Naval Facilities Engineering Command Mid-Atlantic
Norfolk, Virginia

Final

Five-Year Review

Marine Corps Base Camp Lejeune and
Marine Corps Air Station New River
North Carolina

May 2020

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Norfolk, Virginia

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Marine Corps Base Camp Lejeune and
Marine Corps Air Station New River
North Carolina

May 2020

Prepared for NAVFAC Mid-Atlantic
by CH2M HILL, Inc.
111 Corning Road, Suite 116
Cary, North Carolina 27518
NC Engineering License No. F-0699

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NORTH CAROLINA
PROFESSIONAL
May 28 2020
SEAL
038711
ENGINEER
KRISTIN ROGERS BRICKMAN

FIVE-YEAR REVIEW REPORT

MARINE CORPS BASE CAMP LEJEUNE AND MARINE CORPS AIR STATION NEW RIVER NORTH CAROLINA

NAVFAC CLEAN 9000 PROGRAM
CONTRACT N62470-16-D-9000
CONTRACT TASK ORDER WE49

AUGUST 2020

This report documents completion of the Five-Year Review of remedial actions implemented at Marine Corps Base Camp Lejeune and Marine Corps Air Station New River for Operable Units (OUs) 1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, 23, 24, and 25 pursuant to section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended; the National Oil and Hazardous Substance Pollution Contingency Plan, 40 C.F.R. 300.430(f)(4)(ii); and all other applicable guidance. This document was prepared in coordination with Naval Facilities Engineering Command and provided to the U.S. Environmental Protection Agency and the North Carolina Department of Environmental Quality for review and comment. This Five-Year Review is hereby approved.

Approved by:

J. D. ALFORD
Major General, U.S. Marine Corps
Commanding General
Marine Corps Base Camp Lejeune

24 July 2020
Date

C. V. EBITZ, JR
Colonel, U.S. Marine Corps
Commanding Officer
Marine Corps Air Station New River

6 JULY 2020
Date

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
SAM NUNN ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

August 31, 2020

ELECTRONICALLY SUBMITTED

J.D. Alford, Major General
U.S. Marine Corps - EMD, EQB
Marine Corps Base, Building 1
PSC Box 20004
Camp Lejeune, North Carolina 28542 Julian.d.alford@usmc.mil

Colonel Curtis Ebitz, Commanding Officer
Marine Corps Air Station New River
PSC Box 20005
Jacksonville, North Carolina 28540 curtis.ebitz@usmc.mil

Dear General Alford and Colonel Ebitz:

The U.S. Environmental Protection Agency, Region 4, has reviewed the Final 2020 Five-Year Review Report for Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, dated May 2020 and concurs with the protectiveness determinations and site-specific recommendations of the report. The protectiveness determinations are supported by the previously completed Remedial Investigation, Feasibility Study and Baseline Risk Assessment Reports, review of the current applicable or relevant and appropriate requirements, and evaluation of remedy implementation and performance.

Please note that an administrative correction was made in the Report regarding the five-year review period on page iv. The updated review period was March 26, 2019, thru February 28, 2020.

The EPA appreciates the coordination efforts of MCB Camp Lejeune and the level of effort put forth in developing this report. The EPA looks forward to continuing the exemplary working relationship with MCB Camp Lejeune and Mid-Atlantic Division Naval Facilities Engineering Command as we move toward a final cleanup of the Camp Lejeune National Priorities List site.

If you have any questions, please contact Jennifer Tufts, Remedial Project Manager, at 404-562-8513 or by email Tufts.Jennifer@epa.gov.

Sincerely,

CAROL MONELL Digitally signed by CAROL MONELL
Date: 2020.08.31 13:23:04 -04'00'

Carol J. Monell, Director
Superfund & Emergency Management Division

cc: Kirsten (Kitty) Hiortdahl, MCB Camp Lejeune
Dave Cleland, NAVFAC Mid-Atlantic
Randy McElveen, NCDEQ

Executive Summary

The Department of the Navy (Navy), the lead agency, and Marine Corps Base (MCB) Camp Lejeune and Marine Corps Air Station (MCAS) New River conducted this Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Review (FYR) with regulatory oversight from the United States Environmental Protection Agency (USEPA) Region 4 and the North Carolina Department of Environmental Quality (NCDEQ). This is the fifth FYR for MCB Camp Lejeune and MCAS New River. The FYR was conducted in accordance with the *Comprehensive Five-Year Review Guidance* (USEPA, 2001) and supplements (USEPA, 2012a, 2012b, 2016), *Navy/Marine Corps Policy for Conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Reviews* (Navy, 2011), the *Toolkit for Preparing Five-Year Reviews* (Navy, 2013), and the DoD *Defense Environmental Restoration Program (DERP) Management Manual* and 2014 Five-Year Review Procedures Update (DoD, 2012, 2014). This document summarizes the evaluation of remedial actions (RAs) that have been implemented at Operable Units (OUs) that resulted in hazardous substances, pollutants, or contaminants remaining at sites above levels that allow for unlimited use and unrestricted exposure (UU/UE), and for which there is a final Record of Decision (ROD) in place. The following 20 OUs are included in this FYR: OUs 1, 2, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, 23, 24, and 25.

The objective of this FYR is to evaluate remedies at each OU to determine whether they remain protective of human health and the environment in accordance with the requirements set forth in their ROD. The protectiveness of the remedies was evaluated through reviews of technical reports, site visits and inspections, and community involvement activities. In addition, this FYR identifies issues, if any, that may be preventing a particular remedy from functioning as designed or as appropriate, or that could endanger the protection of human health and the environment.

A summary table of the OUs, associated sites, site descriptions, basis for action, site status, remedy components, recommendations and follow-up actions, protectiveness, and FYR status is provided as **Table ES-1**.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name: Marine Corps Base Camp Lejeune and Marine Corps Air Station New River		
EPA ID: NC6170022580		
Region: 4	**State:** North Carolina	**City/County:** Onslow

SITE STATUS	
NPL status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** No

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** Department of the Navy
Author name (Federal or State Project Manager): Naval Facilities Engineering Command, Mid-Atlantic
Review period: March 26, 2019 through February 28, 2020
Date of site inspection: 3/26/2019 to 3/28/2019, 4/12/2019, and 5/15/2019, 5/16/2019
Type of review: Statutory
Review number: 5
Triggering action date: 08/26/2015
Due date (*five years after triggering action date*): 08/26/2020

ISSUES/RECOMMENDATIONS
OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU 4, OU 7, OU 8, OU 10, OU 11, OU 12, OU 13, OU 14, OU 15, OU 19, OU 21, OU 23, OU 24, OU 25

Five-Year Review Summary Form (continued)

ISSUES/RECOMMENDATIONS				
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): 1 (Site 78)	**Issue Category:** Remedy Performance			
	Issue: Volatile organic compounds (VOCs) in groundwater are present in deeper aquifer zones, at higher concentrations, are more widespread than the existing remedy was designed to address, and remedial action objectives (RAOs) are not likely to be met in a reasonable timeframe. A formal evaluation of remedial alternatives to address this contamination has not been completed.			
	Recommendation: Complete the Site 78 Feasibility Study (FS) Amendment to reevaluate alternatives to address VOCs in groundwater.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Navy/Base	USEPA/State	12/31/2020
OU(s): 2 (Site 9)	**Issue Category:** Changed Site Conditions			
	Issue: Tetrachloroethene (PCE) was identified in soil and groundwater at concentrations above the North Carolina Groundwater Quality Standard (NCGWQS) and the maximum soil contamination concentration at Site 9.			
	Recommendation: Refine the extent of PCE in site media at Site 9 and evaluate potential risks to human health and the environment and potential future actions if necessary.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Navy/Base	USEPA/State	12/31/2025
OU(s): 2 (Site 9)	**Issue Category:** Changed Site Conditions			
	Issue: Site 9 was identified as a potential per- and polyfluoroalkyl substances (PFAS) release area based on historical site use. Presence of PFAS compounds has been identified in groundwater at Site 9.			
	Recommendation: Refine the extent of PFAS in site media at Site 9 and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Navy/Base	USEPA/State	12/31/2025

Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS</th></tr>
<tr><td colspan="5">Issues and Recommendations Identified in the Five-Year Review:</td></tr>
<tr><td rowspan="3">OU(s): 2 (Site 82)</td><td colspan="4">Issue Category: Changed Site Conditions</td></tr>
<tr><td colspan="4">Issue: General radioactive materials were identified in buried waste materials at Site 82.</td></tr>
<tr><td colspan="4">Recommendation: Determine if radionuclides are present in groundwater above background.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Yes</td><td>Navy/Base</td><td>USEPA/State</td><td>12/31/2025</td></tr>
<tr><td rowspan="3">OU(s): 2 (Site 82)</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: New contaminant sources have been identified and VOCs in groundwater are more widespread than the existing remedy was designed to address and RAOs are not likely to be met in a reasonable timeframe. A formal evaluation of RAs to address this contamination has not been completed.</td></tr>
<tr><td colspan="4">Recommendation: Complete the Supplemental Remedial Investigation and conduct a FS Amendment to reevaluate alternatives to address new contaminant sources and VOCs in groundwater.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Yes</td><td>Navy/Base</td><td>USEPA/State</td><td>12/31/2025</td></tr>
<tr><td rowspan="3">OU(s): 5 (Site 2)</td><td colspan="4">Issue Category: Monitoring</td></tr>
<tr><td colspan="4">Issue: 4,4’-dichlorodiphenyldichloroethane (DDD) and 4,4’-dichlorodiphenyltrichloroethane (DDT) are present in groundwater and present potential unacceptable risk to human receptors.</td></tr>
<tr><td colspan="4">Recommendation: Reinstate groundwater long-term monitoring (LTM) for 4,4’-DDD and 4,4’-DDT and an aquifer use control boundary 500 feet from groundwater containing 4,4’-DDD and 4,4’-DDT.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Yes</td><td>Navy/Base</td><td>USEPA/State</td><td>12/31/2023</td></tr>
</table>

Five-Year Review Summary Form (continued)

<table>
<tr><th colspan="5">ISSUES/RECOMMENDATIONS</th></tr>
<tr><td colspan="5">Issues and Recommendations Identified in the Five-Year Review:</td></tr>
<tr><td rowspan="3">OU(s): 6 (Site 54)</td><td colspan="4">Issue Category: Changed Site Conditions</td></tr>
<tr><td colspan="4">Issue: Site 54 was identified as a potential PFAS release area based on historical site use. Presence of PFAS compounds has been identified in groundwater at Site 54.</td></tr>
<tr><td colspan="4">Recommendation: Refine the extent of PFAS in site media at Site 54 and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors.</td></tr>
<tr><th>Affect Current Protectiveness</th><th>Affect Future Protectiveness</th><th>Implementing Party</th><th>Oversight Party</th><th>Milestone Date</th></tr>
<tr><td>No</td><td>Yes</td><td>Navy/Base</td><td>USEPA/State</td><td>12/31/2025</td></tr>
<tr><td rowspan="3">OU(s): 16 (Site 89)</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: The remedy is not functioning as intended because recently discovered source areas and deeper groundwater contamination are not being addressed and RAOs are not expected to be met in a reasonable timeframe.</td></tr>
<tr><td colspan="4">Recommendation: Complete the supplemental investigation and re-evaluate the remedial strategy.</td></tr>
<tr><th>Affect Current Protectiveness</th><th>Affect Future Protectiveness</th><th>Implementing Party</th><th>Oversight Party</th><th>Milestone Date</th></tr>
<tr><td>No</td><td>Yes</td><td>Navy/Base</td><td>USEPA/State</td><td>12/31/2025</td></tr>
<tr><td rowspan="3">OU(s): 20 (Site 86)</td><td colspan="4">Issue Category: Changed Site Conditions</td></tr>
<tr><td colspan="4">Issue: Areas within the Site 86 boundary have been identified as potential PFAS release areas based on historical use. Presence of PFAS compounds has been identified in groundwater.</td></tr>
<tr><td colspan="4">Recommendation: Refine the extent of PFAS in site media near Buildings AS502, AS508, AS3900, AS3905 and the MV-22B Osprey crash and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors.</td></tr>
<tr><th>Affect Current Protectiveness</th><th>Affect Future Protectiveness</th><th>Implementing Party</th><th>Oversight Party</th><th>Milestone Date</th></tr>
<tr><td>No</td><td>Yes</td><td>Navy/Base</td><td>USEPA/State</td><td>12/31/2025</td></tr>
</table>

Five-Year Review Summary Form (continued)

PROTECTIVENESS STATEMENT(S)		
Operable Unit: 5, 15	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* Not applicable
Protectiveness Statement: The protectiveness statements for each OU are included in Sections 3 through 22, as applicable, and summarized in Table ES-1.		
Operable Unit: 4, 7, 8, 10, 11, 12, 13, 14, 19, 21, 23, 24, 25	*Protectiveness Determination:* Protective	*Addendum Due Date (if applicable):* Not applicable
Protectiveness Statement: The protectiveness statements for each OU are included in Sections 3 through 22, as applicable, and summarized in Table ES-1.		
Operable Unit: 1, 2, 6, 16, 20	*Protectiveness Determination:* Short-term Protective	*Addendum Due Date (if applicable):* Not applicable
Protectiveness Statement: The protectiveness statements for each OU are included in Sections 3 through 22, as applicable, and summarized in Table ES-1.		

Table ES-1. Five-Year Review Summary Table

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
1	21	Transformer Storage Lot 140	ROD-1994 ESD-1995 LUCIP-2001/2002 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019	1994 - ROD signed for soil removal and LUCs 1995 - ESD for PCB cleanup levels 1995 - Soil Removal Action 2001/2002 to present - LUCs	Prevent human consumption of contaminated groundwater by containing the contaminated groundwater in the surficial aquifer (Interim ROD). Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. To prevent current or future exposure to the contaminated groundwater and soils. Prevent exposure to VOCs in groundwater; prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health. To treat or remove contaminated soil from designated areas of concern.	Soil removal to industrial levels (complete) Non-industrial Use Control - Soil	The remedy at OU 1 is currently protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled. LUCs are in place to prohibit aquifer use, non-industrial use, restrict intrusive activities, and evaluate and/or mitigate potential VI pathways. Groundwater performance monitoring will be conducted to monitor COCs until cleanup levels are achieved. However, in order to ensure the remedy is protective in the long-term, the Navy is preparing an FS Amendment for Site 78 to reevaluate RAOs and remedial alternatives.	None	None
	24	Industrial Area Fly Ash Dump	ROD-1994 Final LTM Report-2001 Five-Year Review-2015 RACR – 2016 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1994 - ROD signed for LTM 1996-1998 - LTM 2001 - NFA recommended in LTM report 2016 - Remedy complete documented in RACR		LTM of groundwater (complete)		None	Site 24 was identified as a potential PFAS release area based on its designation as a dump. There is potential for industrial WWTP sludge received at Site 24 to contain PFAS and Site 24 will be included in a Basewide SI.
	78	Hadnot Point Industrial Area	ROD-1994 LUCIP-2001/2002, 2015 O&M Data-2015-2019 LTM Reports-2015-2017 ESD-2017 VIMS Monitoring Reports-2015-2019 Five-Year Review-2015 LUC Inspections-2015-2019 FS Amendment Investigation-2017-2018 GWTP Evaluation-2017-2018 LTM Data-2018-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1992 - Interim ROD signed for Groundwater Extraction and Treatment 1994 - ROD signed for Soil Removal, Groundwater Extraction and Treatment, LTM, and LUCs 1995 - Soil Removal Action 1995 to present - Groundwater Treatment and LTM 2001/2002 to present – LUCs 2014 to present - VIMS O&M in Building 902 2015 - LUCs updated 2017 - ESD to incorporate VI		Soil removal to industrial levels (complete) Groundwater Extraction and Treatment System LTM of groundwater Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Groundwater Industrial/Non-industrial Use Control - VI		Complete the Site 78 FS Amendment to reevaluate alternatives to address VOCs in groundwater. (12/31/2020)	The Dogwood Street Fire Station, located within the Site 78 boundary, was identified as a potential PFAS release area based on storage of AFFF for firefighting activities. This area will be included in a Basewide SI.

