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PUERTO RICO NS
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CORRECTIVE MEASURES IMPLEMENTATION PLAN SOLID WASTE MANAGEMENT UNIT 54 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 Unit (SWMU) 54
Naval Activity Puerto Rico – Ceiba, Puerto Rico
Corrective Measures Implementation Plan for SWMU 54 Benzene and Ethylbenzene Plume

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 SWMU 54 Benzene and Ethylbenzene Plume 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 Comments Summary	
Regulatory Comments from:	Timothy R. Gordon (EPA Project Coordinator), Robert Young (TechLaw, Inc.), Wilmarie Rivera (PREQB Federal Facilities Coordinator)
Document:	*Corrective Measures Study Addendum SWMU 54 Benzene Plume* and the *Corrective Measures Implementation Plan SWMU 54 Benzene Plume*, Naval Activity Puerto Rico (NAPR), EPA ID PR2170027203, Ceiba, Puerto Rico, dated January 2012
Regulatory Letter Date:	Email Dated: March 30, 2012
Response Due Date:	June 18, 2012
Response Submittal Date:	June 18, 2012

The following comments were generated based on a technical review of the Responses to EPA and EQB comments dated September 9th and 13th, 2011 on the CMS Addendum and CMI Plan dated March 2011. The CMS Addendum Rev. 01 and the CMI Plan Rev. 01, dated January 2012 were also evaluated for compliance with the Responses. An evaluation of the Responses is presented below. Only those general and specific comments which were not adequately addressed are included in the evaluation of the Responses. Following the Responses evaluation below, additional general and specific comments on the CMS Addendum Rev. 01 and CMI Plan Rev, 01 are presented.

The first set of comment evaluations presented below was provided by TechLaw.

GENERAL COMMENTS

Evaluation of Response to EPA General Comment 2: The response partially addresses the comment. The response does not address how the proposed corrective action objective (CAO) and remedial actions will mitigate the at-risk exposure pathways with respect to land use controls (LUCs). The response indicates NAPR is an industrial facility and under the current land use, no direct exposure to site groundwater is occurring, thus no direct exposure to groundwater contamination is occurring. Currently, it is not known whether a LUC plan has been implemented to support the assertions that no exposure to the site groundwater is occurring. LUCs are a necessary component to the remedy to ensure long term protectiveness and will be required until the site is cleaned up for unrestricted exposure and unlimited use. Revise the CMS Addendum Rev. 01 and CMI Plan Rev. 01 to include a reference to an existing document that meets the requirements of the site specific land use control implementation plan (LUCIP) or indicate that one will be prepared for SWMU 54. See Additional General Comment No. 2, below.

Response:

A description of existing LUCs that will be maintained during the remedial action was added to Section 2 of the CMS Addendum. In addition, Section 1.5.2 of the CMI Plan was revised to include a summary of the LUCs to be included in the deed if the parcel were to be transferred.

Evaluation of Response to EPA General Comment 3a, Subpart 4: The response addresses the comment, but additional clarification is required. The information requested in the comment is presented in Section 1.6 of the CMI Plan Rev. 01 and not in Section 1.7 as indicated in the response. Revise the response to provide the correct section reference.

Response:

Comment acknowledged.

Evaluation of Response to EPA General Comment 3, Subpart e: The response partially addresses the comment. The performance criteria are provided in Table 3.1 of the CMI Plan as indicated in the response. However, the performance criteria in Table 3.1 do not specify the expected timeframe. As such, it is unclear if reductions in concentrations must be seen within the span of a few weeks, months, or if a year or more is acceptable. The text on Page 3-5 indicates the design presented in the CMI Plan is adequate to reduce the contaminant concentrations in groundwater to the CAOs within 3 years. However, Table 3-1 does not specify the 3 year time frame indicated in the text. Revise Table 3-1 to include the expected time frame so optimization of system performance is clearly understood.

Response:

Table 3-1 of the CMI Plan was revised as requested.

Evaluation of Response to EPA General Comment 5 and 7: The response addresses the comment with additional clarification required. The information requested in the comment is presented in Appendix C of the CMS Addendum Rev. 01 and not Appendix A as indicated in the response. Revise the response to provide the correct (Appendix A) reference.

Response:

Comment acknowledged.

SPECIFIC COMMENTS FOR CMS ADDENDUM

Evaluation of Response to EPA Specific Comment 2: The response addresses the comment with additional clarification required. The groundwater flow direction is presented only in Figure 3-3, Appendix A, Pilot Scale Test Report, of the CMS Addendum Rev. 01 and not in CMS Addendum Figure 1-2, or in Figure 1-2 in Appendix A as indicated in the response. Revise CMS Addendum Figure 1-2 to include the groundwater flow direction.

Response:

The arrow showing direction of groundwater flow is presented in the bottom left corner of Figure 1-2. The figure was not revised.

Evaluation of Response to EPA Specific Comment 10: The response addresses the comment. However, the TCE concentration presented in the data validation report (DVR) still indicates a

concentration of 1020 µg/L and was not corrected to 100 U µg/L as indicated in the response. Correct the DVR as indicated in the response.

Response:

The revised DVR was not included in the January 2012 submittal. The incorrect DVR has been replaced with the correct version.

TechLaw SPECIFIC COMMENTS FOR CMI PLAN

Evaluation of Response to EPA Specific Comment 1: The response addresses the comment with additional clarification required. The response indicates the requested information is included in Section 3.4.1 of the CMI Plan. However, this information is included in Section 3.5 of the CMI Plan Rev. 01. Revise the response to provide the correct section reference.

Response:

Comment acknowledged.

TechLaw ADDITIONAL GENERAL COMMENTS

1. The CMS Addendum, Appendix A, Section 3.2.3 and Table G-1 indicate TCE results measured in groundwater wells 54MW04 and 54MW05 during the January 2010 period were greater than the respective CAO of 22 µg/L. The text in Section 3.2.3 further indicates that it was determined the detections in monitoring wells that did exceed CAOs did not warrant further investigation because the values were not substantially greater than the respective standard and would be remediated during remedial action intended to address the benzene contamination in groundwater. The 5th bullet on Page 1-8 of the CMS Addendum Rev. 01 states that one deep sparge well will be used to address both the benzene and residual TCE concentrations in the vicinity of 54MW05. Currently, the extent of the TCE problem in groundwater greater than CAOs in the vicinity of 54MW05 is not known. In addition, the biosparge remedy designed to address benzene contamination in groundwater will not be very effective in reducing the TCE concentrations in groundwater via the aerobic biodegradation pathway. As such, volatilization of TCE through the operation of the proposed deep sparge well will be the most likely mechanism for removing TCE from the groundwater. The scope of the TCE problem in groundwater greater than CAOs in the Benzene Area is not known and it appears there is currently no plan or exit strategy to address this issue. Although the CMS Addendum Rev. 01 indicates a deep sparge well will be installed near 54MW05 to treat residual TCE concentrations in the area, additional sampling and analysis for TCE in wells 54MW04 and 54MW06 are not addressed in the CMS Addendum Rev. 01, the CMI Plan Rev. 01 or in the UFP Benzene Plume SAP. As such, it is uncertain how the performance of the biosparge system in reducing TCE in groundwater to below respective CAOs in the Benzene Plume area will be monitored, and evaluated for closure. Revise the CMS Addendum Rev. 01 to address this issue.

   Response:

   Based on comments from EPA, the CAOs for SWMU 54 for were recalculated using 2011 standards. Accordingly, the CAO for TCE was revised to 193 µg/L and the detections of TCE at 54MW04 and 54MW05 no longer exceed the CAO. The text in the pilot test report has been revised to reflect this change.

2. The CMI Plan Rev. 01 indicates that existing Land Use Controls (LUCs) will be included with the corrective action to prevent unintended use of groundwater. However, it is not known whether a site specific LUC implementation plan (LUCIP) currently exits that documents the LUCs, or that one will be prepared for SWMU 54. Preparation of a site specific LUCIP providing the detailed description(s) of the LUCs and/or Institutional Controls (ICs) and procedures for their implementation for contaminated groundwater will be necessary for long term protectiveness. Since groundwater is contaminated above levels that allow for unrestricted exposure and unlimited use, LUCs/ICs will be necessary to prevent current and future exposure and unintended uses of contaminated groundwater and residential land use. Revise the CMI Plan Rev. 01 to indicate whether a LUCIP currently exists or that one will be prepared for SWMU 54. Currently, a description of the LUCs/ICs that will be required to prevent groundwater use and the procedures for verifying their establishment is not known. In addition, the frequency for monitoring and reporting effectiveness as well as the parties responsible (including contact information) for implementing, verifying and monitoring the effectiveness of LUCs/ICs is not known. Revise the CMI Plan Rev. 01 to address this issue.

   Response:

   A description of existing LUCs that will be maintained during the remedial action was added to Section 2 of the CMS Addendum. In addition, Section 1.5.2 of the CMI Plan was revised to include a summary of the LUCs to be included in the deed if the parcel were to be transferred.

