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CORRECTIVE MEASURES STUDY SOLID WASTE MANAGEMENT UNIT 7 AND 8 WITH TRANSMITTAL AND RESPONSE TO COMMENTS NAVAL ACTIVITY PUERTO RICO
6/1/2012
AGVIQ/CH2M HILL

AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL JOINT VENTURE

June 15, 2012

U.S. Environmental Protection Agency - Region II
290 Broadway - 22nd Floor
New York, New York 10007-1866

Attn: Mr. Phil Flax

RE: Contract No. N62470-08-D-1006
Task Order No. JM04
Solid Waste Management Units 7/8
Naval Activity Puerto Rico - Ceiba, Puerto Rico
Corrective Measures Implementation Plan for SWMUs 7/8

Dear Mr. Flax:

AGVIQ-CH2M HILL Constructors Inc. Joint Venture III (AGVIQ-CH2M HILL), on behalf of the Navy, is pleased to provide one hard copy and one electronic copy provided on CD of the Corrective Measures Implementation Plan for SWMUs 7/8 at Naval Activity Puerto Rico. Additional distribution has been made as indicated below.

If you have any questions regarding this submittal, please contact Mr. Stacin Martin at (757) 322-4080.

Sincerely,

AGVIQ-CH2M HILL Constructors Inc. Joint Venture III

Tom Beisel, P.G.
Project Manager

cc: Ms. Debra Evans-Ripley/BRAC PMO SE (letter only)
Mr. David Criswell/BRAC PMO SE (letter only)
Mr. Tim Gordon/USEPA Region II (2 hard copies and 2 CDs)
Mr. Mark E. Davidson, BRAC PMO SE (1 hard copy and 1 CD)
Mr. Stacin Martin/NAVFAC Atlantic (1 hard copy and 1 CD)
Mr. Pedro Ruiz/NAPR (1 CD)
Mr. Carl Soderberg/USEPA Caribbean Office (1 hard copy and 1 CD)
Ms. Gloria Toro/PR EQB (1 hard copy and 1 CD)
Ms. Wilmarie Rivera/PR EQB (1 CD)
Ms. Connie Crossley/Booz Allen Hamilton (1 hard copy and 1 CD)
Ms. Bonnie Capito/NAVFAC LANTDIV (1 hard copy)
Ms. Lisamarie Carrubba/NMFS (1 CD)
Mr. Felix Lopez/U.S. Fish & Wildlife Service (1 CD)
Mr. Mark Kimes/Michael Baker Jr., Inc. (1 CD)

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Responses to EPA Comments Summary	
Regulatory Comments from:	Timothy R. Gordon (EPA Project Coordinator), Corrective Action and Special Projects Section, RCRA Programs Branch
Document:	*Corrective Measures Implementation Plan, Solid Waste Management Units 7/8,* Naval Activity Puerto Rico (NAPR), EPA ID PR2170027203, Ceiba, Puerto Rico, dated November 2011
Regulatory Letter Date:	March 08, 2012
Response Due Date:	June 18, 2012
Response Submittal Date:	June 18, 2012

EPA has completed its review of the CMI Plan (Groundwater), and the MNA Sampling and Analysis Plan (SAP) and the MNA Groundwater Sampling report, submitted by Mr. Tom Beisel's (of AGVIO/CH2MHill) letter of January 5, 2012, on behalf of the Navy. As part of that review EPA requested that our consultant, TechLaw Inc, also review the documents. TechLaw's comments are given in three Technical Reviews, dated February 28, 2012, which I had Emailed to you on March 2, 2012.

Within sixty days of the date of your receipt of this letter, please submit a revised CMI Plan, MNA Sampling and Analysis Plan (SAP) and the MNA Groundwater Sampling report, which address the above comments and those in the three Technical Reviews, dated February 28, 2012, which I had previously Emailed to you on March 2, 2012. The revised documents should be dated with the actual date of submission to EPA, not some earlier date.

In addition, the Puerto Rico Environmental Quality Board (PREQB) in its letter dated January 23, 2012, addressed to myself, had two comments on the CMI Plan, and in its January 24, 2012 letter to me indicated that the MNA SAP was acceptable. I had previously Emailed those letters to you on March 2, 2012. Please address PREQB's comments on the CMI Plan when you revise it to address EPA's above comments.

EPA Comment:

The CMI Plan needs to more clearly describe its scope as regards all the impacted media (surface and subsurface soils, and groundwater) at the site, and the totality of contaminants identified at the site as constituents of concern in the various impacted media. In addition, since monitored natural attenuation (MNA) appears to be a significant component of the groundwater remedy, the CMI plan needs to be revised to include a description of the MNA portion of the remedy, and its relationship to the LNAPL removal. Also, the CMI needs to demonstrate that it is consistent with EPA's guidance "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites", dated April 1999

(OSWER Directive 9200.4.-17P), and the CMI needs to cite the proposed MNA Sampling and Analysis Plan (SAP).

Response:
The CMI plan has been updated with text to describe all the impacted media (soils and groundwater) at the site and all the contaminants identified at the site as COCs in the various impacted media. New subsections 1.3.1 Soil, 1.3.2 Groundwater, 1.3.3 Groundwater Usability Assessment for Naval Activity Puerto Rico, and 1.3.4 Land Use Controls were added to the CMI Plan with the information requested above. In addition, the CMI Plan has been revised to include a description (new subsection 1.3.2 Groundwater) of the MNA portion of the remedy and its relationship to LNAPL removal.

As detailed in the TechLaw Comment 1 (Section EPA Cover Letter Issues Dated September 16, 2011), text has been added to Section 13.0, Exit Strategy, explaining that MNA is considered a component of the remedy for dissolved groundwater contamination and that a work plan has been submitted to the regulators for review. In addition, the text states the MNA work plan will detail the sampling and analysis of groundwater that will be necessary to determine the efficacy of the MNA remedy as a viable remedial action for cleanup of contaminated groundwater.

Responses to TechLaw Comments Summary	
Regulatory Comments from:	Cathy Dare (TechLaw, Inc.)
Document:	*Corrective Measures Implementation Plan, Solid Waste Management Units 7/8*, Naval Activity Puerto Rico (NAPR), EPA ID PR2170027203, Ceiba, Puerto Rico, dated November 2011
Regulatory Letter Date:	February 28, 2012 (Date provided on TechLaw technical review document)
Response Due Date:	June 18, 2012
Response Submittal Date:	June 18, 2012

The following comments were generated based on a review of the Response to EPA Comments dated November 29, 2011 (hereinafter referred to as the RTC), and the Corrective Measures Implementation Plan, Solid Waste Management Units (SWMU) 7/8, dated November 2011 for the Naval Activity Puerto Rico (NAPR) facility, EPA ID PR2170027203, Ceiba, Puerto Rico. The RTC was reviewed to determine whether EPA's comments on the *Corrective Measures Implementation Plan, Solid Waste Management Units 7/8*, dated September 16, 2011, were addressed adequately, and that any necessary revisions were incorporated appropriately into the *Corrective Measures Implementation Plan, Solid Waste Management Units 7/8*, dated November 2011 (CMI Plan). The RTCs were presented as Appendix M, Regulatory Comment and Response Documents, to the November 2011 CMI Plan.

EPA Cover Letter Issues Dated September 16, 2011:

1. In the first paragraph of Page 2 of the cover letter from Mr. Timothy Gordon (EPA) to Mr. Mark Davidson (US Navy) dated September 16, 2011, EPA states "Furthermore, the CMI Plan in effect describes an extended duration, two year pilot plan for addressing the light non-aqueous phase liquid (LNAPL) plumes at SWMU 7/8, rather than a complete and final remedy proposal. While EPA supports the proposal to develop an Engineering Evaluation Report (EER) after two years of system operation, to make recommendations as to the "long-term exit strategy for SWMU 7/8", without a detailed proposal for additional remedial actions following the EER (such as a proposal for monitored natural attenuation following the EER), the current CMI proposal cannot be viewed as constituting the final remedy proposal." This concern has still not been addressed in the CMI Plan. Section 13.0, Exit Strategy, Page 13-1 states "Given the factors outlined above, residual LNAPL may remain after 2 years of system operation. If so, the Navy will evaluate whether the current remedial approach should continue and/or a technology exists to enhance LNAPL recovery." These statements reinforce EPA's previous comment that the current CMI Plan cannot be viewed as constituting the final remedy proposal. The CMI Plan should be revised to discuss that Monitored Natural Attenuation (MNA) is considered a component of the remedy for

dissolved groundwater contamination. The revised text should discuss that a MNA work plan has been submitted to the regulators for review (*Work Plan for Monitored Natural Attenuation Groundwater Sampling at Solid Waste Management Unit (SWMU) 7/8*, dated November 2011). Additionally, the text should indicate the MNA work plan will detail the sampling and analysis of groundwater that will be necessary to determine the efficacy of the MNA remedy as a viable remedial action for cleanup of contaminated groundwater.

Response:
Text has been added to Section 13.0, Exit Strategy, explaining that MNA is considered a component of the remedy for dissolved groundwater contamination and that a work plan has been submitted to the regulators for review. In addition, the text states the MNA work plan will detail the sampling and analysis of groundwater that will be necessary to determine the efficacy of the MNA remedy as a viable remedial action for cleanup of contaminated groundwater.

2. In the last paragraph of Page 2 of the cover letter, EPA discusses the potential transfer of the "Port Parcel" which includes solid waste management units (SWMUs) 7/8 to the Puerto Rico Local Redevelopment Authority (LRA) and questions whether the corrective action objectives (CAOs) need to be updated to reflect changes in the proposed future land usage. In the response, NAPR states that "No change to the established CAOs will be performed despite potential changes in land use. The Navy contends that groundwater beneath the site cannot be used as source of potable water as the water is saline, has high total dissolved solids (TDS), and aquifer yield is too low to sustain pumping at a rate that would fulfill the needs of a public supply source." Unless the site groundwater is reclassified, NAPR should ensure that the CAOs are based on the current classification of groundwater at the facility.

Response:
The CAOs have been revised, a technical memorandum prepared and submitted via an email, and a conference call held with PREQB, EPA, and EPA's new contractor to discuss the newly revised CAOs. The technical memorandum (TM), *Revised Corrective Action Objectives for Solid Waste Management Units 7&8, 54, and 55* (dated June 1, 2012), provides details for the revised CAOs for surface soil, total soil (surface soil and subsurface soil, combined), and groundwater for SWMUs 7/8, and this memorandum is included as Appendix O in the revised CMI report. The revised CAOs for soil and groundwater are detailed in new Subsections 1.3.1 Soil and 1.3.2 Groundwater.

TechLaw Technical Comments Dated August 26, 2011:

Evaluation of the Response to EPA General Comment 1: The response to EPA General Comment 1 is partially adequate. The CMI Plan has been revised as discussed in the RTC to present the CMI information in a format consistent with the components of a Corrective Action Plan as presented in Chapter V (Corrective Measures Implementation) of the EPA *Final RCRA Corrective Action Plan, OSWER Directive 9902.3-2A, dated May 1994* (RCRA CAP). However, it is noted that Sections III [Intermediate Plans and Specifications (30, 50, 60, 90, and/or 95% Design)] and IV [Final Plans and Specifications (100% Design Point)] of the Corrective Measures Implementation Outline have not been included in the CMI Plan. The RTC states in the response to General Comment 1 that "The Navy contends that the simplicity of the LNAPL recovery system negates the need to incorporate the elements detailed in Sections III and IV of the RCRA CAP." While it may be true that the engineering designs for the proposed systems will be more simplistic than some remedial systems, site-specific engineering design diagrams will most likely be drafted by the remedial contractor and therefore should be presented to the regulatory authorities. While it is noted that some vendor information is presented in CMI Plan Appendix L, Operations and Maintenance Plan for the LNAPL Remediation System, the information discussed in CMI Plan Sections 7.1, Trailer-Mounted, Solar Powered Active Skimmer System, and 7.2, Passive Skimmer System, suggest that site-specific design drawings will be drafted prior to implementation in the field. Revise the CMI Plan to present the site-specific engineering design drawings that will be drafted for the implementation of the Solar Powered Active Skimmer and Passive Skimmer systems.

Response:
Aside from the information included in the O&M Manual, there are no site-specific engineering design drawings, nor will additional engineering drawings be created. The Xitech LNAPL recovery systems were installed in August 2011 and are fully operational. The Xitech units are "plug and play" and arrive preassembled. The only remaining activities are to install the pumps, run hose from the wells to the control unit, and program the pump cycle. Therefore, the CMI Plan presents the site-specific engineering design drawings in the O&M Manual (Appendix L) for the implementation of the Solar Powered Active Skimmer and Passive Skimmer systems.

Evaluation of the Response to EPA General Comment 8: The response to EPA General Comment 8 is adequate, however, it is requested that the text be revised to include the clarification provided in the response. Specifically, the comment requested that the text indicate the NAPL thickness gauging frequency for the monitoring wells located near the active and passive skimmers. The NAPR response indicates that monitoring wells located immediately adjacent to the wells with Xitech and DGSI skimmers will be gauged weekly, while the wells containing the skimmers will be gauged quarterly. However, CMI Plan Sections 7.1, Trailer-Mounted, Solar Powered Active Skimmer System, and 7.2, Passive Skimmer System, indicate that "site personnel will routinely gauge wells to monitor variations in LNAPL thickness, and adjust and maintain the (active) passive skimmers." Please revise the CMI Plan text to reflect the weekly and quarterly frequency of LNAPL gauging as presented in the response to General Comment 8.

Response:
A new section has been added to the CMI Plan to reflect the weekly and quarterly frequency of LNAPL gauging as presented in the response to General Comment 8. The following text was added to the CMI Plan:

Since skimmers and associated equipment can interfere with the use of an oil/water interface probe within the well casing, gauging will be performed weekly to monitor fluctuations in the water table in wells located immediately adjacent to wells with Xitech and DGSI skimmers. Water level data will be used to adjust placement of the Xitech and DGSI skimmers to ensure skimmers are positioned to maximize LNAPL recovery and minimize the extraction of any groundwater that may occur if the water table rises above the top of the skimmer. Wells containing Xitech and DGSI skimmers will be *gauged quarterly in conjunction with an ongoing groundwater monitoring and sampling event. A comprehensive round of water level/LNAPL thickness measurements will be performed quarterly, and new wells that contain LNAPL will be equipped with either a Xitech skimmer or passive skimmer, depending on the thickness measured (i.e., a Xitech skimmer will be installed in wells where LNAPL thickness exceeds 1 foot, and passive skimmers will be installed in wells where LNAPL thickness is less than 1 foot). Given the slow rate of LNAPL recharge, the monitoring frequency described above is considered adequate to maximize LNAPL recovery. Additional details on how the system will be operated to recover LNAPL are located in Appendix L.*

Evaluation of the Response to EPA Specific Comment 5: The response to EPA Specific Comment 5 is partially adequate. The comment requested an explanation why eight of the 49 planned test pits locations along Forrestal Drive that could not be excavated due to the presence of underground utilities were not relocated. In the response, NAPR states "based on the absence of LNAPL and spatial distribution of the completed test pits, the 41 test pits were determined to be adequate in defining the LNAPL plume extent." While this explanation is satisfactory, it was not included in the text of Appendix B, Technical Memorandum: Test Pit Excavation and Temporary Sump Installation for SWMU 7 and 8. Revise the text of the appendix to include the explanatory text presented in the comment response.

Response:
The following text has been added to section, *Test Pit Excavation Activities*, in Appendix B, *Technical Memorandum: Test Pit Excavation and Temporary Sump Installation for SWMU 7 and 8*:

Based on the absence of LNAPL and spatial distribution of the completed test pits, the 41 test pits were determined to be adequate in defining the LNAPL plume extent.

Responses to PREQB Comments Summary	
Regulatory Comments from:	Maria V. Rodrigues Munoz (PREQB Manager), Land Pollution Control Area
Document:	*Corrective Measures Implementation Plan, Solid Waste Management Units 7/8,* Naval Activity Puerto Rico (NAPR), EPA ID PR2170027203, Ceiba, Puerto Rico, dated November 2011
Regulatory Letter Date:	January 23, 2012
Response Due Date:	June 18, 2012
Response Submittal Date:	June 18, 2012

Comments:

1. On page 3-1, the active skimmers brands selected are being referred as passive skimmers. This should be revised and clarify.

Response:
Reference to "passive" skimmers on page 3-1 has been changed to "active" skimmers.

2. On the last bullet at page 3-2, the last sentence should refer to Section 4.4 instead of 4.1.

Response:
In the last bullet on page 3-2, the text for Section "4.1" was changed to "4.3" which includes a description of the comprehensive well gauging event conducted on May 18, 2010.

Corrective Measures Implementation Plan
Solid Waste Management Units 7/8

Naval Activity Puerto Rico
Ceiba, Puerto Rico

Revision No. 00

Contract No. N62470-08-D-1006
Task Order No. JM04

Submitted to:

NAVFAC
Naval Facilities Engineering Command

U.S. Naval Facilities Engineering Command Southeast

Prepared by:

AGVIQ Environmental Services
CH2M HILL Joint Venture

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Atlanta, GA 30328

June 2012

Corrective Measures Implementation Plan

Solid Waste Management Units 7/8
Naval Activity Puerto Rico
Ceiba, Puerto Rico

Revision No. 00

Contract No. N62470-08-D-1006
Task Order No. JM04

Submitted to:

U.S. Naval Facilities Engineering Command Southeast

Prepared by:

CH2MHILL Constructors, Inc.

June 2012

Prepared/Approved By:

Tom Beisel, Project Manager	June 15, 2012 Date

Approved By:

Michael Halil, Deputy Program Manager	June 15, 2012 Date

Client Acceptance:

U.S. Navy Responsible Authority	June 15, 2012 Date

Certification Page for Corrective Measures Implementation Plan
(Revision No. 00)
Solid Waste Management Units 7/8

I certify under penalty of law that I have examined and am familiar with the information submitted in this document and all appendices, and that this document and its appendices were prepared either by me personally or under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gathered and presented the information contained herein. I further certify, based on my personal knowledge or on my inquiry of those individuals immediately responsible for obtaining the information, that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowingly and willfully submitting a materially false statement.

Signature: ______________________

Name:

Title: BRAC Environmental Coordinator

Date: June 15, 2012

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Acronyms and Abbreviations

AFVR	aggressive fluid vapor recovery
AGVIQ-CH2M HILL	AGVIQ-CH2M HILL Constructors, Inc. Joint Venture
AST	aboveground storage tank
AVGAS	aviation gasoline
Baker	Baker Environmental, Inc.
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cm/sec	centimeters per second
CMI	Corrective Measures Implementation Plan
CMS	corrective measures study
CAO	corrective action objective
COC	chemical of concern
DGSI	Durham Geo Slope Indicator
EER	Engineering Evaluation Report
EPA	U.S. Environmental Protection Agency
FOSET	Finding of Suitability for Early Transfer
ft/day	feet per day
ft/ft	feet per foot
ft/yr	feet per year
gpm	gallon per minute
IC	institutional control
ID	inner diameter
lb/hr	pound(s) per hour
LNAPL	light non-aqueous phase liquid
LUC	land use control
MNA	monitored natural attenuation
NAPR	Naval Activity Puerto Rico
NSRR	Naval Station Roosevelt Roads
NAVFAC SE	Naval Facilities Engineering Command Southeast
NGVD29	National Geodetic Vertical Datum, 1929
O&M	operation and maintenance
OD	outside diameter
PAH	polynuclear aromatic hydrocarbon
ppm	parts per million
PWR	partially weathered rock
QED	QED Systems Inc.
SMWU	solid waste management unit
scfm	standard cubic feet per minute
SVE	soil vapor extraction
TM	technical memorandum

TPH	total petroleum hydrocarbon
TWFF	Tow Way Fuel Farm
UST	underground storage tank
VOC	volatile organic compound
Xitech	Xitech Systems Inc.

1.0 Introduction

AGVIQ-CH2M HILL Constructors, Inc. Joint Venture III (AGVIQ-CH2M HILL) has been retained by the Department of the Navy, Naval Facilities Engineering Command Southeast (NAVFAC SE) to prepare a Corrective Measures Implementation Plan (CMI) to address the removal of light non-aqueous phase liquids (LNAPLs) from the water table aquifer located at the former Tow Way Fuel Farm (TWFF, designated Solid Waste Management Units 7/8 [SWMUs 7/8]). SWMUs 7/8 is located at Naval Activity Puerto Rico (NAPR) formerly known as Naval Station Roosevelt Roads (NSRR), Ceiba, Puerto Rico. This CMI presents the remedial approach and technologies that will be implemented to reduce the thickness of LNAPL to the corrective action objective (CAO) of 0.01 foot.

The CMI is organized into the following sections:

- 1.0 Introduction
- 2.0 Corrective Measures Objectives and Description
- 3.0 Corrective Measures Study Optimization Activities
- 4.0 Corrective Measures Study Optimization Results
- 5.0 Conceptual Model of Contaminant Migration
- 6.0 Design Criteria
- 7.0 Design Basis
- 8.0 Operation and Maintenance Plan
- 9.0 Waste Management
- 10.0 Project Management
- 11.0 Monitoring and Reporting Requirements
- 12.0 Project Schedule
- 13.0 Exit Strategy
- 14.0 References

Technical Memoranda (TMs) related to SWMUs 7/8 are provided in Appendices A through K; operational instructions for skimmer units recommended to be used at the site are provided in Appendices J and K.

1.1 Site History

The NAPR occupies over 8,600 acres at the northeastern-most portion of Puerto Rico along the Vieques Passage (Figures 1-1 and 1-2). The northern entrance to NAPR is about 35 miles east, along the coastal road (Route 3) from San Juan. The facility was commissioned in 1943 as a Naval Operations Base but was re-designated in 1957 as a Naval Station.

The TWFF is located on a hillside along Forrestal Drive north of Ensenada Honda. The fuel farm was constructed prior to 1957 and originally consisted of nine bomb-proof underground storage tanks (USTs) (Figure 1-3). The tanks were used for the storage of marine diesel fuel (DFM), jet fuel (JP-5), and Bunker C fuel. Closure of Tanks 56A and 56B, which formerly contained DFM, was completed in November 1996 by Reliable Mechanical, Inc. Two 10,000-gallon steel tanks and 329 tons of contaminated soil were bioremediated and disposed of as non-regulated waste. In addition to the nine bomb-proof USTs, two USTs (470 and 471) used for the storage of leaded gasoline and high-octane aviation gasoline (AVGAS) were located south of existing Tank 1088. The leaded gasoline and AVGAS tanks were previously removed; however, details regarding their removal are unknown.

On March 31, 2004, NAPR operations, including the storage and distribution of fuel, were discontinued. The seven remaining USTs (82, 83, 84, 85, 1080, 1082, and 1088) and associated piping were drained and are empty. During the facility's operational history, numerous releases have occurred from the USTs and associated pipelines. The locations of known historical fuel releases are shown on Figure 1-4, which illustrates a summary of the historic distribution of light non-aqueous phase liquids (LNAPLs) based on the previous environmental studies. Existing well locations are shown on Figure 1-5. Groundwater elevation measurements (May 18, 2010) and groundwater flow direction are shown on Figure 1-6. LNAPL thickness and spatial distribution as measured on May 18, 2010 is shown on Figure 1-7.

1.2 Regulatory History

The U.S. Environmental Protection Agency (EPA) Region 2 is the primary agency that regulates environmental activities at the NAPR, and site work is performed under the January 29, 2007 Resource Conservation and Recovery Act (RCRA) Administrative Order on Consent (AOC) - 7003. In addition, the Puerto Rico Environmental Quality Board (PREQB) provides regulatory input. The EPA has assigned the following SWMU designations to the TWFF:

- SWMU 7 – Encompasses environmental impacts from releases that emanated from the nine USTs (currently seven) located on a hillside along Forrestal Road north of Ensenada Honda.
- SWMU 8 – Encompasses TWFF sludge disposal; however, previous investigations were unable to locate evidence of the pits, and the EPA combined SMWU 8 with SWMU 7.

1.3 Summary of Previous Work

Between 1982 and 2005, numerous investigations and remedial tests were performed to determine the extent of petroleum hydrocarbons in the soil and groundwater beneath the TWFF. The results of the work were summarized in a Corrective Measures Study (CMS) report prepared by Baker Environmental, Inc. (Baker, 2005). The CMS included a discussion of contaminant extent in soil and groundwater, LNAPL distribution, the hydraulic and physical properties of the soil and groundwater, pilot test results, and studies performed to formulate remedial strategies for cleanup of the soil and groundwater to risk-based CAOs. The use of LNAPL-only recovery pumps was proposed for the removal of LNAPLs, and monitored natural attenuation (MNA) was proposed to reduce concentrations of select volatile organic compounds (VOCs) to the CAOs. Soil excavation of the upper 2 feet of soil within the fuel farm area was proposed to remove select polynuclear aromatic hydrocarbon (PAH) compounds and arsenic that exceeded the risk-based CAOs. In addition to the CAOs for soil and groundwater, land use controls (LUCs) and/or institutional controls (ICs) are necessary to prevent exposure and unintended uses of contaminated groundwater (Baker, 2005). ICs such as land use restrictions are effective and can be maintained in perpetuity. The EPA approved the CMS on February 9, 2006 (Appendix A).

In 2008, the Navy retained AGVIQ-CH2M HILL to implement the remedial strategies presented in the CMS. The CMS included figures that indicated the extent of LNAPL was confined to the southwestern-western corner of the fuel farm (centered round monitoring well UGW25), and along a narrow band that paralleled the north side of Forrestal Drive. During the review of historical data, AGVIQ-CH2M HILL determined that many of the wells were screened below the water table and LNAPL, if present, could not enter the wells. This finding, coupled with historical data that showed fuel was present in smear zone soil during drilling, suggested the extent of LNAPL was greater than presented in the CMS. The Navy requested that AGVIQ-CH2M HILL evaluate ways to optimize the remedial strategies described in the CMS. AGVIQ-CH2M HILL's optimization strategy was as follows:

- The collection of additional soil samples from the proposed area of excavation to verify whether the contaminants of concern (COCs) polycyclic aromatic hydrocarbons (PAHs) and arsenic were present in soil above the CAOs, and if so evaluate the volume of soil requiring removal prior to mobilizing excavation equipment.
- Advance test pits in the lowland portion of the site to assess whether LNAPLs are present south of Forrestal Drive.
- Install LNAPL recovery wells to evaluate the extent of LNAPL and construct the wells with sufficient amounts of screen to straddle the water table and allow for seasonal fluctuations in the water table.
- Evaluate multiple LNAPL recovery technologies to identify the most technologically sound and cost-effective method to recover LNAPL and reduce the thickness of LNAPL in wells to the CAO of 1/8 inch (0.01 foot).
- For the dissolved hydrocarbon plume, MNA was proposed for reducing concentrations of groundwater COCs, 1,2,4-trimethylbenzene, benzene, and ethylbenzene to applicable CAOs because previous test data collected by Baker suggested that biological degradation of hydrocarbons was occurring.