Table ES-1. Five-Year Review Summary Table
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
2	6	Storage Lots 201 and 203	ROD-1993 LUCIP-2001/2002, 2019 LTM Reports-2015-2017 VI Reports-2009/2011/2015 Five-Year Review-2015 LUC Inspections-2015-2019 SRI Updates-2016-2019 ESD-2017 LTM Data-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1993 - ROD signed for OU 2 Soil Removal, SVE, Groundwater Extraction and Treatment, LTM, and LUCs 1994-1995 - Soil Removal Action 1996 to present – LTM 2001/2002 to present – LUCs 2011 - TCRA to remove chlorobenzene drums 2017 - ESD to incorporate VI 2019 - LUCs updated	Sites 6 and 82: Prevent current and future exposure to contaminated soil and groundwater. Treat or remove contaminated soil. Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health. Reduce or prevent the potential for direct physical contact with MEC/MPPEH which can present unacceptable risk to human health and safety due to the explosive nature of the items/materials. Sites 6 and 82 (continued) Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.	Soil removal to industrial levels (complete) LTM of groundwater Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Intrusive Activities Control – Groundwater Industrial/Non-industrial Use Control - VI	The remedy at OU 2 is currently protective of human health and the environment. Exposure pathways that could result in an unacceptable risk are being controlled. LUCs are in place to prohibit aquifer use, non-industrial use, restrict intrusive activities, and evaluate and/or mitigate potential VI pathways. Active treatment of groundwater and LTM is ongoing at Sites 6 and 82 until cleanup levels are achieved. However, to ensure the remedy is protective in the long term, the Navy intends to refine the extent of PFAS and PCE in site media and evaluate the potential for unacceptable risks and/or potential complete exposure pathways at Site 9; complete the SRI and conduct an FS Amendment at Site 82; and evaluate radionuclides in groundwater at Site 82. In the interim, to facilitate protectiveness at Site 9, the Base GIS and Master Plan maintains current VOC plume data and all construction projects go through environmental review.	None	Site 6 was identified as a potential PFAS release area based on historical use as a disposal and storage area for materials containing PFAS. This site will be included in a Basewide SI.
	9	Piney Green Road Fire Fighting Training Pit	ROD-1993 PFAS Site Inspection-2017 Basewide PFAS PA-2019	1993 - ROD signed for NFA at Site 9		NFA		Refine the extent of PFAS in site media at Site 9 and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors. (12/31/2025) Refine the extent of PCE in site media at Site 9 and evaluate potential risks to human health and the environment and potential future actions if necessary. (12/31/2025)	None
	82	Piney Green Road VOC Area	ROD-1993 LUCIP-2001/2002, 2019 O&M Data-2015-2019 LTM Reports-2015-2017 VI Reports-2009/2011/2015 Five-Year Review-2015 LUC Inspections-2015-2019 SRI Updates-2016-2019 LTM Data-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1993 - ROD signed for OU 2 Soil Removal, SVE, Groundwater Extraction and Treatment, LTM, and LUCs 1994-1995 - Soil Removal Action 1996 – SVE 1996 to present - Groundwater Treatment and LTM 2001/2002 to present – LUCs 2017 - ESD to incorporate VI into remedy 2019 - LUCs updated		Soil removal to industrial levels SVE Groundwater Extraction and Treatment System LTM of groundwater and surface water Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Intrusive Activities Control – Groundwater Industrial/Non-industrial Use Control - VI		Determine if radionuclides are present in groundwater above background. (12/31/2025) Complete the SRI and conduct an FS Amendment to reevaluate alternatives to address new contaminant sources and VOCs in groundwater. (12/31/2025)	Site 82 was identified as a potential PFAS release area based on historical use as a disposal and storage area for materials containing PFAS. This site will be included in a Basewide SI.
	UXO-22	Sites 6 and 82	ESD-2017 LUCIP-2019	2017 - ESD to incorporate MEC/MPPEH into remedy 2019 - LUCs		Intrusive Activities Control - MEC/MPPEH Industrial/Non-industrial Use Control - MEC/MPPEH		None	None

Table ES-1. Five-Year Review Summary Table
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
4	41	Camp Geiger Dump near Former Trailer Park	ROD-1995 LUCIP-2001/2002 IRACR-2006 LTM Report-2001 Closeout Report-2006 Five-Year Review-2010 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA - 2019	1995 - ROD signed for LTM and LUCs 1997-2005 - LTM of groundwater, surface water, and sediment 2001/2002 to present – LUCs 2006 – NFA 2008 - Fence Installed	Prevent future potential exposure to buried contaminated soil and waste. Protect ecological receptors from future potential exposure to contaminated surface water. Prevent future potential exposure to contaminated groundwater.	LTM of groundwater (complete) LTM of surface water and sediment (complete) Aquifer Use Control (500 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Intrusive Activities Control – Groundwater Site Access Control	The remedy at OU 4 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial use, and restrict access and intrusive activities.	None	Site 41 was identified as a potential PFAS release area based on historical use as a disposal and storage area for materials containing PFAS. Based on the timeframe of use and reported instances when a fire truck was present during dumping, there is potential for PFAS-containing materials to be present at the site. This site will be included in a Basewide SI.
	74	Mess Hall Grease Dump Area	ROD-1995 Final LTM Report-2001 LUCIP-2001/2002 Five-Year Review-2010 Closeout Report-2006 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA - 2019	1995 - ROD signed for LTM and LUCs 1997-1998 - LTM 2001 to present – LUCs 2006 – NFA 2011 - Fence installed	Prevent future potential exposure to buried contaminated soil and waste. Prevent future potential use of the shallow groundwater.	LTM of groundwater (complete) Aquifer Use Control (500 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Intrusive Activities Control – Groundwater Site Access Control		None	Site 74 was identified as a potential PFAS release area based on historical use as a disposal and storage area for materials containing PFAS. However, no documentation or institutional knowledge of AFFF or other PFAS-containing material being used, released or transferred was identified at Site 74. No further evaluation was recommended.
5	2	Former Nursery/Day Care Center	ROD-1994 TCRA Closeout Report-1995 LUCIP-2001/2002/2009 Closeout Report-2008 Update to Closeout Report-2011 Five-Year Review-2015 LUC Inspections-2015-2019 Groundwater Investigation-2017-2019 Site Visit-2019 Base Master Planning GIS-2019 Memo to File-2019	1994-TCRA 1994 - ROD signed for LTM and LUCs 1997-2007 - LTM 2001 to present – LUCs 2009 - LUCs updated	TCRA RAO: Remove soil and sediment with concentrations of pesticides that present a potential risk to human health and the environment. ROD RAOs: Prevent future human exposure to the contaminated groundwater. Ensure, through monitoring, that there are no human or environmental exposures due to migration of the contaminant plume offsite.	Soil and sediment removal (complete) LTM of groundwater (VOCs, metals complete, to be reinstated for pesticides in 2023) Aquifer Use Control (1,000 feet) (removed in 2009, to be reinstated) Non-industrial Use Control - Soil (to be removed) Intrusive Activities Control - Groundwater (removed in 2009)	The remedy at OU 5 will be protective of human health and the environment when aquifer LUCs are reinstated. There are currently no complete exposure pathways because groundwater is not used as a potable source as there are no active supply wells within 500 feet of the site. In the interim, until the LUCs are reinstated, the Base GIS and Master Plan maintain existing and proposed LUCs and all construction projects go through environmental review. Groundwater LTM will be conducted to monitor COCs until cleanup levels are achieved.	Reinstate groundwater LTM for 4,4'-DDD and 4,4'-DDT and an aquifer use control boundary 500 feet from groundwater containing 4,4'-DDD and 4,4'-DDT. (12/31/2023)	Site 2 was identified as an area with the potential to use PFAS-containing materials (other than AFFF), but where use of these materials is not well documented or unknown. Site 2 was cataloged should information later indicate operations at this site could result in a potential PFAS release.

Table ES-1. Five-Year Review Summary Table
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
6	36	Camp Geiger Dump Area Near Sewage Treatment Plant	ROD-2005 LUCIP-2005, 2019 Five-Year Review-2015 LUC Inspections-2015-2019 LTM Reports-2015-2018 ESD-2017 Site Visit-2019 LTM Data-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2005 - ROD signed for MNA and LUCs 1998 to present - MNA 2005 to present – LUCs 2017 - ESD to incorporate VI 2019 - LUCs updated	Protect human health by preventing exposure to surface and subsurface soil within the following areas: lead contaminated areas, and unknown disposal materials within the former dump, and the previous soil removal action areas (i.e., PCB, PAH, and pesticide removal action areas). Protect uncontaminated groundwater for future potential beneficial use. Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.	Groundwater MNA LTM of surface water (discontinued) Annual groundwater modeling (discontinued) Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Intrusive Activities Control – Groundwater Industrial/Non-industrial Use Control - VI	The remedy at OU 6 is currently protective of human health and the environment. Exposure pathways that could result in an unacceptable risk are being controlled. LUCs are in place to prohibit non-industrial use and restrict intrusive activities at Sites 36, 43, 44, and 54, and prohibit aquifer use and evaluate and/or mitigate potential VI pathways at Site 36. MNA is ongoing at Site 36 until cleanup levels are achieved. However, to ensure the remedy is protective in the long term, the Navy intends to refine the extent of PFAS in site media and evaluate the potential for unacceptable risks and/or potential complete exposure pathway at Site 54.	None	The former Camp Geiger WWTP, located within the boundary of Site 36, was identified as a potential PFAS release area based on the nature of industrial wastewater received. This area will be included in a Basewide SI.
	43	Agan Street Dump	ROD-2005 LUCIP-2005 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2005 - ROD signed for LUCs 2005 to present - LUCs	Prevent future exposure to the surface and subsurface soil within the former site wide dump from unknown disposed materials and the previous soil removal action area (i.e., PAH removal action area).	Non-industrial Use Control – Soil Intrusive Activities Control - Soil		None	Site 43 was identified as a potential PFAS release area based on historical use as a disposal and storage area for WWTP sludge possibly containing PFAS. This site will be included in a Basewide SI.
	44	Jones Street Dump	ROD-2005 LUCIP-2005 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2005 - ROD signed for LUCs 2005 to present - LUCs	Prevent future exposure to the surface and subsurface soil due to unknown disposed materials within the former site wide dump.	Non-industrial Use Control – Soil Intrusive Activities Control - Soil		None	Site 44 was identified as a potential PFAS release area based on historical use as a disposal area. However, no documentation or institutional knowledge of AFFF, or other PFAS-containing materials being used, released or transferred was identified at Site 44. Therefore no further evaluation was recommended.

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OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
6	54	Crash Crew Fire Training Burn Pit	ROD-2005 LUCIP-2005 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 PFAS Site Inspection-2017 Basewide PFAS PA-2019	2005 - ROD signed for LUCs 2005 to present - LUCs	Prevent future exposure to the surface and subsurface soil within the former burn pit area.	Non-industrial Use Control – Soil Intrusive Activities Control - Soil		Refine the extent of PFAS in site media at Site 54 and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors. (12/31/2025)	None
7	28	Hadnot Point Burn Dump	ROD-1996 LUCIP-2001/2002/2014 RACR-2002 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1996 - ROD signed for LTM and LUCs 1996-2001 – LTM 2001 to present – LUCs 2014 - LUCs updated	Prevent current and future exposure to contaminated groundwater. Protect uncontaminated water for future potential use.	LTM of groundwater (complete) Aquifer Use Control (1,000 feet) Non-industrial Use Control – Waste Intrusive Activities Control - Waste	The remedy at OU 7 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial land use and restrict intrusive activities. .	None	Site 28 was identified as a potential PFAS release area based on burning activities and disposal of industrial waste and the presence of former Hadnot Point WWTP within the site boundary. This site will be included in a Basewide SI.
8	16	Former Montford Point Burn Dump	ROD-1996 LUCIP-2001/2002/2014 ESD-2012 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1996 - ROD signed for NFA 2001 to present - LUCs implemented based on use as a former dump 2012 - ESD to include LUCs as the final remedy 2014 - LUCs updated	Prevent exposure to waste due to the uncertainty of whether it would present unacceptable risk should exposure occur.	Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Intrusive Activities Control - Groundwater	The remedy at OU 8 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use, non-industrial land use, and restrict intrusive activities within the extent of waste and within an area of groundwater contamination above the MCL.	None	Site 16 was identified as a potential PFAS release area based on past use as a dump. However, there was no documentation that PFAS-containing materials were disposed of at the dump. Therefore, no further evaluation was recommended.

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OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
10	35	Camp Geiger Fuel Farm	ROD-2009 LUCIP-2009, 2019 VI Reports-2009/2011/2015 Five-Year Review-2015 LUC Inspections-2015-2019 LTM Reports-2015-2018 ESD-2017 ERD Pilot Study Work Plans-2018 Base Master Planning GIS-2019 Site Visit-2019 LTM Data-2019 AS Pilot Study Work Plan-2019	1994 - Interim ROD signed for soil removal 1995-1996 - Soil Removal Action 1995 - Interim ROD signed for in situ AS trench 1998-2009 - In situ AS trench 1999-2004 – LTM 2009 - ROD signed for horizontal AS, LTM/MNA, and LUCs 2010-2012 – AS 2010 to present - MNA/LUCs 2017-ESD to incorporate VI 2019-LUCs updated	Restore groundwater quality at Site 35 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201, and to prevent human ingestion of water containing COCs (benzene, 1,1,2,2-PCA, PCE, TCE, cis-1,2-DCE, and VC) at concentrations exceeding NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained. Minimize migration of COCs in groundwater to surface water. Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.	AS using horizontal wells (complete) Groundwater MNA Aquifer Use Control (1,000 feet) Industrial/Non-industrial Use Control - VI	The remedy at OU 10 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and evaluate and/or mitigate potential VI pathways. MNA for groundwater COCs will continue until cleanup levels are achieved.	None	As part of the LTM program, surficial aquifer groundwater nearest to Brinson Creek is monitored for exceedances of 10 times the NCSWQS as an indicator for potential impacts to the creek. Concentrations of vinyl chloride in groundwater nearest to Brinson Creek exceeded 10 times the NCSWQS and an investigation of the groundwater to surface water pathway was recommended in the FY 2018 LTM report. The Navy will complete an evaluation of the groundwater to surface water pathway to determine whether groundwater is affecting surface water at concentrations above the NCSWQS and determine whether additional action is warranted as part of the LTM program.
11	80	Paradise Point Golf Course Maintenance Area	TCRA Closeout Report-1996 ROD-1997 LUCIP-2007 ESD-2012 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1997 - ROD signed for NFA 2007 - LUCs implemented based on former soil removal to industrial levels 2012 - ESD to include LUCs as the final remedy	Prevent exposure to pesticides in soil.	Non-industrial Use Control – Soil Intrusive Activities Control - Soil	The remedy at OU 11 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to restrict soil intrusive activities and prohibit non-industrial use within the site boundary, including removal areas where pesticides remain in soil above levels that allow for UU/UE.	None	None
12	3	Old Creosote Plant	ROD-1997 ROD Amendment-2000 LUCIP-2001/2002 VI Report-2009 LTM Reports-2015-2019 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019	1997 - ROD signed for source removal and biological treatment, LTM, LUCs 1997to present – LTM 2000 - ROD Amendment for soil removal, LTM, LUCs 2001/2002 - LUCs	Prevent leaching of SVOCs from subsurface soil to groundwater. Remediate subsurface soil and shallow groundwater. Prevent exposure to VOC and SVOC-contaminated groundwater.	Soil removal to NC SSLs (complete) LTM of groundwater Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control - Groundwater	The remedy at OU 12 protective of human health and the environment. Exposures that could result in unacceptable risks are being controlled. LUCs are in place to restrict intrusive activities, non-industrial land use, and aquifer use, and LTM is ongoing to monitor the COC concentrations until groundwater cleanup levels are achieved.	None	None

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OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
13	63	Verona Loop Dump	ROD-1997 LUCIP-2001/2002, 2014 ESD-2012 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1997 - ROD signed for NFA with institutional controls 2001/2002 to present - LUCs 2012 - ESD to include LUCs as the final remedy 2014 - LUCs updated	Prevent exposure to, and future use of, groundwater. Prevent exposure to waste in place due to the uncertainty of whether it would present unacceptable risk should exposure occur.	Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Intrusive Activities Control - Groundwater	The remedy at OU 13 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial use and restrict intrusive activities in areas of contaminated groundwater and buried waste.	None	Site 63 was identified as a potential PFAS release area based on its designation as a dump site. However, based on the known use of the area, it is not likely that materials containing PFAS were disposed at the site. Therefore, no further evaluation was recommended.
14	69	Rifle Range Chemical Dump	Interim ROD-2000 LUCIP-2001/2002, 2013 (RD) ROD-2013 Five-Year Review-2015 LUC Inspections-2015-2019 O&M Reports-2015-2019 LTM Reports-2015-2018 LTM Data-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2000 - Interim ROD signed for LTM and LUCs 1998-2005 – LTM 2001/2002 – LUCs 2013 - Final ROD signed for multi-layered cap, LTM, and LUCs 2014 - Cap construction complete 2014 to present – LUCs 2015 to present - LTM	Restore groundwater quality to meet NCDENR and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Minimize exposure to potential chemical agent and chemical waste to the maximum extent practicable. Reduce infiltration and leaching of contaminants from waste into groundwater to the maximum extent practicable. Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for UU/UE. Minimize potential degradation of the New River by COC-affected groundwater.	Construction of a multi-layered cap (complete) Groundwater MNA for VOCs and LTM for pesticides, PCBs, and metals. Aquifer Use Control (1,000 feet) Intrusive Activities Control - Soil, Groundwater, and MEC Industrial/Non-industrial Use Control – VI Site Access Control	The remedy at OU 14 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial land use, restrict access, intrusive activities where impacted soil, groundwater or MEC may be present, and evaluate and/or mitigate potential VI pathways. The multi-layer cap is in-place to reduce infiltration and leaching of contaminants from waste into groundwater and prevents direct exposure to the soil and buried waste. MNA and LTM is ongoing to monitor plume stability and confirm that there are no releases from the waste disposal area or potential impacts to surface water.	None	Site 69 was identified in the Basewide PFAS PA as a potential PFAS release area based on its designation as a chemical dump site receiving hazardous chemicals including fire retardants and timeframe of use from 1950 to 1976. An explosion and fire that was responded to by a fire truck was documented but use of AFFF is unknown. This site will be included in a Basewide SI.

