceedances were reported at temporary wells TW004 and TW011 (Figure 3-2), with radium-226 concentrations of 11.0 pCi/L and 6.08 pCi/L, respectively.

Temporary wells TW004 and TW011 are surrounded by numerous other temporary wells where samples also were collected in June 2008; samples from the wells did not contain radium-226 concentrations exceeding the drinking water standard. In addition, statistical testing comparing the 2008 groundwater data with drinking water standards (one-sample t-test) showed that the radium-226 concentration corresponding to the 95th percent upper confidence limit did not exceed the drinking water standard. The radionuclide groundwater data collected in June 2008 are presented in the radiological addendum to this RI/FS Report.

3.7. OUTDOOR AIR MONITORING

Previous outdoor air monitoring activities performed at Parcel E-2 are summarized in the following documents:

- “Final Draft Solid Waste Air Quality Assessment Test” (HLA, 1989)
- Appendix D, Air Sampling Investigations, in the “Parcel E Remedial Investigation, Draft Final Report” (TtEMI, LFR, and U&A, 1997)

- "Perimeter Air Monitoring Program, Final Removal Action Landfill Cap Closeout Report" (TtEMI, 2005b)
- "Final Parcel E Nonstandard Data Gaps Investigation, Landfill Gas Characterization" (TtEMI, 2003e)

The following subsections are brief summaries of the findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding document listed above.

3.7.1. Solid Waste Air Quality Assessment Test (1988 to 1989)

Between October 1988 and February 1989, a Solid Waste Air Quality Assessment Test (SWAQAT) was conducted at several IR sites, including IR Site 01. The SWAQAT included evaluation of meteorological conditions, outdoor air quality, landfill gas compositions, surface gas emissions, and subsurface gas migration. The analysis of gases covered a wide range of organic compounds, including VOCs and methane. Surface gas emissions were not detected during this investigation. The only compounds detected were in outdoor air, upwind from possible sources off site in the surrounding industrial areas. Methane was detected in isolated pockets at IR Site 01 and at the northern edge of the IR Site 01 boundary (near the UCSF compound but within the solid waste footprint).

3.7.2. Outdoor Air Monitoring (1992 to 1996)

As part of the RI program, the Navy performed basewide outdoor air monitoring in three phases. The first phase was conducted in 1992 at IR Sites 01 through 11 and included two upwind and one downwind sampling location. The samples were analyzed for asbestos, metals, VOCs, SVOCs, pesticides, PCBs, and formaldehyde. The detected chemicals showed the highest values of asbestos and pesticides upwind, originating from the industrial areas around HPS. Low levels of VOCs were found at all locations; the highest VOC concentrations were detected at an active industrial area within Parcel D (IR Site 09).

A second phase of sampling was conducted in 1994. Phase II involved collection of samples from 17 locations throughout HPS, including 1 location in Parcel E-2. The samples were analyzed for asbestos, metals, VOCs, SVOCs, pesticides, PCBs, and formaldehyde. The general conclusion of the Phase II sampling was that chemical concentrations in air at HPS are similar to the Bay area regional air quality monitoring results, with only minor differences observed for most chemicals investigated. During the Phase II sampling, a sandblast waste pile was sorted and removed in the East Adjacent Area of Parcel E-2 (Battelle, 1996). Results of the sampling showed that sites in close proximity to the sandblast waste pile had elevated concentrations of asbestos, metals, and PCBs (specifically Aroclor-1260), and that these elevated concentrations were related to this removal. In addition, elevated VOC concentrations at Parcel E-2 may have been influenced by a light industrial park located west of Parcel E-2 (upwind of the

Phase II monitoring location). As a result, additional sampling was recommended to verify that the elevated concentrations were from off-site sources.

The Phase III outdoor air sampling was conducted in 1996 and focused on four locations from Phase II, including the one Parcel E-2 location. Two upwind sampling locations were established along the western boundary of Parcel E-2. The samples were analyzed for asbestos, metals, VOCs, and PCBs. Concentrations of asbestos, metals, and VOCs detected in the Phase III samples were similar to regional background concentrations, and concentrations of PCBs were two orders of magnitude lower than concentrations detected during Phase II. These findings supported the conclusion that removal of the sandblast waste pile in 1994 most likely contributed to the elevated concentrations of asbestos, metals, and PCBs detected during Phase II. In addition, the elevated VOC concentrations measured near IR Site 01/21 in the Phase II samples were not detected during the Phase III investigation. The Phase II and III air monitoring locations in and adjacent to Parcel E-2 are shown on Figure 3-4.

3.7.3. Perimeter Air Monitoring Program, Landfill Cap Construction (2000 to 2001)

A grass fire burned on Parcel E-2 on August 16, 2000. After the surface fire was extinguished, subsurface smoldering was discovered. An initial 24-hour outdoor air sample was collected downwind of the fire area on August 31, 2000, and an air monitoring network was established around the perimeter of Parcel E-2 on September 8, 2000. Air samples were collected at seven stations to evaluate whether chemicals were migrating toward residents and commercial workers. The air monitoring locations established under the perimeter air monitoring program (PAMP) in and adjacent to Parcel E-2 are shown on Figure 3-4.

The PAMP continued from September 8, 2000, until the cap was structurally completed on March 13, 2001. The objective of the PAMP at Parcel E was to identify any conditions requiring corrective measures necessary to ensure that public health and the environment of the nearby community were not compromised by air emissions from the subsurface smoldering and landfill capping activities.

Integrated air samples were collected for analysis of metals, VOCs, SVOCs, pesticides, PCBs, low-resolution and high-resolution dioxins and furans, chlorine compounds, and phosgene. A radioactivity sample was collected during a single sample period. During the PAMP, over 2,400 different analyses were conducted on the more than 1,700 samples collected from the seven-station monitoring network. Action levels for target chemicals were based on a combination of existing action levels established during the Parcel B soil remedial action and EPA Region 9 PRGs (now called regional screening levels).

The PAMP concluded that the PCB compound, Aroclor-1260, was the primary chemical detection that was directly attributable to landfill capping activities. Almost all of the Aroclor-1260 detections were at monitoring Station F, which was in the southeast corner of Parcel E-2 (near the PCB Hot Spot Area that was excavated in 2005 and 2006). Detections of Aroclor-1260 were attributed to construction activities that disturbed surface soil in the area. Construction activities in the area were modified to minimize dust generation in the area. Similar precautions are being implemented during the ongoing removal action in the area, and perimeter air monitoring is also being performed.

Other conclusions from the PAMP included:

- Combustion products such as PAHs and dioxin and furans directly attributable to the fire were not prevalent and were below project duration PAMP action levels and PRGs.
- Of the more than 150 target chemicals or classes of compounds, 98 were not detected at any time during the PAMP. The following chemicals and classes of compounds were not detected: pesticides (except for one detection of endrin below action levels), chlorine or hydrogen chloride, phosgene, low resolution dioxins and furans, benzo(a)pyrene, cadmium, and vinyl chloride.
- Detected concentrations of lead, nickel, and high-resolution dioxins and furans were below the corresponding PAMP action levels and PRGs.
- Benzene and carbon tetrachloride were frequently detected, and observed concentrations exceeded project duration PAMP action levels or PRGs. These concentrations were attributed to outdoor air background concentrations because the project average concentrations of benzene and carbon tetrachloride were less than the corresponding background concentrations reported for the Bay Area Air Quality Management District (BAAQMD) outdoor air monitoring station on Arkansas Street in San Francisco.
- Bis(2-ethylhexyl)phthalate was frequently detected, and observed concentrations exceeded project duration PAMP action levels. However, the PRG was not exceeded. This chemical is ubiquitous in nature and is associated with PVC plastic, including gloves.
- Arsenic and manganese were frequently detected, and observed concentrations exceeded project duration PAMP action levels or PRGs or 24-hour PAMP action levels. These metals are naturally occurring in soil, and observed concentrations of these metals correlated with earth-moving activities during cap construction and wind direction.

The PAMP results are presented in Attachment A of the Final Removal Action Landfill Cap Closeout Report (TtEMI, 2005b; Appendix E of this report). Information on construction of the interim landfill cap is presented in Section 3.8.

3.7.4. Landfill Gas Characterization (2002)

As part of the NDGI, outdoor air and building atmosphere surveys were conducted to assess whether methane was present in outdoor air within 300 feet of the Parcel E-2 Landfill and in buildings or subterranean structures at concentrations exceeding 1.25 percent volume in air. Results of the outdoor air survey indicated that landfill gas was not present in the breathing zone or in building atmospheres within the landfill; within 300 feet of the landfill limit; or within surveyed, accessible buildings outside the 300-foot perimeter. The NDGI outdoor air monitoring locations in and adjacent to Parcel E-2 are shown on Figure 3-4. A more detailed discussion of outdoor air monitoring performed during the landfill gas characterization study is presented in Section 4.2.3.1.

3.8. PREVIOUS REMOVAL ACTIONS

Several CERCLA removal actions and other interim actions have been performed at Parcel E-2. The following is a list of the documents that summarize the results of those removal actions.

- "Field Demonstration and Technology Transfer Report on Sandblasting Grit Recycling Project" (Battelle, 1996)
- "Field Summary Report, Storm Drain Sediment Removal Action" (IT, 1997)
- "Post Construction Report, Site IR-01/21 Industrial Landfill Removal Action (Groundwater Extraction System and Containment Barrier)" (IT, 1999)
- "Removal Action Landfill Cap Closeout Report" (TtEMI, 2005b)
- "Removal Action Closeout Report, Parcel E Landfill Gas Time-Critical Removal Action" (TtEMI, 2004a)
- "Post-Construction Report, Decontaminate Process Equipment, Conduct Waste Consolidation and Provide Asbestos Services in Parcels B, C, D, and E" (TtFW, 2004c)
- "Final Removal Action Completion Report, PCB Hot Spot Soil Excavation Site, Parcels E and E-2" (TtECI, 2007a)
- "Final Removal Action Completion Report, Metal Debris Reef and Metal Slag Area Excavation Sites, Parcels E and E-2" (TtECI, 2007b)

The following subsections are brief summaries of the findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding document listed above.