The focus of this CMI is to describe the remedial approach and technologies that will be implemented to reduce the thickness of LNAPL to the CAO of 0.01 foot. However to more clearly describe the scope for all impacted media at SWMUs 7/8 as detailed in the CMS report (Baker, 2005), brief descriptions of the contaminants identified as COCs in the various impacted media have been provided below for completeness.

1.3.1 Soil

The regulatory-approved remedial action to address soil contamination at SWMUs 7/8 includes the excavation of the upper 2 feet of soil in three areas of concern where the PAH COCs benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and arsenic exceeded their respective CAOs. The CMS report approved by EPA identified industrial land use based CAOs at 2.9 mg/kg, and the construction worker protection based target CAO is 7.3 mg/kg for benzo(a)pyrene. The toxicity equivalence factor (TEF) for benzo(a)anthracene, benzo(b)fluoranthene and indeno(1,2,3-cd)pyrene is 0.1 per EPA guidance for PAH evaluations (i.e., these chemicals are tenfold less toxic than benzo(a)pyrene [TEF = 0.1]). The term, "total soil," refers to surface and subsurface soil up to a depth of 10 feet. Thus the CAOs included in the final CMS report (Baker, 2005) are estimated for an industrial land use based exposure to workers to surface and subsurface soil.

Since the CAOs included in the CMS report for SWMUs 7/8 were developed in 2003 and 2005, the EPA requested these CAOs be revised using the latest calculation methods and toxicity factors (EPA Regional Screening Levels [RSL], updated November 2011) as listed at website: http://www.epa.gov/region9/superfund/prg/. The revised CAOs were also calculated for industrial (indoor) worker and construction worker scenarios. These CAOs were derived using the methods or calculator tool provided in the online resources by EPA on their RSLs website (EPA, 2011), and EPA's latest version of J-E Model groundwater spreadsheet from its online web-link (EPA, 2012). The technical memorandum (TM), *Revised Corrective Action Objectives for Solid Waste Management Units 7&8, 54, and 55* (dated June 1, 2012), provides details for the revised CAOs for surface soil, total soil (surface soil and subsurface soil, combined), and groundwater for SWMUs 7/8 (Appendix N). Revised soil CAOs for the contaminants of concern are presented in Tables 1-1.

The data presented in the CMS indicated that the vertical extent soil contamination above the CAOs was limited to the upper 2 feet of soil. Using the Natural Neighbor interpolation approach of the computer model GMS v5.1, Baker estimated the areal extent of contamination requiring excavation through the extrapolation of a limited set of soil analytical data.

Because the areas requiring excavation were based on modeling results, AGVIQ-CH2M HILL prepared a Work Plan to perform a pre-excavation delineation of SWMUs 7/8 to verify the limits of excavation described in the CMS, and to determine if arsenic is naturally occurring or is a result of past practices used by the Navy. The Work Plan (*Work Plan for Pre-Excavation Delineation at SWMUs 7 and 8*, dated April 2009) was submitted to the Navy during the first quarter of 2009 and approved for implementation in April 2009.

TABLE 1-1
Soil Cocs and Revised CAOs - June 2012
SWMU 7/8 Tow Way Fuel Farm, Naval Activity Puerto Rico

COCs[1]	2009-Maximum Observed Concentration in Soil[1,5] (mg/kg)	Surface Soil Industrial Worker (mg/kg) Revised CAOs[2]	Total Soil Construction Worker (mg/kg) Revised CAOs[2]	Soil Residential (mg/kg) RSLs - November 2011[3]	Soil Industrial CAOs mg/kg May-2012[6]
Metals					
Arsenic	4.3	3.81	55	0.39	3.81
Semivolatiles					
Benz(a)anthracene	ND (<0.13 - <2.4)	7.8	73	0.15	7.8
Benzo(a)Pyrene	ND (<0.13 - <2.4)	7.8 [(4)]	7.3	0.015	7.3
Benzo(b)fluoranthene	ND (<0.13 - <2.4)	7.8	73	0.15	7.8
Indeno-1,2,3-cd-pyrene	ND (<0.13 - <2.4)	7.8	73	0.15	7.8

Notes:
1. Arsenic occurs in background soils, and background arsenic value for surface soil is 2.65 mg/kg. Site maximum is based on 72 samples, and highest UCL is 2.5 mg/kg
2. EPA RSLs calculated using November 2011 from the following web link. See Attachment B. http://www.epa.gov/region9/superfund/prg/
3. EPA Regional Screening Table, November, 2011.
4. For Benzo(a)pyrene, CAO for industrial worker is based on a target risk of 1×10^{-5}, construction worker CAO and residential RSL is based on a target risk of 1×10^{-6}.
5. The PAH concentrations were below detection limits (DL) in all samples. DLs ranged between 0.13 mg/kg to 2.4 mg/kg for individual PAH constituents
(see CMS Addendum, Table 3-1)
6. Proposed industrial CAOs are lower of the industrial worker and construction worker based CAOs

CAO = corrective action objective
COC = contaminant of concern
ND - Non-detect
mg/kg = milligrams per kilogram

Details including the findings and recommendations concerning the CAOs for soil are provided in a CMS addendum (*Corrective Measures Study Addendum, SWMUs 7 and 8 – Revised Soil Remedy*, dated June 2012a). The CMS addendum for soil at SWMUs 7/8 has been submitted to the EPA and PREQB for review.

A CMS Addendum report was prepared (AGVIQ-CH2M HILL, June 2012b) that included the soil sampling results for the soil PAH and arsenic levels proposed in the 2009 work plan. The results summary from the CMS Addendum for the COCs including the select PAHs and arsenic is as follows:

- Based on the analytical results for the surface soil samples, there is no soil contamination at the site that requires corrective actions under industrial land use. PAH concentrations are below lower DLs, i.e., MDLs that ranged between <0.13 mg/kg and <0.4 mg/kg, which are below the revised CAOs (Table 1-1). The site soil contamination levels do not present human or ecological exposure concern. However, due to the MDLs that are above the residential RSL values for PAHs of 0.015 mg/kg to 0.15 mg/kg, soils may contain PAHs at levels below the current DLs, but may be above residential RSLs/CAOs. Therefore, SWMUs 7/8 is recommended for industrial land use with no active remediation, and land use restrictions with LUCs to prevent future unrestricted land use unless additional measures are implemented and approved by EPA for PAHs in site soils.

- Based on the extensive sampling (72 samples analyzed) for arsenic conducted across the site, it concluded that the arsenic distribution patterns indicate absence of specific elevated arsenic concentration areas. The statistical evaluation of the data indicate site arsenic upper-bound concentration limits of the mean are between 1.9 mg/kg and 2.5 mg/kg, which are below the revised CAO target level of 3.81 mg/kg, and also at or below background value of 2.5 mg/kg. No single detection is indicative of extremely elevated values, as the maximum detected concentration at 4.3 mg/kg, is below the levels indicative of any 'hot spot' area. Therefore, the detected arsenic levels at SWMUs 7/8 are below the revised CAOs, and detected arsenic is considered naturally occurring. Therefore, no further action (NFA) is recommended for arsenic in site soils at SWMUs 7/8.

- In summary, the SWMU7/8 soil concentrations for the two COCs, PAHs and arsenic, are either below DLs or similar to background levels. Therefore, NFA is recommended for SWMUs 7/8 soils under industrial land use, as soils do not pose exposure related risks to human health under industrial use scenario. However, because of the MDLs for PAHs that are higher than residential CAOs, the site is recommended for continued industrial land use with LUCs to preclude future unrestricted land use. The site LUCs also protect against site development that may involve construction activities in areas with buried UST and associated pipelines at SWMUs 7/8.

1.3.2 Groundwater

LNAPL Plume

The CAO for LNAPL recovery is to reduce LNAPL thickness in all wells to 0.01 foot or less. The removal strategy as presented in the CMS (Baker, 2005) involved the installation of a fixed-based, passive skimmer system and the use of mobile skimmer systems to achieve the

CAO. Details including the conceptual site model of contaminant migration, design criteria, and design basis concerning the CAO for LNAPL are provided in this CMI Plan.

Dissolved Volatile Organic Compound Plume

Benzene, ethylbenzene, and 1, 2, 4-TMB were identified as the three COCs in groundwater; historical concentrations for each COC are presented in Table 1-2 (Baker, 2005). Through completion of risk-based calculations, the CAOs for cleanup of benzene, ethylbenzene, and 1, 2, 4-TMB in groundwater were determined to be 550, 1,000, and 3,300 µg/L, respectively (Baker, 2005). The area of contamination exceeding the CAOs was located in, and downgradient of the area formerly occupied by the leaded gasoline USTs 470 and 471 (Figure 1-3), which correlates with the distribution of the fuels released. Benzene, ethylbenzene, and 1,2,4-TMB above the CAOs are nearly absent in groundwater beneath areas of the site where lower volatility fuels such as marine diesel fuel, jet fuel (JP-5), and Bunker C fuel were released and currently present (Figure 1-7).

Since the CAOs for SWMUs 7/8 were developed in 2003 and 2005, the EPA requested these CAOs be revised, as previously described above in Section 1.3.1 and in Appendix N. The revised CAOs for cleanup of benzene, ethylbenzene, and 1, 2, 4-TMB in groundwater were estimated to be 160 µg/L, 493 µg/L, and 5,251 µg/L, respectively.

Tricholorethene (TCE) was added as a COC for SWMU 7/8 in June 2012 and the corresponding CAO for cleanup of TCE is 193 µg/L. However, TCE detected during the CMS study are associated with monitoring wells located within SWMU 55. Remedial actions are currently ongoing to reduce TCE concentrations below the revised CAO at SWMU 55.

TABLE 1-2
Revised COCs for Groundwater
SWMU 7/8 Tow Way Fuel Farm, Naval Activity Puerto Rico

COC	Observed Maximum–Historical (µg/L)	Observed Maximum – Most Recent (µg/L)	Revised CAOs (June 2012) (µg/L)
1,2,4-Trimethylbenzene	4,600	4,600	5,251
Benzene	26,000[a]	19,000[a]	160
Ethylbenzene	95,702[b]	18,000[c]	493
Trichloroethene	28,000J[d]	14,900[e]	193

Notes:

[a]located at 470MW1, concentration measured 04/1998 and 01/2002
[b]located at UGW1, concentration measured 03/1991
[c]located at 470MW3, concentration measured 01/2002
[d]located at 7MW07 (SWMU 55), concentration measured 01/2002
[e]located at 55IW01 (SWMU 55), concentration measured 08/2010

COC—chemical of concern
µg/L—micrograms per liter

In conjunction with LNAPL removal, MNA is considered a component of the remedy for dissolved groundwater contamination. An MNA work plan (*Work Plan for Monitored Natural Attenuation Groundwater Sampling at Solid Waste Management Unit (SWMU) 7/8*, dated March

2012) has been submitted to the EPA and PREQB for review. MNA sampling activities detailed in the Work Plan will be conducted to collect data to determine if the aquifer has a favorable geochemical environment and assimilative capacity. Multiple lines of evidence supporting MNA will be used to determine the efficacy of the MNA remedy as a viable remedial action for cleanup of contaminated groundwater. Future monitoring will be used to verify these lines of evidence and track both LNAPL and dissolved plume attenuation.

1.3.3 Groundwater Usability Assessment for Naval Activity Puerto Rico

The TM, *Groundwater Usability Assessment, Naval Activity Puerto Rico, Ceiba, Puerto Rico*, dated May 10, 2012, was created to provide the basis for using risk management when making corrective action determinations that involve potable use of groundwater in accordance with the Resource Conservation and Recovery Act (RCRA) Administrative Order on Consent (RCRA-02-2007-7301). The Groundwater Usability Assessment TM is provided in Appendix O.

Site specific groundwater investigations consider potable use for the purposes of evaluating the nature and extent, contaminant fate and transport, and assessment of associated risk. However, by demonstrating that groundwater beneath NAPR does not have the characteristics nor does it meet the RCRA definition of an "aquifer," the TM provided the rationale for using risk management to preclude the need for treating groundwater to drinking water standards. If a risk management decision is made not to clean up to potable use standards, a land use control prohibiting unrestricted use of groundwater not suitable for potable use underlying the site and downgradient of the site, where contaminated groundwater could migrate, shall be included in the transfer deed.

Regional and NAPR data demonstrate and the Consent Order states that groundwater beneath NAPR does not produce sufficient quantities of water to be used as a potable water supply based on the results of the 1999 (Attachment II of the Consent Order) and 2010 pump test. Further, the groundwater contains high levels of TDS (907 to 45,000 mg/L) and salinity (660 to 35,500 parts per million [ppm]) relative to levels acceptable for potable use, characterizing it as brackish or saline. While desalinization could remove solids from groundwater, the high cost (relative to the cost of obtaining water from the currently available water supply system) would limit its implementation. In addition, the Land Reuse plan developed for the NAPR property anticipates the continued use of surface water as the sole supply of water for potable, agricultural, and industrial use because the water bearing unit beneath NAPR cannot provide an adequate quantity of water for use.

Section 1302.3(A) of PRWQS regulation (PREQB, 2010) classifies all groundwater in Puerto Rico as SG, which is defined under Section 1303.2(F) as groundwater intended for use as source of drinking water supply; however, the low yield of groundwater beneath NAPR and its naturally occurring high levels of TDS and salinity prevent the attainment of that use. In addition, groundwater is not currently used as a potable (or other) source and it has been recognized that there is no intention to use it as such (Navy, 2011). Therefore, while site-specific investigations and subsequent corrective action determinations involving groundwater will determine groundwater characteristics relative to potable use suitability and will consider potable use of groundwater in human health risk evaluations, corrective action do not include achieving potable use standards, as such assumptions are not warranted for sites with groundwater that is not suitable for potable use based on low yield and naturally poor water quality that is underlying NAPR. Land use control.

1.3.4 Land Use Controls

SWMUs 7/8 is currently under industrial land use. The Navy plans to maintain this site under the industrial land use into the future even when there is a property transfer to a new owner. Land use controls (LUCs) are recommended at SWMUs 7/8 to protect human health and the environment and the LUCs consist of engineering controls/and or institutional controls.

Existing LUCs are included as part of the corrective action to prevent the unintended exposure to groundwater. Existing LUCs are described in the Quitclaim Deed for CDR Parcel 2 (includes SWMU 55) signed by the Navy and the LRA on December 20, 2011. If the property is transferred to a new owner, LUCs must be maintained including:

- No permanent residences may be installed on the property.
- No groundwater extraction wells may be installed by the deed grantee.
- Potential for vapor intrusion must be considered by the developer and addressed by the developer, as needed.
- The grantee may not interfere with any existing or future groundwater remedial systems.
- The grantee must complete annual inspections of the property to ensure all LUCs are being complied with and provide written certification of the inspection.
- The grantee must comply with the RCRA Administrative Order on Consent for this property (provided to the Local Redevelopment Authority [LRA] by the U.S. Navy).
- Release of environmental conditions and grantee covenants can be considered only with EPA concurrence.
- In order to develop, improve, use, or maintain the property in a manner inconsistent with the LUCs, the grantee must submit a written request seeking approval to the Director at the NAVFAC BRAC Program Management Office Southeast.

The LUCs will be included in any lease or transfer deed. If development other than industrial use (i.e., residential or per the April 2010 amended Reuse Plan) is proposed, the new owner will be required to work with the PREQB and EPA to establish any additional investigation, risk assessment, and/or cleanup activities. If the property owner wishes to remove the LUC on the groundwater from the deed in the future, it will be the responsibility of the property owner to demonstrate that groundwater meets all state and federal maximum contaminant levels (MCLs), and must obtain approval from the Navy, EPA, and PREQB prior to LUC removal.

2.0 Corrective Measures Objectives and Description

This section presents the corrective measures objectives and background information used to develop a cleanup strategy to remove LNAPLs at SWMUs 7/8.

Relevant background information includes:

- The November 2005 *Corrective Measurements Study* prepared by Baker Environmental, Inc. (Baker, 2005). This report presented the CAOs for LNAPL removal and included a description of the remedial approach proposed to remove LNAPL at SWMUs 7/8.
- The *Remedial Action Optimization Report for Tow Way Fuel Farm* (AGVIQ-CH2M HILL, 2009). This report included a comprehensive review of historical information, identified potential data gaps in the previously collected data, and presented a strategy to verify LNAPL extent and evaluate ways to optimize LNAPL removal.

Major findings associated with these documents are summarized below.

2.1 Corrective Measures Study Report

In November 2005, Baker submitted a CMS report for the TWFF. The remedial plan for SWMUs 7/8 called for the installation of 60 LNAPL recovery wells, connection of these wells to a fixed-based passive skimmer system, and construction of two trailer-mounted (mobile) passive skimmer units to recover LNAPL detected outside the recovery well network. The EPA approved the CMS for implementation on February 9, 2006 (Appendix A). Figure 2-1 illustrates the assumed extent of LNAPL in 2005 and the location of the proposed 60 extraction wells and associated piping.

The CAO for LNAPL recovery is to reduce LNAPL thickness in all wells to 0.01 foot or less. As previously stated, the removal strategy involved the installation of a fixed-based, passive skimmer system and the use of mobile skimmer systems to achieve the CAO. Baker recommended operating the system for 2 years to evaluate whether the passive skimmers removed LNAPL in a timely manner. If after 2 years of operation passive skimming is determined to be ineffective, Baker recommended the evaluation of alternate technologies to enhance LNAPL removal.

2.2 February 2009 – Remedial Action Optimization Report

In February 2009, AGVIQ-CH2M HILL prepared a document entitled "*Remedial Action Optimization Report for Tow Way Fuel Farm*" (AGVIQ-CH2M HILL, 2009). The report was prepared at the request of the Navy to determine if the approach presented in the CMS could be optimized (to ensure the best value to the Navy), while still ensuring the remedy was protective of human health and the environment. AGVIQ-CH2M HILL reviewed 25 years of historical data including: well construction information, previously performed pilot test data, and the proposed strategy and layout of the LNAPL recovery system. Additionally, in

January 2009, AGVIQ-CH2M HILL performed a site visit to gauge the existing well network and determine the current extent of LNAPL.

The primary finding of the Optimization Report was that the extent of LNAPL may be greater than indicated in the CMS because many of the previously installed wells were either screened below the water table or constructed with insufficient lengths of screen to account for seasonal fluctuations in the water table (Tables 2-1 and 2-2). In addition, AGVIQ-CH2M HILL recommended that the Navy evaluate other LNAPL removal technologies because historical data suggested that vacuum enhanced extraction may accelerate the rate of LNAPL removal.

The following recommendations were made:

- Begin the installation of recovery wells adjacent to wells that currently have measureable amounts of LNAPL. In these areas, install wells at 50-foot intervals in the cardinal compass directions (N, S, E, and W) and continue this process until LNAPL is no longer detected in a particular direction.
- Install wells in areas of the site where the thickness of LNAPL historically exceeded 10 feet in wells screened below the water table.
- Construct wells with sufficient screen length to both straddle the LNAPL water interface and account for seasonal fluctuations in the water table.
- Advance test pits south of Forrestal Drive and also immediately north of Forrestal Drive near the former location of Tanks 56A and 56B to determine if LNAPL is present in these areas.
- Test multiple remedial technologies to confirm that passive skimming represents the best value to the Navy.
- Following well installation and selection of a LNAPL recovery technology (or technologies), operate the system(s) for 2 years as indicated in the CMS.

3.0 Corrective Measures Study Optimization Activities

Between June 1, 2009, and May 18, 2010, the following tasks were performed to determine the extent of LNAPL and collect data necessary to evaluate and select the most technologically sound and cost effective remedy to address LNAPL removal at SWMUs 7/8 as detailed in the CMS:

- **Test Pits:** Between June 1, 2009, and July 15, 2009, a total of 41 test pits were advanced to test for the presence of LNAPL in the lowland area south of Forrestal Drive and in the area formerly occupied by Tanks 56A and 56B. A TM detailing the work performed and findings obtained is included in Appendix B.
- **Recovery and Monitoring Well Installation:** Between July 14, 2009, and April 14, 2010, a total of 45 recovery wells and 12 monitoring wells were installed to determine the extent of LNAPL at SWMUs 7/8. A TM detailing the work performed and findings obtained is included in Appendix C.
- **Aggressive Fluids Vapor Recovery (AFVR) Pilot Testing:** Between January 13, 2010, and February 4, 2010, AFVR events were performed at 30 wells containing LNAPL to determine whether AFVR was capable of reducing LNAPL thickness to the CAO of 0.01 foot. Additional testing was also performed at 10 wells to determine if the use of AFVR resulted in changes in LNAPL thickness, water level, and vacuum pressure in nearby observation wells. A TM detailing the work performed and findings obtained is included in Appendix D.
- **Soil Vapor Extraction (SVE) Pilot Test:** Between February 16, 2010, and February 18, 2010, testing was performed to determine the effectiveness of SVE to recover LNAPL measured in wells CHMW07 and 470MW01. These wells were installed in the area formerly occupied by the gasoline storage tanks. A TM detailing the work performed and findings obtained is included in Appendix E.
- **LNAPL Baildown Tests:** On March 10, 2010, three LNAPL baildown tests were performed to determine the hydrocarbon conductivity and transmissivity associated with the LNAPL plume at SWMUs 7/8. These parameters help describe the potential mobility, and ultimately the potential recoverability, of the LNAPL. A TM detailing the work performed and findings obtained is included in Appendix F.
- **Active Skimmer Evaluation:** Between February 16, 2010, and March 11, 2010, a comparative pilot study was performed to evaluate the ability of active skimmers to reduce the thickness of LNAPL on the water table aquifer at SWMUs 7/8. For the study, two active skimmer brands were selected. One unit was manufactured by QED Systems, Inc. (QED) of Ann Arbor Michigan, and the second unit was manufactured by Xitech Systems (Xitech) of Placita, New Mexico. A TM detailing the work performed and findings obtained is included in Appendix G.

- **Total Fluids Recovery Pilot Test:** On March 9 and 10, 2010, testing was performed to determine the effectiveness of extracting groundwater from existing recovery wells to recover LNAPL along Forrestal Drive. A TM detailing the work performed and findings obtained is included in Appendix H.
- **Aquifer Slug Tests:** On October 11 and 12, 2010, 11 aquifer slug tests were performed to determine the hydraulic conductivity associated with the unconfined aquifer. A TM detailing the work performed and findings obtained is included in Appendix I.
- **Comprehensive Well Gauging Event:** On May 18, 2010, a comprehensive round of gauging was performed to determine the extent of LNAPL. No TM is included for this work; however, the gauging data are presented in Section 4.3 of this report.

4.0 Corrective Measures Study Optimization Results

This section presents a summary of the findings obtained following installation of the LNAPL recovery wells, test pits/temporary sumps, and completion of the LNAPL recovery pilot tests to formulate a remedial strategy for cleanup of the LNAPL plume to the risk-based CAO. Detailed descriptions of the work performed are included in Appendices B through I.

4.1 Topography

Land surface elevations at the site range from approximately 9 to 115 feet National Geodetic Vertical Datum, 1929 (NGVD29). SWMUs 7/8 is characterized by a moderately steep valley with two man-made retention areas positioned along the overland flow path of the site.

The site drains through a series of two valve-controlled, surface water retention areas to the Caribbean Sea, which is approximately 400 feet to the southwest. The retention areas were originally created to contain fuel spills from the onsite USTs, with each having a control valve to allow runoff to continue through the area. Currently, the control valves are "open," allowing runoff to flow unimpeded to the ocean. Standing water occurs in depressions within the retention areas after high intensity rainfall events. Note that during the May 2010 sampling event, standing water was observed surrounding CHRW25 and CHRW36 (Figure 1-6).

4.2 Site Geology

The Technical Memorandum, *Well Installation to Determine Light Non-aqueous Phase Liquids Extent at SWMU 7/8*, located in Appendix C, provides additional information of the site geology at SWMUs 7/8. The site geology was evaluated by examining lithologic samples collected during the installation of the LNAPL recovery wells and monitoring wells. Two hydrogeologic cross-sections were constructed to illustrate the subsurface geologic and hydrogeologic conditions beneath the site (Figure 4-1). Hydrogeologic cross-section A-A′ (Figure 4-2) is oriented approximately parallel to groundwater flow beneath the site. Hydrogeologic cross-section B-B′ (Figure 4-3) is oriented approximately perpendicular to groundwater flow beneath the site. Well construction details are summarized in Table 2-1.

The geology at SWMUs 7/8 consists of four primary geologic units: fill, soil consisting of saprolite and partially weathered rock (PWR), bedrock, and marine sediments. Fill material is primarily composed of sand (fine to coarse grained), small amounts of gravel, and varying amounts of silt and clay. In some instances, marine sediments (i.e., shells and coral) were found within the fill material; however, no significant deposits of marine sediments were recovered while drilling in this area. As shown on cross-sections A-A′ (Figure 4-2) and B-B′ (Figure 4-3), the fill material is estimated to range in thickness from 5 to 20 feet. Saprolite and PWR underlie the fill and vary in thickness; however, at some locations saprolite is absent and PWR underlies the fill. Where encountered, the saprolite consists of stiff clays and silt containing rock fragments that become more numerous with increasing depth. The PWR interval consists primarily of dense and stiff gravelly clay and clayey gravel. The gravel consists of fractured, weathered, and fragmented gabbro. Gabbro bedrock underlies the PWR and was encountered within at depths ranging from 5 to 67 feet below ground surface (bgs). The gabbro is well indurated and contains numerous fractures and joints. The cross-sections show that the top of rock surface is undulating, forming bedrock highs and lows.

4.3 Site Hydrogeology

The Technical Memorandum, *Well Installation to Determine Light Non-aqueous Phase Liquids Extent at SWMU 7/8*, located in Appendix C, provides additional information of the unconfined aquifer at SWMUs 7/8. Groundwater beneath the site occurs in two water-bearing zones. A shallow water-bearing zone occurs in the fill, saprolite, and PWR that mantles bedrock. A deeper zone occurs within the fractured bedrock. However, since there is no distinct physical or hydraulic boundary between these two units, both units are considered as one hydrogeologic unit CSM (Baker, 2005).

A complete round of water level and LNAPL thickness measurements was obtained on May 18, 2010 and is summarized on Table 4-1. Review of the data shows that groundwater elevations were shallowest in wells installed south of Forrestal Drive. Water table elevations north of Forrestal Drive were higher. Figure 1-6 depicts the pieziometric surface on May 18, 2010 and illustrates that the direction of groundwater flow mimics the topography of the site and is generally south-southwest towards the bay. Figure 1-6 also shows an area of elevated water levels in the area occupied by wells CHRW25 and CHRW36. These wells are located in a low area near piping that collects surface water run-off from the upper portion of the TWFF.