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
15	88	Former Base Dry Cleaning Facility Building 25	FS-2017 ROD-2019 VIMS O&M Reports-2014-2019 Draft RD-2019 Base Master Planning GIS-2019	2019 - ROD for ISCO, ERD, Bio-barrier MNA, VIMS and Sewer Ventilation System, and LUCs	Restore groundwater quality to meet NCDEQ and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NAC 02L.0201. Reduce groundwater contaminant source mass to the maximum extent practicable within a reasonable timeframe to inhibit migration of COCs to the New River. Prevent human ingestion of and contact with groundwater containing COCs at concentrations above NCGWQS or MCLs, whichever is more stringent. Prevent exposure to COCs in groundwater and soil gas during construction, and through the VI pathway that could result in an unacceptable risk to human health. Restrict intrusive activities and prevent residential use near the ZVI soil mixing treatment area.	ERD ISCO Bio-Barrier Groundwater MNA for VOCs (post-active treatment) VIMS in Building 3, 3B, 37, and 43, Sewer Ventilation System at Building HP57 Aquifer Use Control (1,000 feet) Non-industrial Use Control – Soil Intrusive Activities Control - Soil, Groundwater Industrial/Non-industrial Use Control - VI	The remedy at OU 15 will be protective of human health and the environment when the remedy is fully implemented. Exposure pathways that could result in unacceptable risks will be controlled by LUCs to prohibit aquifer use, non-industrial use, and restrict intrusive activities where groundwater, soil, and soil gas present unacceptable risks, and evaluate and/or mitigate potential VI pathways. VIMS are currently operational and prevent exposure to COCs through the VI pathway. Groundwater is not currently used as a potable supply. To facilitate protectiveness until LUCs are put in-place, the Base GIS and Master Plan maintain existing and proposed LUCs and all construction projects go through environmental review. Groundwater performance monitoring and/or MNA will be conducted to monitor COCs until cleanup levels are achieved.	None	None

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
16	89	Former DRMO	Treatability Study Report-2008 NTCRA (Soil Mixing)-2009 NTCRA (Western Wetland)-2010 ROD/RD-2012 VI Reports-2009/2011/2015 Interim RACR (PRB/aerators)-2014 Interim RACR (AS)-2014 Five-Year Review-2015 LTM Reports-2015-2018 O&M Reports-2015-2019 LUC Inspections-2015-2019 Supplemental Investigation-2019 Site Visit-2019 LTM Data-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	1999-2005 – LTM 2008 - NTCRA for Soil Mixing with ZVI 2010 - NTCRA for Soil/Sediment removal in Western Wetland 2012 - ROD for AS in groundwater, downgradient PRB, surface water aerators, groundwater MNA, and LUCs 2013 to present – AS 2014 to present - PRBs, surface water aerators, MNA, LUCs	Restore groundwater quality at Site 89 to meet NCDENR and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water [Class GA or Class GSA] under 15A NCAC 02L.0201. Minimize degradation of Edwards Creek from COC-impacted groundwater discharging into surface water until surface water COC concentrations meet the NCSWQS. Control exposure to COCs in groundwater and VI from COCs in groundwater.	AS using horizontal wells PRB to treat downgradient groundwater Surface water aerators Groundwtaer MNA Soil vapor monitoring during AS (completed) Aquifer Use Control (500 feet) Intrusive Activities Control – Groundwater Industrial/Non-industrial Use Control (VI) Access Control	The remedy at OU 16 is currently protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use, restrict intrusive activities, and evaluate and/or mitigate potential VI pathways at both sites. At Site 89, active remediation is being conducted to address the VOCs in former DRMO area groundwater (AS) and minimize offsite migration of COCs in downgradient groundwater and surface water (PRB and surface water aerators) and MNA will be conducted until cleanup levels are achieved. However, to ensure that the remedy is protective in the long term the Navy intends to revisit the site remediation strategy to address the current extent of CVOC concentrations indicative of DNAPL and impacted groundwater. At Site 93, a pilot study is being implemented to evaluate ERD to reduce the timeframe to remediation and MNA is ongoing until cleanup levels are met.	Complete the supplemental investigation and re-evaluate the remedial strategy. (12/31/2025)	Site 89 was identified in the Basewide PFAS PA as a potential PFAS release area based on historical use as a waste storage site. Materials stored included expired AFFF concentrate and/or empty AFFF containers. This site will be included in a Basewide SI.
	93	Building TC-942	FS-2005 ROD-2006 RD-2006 Construction Completion Report-2008 LUCIP-2009/2014 IRACR-2009 VI Reports-2009/2011/2015 Five-Year Review-2015 LTM Reports-2015-2018 LUC Inspections-2015-2019 Site Visit-2019 LTM Data-2019 Base Master Planning GIS-2019	1999-2005 – LTM 2006 - ROD signed for ISCO, MNA, LUCs 2006-2008 - ISCO to treat VOCs in groundwater 2008 to present – MNA 2009 to present – LUCs 2014 - LUCs updated	Reduce COC concentrations in the highest concentration areas and reduce exceedances of COCs to meet the NCGWQS or MCLs, whichever is more conservative Prevent human exposure of water containing COCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) at concentrations above NCGWQS or MCLs, whichever is more conservative Achieve suitability of Site 93 groundwater for UU/UE with a reasonable approach and within a reasonable timeframe	ISCO using permanganate (complete) Groundwater MNA Aquifer Use Control (1,000 feet) Intrusive Activities Control – Groundwater Industrial/Non-industrial Use Control - VI		None	None

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
19	84	Building 45	ROD-2009 RD-2009 Five-Year Review-2015 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019	2002-2006 - Soil Removal Actions 2009 - ROD signed for soil removal and LUCs 2009 to present - LUCs	Remove contaminated surface and subsurface soils that contain PCBs in excess of the selected remediation goal (i.e., cleanup level) and prevent exposure to remaining PCB contaminated soil consistent with the requirements for a low occupancy industrial area.	Soil removal and/or soil cover to industrial levels (complete) Non-industrial Use Control – Soil Intrusive Activities Control – Soil Site Access Control	The remedy at OU 19 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit soil intrusive activities and prohibit non-industrial use within the extent of the former soil removal action areas where PCBs remain in soil above levels that allow for UU/UE. A fence was also installed to restrict access within the areas of PCB contamination greater than 10 mg/kg in subsurface soils and warning signs are posted.	None	When the utility corridor lease agreements that are scheduled for renewal in 2026 occur, the Navy and MCB Camp Lejeune EMD will notify the companies with utilities within the PCB AOC and give the option to either properly excavate and dispose of the PCB-contaminated soil or relocate utilities outside of the AOC so that the Base can properly address the contamination.
20	86	Tank Area AS419-AS421	Expanded Supplemental RI-2011 FS-2013 ROD-2014 LUC Inspections-2015-2019 LTM Reports-2015-2018 PFAS Site Inspection-2018 LTM Data-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2014 - ROD signed for MNA and LUCs 2015 to present - MNA and LUCs	Restore groundwater quality to meet NCDEQ and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE.	Groundwater MNA Aquifer Use Control Industrial/Non-industrial Use Control - VI	The remedy at OU 20 is currently protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and evaluate and/or mitigate potential VI pathways and MNA is ongoing until cleanup levels are achieved. However, to ensure that remedy remains protective in the long term, the Navy intends to refine the extent, potential for unacceptable risks and/or potential complete exposure pathway from PFAS in groundwater from Buildings AS502 AS508, AS3900, AS3905, and the MV-22B Osprey crash.	Refine the extent of PFAS in site media near Buildings AS502, AS508, AS3900, AS3905 and the MV-22B Osprey crash and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors. (12/31/2025)	None

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21	73	Amphibious Vehicle Maintenance Facility	Pilot Study Report-2008 RI-2009 FS-2009 ROD-2009 VI Reports-2009/2015 RD-2010 IRACR (AS)-2011 IRACR (biobarrier)-2011/2014 Five-Year Review-2015 LTM Reports-2015-2018 LUC Inspections-2015-2019 ESD-2017 LTM Data-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2000-2005 – LTM 2009 - ROD signed for horizontal AS and downgradient ERD injections (bio-barrier), MNA, and LUCs 2010 to present - MNA and LUCs 2010-2012 – AS 2011 - First bio-barrier injection event 2013 - Second bio-barrier injection event 2017 - ESD to incorporate VI into the remedy 2019 - LUCs updated 2019 - Third bio-barrier injection event	Restore groundwater quality at Site 73 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent human ingestion of water containing COCs (benzene, TCE, cis-1,2-DCE, 1,1-DCE, and VC) at concentrations above NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained. Prevent future residential exposure to petroleum hydrocarbon-contaminated soils above the North Carolina Soil Screening Level (NC SSL) and minimize transport to groundwater. Minimize migration of COCs in groundwater to surface water. Prevent exposure to petroleum in soil; and prevent VI from petroleum in soil and soil gas that could result in an unacceptable risk to human health. Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk.	AS using a horizontal well (complete) Downgradient ERD injections (bio-barrier) Groundwater MNA Aquifer Use Control (1,000 feet) Intrusive Activities Control – Soil Industrial/Non-industrial Use Control - VI (Soil and Groundwater)	The remedy at OU 21 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use, non-industrial use, and evaluate and/or mitigate potential VI pathways. MNA for groundwater COCs and maintenance of the bio-barrier are ongoing until cleanup levels are achieved.	None	Monitoring wells that are currently not in use for LTM or other onsite monitoring are not routinely inspected or repaired. If there are plans to use these wells, routine inspection or repairs should be conducted. If there are no future plans for use and appropriate lines of evidence are presented (trends, redundancy, or condition), then these wells will be proposed for abandonment. A high mobility multi-purpose wheeled vehicle fire occurred within the aquifer use LUC boundary at Site 73. It was identified as a potential PFAS release area because AFFF was used to extinguish the fire. This area will be included in a Basewide SI.
23	49	MCAS Suspected Minor Dump	ROD-2014 RD-2014 IRACR-2014 LUC Inspections-2015-2019 LTM Reports-2015-2018 LTM Data-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2014 - ROD signed for MNA and LUCs 2014 to present - MNA and LUCs	Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE. Minimize potential degradation of the New River by COC-affected groundwater.	Groundwater MNA LTM of pore water Aquifer Use Control (1,000 feet) Industrial/Non-industrial Use Control - VI	The remedy at OU 23 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and evaluate and/or mitigate potential VI pathways. MNA is ongoing until cleanup levels are achieved.	None	None

OU	Site	Site Description	Documents Reviewed	RODs/Remedial Actions and NTCRAs/Removal Actions	RAOs	Remedy Components	OU Protectiveness Statement	Recommendations (Milestones)	Other Findings
24	UXO-06	Fortified Beach Assault Area (ASR #2.65)	ROD-2018 RD-2018 RACR-2019 Site Visit-2019 Base Master Planning GIS-2019 Basewide PFAS PA-2019	2018 - ROD signed for Surface Clearance and LUCs 2019 - Surface Clearance 2019 - LUCs	Reduce or prevent the potential for direct physical contact with MEC/MPPEH, which can present unacceptable risk to human health and safety due to the explosive nature of the items/materials.	Removal of MEC/MPPEH on ground surface Intrusive Activities Control - MEC/MPPEH Industrial/Non-Industrial Use Control - MEC/MPPEH Explosives Safety Education Program	The remedy at OU 24 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks (explosive hazards) are being controlled. LUCs are in place to prohibit intrusive activities, educate site users, and prohibit non-industrial use.	None	The French Creek Fire Station, located within the boundary of Site UXO-06, was identified as a potential PFAS release area based on potential use and/or storage of AFFF. This area will be included in a Basewide SI.
25	UXO-19	Camp Devil Dog Historical Ranges	ROD-2015 RD-2016 RACR-2018 LUC Inspections-2015-2019 Site Visit-2019 Base Master Planning GIS-2019	2015 - ROD signed for LUCs 2016 to present – LUCs 2017 - Warning signs installed	Reduce or prevent the potential for direct physical contact with MEC/MPPEH to allow current and reasonably anticipated land use (infantry training) at the site to continue.	Intrusive Activities Control (MEC) in Developed/ Inaccessible Areas Intrusive Activities Control (MEC) in Undeveloped Areas	The remedy at OU 25 is protective of human health and the environment. Exposure pathways that could result in unacceptable risks (explosive hazards) are being controlled. LUCs are in place to prohibit intrusive activities in developed/inaccessible and undeveloped areas of the site.	None	None

Notes:

AS = air sparging
AFFF = aqueous film-forming foam
COC = constituent of concern
CSM = conceptual site model
DCE = dichloroethene
DRMO = Defense Reutilization and Marketing Office
ERD = enhanced reductive dechlorination
ESD = Explanation of Significant Differences
FS = Feasibility Study
GIS = geographic information system
IRACR = Interim Remedial Action Completion Report
ISCO = in situ chemical oxidation
LTM = long-term monitoring
LUC = land use control
LUCIP = Land Use Control Implementation Plan
MCAS = Marine Corps Air Station
MCL = maximum contaminant level
MEC = munitions and explosives of concern
MNA = monitored natural attenuation
MPPEH = material potentially presenting an explosive hazard
NC SSL = North Carolina Soil Screening Level
NCAC = North Carolina Administrative Code
NCGWQS = North Carolina Groundwater Quality Standards
NCSWQS = North Carolina Surface Water Quality Standards
NFA = No Further Action
NTCRA = non-time-critical removal action
O&M = operations and maintenance
OU = Operable Unit
PA = preliminary assessment
PAH = polycyclic aromatic hydrocarbon
PCA = tetrachloroethane
PCB = polychlorinated biphenyls
PFAS = per- and polyfluoroalkyl substances
PRB = permeable reactive barrier
RACR = Remedial Action Completion Report
RAO = remedial action objective
RD = Remedial Design
RI = Remedial Investigation
ROD = Record of Decision
RSL = regional screening level
SI = site inspection
SVE = soil vapor extraction
PCE = tetrachloroethene
SRI = Supplemental Remedial Investigation
TCE = trichloroethene
TCRA = time-critical removal action
UU/UE = unlimited use/unrestricted exposure
UXO = unexploded ordnance
VC = vinyl chloride
VI = vapor intrusion
VOC = volatile organic compound

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Appendixes

Tables

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Acronyms and Abbreviations

3DMe	three-dimensional microemulsion
3Rs	Recognize, Retreat, Report
AFFF	aqueous film-forming foam
AOC	area of concern
AR	administrative record
ARAR	applicable or relevant and appropriate requirement
AS	air sparging
ASR	Archive Search Report
AST	aboveground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTV	background threshold value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
CSM	conceptual site model
CVOC	chlorinated volatile organic compound
DCA	dichloroethane
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DHC	*Dehalocoiccoides*
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DoD	Department of Defense
DPT	direct-push technology
DRMO	Defense Reutilization and Marketing Office
ERA	ecological risk assessment
ERD	enhanced reductive dechlorination
ERH	electrical resistive heating
ESD	Explanation of Significant Differences
ESRI	Expanded Supplemental Remedial Investigation
EVO	emulsified vegetable oil
ft/day	feet per day
ft/ft	feet per foot
FS	Feasibility Study
FY	Fiscal Year
FYR	Five-Year Review
GIS	geographic information system
GWTP	groundwater extraction and treatment plant
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDD	horizontal directionally drilled
HHRA	human health risk assessment
HPIA	Hadnot Point Industrial Area
HRC	hydrogen release compound