3. The CMI Plan Rev. 01 indicates that 19 monitoring wells (54MW01, 54MW02, 54MW06, 54MW27 through 54MW41, and 54MW43) will be sampled as part of the baseline, performance, and closure monitoring. However, the CMI Plan Rev. 01 does not provide a rationale for the selection of these specific wells in the proposed monitoring network. In particular, it is unclear why shallow wells 54MW03, 54MW22 and 54MW42 and deep wells 54MW04, 54MW05, 54MW19 and 54MW21 will not be monitored as they are located at the downgradient edge of the plume. Revise the CMI Plan Rev. 01 to provide a rationale for the wells selected as part of the monitoring network. In addition, either include these additional wells or explain how the downgradient edge of the plume will be effectively monitored without inclusion of the noted shallow and deep wells into the proposed monitoring network.

   Response:

   The rationale for selection of monitoring locations will be provided in Section 2 of the CMI Plan. Additionally, monitoring wells 54MW03, 54MW04, 54MW05, 54MW19, 54MW21, 54MW22, and 54MW42 will be incorporated into the monitoring network for baseline, performance, and closure monitoring.

4. The CMI Plan Rev. 01, Section 3.5 repeatedly refers to the need to see a decreasing trend. However, neither the CMS Addendum Rev. 01 nor the CMI Plan Rev. 01 defines the requirements for a decreasing trend. Revise the respective documents to define the requirements for a decreasing trend (e.g., is a decrease of 100 µg/L; 10%; 20% or greater) or indicate whether trends will be statistically determined (i.e., Mann Kendall analysis).

Response:

Groundwater concentration data from each sampling event were plotted as a function of time, and numerical trends were developed using linear regression. In addition, trends were analyzed using the Mann-Kendall non-parametric statistical test to determine if COC concentrations are increasing, decreasing, or stable. This information was added to Section 3.5 of the CMI Plan.

TechLaw ADDITIONAL SPECIFIC COMMENT

1. **CMI Plan, Rev. 01, Section 1.5.2, Land Use Controls, Page 1-5:** The text indicates that LUCs to prevent the use of groundwater are included as part of the remedy (during cleanup and after reaching the CAOs) in order to be protective of human health. However, the CMI Plan Rev. 01 does not provide details of the actual LUCs that will be implemented in order to achieve the LUC objective of preventing groundwater usage. Please see Additional General Comment No. 2, above.

   Response:

   A description of existing LUCs that will be maintained during the remedial action was added to Section 2 of the CMS Addendum. In addition, Section 1.5.2 of the CMI Plan was revised to include a summary of the LUCs to be included in the deed if the parcel were to be transferred.

The following set of CMS Addendum comment evaluations were provided by PREQB.

All responses to PREQB comments were found to be adequate with the following exceptions:

GENERAL COMMENT

Puerto Rico's Water Quality Standards Regulation has been updated since the original Corrective Measures Study was prepared. The current version dated March 2010, classifies all groundwater as SG, water intended for use as a drinking water supply. Therefore, in order to comply with this Applicable or Relevant and Appropriate Requirement (ARAR), the Corrective Action Objectives (CAOs) for all chemicals of potential concern need to be updated to reflect this current ARAR.

Response:

As agreed to in the Naval Activity Puerto Rico 2004 Reuse Plan, SWMU 54 will be cleaned up to industrial standards and therefore, the CAO will remain as 22 µg/L per the approved August 2005 CMS. If future development would require lower cleanup objectives, the future developer or property owner at that time will be responsible for achieving the more stringent cleanup standards.

Evaluation of Response to PREQB Comment:

PREQB acknowledges that the future development of the site is subject to what is agreed on the Naval Activity Puerto Rico 2004 Reuse Plan and its 2010 Addendum. The 2007 Consent Order between the Navy and EPA specify that the cleanup levels will be established based on the planned future use. This should not be confused with the ARARs for the site. The 2010 Water Quality Standards Regulation of PREQB classifies all groundwater in Puerto Rico as potable, regardless future land development.

Currently the Navy submitted a Groundwater Usability Assessment to EPA and PREQB. The document was commented by PREQB and we are still awaiting response to the comments and revision to the document. Until any agreement regarding groundwater usability at the NAPR is reached, PREQB will require compliance with its Regulations.

Response:

Comment acknowledged.

PAGE SPECIFIC COMMENTS:

1. Page 1-6, Section 1.2, Bullet 2: Please clarify that when referring to VOC concentrations observed, it is referring to VOC air monitoring at the storm sewer monitoring location SS#3. Also, the storm sewer monitoring locations should be depicted in a Figure.

Response:

The text has been clarified to indicate that observed VOC concentrations are those observed at underground utility structures. Vapor monitoring locations (SS#1, SS32, SS#3) were added to Figure 3-1 and 3-2.

Evaluation of Response to PREQB Comment:

The text (now on Page 1-8, Section 1.3, Bullet 1) was adequately clarified. Please notice that the vapor monitoring locations were added to Figure 1-4 instead of Figures 3-1 and 3-2. Actually, there are no Figures 3-1 and 3-2 on the current version of the document.

Response:

Comment acknowledged.

2. Page 3-5, Section 3.1, Bullet 3: Please provide details as to how you will confirm that soils are suitable for use as backfill.

Response:

Soil will be screened using a field-calibrated photoionization detector (PID) during trenching to determine if the soils are suitable for backfill. Soils that generate a PID response less than 100 parts per million (ppm) and that are free of debris greater than ½ inch in diameter and sharp objects will be deemed suitable for backfill. Unsuitable backfill will be segregated on plastic sheeting for offsite disposal. This information was included in Section 1.6 of the CMI Plan.

Evaluation of Response to PREQB Comment:

Section 1.6 of the Corrective Measures Implementation (CMI) Plan does not mention the use of material determined free of contamination and suitable for backfill as backfill of the piping trenches. Please clarify and, if necessary, include it on the CMS Addendum. Hence, the CMI Plan should be modified to include this practice.

Response:

Because there were no exceedances of CAOs observed in surface soils at SWMU 54, all surface soils are considered free of contamination and suitable for backfill of the piping trenches.

EQB ADDITIONAL COMMENTS:

1. Page 3-1, Section 3.1.2, First Paragraph: Please complete the last sentence to clarify if AGVIQ-CH2MHILL believes that the estimated time required to achieve CAOs will be approximately 3 years.

   Response:

   Section 3.1.2 of the CMS Addendum was revised as requested.

2. Page 3-1, Section 3.1.4: Please revise the sentence. The Naval Activity Reuse Plan (NAVFAC, 2004 and 2010) established the planned reuse of the property, not the CAOs.

   Response:

   Section 3.1.4 of the CMS Addendum was revised as requested.

The following set of CMI Plan comment evaluations were provided by PREQB.

All responses to PREQB comments were found to be adequate with the following exceptions:

GENERAL COMMENT

Puerto Rico's Water Quality Standards Regulation has been updated since the original Corrective Measures Study was prepared. The current version dated March 2010, classifies all groundwater as SG, water intended for use as a drinking water supply. Therefore, in order to comply with this Applicable or Relevant and Appropriate Requirement (ARAR), the Corrective Action Objectives (CAOs) for all chemicals of potential concern need to be updated to reflect this current ARAR.

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Response:

Comment acknowledged.

Corrective Measures Implementation Plan
SWMU 54 Benzene and Ethylbenzene Plume

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
CH2M HILL
JOINT VENTURE

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June 2012

Corrective Measures Implementation Plan

SWMU 54
Benzene and Ethylbenzene Plume

Naval Activity Puerto Rico
Ceiba, Puerto Rico

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Submitted to:

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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
Corrective Measures Implementation Plan
(Revision No. 00)
SWMU 54
Benzene and Ethylbenzene Plume

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: Mark. E. Davidson

Title: BRAC Environmental Coordinator

Date: June 15, 2012

Contents

Appendices - (Provided on CD)

Tables

Figures

Acronyms and Abbreviations

AGVIQ-CH2M HILL	AGVIQ-CH2M HILL Constructors, Inc. Joint Venture III
AS	air sparge
Baker	Baker Environmental, Inc.
bgs	below ground surface
BRAC	Base Realignment and Closure
CAO	corrective action objective
cm/sec	centimeters per second
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
HDPE	high density polyethylene
HSA	hollow stem auger
ID	inner diameter
LRA	Puerto Rico Local Redevelopment Authority
LUC	land use control
µg/L	micrograms per liter
mg/L	milligrams per liter
MNA	monitored natural attenuation
NAPR	Naval Activity Puerto Rico
NAVFAC SE	Naval Facilities Engineering Command Southeast
NFA	no further action
NSRR	Naval Station Roosevelt Roads
OM&M	Operation, Maintenance, and Monitoring
ORP	oxidation-reduction potential
PCB	polychlorinated biphenyl
PVC	polyvinyl chloride

RCRA	Resource Conservation and Recovery Act
scfm	standard cubic feet per minute
SOP	Standard Operating Procedure
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TCLP	toxicity characteristic leaching procedure
TCE	trichloroethene
VOC	volatile organic compound
yd^3	cubic yards