In October 2010, AGVIQ-CH2M HILL performed aquifer slug tests at 11 monitoring wells to estimate the hydraulic conductivity of the aquifer. Seven wells were tested north of Forrestal Drive and five wells were tested south of Forrestal Drive. Test locations are illustrated on Figure 4-4. Aquifer slug test results and test data including transducer output, and graphs of the data are included in Appendix I. Slug test results show that the average hydraulic conductivity is 1.3 feet per day (ft/day) in wells located north of Forrestal Drive, and 3.9 ft/day in wells south of Forrestal Drive. The increased hydraulic conductivity in wells south of Forrestal Drive is probably a result of the higher permeability sand and gravel fill that was used during construction of the harbor area. The average hydraulic gradient based on water level data collected on May 18, 2010 was calculated to be 0.02 feet/foot (ft/ft).

The rate of groundwater moving beneath the site was estimated by the average seepage velocity. The following equation was used to calculate the average seepage velocity:

$$V_x = \frac{Ki}{n_e}$$

Where:

V_x = average seepage velocity in ft/day

K = average hydraulic conductivity (1.3 ft/day in wells north of Forrestal Drive; 3.9 ft/day in wells south of Forrestal Drive; based on the slug test results presented in Appendix I

i = average hydraulic gradient (0.02 ft/ft); based on average gradient data presented on Table 4-2)

n_e = effective porosity (0.3; based on silty saprolitic material [Fetter, 1994])

- Linear velocity North of Forrestal Drive:

$$V_{x\ (\text{North of Forrestal Drive})} = [(1.3)*(0.02)/0.3] = 0.087 \text{ ft/day or 32 feet per year (ft/yr)}$$

- Maximum linear velocity

$$V_{x\ (\text{South of Forrestal Drive})} = [(3.9)*(0.02)/0.3] = 0.26 \text{ ft/day or 95 ft/yr}$$

Biodegradation is acting to stabilize the LNAPL plume at this site. If the LNAPL plume was moving downgradient at the speed of the groundwater, the plume would have migrated nearly 2,000 feet and into the bay over the past 20 years. In reality, the plume appears to have migrated less than 100 feet from the LNAPL source areas.

4.4 LNAPL Extent and LNAPL Baildown Test Results

4.4.1 LNAPL Extent

The Technical Memorandum, *Well Installation to Determine Light Non-aqueous Phase Liquids Extent at SWMU 7/8*, located in Appendix C, provides a detailed description of the extent of LNAPL at SWMUs 7/8. The extent of LNAPL detected on May 18, 2010, is illustrated on Figure 1-7, and individual LNAPL thickness measurements are presented in Table 4-1. Figure 1-7 shows that the LNAPL plume exceeding 0.01 foot in thickness encompasses an area of approximately 4.8 acres and is predominately located within the area occupied by the fuel storage tanks. In addition, Figure 1-7 shows a narrow band of LNAPL extending a distance of about 1,000 feet eastward along a utility corridor located immediately north of Forrestal Drive. Measurable amounts of LNAPL were not detected in wells or test pits/temporary sumps installed south of Forrestal Drive. However, hydrocarbon sheens were observed on groundwater removed from several wells and test pits/temporary sumps. Comparison of Figure 2-1 (prepared by Baker in 2005) and Figure 1-7 shows the extent of LNAPL is significantly greater than previously estimated. A review of the figures also shows that LNAPL has not been detected south of Forrestal Drive.

Three separate areas containing more than 1 foot of LNAPL were identified and are shown on Figure 1-7. The largest and thickest area is located in the southern portion of the TWFF adjacent to and upgradient of the fuel system pump station. In this area, wells exhibiting the thickest accumulations of LNAPL were CHRW21 (10.93 feet), CHRW10 (8.33 feet), CHRW23 (8.18 feet), CHRW20 (7.79 feet), CHRW11 (7.16 feet), and CHRW45 (8.57 feet).The second area of significant LNAPL accumulation is located in a lowland area between tanks 1088 and 85, as delineated by recovery wells CHRW03, CHRW17, CHRW15, CHRW27, and CHRW39. The thickest LNAPL accumulation of 4.83 feet was measured in CHRW27. The third area of LNAPL thickness exceeding 1 foot is located in an area formerly occupied by gasoline storage tanks (470 and 471) situated along the hillside in the southwestern corner of SWMUs 7/8. In this area, the thickest LNAPL accumulation of 2.26 feet was measured in CHMW07.

4.4.2 LNAPL Baildown Test Results

The Technical Memorandum, *Light Non-aqueous Phase Liquid Baildown Test Summary for SWMUs 7 and 8*, located in Appendix F provides a detailed description of LNAPL baildown tests performed at SWMUs 7/8. In March 2010, AGVIQ-CH2M HILL performed three LNAPL baildown tests at recovery wells CHRW21, CHRW23, and CHRW39 (refer to Figure 1-7 for well locations). Testing was performed to estimate the LNAPL conductivity of the formation. Results from these tests indicated LNAPL conductivity was extremely low and ranged from 9.59×10^{-7} to 8.94×10^{-6} centimeters per second (cm/sec). These results confirm the findings obtained by others (Baker, 2005) that the formation at SWMUs 7/8 has a low LNAPL conductivity that limits LNAPL migration and inhibits the rapid recovery of LNAPL. The low conductivity of the formation is likely responsible for limiting migration of LNAPL to the area north of Forrestal Drive.

4.5 LNAPL Recovery Test Results

Between January 13, 2010, and March 11, 2010, multiple technologies were evaluated to determine the most appropriate and cost-effect remedial technology to reduce the thickness of LNAPL at SWMUs 7/8. These technologies included AFVR, SVE, passive skimming using LNAPL recovery pumps operated with and without vacuum induction, and total fluids recovery using top-loading pneumatically operated pumps. A brief synopsis of the work performed and test results obtained from each test are presented below.

4.5.1 AFVR Test

The Technical Memorandum, *Aggressive Fluid Vapor Recovery at SWMU 7/8*, located in Appendix D, provides a detailed description of the AFVR tests performed at SWMUs 7/8. Between January 13, 2010, and February 4, 2010, AGVIQ-CH2M HILL performed multiple AFVR tests to evaluate the ability of this technology to reduce the thickness of LNAPL at SWMUs 7/8. AFVR utilizes either a mobile vacuum-truck or fixed-base remedial system to induce a high vacuum on single or multiple monitoring/recovery wells to simultaneously extract LNAPL, groundwater containing dissolved hydrocarbons, and hydrocarbon vapors.

The test objectives were as follows:

- Determine if AFVR was capable of reducing the thickness of LNAPL in the extraction wells to the cleanup objective of 0.01 foot.
- Determine if the application of a vacuum caused changes in LNAPL thickness, water level, and/or vacuum pressure in adjacent wells.
- Determine the percentage of LNAPL versus groundwater generated following completion of the AFVR events.

The following tasks were performed to achieve these objectives:

- Performed AFVR tests at the following 30 wells: AW01, CHMW07, CHRW1, CHRW02, CHRW03, CHRW04, CHRW07, CHRW08, CHRW10, CHRW11, CHRW13, CHRW15, CHRW20, CHRW21, CHRW23, CHRW24, 470MW01, MTMW01, MTMW02, MTMW04, PW06, RW04, RW05, UGW02, UGW05, UGW12, UGW17, UGW19, UGW21, and UGW25.
- Monitored changes in vacuum pressure and water levels during AFVR tests performed at the following 10 wells: CHRW02, CHRW03, CHRW04, CHRW08, CHRW15, RW05, UGW17, UGW19, UGW21, and UGW25.

The AFVR test used a Guzzler® vacuum truck to induce a vacuum on the test wells. Test locations are illustrated on Figure 4-5. The following is a summary of the major findings obtained following completion of the AFVR tests:

- AFVR temporarily reduced the thickness of LNAPL in 26 of 30 wells containing LNAPL to below the cleanup objective of 0.01 foot. In the remaining four wells (RW05, CHRW15, CHRW03, and CHRW04), the thickness of LNAPL slightly increased compared to pre-test measurements.
- A total of 10,863 gallons of liquids were extracted by AFVR. However, only 18 gallons of LNAPL were measured in the collection tanks after an equilibration period of 2 weeks. The remaining volume (10,845 gallons) was a mixture of groundwater and heavily emulsified fuel that could not be easily separated or measured.
- Changes in vacuum pressure were observed in many of the observation wells during testing. However, the greatest vacuum response and distance of observed pressure response occurred when the surface soil was saturated with rainwater. It is believed the saturated soil acted as an impermeable layer that limited potential short-circuiting of the extracted air to the ground surface.
- The use of AFVR did not result in substantial changes in the thickness of LNAPL in the observation wells. Most extraction wells recovered to their pre-AFVR product levels within a month of the testing.

AFVR Test Summary

Although AFVR temporarily reduced the thickness of LNAPL in most extraction wells to the CAO of 0.01 foot, the amount LNAPL recovered in relationship to the total volume of liquids recovered was low (less than approximately 0.2 percent of total fluids recovered). Additionally, no significant change in LNAPL thickness was observed in adjacent monitoring wells, indicating the formation has a low permeability and is heterogeneous. Lastly, the use of AFVR resulted in emulsification of the extracted fuel. Given the low amount of measurable fuel recovered and the amount of emulsification observed, LNAPL recovery using AFVR is not recommended because operation and maintenance (O&M) of a fixed-based system would be technologically impracticable and cost prohibitive. Additionally, the use of a mobile AFVR vacuum truck for long-term LNAPL recovery would also be cost prohibitive and have limited effectiveness; therefore, AFVR is not recommended.

4.5.2 SVE Test

The TM, *Soil Vapor Extraction Test at SWMUs 7 and 8*, located in Appendix E, provides a detailed description of the SVE tests performed at SWMUs 7/8. Between February 16, 2010, and February 18, 2010, a test was performed to determine the effectiveness of SVE to recover LNAPL in wells CHMW07 and 470MW01 located in the area formerly occupied by the leaded gasoline storage tanks (Figure 4-6). The initial field activity consisted of performing a baseline gauging event of wells CHMW03, CHMW04, CHMW07, CHMW08, CHMW09, CHMW10, 470MW01, 470MW03, and 7MW01A to determine the thickness of LNAPL in both the extraction wells and wells identified for observation. LNAPL was measured in the following monitoring wells prior to startup of the SVE test:

- CHMW07 - LNAPL thickness of 0.36 foot
- 470MW01 - LNAPL thickness of 0.23 foot
- CHMW10 - LNAPL thickness of 0.01 foot

Following the completion of the baseline gauging event, a mobile SVE system equipped with a 60-gallon knockout tank and a Rotron EN6 regenerative vacuum blower capable of producing 200 standard cubic feet per minute (scfm) airflow at 90 inches of water column was connected to CHMW07 and 470MW01 using 2-inch diameter vacuum hose. The system was activated on February 16, 2010, and pressure and flow measurements were collected three times per day for the duration of the test. Vacuum readings at each extraction wellhead were collected using a digital manometer while airflow measurements were collected using a thermal anemometer. In addition, vacuum pressure was measured in seven monitoring wells (CHMW03, CHMW04, CHMW08, CHMW09, CHMW10, 470MW03, and 7MW01A) located in the vicinity of the extraction wells (Figure 4-6). The SVE pilot test operated for approximately 39 hours and was shut down on February 18, 2010.

The following is a summary of the major findings obtained following completion of the SVE test:

- No vacuum influence was observed in the surrounding monitoring wells (CHMW03, CHMW04, CHMW08, CHMW09, CHMW10, 470MW03, and 7MW01).
- Vacuum levels at the extraction wellheads were between 58 and 60 inches of water column and airflow was measured between 15 and 34 scfm. High vacuum coupled with low airflow indicate air permeability of the formation is low.
- Mass removal calculations based upon the observed airflow rates and air analytical results indicate that approximately 15 pounds of C6-C14 range hydrocarbons were recovered from CHMW07 and only approximately 2 pounds of C6-C14 range hydrocarbons were recovered from 470MW01 during the SVE test operation. This translates to an average mass removal rate of approximately 0.4 pound per hour (lb/hr) from CHMW07 and approximately 0.1 lb/hr from 470MW01.
- LNAPL thickness decreased in the extraction wells compared to baseline measurements.

SVE Test Summary

The test results indicate SVE reduced the thickness of LNAPL in the extraction wells; however, vacuum influence in the surrounding formation was not observed during test operation. Based on airflow and pressure measurements, the tight soil formation allows a very limited vacuum influence and airflow from each recovery well. Airflow through the formation to the recovery wells is the primary mechanism promoting volatilization and removal of the hydrocarbon mass. Therefore, the observed low airflow rates from the extraction wells yielded low mass removal rates. Although the SVE test had limited effectiveness removing LNAPL from the individual extraction wells, hundreds of vacuum extraction wells would be required to achieve SVE influence over the entire LNAPL impacted area. As a result, SVE does not appear to be a cost effective remedy to address the removal of LNAPL present at SWMUs 7/8 in the vicinity of CHMW07 and 470MW01.

4.5.3 Total Fluids Recovery Test

The TM, *Groundwater Extraction Test at SWMUs 7 and 8*, located in Appendix H, provides a detailed description of the total fluids recovery tests performed at SWMUs 7/8. On March 9 and 10, 2010, testing was performed to determine the effectiveness of using groundwater extraction from existing recovery wells to recover LNAPL along Forrestal Drive. For these tests, QED Clean Environment AP-4 pneumatic pumps capable of recovering up to approximately 9 gallons per minute (gpm) were installed in pumping wells RW04 and RW05. During the tests, changes in water level and LNAPL thickness were measured in both the pumping wells and observation wells MW01, MW02, PW01, PW02, UGW05, UGW12, UGW13, UGW17, and UGW18 (Figure 4-7). Results of the testing performed on March 9, 2010, indicate groundwater recovery averaged less than 0.2 gpm for RW04 and 0.8 gpm for RW05. In addition, limited drawdown was measured in the adjacent observation wells, although drawdown was observed in both pumping wells. LNAPL was reduced to non-detect in the pumping wells with little change in LNAPL thickness in the adjacent observation wells. Following the completion of the tests on March 9, 2010, a combined total of about 395 gallons of groundwater and 27 gallons of LNAPL were recovered from recovery wells RW04 and RW05.

AGVIQ-CH2M HILL performed a second day of groundwater extraction testing at RW05 on March 10, 2010. Based upon the limited groundwater and LNAPL recovered during the previous day from RW04, the well was not pumped on March 10, 2010. During the second day of operations at RW05, a total of about 391 gallons of groundwater and 7 gallons of LNAPL were recovered. In addition, drawdown was not observed in the adjacent observation wells, but was observed in the pumping well.

Total Fluids Test Summary

Based upon the results from the tests, groundwater extraction (total fluids recovery) is not recommended to remove LNAPL along Forrestal Drive because operation of pumps in RW04 and RW05 were not able to induce sufficient gradient to promote LNAPL movement toward the extraction wells. In addition, decreasing LNAPL recovery rates were observed during testing and the ratio of LNAPL to groundwater recovered decreased significantly during the second day of pumping. In order to recover LNAPL along Forrestal Drive using groundwater extraction, very close well spacing (likely less than 20 feet between extraction wells) would be required. If a 20-foot well spacing was assumed, then over 600 recovery wells would be required to influence the 4.8-acre LNAPL impacted area. Data based upon this test indicate a skimmer system that focuses on LNAPL recovery and minimizes groundwater recovery is best suited for these hydrogeological conditions. Reducing the amount of fuel-contaminated wastewater produced by the product recovery system is a major design objective and will minimize the negative collateral impacts of the system.

4.5.4 Active Skimmers

The TM, *Light Non-aqueous Phase Liquids Recovery Using Active Skimmers,* located in Appendix G, provides a detailed description of the active skimmer tests performed at SWMUs 7/8. Between February 16, 2010, and March 11, 2010, AGVIQ-CH2M HILL performed a comparative study to evaluate the ability of active skimmers to reduce the thickness of LNAPL at SWMUs 7/8. For the study, two active skimmer brands were selected. One unit was manufactured by QED and the second unit was manufactured by Xitech.

The objectives of the study were to:

- Determine which brand maximized LNAPL recovery while minimizing groundwater recovery.
- Evaluate the ability of an active skimmer to recover LNAPL from areas of the site containing less than 2 feet of LNAPL thickness to areas that contain more than 7 feet of LNAPL thickness.
- Determine if the induction of a vacuum during active skimmer operation increased LNAPL recovery.
- Calculate the additional hydrocarbon mass removed in the vapor phase through the induction of vacuum during active skimmer operation.
- Determine if the extraction of LNAPL from wells containing active skimmers resulted in changes in LNAPL thickness within nearby wells.
- Evaluate the relative ease of skimmer programming, adjustment, and operation.

In order to achieve these objectives, the following scope of work was performed:

- Completed a baseline round of well gauging in the wells identified for active skimmer installation (CHRW03, CHRW04, CHRW10, and CHRW11).
- Installed the QED-brand skimmer in wells CHRW03 and CHRW10, and evaluated the ability of the unit to recover LNAPL with and without induction of a vacuum.
- Installed the Xitech-brand skimmer in wells CHRW04 and CHRW11, and evaluated the ability of the unit to recover LNAPL with and without induction of a vacuum.
- Gauged select observation wells located within a 120-foot radius of the recovery wells containing active skimmers to determine if the removal of LNAPL caused a change in LNAPL thickness in adjacent wells.
- Collected air samples for the analysis of benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbons (TPH) using U.S. Environmental Protection Agency (EPA) Method TO-18 to estimate the additional hydrocarbon mass removed during induction of a vacuum during active skimmer operation.

Active Skimmer Test Rationale

AGVIQ-CH2M HILL reviewed available site information and selected two areas of the site to evaluate active skimmer performance. The first area was located just north of the former fuel pump station where LNAPL thickness measurements exceeded 7 feet. The second area was located in a low area midway between Tanks 1088 and 85, where the thickness of LNAPL in most wells was less than 2 feet. Test area locations are shown on Figures 4-8 and 4-9.

Following selection of the test areas, site information was reviewed to select wells that had similar properties so a fair comparison between active skimmers could be made. AGVIQ-CH2M HILL selected the test wells using the following criteria:

- Similar hydrogeologic properties (i.e., wells with similar stratigraphy and rates of groundwater recharge)
- Same LNAPL type
- Similar LNAPL thickness

Based on these criteria, wells CHRW10 and CHRW11 (Figure 4-8) were selected in an area of thickest LNAPL accumulation, and wells CHRW03 and CHRW04 (Figure 4-9) were selected in an area of lower LNAPL accumulation. Testing began in the area of thickest LNAPL accumulation. In this area, the QED skimmer was installed in recovery well CHRW10 and the Xitech skimmer was installed in recovery well CHRW11. Once installed, both active skimmers were programmed and operated in a manner recommended by the manufacturer for optimal LNAPL recovery. The active skimmer test was performed for approximately 1 week. During testing activities, wells located adjacent to the test wells were gauged to evaluate whether the removal of LNAPL resulted in changes in LNAPL thickness.

After the initial test was completed, a low vacuum was induced on the wells to determine if the induction of a vacuum during active skimming increased LNAPL recovery. During the vacuum-enhanced, active skimming test, air samples were collected to estimate the additional amount of hydrocarbon mass removed during vapor extraction, and gauging of adjacent wells was also performed to evaluate potential changes in LNAPL thickness. The vacuum-enhanced, active skimming test was operated for approximately 1 week.

Following testing, the active skimmers were removed, and the test wells were gauged. The post-test gauging results were compared to the pre-test data to determine the net change in LNAPL thickness over the test period that began with skimming alone and ended with vacuum-enhanced skimming.

Once testing was completed in the area of thickest LNAPL accumulation, the skimmers were moved to an area of less LNAPL accumulation. In this area, the QED skimmer was installed in recovery well CHRW03 and the Xitech skimmer was installed in recovery well CHRW04. The procedures used and duration of the tests were the essentially the same as used in the area of thickest LNAPL accumulation.

Active Skimmer Test Results

The major findings obtained from the active skimmer tests were as follows:

- In both the test areas, the Xitech active skimmer pump removed more LNAPL than the QED unit. Cumulatively (both with and without application of a vacuum), the Xitech active skimmer recovered 47 gallons of fuel and the QED active skimmer recovered 19.8 gallons of fuel. However, the LNAPL recovery is largely a function of the LNAPL mobility in formation around each well (not necessarily the type of recovery unit). So the fact that the Xitech unit recovered more product during this limited test should not be the sole reason for selecting the Xitech unit over the QED unit.
- The Xitech active skimmer reduced the thickness of LNAPL to a greater degree than the QED unit.
- The application of a low vacuum on the wells targeted for active skimming had no effect on either increasing the rate of LNAPL recovery or causing pressure gradients in adjacent wells to enhance the migration of LNAPL towards the active skimming wells.
- The high vacuums and low flows measured during the vacuum testing confirmed that this formation has very limited permeability.
- Air samples collected during the induction of a vacuum indicated the additional amount of hydrocarbons removed in the vapor phase was less than one pound over the entire test period.
- The Xitech active skimmer was easier to program and operate than the QED active skimmer.

In summary, active skimmer test results indicate the Xitech active skimmer outperformed and was easier to operate than the QED active skimmer under similar conditions. Test results also showed the induction of a vacuum in recovery wells did not increase the rate of LNAPL recovery. The data confirm the permeability of the formation is low, which makes it difficult to move air or extract water through the formation to enhance LNAPL removal rates.

5.0 Conceptual Model of Contaminant Migration

The results of the work described in this CMI, and previous work performed prior to AGVIQ-CH2M HILL's involvement in the project provides a basis for the current conceptual model of LNAPL distribution at the site. The conceptual model of LNAPL distribution is described below.

The source of the hydrocarbon contamination beneath the site is a result of numerous fuel releases that occurred between 1957 and 1986. Navy records indicate that nearly 1 million gallons of fuel were released to the environment as a result of overfilling, leaking valves and piping, and operator error. Navy records show that the majority of the fuel released was low volatility Bunker C, JP-5, DFM, and Navy Special; however, an unknown quantity of high volatility AVGAS was released in the area now occupied by monitoring wells CHMW07, CHRW42, CHRW43, and 470MW01 located on the western side of the fuel farm.

Eyewitness accounts indicate releases attributed to overfilling of the fuel storage tanks and/or leakage from aboveground piping flowed overland following topography and collected in the bermed lower retention area located south of the unnamed road that separates the upper tank farm (Tanks 82, 83, 84, 1080, and 1082) from the lower tank farm (Tank 85 and former Tanks 56A and 56B) (Figure 1-3). Navy personnel indicate that much of the fuel was pumped from the collection basin and recycled; however, the remaining fuel soaked into the soil. Navy records also indicate that several of the buried fuel pipelines leading from the fuel system pump house to Pier 1 leaked and released unknown quantities of fuel to the soil and groundwater south of Forrestal Drive; however, records indicate a majority of the fuel was recovered during the repair work.

Figure 1-4 illustrates the distribution of LNAPL detected on the water table between 1986 (start of investigation work) and 2004 (base closure and draining of the fuel system) and was created by marking an LNAPL extent line around every point where LNAPL was historically detected. Based on historical Navy records, the majority of LNAPL was detected in wells installed within the lower retention area north of Forrestal Drive and within 10 wells (RW04 through RW08 and wells UGW12, UGW13, UGW17, UGW19, and UGW21) installed immediately north and parallel to Forrestal Drive. These 10 wells were installed at the base of a steeply sloped road cut and adjacent to a gravel-filled utility trench that was cut into bedrock as confirmed by Navy personnel and attempted excavations for test pits. LNAPL was also detected in seven wells (UGW06, UGW08, UGW09, UGW10, GW06, 7MW11, and 7MW13) located south Forrestal Drive. These wells were installed adjacent to fuel system piping that led from the pump house to Pier 1.

In 2009, the Navy retained AGVIQ-CH2M HILL to install the LNAPL recovery system described in the CMS (Baker, 2005). However, prior to installation, the Navy requested AGVIQ-CH2M HILL develop an optimization-strategy for LNAPL recovery, and determine whether the configuration of the LNAPL plume had changed since the CMS was approved by the EPA for implementation on February 9, 2006. Between June 1, 2009 and May 18, 2010, AGVIQ-CH2M HILL installed 57 wells and excavated 41 test pits to determine the configuration of the LNAPL plume. Comparison of Figures 1-4 and 1-7 shows the greatest area of LNAPL accumulation remains unchanged and is located north of Forrestal Drive in the following areas: 1) lower retention area, 2) near the pump house, and 3) along the utility corridor located immediately north of and parallel to Forrestal Drive. In addition, LNAPL is now absent south of Forrestal Drive, which suggests leaky pipelines were the source of LNAPL contamination; once the system was drained, the LNAPL dissipated.

The current distribution of LNAPL is influenced by the geology and hydrogeology of the site, and migration of LNAPL along utility corridors. As previously stated, following the historical releases most of the fuel migrated overland and collected in the lower retention area. Product that was not recovered during emergency response efforts migrated through the soil column to the water table. Based on evaluation of boring logs, the migration pathways appear to have been along zones of higher permeability, and include sand stringers and fractures within the PWR and bedrock. In addition, LNAPL migrated along man-made zones of higher permeability such as the gravel filled utility trench located north of Forrestal Drive, and along the fuel distribution piping trenches leading from the pump house to Pier 1. Once LNAPL encountered the water table, LNAPL migrated with groundwater toward the bay in a south-southwest direction. However, the eastern lobe of LNAPL migration that parallels Forrestal Drive is a result of preferential LNAPL migration through the gravel fill material within the utility trench cut into bedrock.

In addition to the lateral migration of LNAPL, seasonal fluctuations in water levels have vertically distributed LNAPL within a 2- to 10-foot smear zone. Fluctuations in water levels are a result of rainfall events with highs and lows most pronounced during the hurricane season (June though November) and dry season (December through May). Most of the LNAPL plume is present at depths greater than 10 feet bgs, and therefore represents no risk to visitors or trespassers.