IAS	Initial Assessment Study
IMAC	interim maximum allowable concentration
IRACR	Interim Remedial Action Completion Report
IRP	Installation Restoration Program
ISCO	in situ chemical oxidation
LCH	lower Castle Hayne
LNAPL	light nonaqueous phase liquid
LTM	long-term monitoring
LUC	land use control
LUCIP	Land Use Control Implementation
µg/L	microgram(s) per liter
MCH	middle Castle Hayne
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
MEC	munitions and explosives of concern
MEE	methane, ethane, ethene
mg/kg	milligram per kilogram
MK	Mann-Kendall
MMRP	Military Munitions Response Program
MNA	monitored natural attenuation
MPPEH	material potentially presenting an explosive hazard
NA	natural attenuation
NACIP	Navy Assessment and Control of Installation Pollutants
NAIP	natural attenuation indicator parameter
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NC SSL	North Carolina Soil Screening Level
NC VISL	North Carolina Vapor Intrusion Screening Level
NCAC	North Carolina Administrative Code
NCDEQ	North Carolina Department of Environmental Quality
NCGWQS	North Carolina Groundwater Quality Standard
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NCSWQS	North Carolina Surface Water Quality Standard
NFA	no further action
NTCRA	non-time-critical removal action
O&G	oil and grease
O&M	operation and maintenance
ORC	oxygen release compound
ORP	oxidation-reduction potential
OU	Operable Unit
OWS	oil/water separator
PA	Preliminary Assessment
PAH	polycyclic aromatic hydrocarbon
PCA	tetrachloroethane
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PFC	perfluorinated compound

PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonate
POL	petroleum, oil, and lubricants
ppm	parts per million
PRAP	Proposed Remedial Action Plan (now referred to as Proposed Plan)
PRB	permeable reactive barrier
PTW	principle threat waste
RA	remedial action
RAB	Restoration Advisory Board
RACR	Remedial Action Completion Report
RAO	remedial action objective
RBC	risk-based concentration
RC	response complete
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RI	remedial investigation
RIP	remedy in place
ROD	Record of Decision
RSL	regional screening level
SARA	Superfund Amendments and Reauthorization Act
SBGR	subgrade biogeochemical reactor
scfm	standard cubic feet per minute
SI	Site Inspection
SRI	Supplemental Remedial Investigation
SVE	soil vapor extraction
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TCE	trichloroethylene
TCRA	time-critical removal action
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
TSI-DC	Terra Systems Incorporated DC Bioaugmentation Culture
UCH	upper Castle Hayne
USEPA	United States Environmental Protection Agency
UST	underground storage tank
UU/UE	unlimited use and unrestricted exposure
UXO	unexploded ordnance
VC	vinyl chloride
VI	vapor intrusion
VIMS	vapor intrusion mitigation system
VOC	volatile organic compound
WWTP	wastewater treatment plant
ZVI	zero-valent iron

SECTION 1

Introduction

This document presents the fifth Five-Year Review (FYR) for Marine Corps Base (MCB) Camp Lejeune and Marine Corps Air Station (MCAS) New River, North Carolina, prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The previous FYR was completed in 2015. This FYR evaluates the remedial actions (RAs) that have been implemented within 20 operable units (OUs) at MCB Camp Lejeune or MCAS New River, for which there is a Final Record of Decision (ROD).

This document has been prepared by the Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic, MCB Camp Lejeune, and MCAS New River for submittal to United States Environmental Protection Agency (USEPA) Region 4 and the North Carolina Department of Environmental Quality (NCDEQ).

1.1 Objectives and Approach

The objective of this FYR is to evaluate the RAs at MCB Camp Lejeune and MCAS New River and determine whether they remain protective of human health and the environment in accordance with the requirements outlined in the ROD or applicable post-ROD decision documents for each OU. The protectiveness of the remedies was evaluated through reviews of technical reports, site visits and inspections, and community involvement activities. In addition, this FYR identifies issues, if any, that may be preventing a particular remedy from functioning as designed or as appropriate, or that could impact the protection of human health and the environment.

The Department of the Navy (Navy) has prepared this FYR pursuant to CERCLA 121 and the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). CERCLA Section 121 states the following:

> "If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section [104] or [106], the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews."

USEPA interpreted this requirement further in the NCP as stated in 40 *Code of Federal Regulations* 300.430 (f)(4)(ii): "If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action."

The statutory review process was initiated based on the RA at OU 2 in September 1993. The first FYR was completed in 1999 (Baker, 1999). The second, third, and fourth FYRs were completed in 2005 (Baker, 2005), 2010, and 2015 (CH2M, 2010, 2015). The current FYR is required because hazardous contaminants remain at concentrations exceeding criteria that allow for unlimited use and unrestricted exposure (UU/UE) at each of the 20 OUs addressed in this document.

1.2 Installation Background

MCB Camp Lejeune and MCAS New River, also referred to as Camp Lejeune or the Base, cover more than 156,000 acres of land in Onslow County, North Carolina, near the southern boundary of the city of Jacksonville (**Figure 1-1**). The Base is bordered by the Atlantic Ocean to the east and bisected by the New River, which flows into the Atlantic Ocean in a southeasterly direction.

Commissioned in 1941, the Base currently provides military training operations and maintains combat-ready warfighters for deployment and humanitarian missions abroad. The Base provides housing, training facilities, and logistical support for Fleet Marine Force Units and other assigned units.

1.2.1 Regional Water Use

Potable water is provided to the Base and surrounding area by water supply wells that pump groundwater from the deeper Castle Hayne aquifer. There are currently active water supply wells on Base that rely on groundwater as the supply source. The supply wells are included in the Base's annual wellhead monitoring program to ensure compliance with drinking water standards. Regionally, in southeastern North Carolina, the Castle Hayne aquifer may be used as a potable source of domestic water supply and for watering lawns or filling swimming pools.

1.2.2 Environmental Restoration Program

Historical operations, storage, and disposal practices at the Base have resulted in environmental impacts to soil and groundwater. The Base has been actively engaged with environmental investigations and remediation programs since 1981, beginning with the Navy Assessment and Control of Installation Pollutants (NACIP) Program. The Initial Assessment Study (IAS) (WAR, 1983) was the first investigation of potentially hazardous sites at the Base conducted under the NACIP. The IAS identified areas of concern (AOCs) that might cause threats to human health and the environment as a result of past storage, handling, and disposal of hazardous materials.

The Navy's Installation Restoration Program (IRP) was initiated in 1986, following enactment of the Superfund Amendments and Reauthorization Act (SARA) legislation. The IRP, which was implemented to follow the requirements of SARA, replaced NACIP. The Base was placed on the CERCLA National Priorities List on October 4, 1989 (54 *Federal Register* 41015, October 4, 1989). Following the listing, a Federal Facilities Agreement between USEPA Region 4, North Carolina Department of Environment and Natural Resources (now NCDEQ), and the Navy was signed in February 1991.

As part of the requirements established under CERCLA, an administrative record (AR) file has been established for the Base. The AR is a compilation of all documents the Department of Defense (DoD) uses to select an RA or removal action for a site. The AR is available online at: http://go.usa.gov/Dy5T. Internet access is available to the public at the Onslow County Public Library.

1.3 Operable Units and Sites

There are currently 26 OUs located aboard MCB Camp Lejeune and MCAS New River, 1 does not have a completed ROD, 1 was not signed before September 30, 2019 and was therefore not included, and 4 are no further action (NFA) status documented in RODs. The remaining 20 OUs were identified for this FYR. Each OU comprises one or more sites that were grouped by proximity, common waste types, and/or common operational activities (**Table 1-1**). The OUs and respective sites that are reviewed in this FYR are shown on **Figure 1-2**.

1.4 Report Organization

The FYR for MCB Camp Lejeune and MCAS New River consists of an Executive Summary and 22 sections, organized as follows:

- **Executive Summary —** Summarizes the FYR process conducted at MCB Camp Lejeune and MCAS New River and findings. A summary table of the OUs, associated sites, site descriptions, documents reviewed, basis for action, site status, remedy components, recommendations and follow-up actions, protectiveness determinations, and FYR status is provided as **Table ES-1**.
- **Section 1 —** Introduces the FYR and its purpose and provides the background of the Base and the OUs.
- **Section 2 —** Describes the FYR process.

- **Sections 3 through 22 —** Evaluates each of the 20 OUs included in this FYR. Discussion elements for each OU include the site history and background, site chronology, and site characterization; description of RAs (remedy implementation and remedy operation and maintenance [O&M]); progress since the last FYR; technical assessment; issues, recommendations and follow-up actions; and statement of protectiveness. References, figures, tables, and a photograph log are provided within each section, as applicable.

Appendixes are provided at the end of the document.

1.5 References

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CH2M HILL, Inc. (CH2M). 2010. *Five-year Review. Marine Corps Base Camp Lejeune, North Carolina*. August.

CH2M. 2015. *Five-year Review. Marine Corps Base Camp Lejeune, North Carolina*. August.

Water and Air Research, Inc. (WAR). 1983. *Initial Assessment Study for MCB Camp Lejeune, North Carolina.*

Table 1-1. Summary of Sites by Operable Unit

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

OU	SITE NO.	Site Description	Primary Reason for OU Selection	Inclusion in the FYR
1	21	Transformer Storage Lot 140	Geographic location of sites.	Included
	24	Industrial Area Fly Ash Dump		Included
	78	Hadnot Point Industrial Area		Included
2	6	Storage Lots 201 and 203	Geographic location of sites.	Included
	9	Fire Fighting Training Pit at Piney Green Road		Included
	82	Piney Green Road VOC Area		Included
	UXO-22	UXO-22 - Sites 6 and 82		Included
3	48	MCAS Mercury Dump	Unique waste source (mercury).	Not Included – NFA ROD
4	41	Camp Geiger Dump near Former Trailer Park	Similar characteristic of suspected waste (chemical warfare materials).	Included
	74	Mess Hall Grease Dump Area		Included
5	2	Former Nursery/Day Care Center	Unique waste source (pesticides).	Included
6	36	Camp Geiger Dump Area Near Sewage Treatment Plant	Geographic location of sites. Similar characteristics of material disposed (POL, waste oils, solvents) and contaminants detected (metals, VOCs, O&G).	Included
	43	Agan Street Dump		Included
	44	Jones Street Dump		Included
	54	Crash Crew Fire Training Burn Pit		Included
7	1	French Creek Liquids Disposal Area	Geographic location of sites. Similar characteristics of suspected waste (O&G, POL, and metals).	Not Included – RC
	28	Hadnot Point Burn Dump		Included
	30	Sneads Ferry Road Fuel Tank Sludge Area		Not Included – NFA ROD
8	16	Former Montford Point Burn Dump	Isolated site with unique waste source.	Included
9	65	Engineer Area Dump	Isolated site with unique waste source.	Not Included – NFA ROD
10	35	Camp Geiger Fuel Farm	Former fuel farm with suspected chlorinated solvent disposal.	Included
11	7	Tarrawa Terrace Dump	Geographic location of sites.	Not Included – NFA ROD
	80	Paradise Point Golf Course Maintenance Area		Included
12	3	Old Creosote Plant	Isolated site with unique waste source.	Included
13	63	Verona Loop Dump	Isolated site with unique waste source.	Included
14	69	Rifle Range Chemical Dump	Isolated site with unique waste source.	Included
15	88	Base Dry Cleaners	Suspected waste (dry cleaning solvent).	Included

Table 1-1. Summary of Sites by Operable Unit

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

OU	SITE NO.	Site Description	Primary Reason for OU Selection	Inclusion in the FYR
16	89	Former DRMO	Geographic location of sites and adjacent surface water body. Similar waste characteristics (solvents).	Included
	93	Building TC-942		Included
17	90	Building BB-9	Former UST sites with similar contamination detected in groundwater.	Not Included – NFA ROD
	91	Building BB-51		Not Included – NFA ROD
	92	Building BB-46		Not Included – NFA ROD
18	94	PCX Service Station	Active PCX Service Station transferred to the IRP. Petroleum releases addressed under UST Program and chlorinated solvents addressed under IRP OU 1.	Not Included – NFA ROD
19	84	Building 45	Isolated site with PCBs.	Included
20	86	Tank Area AS419-AS421 at MCAS	Site 86 was originally included under OU 6 but separated based on VOC concentrations.	Included
21	73	Courthouse Bay Liquids Disposal Area	Isolated site with suspected waste disposal (POL, solvents).	Included
22	96	Building 1817 UST	Transferred to IRP from RCRA based on chlorinated VOC plume identified.	Not Included - ROD not complete
23	49	MCAS Suspected Minor Dump	Isolated site with chlorinated VOCs in groundwater.	Included
24	UXO-06	Fortified Beach Assault Area (ASR #2.65)	Isolated site with potential MEC.	Included
25	UXO-19	M-4, Rifle Grenade Range (ASR #2.104) K-22 Practice Hand Grenade Course (ASR #2.111) M115 Hand Grenade Range (ASR #2.168) (Camp Devil Dog Historical Ranges)	Isolated site with potential MEC.	Included
26	UXO-24	Camp Geiger Area	Geographic location of sites.	Not Included - ROD not signed before FY20
	Site 37	Camp Geiger Area Surface Dump		Not Included - ROD not signed before FY20

Notes:
DRMO = Defense Reutilization and Marketing Office
O&G = oil and grease
OU = Operable Unit
MCAS = Marine Corps Air Station
MEC = munitions and explosives of concern
NFA = No Further Action
PCB = polychlorinated biphenyl
POL = petroleum, oil, lubricants
RC = response complete
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision
UST = underground storage tank
VOC = volatile organic compound

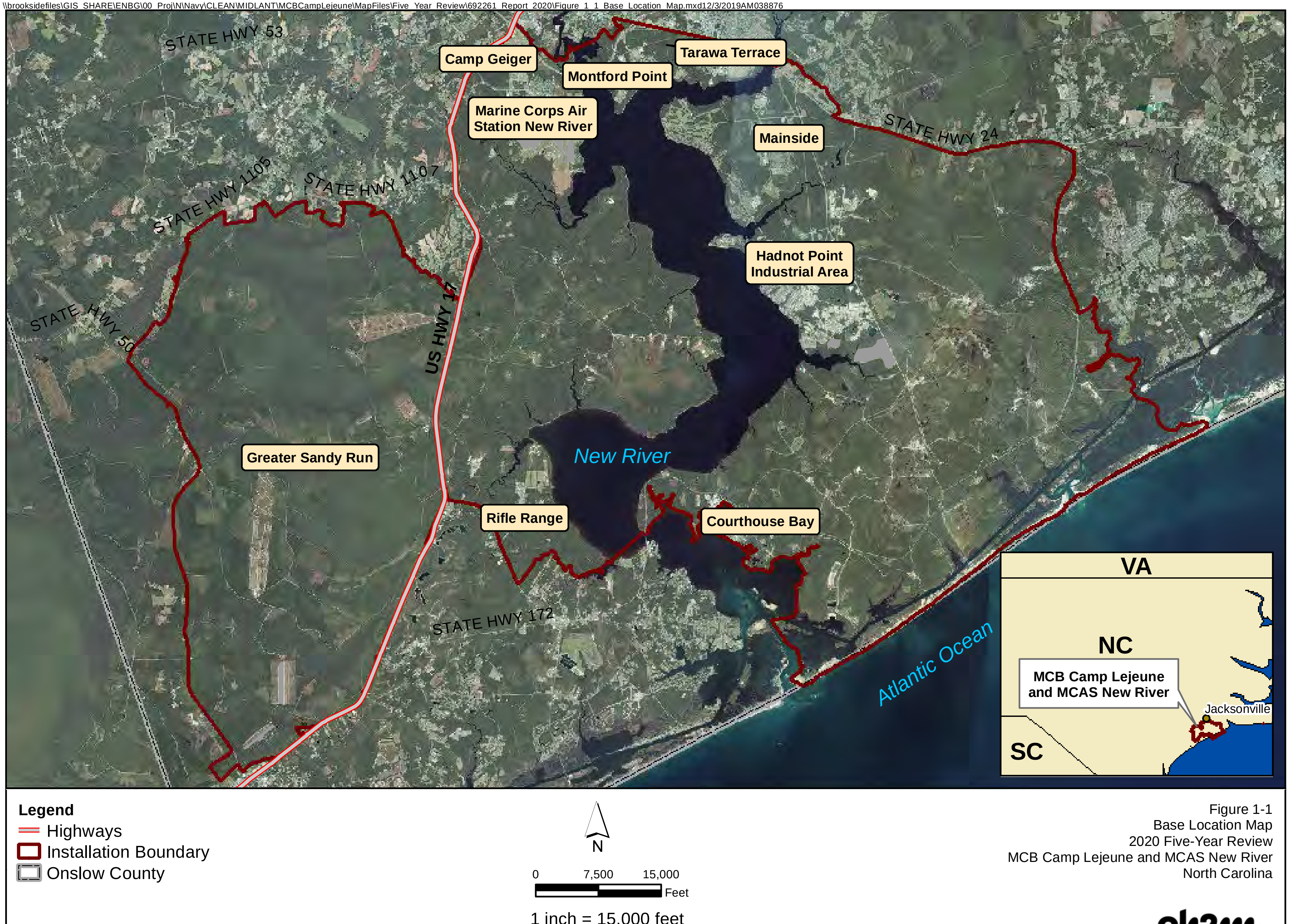

Figure 1-1
Base Location Map
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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Legend

RIP Sites with LUCs:

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary
- Intrusive Activites Control Boundary (Soil)
- Intrusive Activites Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil
- Industrial/Non-Industrial Use Control Boundary (MEC/MPPEH)
- Intrusive Activities Control Boundary (MEC/MPPEH)
- Intrusive Activities Control in Undeveloped Areas (MEC/MPPEH)
- UXO Safety Awareness Program
- Site Boundary
- Installation Boundary

Note:
LUC boundaries depicted may have multiple LUCs associated and the most conservative LUC is shown.
Proposed LUC boundaries are dashed.