1.0 Conceptual Design

1.1 Introduction

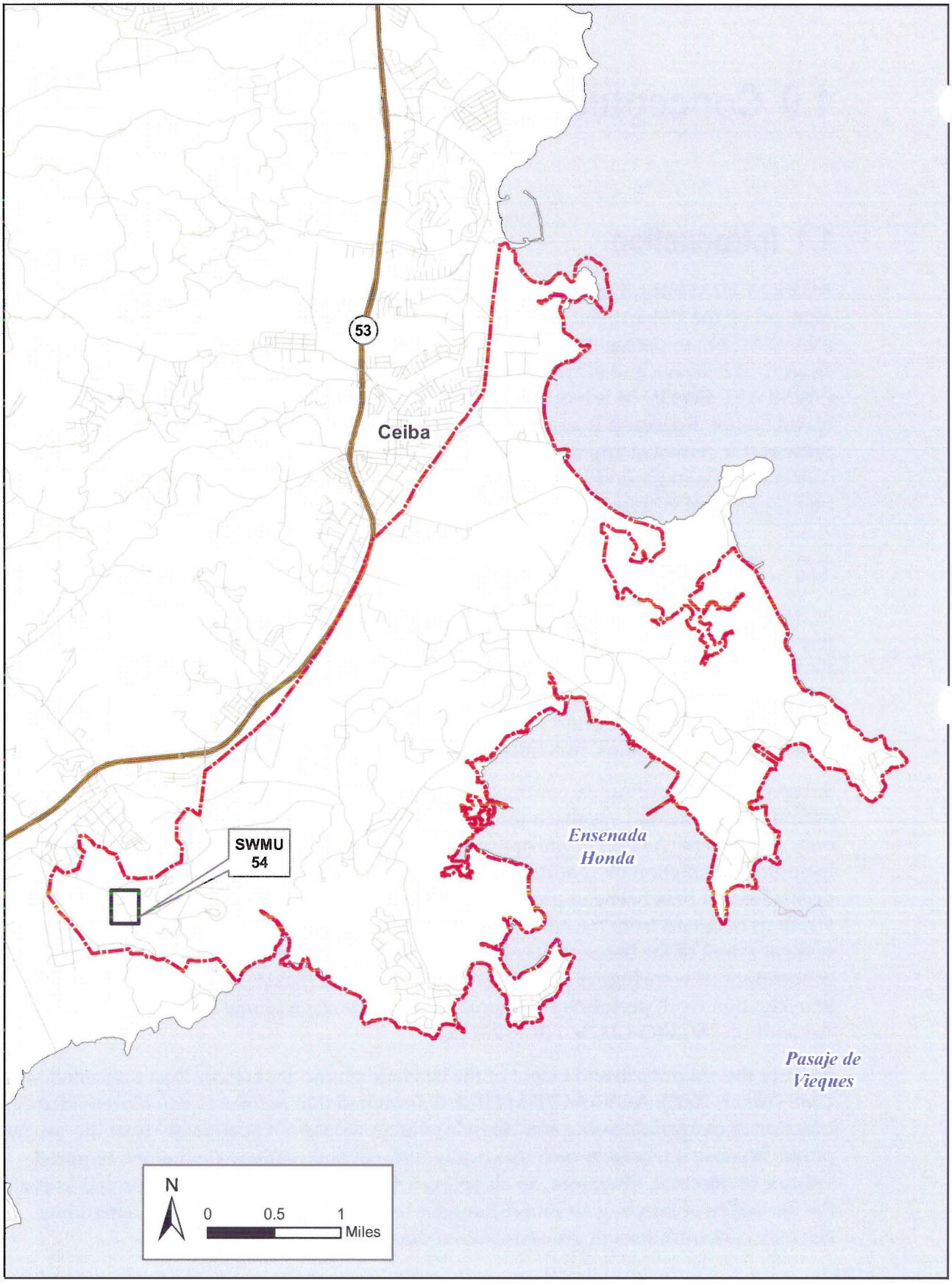
AGVIQ-CH2M HILL Constructors, Inc. Joint Venture III (AGVIQ-CH2M HILL) has been retained by the Department of the Navy, Naval Facilities Engineering Command Southeast (NAVFAC SE) to prepare a Corrective Measures Implementation (CMI) Plan to address the cleanup of benzene and ethylbenzene in groundwater beneath Solid Waste Management Unit (SWMU) 54. SWMU 54 is located at Naval Activity Puerto Rico (NAPR), formerly known as Naval Station Roosevelt Roads (NSRR), in Ceiba, Puerto Rico (Figure 1-1). This CMI plan presents the remedial approach and technologies that will be implemented to reduce benzene concentrations in groundwater to the corrective action objective (CAO) of 160 micrograms per liter (µg/L) and ethylbenzene to the CAO of 493 µg/L.

1.2 Site Background

In 2005, Baker Environmental, Inc. (Baker) prepared a *Corrective Measures Study Final Report* (hereinafter referred to as the CMS) for remedial actions at NAPR, including SWMU 54 (Baker, 2005). The CMS included human health and ecological risk assessments to develop CAOs for the cleanup of contaminants in groundwater. A CAO of 550 µg/L was calculated for benzene at SWMU 54, and the subsurface injection of oxygen-releasing compounds was proposed to achieve the CAO. Ethylbenzene did not exceed the CAO developed in the CMS.

Subsequently, NAVFAC SE contracted AGVIQ-CH2M HILL to review the CMS and optimize the remedial approach for the site. The work was based on the CMS and focused only on benzene. As part of the optimization, an additional investigation was performed including installation of 32 additional monitoring wells to determine the horizontal and vertical extent of benzene in groundwater prior to implementing corrective actions. Findings obtained from the additional investigation work indicated that the horizontal and vertical extent of the benzene was greater than described in the CMS, and benzene concentrations were higher than presented in the CMS (Baker, 2005). The additional investigation work performed to characterize the benzene plume is described in the CMS Addendum (AGVIQ-CH2M HILL, 2012a).

Because the magnitude and extent of the benzene plume are greater than presented in the CMS (Baker, 2005), AGVIQ-CH2M HILL determined that aerobic in situ bioremediation via injection of oxygen-releasing compounds (slurry) would not adequately treat the benzene plume because it would be technologically difficult and costly to deliver the required volume of injectant. Therefore, an air sparge (AS) pilot-scale test was performed to evaluate the feasibility of injecting air into the aquifer to volatilize and biodegrade remaining benzene concentrations in groundwater to the CAO.



Road

Expressway

Naval Station Roosevelt Roads Boundary

FIGURE 1
SWMU 54 Location
SWMU 54
Naval Activity Puerto Rico

AS pilot-scale testing was performed in May 2010. During the pilot-scale test, air was injected into a single well (54AS01) at varying pressures and flows, and changes in water level, dissolved oxygen (DO), and oxidation-reduction potential (ORP) were monitored to evaluate air distribution. Details regarding the pilot-scale testing are provided in the CMS Addendum (AGVIQ-CH2M HILL, 2012a). Conclusions from the pilot-scale test results include the following:

- Air distribution in the subsurface at SWMU 54 is highly variable and is a function of the air injection rate and the heterogeneity of the formation.

  Based on these results, injected air is expected to travel along zones that have a higher permeability (and associated hydraulic conductivity). These same high permeability zones are likely the same pathways along which the benzene originally migrated. In these zones, benzene will decrease in concentration through volatilization and aerobic biological degradation. The smaller amount of benzene sorbed in the lower permeability units will decrease in concentration through a combination of aerobic biodegradation, dilution, and dispersion.

- AS was effective in distributing air to the formation at SWMU 54 to promote volatilization of benzene and increased DO to support aerobic biodegradation of benzene. Increases in DO and ORP concentrations were primarily observed in the deep monitoring wells (screened deeper than 15 feet bgs) because of the placement of the injection well screen at approximately 24 to 26 feet bgs.

- DO response was observed as far away from the injection well as 40 feet; however, results were not consistent in all directions around the monitoring well.

  Based on a review of pilot-scale results, a conservative radius of influence for a single injection well is estimated to be approximately 15 feet at an injection flow rate of 4 standard cubic feet per minute (scfm). An injection flow rate of 4 scfm was selected based on DO response observed in deep zone monitoring wells during pilot-scale testing. Because the hydraulic conductivity results for both the deep and shallow zones were similar (2.6E-4 centimeters per second [cm/sec] to 9.4E-4 cm/sec), the same DO and ORP response is expected in shallow zone monitoring wells with the proper placement of the injection well screen at the base of the zone. DO response was observed as far away from the injection well as 40 feet; however, results were not consistent in all directions around the monitoring well. Based on a review of pilot-scale test results, a conservative radius of influence for a single injection well is estimated to be approximately 15 feet at an injection flow rate of 4 scfm.

  During pilot testing, a similar DO response was not observed at 4 scfm in the shallow zone monitoring wells because the injection well was screened in the deep zone and because the nearest shallow monitoring well to the injection well was approximately 17 feet away. A similar DO response is expected at 4 scfm in the shallow zone when injection wells are installed in the shallow unit and monitoring wells are located at a closer proximity to the injection wells. AS injection well spacing of 20 feet between wells is recommended for full-scale application to provide overlap of sparging influence and adequately distribute the air into the formation at a low injection flow rate. The system

will be equipped with additional capacity to increase injection flow to each AS well if necessary.

- Volatile organic compound (VOC) concentrations observed at storm sewer monitoring location SS#3 (located approximately 65 feet south of the AS injection well) during air monitoring indicate that VOCs liberated from groundwater during the AS pilot-scale test may be traveling through the gravel backfill that surrounds the sewer pipe. Because of the highly variable nature of the distribution of air both horizontally and vertically, and the potential for VOC-laden air to migrate along the backfill of the utility corridors, the AS system was designed with an operational rate of 4 scfm per injection point to minimize effects of volatilization.