Test data collected by Baker et al., combined with the recent test data collected by AGVIQ-CH2M HILL, indicate the subsurface stratigraphy and hydraulic characteristics of the aquifer materials have a profound impact on both the migration and recoverability of LNAPL. An important fact is the aquifer materials consist of saprolite (in-place chemically weathered bedrock), PWR (consisting of saprolite and impermeable blocks of gabbro-bedrock), and massive gabbro bedrock, with the exception of the overlying fill and marine sediments located south of Forrestal Drive. The permeability of these material ranges from about 1×10^{-6} to 1×10^{-7} cm/sec. Aquifer tests performed by Baker et al. shows that the hydraulic conductivity of the aquifer north of Forrestal Drive is less than 1×10^{-6} cm/sec, and the yield of the aquifer ranged from 0.009 and 0.13 gpm. These results were confirmed by AGVIQ-CH2M HILL during the LNAPL recovery and bail-down tests performed as part of the CMI, and showed the hydraulic conductivity is between 1.7×10^{-6} and 9.4×10^{-7} cm/sec. Previous attempts by others to increase aquifer yield included pneumatic fracturing coupled with the use of bioslurping. These efforts had minimal effect on increasing the yield of the formation or enhancing product recovery rates, as the low permeability of the formation inhibited product migration toward extraction wells. Following completion of the LNAPL recovery tests in wells containing over 8 feet of product, AGVIQ-CH2M HILL noted that LNAPL levels did not rebound to pre-test levels until approximately 2 months later.

The top-of-rock surface is undulating, forming bedrock highs and lows that create subsurface "dams" that further inhibit LNAPL migration south of Forrestal Drive, as illustrated on Figures 4-2 and 4-3. In essence, the bedrock highs trap LNAPL, and contribute to the thick accumulations (greater than 8 feet) measured in wells CHRW10, CHRW11, CHRW20, and CHRW21.

Although not detailed in the CMI, field activities have been performed to determine if hydrocarbon compounds are present in the upper 2 feet of soil within the fuel farm, and if a significant dissolved hydrocarbon plume is present in groundwater. In 2010, 86 soil borings were advanced to determine if PAH and arsenic were present in the upper 2 feet of soil. Hydrocarbons were not detected in the upper 2 feet of soil, indicating surface soil poses no risk to human health and the environment. Previous data collected by Baker (refer to the CMS), and recent data collected by AGVIQ-CH2M HILL indicate groundwater contains very little dissolved hydrocarbon contamination despite the presence of a LNAPL plume with the exception of the AVGAS area. Limited dissolved hydrocarbon contamination exists because the product-types (Bunker C, Navy Special, Diesel, and JP-5) released have a low solubility and therefore, are not easily leached to groundwater. Within the AGVAS plume area (CHMW07, CHRW42, CHRW43, and 470MW01), VOCs (1,2,4-trimethylbenzene, benzene, and ethylbenzene) are present in groundwater; however, analytical results indicate that despite the presence of LNAPL, dissolved hydrocarbon constituents attenuate to non-detect concentrations approximately 200 feet downgradient of the AVGAS plume through sulfate reduction. Therefore, test data confirm that even in the absence of active LNAPL removal, the dissolved hydrocarbon plume will attenuate to non-detect concentrations.

6.0 Design Criteria

The permeability of the formation at SWMUs 7/8 is low, as indicated by the results from the AFVR, SVE, total fluids, and LNAPL active skimming tests. A formation with a low permeability inhibits the rapid recovery of LNAPL, thus minimizing the effects of extraction technologies to enhance LNAPL recovery. Our findings are in agreement with those obtained by Baker (2005), and confirm that a cost-effective solution to rapidly remove LNAPL is currently unavailable.

Because the movement of LNAPL toward recovery wells is very slow, the use of high energy and expensive multi-phase extraction equipment will have very marginal benefits and is not recommended; rather, the use of active and passive skimming devices is favored. The use of skimmers to recover LNAPL is the same technology proposed in the CMS that was approved by the EPA in February 2006 (Baker, 2005). However, the LNAPL recovery approach described in the CMS specified the installation of 60 recovery wells (14 immediately north and adjacent to Forrestal Drive and 46 along the western side of the fuel farm) and the installation of a fixed-based skimmer system to address LNAPL recovery from the 60 wells (Figure 2-1). The CMS approach also specified the construction of two trailer-mounted (mobile) skimmer units to recover LNAPL detected outside the recovery well network.

The approach proposed by AGVIQ-CH2M HILL at SWMUs 7/8 also specifies the use of skimmers, but the implementation approach is different from that proposed in the CMS because of a significantly greater horizontal extent of LNAPL and variation in LNAPL thickness over hilly terrain. The proposed approach uses only mobile skimmer systems instead of a combination of fixed-based/mobile skimmer systems. This approach would negate the need to expand the recovery system each time LNAPL is detected in a new well above 0.01 foot.

Based on the current horizontal extent of LNAPL, variability in LNAPL thickness, and low formation permeability, the following approach is proposed:

- Construct four trailer-mounted, solar-powered mobile Xitech skimming units to recover LNAPL in areas of SWMUs 7/8 where the thickness of LNAPL exceeds 1 foot. Xitech's solar-powered units use photo-voltaic panels to power a small air compressor that drives up to eight Xitech active skimmers and provides electricity to power the controller. Systems would have the option to use commercial power if required. This concept will provide maximum flexibility to have some skimmer units remain on higher producing wells, while other units rotate among lower producing wells.
- Install Durham Geo Slope Indicator (DGSI) passive skimming devices in wells where the thickness of LNAPL is between 0.01 and 0.99 foot.
- Minimize the production of wastewater and recycle the recovered LNAPL.

7.0 Design Basis

This section describes the trailer-mounted, solar powered Xitech skimmer units with associated active skimmer devices and individual DGSI passive skimmer devices proposed for LNAPL recovery at SWMUs 7/8. The extent of LNAPL (May 18, 2010) at SWMUs 7/8 is shown on Figure 1-7. The proposed initial well locations for the Xitech and DGSI skimmer devices are shown on Figure 7-1. This flexible approach allows for switching between active and passive skimmer systems as the LNAPL production of each well is determined over time. Details of the skimmer devices and designated wells are summarized in Table 7-1.

7.1 Trailer-Mounted, Solar Powered Active Skimmer System

The use of four trailer-mounted, mobile skimmer control units is proposed to recover LNAPL from wells where the thickness of LNAPL exceeds 1 foot (25 wells). Each mobile trailer unit will contain the equipment necessary to power and operate eight separate active skimmers and containerize the LNAPL recovered. Based on the results of the active skimmer comparative study, the active skimming system manufactured by Xitech will be used to recover LNAPL.

Each trailer unit will be equipped with a solar-powered programmable controller, an air compressor, a double-walled 250-gallon fuel storage tank, and solar panels. Each individual controller can be programmed to operate up to eight separate active skimmer devices in a series (one after another). The controller and compressor will be housed in a waterproof, vented steel 3-foot by 5-foot Knack™ job box bolted to the trailer floor. Other components housed within the job box will include an eight-well air control manifold and the electrical equipment necessary to program the controller and operate a high-level cut-off switch on the trailer-mounted LNAPL storage tank. Tubing leading from the air manifold to each targeted well for skimmer installation will exit the back of job box. Tubing between the job box and each individual wellhead will be enclosed in either fiber reinforced tubing or rigid-wall hose as a means of secondary containment. Equipment specifications for the controller, compressor, and skimmer along with a picture of an example mobile skimmer unit are included in Appendix J.

Xitech active skimmers will be installed in each designated well and positioned in the same manner as detailed in the active skimmer evaluation TM provided in Appendix G. Once all equipment is installed and connected, each active skimmer will be programmed and operated to reduce the LNAPL thickness of all wells within the 8-well cluster to 0.01 foot or less. Xitech active skimmers will be operated in each designated well until the CAO of 0.01 foot is achieved or the LNAPL production drops to the point where a passive skimmer is more appropriate. Site personnel will routinely gauge wells to monitor variations in LNAPL thickness and adjust and maintain the active skimmers (see Section 7.3). Additional wells not specified in Table 7-1 will be added to a Xitech trailer-mounted unit if LNAPL thickness exceeds 1 foot in the well. Figure 7-1 illustrates areas in the well field that are targeted for installation of the Xitech active skimmers. The trailer-mounted units will be placed in the approximate center of the well clusters to reduce the length of discharge tubing.

7.2 Passive Skimmer System

DGSI passive skimmers will be installed in wells where the thickness of LNAPL is less than 1 foot (32 wells). The DGSI passive skimmer utilizes the F.A.P. Plus™ skimmer to provide a 36-inch floating intake for the recovery of free phase products such as gasoline, diesel, and jet fuel, and is used when minimal product is present or slow recovery rates are expected. The DGSI passive recovery device is designed to recover and reduce the thickness of LNAPL in either 2- or 4-inch internal diameter (ID) wells to less than 0.01 foot. To begin LNAPL recovery, the DGSI passive skimmer will be lowered into a well and suspended from the well cap, so that the hydrophobic filter element of the skimmer straddles the LNAPL water interface. The hydrophobic filter allows only LNAPL to enter the skimmer. LNAPL that passes through the filter gravity drains into a collection reservoir that is located below the filter inlet. The collection capacity of the storage reservoir ranges from 0.13 to 0.45 gallons depending on the skimmer size (1.75-inch outside diameter (OD) versus 3.5-inch OD, respectively). A drain-valve located on the base of storage reservoir allows the user to drain LNAPL into storage drums or tanks. The skimmers will be ordered with transparent reservoirs to allow visual inspection of the recovered LNAPL. Vendor information for the DGSI passive skimmer is provided in Appendix K.

DGSI passive skimmers will be operated in each designated well until the CAO of 0.01 feet is achieved or the LNAPL production increases to the point where an active skimmer is more appropriate. Site personnel will routinely gauge wells to monitor variations in LNAPL thickness, and adjust and maintain the passive skimmers (see Section 7.3). Manufacturer information indicates the DGSI passive skimmers are ideally suited to reduce the thickness of LNAPL from 1 foot to a sheen. Additional passive skimmers will be installed in wells not specified in Table 7-1 with an LNAPL thickness of less than 1 foot. Figure 7-1 illustrates areas in the well field that are targeted for installation of the DGSI passive skimmers.

7.3 Gauging Frequency

Since skimmers and associated equipment can interfere with the use of an oil/water interface probe within the well casing, gauging will be performed weekly to monitor fluctuations in the water table in wells located immediately adjacent to wells with Xitech and DGSI skimmers. Water level data will be used to adjust placement of the Xitech and DGSI skimmers to ensure skimmers are positioned to maximize LNAPL recovery and minimize the extraction of any groundwater that may occur if the water table rises above the top of the skimmer.

Wells containing Xitech and DGSI skimmers will be gauged quarterly in conjunction with an ongoing groundwater monitoring and sampling event. A comprehensive round of water level/LNAPL thickness measurements will be performed quarterly, and new wells that contain LNAPL will be equipped with either a Xitech skimmer or passive skimmer, depending on the thickness measured (i.e., a Xitech skimmer will be installed in wells where LNAPL thickness exceeds 1 foot, and passive skimmers will be installed in wells where LNAPL thickness is less than 1 foot). Given the slow rate of LNAPL recharge, the monitoring frequency described above is considered adequate to maximize LNAPL recovery. Additional details on how the system will be operated to recover LNAPL are located in Appendix L.

8.0 Operation and Maintenance Plan

The *Operations and Maintenance Plan for the LNAPL Remediation System at SWMUs 7/8*, located in Appendix L, provides a detailed description of the procedures for performing operations, long-term maintenance, and monitoring of the corrective measure along with the final plans and specifications based on the conceptual site design. The Plan provides instructions for O&M of the remediation systems, waste management, staffing requirements, records keeping, emergency operations, and general safety associated with LNAPL remediation activities at SWMUs 7/8.

9.0 Waste Management

LNAPL recovered by both the Xitech and DGSI skimmer systems will be transferred to and stored in one of four doubled-walled, 250-gallon aboveground storage tanks (ASTs) mounted onto the associated portable trailers. LNAPL recovered from monitoring well UGW13 will be transferred to and stored in a 55-gallon drum placed inside a 90-gallon overpack drum. If the 55-gallon drum located at UGW13 reaches its maximum capacity before any of the trailer-mounted ASTs, the fuel output line will be connected to a second 55-gallon drum / 90-gallon overpack combination for additional storage. LNAPL recovered by all DGSI skimmers will be transferred to and stored in one of the trailer-mounted ASTs. Note: All LNAPL recovered from the AVGAS area must not be mixed with LNAPL from the other areas and can only be stored in the associated trailer-mounted AST.

The level of LNAPL will be monitored weekly; LNAPL removal activities will occur once an AST is filled to within 80 percent capacity. The LNAPL will be pumped from each AST by a certified waste hauler for transport to a petroleum recycling center located on the island.

The *Operations and Maintenance Plan for the LNAPL Remediation System at SWMUs 7/8,* located in Appendix L, provides a detailed description of waste management practices associated with LNAPL remediation activities at SWMUs 7/8.

10.0 Project Management

Project staff personnel for the LNAPL remediation activities at SWMUs 7/8 are listed below:

Name	Title	Telephone Number
Tom Beisel	Project Manager	678-530-4033
Bryan Burkingstock	Task Manager	678-530-4060
Tom Kessler	Senior Geologist	678-530-4197
Andrew O'Conor	Site Supervisor	843-200-3825
Alicia Nobles	QA/QC Manager	678-530-4576
Carlos Brown	Onsite Technical	787-435-6086

Subcontractors that will provide services for the LNAPL remediation activities at SWMUs 7/8 are listed in below:

Subcontractor Name	Service Provided	Telephone Number
Durham Geo Slope Indicator	Passive Skimmer Support	770-465-7557
Xitech Instruments Inc.	Xitech Skimmer and Controller Support	888-867-9483
Alpha Analytical Inc.	Waste Characterization	508-898-9220
TBD	Waste Transportation/Disposal	

11.0 Monitoring and Reporting Requirements

The *Operations and Maintenance Plan for the LNAPL Remediation System at SWMUs 7/8,* located in Appendix L, provides a detailed description of the monitoring and reporting requirements for the LNAPL remediation activities at SWMUs 7/8.

11.1 Monitoring

During the 2-year period of system operation, all site wells will be gauged quarterly, including those containing skimmers, to determine LNAPL distribution and thickness. An initial comprehensive gauging event will be performed to determine if the distribution of LNAPL has changed since May 18, 2010. These data will be evaluated, and all wells exhibiting LNAPL thicknesses greater than 1 foot will be equipped with Xitech pumps and all wells with an LNAPL thickness less than 1 foot will be equipped with DGSI skimmers. Therefore, the actual number of wells may differ from those presented in Table 7-1. Once installed, weekly O&M will be performed to monitor LNAPL recovery rates and adjust pump inlets to maximize LNAPL recovery. Additionally, product recovery volumes will be logged.

At the beginning of each quarterly event, a comprehensive round of well gauging will be performed to re-baseline LNAPL distribution. One week prior to gauging, the DGSI and Xitech skimmers will be removed to allow LNAPL thicknesses to equilibrate. Following the equilibration period, all site wells will be gauged using an oil/water interface probe and the data will be evaluated to determine if additional skimmers are required to recover LNAPL, or if the existing skimmers can be moved to new locations. In this manner, existing equipment can be used and new skimmers added as necessary to ensure all wells containing LNAPL are addressed.

In order to monitor variations in LNAPL thickness across SWMUs 7/8 and maximize LNAPL recovery, wells will be gauged as follows:

- **Baseline Gauging Event:** A site-wide, baseline gauging event will be performed prior to installing either the Xitech or DGSI skimmer systems. These data will be used to select the position of the skimmer inlets, verify the LNAPL distribution at SWMUs 7/8, and ensure the appropriate skimmers are placed in the correct wells. Additionally, the gauging data will serve as a baseline to compare future changes in LNAPL thickness resulting from LNAPL removal.

- **Monitoring of LNAPL Removal Wells:** AGVIQ-CH2M HILL will visually observe the LNAPL removal wells weekly to evaluate whether the skimmer systems are removing LNAPL. In addition, sentinel wells (monitoring wells historically without product but located within and around the skimmer well network) will be measured weekly to determine if the skimmer inlets require repositioning to account for fluctuations in the water table. The evaluation will be based on the travel length of the inlet for the skimmers (approximately 3 feet) and the frequency of fluctuations that exceed this length.

- **Site-wide Comprehensive Gauging:** In order to evaluate potential changes in LNAPL distribution and thickness, AGVIQ-CH2M HILL will perform quarterly comprehensive gauging events for 2 years to determine if additional skimmers are required to recover LNAPL, or if the existing skimmers can be moved to new locations.

- **Post-LNAPL Recovery Gauging Event:** A site-wide, post-recovery gauging event will be performed after 2 years of operation to evaluate the effectiveness of using the skimmer systems to reduce the thickness of LNAPL in wells to 0.01 foot or less. To perform this task, all passive skimmers will be removed from wells and a period of at least 2 months will be allowed for product stabilization; a site-wide gauging event will follow. Gauging data from the Post-LNAPL Recovery event will be compared to the baseline data to determine the effectiveness of using active and passive skimmers at SWMUs 7/8.

11.2 Reporting

Reports will include preparation of the follow documents:

- **Semiannual Status Reports:** AGVIQ-CH2M HILL will prepare semiannual status reports that document the performance of the LNAPL recovery system. The reports will document the cumulative amount of LNAPL recovered, present figures illustrating changes in LNAPL distribution, discuss operating efficiency of the skimmers, and provide recommendations for movement of system components to areas where LNAPL was newly detected.

- **Engineering Evaluation Report (EER):** After 2 years of system operation and following the post-LNAPL recovery gauging event, AGVIQ-CH2M HILL will prepare an EER that provides a comprehensive summary of the LNAPL recovery data and includes an evaluation of the ability of the current remedial approach to achieve cleanup. Depending on these findings, recommendations will be made and may include: continuation of the current approach, modification of the current approach (i.e., increase the number of Xitech or DGSI skimmers), evaluation of new technologies that may emerge over the next few years to enhance LNAPL recovery, and/or completion of a risk-evaluation to allow residual LNAPL to remain if recovery data show it is impractical to reduce the thickness of LNAPL to 0.01 foot. The ERR will include a long-term exit strategy for SWMUs 7/8, as outlined in Section 9.

12.0 Project Schedule

A detailed schedule for system installation and operation which includes all significant steps is provided below. Major steps include the procurement of the equipment (both the Xitech and DGSI skimmers), fabrication of the trailer units, and installation and initial startup of the LNAPL recovery system. Once the system is operational, monitoring (gauging and maintenance) will be performed, and semi-annual reports will be prepared over the 2-year period of operation. Following the 2-year period of system operation, an EER will be prepared. Monitoring and reporting requirements are described in Section 11. The anticipated start and completion date for each task for each event is summarized below.

Activity ID	Activity Name	Start	Finish
	Initial Skimmer Installation Activities		
	Procurement of Equipment	2/1/2011	5/10/2011
	Fabrication of Trailer Units	2/1/2011	5/10/2011
	Skimmer Installation	5/12/2011	7/22/2011
BL1	Skimmer Initial Startup and Monitoring	7/25/2011	7/29/2011
BL2	Removal of Skimmers for Gauging Event	8/15/2011	8/15/2011
BL3	Skimmer Inspection and Maintenance (as Needed)	8/16/2011	8/23/2011
BL4	Site-wide Groundwater Gauging Event	8/24/2011	8/24/2011
BL5	Install and Test Xitech / DGSI Skimmers	8/25/2011	8/26/2011
	First Quarter of System Operation		
Q11	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	7/25/2011	11/25/2011
Q12	Removal of Skimmers for Gauging Event	11/28/2011	11/28/2011
Q13	Skimmer Inspection and Maintenance (as Needed)	11/30/2011	12/6/2011
Q14	Site-wide Groundwater Gauging Event	12/7/2011	12/7/2011
Q15	Install and Test Xitech / DGSI Skimmers	12/8/2011	12/9/2011
	Second Quarter of System Operation		
Q21	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	12/12/2011	2/24/2012
Q22	Removal of Skimmers for Gauging Event	2/27/2012	2/27/2012
Q23	Skimmer Inspection and Maintenance (as Needed)	2/28/2012	3/6/2012
Q24	Site-wide Groundwater Gauging Event	3/7/2012	3/7/2012
Q25	Install and Test Xitech / DGSI Skimmers	3/8/2012	3/9/2012
Q26	First Semi-Annual Status Report	3/12/2012	3/30/2012
	Third Quarter of System Operation		
Q31	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	3/12/2012	5/4/2012
Q32	Removal of Skimmers for Gauging Event	5/7/2012	5/7/2012
Q33	Skimmer Inspection and Maintenance (as Needed)	5/8/2012	5/15/2012
Q34	Site-wide Groundwater Gauging Event	5/16/2012	5/16/2012
Q35	Install and Test Xitech / DGSI Skimmers	5/17/2012	5/18/2012

Activity ID	Activity Name	Start	Finish
	Fourth Quarter of System Operation		
Q41	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	5/21/2012	8/3/2012
Q42	Removal of Skimmers for Gauging Event	8/6/2012	8/6/2012
Q43	Skimmer Inspection and Maintenance (as Needed)	8/7/2012	8/14/2012
Q44	Site-wide Groundwater Gauging Event	8/15/2012	8/15/2012
Q45	Install and Test Xitech / DGSI Skimmers	8/16/2012	8/17/2012
Q46	Second Semi- Annual Status Report	8/20/2012	9/7/2012
	Fifth Quarter of System Operation		
Q51	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	8/20/2012	11/2/2012
Q52	Removal of Skimmers for Gauging Event	11/5/2012	11/5/2012
Q53	Skimmer Inspection and Maintenance (as Needed)	11/6/2012	11/13/2012
Q54	Site-wide Groundwater Gauging Event	11/14/2012	11/14/2012
Q55	Install and Test Xitech / DGSI Skimmers	11/15/2012	11/16/2012
	Sixth Quarter of System Operation		
Q61	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	11/19/2012	2/1/2013
Q62	Removal of Skimmers for Gauging Event	2/4/2013	2/4/2013
Q63	Skimmer Inspection and Maintenance (as Needed)	2/5/2013	2/12/2013
Q64	Site-wide Groundwater Gauging Event	2/13/2013	2/13/2013
Q65	Install and Test Xitech / DGSI Skimmers	2/14/2013	2/15/2013
Q66	Third Semi- Annual Status Report	2/18/2013	3/8/2013
	Seventh Quarter of System Operation		
Q71	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	2/18/2013	5/3/2013
Q72	Removal of Skimmers for Gauging Event	5/6/2013	5/6/2013
Q73	Skimmer Inspection and Maintenance (as Needed)	5/7/2013	5/14/2013
Q74	Site-wide Groundwater Gauging Event	5/15/2013	5/15/2013
Q75	Install and Test Xitech / DGSI Skimmers	5/16/2013	5/17/2013
	Eighth Quarter of System Operation		
Q81	Weekly Skimmer Operation Test, Sentinel Well Gauging, Tank Quantity Measurements	5/20/2013	8/2/2013
Q82	Removal of Skimmers for Gauging Event	8/5/2013	8/5/2013
Q83	Skimmer Inspection and Maintenance (as Needed)	8/6/2013	8/13/2013
Q84	Site-wide Groundwater Gauging Event	8/14/2013	8/14/2013
Q85	Install and Test Xitech / DGSI Skimmers	8/15/2013	8/16/2013
Q86	Engineering Evaluation Report	8/19/2013	9/18/2013

13.0 Exit Strategy

Research performed by Beckett and Lundegard (1997) indicates that in the oil industry, only about 40 percent of the mobile oil present in an oil reservoir can be recovered. Similarly, the efficiency of LNAPL recovery in the environmental field is also low, especially in tight formations where viscous fuels (e.g., fuel oil, diesel, bunker oil, or Navy Special) were released. Beckett and Lundegard indicate that under most conditions, LNAPL pumping will not recover more than about 50 percent of the original LNAPL in-place with 30 percent being typical. These findings imply that LNAPL recovery is not an effective risk reduction measure under a wide range of conditions, except for certain containment and plume management strategies. Therefore, for most conditions, LNAPL recovery reduces the longevity of risk but not the magnitude of the risk. Thus, risk longevity reductions are best in permeable soil and for low viscosity fuels such as gasoline because these fuels have a greater potential to leach volatile organic compounds to groundwater, resulting in the formation of a dissolved hydrocarbon plume.

The data collected as part of the LNAPL baildown and remediation testing described in Sections 3 and 4 indicate the permeability of the formation is low. The low permeability coupled with heterogeneous nature of the subsurface materials inhibits LNAPL migration and lowers the potential risk to receptors located downgradient of the LNAPL plume, while also limiting the recoverability of residual LNAPL. Given these properties, it is possible that after 2 years of system operation, residual LNAPL may remain at thicknesses that exceed the CAO of 0.01 foot.

Observations made during well development and remedial testing indicates that most of the fuel encountered at SWMUs 7/8 consists of low volatility diesel, Navy Special, and kerosene-like jet fuel. These fuels contain few volatile compounds with associated residual LNAPL, presenting a low risk to potential receptors if not completely removed to the CAO. Conversely, gasoline detected on the western edge of SWMUs 7/8 represents a potentially greater risk because of the presence of elevated levels of volatile compounds, and may require implementation of a more aggressive remedial approach after 2 years of skimmer operation in order to reduce potential future risk.

In conjunction with LNAPL removal, MNA is considered a component of the remedy for dissolved groundwater contamination. An MNA work plan (*Work Plan for Monitored Natural Attenuation Groundwater Sampling at Solid Waste Management Unit (SWMU) 7/8*, dated March 2012) has been submitted to the EPA and PREQB for review. MNA sampling activities detailed in the Work Plan will be conducted to collect data to determine if the aquifer has a favorable geochemical environment and assimilative capacity. Multiple lines of evidence supporting MNA will be used to determine the efficacy of the MNA remedy as a viable remedial action for cleanup of contaminated groundwater. Future monitoring will be used to verify these lines of evidence and track both LNAPL and dissolved plume attenuation.

To increase confidence that LNAPL removal (in conjunction with MNA for dissolved groundwater contamination) through the use of skimmers will be a successful and timely remediation approach, a comprehensive summary of the LNAPL recovery data will be evaluated and included in the 2-year EER. The initial rates based on 2 years of data are initial estimates that must be refined over time. Accurate determination of actual LNAPL removal and attenuation rates will require 5 or more years. Given the factors outlined above, residual LNAPL may remain after 2 years of system operation. If so, the Navy will evaluate whether the current remedial approach should continue and/or a technology exists to enhance LNAPL recovery.

Regulatory comments and associated Navy responses associated with this CMI plan are provided in Appendix M.