N

0 2,500 5,000 10,000 Feet

1 inch = 2,500 feet

Imagery Source: ©2017 Esri

Figure 1-2
OU Location Map
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

Five-Year Review Process

The FYR for MCB Camp Lejeune and MCAS New River was conducted in accordance with the *Comprehensive Five-Year Review Guidance* (USEPA, 2001) and supplements (USEPA, 2012a, 2012b, 2016), *Navy/Marine Corps Policy for Conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Five-Year Reviews* (Navy, 2011), the *Toolkit for Preparing Five-Year Reviews* (Navy, 2013), and the DoD *Defense Environmental Restoration Program (DERP) Management Manual* and 2014 FYR Procedures Update (DoD, 2012, 2014). Remedy protectiveness for the 20 OUs was evaluated through technical document reviews, site inspections, and community involvement activities as described in the following subsections.

2.1 Document and Data Review

The FYR consisted of a review of site-specific documentation and data for each OU including:

- Decision documents to identify the potential risks to human health and the environment, remedial action objectives (RAOs), the selected remedy, and applicable or relevant and appropriate requirements (ARARs).
- Remedial design (RD) to evaluate the design components for the remedy, as well as any monitoring requirements and land use control (LUC) elements and boundaries.
- Interim Remedial Action Completion Reports (IRACRs)/Remedial Action Completion Reports (RACRs) (if applicable) to confirm that the remedies are operational and functional in accordance with the RAOs and RD.
- Follow-up monitoring reports and data to assess remedy performance and continued protection of human health and the environment.

2.2 Technical Assessment

Information from the document and data review was used to answer three technical assessment questions from USEPA guidance. The type of information used for each question is discussed in this section.

Question A: Is the remedy functioning as intended by the decision documents?

The following information was used to address this question: decision documents, remedy performance monitoring data, long-term monitoring (LTM) and/or monitored natural attenuation (MNA) data, and quarterly LUC inspection findings in comparison with the RAOs.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy selection still valid?

The following information was used to address this question:

Exposure Assumptions: review of chemicals of emerging concern (discussed in **Section 2.2.1**), new pathways of concern, and changes in land use documented in the Base Master Planning and geographic informations systems (GIS) databases.

Toxicity Data: review of the toxicity and USEPA regional screening levels (RSLs) for chemicals of concern (COCs) to identify potential concerns in relation to the previous human health risk assessments (HHRA) (**Table 2-1**).

Cleanup Levels: review of current ARARs and standards on which the ROD cleanup levels are based.

Validity of RAOs: review of existing RAOs against changes discussed in the previous sections to determine whether additional RAOs are necessary to maintain protectiveness or if one or more existing RAOs are not necessary based on remedy function.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

The following information was used to answer this question: external factors that were not apparent during remedy selection and were not covered under Questions A and B, such as resilience to extreme weather events (discussed in **Section 2.2.2**).

2.2.1 Chemicals of Emerging Concern

Certain per- and polyfluoroalkyl substances (PFAS) have been identified as chemicals of emerging concern by the Navy (Navy, 2017) and USEPA. The Department of Defense (DoD) has released guidance related to the use of screening levels in PFAS investigations (DoD, 2019); the following is a summary of potentially applicable screening levels for groundwater. USEPA lifetime health advisory levels of 40 nanograms per liter, based on a hazard index of 0.1, have been established for two PFAS compounds (perfluorooctanoic acid [PFOA] and perfluorooctane sulfonate [PFOS]) in drinking water (USEPA, 2019). The USEPA lifetime health advisory for drinking water (70 nanograms per liter) for PFOS and PFOA (combined or individual) is the recommended preliminary remediation goal for groundwater that is a potential source of drinking water. A tap water RSL is also published for perfluorobutane sulfonate (PFBS) and tap water RSLs for PFOA and PFOS can also be calculated using USEPA's RSL calculator. There is also a North Carolina interim maximum allowable concentration (IMAC) for PFOA.

PFAS compounds have been used in a variety of industrial and military applications such as aqueous film-forming foam (AFFF), which may have been used to put out fires at former firefighting training areas or crashes at Air Stations. Historical activities that may have resulted in releases of PFAS to the environment, such as use of AFFF during fire and emergency response, testing, and training activities and chromium plating operations, at Naval installations, has prompted the Navy to develop and implement a PFAS Preliminary Assessment/Site Inspection (PA/SI) process to identify and prioritize the investigation of sites with known or potential PFAS releases.

A Basewide PFAS PA was completed in 2019 (CH2M, 2019). Areas of interest evaluated in the PA included those where AFFF may have been applied, released, or stored and transferred and include the following activities: firefighting training and fire suppression, electroplating, landfill operations, waste disposal areas, and wastewater treatment plants (WWTPs).

Areas cataloged due to their potential to utilize PFAS-containing materials (other than AFFF), but where use of these materials is not well documented or unknown (such as hobby shops, paint shops, car washes, and pesticide shops), have been cataloged in case information at a later date indicates operations at these areas could result in a potential PFAS release.

Several FYR sites were identified in the Basewide PFAS PA for further investigation based on historical site use and supporting evidence such as documents, interviews, or site inspections that identified the potential for AFFF releases. Potential PFAS release areas unrelated to site use but within a FYR site boundary were also identified for further investigation. These potential PFAS release areas are discussed in their respective sections as other findings where data has not been collected.

2.2.2 Resilience to Extreme Weather

Eastern North Carolina, where MCB Camp Lejeune and MCAS New River are located, is subject to extreme weather events such as hurricanes, tropical storms, tornadoes, and flooding. In October 2016, Hurricane Matthew caused widespread destruction in eastern North Carolina, leading to a major disaster declaration from the Federal Emergency Management Agency that encompassed 48 counties, including Onslow County (Onslow County, 2017). In September 2018, Hurricane Florence caused widespread damage to MCB Camp Lejeune and MCAS New River. When it was safe to do so, each IRP site was inspected and a summary of damage was provided to the Navy and MCB Camp Lejeune Environmental Management Division. The majority of the hurricane damage was to fences and monitoring wells and access pathways from downed trees. Additional damage included downed power lines and washouts in areas near creeks and waterways. Repairs were made in areas that were considered high priority as determined by how the damage affects protectiveness and the extent of the damage. Repairs were completed between October 2018 and March 2019.

As part of the technical assessment Question C: Has any other information come to light that could affect protectiveness, the 2016 Recommended Five-Year Review Template provides the following guidance (USEPA, 2016):

> *This question may address site changes or vulnerabilities that may be related to climate change impacts not apparent during remedy selection, remedy implementation or O&M (e.g., sea level rise, changes in precipitation, increasing risk of floods, changes in temperature, increasing intensity of hurricanes and increasing wildfires, melting permafrost in northern regions, etc.).*

Because of the likeliness of extreme weather events occurring in the future in the vicinity of MCB Camp Lejeune and MCAS New River, a qualitative assessment of resilience is provided in each of the respective OU sections.

2.3 Site Inspections

MCB Camp Lejeune Environmental Management Division conducts quarterly inspections to verify compliance with land use restrictions and maintain the integrity of current or future remedial or monitoring systems. The annual reports from 2015 to 2019 are provided in **Appendix A**.

CH2M conducted an inspection of the FYR sites on March 26 through 28 and April 14, 2019. Inspection checklists are provided in **Appendix B**. The Partnering Team, consisting of representatives from NAVFAC Mid-Atlantic, MCB Camp Lejeune Environmental Management Division, USEPA Region 4, and NCDEQ, conducted a site visit of key FYR sites on May 15 and 16, 2019. Any findings were noted and are discussed in individual OU sections.

2.4 Community Involvement

The Marine Corps has taken a proactive approach to site cleanup by reaching out to the local community through the Restoration Advisory Board (RAB). The RAB was created in 1995 and is made up of members of the community, civic and business organizations, and civilian employees. The RAB meets quarterly to review ongoing investigation activities and findings, and to discuss cleanup alternatives and actions.

Additional information related to community involvement is found in the Community Involvement Plan, located along with the AR, on the IRP web site: http://go.usa.gov/Dy5T.

The Base also hosts a public web site where information is posted to enhance information exchange between the Base and community: http://go.usa.gov/x3f7m

Activities to involve the community in the FYR process were initiated with a notification published in early May 2019 in local newspapers (*The Globe* and *The Jacksonville Daily News*) that announced that the FYR process was occurring at MCB Camp Lejeune and MCAS New River. The community was also informed of the initiation of the FYR at a RAB meeting on May 15, 2019. When the FYR has been finalized, a notice will be sent to these newspapers indicating the results of the review and that the report is available to the public.

2.5 Interviews

An update to the Community Involvement Plan was initiated in November 2019. In-person interviews were conducted with local government officials and members of the on-Base and surrounding communities representing local businesses, employees working on-Base, and Base residents. Additional advertisements for the November 2019 RAB meeting attracted an increased number of attendees. A review of the Community Involvement Plan was presented at the November 2019 RAB meeting and feedback was gathered from attendees. Results of the interviews and the feedback gathered at the RAB meeting will be summarized in the Fiscal Year (FY) 2020 Community Involvement Plan Update. The plan is a public document, which will be used by Marine Corps and Navy officials as a guide for community involvement in the environmental and munitions response program.

2.6 Next Five-Year Review

The next FYR is due to be finalized in 2025.

2.7 References

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United States Environmental Protection Agency (USEPA). 2001. *Comprehensive Five-Year Review Guidance.*

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USEPA. 2012b. *Assessing Protectiveness at Sites for Vapor Intrusion: Supplement to the Comprehensive Five-Year Review Guidance.* November.

USEPA. 2016. *Recommended Five-Year Review Template.*

USEPA. 2019. *Interim Recommendations to Address Groundwater Contaminated with Perfluorooctonoic Acid and Perfluorooctanesulfonate.* Office of Land and Emergency Management (OLEM) Directive No. 9283.1-47. December.

Table 2-1. Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2019)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

					Ingestion Exposure										Inhalation Exposure [a]									
					Oral Reference Dose (RfDo) (mg/kg-day)					Cancer Slope Factor (CSFo) $(mg/kg\text{-}day)^{-1}$					Inhalation Reference Concentration (RfC) (mg/m^3)					Inhalation Unit Risk (IUR) $(ug/m^3)^{-1}$				
Operable Unit	Site Number	Chemical Group	Chemical of Concern	CAS	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk
OU 1	Sites 21, 24, and 78	VOC	1,1,2,2-Tetrachloroethane	79-34-5	2.0E-02	I	2.0E-02	I	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.8E-05	I	5.8E-05	C	--
		VOC	1,1-Dichloroethene	75-35-4	5.0E-02	I	5.0E-02	I	--	--	--	--	--	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--
		VOC	1,2,4-Trimethylbenzene	95-63-6	--	--	1.0E-02	I	Increase	--	--	--	--	--	7.0E-03	P	6.0E-02	I	Increase	--	--	--	--	--
		VOC	1,2-Dichloroethane	107-06-2	6.0E-03	X	6.0E-03	X	--	9.1E-02	I	9.1E-02	I	--	7.0E-03	P	7.0E-03	P	--	2.6E-05	I	2.6E-05	I	--
		VOC	1,2-Dichloroethene (Total) [c]	540-59-0	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	Ethylbenzene	100-41-4	1.0E-01	I	1.0E-01	I	--	1.1E-02	C	1.1E-02	C	--	1.0E+00	I	1.0E+00	I	--	2.5E-06	C	2.5E-06	C	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	Toluene	108-88-3	8.0E-02	I	8.0E-02	I	--	--	--	--	--	--	5.0E+00	I	5.0E+00	I	--	--	--	--	--	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		VOC	Xylenes (total)	1330-20-7	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	1.0E-01	I	1.0E-01	I	--	--	--	--	--	--
		SVOC	Benzo(a)anthracene	56-55-3	--	--	--	--	--	7.3E-01	E	1.0E-01	E	Decrease	--	--	--	--	--	1.1E-04	C	6.0E-05	E	Decrease
		SVOC	Benzo(a)pyrene	50-32-8	--	--	3.0E-04	I	Increase	7.3E+00	I	1.0E+00	I	Decrease	--	--	2.0E-06	I	Increase	1.1E-03	C	6.0E-04	E	Decrease
		SVOC	Benzo(b)fluoranthene	205-99-2	--	--	--	--	--	7.3E-01	E	1.0E-01	E	Decrease	--	--	--	--	--	1.1E-04	C	6.0E-05	E	Decrease
		SVOC	Benzo(k)fluoranthene	207-08-9	--	--	--	--	--	7.3E-02	E	1.0E-02	E	Decrease	--	--	--	--	--	1.1E-04	C	6.0E-06	E	Decrease
		SVOC	Chrysene	218-01-9	--	--	--	--	--	7.3E-03	E	1.0E-03	E	Decrease	--	--	--	--	--	1.1E-05	C	6.0E-07	E	Decrease
		SVOC	Dibenz(a,h)anthracene	53-70-3	--	--	--	--	--	7.3E+00	E	1.0E+00	E	Decrease	--	--	--	--	--	1.2E-03	C	6.0E-04	E	Decrease
		SVOC	Fluoranthene	86-73-7	4.0E-02	I	4.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	Indeno(1,2,3-cd)pyrene	193-39-5	--	--	--	--	--	7.3E-01	E	1.0E-01	E	Decrease	--	--	--	--	--	1.1E-04	C	6.0E-05	E	Decrease
		SVOC	Naphthalene	91-20-3	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	3.0E-03	I	3.0E-03	I	--	3.4E-05	C	3.4E-05	C	--
		SVOC	Phenanthrene [j]	85-01-8	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	Phenol	108-95-2	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	2.0E-01	C	2.0E-01	C	--	--	--	--	--	--
		SVOC	Pyrene	129-00-0	3.0E-02	I	3.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		PCB	Total PCBs [d]	--	2.0E-05	I	2.0E-05	I	--	2.0E+00	I	2.0E+00	I	--	--	--	--	--	--	5.7E-04	I	5.7E-04	I	--
		Pesticide	4,4-DDD	72-54-8	--	--	3.0E-05	X	Increase	2.4E-01	I	2.4E-01	I	--	--	--	--	--	--	6.9E-05	C	6.9E-05	C	--
		Pesticide	4,4-DDE	72-55-9	--	--	3.0E-04	X	Increase	3.4E-01	I	3.4E-01	I	--	--	--	--	--	--	9.7E-05	C	9.7E-05	C	--
		Pesticide	4,4-DDT	50-29-3	5.0E-04	I	5.0E-04	I	--	3.4E-01	I	3.4E-01	I	--	--	--	--	--	--	9.7E-05	I	9.7E-05	I	--
		Pesticide	Chlordane (total)	12789-03-6	5.0E-04	I	5.0E-04	I	--	3.5E-01	I	3.5E-01	I	--	7.0E-04	I	7.0E-04	I	--	1.0E-04	I	1.0E-04	I	--
		Pesticide	Dieldrin	60-57-1	5.0E-05	I	5.0E-05	I	--	1.6E+01	I	1.6E+01	I	--			--	--	Decrease	4.6E-03	I	4.6E-03	I	--
		Pesticide	Heptachlor epoxide	1024-57-3	1.3E-05	I	1.3E-05	I	--	9.1E+00	I	9.1E+00	I	--	--	--	--	--	--	2.6E-03	I	2.6E-03	I	--
		Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Barium	7440-39-3	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.0E-04	H	5.0E-04	H	--	--	--	--	--	--
		Metal	Beryllium	7440-41-7	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	2.0E-05	I	2.0E-05	I	--	2.4E-03	I	2.4E-03	I	--
		Metal	Cadmium	7440-43-9	5.0E-04	I	5.0E-04	I	--	--	--	--	--	--	1.0E-05	A	1.0E-05	A	--	1.8E-03	I	1.8E-03	I	--
		Metal	Chromium [e]	18540-29-9	3.0E-03	I	3.0E-03	I	--	5.0E-01	J	5.0E-01	C	--	1.0E-04	I	1.0E-04	I	--	8.4E-02	S	8.4E-02	S	--
		Metal	Cobalt	7440-48-4	3.0E-04	P	3.0E-04	P	--	--	--	--	--	--	6.0E-06	P	6.0E-06	P	--	9.0E-03	P	9.0E-03	P	--
		Metal	Copper	7440-50-8	4.0E-02	H	4.0E-02	H	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Iron	7439-89-6	7.0E-01	P	7.0E-01	P	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Manganese [h]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
		Metal	Mercury [i]	7439-97-6	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--
		Metal	Nickel	7440-02-0	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	9.0E-05	A	9.0E-05	A	--	2.6E-04	C	2.6E-04	C	--
		Metal	Selenium	7782-49-2	5.0E-03	I	5.0E-03	I	--	--	--	--	--	--	2.0E-02	C	2.0E-02	C	--	--	--	--	--	--
		Metal	Vanadium	7440-62-2	5.0E-03	S	5.0E-03	S	--	--	--	--	--	--	1.0E-04	A	1.0E-04	A	--	--	--	--	--	--
		Metal	Zinc	7440-66-6	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 2-1. Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2019)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