- Shallow injection wells installed to a depth of approximately 16 to 18 feet below ground surface (bgs) will be utilized to address VOC concentrations in the shallow zone, while deeper injection wells installed to a depth of approximately 26 to 28 feet bgs should be installed to address intermediate zone impacts.

- AS wells should be individually plumbed from a common equipment manifold and operated on a pulsed frequency to minimize the size of the AS compressor required and to limit the potential for vapor migration along utility corridors or other preferential pathways.

Based on the favorable pilot-scale test results, NAVFAC SE will amend the remedial approach presented in the CMS (Baker, 2005) using biosparging. Biosparging will combine the benefits of oxygen addition to groundwater and the unsaturated zone to increase aerobic biodegradation of benzene, and the benefits of air sparging to volatilize benzene from site groundwater. Biosparge system details are described in Section 3.

1.3 Corrective Action Objectives

The 2005 CAO development is summarized below and is fully described in the CMS (Baker, 2005). The U.S. Environmental Protection Agency (EPA) conditionally approved the CMS (Baker, 2005) on October 13, 2005, contingent upon completion of the pilot-scale tests and CMI Plan.

Appendix B of the CMS (Baker, 2005) included a derivation of groundwater CAOs for VOCs. The 2005 groundwater CAOs were developed based on an industrial use of SWMU 54. The CAOs were estimated using the Johnson-Ettinger Model for the target groundwater levels protective of industrial worker exposure to indoor air in an industrial building and construction workers having direct contact with shallow groundwater.

The 2005 CAO for benzene was used to delineate the benzene plume and design the corrective action during the pilot-scale testing in 2009 to 2010. Ethylbenzene did not exceed the 2005 CAO and was not taken into consideration during the pilot-scale testing, although future site work will require consideration of ethylbenzene and benzene.

In May 2012, the 2005 CAOs were revised using EPA's regional screening levels (November 2011 version) based calculation methods and toxicity factors, as recommended by EPA. The derivations of the revised CAOs are detailed in the CMS Addendum (AGVIQ-CH2M HILL, 2012a).

The revised CAO for benzene in groundwater is 160 µg/L and the revised CAO for ethylbenzene is 493 µg/L.

1.4 Contaminant Migration Potential

The SWMU 54 benzene plume appears to have multiple sources, a deeper plume associated with the former underground storage tank on the east side of Bairoko Street, shallow plumes from unknown sources on the east side of Bairoko Street, and a shallow plume from an unknown source on the west side of Bairoko Street. Because there is no current baseline data for ethylbenzene, it is assumed it will be associated with the benzene plumes. Ethylbenzene tends to be more sorbed to soils and less soluble in groundwater when compared to benzene, so migration of ethylbenzene will be more limited than benzene (Oak Ridge National Laboratory, 1989). No further releases of benzene or ethylbenzene are occurring at SWMU 54.

No surface water bodies are located within the SWMU 54, or in the immediate downgradient areas of the site. The benzene and ethylbenzene plume is wholly contained in the SWMU 54 area within the NAPR property. The rate of groundwater flow has been determined to be very slow at 0.003 feet per day, or about 1 foot per year. Thus, groundwater contaminated with benzene and ethylbenzene is not migrating outside the SWMU 54 area and no surface water discharge is expected from the contaminant plume at SWMU 54. No human receptors have been identified in the SWMU 54 or downgradient areas under current land use.

Benzene and ethylbenzene exist in the dissolved phase and may migrate with groundwater. In addition, both compounds may also volatilize from groundwater into soil gas and then further to ambient air. However, air monitoring conducted during field activities in 2009 and 2010 indicated no significant concentrations of VOCs in ambient air.

1.5 Description of Corrective Measures

1.5.1 Technical Approach

The contaminant plume remediation will be accomplished through installation of a biosparge system. Sparge wells will be installed in both the shallow and deep zones and air will be injected at approximately 4 scfm to increase the DO content of the aquifer and enhance aerobic degradation of benzene and ethylbenzene in situ. Although the benzene CAO is 160 µg/L and the ethylbenzene CAO is 493 µg/L, the biosparge system will be installed to the boundary of the 100 µg/L benzene. It is assumed the ethylbenzene plume exceeding 493 µg/L will be contained within this area. Baseline monitoring will be conducted to confirm the ethylbenzene extent prior to installation of the biosparge system.

1.5.2 Land Use Controls

Current land use controls (LUCs), including restricted access to the SWMU 54 area through security fencing and prohibited use of groundwater, will be maintained until the CAOs are achieved in both the trichloroethene (TCE) area and the benzene area. When corrective action is complete, 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 Resource Conservation and Recovery Act (RCRA) Administrative Order on Consent for this property (provided to the Puerto Rico 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 Base Realignment and Closure (BRAC) Program Management Office, Southeast.

1.5.3 Summary of Major Assumptions

A summary of major assumptions used in development of this technical approach are outlined below:

- **DO response in the shallow zone will be similar to response in the deep zone observed during pilot testing.** This assumption is based on a review of the aquifer slug test results included with the CMS Addendum (AGVIQ-CH2M HILL, 2012a). Results indicate an average hydraulic conductivity for wells completed in the saprolite of approximately 2.6E-4 centimeters per second (cm/sec) and for wells completed in the clay of approximately 9.4E-4 cm/sec. Because little variation has been observed in the hydraulic conductivity results for the two units, distribution of DO is expected to be similar in both zones.
- **Groundwater salinity will not adversely affect remediation of the benzene plume.** Salinity values calculated based on conductivity data collected during well purging average approximately 1 part per thousand. Based on the low salinity values (within the range of fresh to brackish water) observed during groundwater sampling and the location of the site greater than 1 mile from the ocean, salinity was not considered to have potential for adverse impacts to the treatment process (aerobic degradation).

1.6 Waste Management

1.6.1 Solid Waste

Soil cuttings generated from well installation will be containerized in 20-cubic yard (yd^3) rolloff boxes at a Base-approved temporary storage location pending waste characterization and offsite disposal. Based on soil waste characterization data collected during the pilot-scale testing, soil cuttings are expected to be non-hazardous.

One soil sample will be collected for waste characterization from each roll-off box. The soil samples will be analyzed for toxicity characteristic leaching procedure (TCLP) VOCs (SW1311/8260C), TCLP semivolatile organic compounds (SVOCs) (SW1311/8270D), TCLP metals (SW1311/6010C/7470A), TCLP pesticides (SW1311/8081B), TCLP herbicides (SW1311/8151A), polychlorinated biphenyls (PCBs) (SW8082), corrosivity (SW9045), and ignitability (SW1010).

Soils generated during trenching will be temporarily piled on the side of the trench. Soils that are free of debris greater than ¼-inch in diameter and sharp objects will be deemed suitable for backfill. During the CMS, a quantitative CAO for benzo(a)pyrene was developed for surface soils. However, no surface soil samples were observed to exceed this CAO and surface soils are considered appropriate for reuse. Unsuitable backfill will be segregated and handled in accordance with soil cuttings.

1.6.2 Liquid Waste

Liquids from decontamination, well development, and purge water will be placed in 600-gallon poly tanks within secondary containment at Base-approved temporary storage locations pending waste characterization and offsite disposal. Based on liquid waste characterization data collected during the pilot-scale testing, soil cuttings are expected to be non-hazardous.

One liquid sample will be collected per a year and analyzed for RCRA VOCs (SW8260C), RCRA SVOCs (SW8270D), RCRA metals (SW6010C/7470A), RCRA pesticides (SW8081B), PCBs (SW8082A), herbicides (SW8151A), corrosivity (SW9045), and ignitability (SW 1010).

1.7 Required Permits

According to the NAPR, no dig permit will be required for this project. The Puerto Rico Environmental Quality Board has indicated the injection notification for pilot-scale testing should be amended to include the corrective action sparging application.

2.0 Operation, Maintenance, and Monitoring

2.1 Operation, Maintenance, and Monitoring Plan

An Operation, Maintenance, and Monitoring (OM&M) Plan will be developed based on the final system installation and operating conditions. Because of the dynamic nature of in situ systems, it is not possible to design optimal operating conditions prior to construction and therefore, it is most efficient to generate an OM&M Plan after system construction.

System monitoring will be performed to evaluate the effectiveness of biosparging to achieve the remedial objectives and determine when the system will be turned off. Additionally, system flow and pressure measurements will be recorded during the OM&M site visits.

The OM&M Plan will contain the following elements:

1.0 Introduction

- Purpose and Scope
- System Description

2.0 System Operations

- Startup Procedures
- Vapor Monitoring
- Routine Operations
- Biofouling Evaluation
- Shut Down Procedures
- Emergency Procedures
- Summary of Normal Operating Conditions

3.0 System Monitoring

- Data Collection Procedures
- Performance Monitoring

4.0 Waste Management

5.0 OM&M Contingency Procedures

6.0 References

Appendices

- Process and Instrumentation Diagram
- Equipment Building Layout
- Electrical Drawings
- Equipment Cut Sheets and Manuals
- Startup Checklist
- Routine Operational Data Collection Form
- Shut Down Checklist

2.2 Performance Monitoring

Quarterly groundwater sampling events will be conducted beginning 90 days after the completion of system startup. Quarterly monitoring will be conducted for the first year following system activation to evaluate and optimize the biosparge system operations and semi-annually thereafter during active system operations (expected to be a total of up to 3 years). Groundwater samples will be collected from monitoring wells 54MW01 through 54MW06, 54MW19 through 54MW22, 54MW27 through 54MW43, and two new monitoring wells. These samples will be analyzed for benzene and ethyl benzene to evaluate system effectiveness. The sample locations are shown on Figure 2-1. All sampling and analyses will be conducted in accordance with the Sampling and Analysis Plan (AGVIQ-CH2MHILL, 2012b). Table 2-1 provides rationale for the wells selected for performance, baseline, and closure monitoring.