14.0 References

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Tables

TABLE 2-1
Summary of Piezometer, Monitoring, and Recovery Well Construction Details
Naval Activity Puerto Rico

Well ID	Ground Elevation[1] (feet NGVD29)[2]	Top of Casing (TOC) Elevation (feet NGVD29)[2]	Flush / Stick-up	Height from TOC to Ground Surface (feet)	Depth, Top of Screen (feet BTOC)[3]	Depth, Bottom of Screen (feet BTOC)	Measure d Total Depth[4] (feet BTOC)	Riser Material	Riser Diameter (inch)	Screen Length (feet)	Borehole Log / Completion Form available?	Date Installed
CHRW01	19.05	21.59	Stick-up	2.5	8.0	38.0	38.5	Sch 40 PVC	4	30.0	yes	11/12/2009
CHRW02	19.59	22.36	Stick-up	2.8	9.8	39.8	40.3	Sch 40 PVC	4	30.0	yes	11/10/2009
CHRW03	23.88	26.73	Stick-up	2.9	7.5	37.5	38.0	Sch 40 PVC	4	30.0	yes	11/11/2009
CHRW04	25.63	28.47	Stick-up	2.8	6.4	36.4	36.9	Sch 40 PVC	4	30.0	yes	10/19/2009
CHRW05	22.65	25.53	Stick-up	2.9	8.2	38.2	38.7	Sch 40 PVC	4	30.0	yes	10/21/2009
CHRW06	47.42	50.20	Stick-up	2.8	35.2	75.2	75.7	Sch 40 PVC	4	40.0	yes	11/2/2009
CHRW07	51.15	53.82	Stick-up	2.7	31.8	71.8	72.3	Sch 40 PVC	4	40.0	yes	11/4/2009
CHRW08	51.82	54.56	Stick-up	2.7	25.0	65.0	65.5	Sch 40 PVC	4	40.0	yes	10/14/2009
CHRW09	51.48	54.20	Stick-up	2.7	29.8	69.8	70.3	Sch 40 PVC	4	40.0	yes	10/29/2009
CHRW10	23.20	24.80	Stick-up	1.6	8.6	38.6	39.05	Sch 40 PVC	4	30.0	yes	1/12/2010
CHRW11	20.20	21.61	Stick-up	1.4	8.4	38.4	38.9	Sch 40 PVC	4	30.0	yes	11/13/2009
CHRW12	29.09	29.08	Flush	-0.01	4.5	44.5	45.0	Sch 40 PVC	4	40.0	yes	1/21/2010
CHRW13	17.21	20.54	Stick-up	3.3	7.9	37.9	38.4	Sch 40 PVC	4	30.0	yes	1/14/2010
CHRW14	21.74	24.46	Stick-up	2.7	7.0	37.0	37.5	Sch 40 PVC	4	30.0	yes	1/8/2010
CHRW15	24.36	27.26	Stick-up	2.9	6.8	36.8	37.3	Sch 40 PVC	4	30.0	yes	1/11/2010
CHRW16	56.70	59.64	Stick-up	2.9	31.0	71.0	71.5	Sch 40 PVC	4	40.0	yes	1/15/2010
CHRW17	55.31	58.02	Stick-up	2.7	29.4	69.4	69.9	Sch 40 PVC	4	40.0	yes	1/18/2010
CHRW18	14.10	17.11	Stick-up	3.0	8.0	38.0	38.5	Sch 40 PVC	4	30.0	yes	2/12/2010
CHRW19	21.05	21.00	Flush	0.0	4.8	34.8	35.3	Sch 40 PVC	4	30.0	yes	1/29/2010
CHRW20	21.89	24.87	Stick-up	3.0	8.1	38.1	38.6	Sch 40 PVC	4	30.0	yes	2/2/2010
CHRW21	17.75	20.61	Stick-up	2.9	7.7	37.7	38.2	Sch 40 PVC	4	30.0	yes	2/9/2010
CHRW22	16.73	19.49	Stick-up	2.8	7.9	37.9	38.4	Sch 40 PVC	4	30.0	yes	1/26/2010
CHRW23	23.36	26.18	Stick-up	2.8	7.8	37.8	38.3	Sch 40 PVC	4	30.0	yes	1/28/2010
CHRW24	17.53	20.15	Stick-up	2.6	9.8	29.8	30.3	Sch 40 PVC	4	20.0	yes	1/27/2010
CHRW25	19.75	22.73	Stick-up	3.0	7.8	37.8	38.3	Sch 40 PVC	4	30.0	yes	2/5/2010

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Naval Activity Puerto Rico

Well ID	Ground Elevation(1) (feet NGVD29)(2)	Top of Casing (TOC) Elevation (feet NGVD29)(2)	Flush / Stick-up	Height from TOC to Ground Surface (feet)	Depth, Top of Screen (feet BTOC)(3)	Depth, Bottom of Screen (feet BTOC)	Measured Total Depth(4) (feet BTOC)	Riser Material	Riser Diameter (inch)	Screen Length (feet)	Borehole Log / Completion Form available?	Date Installed
CHRW26	20.29	22.92	Stick-up	2.6	7.5	37.5	38.0	Sch 40 PVC	4	30.0	yes	2/8/2010
CHRW27	23.12	25.98	Stick-up	2.9	7.8	37.8	38.3	Sch 40 PVC	4	30.0	yes	2/4/2010
CHRW28	25.31	27.92	Stick-up	2.6	7.6	37.6	38.1	Sch 40 PVC	4	30.0	yes	2/3/2010
CHRW29	57.97	60.91	Stick-up	2.9	27.9	67.9	68.39	Sch 40 PVC	4	40.0	yes	2/17/2010
CHRW30	39.52	42.53	Stick-up	3.0	31.4	61.4	61.86	Sch 40 PVC	4	30.0	yes	2/18/2010
CHRW31	12.17	14.95	Stick-up	2.8	7.8	37.8	38.32	Sch 40 PVC	4	30.0	yes	2/16/2010
CHRW32	17.91	20.50	Stick-up	2.6	7.9	37.9	38.42	Sch 40 PVC	4	30.0	yes	3/17/2010
CHRW33	26.10	29.22	Stick-up	3.1	8.0	38.0	38.45	Sch 40 PVC	4	30.0	yes	3/16/2010
CHRW34	19.59	22.30	Stick-up	2.7	7.9	37.9	38.4	Sch 40 PVC	4	30.0	yes	3/12/2010
CHRW35	36.95	36.94	Flush	-0.01	15.2	55.2	55.74	Sch 40 PVC	4	40.0	yes	3/16/2010
CHRW36	19.45	22.25	Stick-up	2.8	7.7	37.7	38.23	Sch 40 PVC	4	30.0	yes	2/19/2010
CHRW37	20.19	23.09	Stick-up	2.9	7.8	37.8	38.32	Sch 40 PVC	4	30.0	yes	2/24/2010
CHRW38	23.58	26.37	Stick-up	2.8	7.6	37.6	38.12	Sch 40 PVC	4	30.0	yes	2/26/2010
CHRW39	26.56	29.27	Stick-up	2.7	7.5	37.5	37.97	Sch 40 PVC	4	30.0	yes	2/22/2010
CHRW40	22.10	25.18	Stick-up	3.1	9.3	39.3	39.76	Sch 40 PVC	4	30.0	yes	2/23/2010
CHRW41	41.03	43.82	Stick-up	2.8	31.2	71.2	71.66	Sch 40 PVC	4	40.0	yes	3/24/2010
CHRW42	30.52	33.29	Stick-up	2.8	9.3	49.3	49.82	Sch 40 PVC	4	40.0	yes	3/18/2010
CHRW43	25.61	28.42	Stick-up	2.8	10.3	50.3	50.75	Sch 40 PVC	4	40.0	yes	3/19/2010
CHRW44	16.64	19.48	Stick-up	2.8	8.6	38.6	39.05	Sch 40 PVC	4	30.0	yes	3/25/2010
CHRW45	11.83	14.65	Stick-up	2.8	7.4	27.4	27.92	Sch 40 PVC	4	20.0	yes	3/25/2010
CHMW01	9.75	9.46	Flush	-0.3	4.7	24.7	25.2	Sch 40 PVC	4	20.0	yes	11/17/2009
CHMW02	10.85	10.59	Flush	-0.3	4.7	24.7	25.2	Sch 40 PVC	4	20.0	yes	11/18/2009
CHMW03	15.31	18.17	Stick-up	2.9	7.8	37.8	38.3	Sch 40 PVC	4	30.0	yes	12/3/2009
CHMW04	13.86	16.86	Stick-up	3.0	5.6	35.6	36.1	Sch 40 PVC	4	30.0	yes	12/18/2009
CHMW05	11.76	14.51	Stick-up	2.7	7.6	27.6	28.1	Sch 40 PVC	4	20.0	yes	11/23/2009

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CHMW06	11.59	14.37	Stick-up	2.8	7.7	27.7	28.2	Sch 40 PVC	4	20.0	yes	11/19/2009
CHMW07	30.37	32.88	Stick-up	2.5	8.0	48.0	48.5	Sch 40 PVC	4	40.0	yes	12/7/2009
CHMW08	31.69	34.52	Stick-up	2.8	7.7	47.7	48.2	Sch 40 PVC	4	40.0	yes	12/1/2009
CHMW09	22.32	25.22	Stick-up	2.9	11.9	41.9	42.4	Sch 40 PVC	4	30.0	yes	12/17/2009
CHMW10	50.01	52.46	Stick-up	2.5	29.5	69.5	70.0	Sch 40 PVC	4	40.0	yes	12/2/2009
CHMW11	10.34	13.06	Stick-up	2.7	7.6	37.6	38.05	Sch 40 PVC	4	30.0	yes	3/23/2010
CHMW12	9.17	11.71	Stick-up	2.5	8.6	28.6	29.06	Sch 40 PVC	4	20.0	yes	3/22/2010
55MW01	11.93	14.89	Stick-up	3.0	27.5	42.5	43.0	Sch 40 PVC	2	15.0	yes	10/1/2009
55MW02	11.98	14.82	Stick-up	2.8	12.0	27.0	27.5	Sch 40 PVC	2	15.0	yes	10/2/2009
55MW03	13.70	16.66	Stick-up	3.0	27.1	42.1	42.6	Sch 40 PVC	2	15.0	yes	10/8/2009
55MW04	13.36	16.40	Stick-up	3.0	13.2	28.2	28.7	Sch 40 PVC	2	15.0	yes	10/9/2009
55MW05	10.91	13.81	Stick-up	2.9	28.3	43.3	43.8	Sch 40 PVC	2	15.0	yes	10/22/2009
55MW06	10.85	13.87	Stick-up	3.0	13.1	28.1	28.6	Sch 40 PVC	2	15.0	yes	10/21/2009
55MW07	12.02	14.59	Stick-up	2.6	27.8	42.8	43.3	Sch 40 PVC	2	15.0	yes	10/15/2009
55MW08	11.98	14.55	Stick-up	2.6	12.7	27.7	28.2	Sch 40 PVC	2	15.0	yes	10/15/2009
55MW09	7.47	10.16	Stick-up	2.7	27.8	42.8	43.3	Sch 40 PVC	2	15.0	yes	10/16/2009
55MW10	7.51	10.16	Stick-up	2.7	10.8	25.8	26.3	Sch 40 PVC	2	15.0	yes	10/20/2009
55MW11	7.49	10.49	Stick-up	3.0	27.3	42.3	42.8	Sch 40 PVC	2	15.0	yes	2/16/2010
55MW12	13.45	16.01	Stick-up	2.6	17.7	32.7	33.2	Sch 40 PVC	2	15.0	yes	2/10/2010
55MW13	10.06	12.57	Stick-up	2.5	17.9	27.9	28.4	Sch 40 PVC	2	10.0	yes	4/7/2010
55MW14	10.29	12.69	Stick-up	2.4	27.8	42.8	43.3	Sch 40 PVC	2	15.0	yes	1/29/2010
55MW15	11.48	14.29	Stick-up	2.8	43.1	58.1	58.6	Sch 40 PVC	2	15.0	yes	2/3/2010
55MW16	11.48	14.36	Stick-up	2.9	18.0	33.0	33.5	Sch 40 PVC	2	15.0	yes	2/11/2010
55MW17	9.78	9.62	Flush	-0.2	7.1	22.1	22.6	Sch 40 PVC	2	15.0	yes	1/19/2010
55MW18	9.04	8.87	Flush	-0.2	48.8	58.8	59.3	Sch 40 PVC	2	10.0	yes	1/25/2010

TABLE 2-1
Summary of Piezometer, Monitoring, and Recovery Well Construction Details
Naval Activity Puerto Rico

Well ID	Ground Elevation[1] (feet NGVD29)[2]	Top of Casing (TOC) Elevation (feet NGVD29)[2]	Flush / Stick-up	Height from TOC to Ground Surface (feet)	Depth, Top of Screen (feet BTOC)[3]	Depth, Bottom of Screen (feet BTOC)	Measured Total Depth[4] (feet BTOC)	Riser Material	Riser Diameter (inch)	Screen Length (feet)	Borehole Log / Completion Form available?	Date Installed
55MW19	8.33	8.08	Flush	-0.2	49.1	59.1	59.6	Sch 40 PVC	2	10.0	yes	1/13/2010
55MW20	8.31	8.18	Flush	-0.1	14.2	29.2	29.7	Sch 40 PVC	2	15.0	yes	1/18/2010
55MW21	7.39	10.03	Stick-up	2.6	28.0	43.0	43.5	Sch 40 PVC	2	15.0	yes	4/7/2010
55MW22	7.39	10.03	Stick-up	2.6	55.3	70.3	70.8	Sch 40 PVC	2	15.0	yes	4/8/2010
55MW23	7.11	9.84	Stick-up	2.7	31.5	46.5	47.0	Sch 40 PVC	2	15.0	yes	4/14/2010
55IW01	13.71	16.19	Stick-up	2.5	13.0	28.0	28.51	Sch 40 PVC	2	15.0	yes	9/16/2009
55IW02	13.48	16.12	Stick-up	2.6	27.8	42.8	43.25	Sch 40 PVC	2	15.0	yes	9/24/2009
55IW03	12.93	15.60	Stick-up	2.7	18.4	33.4	33.85	Sch 40 PVC	2	15.0	yes	8/25/2009
55IW04	13.41	16.03	Stick-up	2.6	27.5	42.5	43.01	Sch 40 PVC	2	15.0	yes	9/25/2009
UGW01	15.03	16.71	Stick-up	1.7	14.6	24.6	26.9	Sch 40 PVC	2	10	yes	2/26/1991
UGW02	60.57	62.20	Stick-up	1.6	48.4	58.4	58.3	Sch 40 PVC	2	10	yes	3/5/1991
UGW03	23.37	25.22	Stick-up	1.8	25.4	35.4	35.4	Sch 40 PVC	2	10	yes	3/6/1991
UGW04	19.30	20.60	Stick-up	1.3	25.3	35.3	35.4	Sch 40 PVC	2	10	yes	3/7/1991
UGW05	14.59	16.40	Stick-up	1.8	8.6	28.6	30.4	Sch 40 PVC	2	20	yes	3/7/1991
UGW06	9.75	11.56	Stick-up	1.8	8.4	18.4	20.0	Sch 40 PVC	2	10	yes	3/20/1991
UGW07	8.46	10.09	Stick-up	1.6	6.3	16.3	18.1	Sch 40 PVC	2	10	yes	3/20/1991
UGW08	8.73	10.36	Stick-up	1.6	7.5	17.5	18.7	Sch 40 PVC	2	10	yes	3/21/1991
UGW09	9.77	9.58	Flush	-0.2	9.9	19.9	19.4	Sch 40 PVC	2	10	yes	3/22/1991
UGW10	9.26	10.83	Stick-up	1.6	8.9	18.9	18.8	Sch 40 PVC	2	10	yes	3/25/1991
UGW11	8.15	9.79	Stick-up	1.6	7.5	17.5	18.6	Sch 40 PVC	2	10	yes	3/25/1991
UGW12	12.81	14.34	Stick-up	1.5	13.1	23.1	24.7	Sch 40 PVC	2	10	yes	3/26/1991
UGW13	12.25	13.71	Stick-up	1.5	15.9	25.9	26.0	Sch 40 PVC	2	10	yes	3/26/1991
UGW14	18.18	19.59	Stick-up	1.4	28.8	38.4	38.8	Sch 40 PVC	2	10	yes	3/27/1991
UGW15	10.98	12.63	Stick-up	1.7	7.9	17.9	19.1	Sch 40 PVC	2	10	yes	3/28/1991
UGW16	12.37	13.80	Stick-up	1.4	10.4	20.4	21.9	Sch 40 PVC	2	10	yes	4/2/1991

TABLE 2-1
Summary of Piezometer, Monitoring, and Recovery Well Construction Details
Naval Activity Puerto Rico

Well ID	Ground Elevation[1] (feet NGVD29)[2]	Top of Casing (TOC) Elevation (feet NGVD29)[2]	Flush / Stick-up	Height from TOC to Ground Surface (feet)	Depth, Top of Screen (feet BTOC)[3]	Depth, Bottom of Screen (feet BTOC)	Measured Total Depth[4] (feet BTOC)	Riser Material	Riser Diameter (inch)	Screen Length (feet)	Borehole Log / Completion Form available?	Date Installed
UGW17	11.07	12.66	Stick-up	1.6	13.7	23.7	24.9	Sch 40 PVC	2	10	yes	4/2/1991
UGW18	13.34	14.64	Stick-up	1.3	10.4	20.4	21.9	Sch 40 PVC	2	10	yes	4/3/1991
UGW19	11.13	12.60	Stick-up	1.5	8.5	18.5	20.3	Sch 40 PVC	2	10	yes	11/15/1993
UGW20R	9.32	9.16	Flush	-0.2	7.0	17.0	13.7	Sch 40 PVC	2	10	yes	11/17/1993
UGW21	11.58	13.97	Stick-up	2.4	7.5	12.5	14.6	Sch 40 PVC	2	5	yes	11/18/1993
UGW22[5]	13.27	11.49	Flush	-1.8	5.0	25.0	20.3	Sch 40 PVC	6	20	yes	11/18/1993
UGW23	67.04	69.45	Stick-up	2.4	51.0	66.0	68.5	Sch 40 PVC	4	15	yes	12/11/1993
UGW24	77.26	79.18	Stick-up	1.9	63.0	78.0	81.8	Sch 40 PVC	4	15	yes	12/16/1993
UGW25	51.73	54.21	Stick-up	2.5	39.0	54.0	57.5	Sch 40 PVC	4	15	yes	12/17/1993
UGW26	11.01	10.91	Flush	-0.1	41.0	46.0	46.5	Sch 40 PVC	4	5	no	12/16/1993
UGW32	84.73	87.51	Stick-up	2.8	74.0	89.0	92.1	Sch 40 PVC	2	15	no	6/22/1994
UGW33	110.53	113.51	Stick-up	3.0	N/A	N/A	N/A	Sch 40 PVC	2	N/A	no	N/A
UGW34	88.81	91.34	Stick-up	2.5	80.0	95.0	98.0	Sch 40 PVC	2	15	no	6/27/1994
PW01	13.94	15.48	Stick-up	1.5	4.0	24.0	19.6	Sch 40 PVC	2	20	yes	9/26/1995
PW02	13.61	15.79	Stick-up	2.2	4.0	24.0	26.8	Sch 40 PVC	2	20	yes	9/20/1995
PW03	15.34	17.75	Stick-up	2.4	4.0	24.0	26.6	Sch 40 PVC	2	20	yes	9/22/1995
PW05	15.19	17.53	Stick-up	2.3	4.0	24.0	26.9	Sch 40 PVC	4	20	yes	9/23/1995
PW06	15.83	15.97	Stick-up	0.1	4.0	24.0	24.9	Sch 40 PVC	4	20	yes	9/26/1995
MW01	13.78	16.05	Stick-up	2.3	4.0	16.0	14.8	Sch 40 PVC	2	15	yes	9/19/1995
MW02	13.73	15.60	Stick-up	1.9	5.0	25.0	27.1	Sch 40 PVC	2	20	yes	9/12/1995
MW03	15.59	13.90	Stick-up	-1.7	4.5	24.0	22.4	Sch 40 PVC	2	19.5	yes	9/25/1995
MW04	14.68	16.68	Stick-up	2.0	4.5	24.0	26.9	Sch 40 PVC	2	19.5	yes	9/22/1995
RW01	21.42	20.59	Flush	-0.8	10.0	30.0	28.3	Sch 40 PVC	6	20	yes	10/17/1996
RW02	18.92	18.13	Flush	-0.8	10.0	30.0	25.8	Sch 40 PVC	6	20	yes	10/16/1996
RW04	12.15	11.23	Flush	-0.9	5.0	25.0	18.9	Sch 40 PVC	6	20	yes	10/23/1996

TABLE 2-1
Summary of Piezometer, Monitoring, and Recovery Well Construction Details
Naval Activity Puerto Rico

Well ID	Ground Elevation[1] (feet NGVD29)[2]	Top of Casing (TOC) Elevation (feet NGVD29)[2]	Flush / Stick-up	Height from TOC to Ground Surface (feet)	Depth, Top of Screen (feet BTOC)[3]	Depth, Bottom of Screen (feet BTOC)	Measured Total Depth[4] (feet BTOC)	Riser Material	Riser Diameter (inch)	Screen Length (feet)	Borehole Log / Completion Form available?	Date Installed
RW05	12.07	10.50	Flush	-1.6	5.0	25.0	17.8	Sch 40 PVC	6	20	yes	10/25/1996
RW06	11.74	9.97	Flush	-1.8	5.0	25.0	--	Sch 40 PVC	6	20	yes	10/28/1996
RW07	11.45	8.77	Flush	-2.7	5.0	20.0	--	Sch 40 PVC	6	15	yes	10/18/1996
RW08	11.63	10.00	Flush	-1.6	5.0	20.0	--	Sch 40 PVC	6	15	yes	10/21/1996
GW02	12.17	13.91	Stick-up	1.7	N/A	N/A	22.8	N/A	2	N/A	no	N/A
GW03	11.32	13.49	Stick-up	2.2	N/A	N/A	33.7	N/A	2	N/A	no	N/A
GW04	11.03	13.17	Stick-up	2.1	N/A	N/A	20.3	N/A	2	N/A	no	N/A
GW06	9.00	11.04	Stick-up	2.0	N/A	N/A	25.3	N/A	2	N/A	no	N/A
470MW01	30.24	33.17	Stick-up	2.9	20.0	34.5	38.4	Sch 40 PVC	2	14.5	no	5/15/1995
470MW03	20.70	23.23	Stick-up	2.5	17.3	26.8	30.3	Sch 40 PVC	2	9.5	no	5/26/1995
7MW01A	25.80	28.47	Stick-up	2.7	49.0	69.0	72.4	Sch 40 PVC	2	20	yes	5/2/1996
7MW02A	45.73	48.64	Stick-up	2.9	40.0	60.0	62.7	Sch 40 PVC	2	20	yes	4/21/1996
7MW03	77.01	79.37	Stick-up	2.4	94.0	134.0	138.4	Sch 40 PVC	2	40	yes	4/8/1996
7MW04	80.75	82.65	Stick-up	1.9	96.0	106.0	107.5	Sch 40 PVC	2	10	yes	4/16/1996
7MW05	12.22	14.24	Stick-up	2.0	5.0	25.0	28.1	Sch 40 PVC	2	20	yes	10/22/1997
7MW06	8.36	8.31	Flush	0.0	5.0	25.0	25.1	Sch 40 PVC	2	20	yes	10/23/1997
7MW07	13.44	15.47	Stick-up	2.0	5.0	25.0	28.1	Sch 40 PVC	6	15	no	N/A
7MW08	11.81	11.47	Flush	-0.3	8.0	28.0	28.4	Sch 40 PVC	6	20	yes	10/28/1997
7MW09	59.21	61.42	Stick-up	2.2	28.7	58.7	62.1	Sch 40 PVC	6	20	yes	10/24/1997
7MW10	7.02	7.03	Flush	0.0	2.0	12.0	12.4	Sch 40 PVC	2	10	yes	1/15/2002
7MW11	9.22	9.14	Flush	-0.1	2.0	12.0	11.9	Sch 40 PVC	4	10	yes	1/15/2002
7MW12	8.17	8.11	Flush	-0.1	2.0	10.5	10.9	Sch 40 PVC	4	8.5	yes	1/31/2002
7MW13	8.64	8.53	Flush	-0.1	2.0	12.0	12.6	Sch 40 PVC	4	10	yes	1/14/2002
7MW14	6.58	6.53	Flush	-0.1	2.0	12.0	12.0	Sch 40 PVC	4	10	yes	1/14/2002
7MW15	11.61	14.23	Stick-up	2.6	2.2	12.2	14.6	Sch 40 PVC	4	10	yes	1/15/2002

TABLE 2-1
Summary of Piezometer, Monitoring, and Recovery Well Construction Details
Naval Activity Puerto Rico

Well ID	Ground Elevation[1] (feet NGVD29)[2]	Top of Casing (TOC) Elevation (feet NGVD29)[2]	Flush / Stick-up	Height from TOC to Ground Surface (feet)	Depth, Top of Screen (feet BTOC)[3]	Depth, Bottom of Screen (feet BTOC)	Measured Total Depth[4] (feet BTOC)	Riser Material	Riser Diameter (inch)	Screen Length (feet)	Borehole Log / Completion Form available?	Date Installed
7MW16	17.87	20.25	Stick-up	2.4	2.3	17.3	18.6	Sch 40 PVC	4	15	yes	1/30/2002
7MW17	45.22	47.85	Stick-up	2.6	26.0	46.0	49.7	Sch 40 PVC	4	20	yes	3/1/2002
7MW18	73.27	75.52	Stick-up	2.2	57.5	77.5	79.4	Sch 40 PVC	4	20	yes	1/29/2002
7MW19	114.55	117.07	Stick-up	2.5	97.8	117.8	120.6	Sch 40 PVC	2	20	yes	1/24/2002
7MW20	11.13	13.54	Stick-up	2.4	5.0	15.0	18.0	Sch 40 PVC	4	10	yes	1/11/2002
7MW21	6.78	6.65	Flush	-0.1	10.0	20.0	19.9	Sch 40 PVC	2	10	no	9/22/2003
7MW22	9.94	9.79	Flush	-0.2	12.0	22.0	22.2	Sch 40 PVC	2	10	no	9/22/2003
7MW23	9.27	9.06	Flush	-0.2	9.0	19.0	18.8	Sch 40 PVC	2	10	no	9/22/2003
7MW24	10.65	10.49	Flush	-0.2	12.0	22.0	22.3	Sch 40 PVC	2	10	no	N/A
MTMW01	23.61	23.29	Flush	-0.3	19.5	39.5	33.6	Sch 40 PVC	2	20	yes	N/A
MTMW02	23.10	22.48	Flush	-0.6	18.0	38.0	36.7	Sch 40 PVC	2	20	yes	N/A
MTMW03	22.63	22.45	Flush	-0.2	15.0	35.0	34.8	Sch 40 PVC	2	20	yes	N/A
MTMW04	22.28	22.26	Flush	0.0	16.0	36.0	34.1	N/A	2	20	Yes	N/A
AW01	22.65	22.52	Flush	-0.1	20.5	35.5	30.3	N/A	2	15	no	N/A
AW02	21.95	21.72	Flush	-0.2	16.0	31.0	29.4	N/A	2	15	no	N/A