					Ingestion Exposure										Inhalation Exposure [a]									
					Oral Reference Dose (RfDo) (mg/kg-day)					Cancer Slope Factor (CSFo) (mg/kg-day)$^{-1}$					Inhalation Reference Concentration (RfC) (mg/m^3)					Inhalation Unit Risk (IUR) (ug/m^3)$^{-1}$				
Operable Unit	Site Number	Chemical Group	Chemical of Concern	CAS	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk
OU 2	Sites 6 and 82	VOC	1,1,2,2-Tetrachloroethane	79-34-5	2.0E-02	I	2.0E-02	I	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.8E-05	I	5.8E-05	C	--
		VOC	1,1,2-Trichloroethane	79-00-5	4.0E-03	I	4.0E-03	I	--	5.7E-02	I	5.7E-02	I	--	2.0E-04	X	2.0E-04	X	--	1.6E-05	I	1.6E-05	I	--
		VOC	1,1-Dichloroethene	75-35-4	5.0E-02	I	5.0E-02	I	--	--	--	--	--	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--
		VOC	1,2-Dichloroethane	107-06-2	6.0E-03	X	6.0E-03	X	--	9.1E-02	I	9.1E-02	I	--	7.0E-03	P	7.0E-03	P	--	2.6E-05	I	2.6E-05	I	--
		VOC	1,2-Dichloroethene (Total) [c]	540-59-0	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	1,4-Dichlorobenzene	106-46-7	7.0E-02	A	7.0E-02	A	--	5.4E-03	C	5.4E-03	C	--	8.0E-01	I	8.0E-01	I	--	1.1E-05	C	1.1E-05	C	--
		VOC	1,2-Dichloropropane	78-87-5	4.0E-02	A	4.0E-02	P	--	3.6E-02	P	3.7E-02	P	Increase	4.0E-03	I	4.0E-03	I	--	1.0E-05	C	3.7E-05	P	Increase
		VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	C	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	Chlorobenzene	108-90-7	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	5.0E-02	P	5.0E-02	P	--	--	--	--	--	--
		VOC	Chloroform	67-66-3	1.0E-02	I	1.0E-02	I	--	3.1E-02	C	3.1E-02	C	--	9.8E-02	A	9.8E-02	A	--	2.3E-05	I	2.3E-05	I	--
		VOC	Chloromethane	74-87-3	--	--	--	--	--	--	--	--	--	--	9.0E-02	I	9.0E-02	I	--	--	--	--	--	--
		VOC	Ethylbenzene	100-41-4	1.0E-01	I	1.0E-01	I	--	1.1E-02	C	1.1E-02	C	--	1.0E+00	I	1.0E+00	I	--	2.5E-06	C	2.5E-06	C	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		PCB	Total PCBs [d]	--	2.0E-05	I	2.0E-05	I	--	2.0E+00	I	2.0E+00	I	--	--	--	--	--	--	5.7E-04	I	5.7E-04	I	--
		Pesticide	4,4-DDT	50-29-3	5.0E-04	I	5.0E-04	I	--	3.4E-01	I	3.4E-01	I	--	--	--	--	--	--	9.7E-05	I	9.7E-05	I	--
		Metal	Aluminum	7429-90-5	1.0E+00	P	1.0E+00	P	--	--	--	--	--	--	5.0E-03	P	5.0E-03	P	--	--	--	--	--	--
		Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Barium	7440-39-3	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.0E-04	H	5.0E-04	H	--	--	--	--	--	--
		Metal	Beryllium	7440-41-7	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	2.0E-05	I	2.0E-05	I	--	2.4E-03	I	2.4E-03	I	--
		Metal	Cadmium [g]	7440-43-9	1.0E-03	I	1.0E-03	I	--	--	--	--	--	--	1.0E-05	A	1.0E-05	A	--	1.8E-03	I	1.8E-03	I	--
		Metal	Chromium [e]	18540-29-9	3.0E-03	I	3.0E-03	I	--	5.0E-01	J	5.0E-01	J	--	1.0E-04	I	1.0E-04	I	--	8.4E-02	S	8.4E-02	S	--
		Metal	Cobalt	7440-48-4	3.0E-04	P	3.0E-04	P	--	--	--	--	--	--	6.0E-06	P	6.0E-06	P	--	9.0E-03	P	9.0E-03	P	--
		Metal	Iron	7439-89-6	7.0E-01	P	7.0E-01	P	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Manganese [h]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
		Metal	Mercury [i]	7439-97-6	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--
		Metal	Thallium	7440-28-0	1.0E-05	X	1.0E-05	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Vanadium	7440-62-2	5.0E-03	S	5.0E-03	S	--	--	--	--	--	--	1.0E-04	A	1.0E-04	A	--	--	--	--	--	--
OU2	Site UXO-22	No COCs Identified in ESD																						
OU 4	Sites 41 and 74	Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Beryllium	7440-41-7	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	2.0E-05	I	2.0E-05	I	--	2.4E-03	I	2.4E-03	I	--
		Metal	Cadmium [f]	7440-43-9	5.0E-04	I	5.0E-04	I	--	--	--	--	--	--	1.0E-05	A	1.0E-05	A	--	1.8E-03	I	1.8E-03	I	--
		Metal	Chromium [e]	18540-29-9	3.0E-03	I	3.0E-03	I	--	5.0E-01	J	5.0E-01	C	--	1.0E-04	I	1.0E-04	I	--	8.4E-02	S	8.4E-02	S	--
		Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Manganese [h]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
		Metal	Nickel	7440-02-0	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	9.0E-05	A	9.0E-05	A	--	2.6E-04	C	2.6E-04	C	--

Table 2-1. Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2019)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

					Ingestion Exposure										Inhalation Exposure [a]									
					Oral Reference Dose (RfDo) (mg/kg-day)					Cancer Slope Factor (CSFo) (mg/kg-day)$^{-1}$					Inhalation Reference Concentration (RfC) (mg/m^3)					Inhalation Unit Risk (IUR) (ug/m^3)$^{-1}$				
Operable Unit	Site Number	Chemical Group	Chemical of Concern	CAS	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk
OU 5	Site 2	VOC	Ethylbenzene	100-41-4	1.0E-01	I	1.0E-01	I	--	1.1E-02	C	1.1E-02	C	--	1.0E+00	I	1.0E+00	I	--	2.5E-06	C	2.5E-06	C	--
		VOC	Toluene	108-88-3	8.0E-02	I	8.0E-02	I	--	--	--	--	--	--	5.0E+00	I	5.0E+00	I	--	--	--	--	--	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Xylene (total)	1330-20-7	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	1.0E-01	I	1.0E-01	I	--	--	--	--	--	--
		SVOC	Acenaphthene	83-32-9	6.0E-02	I	6.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	2,4-Dimethyphenol	105-67-9	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	2-Methylnaphthalene	91-57-6	4.0E-03	I	4.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	Naphthalene	91-20-3	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	3.0E-03	I	3.0E-03	I	--	3.4E-05	C	3.4E-05	C	--
		SVOC	Phenol	108-95-2	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	2.0E-01	C	2.0E-01	C	--	--	--	--	--	--
		Pesticide	4,4-DDD	72-54-8	--	--	3.0E-05	X	Increase	2.4E-01	I	2.4E-01	I	--	--	--	--	--	--	6.9E-05	C	6.9E-05	C	--
		Pesticide	4,4-DDE	72-55-9	--	--	3.0E-04	X	Increase	3.4E-01	I	3.4E-01	I	--	--	--	--	--	--	9.7E-05	C	9.7E-05	C	--
		Pesticide	4,4-DDT	50-29-3	5.0E-04	I	5.0E-04	I	--	3.4E-01	I	3.4E-01	I	--	--	--	--	--	--	9.7E-05	I	9.7E-05	I	--
		Pesticide	Chlordane (total)	12789-03-6	5.0E-04	I	5.0E-04	I	--	3.5E-01	I	3.5E-01	I	--	7.0E-04	I	7.0E-04	I	--	1.0E-04	I	1.0E-04	I	--
		Pesticide	Dieldrin	60-57-1	5.0E-05	I	5.0E-05	I	--	1.6E+01	I	1.6E+01	I	--	--	--	--	--	--	4.6E-03	I	4.6E-03	I	--
		Pesticide	Heptachlor	76-44-8	5.0E-04	I	5.0E-04	I	--	4.5E+00	I	4.5E+00	I	--	--	--	--	--	--	1.3E-03	I	1.3E-03	I	--
		Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Barium	7440-39-3	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.0E-04	H	5.0E-04	H	--	--	--	--	--	--
		Metal	Beryllium	7440-41-7	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	2.0E-05	I	2.0E-05	I	--	2.4E-03	I	2.4E-03	I	--
		Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Vanadium	7440-62-2	5.0E-03	S	5.0E-03	S	--	--	--	--	--	--	1.0E-04	A	1.0E-04	A	--	--	--	--	--	--
OU 6	Sites 36, 43, 44, and 54	VOC	1,1,2,2-Tetrachloroethane	79-34-5	2.0E-02	I	2.0E-02	I	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.8E-05	I	5.8E-05	C	--
		VOC	1,1-Dichloroethene	75-35-4	5.0E-02	I	5.0E-02	I	--	--	--	--	--	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--
		VOC	1,2-Dichloroethane	107-06-2	6.0E-03	X	6.0E-03	X	--	9.1E-02	I	9.1E-02	I	--	7.0E-03	P	7.0E-03	P	--	2.6E-05	I	2.6E-05	I	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	trans-1,2-Dichloroethene	156-60-5	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	1,2-Dichloroethene (Total) [c]	540-59-0	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl Chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		Metal	Aluminum[k]	7429-90-5	1.0E+00	P	1.0E+00	P	--	--	--	--	--	--	5.0E-03	P	5.0E-03	P	--	--	--	--	--	--
		Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Iron[k]	7439-89-6	7.0E-01	P	7.0E-01	P	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Mercury [i]	7439-97-6	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--
OU 7	Site 28	Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Manganese[h,k]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
OU 8	Site 16	No COCs Identified in ROD																						
OU 10	Site 35	VOC	1,1,2,2-Tetrachloroethane	79-34-5	2.0E-02	I	2.0E-02	I	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.8E-05	I	5.8E-05	C	--
		VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		Metal	Antimony	7440-36-0	4.0E-04	I	4.0E-04	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Barium	7440-39-3	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.0E-04	H	5.0E-04	H	--	--	--	--	--	--
		Metal	Cadmium	7440-43-9	5.0E-04	I	5.0E-04	I	--	--		--	--	--	1.0E-05	A	1.0E-05	A	--	1.8E-03	I	1.8E-03	I	--
		Metal	Chromium [e]	18540-29-9	3.0E-03	I	3.0E-03	I	--	5.0E-01	J	5.0E-01	C	--	1.0E-04	I	1.0E-04	I	--	8.4E-02	S	8.4E-02	S	--
		Metal	Manganese[h]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
		Metal	Mercury [i]	7439-97-6	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--	3.0E-04	I	3.0E-04	I	--	--	--	--	--	--
		Metal	Vanadium	7440-62-2	5.0E-03	S	5.0E-03	S	--	--	--	--	--	--	1.0E-04	A	1.0E-04	A	--	--	--	--	--	--

Table 2-1. Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2019)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

					Ingestion Exposure										Inhalation Exposure [a]									
					Oral Reference Dose (RfDo) (mg/kg-day)					Cancer Slope Factor (CSFo) $(mg/kg\text{-}day)^{-1}$					Inhalation Reference Concentration (RfC) (mg/m^3)					Inhalation Unit Risk (IUR) $(ug/m^3)^{-1}$				
Operable Unit	Site Number	Chemical Group	Chemical of Concern	CAS	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk
OU 11	Site 80	Pesticide	4,4-DDD	72-54-8	--	--	3.0E-05	X	Increase	2.4E-01	I	2.4E-01	I	--	--	--	--	--	--	6.9E-05	C	6.9E-05	C	--
		Pesticide	4,4-DDT	50-29-3	5.0E-04	I	5.0E-04	I	--	3.4E-01	I	3.4E-01	I	--	--	--	--	--	--	9.7E-05	I	9.7E-05	I	--
		Pesticide	Aldrin	309-00-2	3.0E-05	I	3.0E-05	I	--	1.7E+01	I	1.7E+01	I	--	--	--	--	--	--	4.9E-03	I	4.9E-03	I	--
		Pesticide	Alpha-Chlordane	12789-03-6	5.0E-04	I	5.0E-04	I	--	3.5E-01	I	3.5E-01	I	--	7.0E-04	I	7.0E-04	I	--	1.0E-04	I	1.0E-04	I	--
		Pesticide	Dieldrin	60-57-1	5.0E-05	I	5.0E-05	I	--	1.6E+01	I	1.6E+01	I	--	--	--	--	--	--	4.6E-03	I	4.6E-03	I	--
		Pesticide	Gamma-Chlordane	5566-34-7	5.0E-04	I	5.0E-04	I	--	3.5E-01	I	3.5E-01	I	--	7.0E-04	I	7.0E-04	I	--	1.0E-04	I	1.0E-04	I	--
		Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
OU 12	Site 3	VOC	2-Methylnaphthalene	91-57-6	4.0E-03	I	4.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	Chloroform	67-66-3	1.0E-02	I	1.0E-02	I	--	3.1E-02	C	3.1E-02	C	--	9.8E-02	A	9.8E-02	A	--	2.3E-05	I	2.3E-05	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		SVOC	2,4-Dimethylphenol	105-67-9	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	2-Methylphenol	95-48-7	5.0E-02	I	5.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	Acenaphthene	83-32-9	6.0E-02	I	6.0E-02	I	--	--	--	--	--	--			--	--	Decrease	--	--	--	--	--
		SVOC	Benzo(a)anthracene	56-55-3	--	--	--	--	--	7.3E-01	E	1.0E-01	E	Decrease	--	--	--	--	--	1.1E-04	C	6.0E-05	E	Decrease
		SVOC	Benzo(a)pyrene	50-32-8	--	--	3.0E-04	I	Increase	7.3E+00	I	1.0E+00	I	Decrease	--	--	2.0E-06	I	Increase	1.1E-03	C	6.0E-04	E	Decrease
		SVOC	Benzo(b)fluoranthene	205-99-2	--	--	--	--	--	7.3E-01	E	1.0E-01	E	Decrease	--	--	--	--	--	1.1E-04	C	6.0E-05	E	Decrease
		SVOC	Benzo(k)fluoranthene	207-08-9	--	--	--	--	--	7.3E-02	E	1.0E-02	E	Decrease	--	--	--	--	--	1.1E-04	C	6.0E-06	E	Decrease
		SVOC	Bis(2-ethylheyxl)phthalate	117-81-7	2.0E-02	I	2.0E-02	I	--	1.4E-02	I	1.4E-02	I	--	--	--	--	--	--	2.4E-06	C	2.4E-06	C	--
		SVOC	Carbazole	86-74-8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	Chrysene	218-01-9	--	--	--	--	--	7.3E-03	E	1.0E-03	E	Decrease	--	--	--	--	--	1.1E-05	C	6.0E-07	E	Decrease
		SVOC	Dibenzofuran	132-64-9	1.0E-03	X	1.0E-03	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	Naphthalene	91-20-3	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	3.0E-03	I	3.0E-03	I	--	3.4E-05	C	3.4E-05	C	--
		SVOC	Phenanthrene [j]	85-01-8	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		SVOC	Phenol	108-95-2	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	2.0E-01	C	2.0E-01	C	--	--	--	--	--	--
		Metal	Aluminum	7429-90-5	1.0E+00	P	1.0E+00	P	--	--	--	--	--	--	5.0E-03	P	5.0E-03	P	--	--	--	--	--	--
		Metal	Iron	7439-89-6	7.0E-01	P	7.0E-01	P	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OU 13	Site 63	Metal	Iron	7439-89-6	7.0E-01	P	7.0E-01	P	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Zinc	7440-66-6	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OU 14	Site 69	VOC	1,1,2,2-Tetrachloroethane	79-34-5	2.0E-02	I	2.0E-02	I	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.8E-05	C	5.8E-05	C	--
		VOC	1,1,2-Trichloroethane	79-00-5	4.0E-03	I	4.0E-03	I	--	5.7E-02	I	5.7E-02	I	--	2.0E-04	X	2.0E-04	X	--	1.6E-05	I	1.6E-05	I	--
		VOC	1,2-Dichloroethane	107-06-2	6.0E-03	X	6.0E-03	X	--	9.1E-02	I	9.1E-02	I	--	7.0E-03	P	7.0E-03	P	--	2.6E-05	I	2.6E-05	I	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	trans-1,2-Dichloroethene	156-60-5	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		Pesticide	Alpha-BHC	319-84-6	8.0E-03	A	8.0E-03	A	--	6.3E+00	I	6.3E+00	I	--	--	--	--	--	--	1.8E-03	I	1.8E-03	I	--
		Pesticide	Dieldrin	60-57-1	5.0E-05	I	5.0E-05	I	--	1.6E+01	I	1.6E+01	I	--	--	--	--	--	--	4.6E-03	I	4.6E-03	I	--
		Pesticide	Heptachlor epoxide	1024-57-3	1.3E-05	I	1.3E-05	I	--	9.1E+00	I	9.1E+00	I	--	--	--	--	--	--	2.6E-03	I	2.6E-03	I	--
		PCB	Aroclor 1260	11096-82-5	--	--	--	--	--	2.0E+00	S	2.0E+00	S	--	--	--	--	--	--	5.7E-04	S	5.7E-04	S	--
		Metal	Beryllium	7440-41-7	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	2.0E-05	I	2.0E-05	I	--	2.4E-03	I	2.4E-03	I	--
		Metal	Chromium [e]	18540-29-9	3.0E-03	I	3.0E-03	I	--	5.0E-01	C	5.0E-01	J	--	1.0E-04	I	1.0E-04	I	--	8.4E-02	S	8.4E-02	S	--
		Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Manganese [h]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
		Metal	Thallium	7440-28-0	1.0E-05	X	1.0E-05	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Vanadium	7440-62-2	5.0E-03	S	5.0E-03	S	--	--	--	--	--	--	1.0E-04	A	1.0E-04	A	--	--	--	--	--	--
		Metal	Zinc	7440-66-6	3.0E-01	I	3.0E-01	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OU 15 [l]	Site 88	VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		SVOC	Naphthalene	91-20-3	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	3.0E-03	I	3.0E-03	I	--	3.4E-05	C	3.4E-05	C	--