TABLE 2-1
Monitoring Well Matrix
SWMU 54
Naval Activity Puerto Rico

Well ID	Monitoring Group	Rationale
54MW01	Baseline, Performance, Closure	Shallow zone well impacted by benzene and located within shallow treatment area.
54MW02	Baseline, Performance, Closure	Shallow zone well impacted by benzene and located within shallow treatment area
54MW03	Baseline, Performance, Closure	Shallow zone well where benzene has not historically been detected above CAO; however, well located downgradient of southern edge of shallow treatment area.
54MW04	Baseline, Performance, Closure	Deep zone well where benzene has not historically been detected above CAO; however, well located downgradient of deep treatment area.
54MW05	Baseline, Performance, Closure	Deep zone well where benzene has not historically been detected above CAO; however, well located downgradient of deep treatment area.
54MW06	Baseline, Performance, Closure	Shallow zone well impacted by benzene and located within shallow treatment area.
54MW19	Baseline, Performance, Closure	Deep zone well where benzene has not historically been detected above CAO; however, well located downgradient of deep treatment area.
54MW20	Baseline, Performance, Closure	Shallow zone well impacted by benzene and located within shallow treatment area.
54MW21	Baseline, Performance, Closure	Deep zone well where benzene has not historically been detected above CAO; however, well located downgradient of deep treatment area.
54MW22	Baseline, Performance, Closure	Shallow zone well where benzene has not historically been detected above CAO; however, well located downgradient of southern edge of shallow treatment area.

TABLE 2-1
Monitoring Well Matrix
SWMU 54
Naval Activity Puerto Rico

Well ID	Monitoring Group	Rationale
54MW23	None	Deep zone well where benzene has not been detected above CAO historically; other deep zone monitoring wells in direction of groundwater flow used to monitor downgradient migration closer to treatment area.
54MW24	None	Shallow zone well where benzene has not been detected above CAO historically and not in direction of primary groundwater flow.
54MW25	None	Deep zone well where benzene has not been detected above CAO historically and not in direction of primary groundwater flow.
54MW26	None	Shallow zone well where benzene has not been detected above CAO historically and not in direction of primary groundwater flow.
54MW27	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
54MW28	Baseline, Performance, Closure	Shallow zone where benzene has not been detected above CAO historically; however, the well lies in the deep zone treatment area and will be monitored during active operations.
54MW29	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
54MW30	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
55MW31	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
54MW32	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
54MW33	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
54MW34	Baseline, Performance, Closure	Shallow zone well impacted by benzene and located within shallow treatment area.
54MW35	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
54MW36	Baseline, Performance, Closure	Deep zone well impacted by benzene and located within deep treatment area.
54MW37	Baseline, Performance, Closure	Deep zone well where benzene has not been detected above CAO historically; however, well is located immediately downgradient of deep treatment area.
54MW38	Baseline, Performance, Closure	Deep zone well where benzene has not been detected above CAO historically; however, well is located downgradient of deep treatment area.
54MW39	Baseline, Performance, Closure	Deep zone well where benzene has not been detected above CAO historically; however, well is located downgradient of deep treatment area.

TABLE 2-1
Monitoring Well Matrix
SWMU 54
Naval Activity Puerto Rico

Well ID	Monitoring Group	Rationale
54MW40	Baseline, Performance, Closure	Shallow zone well where benzene has not been detected above CAO historically; however, well located immediately downgradient of shallow treatment area in primary direction of groundwater flow.
54MW41	Baseline, Performance, Closure	Deep zone well where benzene has not been detected above CAO historically; however, well is located downgradient of deep treatment area and is located within the shallow zone treatment area.
54MW42	Baseline, Performance, Closure	Shallow zone well where benzene has not been detected above CAO historically; however, well located immediately downgradient of shallow treatment area.
54MW43	Baseline, Performance, Closure	Shallow zone well impacted by benzene and located within shallow treatment area.
54MW44	None	Upgradient deep zone well where benzene has not historically been detected above CAO.
54MW45	Baseline, Performance, Closure	Shallow zone well to be installed during baseline sampling event.
54MW46	Baseline, Performance, Closure	Shallow zone well to be installed during baseline sampling event.
510DW1	None	Deep zone well impacted by benzene and located within deep treatment area; however, located approximately 10 feet from 54MW27 that monitors similar zone.
510DW2	None	Deep zone well impacted by benzene and located within deep treatment area; however, located approximately 10 feet from 54MW33 that monitors similar zone.
510MW1	None	Shallow zone well where benzene has not been detected above CAO historically and is located outside the shallow zone treatment area.
510MW2	None	Shallow zone well where benzene has not been detected above CAO historically.
510MW3	None	Shallow zone well where benzene has not been detected above CAO historically and is located well outside the shallow zone treatment area.
510MW4	None	Shallow zone well where benzene has not been detected above CAO historically and is located well outside the shallow zone treatment area.

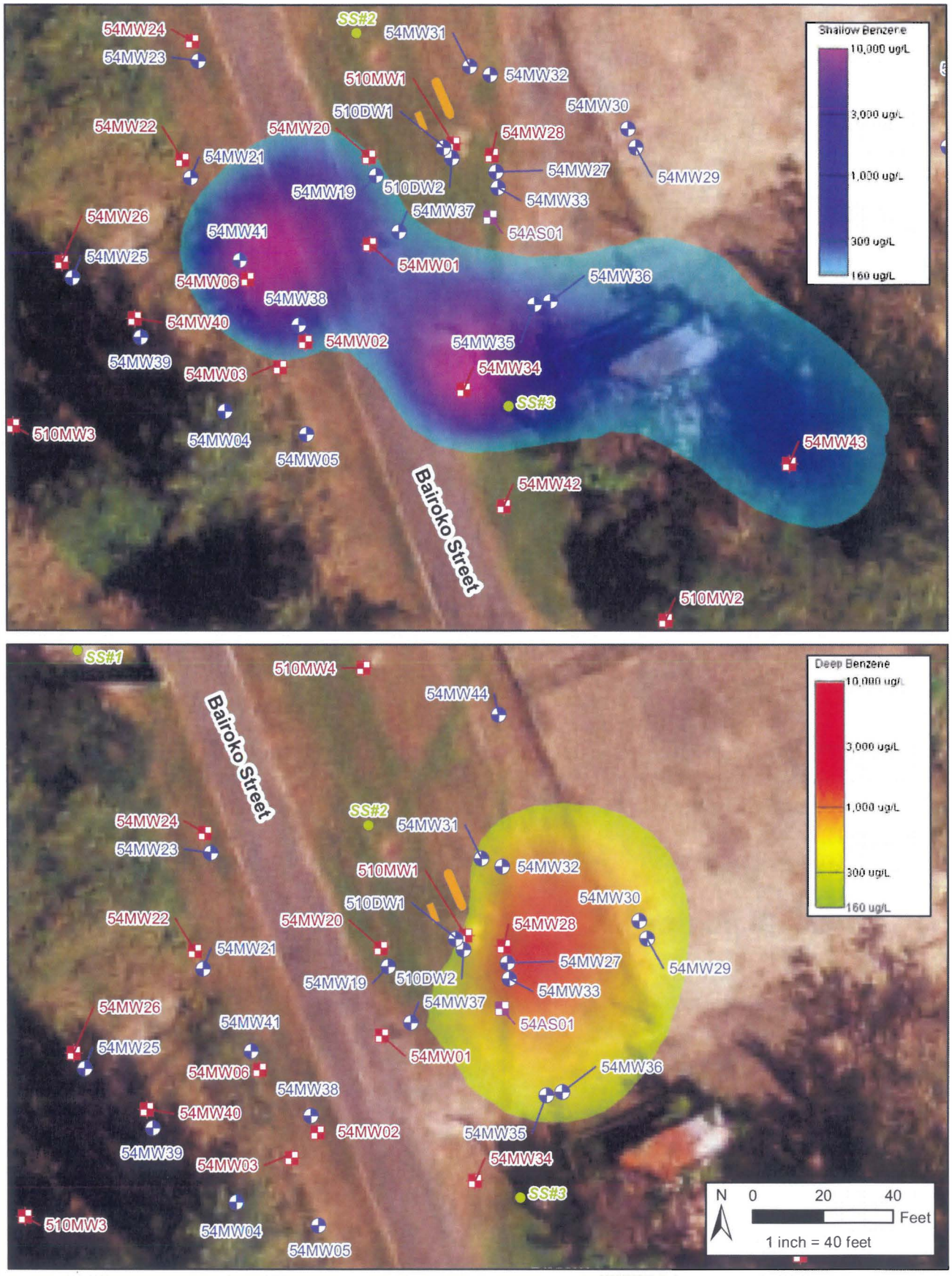


FIGURE 2-1
Benzene Concentrations Exceeding Corrective Action Objective
August 2009 Through October 2010
SWMU 54
Naval Activity Puerto Rico

CH2MHILL.