Notes:
(1) Ground surface elevation is measured from the concrete well pad at the base of the well with the exception of PW-1 which was taken from ground surface because a well pad was not installed.
(2) NGVD: National Geodetic Vertical Datum of 1929
(3) BTOC : below top-of-casing
(4) Measured post well development by CH2M HILL.
(5) This well is the same as RW03.
N/A: No data is available

TABLE 2-2
Comparison of Groundwater and Top of Screen Depths for Previously Existing Wells
Naval Activity Puerto Rico

Well ID	Depth, Top of Screen (feet BTOC)[1]	Depth to Water (January 21, 2009)[2] (feet BTOC)	Groundwater Above Screened Interval	Groundwater within the Screened Interval
UGW01	16.38	11.11	X	----
UGW02	49.93	49.53	X	----
UGW03	27.37	17.62	X	----
UGW04	26.68	11.94	X	----
UGW05	10.58	15.52	----	X
UGW06	10.12	9.19	X	----
UGW07	7.93	7.20	X	----
UGW08	9.18	7.02	X	----
UGW09	9.69	6.87	X	----
UGW10	10.46	9.47	X	----
UGW11	9.06	8.91	X	----
UGW12	14.69	10.73	X	----
UGW13	17.35	10.82	X	----
UGW14	29.79	14.61	X	----
UGW15	9.61	11.31	----	X
UGW16	11.93	11.76	X	----
UGW17	15.39	10.03	X	----
UGW18	11.91	11.95	----	X
UGW19	9.95	9.83	X	----
UGW20R	6.79	8.02	----	X
UGW21	9.76	11.56	----	X
UGW22	2.20	6.49	----	X
UGW23	53.41	62.35	----	X
UGW24	65.04	70.96	----	X
UGW25	41.52	46.87	----	X
UGW26	41.00	7.64	X	----
UGW32	74.00	76.34	----	X
UGW34	80.00	83.21	----	X
PW01	5.60	10.08	----	X
PW02	6.23	11.20	----	X
PW03	6.19	12.08	----	X
PW05	6.52	10.45	----	X
PW06	6.21	10.77	----	X
MW01	4.00	10.56	----	X
MW02	7.00	10.75	----	X
MW03	6.51	7.85	----	X
MW04	6.71	10.01	----	X
RW01	9.30	14.98	----	X
RW02	9.16	11.37	----	X
RW04	4.13	5.87	----	X
RW05	3.48	7.23	----	X
RW06	3.37	6.91	----	X
RW07	2.37	N/A	N/A	N/A
RW08	3.39	7.47	----	X

TABLE 2-2
Comparison of Groundwater and Top of Screen Depths for Previously Existing Wells
Naval Activity Puerto Rico

Well ID	Depth, Top of Screen (feet BTOC)(1)	Depth to Water (January 21, 2009)(2) (feet BTOC)	Groundwater Above Screened Interval	Groundwater within the Screened Interval
GW02	N/A	10.22	N/A	N/A
GW03	N/A	10.08	N/A	N/A
GW04	N/A	9.34	N/A	N/A
GW06	N/A	8.64	N/A	N/A
470MW01	20.00	27.47	----	X
470MW03	17.50	19.48	----	X
7MW01A	51.63	24.78	X	----
7MW02A	42.91	41.80	X	----
7MW03	96.33	67.48	X	----
7MW04	97.94	74.99	X	----
7MW05	6.99	11.82	----	X
7MW06	4.80	7.32	----	X
7MW07	2.03	13.23	----	X
7MW08	7.75	9.11	----	X
7MW09	40.88	54.83	----	X
7MW10	1.81	6.16	----	X
7MW11	1.79	6.76	----	X
7MW12	1.81	7.68	----	X
7MW13	1.79	6.31	----	X
7MW14	1.98	5.57	----	X
7MW15	4.87	9.75	----	X
7MW16	4.68	9.78	----	X
7MW17	29.04	40.17	----	X
7MW18	59.74	67.81	----	X
7MW19	100.29	109.35	----	X
7MW20	7.37	11.11	----	X
7MW21	10.00	5.79	X	----
7MW22	12.00	8.03	X	----
7MW23	9.00	7.50	X	----
7MW24	12.00	8.54	X	----
MTMW01	19.43	15.85	X	----
MTMW02	17.88	17.38	X	----
MTMW03	14.9	15.09	----	X
MTMW04	15.93	16.76	----	X
AW01	20.44	14.91	X	----
AW02	15.9	16.16	----	X

Notes:
(1) BTOC : below top-of-casing
(2) Gauged by CH2M HILL on January 21, 2009.
N/A - Not Available

TABLE 4-1
Summary of Groundwater Elevations at SMWU 7/8 (May 18, 2010)
Naval Activity Puerto Rico

Well Identification	Ground Elevation (feet NGVD29)	Top of Casing (TOC) Elevation (feet NGVD29)	Groundwater Elevation (feet NGVD29)	Groundwater Elevation Corrected[1] (feet NGVD29)	Product Elevation (feet NGVD29)	Depth to Water (feet BTOC)	Depth to Product (feet BTOC)	Depth to Water Corrected[2] (feet BTOC)	Product Thickness (feet)
CHRW01	19.05	21.59	2.55	3.65	3.92	19.04	17.67	17.94	1.37
CHRW02	19.59	22.36	3.00	3.82	4.02	19.36	18.34	18.54	1.02
CHRW03	23.88	26.73	1.88	3.75	4.22	24.85	22.51	22.98	2.34
CHRW04	25.63	28.47	3.37	4.32	4.56	25.10	23.91	24.15	1.19
CHRW05	22.65	25.53	4.28	4.34	4.36	21.25	21.17	21.19	0.08
CHRW06	47.42	50.20	3.22	--	--	46.98	--	--	--
CHRW07	51.15	53.82	4.11	4.32	4.37	49.71	49.45	49.50	0.26
CHRW08	51.82	54.56	4.03	4.30	4.37	50.53	50.19	50.26	0.34
CHRW09	51.48	54.20	3.23	--	--	50.97	--	--	--
CHRW10	23.20	24.80	-4.38	2.28	3.95	29.18	20.85	22.52	8.33
CHRW11	20.20	21.61	-3.87	1.86	3.29	25.48	18.32	19.75	7.16
CHRW12	29.09	29.08	-0.02	3.58	4.48	29.10	24.60	25.50	4.50
CHRW13	17.21	20.54	1.99	3.67	4.09	18.55	16.45	16.87	2.10
CHRW14	21.74	24.46	3.52	3.77	3.83	20.94	20.63	20.69	0.31
CHRW15	24.36	27.26	0.43	3.70	4.52	26.83	22.74	23.56	4.09
CHRW16	56.70	59.64	3.83	3.99	4.04	55.81	55.60	55.64	0.21
CHRW17	55.31	58.02	2.43	4.29	4.75	55.59	53.27	53.73	2.32
CHRW18	14.10	17.11	3.30	3.35	3.37	13.81	13.74	13.75	0.07
CHRW19	21.05	21.00	3.30	3.42	3.45	17.70	17.55	17.58	0.15
CHRW20	21.89	24.87	-2.84	3.39	1.97	27.71	19.92	21.48	7.79
CHRW21	17.75	20.61	-5.44	3.30	2.63	26.05	15.12	17.31	10.93
CHRW22	16.73	19.49	3.71	--	--	15.78	--	--	--
CHRW23	23.36	26.18	-3.03	3.52	2.33	29.21	21.03	22.67	8.18
CHRW24	17.53	20.15	0.42	3.54	4.33	19.73	15.82	16.60	3.91
CHRW25	19.75	22.73	7.42	--	--	15.31	--	--	--
CHRW26	20.29	22.92	3.85	3.90	1.29	19.07	19.00	19.01	0.07
CHRW27	23.12	25.98	-0.17	3.69	1.80	26.15	21.32	22.29	4.83
CHRW28	25.31	27.92	3.77	3.81	1.21	24.15	24.10	24.11	0.05
CHRW29	57.97	60.91	2.80	3.95	4.24	58.11	56.67	56.96	1.44
CHRW30	39.52	42.53	4.29	--	--	38.24	--	--	--
CHRW31	12.17	14.95	3.12	--	--	11.83	--	--	--
CHRW32	17.91	20.50	3.24	--	--	17.26	--	--	--
CHRW33	26.10	29.22	3.40	3.46	3.48	25.82	25.74	25.76	0.08
CHRW34	19.59	22.30	3.65	3.68	3.69	18.65	18.61	18.62	0.04
CHRW35	36.95	36.94	3.78	--	--	33.16	--	--	--
CHRW36	19.45	22.25	15.95	--	--	6.30	--	--	--
CHRW37	20.19	23.09	3.78	3.78	3.79	19.31	19.30	19.30	0.01
CHRW38	23.58	26.37	3.06	3.75	3.92	23.31	22.45	22.62	0.86
CHRW39	26.56	29.27	0.41	3.72	4.54	28.86	24.73	25.56	4.13
CHRW40	22.10	25.18	3.80	--	--	21.38	--	--	--

TABLE 4-1
Summary of Groundwater Elevations at SMWU 7/8 (May 18, 2010)
Naval Activity Puerto Rico

Well Identification	Ground Elevation (feet NGVD29)	Top of Casing (TOC) Elevation (feet NGVD29)	Groundwater Elevation (feet NGVD29)	Groundwater Elevation Corrected[1] (feet NGVD29)	Product Elevation (feet NGVD29)	Depth to Water (feet BTOC)	Depth to Product (feet BTOC)	Depth to Water Corrected[2] (feet BTOC)	Product Thickness (feet)
CHRW41	41.03	43.82	3.14	--	--	40.68	--	--	--
CHRW42	30.52	33.29	3.08	3.13	3.15	30.21	30.14	30.15	0.07
CHRW43	25.61	28.42	2.77	3.08	3.16	25.65	25.26	25.34	0.39
CHRW44	16.64	19.48	3.02	--	--	16.46	--	--	--
CHRW45	11.83	14.65	-3.79	3.07	4.78	18.44	9.87	11.58	8.57
CHMW01	9.75	9.46	1.40	--	--	8.06	--	--	--
CHMW02	10.85	10.59	2.43	--	--	8.16	--	--	--
CHMW03	15.31	18.17	3.97	--	--	14.20	--	--	--
CHMW04	13.86	16.86	3.11	--	--	13.75	--	--	--
CHMW05	11.76	14.51	2.70	--	--	11.81	--	--	--
CHMW06	11.59	14.37	2.49	--	--	11.88	11.85	11.86	0.03
CHMW07	30.37	32.88	1.33	3.14	3.59	31.55	29.29	29.74	2.26
CHMW08	31.69	34.52	2.93	3.05	3.07	31.59	31.45	31.48	0.14
CHMW09	22.32	25.22	3.26	--	--	21.96	--	--	--
CHMW10	50.01	52.46	2.85	3.16	3.23	49.61	49.23	49.31	0.38
CHMW11	10.34	13.06	1.22	--	--	11.84	--	--	--
CHMW12	9.17	11.71	0.96	--	--	10.75	--	--	--
55MW01	11.93	14.89	2.45	--	--	12.44	--	--	--
55MW02	11.98	14.82	2.67	--	--	12.15	--	--	--
55MW03	13.70	16.66	2.53	--	--	14.13	--	--	--
55MW04	13.36	16.40	2.51	--	--	13.89	--	--	--
55MW05	10.91	13.81	2.73	--	--	11.08	--	--	--
55MW06	10.85	13.87	2.74	--	--	11.13	--	--	--
55MW07	12.02	14.59	1.94	--	--	12.65	--	--	--
55MW08	11.98	14.55	1.92	--	--	12.63	--	--	--
55MW09	7.47	10.16	1.22	--	--	8.94	--	--	--
55MW10	7.51	10.16	1.20	--	--	8.96	--	--	--
55MW11	7.49	10.49	1.17	--	--	9.32	--	--	--
55MW12	13.45	16.01	2.19	--	--	13.82	--	--	--
55MW13	10.06	12.57	1.47	--	--	11.10	--	--	--
55MW14	10.29	12.69	1.49	--	--	11.20	--	--	--
55MW15	11.48	14.29	2.61	--	--	11.68	--	--	--
55MW16	11.48	14.36	2.61	--	--	11.75	--	--	--
55MW17	9.78	9.62	1.43	--	--	8.19	--	--	--
55MW18	9.04	8.87	0.82	--	--	8.05	--	--	--
55MW19	8.33	8.08	1.48	--	--	6.60	--	--	--
55MW20	8.31	8.18	1.19	--	--	6.99	--	--	--
55MW21	7.39	10.03	0.70	--	--	9.33	--	--	--
55MW22	7.39	10.03	3.79	--	--	6.24	--	--	--
55MW23	7.11	9.84	0.67	--	--	9.17	--	--	--

TABLE 4-1
Summary of Groundwater Elevations at SMWU 7/8 (May 18, 2010)
Naval Activity Puerto Rico

Well Identification	Ground Elevation (feet NGVD29)	Top of Casing (TOC) Elevation (feet NGVD29)	Groundwater Elevation (feet NGVD29)	Groundwater Elevation Corrected[1] (feet NGVD29)	Product Elevation (feet NGVD29)	Depth to Water (feet BTOC)	Depth to Product (feet BTOC)	Depth to Water Corrected[2] (feet BTOC)	Product Thickness (feet)
55IW01	13.71	16.19	2.42	--	--	13.77	--	--	--
55IW02	13.48	16.12	2.13	--	--	13.99	--	--	--
55IW03	12.93	15.60	2.30	--	--	13.30	--	--	--
55IW04	13.41	16.03	2.39	--	--	13.64	--	--	--
UGW01	15.03	16.71	4.25	4.34	4.36	12.46	12.35	12.37	0.11
UGW02	60.57	62.20	5.55	5.63	5.65	56.65	56.55	56.57	0.10
UGW03	23.37	25.22	4.35	--	--	20.87	--	--	--
UGW04	19.30	20.60	3.69	--	--	16.91	--	--	--
UGW05	14.59	16.40	3.21	3.26	3.27	13.19	13.13	13.14	0.06
UGW06	9.75	11.56	2.36	--	--	9.20	--	--	--
UGW07	8.46	10.09	3.57	--	--	6.52	--	--	--
UGW08	8.73	10.36	2.90	--	--	7.46	--	--	--
UGW09	9.77	9.58	2.02	--	--	7.56	--	--	--
UGW10	9.26	10.83	1.41	--	--	9.42	--	--	--
UGW11	8.15	9.79	-0.07	--	--	9.86	--	--	--
UGW12	12.81	14.34	2.64	3.04	3.14	11.70	11.20	11.30	0.50
UGW13	12.25	13.71	2.02	2.74	2.92	11.69	10.79	10.97	0.90
UGW14	18.18	19.59	3.75	--	--	15.84	--	--	--
UGW15	10.98	12.63	1.15	--	--	11.48	--	--	--
UGW16	12.37	13.80	2.08	--	--	11.72	--	--	--
UGW17	11.07	12.66	2.70	2.75	2.76	9.96	9.90	9.91	0.06
UGW18	13.34	14.64	2.37	--	--	12.27	--	--	--
UGW19	11.13	12.60	3.27	--	--	9.33	--	--	--
UGW20R	9.32	9.16	1.24	--	--	7.92	--	--	--
UGW21	11.58	13.97	2.54	2.69	2.73	11.43	11.24	11.28	0.19
UGW22	13.27	11.49	3.70	--	--	7.79	--	--	--
UGW23	67.04	69.45	4.14	--	--	65.31	--	--	--
UGW24	77.26	79.18	4.40	--	--	74.78	--	--	--
UGW25	51.73	54.21	3.74	4.30	4.43	50.47	49.78	49.92	0.69
UGW26	11.01	10.91	2.85	--	--	8.06	--	--	--
UGW32	84.73	87.51	5.03	--	--	82.48	--	--	--
UGW33	110.53	113.51	3.46	--	--	110.05	--	--	--
UGW34	88.81	91.34	4.28	--	--	87.06	--	--	--
PW01	13.94	15.48	4.06	--	--	11.42	--	--	--
PW02	13.61	15.79	3.52	3.57	3.58	12.27	12.21	12.22	0.06
PW03	15.34	17.75	4.74	--	--	13.01	--	--	--
PW05	15.19	17.53	5.45	--	--	12.08	--	--	--
PW06	15.83	15.97	4.05	--	--	11.92	11.90	11.90	0.02
MW01	13.78	16.05	4.50	--	--	11.55	--	--	--
MW02	13.73	15.60	3.68	--	--	11.92	--	--	--

TABLE 4-1
Summary of Groundwater Elevations at SMWU 7/8 (May 18, 2010)
Naval Activity Puerto Rico

Well Identification	Ground Elevation (feet NGVD29)	Top of Casing (TOC) Elevation (feet NGVD29)	Groundwater Elevation (feet NGVD29)	Groundwater Elevation Corrected(1) (feet NGVD29)	Product Elevation (feet NGVD29)	Depth to Water (feet BTOC)	Depth to Product (feet BTOC)	Depth to Water Corrected(2) (feet BTOC)	Product Thickness (feet)
MW03	15.59	13.90	4.66	--	--	9.24	--	--	--
MW04	14.68	16.68	4.90	4.95	4.96	11.78	11.72	11.73	0.06
RW01	21.42	20.59	3.77	--	--	16.82	--	--	--
RW02	18.92	18.13	4.10	--	--	14.03	--	--	--
RW04	12.15	11.23	3.53	--	--	7.70	--	--	--
RW05	12.07	10.50	2.87	--	--	7.63	--	--	--
RW06	11.74	9.97	2.96	--	--	7.01	--	--	--
RW07	11.45	8.77	7.56	--	--	1.21	--	--	--
RW08	11.63	10.00	2.70	--	--	7.30	--	--	--
GW02	12.17	13.91	3.02	--	--	10.89	--	--	--
GW03	11.32	13.49	2.92	--	--	10.57	--	--	--
GW04	11.03	13.17	4.13	--	--	9.04	--	--	--
GW06	9.00	11.04	2.23	--	--	8.81	--	--	--
470MW01	30.24	33.17	3.00	3.22	3.28	30.17	29.89	29.95	0.28
470MW03	20.70	23.23	2.90	--	--	20.33	--	--	--
7MW01A	25.80	28.47	2.96	--	--	25.51	--	--	--
7MW02A	45.73	48.64	4.11	--	--	44.53	--	--	--
7MW03	77.01	79.37	5.37	--	--	74.00	--	--	--
7MW04	80.75	82.65	4.09	--	--	78.56	--	--	--
7MW05	12.22	14.24	2.98	--	--	11.26	--	--	--
7MW06	8.36	8.31	1.02	--	--	7.29	--	--	--
7MW07	13.44	15.47	2.37	--	--	13.10	--	--	--
7MW08	11.81	11.47	2.38	2.50	2.53	9.09	8.94	8.97	0.15
7MW09	59.21	61.42	4.00	--	--	57.42	--	--	--
7MW10	7.02	7.03	0.87	--	--	6.16	--	--	--
7MW11	9.22	9.14	2.14	--	--	7.00	--	--	--
7MW12	8.17	8.11	0.63	--	--	7.48	--	--	--
7MW13	8.64	8.53	1.95	--	--	6.58	--	--	--
7MW14	6.58	6.53	1.07	--	--	5.46	--	--	--
7MW15	11.61	14.23	4.61	--	--	9.62	--	--	--
7MW16	17.87	20.25	12.03	--	--	8.22	--	--	--
7MW17	45.22	47.85	4.26	--	--	43.59	--	--	--
7MW18	73.27	75.52	4.25	--	--	71.27	--	--	--
7MW19	114.55	117.07	4.09	--	--	112.98	--	--	--
7MW20	11.13	13.54	2.09	--	--	11.45	--	--	--
7MW21	6.78	6.65	0.88	--	--	5.77	--	--	--
7MW22	9.94	9.79	1.72	--	--	8.07	--	--	--
7MW23	9.27	9.06	1.54	--	--	7.52	--	--	--
7MW24	10.65	10.49	5.01	--	--	5.48	--	--	--
MTMW01	23.61	23.29	2.05	4.30	4.86	21.24	18.43	18.99	2.81

TABLE 4-1
Summary of Groundwater Elevations at SMWU 7/8 (May 18, 2010)
Naval Activity Puerto Rico

Well Identification	Ground Elevation (feet NGVD29)	Top of Casing (TOC) Elevation (feet NGVD29)	Groundwater Elevation (feet NGVD29)	Groundwater Elevation Corrected(1) (feet NGVD29)	Product Elevation (feet NGVD29)	Depth to Water (feet BTOC)	Depth to Product (feet BTOC)	Depth to Water Corrected(2) (feet BTOC)	Product Thickness (feet)
MTMW02	23.10	22.48	1.89	3.71	4.16	20.59	18.32	18.77	2.27
MTMW03	22.63	22.45	--	--	--	--	--	--	--
MTMW04	22.28	22.26	2.01	3.75	4.19	20.25	18.07	18.51	2.18
AW01	22.65	22.52	--	--	--	--	--	--	--
AW02	21.95	21.72	3.77	--	--	17.95	--	--	--
TS-13	8.91	12.39	3.79	--	--	8.60	--	--	--
TS-14	8.79	12.22	4.64	--	--	7.58	--	--	--
TS-16	7.58	11.00	2.03	--	--	8.97	--	--	--
TS-17	6.97	10.36	2.20	--	--	8.16	--	--	--
TS-18	9.12	12.67	1.77	--	--	10.90	--	--	--
TS-19	8.80	11.83	1.20	--	--	10.63	--	--	--
TS-25	8.60	11.89	2.48	--	--	9.41	--	--	--
TS-31	9.04	12.57	1.63	--	--	10.94	--	--	--
TS-41	9.2	12.73	NM	--	--	NM	--	--	--
TS-43	8.59	12.03	1.48	--	--	10.55	--	--	--
TS-44	8.22	11.70	1.32	--	--	10.38	--	--	--

Notes:

(1) Corrected Groundwater Elevation = Top-of-Casing Elevation - Corrected Depth to Groundwater

(2) Corrected Depth to Groundwater = Depth to Groundwater - (Product Thickness * Specific Gravity of Combined Fuel (assumed 0.8))

Wells associated with SWMU 55 (55MW# and 55IW#) were gauged to provide additional information regarding groundwater flow.

NGVD29 = National Geodetic Vertical Datum of 1929

BTOC = below top-of-casing

NM = not measured

TABLE 4-2
Gradients between Selected Well Pairs at SWMUs 7/8 (May 18, 2010)
Naval Activity Puerto Rico

Well Pair	Northing	Easting	Groundwater Elevation Corrected[1] (feet NGVD29)	Distance Between Wells (feet)	Gradient (feet/feet)
North of Forrestal Drive					
CHRW01	146309.20	782075.87	3.65	49.40	0.04
CHRW11	146260.04	782080.70	1.86		
MW04	146146.52	782095.63	4.95	60.92	0.03
CHRW18	146197.90	782062.89	3.35		
CHRW11	146260.04	782080.70	1.86	44.40	0.03
CHRW20	146270.79	782037.62	3.39		
UGW25	146661.74	781850.90	4.30	57.55	0.02
CHRW09	146655.79	781793.66	3.23		
UGW25	146661.74	781850.90	4.30	255.76	0.004
470MW01	146487.65	781663.53	3.22		
UGW25	146661.74	781850.90	4.30	394.34	0.004
CHMW05	146443.74	781522.30	2.70		
CHRW43	146441.91	781695.09	3.08	50.85	0.001
CHRW44	146391.12	781692.58	3.02		
CHRW30	146735.14	782156.06	4.29	388.43	0.002
CHRW22	146367.89	782029.58	3.71		
UGW23	146489.61	782311.06	4.14	306.67	0.001
CHRW22	146367.89	782029.58	3.71		
CHRW38	146500.24	782088.60	3.75	34.47	0.002
CHRW27	146508.35	782055.10	3.69		
CHRW26	146500.38	781991.91	3.90	48.02	0.3
CHRW36	146455.93	781973.73	15.95		
CHRW07	146663.19	781916.79	4.32	409.18	0.0007
7MW15	146260.72	781842.99	4.61		
CHRW07	146663.19	781916.79	4.32	63.32	0.0002
CHRW08	146694.57	781861.80	4.30		
CHRW23	146347.86	782132.71	3.52	74.65	0.0003
CHRW24	146393.65	782073.76	3.54		
CHRW39	146600.73	782067.21	3.72	235.86	0.00003
CHRW22	146367.89	782029.58	3.71		

TABLE 4-2
Gradients between Selected Well Pairs at SWMUs 7/8 (May 18, 2010)
Naval Activity Puerto Rico

Well Pair	Northing	Easting	Groundwater Elevation Corrected[1] (feet NGVD29)	Distance Between Wells (feet)	Gradient (feet/feet)
South of Forrestal Drive					
UGW08	145832.15	781929.96	2.90	132.49	0.007
7MW13	145714.11	781869.79	1.95		
CHMW05	146443.74	781522.30	2.70	316.56	0.005
CHMW12	146185.29	781339.50	0.96		
GW02	146346.32	781691.88	3.02	312.93	0.006
UGW20R	146101.39	781497.10	1.24		
CHRW20	146270.79	782037.62	3.39	581.42	0.002
7MW13	145714.11	781869.79	1.95		
			maximum gradient		0.3
			minimum gradient		0.00003
			average gradient		0.02

Notes:

(1) Corrected Groundwater Elevation = Top-of-Casing Elevation - Corrected Depth to Groundwater

NGVD29 = National Geodetic Vertical Datum of 1929

TABLE 7-1
Summary of Passive Skimmer Locations at SMWUs 7/8
Naval Activity Puerto Rico

DGSI Skimmer		Xitech Skimmer	
Well ID	LNAPL Thickness (feet)	Well ID	LNAPL Thickness (feet)
CHRW05	0.08	CHRW01	1.37
CHRW07	0.26	CHRW02	1.02
CHRW08	0.34	CHRW03	2.34
CHRW14	0.31	CHRW04	1.19
CHRW16	0.21	CHRW10	8.33
CHRW18	0.07	CHRW11	7.16
CHRW19	0.15	CHRW12	4.50
CHRW26	0.07	CHRW13	2.10
CHRW28	0.05	CHRW15	4.09
CHRW33	0.08	CHRW17	2.32
CHRW34	0.04	CHRW20	7.79
CHRW37	0.01	CHRW21	10.93
CHRW42	0.07	CHRW23	8.18
CHRW43	0.39	CHRW24	3.91
CHMW06	0.03	CHRW27	4.83
CHMW08	0.14	CHRW29	1.44
CHMW10	0.38	CHRW39	4.13
UGW01	0.11	CHRW45	8.57
UGW02	0.10	CHMW07	2.26
UGW05	0.06	MTMW01	2.81
UGW12	0.50	MTMW02	2.27
UGW17	0.06	MTMW04	2.18
UGW21	0.19	UGW13*	0.90
UGW25	0.69	CHRW38*	0.86
PW02	0.06	CHRW09*	0
PW06	0.02		
MW04	0.06		
470MW01	0.28		
7MW08	0.15		
CHRW32*	0		
CHRW41*	0		