3.8.1. Sandblast Waste Fixation (1991 to 1995)

Sandblast operations that generated sandblast waste containing paint chips, heavy metals, and oil were conducted at numerous locations at HPS. A field treatment demonstration was planned to evaluate whether sandblast waste could be stabilized and recycled into asphalt (Battelle, 1989). Between 1991 and 1995, 4,665 tons of sandblast waste was collected and consolidated in Parcel E-2 (see Figure 3-4). In addition, about 245 tons of sandblast waste was collected from eight small piles around HPS, including 2 tons from IR Site 11/14/15 in Parcel E. The waste was sent to an asphalt plant, where it was successfully reused in the manufacture of asphalt. This removal action was completed in 1995.

3.8.2. Storm Drain Sediment Removal Action (1996 to 1997)

From September 1996 to September 1997, the Navy removed accumulated sediments from the storm drain system at HPS to limit potential transport of contaminated sediments to San Francisco Bay as part of a non-time-critical removal action (NTCRA). The storm drain system at HPS consists of approximately 107,000 linear feet of piping, less than 1,000 feet of which are present in Parcel E-2. Most storm drain lines within Parcel E-2 were inaccessible during the NTCRA, except for a short section of storm drain (less than 200 feet) southwest of Building 810. Activities consisted of (1) removing sediment and debris from accessible storm drain lines, catch basins, and manholes; (2) pre- and post-cleaning video inspections of the pipelines; and (3) water jetting of the pipelines, catch basins, and manholes. Sediments generated during cleaning of the accessible sewers were dewatered, sampled, analyzed for waste characterization purposes, and disposed of at a licensed, off-site facility.

3.8.3. Groundwater Extraction System and Containment Barrier (1997 to 1998)

Previous investigations identified high PCB concentrations in groundwater in the southeast portion of Parcel E-2. To prevent the potential transport of PCBs to the bay, the Navy constructed a sheet-pile wall and GES to contain groundwater in this area as part of a NTCRA. Construction activities began in August 1997 and were completed in July 1998, when the GES was activated (IT, 1999). The GES was deactivated in April 2005, and components of the system were removed; the system remains offline following implementation of the removal action at the PCB Hot Spot Area (TtECI, 2007a). The sheet-pile wall, which is 614 feet long, consists of 410 sheet piles that vary in length from 12 to 55 feet (IT, 1999). The former GES, which was located inland of the sheet-pile wall, consisted of two sections:

A 240-foot-long northern collection system consisting of seven 6-inch-diameter extraction wells (spaced 40 to 50 feet apart and ranging from 18 to 24 feet bgs in depth) connected via a 3-inch diameter discharge pipe located 2 feet bgs;

A 239-foot-long southern collection system consisting of below ground, horizontal slotted pipe (4-inch diameter, ranging from 1.7 to 1.0 feet above msl in elevation) and two collection sumps.

Figure 1-3 shows the location of the sheet-pile wall and former GES. Concentrations of chemicals in groundwater were low enough that extracted groundwater could be discharged into the San Francisco publicly owned treatment system without pre-treatment. O&M of the GES was permitted through the CCSF Industrial Wastewater Discharge Class I Permit No. 98-0301 issued on December 14, 1998, and updated on December 14, 2001.

An evaluation of the former GES (IT, 2001) concluded that, even with the presence of the extraction system, a groundwater mound occurs between the sheet-pile wall and the Parcel E-2 Landfill during winter and spring months. During heavy rainfall events, ponding occurs at the ground surface in the area of the groundwater mound. The evaluation recommended that surface water management controls be taken to prevent increased recharge and the resulting groundwater mound in the area of the former GES, and that more passive groundwater control measures, such as phytoremediation, be evaluated as an alternative to the former GES (IT, 2001). The remedial alternative analysis in the FS portion of this report (Sections 12 through 14) evaluates groundwater containment around the Parcel E-2 Landfill (and other nearshore contaminant sources to the bay) and the appropriate means of controlling groundwater (both upgradient and downgradient).

3.8.4. Landfill Cap Construction (2000 to 2001)

On August 16, 2000, a brush fire burned approximately 45 percent of the landfill surface area. The surface fire was extinguished within 6 hours, but small subsurface areas (less than 5 acres) continued to smolder for approximately 1 month after the fire was extinguished (ATSDR, 2001). As part of a TCRA, an interim cap was constructed to extinguish the fire and prevent the occurrence of future fires under the capped areas. Figure 1-3 shows the area burned by the fire and the area capped during the removal action. The interim cap consists of a multilayer system of sub-base soil, HDPE membrane, synthetic drainage layer, and topsoil. Because the interim cap effectively limits air intrusion into the landfill, the effect was a smothering of any smoldering subsurface areas remaining from the fire. In addition, the interim cap significantly reduces stormwater infiltration through the landfill, thereby reducing the potential for hazardous substances to leach out from the landfill. The interim cap encompasses approximately 14.5 acres and has been vegetated to stabilize surface soil and limit erosion. Additional information on construction of the interim cap is provided in the Final Removal Action Landfill Cap Closeout Report (TtEMI, 2005b; Appendix E of this report).

3.8.5. Landfill Gas Removal Action (2002 to 2003)

Based on the findings of the landfill gas characterization, a TCRA was conducted to address explosion hazards and human health risks associated with off-site migration of landfill gas. The TCRA was designed to achieve the following goals: (1) reduce concentrations of methane detected at the northern edge of the Parcel E-2 Landfill (in the subsurface under both Navy and UCSF property) to less than the LEL of 5 percent; and (2) prevent landfill gas migration onto the nearby UCSF compound, including methane and NMOCs. To achieve these goals, the TCRA consisted of installation and operation of a gas control, extraction, and treatment system.

The gas extraction system consists of 2 mobile extraction unit trailers, 10 extraction wells, and 5 GMPs on the UCSF compound. The gas control system was installed along the northern boundary of the landfill and consists of an HDPE barrier wall, a gas collection trench sealed (on top) with bentonite, a horizontal perforated gas collection pipe, five gas vents, and a mobile active extraction unit to assist venting when necessary. Figure 1-3 shows the major components of the gas extraction and control system; a conceptual cross section of the landfill gas control system is presented on Figure 3-5. Mobile and permanent treatment systems remove NMOCs from the vented and extracted gas.

The gas control system is monitored using a network of 32 GMPs: 11 GMPs located immediately adjacent to the HDPE barrier wall; 3 GMPs along the western boundary of the Parcel E-2 Landfill; 5 GMPs located on the UCSF compound; and 13 GMPs along Crisp Avenue. The locations of these GMPs, along with other components of the landfill gas monitoring program, are shown on Figure 3-6. The ongoing landfill gas monitoring program, which was initiated after completion of the TCRA, is discussed in more detail in Section 3.9.2.

During the TCRA, modifications to the gas extraction and control systems were implemented to improve the effectiveness of the systems. The gas control system was enhanced through installation of a grout curtain in the gas collection trench on the north side of the HDPE barrier wall, installation of a new treatment unit connected to an additional gas control system vent, and rehydration of the bentonite seal. Figure 1-3 shows the location of the grout curtain.

Upon completion of the TCRA, the control system was switched to a combination of passive and active operation. Four of the five vents operate passively. Active gas extraction and treatment is performed at a single vent (PV-02) to ensure that the risk of off-site migration of landfill gas is virtually eliminated. Additional information on construction of the interim landfill gas control system is provided in the Landfill Gas Time-Critical Removal Action Closeout Report (TtEMI, 2004a; Appendix F of this report). More detailed information about the landfill gas removal action is discussed in Section 4.2.3.2.

3.8.6. Shoreline Cleanup (2003 to 2004)

As part of a waste consolidation effort throughout HPS, hazardous and nonhazardous debris along the Parcels E and E-2 shoreline (including portions of the Panhandle Area) was characterized and disposed of off site. The shoreline cleanup was performed from September 2003 to June 2004. Debris consisted primarily of brick, metal scrap, concrete, and wood. The debris was subsequently characterized for disposal and fell into one of two categories: nonhazardous debris or non-Resource Conservation and Recovery Act (RCRA) hazardous wood containing creosote.

The shoreline debris also included three large wooden and metal barges within the intertidal zone of Parcel E-2 and F. The barges were removed in accordance with a site-specific plan (developed to ensure compliance with the substantive aspects of the USACE Nationwide Permit Number 38), and soil erosion and sediment controls were used to avoid or minimize adverse effects to San Francisco Bay and its aquatic life. After each barge was removed, the newly exposed areas were recontoured using hand tools. The resulting debris was consolidated with like debris for subsequent transportation and disposal or recycling.

The following materials were accumulated, characterized (as required), and disposed of as part of the Parcel E shoreline cleanup:

- Twenty-seven truckloads (containing an estimated 468 cubic yards) of non-RCRA hazardous waste debris (poles with creosote) sent to Chemical Waste Management's Kettleman Hills Landfill
- Twenty-five truckloads (containing an estimated 400 cubic yards) of non-regulated, nonhazardous debris disposed of at Waste Management's Altamont Landfill
- Eighty-one tons of metal debris sent to Circosta Metals for recycling
- A total of 344 used and waste tires was disposed of at Waste Recovery West, Livermore, California.
- Approximately 10 cubic yards of suspected asbestos-containing material was collected by a qualified asbestos abatement subcontractor during the Parcel E shoreline cleanup. This material was disposed of at Chemical Waste Management's Altamont Landfill.

Because the Parcel E shoreline has been identified as an area containing radiological devices (such as, dials and deck markers with radioluminescent paint), a screening protocol was implemented to ensure that no radiological materials were removed from the site during the Parcel E shoreline cleanup. This protocol was approved by the Navy's Radiological Affairs Support Office (RASO) prior to its implementation and involved screening suspect debris (such as metal scrap and sediment-laden debris). No radiological devices or other contamination were identified in the material collected as part of the shoreline cleanup.