Table 2-1. Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2019)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

					Ingestion Exposure										Inhalation Exposure [a]									
					Oral Reference Dose (RfDo) (mg/kg-day)					Cancer Slope Factor (CSFo) $(mg/kg\text{-}day)^{-1}$					Inhalation Reference Concentration (RfC) (mg/m^3)					Inhalation Unit Risk (IUR) $(ug/m^3)^{-1}$				
Operable Unit	**Site Number**	**Chemical Group**	**Chemical of Concern**	**CAS**	**Historical Value [a]**	**Source**	**Current Value [b]**	**Source**	**Impact on Estimated Hazard**	**Historical Value [a]**	**Source**	**Current Value [b]**	**Source**	**Impact on Estimated Risk**	**Historical Value [a]**	**Source**	**Current Value [b]**	**Source**	**Impact on Estimated Hazard**	**Historical Value [a]**	**Source**	**Current Value [b]**	**Source**	**Impact on Estimated Risk**
OU 16	Sites 89 and 93	VOC	1,1,2,2-Tetrachloroethane	79-34-5	2.0E-02	I	2.0E-02	I	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.8E-05	C	5.8E-05	C	--
		VOC	1,1,2-Trichloroethane	79-00-5	4.0E-03	I	4.0E-03	I	--	5.7E-02	I	5.7E-02	I	--	2.0E-04	X	2.0E-04	X	--	1.6E-05	I	1.6E-05	I	--
		VOC	1,2-Dichloroethane	107-06-2	6.0E-03	X	6.0E-03	X	--	9.1E-02	I	9.1E-02	I	--	7.0E-03	P	7.0E-03	P	--	2.6E-05	I	2.6E-05	I	--
		VOC	1,2-Dichloroethene (Total) [c]	540-59-0	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	trans-1,2-Dichloroethene	156-60-5	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		Metal	Arsenic[k]	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Lead	7439-92-1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Manganese [h]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
OU 19	Site 84	SVOC	Benzo(a)pyrene	50-32-8	--	--	3.0E-04	I	Increase	7.3E+00	I	1.0E+00	I	Decrease	--	--	2.0E-06	I	Increase	1.1E-03	C	6.0E-04	E	Decrease
		SVOC	2-Methyl-4-chlorophenoxyacetic acid	94-74-6	5.0E-04	I	5.0E-04	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Pesticide	Heptachlor	76-44-8	5.0E-04	I	5.0E-04	I	--	4.5E+00	I	4.5E+00	I	--	--	--	--	--	--	1.3E-03	I	1.3E-03	I	--
		PCB	Aroclor 1260	11096-82-5	--	--	--	--	--	2.0E+00	I	2.0E+00	S	--	--	--	--	--	--	5.7E-04	S	5.7E-04	S	--
		PCB	Total PCBs [d]	--	2.0E-05	I	2.0E-05	I	--	2.0E+00	I	2.0E+00	I	--	--	--	--	--	--	5.7E-04	I	5.7E-04	I	--
		Metal	Antimony	7440-36-0	4.0E-04	I	4.0E-04	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Arsenic	7440-38-2	3.0E-04	I	3.0E-04	I	--	1.5E+00	I	1.5E+00	I	--	1.5E-05	C	1.5E-05	C	--	4.3E-03	I	4.3E-03	I	--
		Metal	Iron	7439-89-6	7.0E-01	P	7.0E-01	P	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		Metal	Manganese [h]	7439-96-5	2.4E-02	I	2.4E-02	I	--	--	--	--	--	--	5.0E-05	I	5.0E-05	I	--	--	--	--	--	--
		Metal	Thallium	7440-28-0	1.0E-05	X	1.0E-05	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OU 20	Site 86	VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		Metal	Chromium [e,k]	18540-29-9	3.0E-03	I	3.0E-03	I	--	5.0E-01	J	5.0E-01	J	--	1.0E-04	I	1.0E-04	I	--	8.4E-02	S	8.4E-02	S	--
OU 21	Site 73	VOC	1,1-Dichloroethene	75-35-4	5.0E-02	I	5.0E-02	I	--	--	--	--	--	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--
		VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
		TPH	C11-C22 Aromatic Hydrocarbon Fraction [m]	N/A	4.0E-02	TPHCWG	4.0E-02	P	--	2.0E-01	TPHCWG	N/A		Decrease	--	--	--	--	--	--	--	--	--	--
OU 23	Site 49	VOC	1,1,2,2-Tetrachloroethane	79-34-5	2.0E-02	I	2.0E-02	I	--	2.0E-01	I	2.0E-01	I	--	--	--	--	--	--	5.8E-05	C	5.8E-05	C	--
		VOC	1,1,2-Trichloroethane	79-00-5	4.0E-03	I	4.0E-03	I	--	5.7E-02	I	5.7E-02	I	--	2.0E-04	X	2.0E-04	X	--	1.6E-05	I	1.6E-05	I	--
		VOC	1,2-Dichloroethane	107-06-2	6.0E-03	X	6.0E-03	X	--	9.1E-02	I	9.1E-02	I	--	7.0E-03	P	7.0E-03	P	--	2.6E-05	I	2.6E-05	I	--
		VOC	Benzene	71-43-2	4.0E-03	I	4.0E-03	I	--	5.5E-02	I	5.5E-02	I	--	3.0E-02	I	3.0E-02	I	--	7.8E-06	I	7.8E-06	I	--
		VOC	cis-1,2-Dichloroethene	156-59-2	2.0E-03	I	2.0E-03	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Tetrachloroethene	127-18-4	6.0E-03	I	6.0E-03	I	--	2.1E-03	I	2.1E-03	I	--	4.0E-02	I	4.0E-02	I	--	2.6E-07	I	2.6E-07	I	--
		VOC	trans-1,2-Dichloroethene	156-60-5	2.0E-02	I	2.0E-02	I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		VOC	Trichloroethene	79-01-6	5.0E-04	I	5.0E-04	I	--	4.6E-02	I	4.6E-02	I	--	2.0E-03	I	2.0E-03	I	--	4.1E-06	I	4.1E-06	I	--
		VOC	Vinyl chloride	75-01-4	3.0E-03	I	3.0E-03	I	--	7.2E-01	I	7.2E-01	I	--	1.0E-01	I	1.0E-01	I	--	4.4E-06	I	4.4E-06	I	--
OU 24	Site UXO-06	No COCs Identified in ROD																						
OU 25	Site UXO-19	No COCs Identified in ROD																						

Table 2-1. Comparison Between Historical Toxicity Values and Current Toxicity Values (as of 2019)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

					Ingestion Exposure										Inhalation Exposure [a]									
					Oral Reference Dose (RfDo) (mg/kg-day)					Cancer Slope Factor (CSFo) $(mg/kg\text{-}day)^{-1}$					Inhalation Reference Concentration (RfC) (mg/m^3)					Inhalation Unit Risk (IUR) $(ug/m^3)^{-1}$				
Operable Unit	Site Number	Chemical Group	Chemical of Concern	CAS	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Hazard	Historical Value [a]	Source	Current Value [b]	Source	Impact on Estimated Risk

Notes:
Inhalation values listed for non-volatile compounds (e.g., metals) are only applicable to dust inhalation and would not be appropriate for groundwater.
Source:
[a] Historical toxicity factors are toxicity factors available when the last Five-Year Review report was prepared in 2015. The historical factors were obtained from the May 2014 version of RSL table.
[b] Current toxicity factors are presented in the May 2019 version of RSL table.
[c] trans-1,2-Dichloroethene used as surrogate for total 1,2-dichloroethene for historic and current toxicity factors.
[d] Aroclor 1254 used as surrogate for total PCBs toxicity factors.
[e] Toxicity factors for chromium VI used for chromium.
[f] The RfD_o for cadmium, and current cadmium RfD_o were used for evaluation in water in the risk assessment.
[g] The RfD_o for cadmium, and current cadmium RfD_o were used for evaluation in soil/sediment in the risk assessment.
[h] The RfD_o for manganese was modified to account for the background dietary intake through food consumption.
[i] The toxicity factors for mercuric chloride used as surrogate for mercury.
[j] The toxicity factors for for anthracene used as surrogate for phenanthrene.
[k] Not retained as a COC because suspected to be a result of natural conditions and not site operations.
[l] Historical values for OU 15 are presented in the May 2016 version of the RSL table. The HHRA for OU 15 was prepared after the last five year review.
[m] Historical values for C11-C22 Aromatic Hydrocarbon Fraction are from the Total Petroleum Hydrocarbon Criteria Working Group, Volume 4. 1997.

A = Agency for Toxic Substances and Disease Registry
C = California Environmental Protection Agency
E = Environmental Criteria and Assessment Office
H = Health Effects Assessment Summary Tables (HEAST)
I = Integrated Risk Information System (IRIS)
J = New Jersey Department of Environmental Protection (NJDEP)
P = Provisional Peer-Reviewed Toxicity Value (PPRTV)
S (Chromium) = For hexavalent chromium, IRIS shows an air unit risk of 1.2E-2 per $(\mu g/m^3)$. While the exact ratio of hexavalent to trivalent chromium in the data used to derive the IRIS air unit risk value is not known, it is likely that both hexavalent and trivalent chromium were present. The RSLs calculated using the IRIS air unit risk assume that the hexavalent to trivalent chromium ratio is 1:6.
S (Vanadium) = Oral RfD toxicity value for vanadium in RSL table is derived from the IRIS oral RfD for vanadium pentoxide by factoring out the molecular weight of the oxide ion.
S (PCBs/Aroclors) = Aroclor 1016 is considered "lowest risk" and assigned appropriate toxicity values. All other Aroclors are assigned the high risk toxicity values.
TPHCWG = Total Petroleum Hydrocarbon Criteria Working Group
X = Appendix PPRTV Screen (See RSL FAQ #31 from November 2018)

<u>Acronyms:</u>
-- No change from last Five-Year Review
COC - chemical of concern
PCB - polychlorinated biphenyl
SVOC - semi-volatile organic compound
VOC - volatile organic compound
mg/m^3 - milligrams per cubic meter
ug/m^3 - micrograms per cubic meter
CAS - chemical abstracts service

Operable Unit 1 (Sites 21, 24, and 78)

3.1 Site History and Background

OU 1 Timeline	
Year	**Event**
1983	IAS
1984-1990	Confirmation Study (Sites 21 & 24)
1984-1992	Interim RI/Interim FS/Interim PRAP/Interim ROD for Surficial Aquifer (Site 78)
1994	RI/FS (Sites 21 & 24)
1994	PRAP and ROD (OU 1)
1994-Present	Groundwater treatment and LTM (Site 78)
1995	ESD and Soil Removal (Sites 21 & 78)
1996-1997	LTM (Site 24)
1998	Notice of Non-significant Changes (Site 78)
2000	Optimization Study (Site 78)
2001-2002	Natural Attenuation Evaluation (Site 78) LUCs (Sites 21 and 78)
2001	Remedy Complete (Site 24)
2003-2005	ORC and Hydrogen Release Compound Pilot Study (Site 78)
2007-2015	Basewide VI Evaluation (Site 78)
2009-2012	HPIA Evaluation (Site 78)
2009-2011	Plume Delineation (Site 78)
2011-2014	Supplemental Groundwater Investigation (Site 78)
2012	Hadnot Point Construction Area Risk Evaluation Update (Site 78)
2012-2013	Historical Metals Evaluation (Site 78)
2012-Present	ERD, ISCO, and AS Pilot Studies (Site 78)
2014-Present	VIMS O&M (Site 78)
2015	LUCIP Update (Site 78)
2017	RACR (Site 24)
2017	ESD (Site 78)
2017-2018	FS Amendment Investigation (Site 78)
2017-2018	GWTP Evaluation (Site 78)
2019	Basewide PFAS PA (Sites 24 & 78)

OU 1 is within the Hadnot Point Industrial Area (HPIA) on the Mainside of the Base, approximately 1 mile east of the New River and 2 miles south of State Route 24 (**Figure 1-2**). OU 1 consists of three sites (Sites 21, 24, and 78) that have been grouped together because of their proximity to one another. The remedy at Site 24, the Industrial Area Fly Ash Dump, was completed in 2001 and documented as complete in a Remedial Action Completion Report (RACR) signed in 2017. Site 24 is included in this FYR to document site closure and response complete that occurred during this FYR cycle.

Site 21 — the **Transformer Storage Lot 140** covers approximately 10 acres within OU 1 (**Figure 3-1**). From 1950 to 1951, a pit located in the northern portion of Site 21 was used as a drainage receptor for oil from transformers. Surface discharge of transformer oils was also reported. The quantity of oil disposal is unknown. The pit reportedly measured 25 to 30 feet long by 6 feet wide and 8 feet deep. In 1958, a pest control shop was moved from Building 712 (Site 2) to Building 1105, located in the southern portion of Site 21. From 1958 to 1977, Building 1105 was used for pesticide mixing and as a cleaning area for pesticide application equipment. Overland discharge of wastewater generated during cleaning operations was documented. The estimated quantity of wastewater discharged was approximately 350 gallons per week in 1977.