Trend analysis will be completed based on performance monitoring results and evaluated to determine if active remediation should continue, be discontinued, or if system modifications (including installation of additional injection wells and system expansion) should be completed to enhance system effectiveness. Once CAOs have been achieved and demonstrated through performance monitoring and the system is deactivated, the 1 year quarterly closure groundwater monitoring program will be implemented. If concentration rebound occurs during closure monitoring, reactivating system operations and implementation of long-term monitored natural attenuation (MNA) monitoring will be evaluated. Results of these evaluations will be provided to EPA for review and comment in the semi-annual reports.

During well purging, field measurements of DO, turbidity, conductivity, pH, salinity, temperature, and ORP will be recorded. DO concentrations will be monitored with a goal of achieving greater than 2 milligrams per liter (mg/L) throughout the monitoring network. Following the collection of the field measurements, water quality samples will be collected from each well for the analysis of benzene and ethylbenzene using EPA Method 8260B. Purge water generated during sampling will be managed in accordance with the procedures described in Section 1.6.

2.3 Vapor Monitoring

Vapor monitoring will be performed to test for the presence of VOC vapors in storm sewer vaults within the area of sparge influence, SS#1, SS#2, and SS#3 on Figure 2-1. Prior to system startup, a photoionization detector will be used to collect baseline VOC readings in all nearby storm sewer vaults and manholes. During the first week of system startup, vapor monitoring will be performed daily to monitor potential changes in vapor concentrations. If vapor concentrations increase from baseline conditions observed during the first day of operations, system operation may be modified (that is, decrease flow rates) to minimize the buildup and/or migration of vapors. A comparison against baseline conditions rather than a concentration limit will be used to determine if mitigation measures are required.

2.4 Reporting

A summary of the SWMU 54 activities described in this CMI Plan, and the progress of each activity, will be presented in semi-annual technical reports. The outline of the reports is as follows:

Executive Summary

1.0 Introduction

- Purpose and Scope
- Background Information

2.0 Summary of Activities Completed During Monitoring Period

- Biosparge System Operations (including discussion of problems encountered and how they were addressed)
- Well Gauging and Sampling Procedures

- Summary of Contact with Local Community or Government and Public Interest Groups

3.0 Discussion of Results

- Groundwater Flow
- Groundwater Monitoring Results
- Vapor Monitoring Results
- System Effectiveness Evaluation
- Lessons Learned

4.0 Conclusions and Recommendations (including proposed work for next reporting period)

5.0 References

3.0 Final Plans and Specifications

The CMS (Baker, 2005) was amended to recommend implementation of biosparge to address benzene and ethylbenzene in groundwater at SWMU 54. The biosparge technology is described in the CMS Addendum (AGVIQ CH2M HILL, 2012a). The fieldwork is summarized in the following subsections.

3.1 Site Preparation

According to the NAPR, no dig permit will be required for this project; however, utilities are known to exist in the area and a utility clearance will be conducted in the work area prior to beginning intrusive activities.

3.2 Baseline Monitoring

Two monitoring wells will be installed to complete the horizontal delineation on the southeast side of the shallow plume, as shown in Figure 3-1. The wells will be installed using hollow-stem auger (HSA) drilling techniques. As the boring is advanced, soil samples will be collected every 5 feet for lithologic description.

The wells will be constructed using 2-inch inner diameter polyvinyl chloride (PVC) casing. The monitoring well screens will be placed between 10 and 25 feet bgs, and constructed of 0.020-inch slot screen. The wells will be finished with a threaded 2-inch PVC riser to reach ground surface. Sand filter pack and bentonite seal material will be installed, and the annular space will be grouted to the ground surface with Portland cement grout. Each well will be completed with a 3-foot by 3-foot cement pad with locking cover. Additionally, four bollards painted yellow will be installed at each corner of the well pad. Actual depth of the wells may be changed in accordance with observations made by the field personnel during well installation activities.

The wells will be developed after the annular space grout has been allowed to cure for a minimum of 24 hours. The development procedures will comply with the SOPs provided in Appendix A.

The coordinate locations and elevations of the installed wells will be surveyed by a land surveyor registered in Puerto Rico. The wells will be surveyed relative to a previously established benchmark. The horizontal location will be surveyed to an accuracy of 0.1 foot, and the ground surface and top of casing elevations will be surveyed to an accuracy of 0.01 foot.

Soil cuttings generated during well installation will be managed in accordance with the procedures described in Section 1.6.

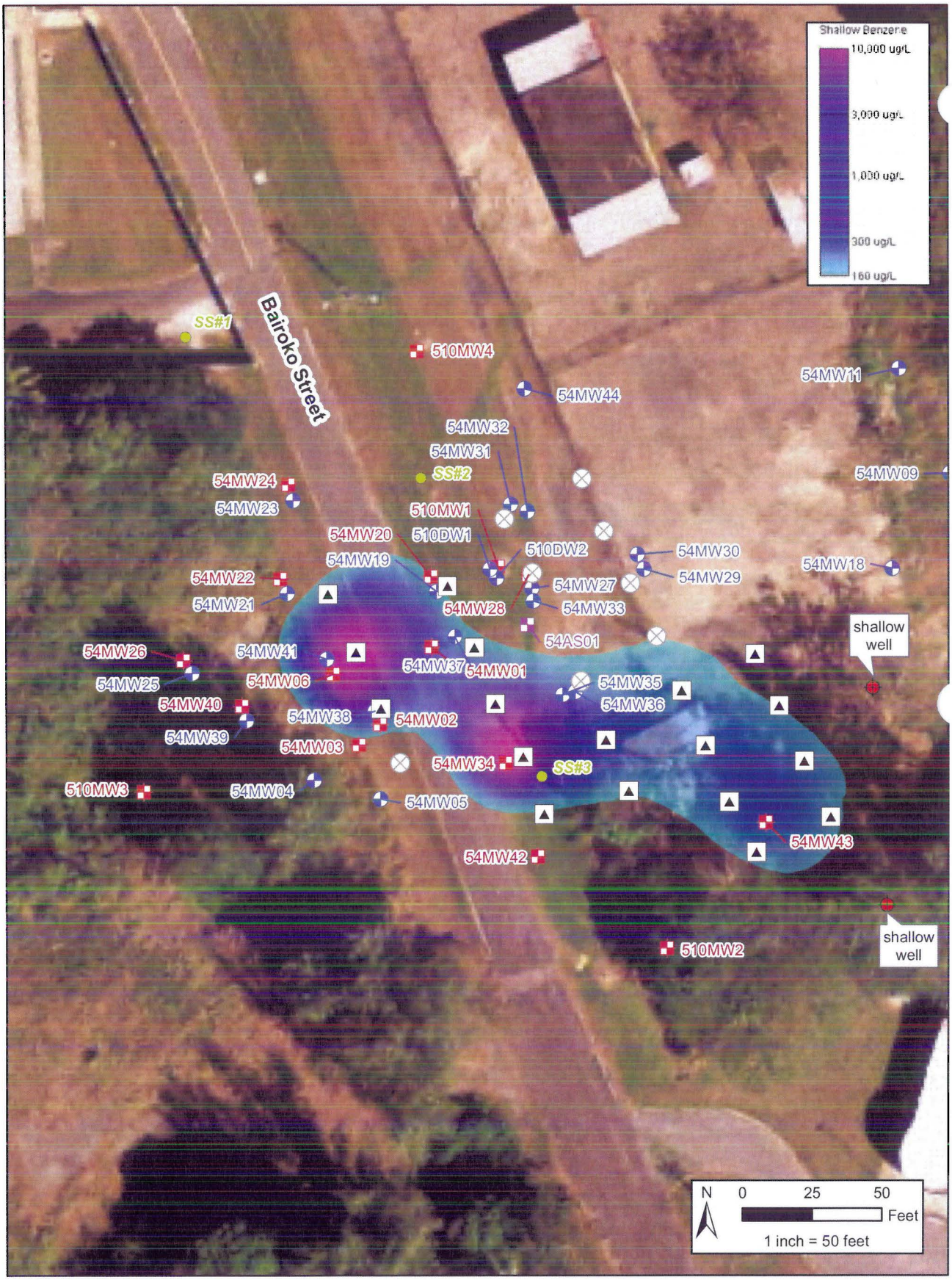


FIGURE 3-1
Proposed Shallow Biosparge Layout
SWMU 54
Naval Activity Puerto Rico

CH2MHILL.

Baseline groundwater sampling will be conducted prior to injection well installation. Groundwater samples will be collected from monitoring wells 54MW01through 54MW06, 54MW19 through 54MW22, 54MW27 through 54MW43, and the two new monitoring wells to evaluate benzene, ethylbenzene, and DO concentrations prior to system startup. The sample locations are shown on Figure 2-1. All sampling and analyses will be conducted in accordance with the field Standard Operating Procedures (SOPs) (Appendix A) and the Sampling and Analysis Plan (AGVIQ-CH2MHILL, 2012b).

During well purging, field measurements of DO, turbidity, conductivity, pH, salinity, temperature, and ORP will be recorded. Following the collection of the field measurements, water quality samples will be collected from each well for the analysis of benzene using EPA Method 8260B. Purge water generated during sampling will be managed in accordance with the procedures described in Section 1.6.