3.8.7. Metal Slag Area Removal Action (2005 to 2007)

The TCRA at the Metal Slag Area was performed in conjunction with the removal of the Metal Debris Reef located in the southeast portion of Parcel E. The TCRA was designed to remove metal slag and debris containing low-level radiological material, as well as nonradiological chemical contamination incidental to the removal of the area. Site characterization was performed to delineate the vertical and lateral extents of the metal debris and slag prior to excavation (as discussed in Section 3.3.3). The excavation was performed in a series of 12-inch lifts, to maximum depths ranging between 3 and 6 feet bgs. After the initial excavation was completed, trenches were extended beyond the excavation perimeter to confirm the extent of metal debris and slag. Additional metal debris was found at the northern, southern, and southwestern edges of the excavation and, as a result, the excavation boundaries were extended to remove this material (TtECI, 2007b).

Approximately 8,200 cubic yards of soil, metal slag, and debris was removed and disposed of off site as part of this removal action (TtECI, 2007b). Out of this total volume, approximately 74 cubic yards of soil and sediment was segregated as radiologically impacted. Also, 32 radiological devices, 15 cubic yards of radiological debris (primarily fire bricks), and approximately 30 cubic yards of metal debris were identified within the removal area (Navy, 2006a and 2006b; TtECI, 2007b). In addition to this radiologically impacted debris, six waste drums were recovered from the removal area and were characterized prior to off-site disposal. Five of the six drums contained soil and debris contaminated with PCBs; the sixth drum contained soil and debris with elevated levels of radium-226 (TtECI, 2007b). Post-excavation soil samples were collected and analyzed for cesium-137, radium-226, and strontium-90 (the ROCs identified in the HRA [NAVSEA, 2004]). Analytical results for 174 of the 185 post-excavation soil samples met the specified radiological remedial objectives. None of the samples that failed to meet the specified radiological remedial objectives indicated widespread radiological contamination is present at the Metal Slag Area. In addition, remaining radiological materials are covered with clean soil, thereby preventing direct exposure to surrounding populations and wildlife (TtECI, 2007b).

Concurrent with the radiological soil analyses, post-excavation soil samples were also collected and analyzed for metals, PCBs, and organochlorine pesticides. Because the focus of the TCRA was to remove radiological material, these chemical results did not prompt additional excavation activities and were intended only to supplement the soil characterization in the Metal Slag Area. The reported concentrations of PCBs and several metals in these samples warrant further analysis in this RI/FS Report. Post-excavation chemical sampling results are summarized in Section 4.3.2 and Section 7 (HHRA). Wetlands mitigation activities (which are associated with the removal action) are currently being planned and are anticipated to occur in conjunction with the Parcel E-2 remedial action.

3.8.8. PCB Hot Spot Area Removal Action (2005 to 2007)

The TCRA at the PCB Hot Spot Area was designed to remove PCB- and petroleum hydrocarbon-contaminated soil and debris, possibly containing low-level radiological material. Excavation involved (1) removal of soil containing PCBs at concentrations greater than the depth-based removal action goals (1 milligram per kilogram [mg/kg] from the surface to 3 feet bgs and 100 mg/kg deeper than 3 feet bgs); (2) TPH at concentrations greater than 3,500 mg/kg; or (3) radiological contaminants above the radiological remedial objectives. The removal action goals also included removal of free-phase petroleum hydrocarbons, to the extent practicable. The excavation was performed in a series of 12-inch lifts, to a maximum depth of 21 feet bgs. During excavation activities, oil-stained soil and free-phase product were observed along the western and southwestern sidewall of the excavation boundary; however, further excavation in these areas was not possible because of their proximity to San Francisco Bay. Visual observation and field-screening test kits of exploratory potholes excavated between the excavation and the bay identified contamination (including oil staining and free-phase product) (TtECI, 2007a). The Navy initiated a follow-on removal action to address contaminated soil and free-phase product between the 2007 excavation boundary and the bay (Navy, 2010); the follow-on removal action was initiated in March 2010 and was projected to be completed in 2011.

Approximately 44,500 cubic yards of soil and debris was removed and disposed of off site as part of this removal action. Out of this total volume, 533 cubic yards of soil and fire brick was segregated as radiologically impacted. Also, 40 radiological devices, 78 cubic yards of metal debris, and 19 pieces of other radioactively contaminated debris were identified within the removal area (TtECI, 2007a). In addition to this radiologically impacted debris, 110 drums and 537 assorted waste containers were recovered from the central portion of the removal area and were characterized prior to off-site disposal. The drums, which were discovered in varying degrees of decay, contained grease, oil, soil, asphalt, and tar substances. Waste characterization data indicated that the drums contained various chemicals, including PCBs. Two of the drums contained mixed waste with radiological contamination. The small containers contained various laboratory chemicals, ranging from strong acids and bases to solvents, alcohols, and inorganic salts (TtECI, 2007a).

In addition, 41 pieces of material potentially presenting an explosive hazard (MPPEH) were discovered in the removal area. MPPEH is an interim designation for any component of ordnance or explosive munitions that may have come into contact with energetic material (i.e., high explosives or propellant) and could have energetic residue remaining. This interim designation applies to items for which the presence or absence of energetic residue cannot be immediately verified by visual inspection. Following verification and documentation that MPPEH does not present an explosive hazard, as performed by two competent unexploded ordnance (UXO) technicians, such items are referred to as material documented as safe (MDAS). MPPEH encountered in the removal area primarily included expended cartridge casings of various calibers and protective caps, but also included an empty 5-inch practice projectile and a 3-pound practice bomb (TtECI, 2010). Of the 41 MPPEH items discovered in the removal area, 20 items were verified to not present an explosive hazard and were reclassified as MDAS. All MDAS were properly inspected, transported, demilitarized (i.e., crushed, shredded, or cut to no longer resemble military munitions), and shipped off site as scrap metal (TtECI, 2010). The remaining 21 MPPEH items appeared to have been subject to previous demilitarization actions and could not be completely inspected by UXO technicians for possible explosive hazards. Although the type, age, and condition of these 21 MPPEH items did not suggest a high potential for residual energetic material, the Navy, as a precautionary measure, properly handled, transported, and disposed of these items as either material documented as an explosive hazard (MDEH) (20 items consisting of expended cartridge casings of various calibers) or munitions and explosives of concern (MEC) (1 item. 3-pound practice bomb) (TtECI, 2010). All MDAS, MDEH, and MEC were also radiologically screened to verify that no radiological contamination was present.

Post-excavation soil samples were collected and analyzed for PCBs and petroleum hydrocarbons. In addition to the PCB and petroleum hydrocarbons analyses, post-excavation sidewall samples were also analyzed for organochlorine pesticides, metals, and, if petroleum hydrocarbons were present, PAHs. Additional analysis for VOCs, SVOCs, and organochlorine pesticides were performed for bottom samples collected in the vicinity of the buried drums. The reported concentrations of PCBs and petroleum hydrocarbons in these samples warrant further analysis in this RI/FS Report. Analytical results for post-excavation samples are presented in Sections 4.2.4 and 4.4.2 and in Section 7 (HHRA) of this RI/FS Report. Additional post-excavation soil samples were collected and analyzed for cesium-137, radium-226, and strontium-90 (the ROCs identified in the HRA [NAVSEA, 2004]). Analytical results for all post-excavation soil samples met the specified radiological remedial objectives.

3.9. ONGOING MONITORING PROGRAMS

The results of the ongoing monitoring performed at Parcel E-2 are summarized in the following documents:

- Groundwater Monitoring Reports, Parcels C, D, E, and E-2 (Kleinfelder, Inc. and CDM Federal Programs Corporation, 2005a through 2005c and 2006a through 2006c; CE2-Kleinfelder Joint Venture, 2006, 2007a, 2007b, 2007d through 2007f, 2008a, and 2008d, 2009b, 2009d, 2010a, and 2010b)
- Gas Monitoring Reports (ITSI, 2004a through 2004g, 2005a through 2005n, 2006a through 2006g, 2006i through 2006m, 2007a through 2007c, 2007e through 2007g, 2008a through 2008c, 2008e, 2009a through 2009d, and 2010a through 2010c)
- Annual Reports for Stormwater Discharge Management (TtEMI, 2004d; AFA Construction Group [AFA] and Eagle Environmental Construction [EEC], 2005a; EEC, 2006 and 2007; and MARRS and MACTEC, 2008a, 2009a, and 2010)
- Annual Reports for Landfill Cap Operations and Maintenance (ITSI, 2006h, 2007d, 2008d, 2010d, and 2010e)

The following subsections are brief summaries of the monitoring programs and the current findings from each of the documents listed above. Unless otherwise indicated, all information included in each summary was derived from the corresponding documents listed above.

3.9.1. Groundwater Monitoring (2004 to present)

In June 2004, the Navy began regular monitoring at Parcel E-2 under the BGMP (TtEMI, 2004e). Since June 2004, the BGMP has been updated several times to optimize the monitoring network within Parcel E-2 and other HPS parcels (CE2-Kleinfelder Joint Venture, 2007c, 2007g, 2008b, 2008c, and 2009c). The current groundwater monitoring locations in and adjacent to Parcel E-2 are shown on Figure 3-7. Samples are collected from 13 A-aquifer wells and 6 B-aquifer wells to monitor chemicals that previously had been detected and to establish a baseline for other chemicals and water quality parameters that might be related to the landfill. Analyses at these wells, which are located within 300 feet of the Landfill Area, were selected based on 27 CCR requirements and an evaluation of previously detected chemicals. In addition, samples are collected from four A-aquifer wells in the southern end of the Panhandle Area (wells IR01MWI-7, IR01MW62A, IR01MW63A, and IR01MW65A) to monitor chemicals previously detected at concentrations that may pose a potential risk to human health and the environment (CE2-Kleinfelder Joint Venture, 2009c).