Note:

LNAPL = Light Non-Aqueous Phase Liquid
* = Based on LNAPL thickness measurements collected after May 18, 2010

Figures

City
Major Road
Naval Station Roosevelt Roads Boundary

N

0 5 10 20 Miles

FIGURE 1-1
NAPR Location in Puerto Rico
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\BASELOCATION.MXD JCARR3 2/10/2011 10:32:03

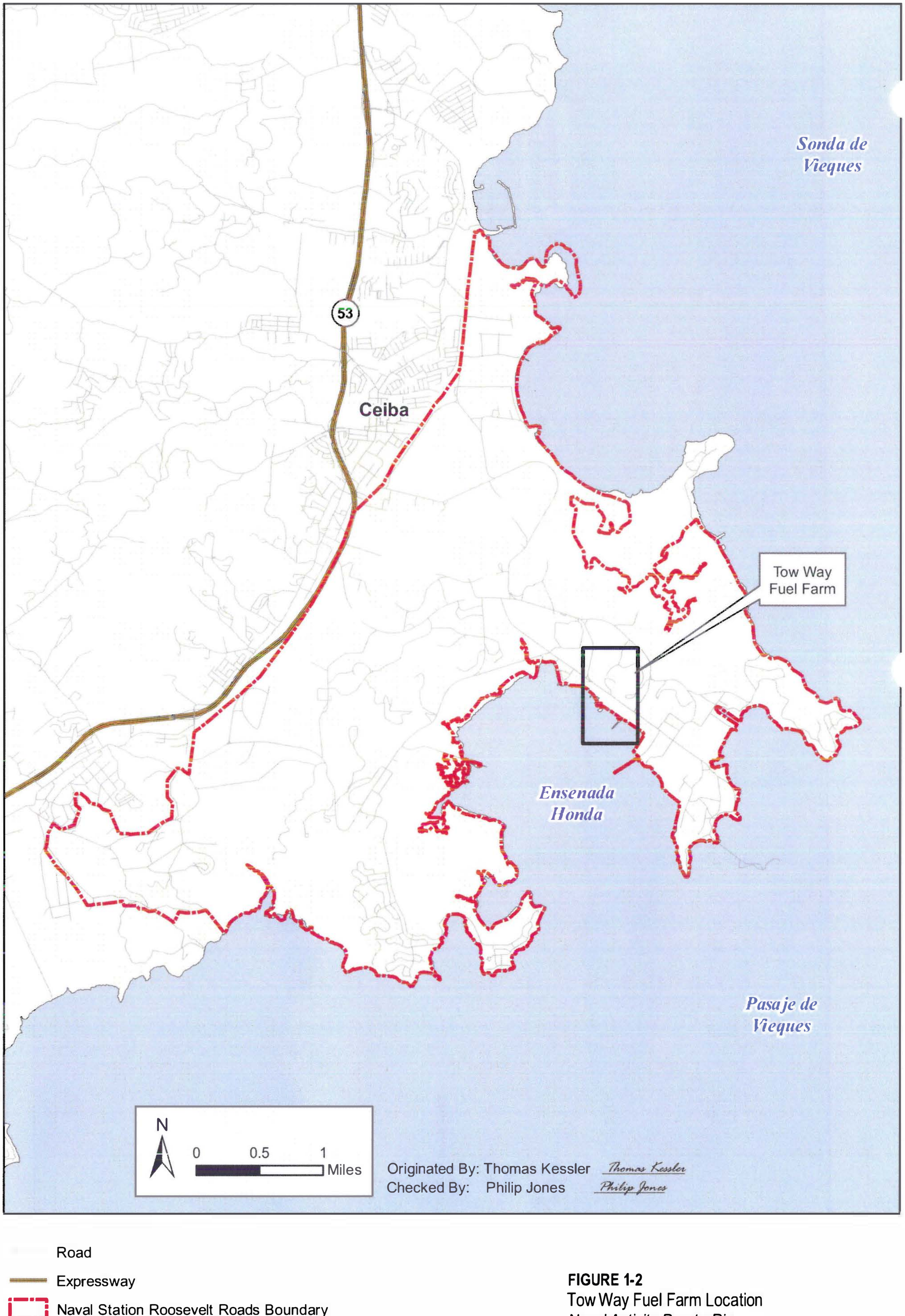
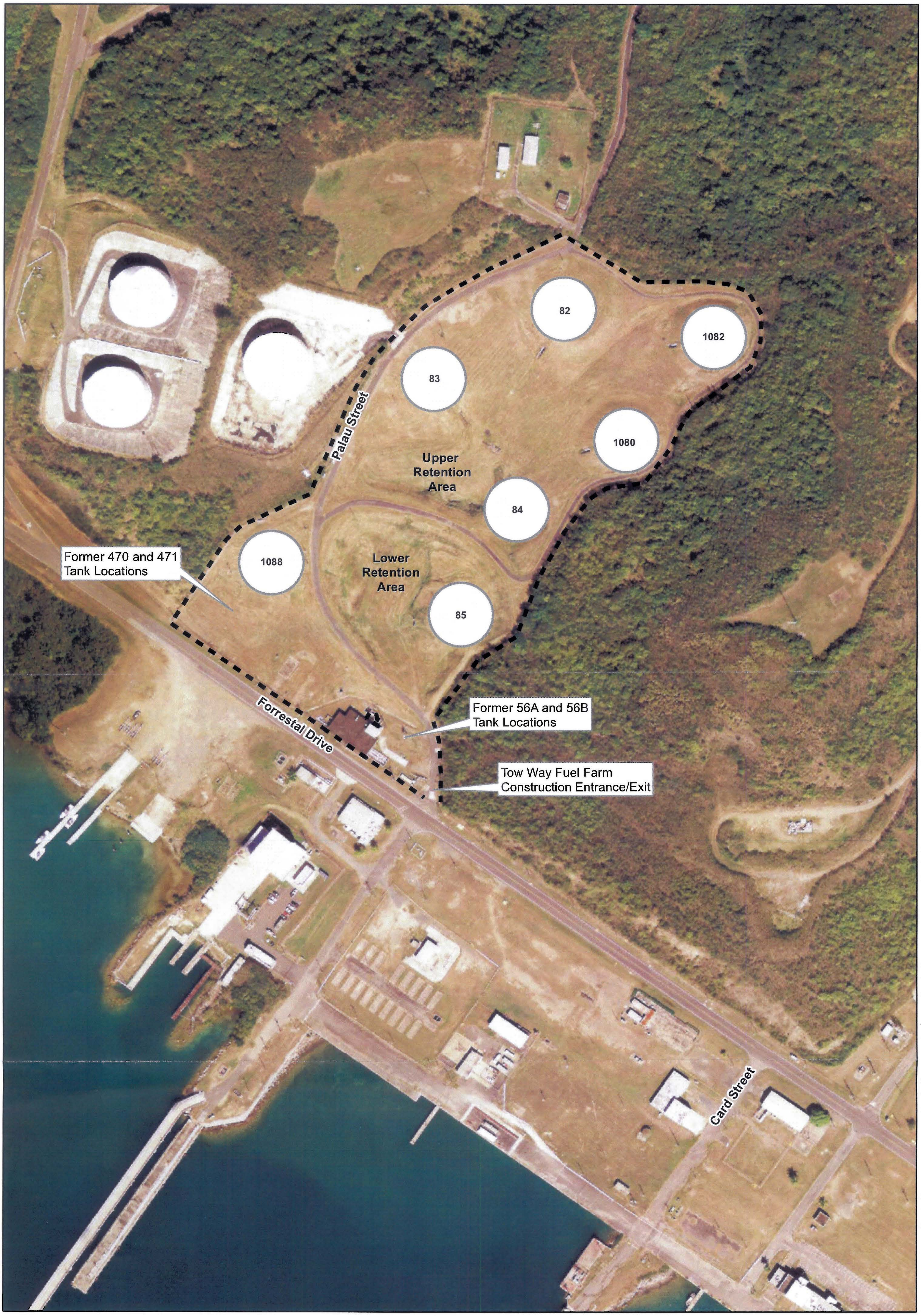


FIGURE 1-2
Tow Way Fuel Farm Location
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\TOWWAYFUELFARMLOCATION.MXD JCARR3 2/10/2011 10:33:56



Fence

Former Fuel Tank

Originated By: Thomas Kessler *Thomas Kessler*
Checked By: Philip Jones *Philip Jones*

N

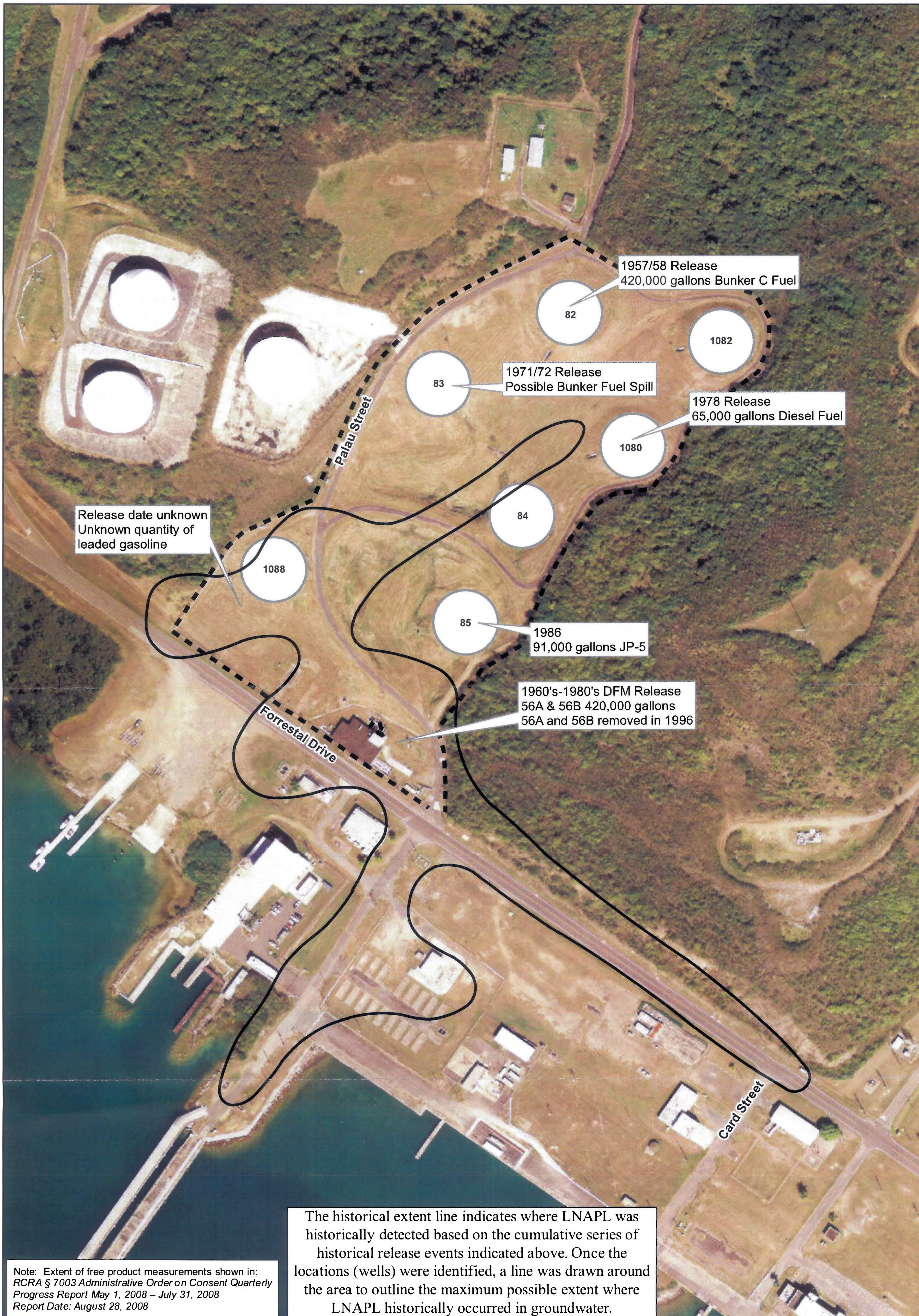
0 100 200 Feet

1 inch = 200 feet

FIGURE 1-3
SWMU 7/8 Base Map
Tow Way Fuel Farm
Naval Activity Puerto Rico

ATL \\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\BASEMAP.MXD MEDELSON 10/13/2011 2:15:12 PM

CH2MHILL.



Historical Extent of Light Non-Aqueous Phase Liquids (LNAPL)

Fence

85 Former Fuel Tank

N 0 100 200 Feet
1 inch = 200 feet

FIGURE 1-4
Historical Extent of LNAPL
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL.

ATL \\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\HISTORIC_FREE_PRODUCT.MXD MEDELSON 10/13/2011 2:15:56 PM

FIGURE 1-5
SWMUs 7/8 Monitoring and Recovery Well Site Map
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\SWMU7_8_55-ALLWELLS.MXD BBODINSO 11/18/2010 16:13:39

Monitoring and Observation Well	Fence
Recovery Well	Stormwater Retention Area
Potentiometric Contour (Dashed Where Inferred)	
Groundwater Flow	

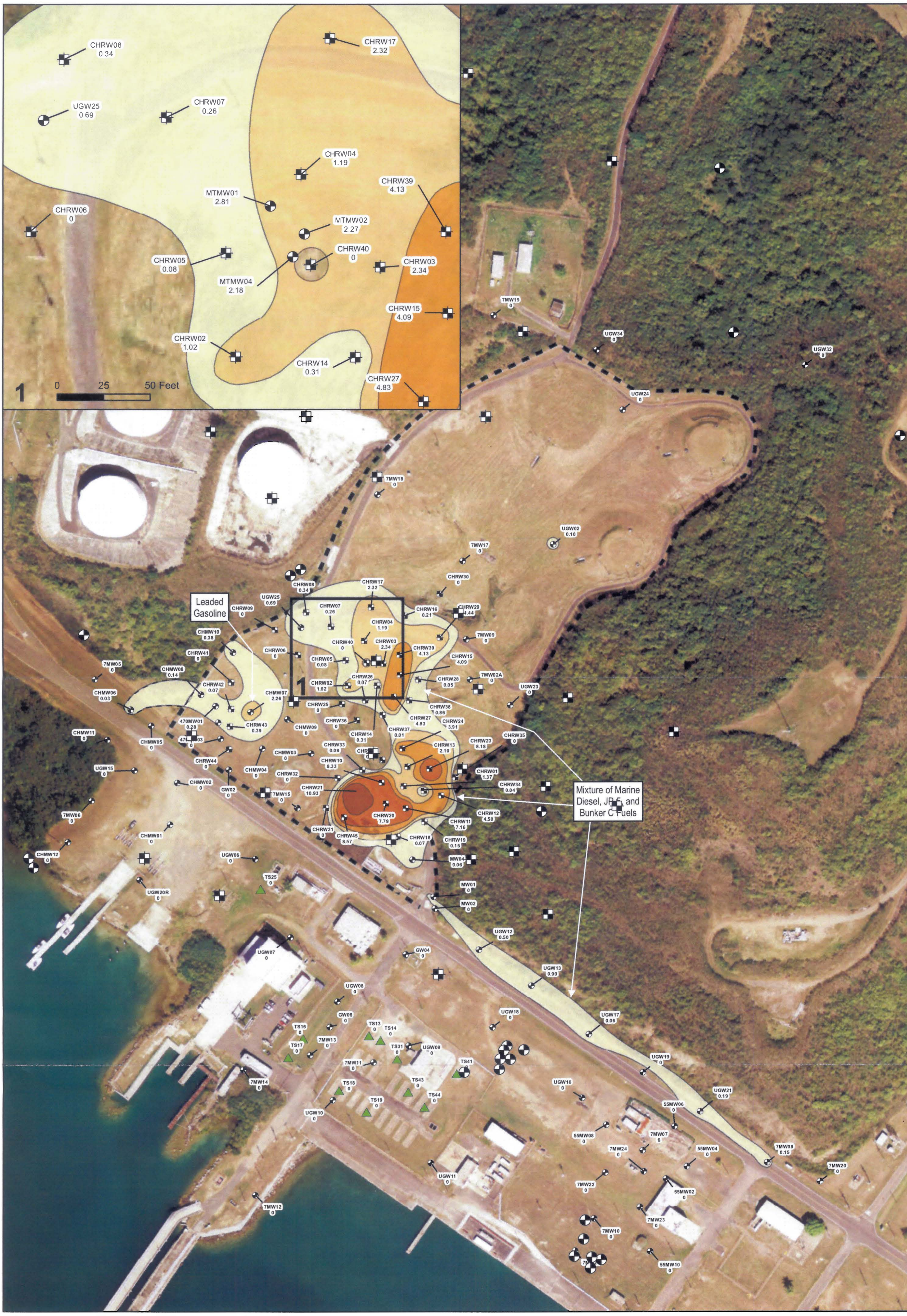
Originated By: Bryan Burkingstock *Bryan Burkingstock*
Checked By: Thomas Kessler *Thomas Kessler*

N 0 100 200 Feet
1 inch = 200 feet

FIGURE 1-6
SWMUs 7/8 Groundwater Piezometric Surface
(May 18, 2010)
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\SWMU7_8_55-GWFLOW052010.MXD BBODINSO 11/18/2010 17:12:38



Monitoring and Observation Well
Recovery Well
Test Pit with Temporary Sump (TS) Installed
Fence

Product Thickness (in Feet)
Dashed Where Inferred

- 9-12
- 6-9
- 3-6
- 1-3
- 0.01-1

Originated By: Thomas Kessler *Thomas Kessler*
Checked By: Philip Jones *Philip Jones*

N

0 100 200 Feet
1 inch = 200 feet

FIGURE 1-7
SWMUs 7/8 and 55 LNAPL Thickness (May 18, 2010)
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL.

DVR \\MANAGED.LOCAL\CRITIGEN\PROJECTS\USNAVYPUERTORICO20000317\MAPFILES\SWMU7_8_55-GWPZSURFACE-PTHICK_BW-20100518.MXD JCARR 4/10/2012 9:36:23 AM

Symbol	Legend	Symbol	Legend
⊠	Junction Vault	──	Conveyance Piping
⯐	PSH Recovery Well	▬ ▬	Fence
		▭	Assumed Extent of Dissolved Contaminant Plume

Originated By: Thomas Kessler *Thomas Kessler*
Checked By: Philip Jones *Philip Jones*

N

0 100 200 Feet

1 inch = 200 feet

FIGURE 2-1
Corrective Measures Study
Proposed LNAPL Recovery Well Locations
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\CMS_PROPWELLS.MXD JCARR3 2/10/2011 10:01:24

Monitoring and Observation Well
Recovery Well
Cross-Section
Fence

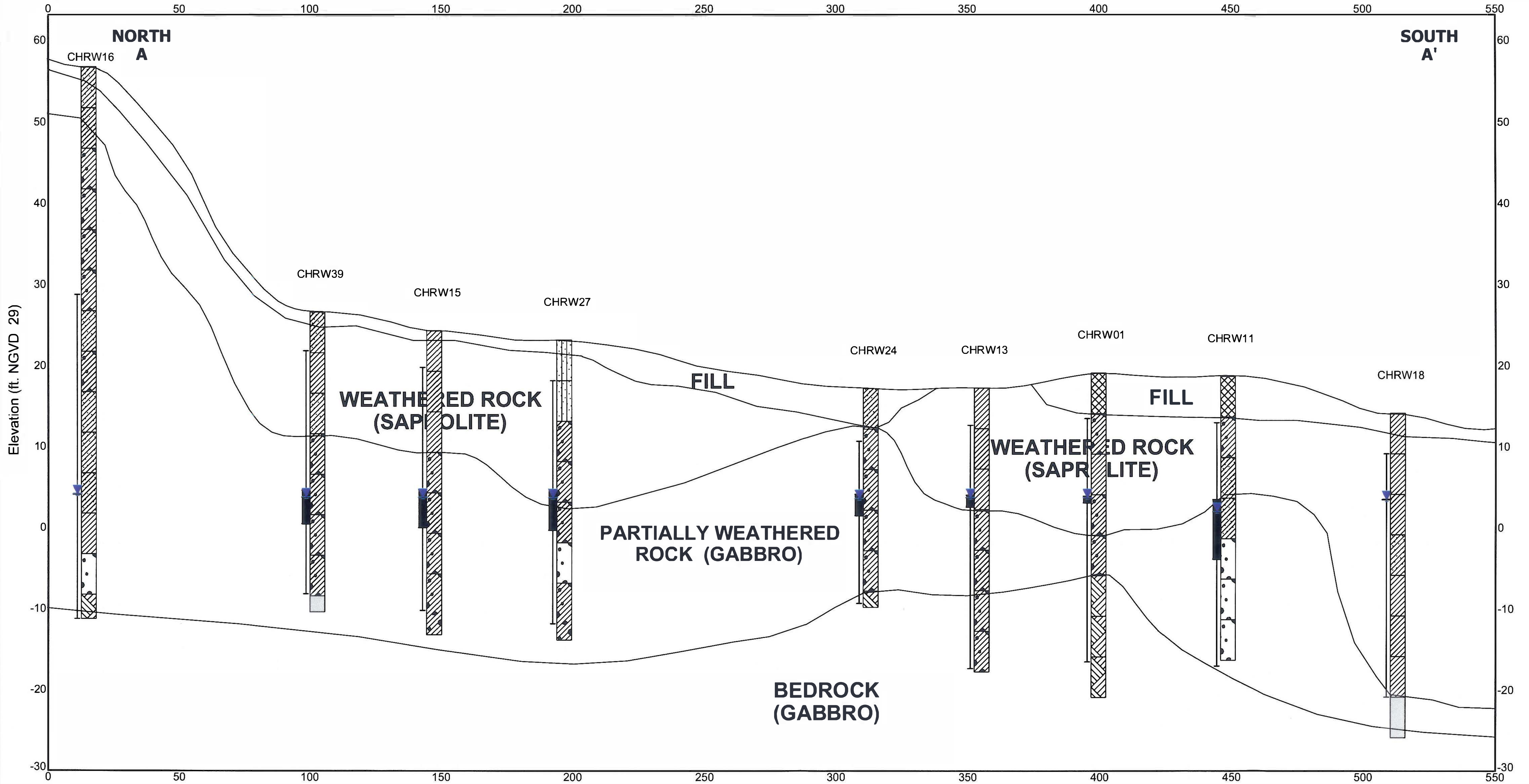
N

0 100 200 Feet
1 inch = 200 feet

FIGURE 4-1
SWMUs 7/8 Cross-section Location Map
Tow Way Fuel Farm
Naval Station Roosevelt Roads, Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\SWMU7_8_55-CROSSSECTIONLOCATION042910.MXD BBODINSO 5/20/2010 09:07:49



Note:
The geologic interpretations on this map were generalized from and interpolated between drilling points. Information on actual subsurface conditions exists only at the specified locations. The actual subsurface conditions may differ from those interpreted on this cross section.

VERTICAL SCALE: 1" = 12.4'
HORIZONTAL SCALE: 1" = 37.9'
VERTICAL EXAGGERATION = 3.1x

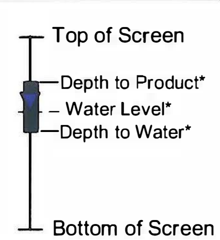
GEOLOGIC UNITS

FILL: mix of fines and rock fragments

WEATHERED ROCK: moist, stiff clays and silts, none to weak cementation, and fairly easy drilling.

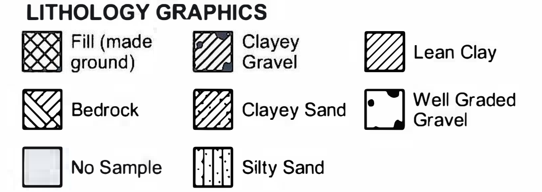
PARTIALLY WEATHERED ROCK: moist becoming saturated towards base, dense and stiff consistancy, fractured towards base, gravels are gabbro rock fragments, unconsolidated, mostly gravelly clay and clayey gravel, and becoming difficult to auger drill.