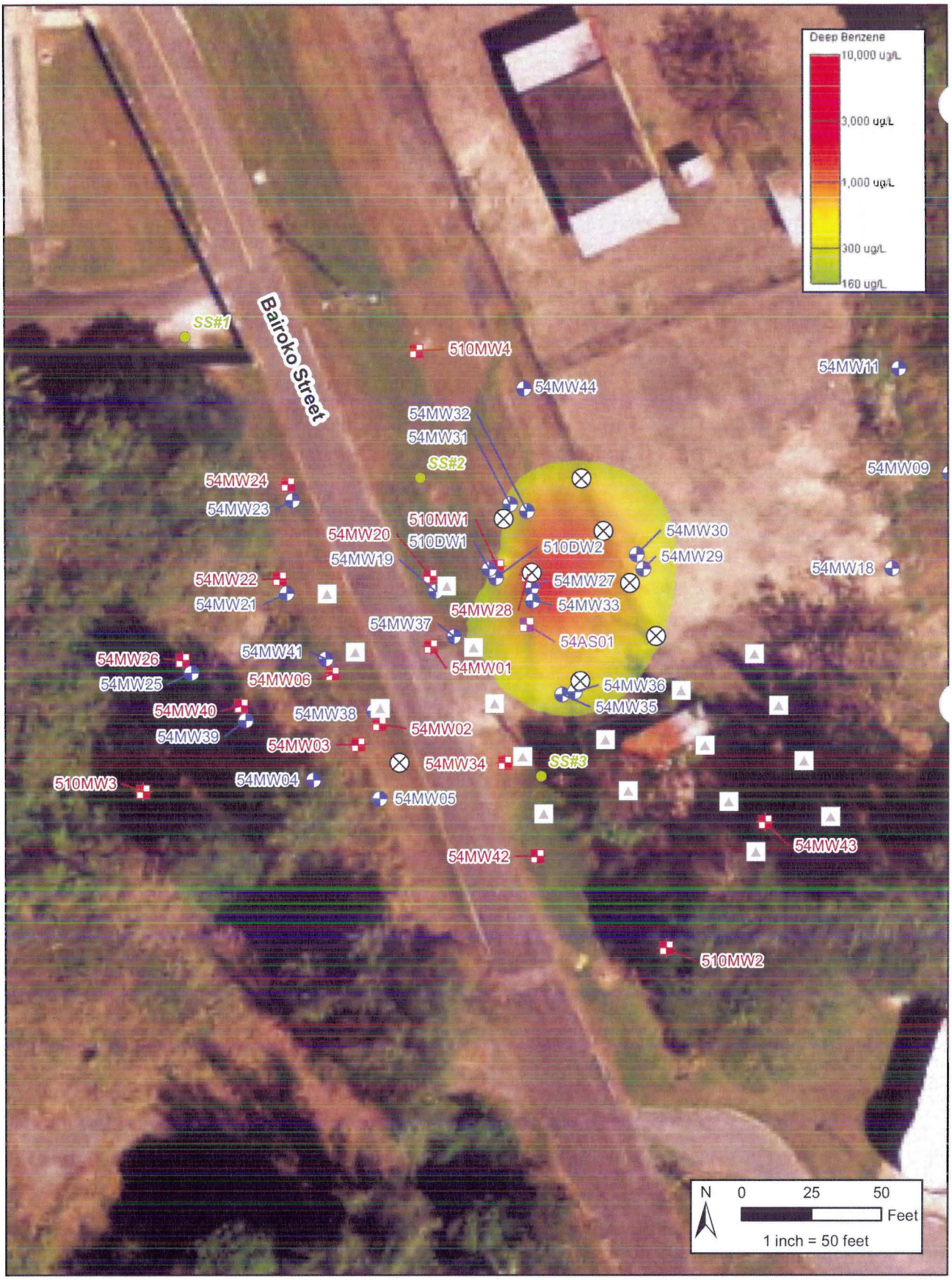
3.3 Well Installation

Twenty-six vertical air injection wells will be installed within the contaminant plume. Eighteen shallow injection wells will be installed to treat the upper portion of the plume (top of water table to approximately 15 feet bgs), and eight deep injection wells will be installed to treat the lower portion of the plume (approximately 15 to 25 feet bgs). In addition, existing injection well 54AS01, installed as part of the May 2010 pilot-scale test, will also be used to treat the lower portion of the plume. The proposed locations of the shallow and deep injection wells are depicted on Figures 3-1 and 3-2, respectively. The wells will be placed in rows oriented perpendicular to the direction of groundwater flow. As illustrated on Figures 3-1 and 3-2, five rows of shallow injection wells and three rows of deep injection wells will be installed. The wells will be spaced approximately 20 feet apart, though the final placement may be adjusted to avoid utilities. Additionally, the well spacing or number of injection wells may be revised after the baseline benzene and ethyl benzene data are acquired. The wells will be installed using HSA drilling techniques.

Both the shallow and deep injection wells will be constructed using 2 feet of 2-inch inner diameter (ID) PVC continuously wrapped well screen (0.020-inch slot size), and a variable amount of casing. The shallow injection wells will be screened from 16 to 18 feet bgs, and the deep injection wells will be screened from 26 to 28 feet bgs. At both the shallow and deep wells, sand pack will be placed around the well screen and brought to a height 2 feet above the top of the screen, followed by 2 feet of bentonite. The remainder of the annular space will be filled to within 1 foot of the ground surface using Portland cement grout slurry containing 3 to 5 percent bentonite. The injection wells will be developed after the grout has cured for a minimum of 24 hours. The development procedures will comply with the SOPs provided in Appendix A.

Soil and liquids generated during the installation of the injection wells will be containerized and managed in accordance with the procedures outlined in Section 1.6.

The locations and elevations of the newly installed injection wells will be surveyed by a land surveyor registered in Puerto Rico. The wells will be surveyed relative to a previously established benchmark. The horizontal location will be surveyed to an accuracy of 0.1 foot, and the ground surface will be surveyed to an accuracy of 0.01 foot. Top of casing elevations



Monitoring Well Screened Primarily Less than 15 ft bgs

Monitoring Well Screened Primarily Greater than 15 ft bgs

Deep Biosparge Well

Shallow Biosparge Well

Storm Sewer Monitoring Location

Note: Corrective Action Objective (CAO) for Benzene = 160 µg/L

FIGURE 3-2
Proposed Deep Biosparge Layout
SWMU 54
Naval Activity Puerto Rico

CH2MHILL

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for each biosparge well will not be surveyed because the wells will be buried during biosparge system trenching.

3.4 Biosparge System Installation and Operations

Air will be injected into the AS wells at a flow rate of less than 4 scfm per injection well with the goal of sufficiently aerating the aquifer to increase oxygen levels in groundwater and stimulate aerobic biodegradation of benzene and ethylbenzene. The system will be designed with additional capacity to increase flow rates to as high as 15 scfm by adjusting the pulsing strategy and the number of wells operating at one time.

An air compressor housed in a modified shipping container will be used to deliver air to the formation. Air will be delivered from the compressor to each sparge well through a delivery manifold (located within the shipping container) equipped with up to five separate zones for air delivery. Air will be delivered to each individual sparge well through buried high-density polyethylene (HDPE) pipe. The system piping and well connections will be installed below ground and will not be accessible to the public. The remediation equipment shipping container will be located inside a fenced site secured with a locking gate. Soil generated during the installation of the biosparge system will be containerized and managed in accordance with the procedures outlined in Section 1.6.

The system will be programmed to pulse the injection of air to each zone to minimize channeling effects, minimize vapor migration potential, save electricity, and increase system performance. The system will be equipped with a wireless telemetry unit to monitor system performance and notify the operator if a fault condition occurs. A Process and Instrumentation Diagram for the proposed biosparge system is provided in Appendix B.

3.5 Biosparge Operations Optimization and Exit Strategy

An observational approach to optimization will be used for the biosparge system. Baseline groundwater monitoring to assess benzene, ethylbenzene, and DO concentrations will be completed before turning on the system. During the first week of operation, DO concentrations will be measured from eight wells in the monitoring well network (54MW01, 54MW06, 54MW27, 54MW30, 54MW32, 54MW34, 54MW36, and 54MW43) using a YSI 600XLM down-hole data logger to evaluate DO distribution in the aquifer. After initial startup monitoring, performance monitoring events will be performed to evaluate system performance (discussed further in Section 2.0). The eight wells were selected because they provide adequate spatial distribution throughout both the shallow and deep treatment zones to determine DO distribution during startup. Four shallow wells (54MW01, 54MW06, 54MW34, and 54MW43) will be used to observe changes in DO concentration in the shallow treatment zone while four deep wells (54MW27, 54MW30, 54MW32, and 54MW36) will be used to observe changes in DO concentration in the deep treatment zone during startup operations. If the monitoring data do not show decreasing trends in benzene and ethylbenzene concentrations within the first year of operation, then optimization of the system will be evaluated. Table 3-1 summarizes the operational parameters that can be optimized and the expected impact of optimization.