Eleven rounds of validated groundwater monitoring data (through October 2007, when the data set was "locked" for the purposes of performing the nature and extent evaluation and risk assessments) were available for consideration in the Draft Final RI/FS Report. The groundwater monitoring data are evaluated, in conjunction with data from the RI and GDGIs (see Section 5).

In addition to the regular groundwater monitoring, groundwater flow patterns in the A-aquifer are evaluated by the development of groundwater elevation maps as part of the BGMP. A-aquifer groundwater elevation measurements are collected using a methodology designed to reduce the significance of tidal effects on the general definition of the potentiometric surface (CE2-Kleinfelder Joint Venture, 2009c).

3.9.2. Gas Monitoring and Control (2004 to present)

Landfill gas is being monitored on a regular basis under the Interim Landfill Gas Monitoring and Control Plan (TtEMI and ITSI, 2004c) to verify that hazardous levels of landfill gas are not migrating beyond the fence line of the landfill and onto the UCSF compound. The monitoring locations include 32 GMPs, 5 passive vents, 27 groundwater wells and piezometers (used for gas monitoring), and subterranean structure locations both on Parcel E-2 and within the UCSF compound (see Figure 3-6). The gas monitoring reports present results of the landfill gas monitoring, the status of the gas extraction system (active operation and passive operation), maintenance observations on the gas control system, and meteorological data. Several subsurface utilities associated with the GES were removed in summer 2005 during implementation of the removal action at the PCB Hot Spot Area and were not available for monitoring.

The ongoing landfill gas control program, based on the Interim Landfill Gas Monitoring and Control Plan (TtEMI and ITSI, 2004c), includes notification and response procedures in the event that hazardous levels of landfill gas are detected beyond the fence line of the landfill and beneath the UCSF compound. During monitoring performed since January 2004, all concentrations of NMOCs were below action levels and regulatory requirements identified in the Interim Landfill Gas Monitoring and Control Plan. Methane concentrations have, in nearly all cases, remained below specified action levels; however, methane concentrations exceeding specified action levels were detected occasionally. In these instances, the Navy notified the appropriate parties and implemented response measures to control methane at the fence line of the landfill and at the GMPs located on the UCSF property.

3.9.3. Stormwater Discharge Management (2003 to present)

Stormwater discharge in Parcel E-2 is managed in accordance with a SWDMP that was originally published in 2003 (TtEMI, 2003c). The 2003 SWDMP has been revised several times to reflect current site conditions, clarify or change the discharge locations, and update the list of BMPs (TtEMI, 2005a; AFA and EEC, 2005b). In 2007, the Parcel E-2 SWDMP was integrated with the basewide SWDMP to streamline the stormwater program (MARRS and MACTEC, 2007). The Parcel E-2 stormwater program involves quarterly visual observations of non-stormwater discharge, sampling and analysis of stormwater, monthly visual observations of stormwater discharge, and an annual comprehensive site compliance evaluation (MARRS and MACTEC, 2009b). Stormwater monitoring locations are shown on Figure 2-22 and are discussed in more detail in Section 2.3. Figure 2-22 also depicts BMPs that are used at Parcel E-2 to control stormwater discharges.

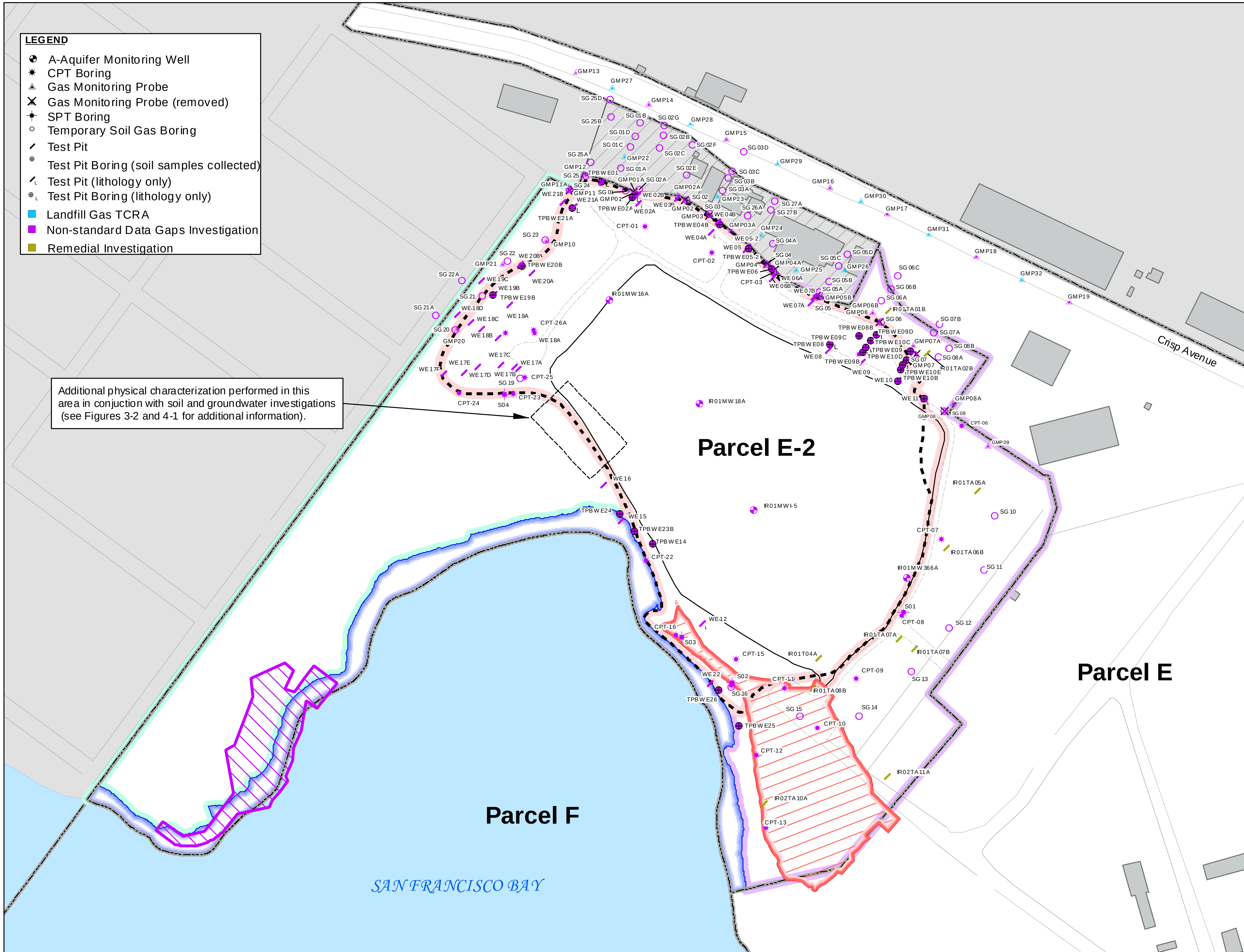
Results of the Parcel E-2 stormwater program are summarized on an annual basis (TtEMI, 2004d; AFA and EEC, 2005a; EEC, 2006 and 2007; MARRS and MACTEC, 2008a, 2009a, and 2010). Results to date indicate no incidents of noncompliance at Parcel E-2, except in isolated locations where BMPs require modification to better control erosion and sediment transport from neighboring properties.

3.9.4. Landfill Cap Inspection and Maintenance (2003 to present)

Inspection and maintenance of the interim landfill cap is performed in accordance with a site-specific O&M Plan (TtEMI, 2003b). The O&M Plan addresses and provides guidance for inspecting and reporting activities that are required to ensure the integrity of the landfill cap. In addition, the SWDMP contains requirements that facilitate and support implementation of the O&M Plan. Also included in the O&M Plan are emergency response procedures, which are to be followed in the event of flood, major storm event, earthquake, or fire.

Operations associated with the closed landfill include (1) an irrigation system to maintain the vegetative cover and (2) mowing of the vegetative cover on and adjacent to the cap to reduce potential fire hazards and prevent the growth of large shrubs and trees whose root structure could penetrate the cap. The irrigation system, along with other components of the interim cap, is inspected on a quarterly basis to ensure that it is functioning properly and providing adequate water to the vegetative cover. Inspection and mowing of the vegetative cover is performed twice per year. Results of the inspection and maintenance activities are summarized on an annual basis (ITSI, 2006h, 2007d, 2008d, 2010d, and 2010e). Results to date confirm that the landfill cap is being properly maintained in accordance with the site-specific O&M Plan (TtEMI, 2003b).

Figures



Road

Gravel Road

Parcel Boundary

Building

UCSF Compound

Landfill Area

East Adjacent Area

Panhandle Area

Shoreline Area

San Francisco Bay

Non-Navy Property

Estimate of Solid Waste Extent

Removal Actions

Metal Slag Area (2007 excavation limit)[a]

PCB Hot Spot Area (2007 excavation limit)[a]

Notes:

Figure depicts sample locations associated with investigations of physical characteristics of Landfill Area. See Figure 3-2 for soil and groundwater sample locations.