BEDROCK: hard, strong cementation, consolidated, less fractured, more competent, undulating contact, and auger rig refusal



*Measured April 9, 2010
Corrected Depth to Groundwater = Depth to Groundwater - (Product Thickness * Specific Gravity of Combined Fuel (assumed 0.8))

LITHOLOGY GRAPHICS



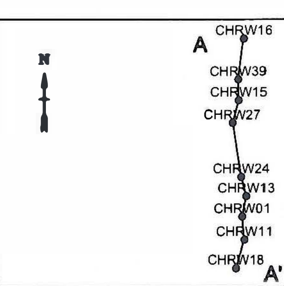
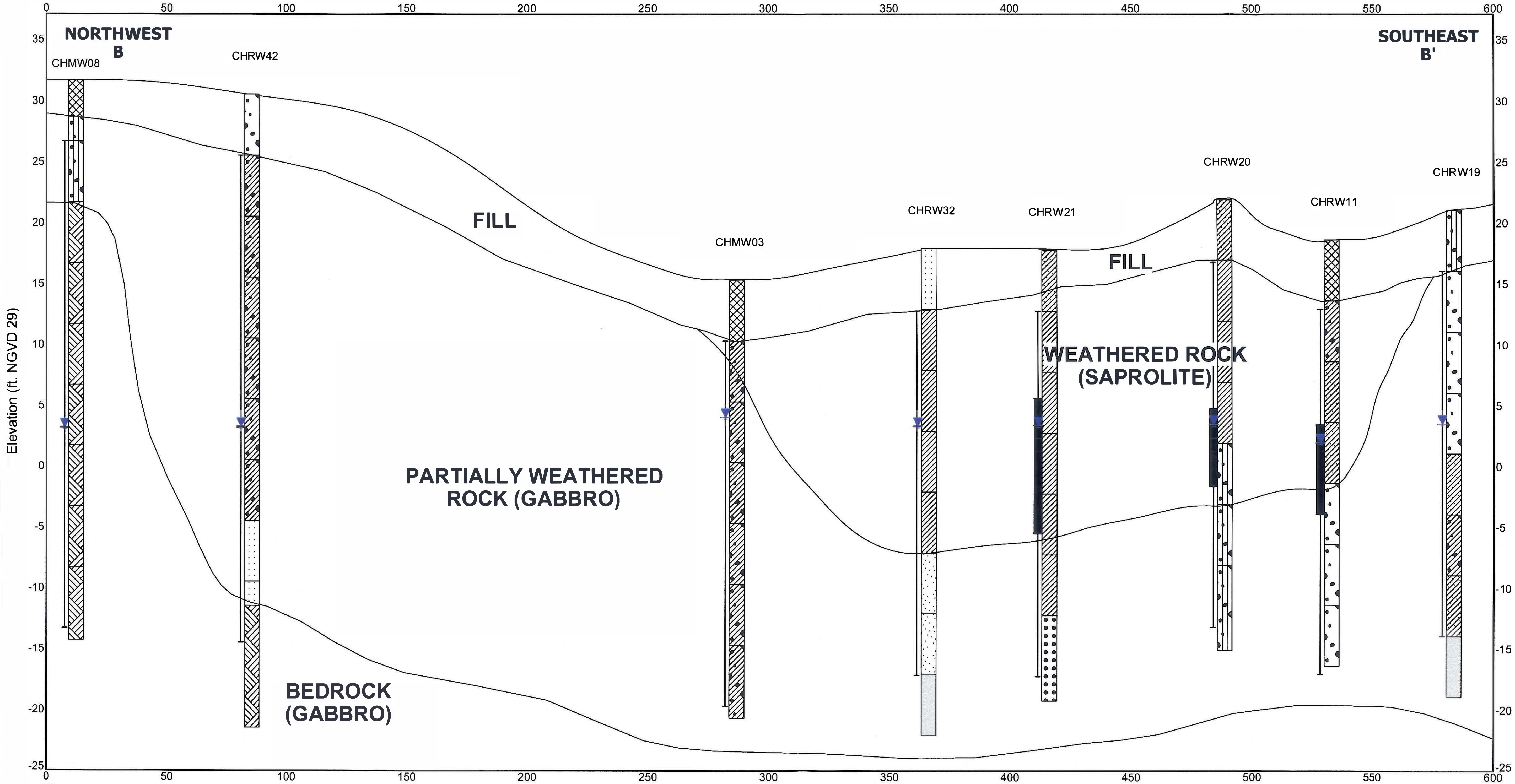


FIGURE 4-2
A-A' CROSS-SECTION
Tow Way Fuel Farm
Naval Station Roosevelt Roads,
Puerto Rico

CH2MHILL

FIGURE6_NORTH_NAPR.GPJ CH2M GEOTECH.GDT 5/25/10



Note:
The geologic interpretations on this map were generalized from and interpolated between drilling points. Information on actual subsurface conditions exists only at the specified locations. The actual subsurface conditions may differ from those interpreted on this cross section.

VERTICAL SCALE: 1" = 8.3'
HORIZONTAL SCALE: 1" = 41.4'
VERTICAL EXAGGERATION = 5.0x

GEOLOGIC UNITS

FILL: mix of fines and rock fragments

WEATHERED ROCK: moist, stiff clays and silts, none to weak cementation, and fairly easy drilling.

PARTIALLY WEATHERED ROCK: moist becoming saturated towards base, dense and stiff consistancy, fractured towards base, gravels are gabbro rock fragments, unconsolidated, mostly gravelly clay and clayey gravel, and becoming difficult to auger drill.

BEDROCK: hard, strong cementation, consolidated, less fractured, more competent, undulating contact, and auger rig refusal

Top of Screen
Depth to Product*
Water Level*
Depth to Water*
Bottom of Screen

*Measured April 9, 2010
Corrected Depth to Groundwater = Depth to Groundwater - (Product Thickness * Specific Gravity of Combined Fuel (assumed 0.8))

LITHOLOGY GRAPHICS

Fill (made ground)
Clayey Gravel
Silty Gravel
Bedrock
Clayey Sand
Well Graded Gravel
No Sample
Lean Clay
Poorly Graded Gravel
Poorly-Graded Sand
Well Graded Sand

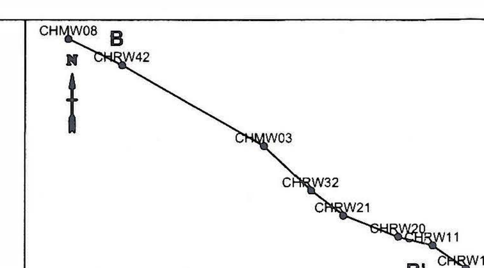


FIGURE 4-3
B-B' CROSS-SECTION
Tow Way Fuel Farm
Naval Station Roosevelt Roads,
Puerto Rico

CH2MHILL

FIGURE7_EAST NAPR.GPJ CH2M GEOTECH.GDT 5/25/10

● Monitoring and Observation Well

▬ ▬ Fence

CHMW12 Slug Test Performed

Originated By: Bryan Burkingstock *Bryan Burkingstock*
Checked By: Thomas Kessler *Thomas Kessler*

N 0 90 180 Feet

1 inch = 180 feet

FIGURE 4-4
Location of SWMUs 7/8 Slug Tests
Tow Way Fuel Farm
Naval Activity Puerto Rico

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\SWMU_SLUGTESTS_201005.MXD ECLARK1 10/27/2010 15:32:48

CH2MHILL

Monitoring Well
Recovery Well
Fence

N

0 100 200 Feet

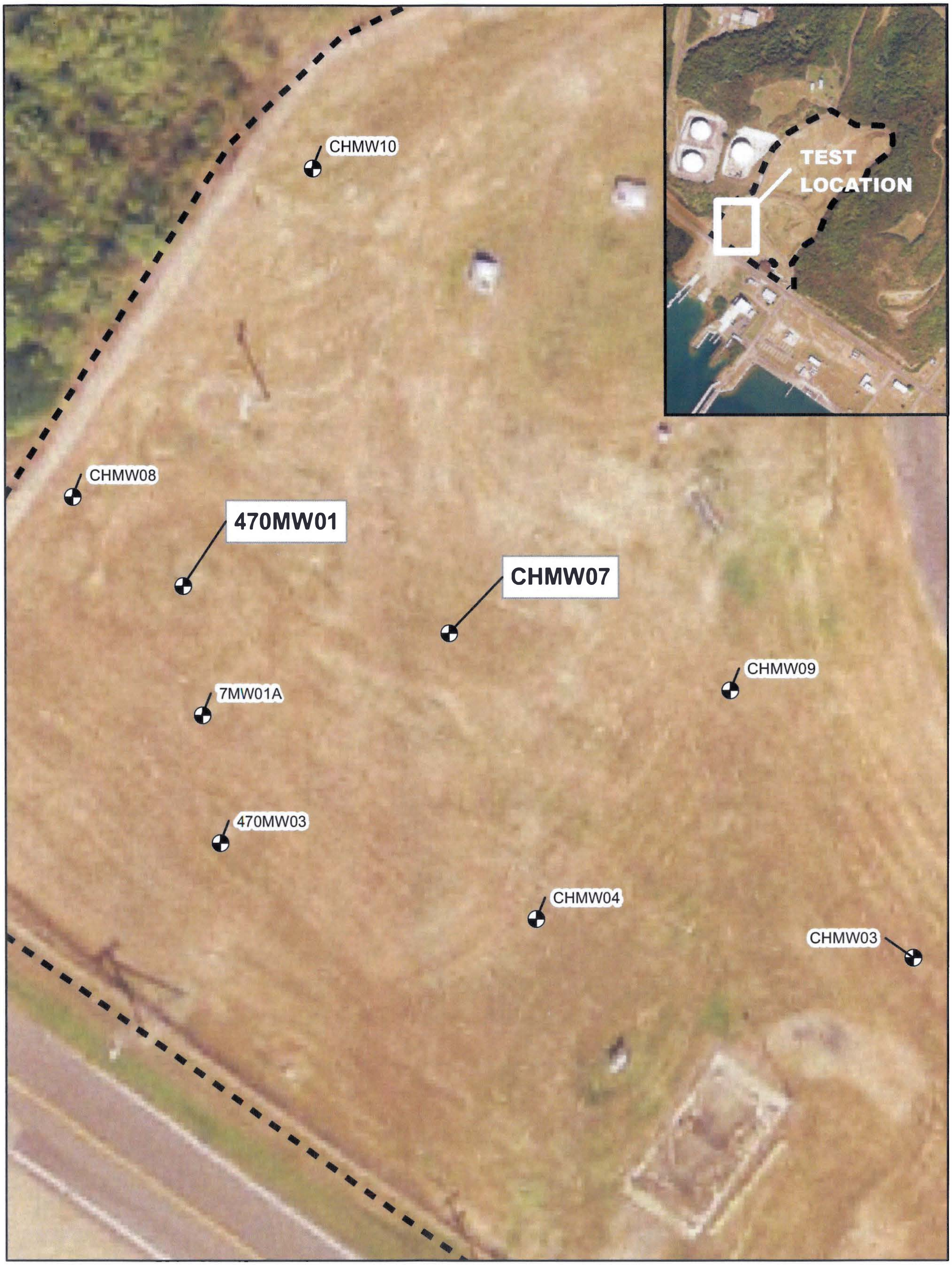
1 inch = 200 feet

Originated By: Thomas Kessler *Thomas Kessler*
Checked By: Philip Jones *Philip Jones*

FIGURE 4-5
Aggressive Fluid Vapor Recovery Test Wells
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\AGGRESSIVEFLUIDVAPORRECOVERY.MXD JCARR3 2/10/2011 10:26:11



Monitoring and Observation Well

Recovery Well

Fence

N

0 20 40 Feet

1 inch = 40 feet

Originated By: Thomas Kessler *Thomas Kessler*

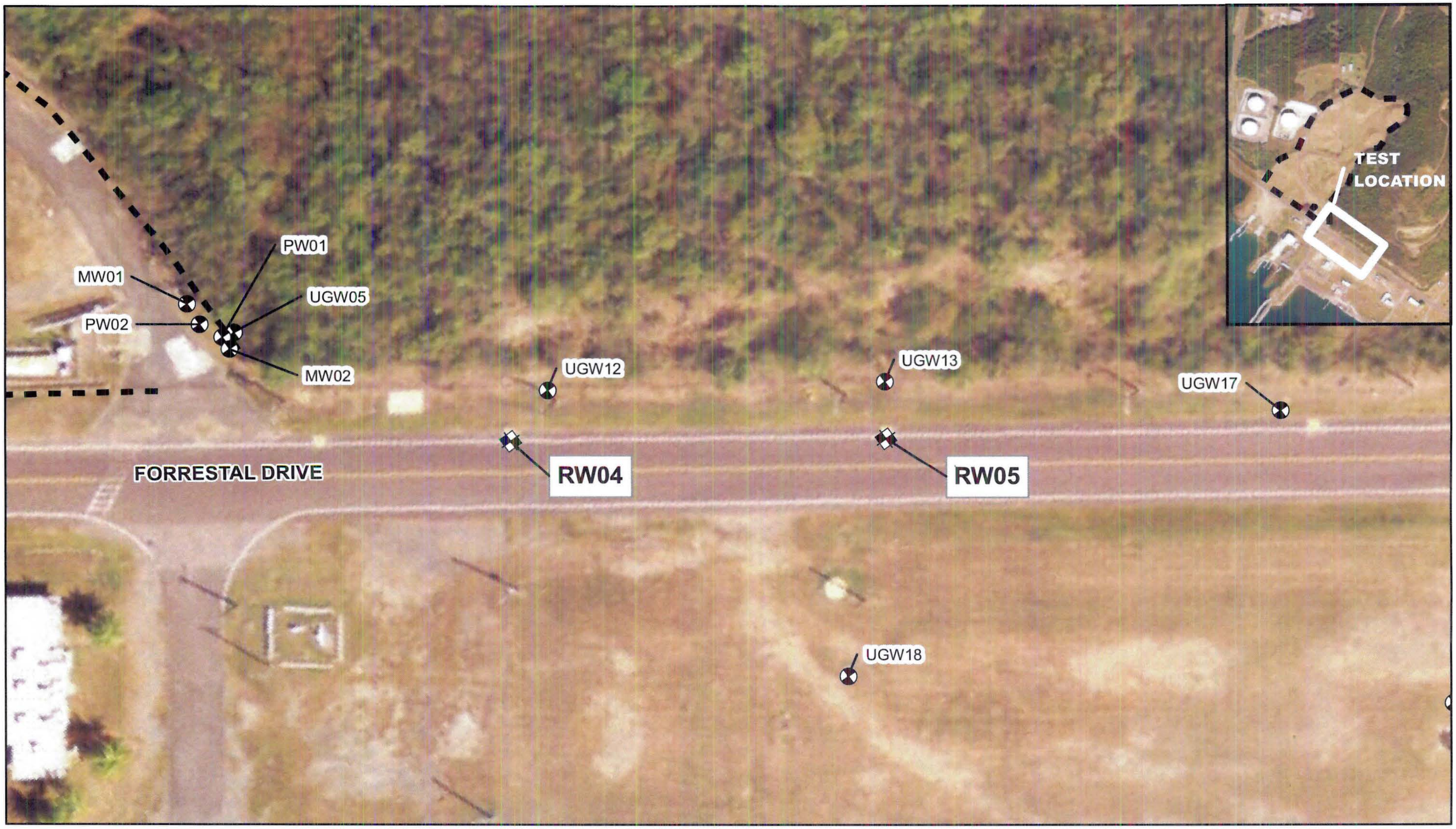
Checked By: Philip Jones *Philip Jones*

FIGURE 4-6

Soil Vapor Extraction Test Location
at Wells 470MW01 and CHMW07
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\SOILVAPOR-470MW01ANDCHMW07.MXD JCARR3 2/10/2011 10:36:41



Monitoring and Observation Well

Recovery Well

Fence

N

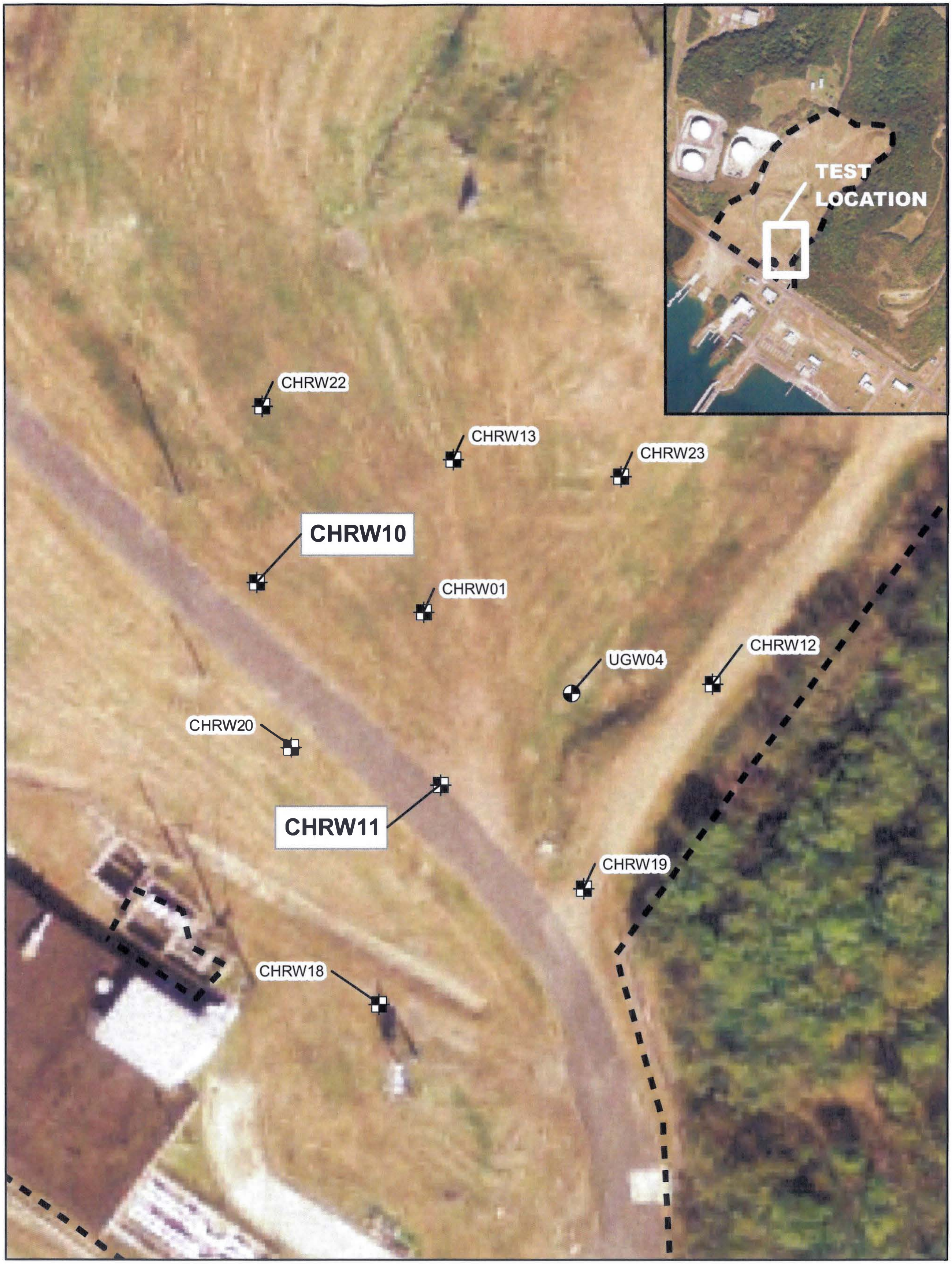
0 30 60 Feet

1 inch = 60 feet

Originated By: Thomas Kessler *Thomas Kessler*

Checked By: Philip Jones *Philip Jones*

FIGURE 4-7
Groundwater Extraction Pilot Test
at RW04 and RW05
Tow Way Fuel Farm
Naval Activity Puerto Rico



Monitoring and Observation Well
Recovery Well
Fence

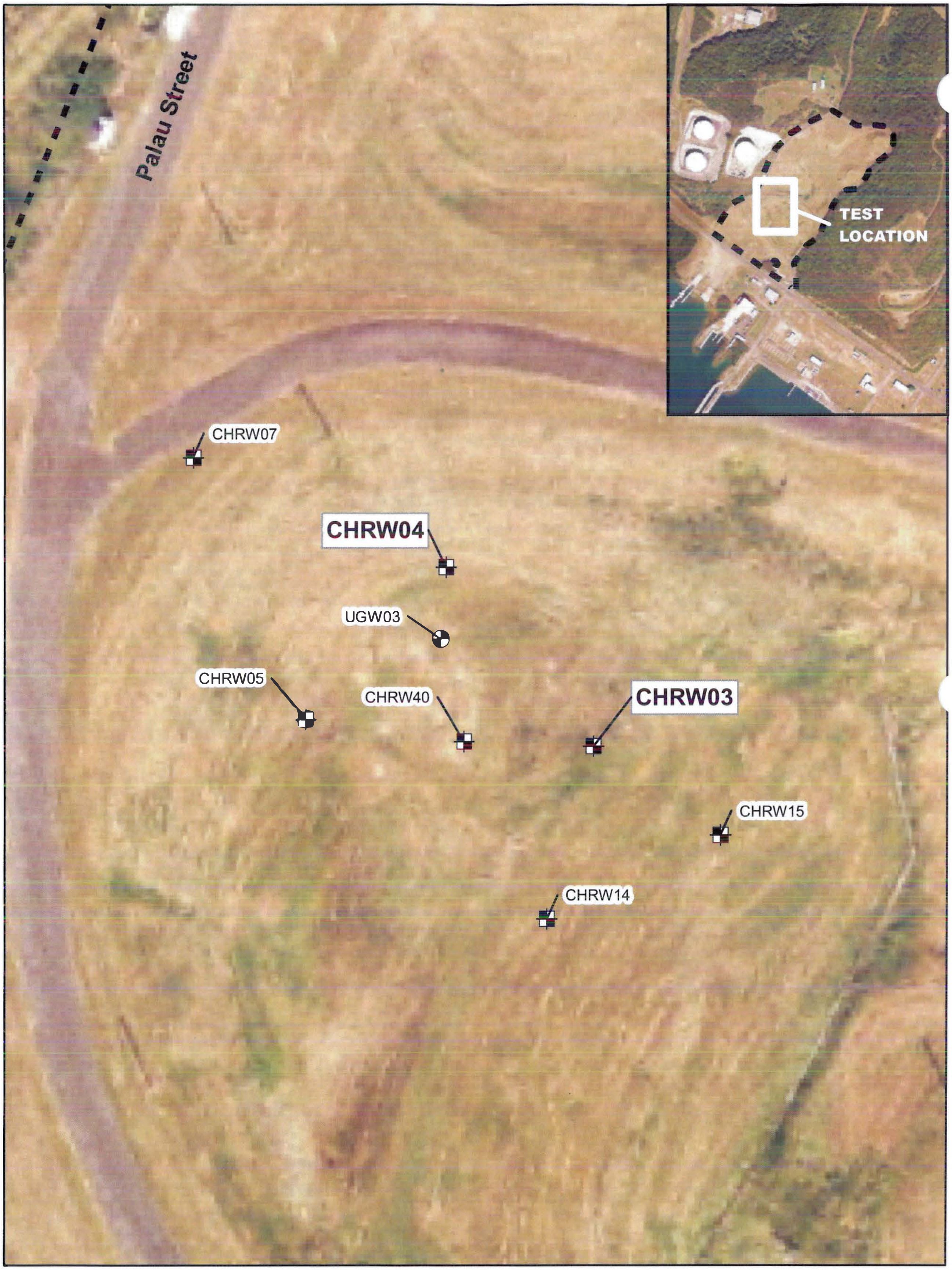
N 0 20 40 Feet
1 inch = 40 feet

Originated By: Thomas Kessler *Thomas Kessler*
Checked By: Philip Jones *Philip Jones*

FIGURE 4-8
Skimmer Test Area
CHRW10 and CHRW11
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL

\\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\SKIMPRODPILOT-CHRW10ANDCHRW11.MXD JCARR3 2/10/2011 10:41:00



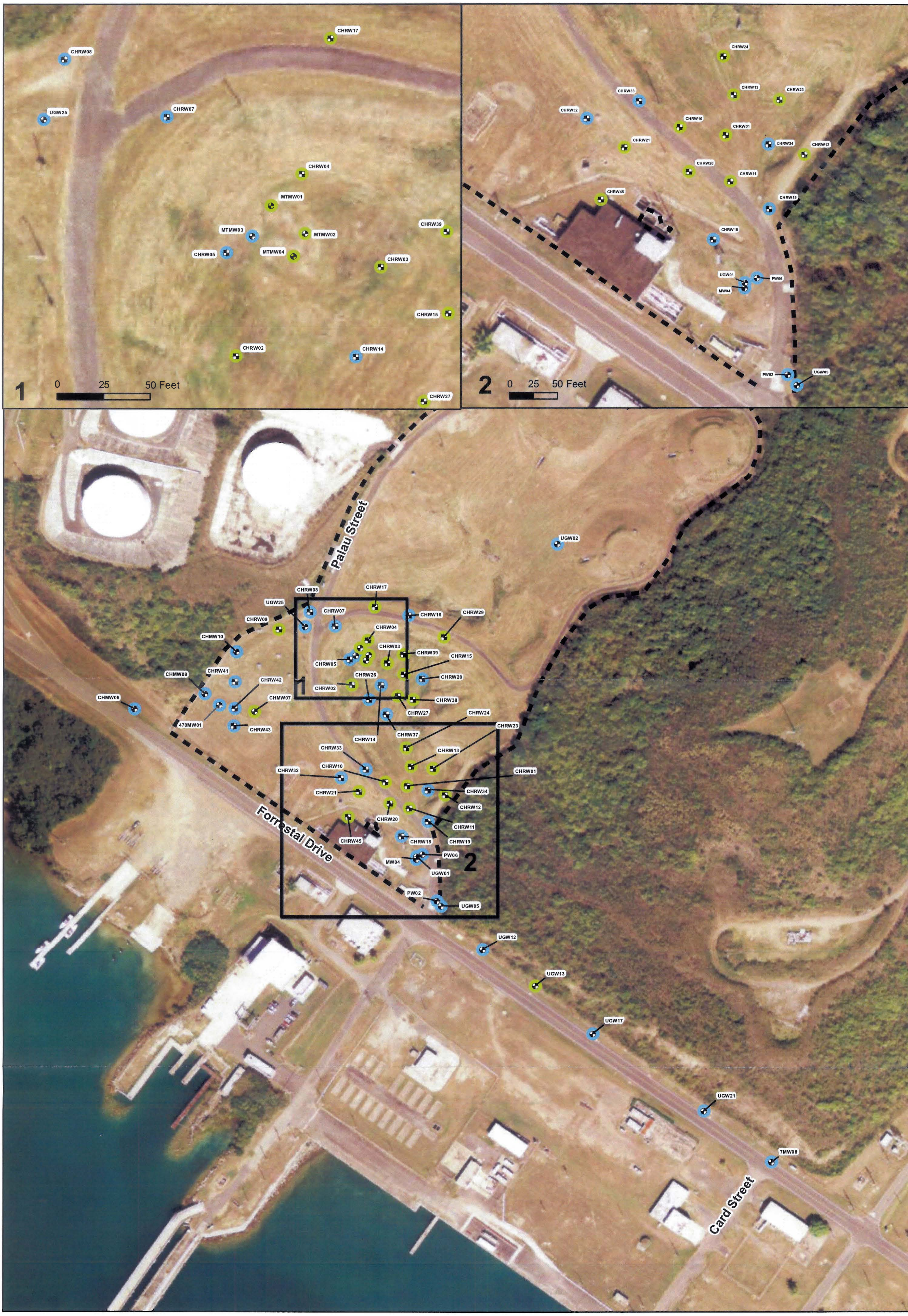
Monitoring and Observation Well
Recovery Well
Fence

N
0 20 40
Feet
1 inch = 40 feet

Originated By: Thomas Kessler *Thomas Kessler*
Checked By: Philip Jones *Philip Jones*

FIGURE 4-9
Skimmer Test Area
CHRW03 and CHRW04
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL



Monitoring and Observation Well
Recovery Well
Hydro Skimmer
Xitech Skimmer
Fence

N

0 100 200 Feet

1 inch = 200 feet

Originated By: Philip Jones *Philip Jones*
Checked By: Ailicia Nobles *Ailicia Nobles*

FIGURE 7-1
Xitech and DGSI Skimmer Location Map
Tow Way Fuel Farm
Naval Activity Puerto Rico

CH2MHILL.

ATL \\GALILEO\PROJ\USNAVY\378718_PUERTORICO\MAPFILES\XITECHANDDGSISKIMMER.MXD MEDELSON 10/13/2011 2:12:19 PM