TABLE 3-1
Optimization Guidance
SWMU 54
Naval Activity Puerto Rico

Parameter	Design	Impact
Flow Rate per Well	2 to 4 scfm	Increased air flow rate could expand oxygen influence /treatment zone. The performance trigger for flow rate adjustment will be evaluation of the DO in monitoring wells. If DO is not maintained at 2 mg/L at a pa ticular monitoring well during the first 6 months of operation, flow rates at sparge wells in the vicinity of that well may be adjusted.
Pulsed Cycles	Three to four cycles per day	Sho tening the pulse cycle could allow each zone to receive air more frequently. This may be necessa y to sustain oxygen if biodegradation rates are high. The performance trigger for flow rate adjustment will be evaluation of the DO in monitoring wells. If DO is not maintained at 2 mg/L at a pa ticular well during the first 6 months of operation, flow rates at sparge wells in the vicinity of that well may be adjusted.
Nutrient Addition	None	The addition of a nitrogen/phosphorus/phosphate in a liquid injection could enhance the rate of aerobic biodegradation. If groundwater concentrations do not indicate a decreasing trend from the previous sampling event within the first year of operation, nutrient addition will be considered.
Radius of Influence	15 feet	The installation of additional biosparge wells could improve coverage of the plume if the estimated radius of influence is not achieved at all locations. The biosparge system will be sized to accommodate system expansion, if it is required. Additional wells will be considered if review of DO monitoring data does not indicate that DO levels are maintained at a minimum of 2 mg/L throughout the monitoring network and groundwater concentrations do not indicate a decline within the first year of operation.

Based on experience at other sparge sites, as discussed in the revised CMS Addendum, AGVIQ-CH2M HILL believes that the design presented in this CMI is adequate to reduce contaminant concentrations in groundwater to the CAOs within about 3years. AGVIQ-CH2M HILL notes that the system will be designed with the flexibility to accommodate the injection of air into additional wells in the event reductions in contaminant concentrations to the CAOs do not occur during the performance period noted. The system was designed based on guidance presented in the *Air Sparging Guidance Document, NFESC Technical Report T-2193-ENV* (NAVFAC, 2001).

Benzene and ethylbenzene data from each sampling event will be plotted as a function of time and numerical trends will be developed using linear regression. In addition, trends will be analyzed using the Mann-Kendall non-parametric statistical test to determine if contaminant concentrations are increasing, decreasing, or stable. If monitoring data collected during system operations do not indicate decreasing trends in benzene and ethylbenzene concentrations or indicate inadequate distribution of DO in the formation (average less than 2 mg/L throughout the treatment zone based on field monitoring), optimization of the system will be completed. Optimization may include adjusting flow rates and/or pressures; modifying pulsing strategies; expansion of the system footprint; and addition of nutrients to stimulate biological activity. Once plume concentrations have been reduced to the CAOs for benzene and ethylbenzene, 1 year of closure quarterly

groundwater monitoring data will be collected to determine if additional monitoring or corrective measures are required. If benzene and ethylbenzene concentrations do not exceed the CAOs, NAVFAC SE will request no further action (NFA) for the site.

If benzene and ethylbenzene concentrations reach asymptotic levels in excess of the CAOs during active operations, then an evaluation will be completed to determine if concentrations have been reduced to the point where MNA can effectively be implemented. The results of the evaluation will be used to determine if additional system optimization steps are necessary or determine if the system can be shut down. If MNA is implemented, then a more comprehensive long-term monitoring program will be proposed. All evaluations completed to substantiate shutdown of the remediation system will be submitted to EPA for review and comment.

3.6 Implementation Schedule

An implementation schedule is presented on Figure 3-3.

4.0 References

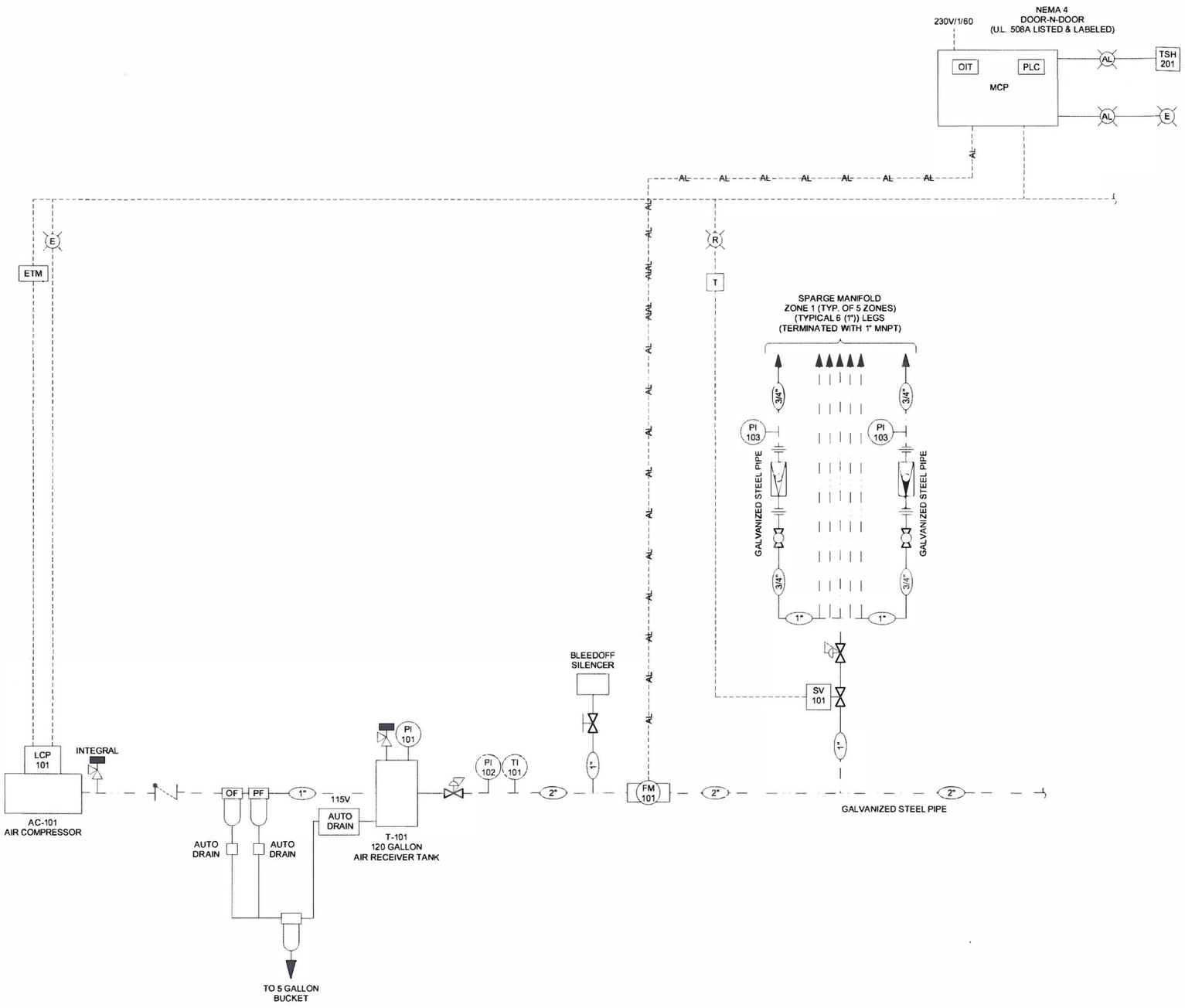
AGVIQ-CH2M HILL. 2012a. *Corrective Measures Study Addendum, SWMU 54 Benzene and Ethylbenzene Plume, Naval Activity Puerto Rico.* Prepared for Naval Facilities Engineering Command Southeast. December.

AGVIQ-CH2M HILL. 2012b. *Sampling and Analysis Plan, Corrective Action at Solid Waste Management Unit 54 – Benzene Plume, Naval Activity Puerto Rico.* Prepared for Naval Facilities Engineering Command Southeast. December.

Baker Environmental, Inc. (Baker). 2005. *Corrective Measures Study Final Report for SWMUs 54 and 55, Naval Station Roosevelt Roads, Ceiba, Puerto Rico.* August.

Oak Ridge National Laboratory Tennessee Health and Safety Research Division (Oak Ridge National Laboratory). 1989. *The Installation Restoration Program Toxicology Guide. Volume 1.* July.

Naval Facilities Engineering Command (NAVFAC). 2001. *Air Sparging Guidance Document, NFESC Technical Report TR-2193-ENV.* August.



CF	CONDENSATE FILTER
ETM	ELAPSED TIME METER
FM	FLOWMETER
LCP	LOCAL CONTROL PANEL
MCP	MATER CONTROL PANEL
OF	OIL FILTER
OIT	OPERATOR INTERFACE TERMINAL
PF	PARTICULATE FILTER
PI	PRESSURE INDICATOR
PLC	PROGRAMMABLE LOGIC CONTROLLER
SV	SOLENOID VALVE
T	TIMER
TI	TEMPERATURE INDICATOR
TSH	TEMPERATURE SWITCH
	BALL VALVE
	CHECK VALVE
	GATE VALVE
	FLOWMETER
	RELIEF VALVE
	REGULATOR
	UNION
AL	ALARM LIGHT
R	RUN LIGHT
E	EMERGENCY STOP
	AIR LINE
	CONTROL LINE
	WATER LINE
AL	ANALOG LINE

DSGN	K.McCORD				
DR	D.T.HERR				
CHK	T.KESSLER				
APVD		NO.	DATE	REVISION	BY	APVD

BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

CH2MHILL

NAVAL ACTIVITY PUERTO RICO
SWMU 54 BIOSPARGE SYSTEM

SHEET 1
DWG NO. 1-1
DATE January 2011
PROJ NO. 378718.20.04.92.03

P&ID-1.DWG 24-Jan-2011