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

CPT = Cone Penetrometer Test
PCB = polychlorinated biphenyl
SPT = Standard Penetrometer Test
TCRA = Time-Critical Removal Action
UCSF = University of California, San Francisco

N

300 0 300

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-1

LANDFILL CHARACTERIZATION SAMPLING LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Section 3\Current Figures\3-1 Landfill Characterization Sampling Locations1.mxd

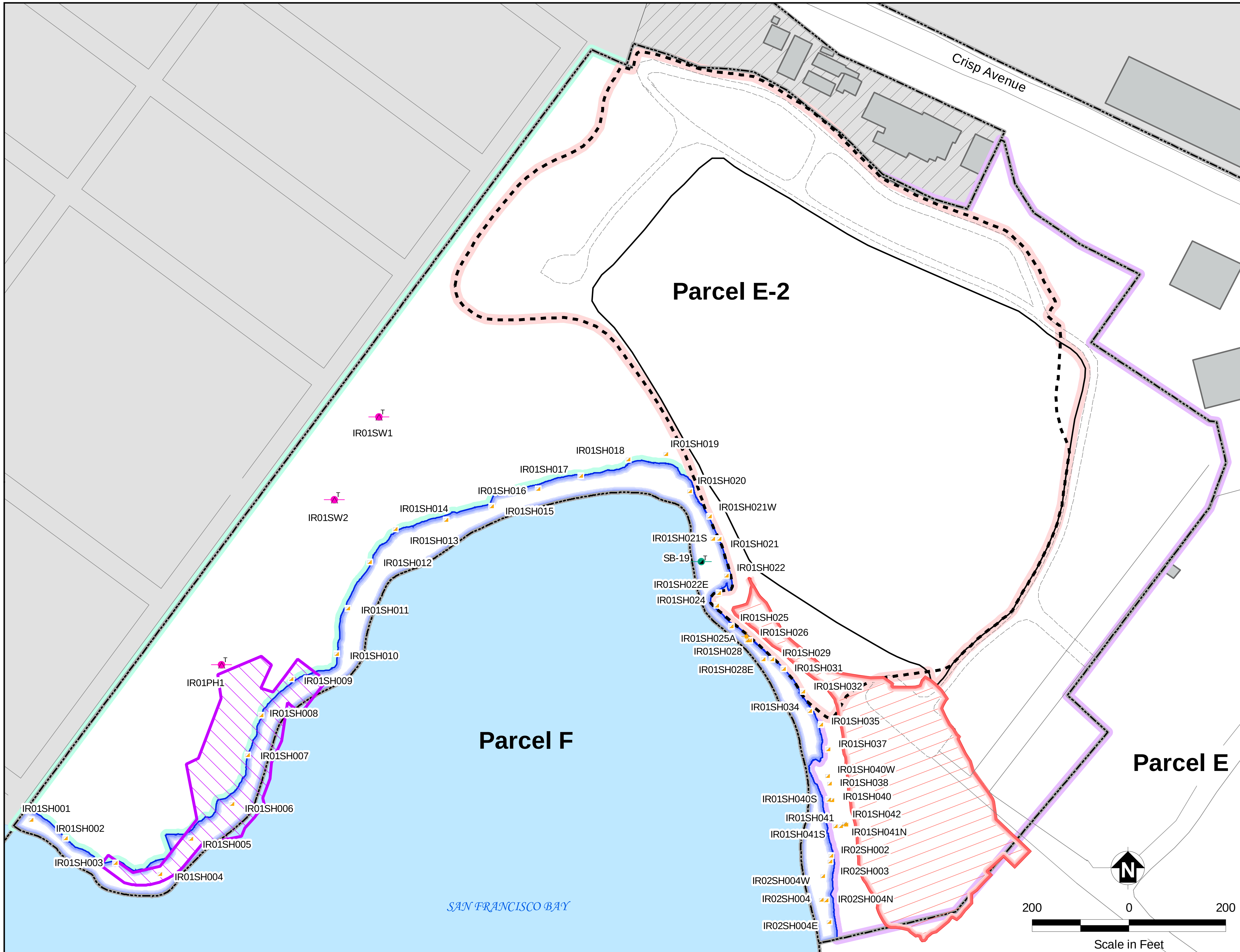
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-2

SOIL AND GROUNDWATER SAMPLING LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

2009-12-16 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Section 3\Current Figures\3-2 Soil and Groundwater Sampling Locations.mxd



Shoreline Sediment Sample
Surface Sediment Sample (co-located with Tissue Sample)
Surface Soil Sample (co-located with Tissue Sample)
Tissue Sample
ERA Validation Study
Parcel F Validation Study
Standard Data Gaps Investigation
Road
Gravel Road
Estimate of Solid Waste Extent
Interim Landfill Cap Extent
Parcel Boundary
Shoreline Area
Landfill Area
East Adjacent Area
Panhandle Area
Building
UCSF Compound
San Francisco Bay
Non-Navy Property

Removal Actions

Metal Slag Area (2007 excavation limit)[a]
PCB Hot Spot Area (2007 excavation limit)[a]

Notes:

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

ERA = Ecological Risk Assessment
PCB = polychlorinated biphenyl
UCSF = University of California, San Francisco

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

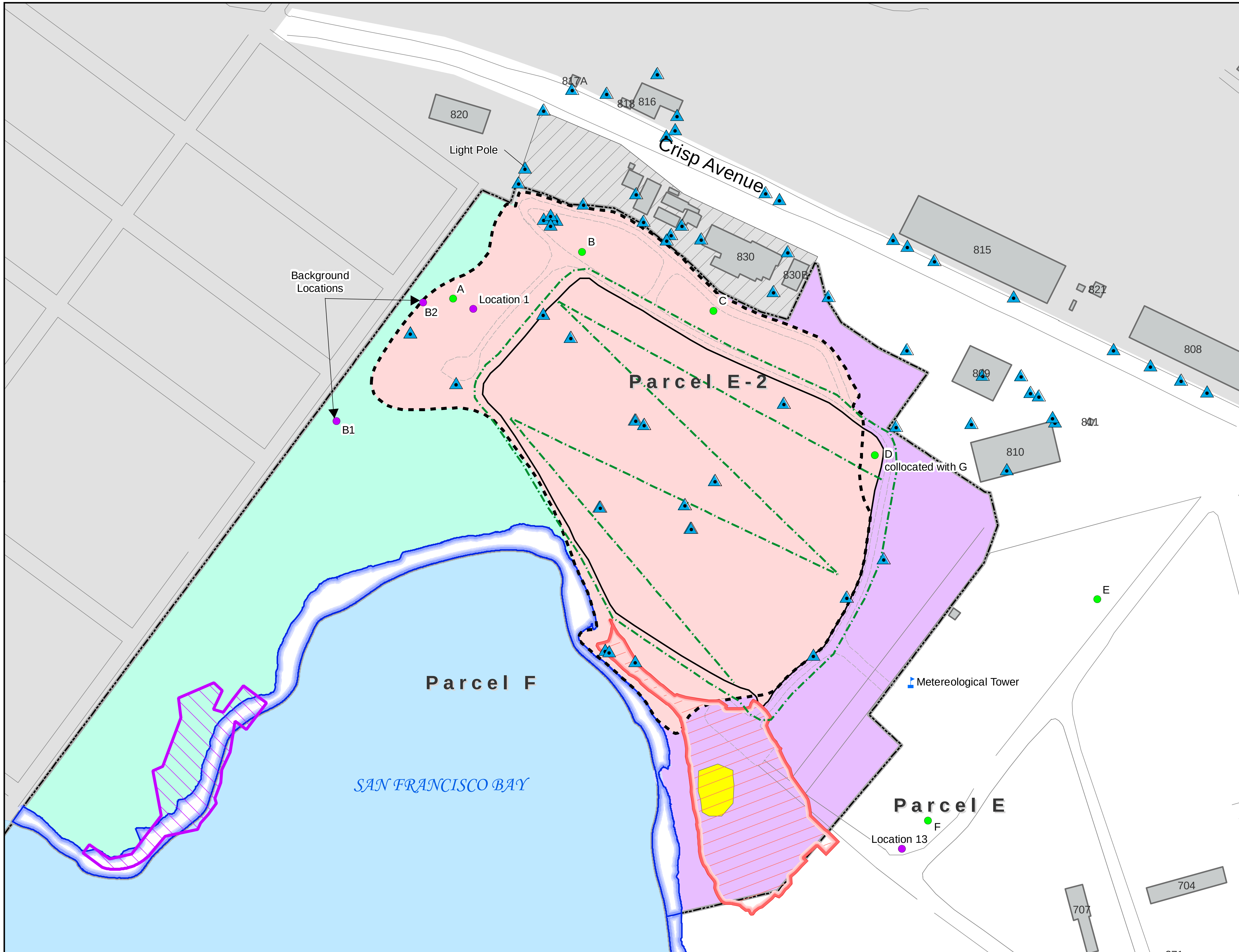
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-3

ECOLOGICAL SAMPLING LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

N:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Section 3\Current Figures\3-3 Ecological Sampling Locations.mxd



Meteorological Tower
Phase II/III Air Monitoring Locations
Air Monitoring Location During Landfill Cap Construction
Former Sandblast Waste Pile (1994) Present During Phase II Monitoring Investigation
Outdoor Air Survey Location (during gas characterization study)
Transect Location (during gas characterization study)
Parcel Boundary
Estimate of Solid Waste Extent
Interim Landfill Cap Extent
Non-Navy Property
UCSF Compound
Landfill Area
East Adjacent Area
Panhandle Area
Shoreline Area
Building
Road
Gravel Road

Removal Actions

Metal Slag Area (2007 excavation limit)[a]
PCB Hot Spot Area (2007 excavation limit)[a]

Notes:

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

PCB = polychlorinated biphenyl
UCSF = University of California, San Francisco

250 0 250
Scale in Feet

ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

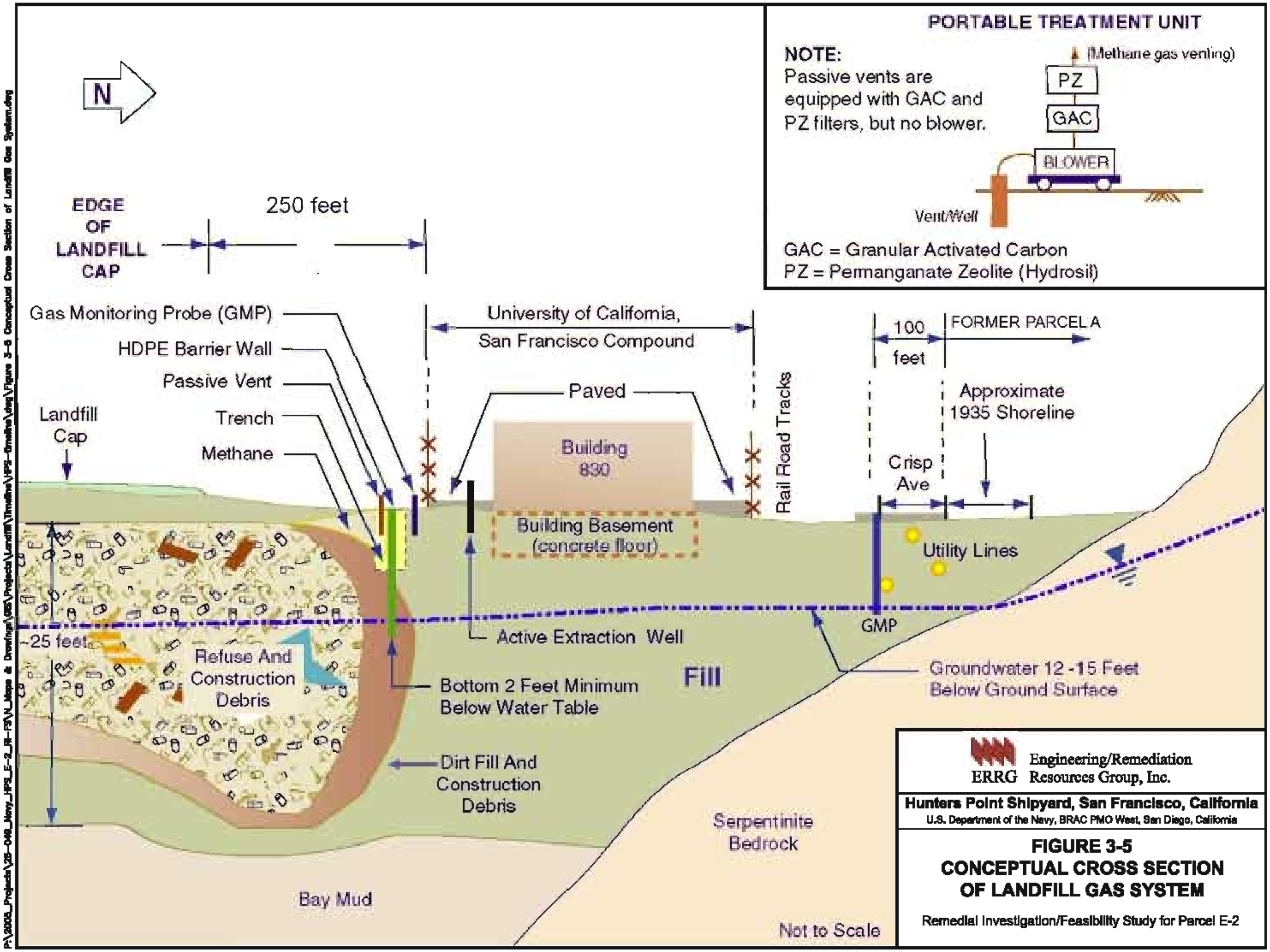
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-4

OUTDOOR AIR MONITORING LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

2005-12-16 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Section 3\Current Figures\3-4 Ambient Air Monitoring Locations.mxd



ERRG Engineering/Remediation Resources Group, Inc.

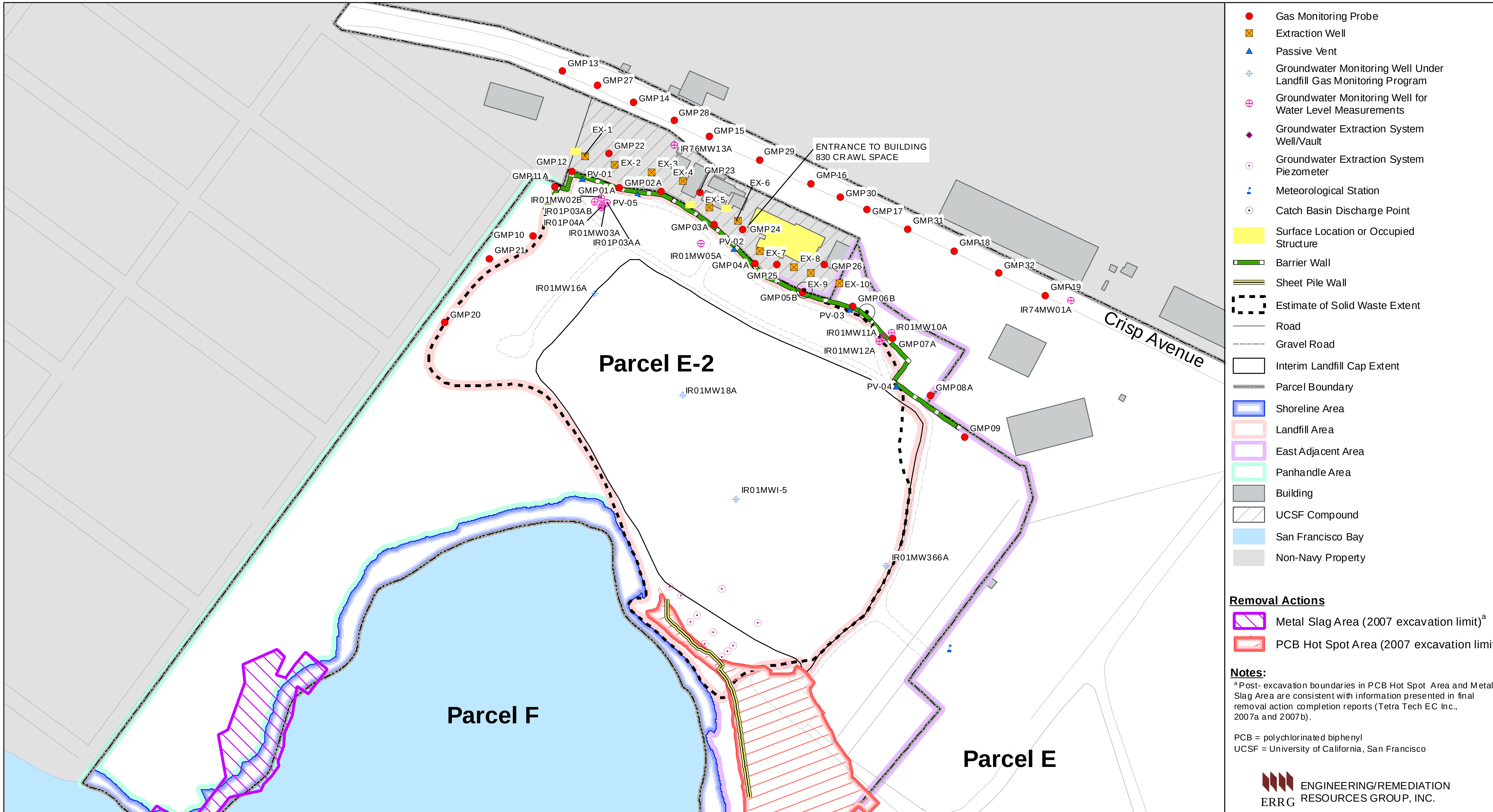
Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-5
CONCEPTUAL CROSS SECTION OF LANDFILL GAS SYSTEM

Remedial Investigation/Feasibility Study for Parcel E-2

Reference: TTEMI AND ITSI, 2004. Final Interim Landfill Gas Monitoring and Control Plan



Hunters Point Shipyard, San Francisco, California

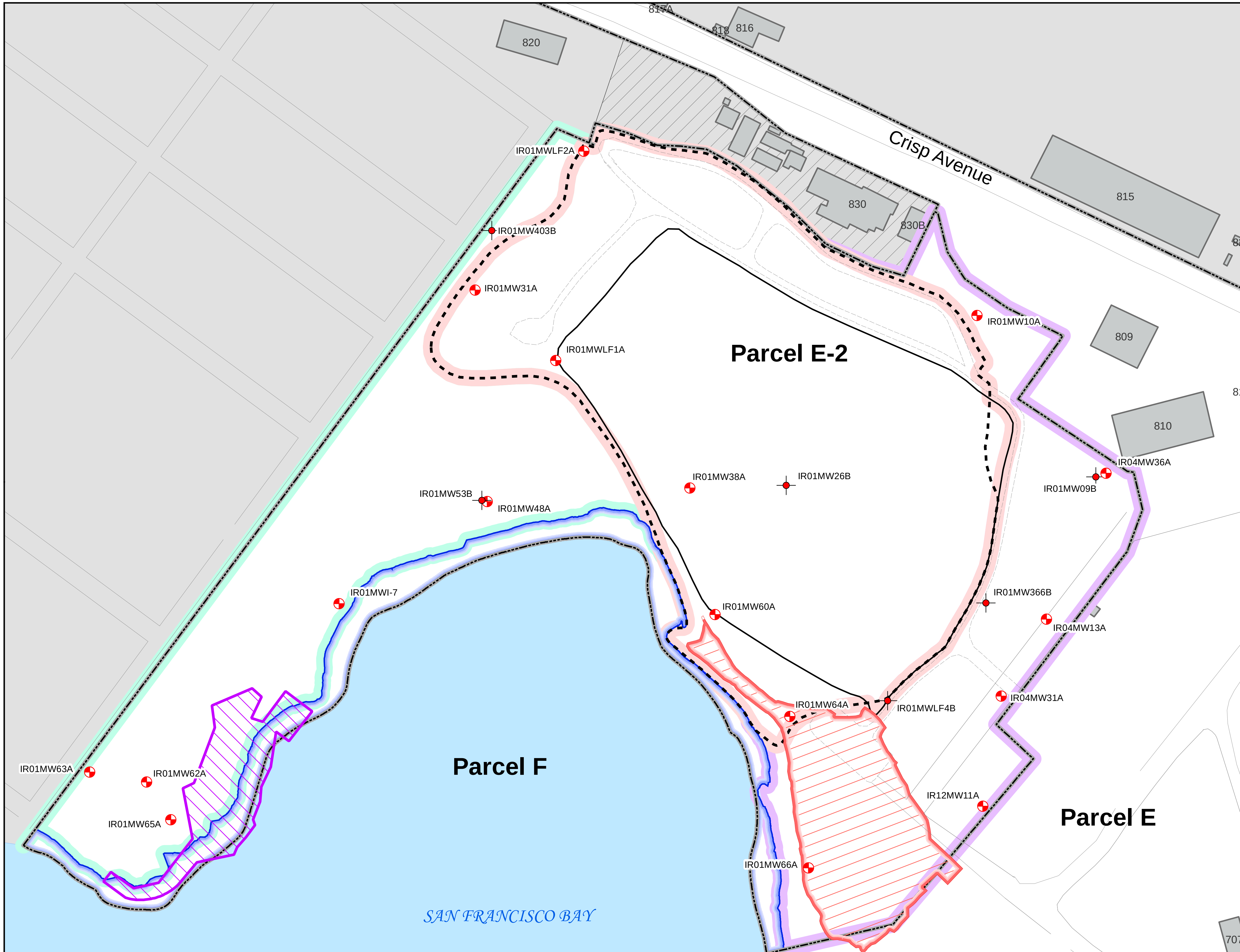
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-6

LANDFILL GAS MONITORING SYSTEM LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Section 3\Current Figures\3-7 Landfill Gas Extraction and Control System and Components.mxd



Basewide Groundwater Monitoring Program (2010)

- A-Aquifer Monitoring Well
- B-Aquifer Monitoring Well
- Road
- Gravel Road
- Estimate of Solid Waste Extent
- Interim Landfill Cap Extent
- Parcel Boundary
- Shoreline Area
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Building
- UCSF Compound
- San Francisco Bay
- Non-Navy Property

Removal Actions

- Metal Slag Area (2007 excavation limit)[a]
- PCB Hot Spot Area (2007 excavation limit)[a]

Notes:

[a] Post- excavation boundaries in PCB Hot Spot Area and Metal Slag Area are consistent with information presented in final removal action completion reports (Tetra Tech EC Inc., 2007a and 2007b).

PCB = polychlorinated biphenyl
UCSF = University of California, San Francisco

250 0 250
Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-7

GROUNDWATER MONITORING NETWORK FOR PARCEL E-2 LANDFILL

Remedial Investigation/Feasibility Study for Parcel E-2

P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Section 3\Current Figures\3-6 Groundwater Monitoring Network for Industrial Landfill Area.mxd

Tables

Table 3-1. Summary of Characterization Activities
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Tasks	Number of Borings, Wells, Test Pits, or Samples	Characterization			
		Landfill	Soil	Groundwater	Aquifer
Remedial Investigation					
Soil Borings [a]	66	X	X		
Test Pits	10	X	X		
Soil Samples [b]	585		X		
Groundwater Monitoring Wells [c]	34			X	
Surface Soil Samples	18		X		
Groundwater Samples [d]	187			X	
Piezometers	4				X
Oil Samples	1	X			
Data Gaps Investigations, Landfill Compliance Monitoring, and Removal Actions (through March 2008)					
Soil Borings	58		X		
Test Pits	30	X	X		
Groundwater Monitoring Wells	8			X	
Temporary Wells	61			X	
Piezometers	7				X
Soil Samples [e]	236		X		
Surface Soil Samples	0		X		
Post-Excavation Soil Samples	274		X		
Groundwater Samples	567			X	
Additional Activities					
Geophysical Survey (RI)	Ecological Assessments				
Soil Gas Surveys (RI and NDGI)	Shoreline Sediment Characterization (SDGI)				
Ambient Air Surveys (RI and NDGI)	Wetland Delineation/Assessment (RI and NDGI)				
Landfill Gas Monitoring (NDGI)	Aquifer Testing (RI)				
Liquefaction Potential Study (NDGI)	Tidal Influence Studies (RI and GDGI)				
Radiological Assessments	Stormwater Management and Monitoring				

Notes:

a Includes 46 soil borings and 20 monitoring well borings

b Includes 374 samples from soil borings, 175 samples from monitoring well borings, and 11 samples from test pits

c Includes 28 A-aquifer monitoring wells and 6 B-aquifer monitoring wells

d Includes 171 samples collected from monitoring wells (147 from A-aquifer monitoring wells and 24 from B-aquifer monitoring wells), 1 sample from a Hydropunch™ boring, and 15 grab groundwater samples collected from open boreholes

e Includes 139 samples from soil borings and 55 samples from test pits, 21 from metal slag samples, and 21 from the shoreline

GDGI groundwater data gaps investigation
NDGI nonstandard data gaps investigation
RI remedial investigation
SDGI standard data gaps investigation

Table 3-2. Chronology of Landfill Characterization Activities
Remedial Investigation/Feasibility Study for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
RI, Phase I, Reconnaissance Activities	October 1988	Em Transects	NA	▪ Boundaries of IR Site 01/21	▪ Locate boundaries and areas of differing waste composition
RI, Phase I, Reconnaissance Activities	October 1988	GPR	NA	▪ Northeast boundary of IR Site 01/21	▪ Delineate the northeast boundary due to inconclusive Em data
RI, Phase I, Reconnaissance Activities	October 1988	Test Pits	IR01T001, IR01T02A, IR01T02B, IR01T03A, IR01T03B, IR01T04A*, IR01T04B	▪ Presumed landfill boundaries (based on Em and GPR results)	▪ Confirm or deny the boundaries of the landfill
RI, Phase III, Contingency Sampling	March 1992	Piezometer Oil Sample	IR01P03A	▪ North corner of IR Site 01/21	▪ Identify hazardous substances potentially in groundwater
NDGI, Landfill Gas Characterization	April 2002	Temporary Soil Gas Probes	SG01 through SG27 (including step-outs)	▪ Adjacent to landfill	▪ Delineate and characterize landfill gas
NDGI, Landfill Gas Characterization	April to November 2002	GMPs	GMP01 through GMP21	▪ Northern portion of IR Site 01/21 ▪ UCSF Compound ▪ Crisp Avenue	▪ Evaluate potential landfill gas migration ▪ Evaluate performance of landfill gas removal action ▪ Monitor landfill gas migration

Table 3-2. Chronology of Landfill Characterization Activities *(continued)*
Remedial Investigation/Feasibility Study for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
NDGI, Landfill Lateral Extent Evaluation	March to April 2002	Test Pits/Test Pit Borings	WE01 through WE22 (including step-outs)	▪ Adjacent to landfill	▪ Determine the edge of the continuous physical waste in the landfill
NDGI, Landfill Liquefaction Potential Evaluation	April 2002	CPT/SPT Borings	CPT-01 through CPT-26, S01 through S05	▪ Adjacent to landfill	▪ Evaluate the potential for subsurface layers, in the vicinity of the landfill to liquefy during an earthquake

Notes:

*	Sample location within Landfill Area
CPT	cone penetrometer test
Em	electromagnetic
GMP	gas monitoring probe
GPR	ground-penetrating radar
IR	Installation Restoration
NA	not applicable
NDGI	Nonstandard data gaps investigation
RI	Remedial Investigation
SPT	standard penetrometer test
UCSF	University of California, San Francisco

Table 3-3. Chronology of Soil Characterization Activities
Remedial Investigation/Feasibility Study for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
RI, Phase I, Reconnaissance Activities	November to December 1988	Soil Borings	IR01B001, IR01B008, IR01B025, IR01B036, IR01B046*, IR01B052	▪ Shoreline ▪ Central portion of the site ▪ North corner of IR Site 01/21	▪ Subsurface stratigraphy data ▪ Depth to bedrock
RI, Phase I, Reconnaissance Activities	May to June 1989	Phase I Soil Gas Survey	100-foot grid with 92 stations	▪ Throughout IR Site 01/21	▪ Qualitative indication of the distribution of VOCs in soil
RI, Phase II, Primary Sampling Activities	October to November 1990	Soil Borings / Monitoring Well Borings	IR01B01A*, IR01B023*, IR01B032, IR01B34, IR01B35, IR01B039*, IR01B040*, IR01B041*, IR01B048A, IR01B049, IR01B050, IR01B055, IR01B56, IR01B060, IR01B061, IR01B064, IR01MW42A*, IR01MW48A	▪ Within and surrounding the reported landfill boundary	▪ Investigate the nature and extent of hazardous substances present
RI, Phase II, Primary Sampling Activities	December 1990	Surface Soil Samples	IR01SS082, IR01SS083, IR01SS084	▪ Western perimeter of IR Site 01/21	▪ Characterize nature and extent of hazardous substances in surface soil and their potential impact on air quality

Table 3-3. Chronology of Soil Characterization Activities *(continued)*
Remedial Investigation/Feasibility Study for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
RI, Phase II, Primary Sampling Activities	March to April 1991	Soil Borings / Monitoring Well Borings	IR01B003A*, IR01B004*, IR01B005A*, IR01B031A*, IR01MW02B*, IR01MW03A*, IR01MW07A, IR01MW26B*, IR01MW38A*, IR01MW43A*, IR01MW44A, IR01MW53B, IR01MW58A	▪ Northern perimeter of the site ▪ Shoreline of IR Site 01/21	▪ Investigate the nature and extent of hazardous substances at IR Site 01/21
RI, Phase II, Primary Sampling Activities	May to June 1991	Test Pits	IR01TA01B, IR01TA02B, IR01TA05A, IR01TA05B, IR01TA07A, IR01TA07D, IR01TA08A, IR01TA08B, IR02TA09A, IR02TA09B, IR02TA10A, IR02TA10B	▪ Eastern perimeter of IR Site 01/21 and Parcel E-2	▪ Estimate the boundaries of the landfill ▪ Delineate an area of sandblast waste deposits
RI, Phase III, Contingency Sampling Activities	December 1991 to January 1992	Soil Borings / Monitoring Well Borings	IR02B249, IR01MW17B*, IR01MW47B, IR01MW62A, IR01MW63A	▪ North portion of IR Site 01/21 ▪ Southeast corner of IR Site 01/21 near the shoreline ▪ Southwest corner of Parcel E-2 ▪ In the vicinity of station IR01B061 ▪ Southwest corner of the site near the shoreline	▪ Evaluate the nature and extent of hazardous substances at IR Site 01/21 ▪ Evaluate the nature and extent of hazardous substances north of Triple A Site 14 (soil boring initially drilled for investigation of IR Site 02, now within boundary of IR Site 01/21)

Table 3-3. Chronology of Soil Characterization Activities *(continued)*
Remedial Investigation/Feasibility Study for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
RI, Phase III, Contingency Sampling Activities	April to May 1992	Soil Borings / Monitoring Well Borings	IR01MW05A*, IR01MW16A*, IR01MW18A*, IR01MW31A,* IR01B006*, IR01B011*, IR01B012, IR01B013*, IR01B015, IR01B018G*, IR01B019*, IR01B021*, IR01B021A*, IR01B024*, IR01B028, IR01B029*, IR01B030*, IR01B033, IR01B045	▪ Throughout Parcel E-2 ▪ Vicinities of IR01B023, IR01B040, IR01B041, IR01B035, IR01B032	▪ Characterize Parcel E-2 ▪ Resample to replace unusable analytical data
RI, Phase III, Contingency Sampling Activities	June 1992	Soil Borings	IR01B273, IR01B274, IR01B275*, IR01B364, IR01B365	▪ Vicinities of IR01B055, IR01B049, IR01B050, IR01B040	▪ Resample to replace unusable analytical data
RI, Phase III, Contingency Sampling Activities	June 1992	Surface Soil Samples	IR01SS351, IR01SS353, IR01SS366*	▪ Vicinities of IR01SS351, IR01SS353, IR01SS366	▪ Resample to replace unusable analytical data
RI, Supplemental Sampling Activities	October 1995	Monitoring Well Boring	IR01MW367A	▪ East margin of Parcel E-2	▪ Characterize the nature and extent of hazardous substances
RI, Supplemental Sampling Activities	November 1995	Surface Soil Samples	IR72SS18, IR72SS19, IR72SS20, IR72SS24	▪ Northeast corner of Parcel E-2	▪ Assess the content of metals in shallow soil ▪ Evaluate hazardous substances in shallow soils in stained areas
RI, Supplemental Sampling Activities	October 1995 to February 1996	Soil Borings	IR72B034, IR72B035, IR72B039	▪ Northeast corner of Parcel E-2	▪ Evaluate possible hazardous substances in soil at a lumber and motor storage area
RI, Supplemental Sampling Activities	June 1996	Soil Boring	IR76B002	▪ Northeast corner of Parcel E-2	▪ Investigate the extent of the landfill in the vicinity of Building 830

Table 3-3. Chronology of Soil Characterization Activities *(continued)*
Remedial Investigation/Feasibility Study for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
NDGI, Landfill Lateral Extent Evaluation	March and September 2002	Test Pits	WE01, WE02B, WE03B, WE04B, WE05, WE06A, WE06B, WE07B, WE08, WE09, WE10, WE15, WE16, WE17A, WE17B, WE17C, WE17D, WE17E, WE17F, WE18A, WE18B, WE18C, WE18D, WE19A, WE19B, WE19C, WE20A, WE20B, WE21A, WE21B	▪ Around landfill perimeter	▪ To determine the nature of chemicals in soil in the vicinity of the landfill
SDGI, Shoreline Soil Sampling	September 2002 to February 2003	Surface Samples	IR01SH023, IR01SH027, IR01SH030, IR01SH033, IR01SH036, IR01SH039, IR02SH001	▪ Along bayward side of sheet-pile wall	▪ Characterize the landfill and shoreline interface
SDGI, Onshore Soil Sampling	September 2002 to February 2003	Soil Borings	IR01B366 through IR01B399, IR02B402, IR02B404, IR02B409, IR02B434, IR02B435, IR02B437, IR02B438, IR02B449, IR02B452, IR02B470, IR02B512, IR02B515, IR02B517, IR02B526, IR12B037 through IR12B042	▪ Throughout Parcel E-2 (in areas adjacent to landfill) ▪ Portions of adjacent IR Sites 02 and 12	▪ Bound known source area or single-point location ▪ Bound potential source identified in aerial photographs

Notes:

*	Sample location within Landfill Area
IR	Installation Restoration
NDGI	nonstandard data gaps investigation
RI	Remedial Investigation
SDGI	standard data gaps investigation
VOCs	volatile organic compounds

Table 3-4. Chronology of Groundwater Characterization Activities
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
Confirmation Study Verification Step	September 1986	Monitoring Well Installation	IR01MWI-1, IR01MWI-2, IR01MWI-3, IR01MWI-4, IR01MWI-5, IR01MWI-6, IR01MWI-7, IR01MWI-8, IR01MWI-9	▪ Throughout IR Site 01/21	▪ Confirmation study and verification setup
RI, Phase II, Primary Sampling Activities	October 1990	Monitoring Well Installation	IR01MW42A*, IR01MW48A	▪ East perimeter of Parcel E-2 ▪ Central portion of Parcel E-2 near the shoreline	▪ Calculate hydraulic gradients ▪ Estimate the nature and extent of hazardous substances in the A-aquifer
RI, Phase II, Primary Sampling Activities	October to November 1990	Grab Groundwater Samples[1]	IR01B039*, IR01B050, IR01B061, IR01B064	▪ Throughout IR Site 01/21	▪ Assess groundwater quality in the A-aquifer ▪ Locate future monitoring wells
RI, Phase II, Primary Sampling Activities	March to April 1991	Monitoring Well Installation	IR01MW02B*, IR01MW03A*, IR01MW07A, IR01MW26B*, IR01MW38A*, IR01MW43A*, IR01MW44A, IR01MW53B, IR01MW58A	▪ North perimeter of Parcel E-2 ▪ Shoreline of IR Site 01/21	▪ Calculate hydraulic gradients ▪ Evaluate the nature and extent of hazardous substances in the A-aquifer ▪ Monitor B-aquifer water quality
RI, Phase III, Contingency Sampling Activities	December 1991 to January 1992	Monitoring Well Installation	IR01MW17B*, IR01MW47B, IR01MW62A, IR01MW63A	▪ North portion of Parcel E-2 ▪ Southeast corner of Parcel E-2 near the shoreline ▪ Southwest corner of Parcel E-2 near the shoreline	▪ Evaluate the nature and extent of hazardous substances in the A-aquifer ▪ Evaluate groundwater flow from the west corner of the site

Table 3-4. Chronology of Groundwater Characterization Activities *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
RI, Phase III, Contingency Sampling Activities	April to May 1992	Monitoring Well Installation	IR01MW05A*, IR01MW16A*, IR01MW18A*, IR01MW31A*	▪ North portion of IR Site 01/21 ▪ Central portion of IR Site 01/21	▪ Evaluate the nature and extent of hazardous substances in the A-aquifer ▪ Evaluate groundwater flow from the northwest corner of the site
RI, Phase III, Contingency Sampling Activities	April to June 1992	Grab Groundwater Samples[1]	IR01B011*, IR01B012*, IR01B021*, IR01B030*, IR01B274, IR01B275*	▪ Throughout IR Site 01/21	▪ Assess groundwater quality in the A-aquifer ▪ Locate future monitoring wells
RI, Supplemental Sampling Activities	October 1995	Monitoring Well Installation	IR01MW367A	▪ East perimeter of Parcel E-2	▪ Better characterize the nature and extent of hazardous substances in the A-aquifer
RI, Supplemental Sampling Activities	June 1996	Monitoring Well Installation and Hydropunch Groundwater Sample[1]	IR01MW400A, IR01MW401A, IR01MW402A, IR01MW403A, IR76B002	▪ West perimeter of the site ▪ Northeast corner of IR Site 01/21	▪ Measure the groundwater gradient along the western boundary ▪ Assess groundwater quality
Groundwater Data Gaps Investigation	October 2002	Monitoring Well Installation	IR01MW10A, IR01MW11A, and IR01MW12A	▪ Northeast corner of IR Site 01/21	▪ Measure groundwater levels and water quality adjacent to landfill gas barrier
Groundwater Data Gaps Investigation	October 2002	Piezometer Installation	IR01P04A	▪ Northeast corner of IR Site 01/21	▪ Measure groundwater levels adjacent to landfill gas barrier (replacement for decommissioned IR01P03A)
Groundwater Monitoring Program	June 2004	Monitoring Well Installation	IR01MW366B, IR01MW403B, IR01MWLF1A, IR01MWLF2A, IR01MWLF4A, and IR01MWLF4B	▪ Adjacent to landfill area	▪ Supplement monitoring well network (per 27 CCR)

Table 3-4. Chronology of Groundwater Characterization Activities *(continued)*
Remedial Investigation/Feasibility Study Report for Parcel E-2, Hunters Point Shipyard

Investigation Phase	Date	Sample Type(s)	Sample ID(s)	General Location	Sampling Purpose
Groundwater Monitoring Program	April 2007	Monitoring Well Installation and Redevelopment	IR01MW64A* IR01MW60A*[,2]	▪ Southeast portion of landfill area	▪ To replace monitoring wells decommissioned during PCB Hot Spot removal action
Groundwater Data Gaps Investigation	March 2008	Temporary Wells	TW01 through TW61[3], PZ131F, PZ138E, PZ138F, PZ144E, PZ150D, PZ150E, and PZ161D[4]	▪ Adjacent to Parcel E-2 shoreline	▪ Evaluate chemical concentrations (dissolved metals, PCBs, petroleum hydrocarbons, and ammonia) along the Parcel E-2 shoreline

Notes:

*	Sample location within Landfill Area
1	Sample collected from soil boring
2	Existing well (from 1999 – installed as part of groundwater removal action); redevelopment prior to incorporating into monitoring network
3	Grab groundwater sample collected from temporary well
4	Grab groundwater sample collected from existing piezometer (from 1999 – installed as part of groundwater removal action)
27 CCR	Title 27 California Code of Regulations
IR	Installation Restoration
PCB	polychlorinated biphenyl
RI	Remedial Investigation