Site 24 — the **Industrial Area Fly Ash Dump** covers approximately 100 acres within OU 1 (**Figure 3-1**). Site 24 was used for the disposal of fly ash, cinders, solvents, used paint-stripping compounds, sewage sludge, and water treatment sludge from the late 1940s to 1980s. Sludge from the WWTP and sewage treatment plant were reportedly disposed at this site since the late 1940s. Construction debris was reportedly disposed at the site in the 1960s. During 1972 to 1979, fly ash cinders and used cleaning solvents were dumped on the ground surface. An estimated 31,500 tons of fly ash was disposed at the site and an estimated 45,000 gallons of stripping compounds was disposed over a 7-year period.

Site 78 — the **HPIA** covers approximately 800 acres and is located within OU 1 (**Figure 3-1**). The HPIA, constructed in the late 1930s, was the first developed area at MCB Camp Lejeune. The HPIA consists of maintenance shops, warehouses, painting shops, printing shops, auto body shops, and other small industrial facilities.

Due to the industrial nature of the site, many spills and leaks have occurred over the years. Most of these spills and leaks have consisted of petroleum-related products and solvents from USTs and drums.

3.2 Site Characterization

The findings from various investigations at OU 1 that are pertinent to the FYR are summarized in this section.

3.2.1 Physical Characteristics

- **Surface Features –** Sites 21 and 78 are primarily developed and flat while Site 24 is developed in the northern portion of the site and is primarily wooded. Storm water runoff is conveyed primarily via man-made ditches and storm sewers to Beaver Dam Creek to the north, Cogdels Creek (and unnamed tributaries) to the south, and the New River to the west of the site.
- **Geology and Hydrogeology –** The subsurface at OU 1 generally consists of Coastal Plain deposits comprising layers of sand, silt, and clay underlain by sand, fossils, and limestone beds. Groundwater is a medium of concern and the affected aquifers include the surficial aquifer which extends from ground surface to 30 feet below ground surface [bgs]), upper Castle Hayne (UCH) aquifer from 30 to 60 feet bgs, middle Castle Hayne (MCH) aquifer from 60 to 125 feet bgs, and lower Castle Hayne (LCH) aquifer up to 150 feet bgs. Surficial aquifer groundwater flows toward Cogdels Creek and the New River and Castle Hayne aquifer groundwater flows toward the New River (**Figure 3-1**). In the surficial aquifer the hydraulic conductivity is 2.8 feet per day (ft/day), in the UCH aquifer the hydraulic conductivity is 32.1 ft/day, and in the MCH aquifer the hydraulic conductivity is 1.1 ft/day. Downward vertical gradients are generally observed at OU 1 and are approximately 0.063 feet per foot (ft/ft) from the surficial to the UCH aquifer, a downward vertical gradient from the UCH to the MCH aquifer (0.004 ft/ft), and a slight downward vertical gradient from the MCH to the LCH aquifer (0.003 ft/ft).

3.2.2 Land Use

- **Current Land Use –** Sites 21 and 78 are primarily industrial areas. Site 21 is used for storage and Site 78 is made up of maintenance shops, warehouses, painting shops, printing shops, auto body shops, and other industrial facilities. The wooded area of Site 24 is used for military vehicle maneuvers.
- **Future Land Use –** There are no anticipated changes in land use.

3.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 1. Details are provided in the Remedial Investigation (RI) report (Baker, 1994a) and the ROD (Baker, 1994d).

Soil, groundwater, sediment, and surface water were investigated. Soil, sediment, and surface water data was evaluated by site, and groundwater data was evaluated as an OU in the risk assessments. The HHRA evaluated current military personnel and potential future adult and child residents and construction workers. Potential unacceptable risks to future residents were identified from exposure to metals and VOCs in surficial and shallow UCH aquifer groundwater for OU 1. Although not a risk driver, heptachlor epoxide was reported above the North Carolina Groundwater Quality Standard (NCGWQS) in groundwater samples collected at Site 24. Isolated areas with higher concentrations of polychlorinated biphenyls (PCBs) in soil at Site 21 exceeded industrial risk levels and were recommended for removal. The ecological risk assessment (ERA) evaluated terrestrial and aquatic receptors. Potential unacceptable ecological risks were identified from exposure to pesticides in soil at Site 78.

Site 78 was included in a Basewide vapor intrusion (VI) evaluation from 2007 to 2015 to assess the potential for site COCs to impact VI in existing buildings within 100 feet of the groundwater plume (AGVIQ/CH2M, 2009; CH2M, 2015b). The phased VI evaluation indicated that, although VI was not presently a significant pathway of concern at any of the buildings investigated, indoor air concentrations could exceed the vapor intrusion screening levels

(VISLs) should VI occur in the future at Building 902. As a precautionary measure, in January 2012, a vapor intrusion mitigation system (VIMS) was installed in Building 902 (CH2M, 2014a). Additionally, based on site-specific COCs, indoor air concentrations could exceed VISLs should VI occur in the future if new construction were to take place or if building or land use changes within 100 feet of the groundwater VOC plume (CH2M, 2017).

3.3 Remedial Action Objectives

The interim ROD for Site 78 was signed in September 1992 (Baker, 1992d), the final ROD for OU 1 was signed in September 1994 (Baker, 1994d), and the Explanation of Significant Differences (ESD) was signed in June 2017 (CH2M, 2017). The current RAOs are as follows:

- Prevent human consumption of contaminated groundwater by containing the contaminated groundwater in the surficial aquifer.
- Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A North Carolina Administrative Code (NCAC) 02L.0201.
- Prevent current or future exposure to the contaminated groundwater and contaminated soils.
- Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.
- Treat or remove contaminated soil from designated AOCs.

The COCs and cleanup levels for OU 1 are presented in **Table 3-1**.

3.4 Remedial Actions

The RA for OU 1 includes the following major components:

- Two groundwater extraction and treatment (GWTP) systems to prevent migration of VOC plumes in the surficial aquifer groundwater at Site 78 North and Site 78 South.
- LTM to monitor changes in groundwater COC extent at Sites 24 and 78 and to monitor the effectiveness of the treatment system. Groundwater contamination at Site 21 is being addressed under LTM for Site 78.
- Removal of pesticide and PCB-contaminated soil from Sites 21 and 78 to industrial levels.
- VIMS to mitigate the potential for a future VI pathway at Building 902.
- LUCs to prevent exposure to COCs in soil and groundwater and indoor air via the VI pathway.

3.5 Remedy Implementation

Soil Removal

In 1995, approximately 650 tons of pesticide-contaminated soil and 161 tons of PCB-contaminated soil were excavated from Site 21 and Site 78 South to meet industrial criteria and disposed of offsite (OHM, 1996).

Groundwater Extraction and Treatment System

The Site 78 North and Site 78 South GWTP systems began operation in 1994 and were expanded in 1996. Groundwater from the recovery wells and sumps is treated in the following sequence:

1. Oil/Water Separator (OWS)
2. Flocculation Tank
3. Settling Tank
4. Sand Filter
5. Air Stripper

6. Bag Filters
7. Carbon Vessels
8. Effluent Holding Tank
9. Effluent discharge to sanitary sewer

The system was initially designed with 15 recovery wells screened within the surficial aquifer and shallow portion of the UCH aquifer (from 25 to 35 feet bgs); however, several were taken offline in 1996 based on low influent concentrations (USMC, 1997). Site 78 North consists of seven recovery wells, three of which are currently operational, and Site 78 South consists of eight recovery wells, of which six are currently operational (**Figure 3-1**).

Vapor Intrusion Mitigation System

The VIMS at Building 902 was installed in 2012. The VIMS at Building 902 is a subslab depressurization system that uses fans to place a negative pressure beneath the floor slab and under the footprint of the building. The negative pressure reverses the flow of contaminants into the indoor space and removes subslab VOCs. O&M is conducted as described in the following section.

Long-term Monitoring and Land Use Controls

LTM at Sites 24 and 78 was initiated in 1994 and 1996, respectively, and is ongoing at Site 78, as described in the following section. LTM at Site 24 was discontinued in 1998 when cleanup levels were met (CH2M, 2016b). LUCs were implemented at OU 1 in 2001 and updated in 2002 (Baker, 2002) and 2015 (CH2M, 2016a). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 1,000 feet of groundwater within the surficial and Castle Hayne aquifer groundwater with concentrations of VOCs exceeding NCGWQS/Maximum Contaminant Levels (MCLs).
- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use such as residential housing, hospitals, hotels, nursing homes, and day care facilities within the extent of the former soil removal areas at Sites 21 and 78.
- **Intrusive Activities Control (Groundwater):** Restrict intrusive activities within the extent of groundwater contamination. This LUC boundary encompasses areas that are within 100 feet of surficial aquifer groundwater with concentrations of VOCs exceeding NCGWQS/MCLs.
- **Industrial/Non-Industrial Use Control (VI):** Evaluate future buildings and land use for potential VI pathways, before construction begins, within the extent of groundwater contamination remaining in place above concentrations that allow for UU/UE. This LUC boundary encompasses areas that are within 100 feet of surficial and Castle Hayne aquifer groundwater with concentrations of VOCs exceeding NCGWQS/MCLs.

3.5.1 Remedy Operation and Maintenance

Ongoing operations at Site 78 include operation of the GWTP, LTM, and LUCs. The total annual cost is approximately $190,000. The only operations at Site 21 are LUCs and Site 24 is remedy complete status.

Groundwater Extraction and Treatment System

Daily and weekly treatment system inspections include: recording system totalizer and pressure readings on sand filters and carbon vessels and inspecting health and safety equipment and other plant equipment. Routine maintenance consists of bag filter replacement, air compressor maintenance, air stripper maintenance, OWS and settling tank cleaning, and backwashing sand filters and carbon vessels. Monthly O&M reports are included as attachments to the annual LTM reports.

The Site 78 North plant currently treats water from three recovery wells that span the surficial and shallow portion of the UCH aquifer (IR78-RW10, IR78-RW11, and IR78-RW12), shown on **Figure 3-1**. The Site 78 South plant currently treats water from seven recovery wells that span the surficial and shallow portion of the UCH aquifer: IR78-RW05, IR78-RW06, IR78-RW08, IR78-RW13, IR78-RW14, and IR78-RW15 shown on **Figure 3-1**.

Long-term Monitoring

LTM at Site 78 was initiated in 1994 and initially consisted of collecting groundwater samples from 21 surficial, 2 UCH, and 2 MCH aquifer monitoring wells and 8 supply wells for VOCs, metals, total suspended solids (TSS), total dissolved solids (TDS), and oil and grease (O&G). The LTM protocol was changed in a 1997 notice of Non-Significant Change that removed TSS, TDS, O&G, and metals from the analytical protocol. TSS and TDS were removed because they are not required to evaluate VOC attenuation. O&G analysis was removed from the groundwater protocol because it is only required for treatment plant influent and effluent. Metals were removed from the sampling protocol because there was no history or evidence to suggest metal disposal activities may have occurred at Site 78 and concentrations were typical of natural conditions throughout the Base (USMC, 1997). However, based on recommendations in the 2010 FYR, a historical metals evaluation was conducted, and metals were identified in surficial aquifer groundwater at concentrations presenting potential unacceptable risks to human receptors (CH2M, 2013a). The LTM network has been updated to encompass the extent of contamination identified through supplemental investigations, and currently includes 34 surficial, 19 UCH, 18 MCH, and 4 LCH aquifer monitoring wells, 3 surficial aquifer recovery wells, and 7 UCH aquifer recovery wells. The supply wells are currently inactive and/or abandoned and are no longer included in the LTM well network. Groundwater samples are collected annually and are analyzed for VOCs. Groundwater samples collected from surficial aquifer monitoring wells are analyzed for metals every 5 years (CH2M, 2019c).

In addition to comparison with cleanup levels (**Table 3-1**), all surficial aquifer VOC data are screened against the non-residential North Carolina Vapor Intrusion Screening Levels (NC VISLs) consistent with the overall site use, to evaluate whether concentrations indicate potential for a complete VI pathway. Starting in FY 2019, Mann-Kendall (MK) statistical analysis is performed to evaluate the significance of historical COC concentration trends.

Vapor Intrusion Mitigation System

VIMS O&M at Building 902 was initiated in 2012 and consists of weekly inspections of the VIMS components (fan/blower, piping, gauges), quarterly monitoring of system operating parameters (flow rate, riser vacuum, short-term differential pressure) from 16 VIMS nodes and 8 subslab probes, and semi-annual collection of exhaust and indoor and outdoor air samples for tetrachloroethene (PCE) and trichloroethene (TCE) analysis.

Land Use Controls

LUCs are shown on **Figure 3-1** and summarized in **Table 3-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed and no damage to the site was observed. The FYR site inspection, conducted in March 2019, did not identify any issues affecting protectiveness (**Appendix B**). An interview with the treatment plant operator indicated that the O&M manual on file was outdated as many of the components had been replaced with newer or different models. The OU is currently undergoing a comprehensive remedy evaluation and the O&M manual will be updated if necessary, based on the conclusion of the evaluation.

Table 3-2. OU 1 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	754	January 2016	December 8, 2015
Non-Industrial Use Control Boundary (Soil)	0.70		
Intrusive Activities Control Boundary (Groundwater)	38.40		
Industrial/Non-industrial Use Control (VI)	54.14		

Note:
LUCIP = Land Use Control Implementation Plan

3.5.2 Post-ROD Removal Actions and Pilot Studies

Pilot studies and RAs were completed within OU 1 under the IRP after the ROD was signed. The locations of pilot studies and the Hadnot Point Fuel Farm are shown on **Figure 3-3**.

Site 78 North

Oxygen Release Compound Pilot Study

In 2003, a pilot study was initiated to evaluate effectiveness of in situ technologies to treat chlorinated compounds in groundwater. From 2003 to 2005, an oxygen release compound (ORC) was injected into groundwater using direct-push technology (DPT) methods at 25 locations targeting groundwater with vinyl chloride (VC) concentrations higher than 1,000 micrograms per liter (µg/L) at Site 78 North (approximately 6 to 44 feet bgs). Approximately 90 pounds of ORC slurry were injected per location, resulting in 2,250 pounds of ORC total. The concentration of VC in groundwater at Site 78 North was reduced by 25 to 50 percent (Baker and CH2M, 2005).

Air Sparging Pilot Study

In 2017, a pilot study was initiated at Site 78 North to evaluate the effectiveness of air sparging in response to the 2015 FYR recommendation to continue to evaluate alternative treatment technologies to address groundwater contamination. The system was installed in November 2017 and ran continuously for 12 months. Quarterly monitoring was conducted through November 2018 and a rebound test was conducted in February 2019. Results will be presented in the forthcoming Feasibility Study (FS) Amendment.

Enhanced Pump and Treat Pilot Test

In 2018, a recovery well test was conducted in the Building 901/902/903 area to evaluate the effectiveness of pumping to reduce VOC concentrations. A pump was installed and operated for 12 days. The results indicated that although a capture zone could be sustained, there were minimal changes in COC concentrations in groundwater, suggesting that contaminant mass removal was not improved and continued pumping at the test well was not expected to accelerate cleanup (CH2M, 2019b).

Site 78 South

Hydrogen Release Compound Pilot Study

In 2003, a pilot study was initiated to evaluate the effectiveness of in situ technologies to treat chlorinated compounds in groundwater. From 2003 to 2005, a hydrogen release compound (HRC) was injected into groundwater using DPT methods at 38 locations targeting groundwater TCE concentrations greater than 1,000 µg/L at Site 78 South (approximately 6 to 50 feet bgs). Approximately 270 to 330 pounds of HRC were injected per location, resulting in 11,100 pounds of HRC total. The concentration of TCE in groundwater at Site 78 South was reduced by an order-of-magnitude at the majority of wells, but dechlorination was not complete and appeared to stall at cis-1,2-dichloroethene (DCE) (Baker and CH2M, 2005).

ISCO and ERD Treatability Study

In 2012, a treatability study was initiated to evaluate potential technologies to treat TCE concentrations ranging from 4,300 to 12,000 µg/L (CH2M, 2013b). Prior to field implementation, bench scale testing was completed to compare in situ chemical oxidation (ISCO) via persulfate and enhanced reductive dechlorination (ERD) substrates with and without bioaugmentation. Bench scale testing indicated that ISCO would not be effective in treating the COCs at Site 78 South and ERD with bioaugmentation would be the most effective technology. Injections of EHC-L substrate and Terra Systems Incorporated DC (TSI-DC) bioaugmentation culture were initiated in December 2013 into two injection wells screened in the UCH aquifer (50 to 60 feet bgs). The performance monitoring data indicated that ERD would be effective at Site 78 South with adequate distribution. TCE concentrations were reduced by 94 percent and total chlorinated volatile organic compound (CVOC) concentrations were reduced by nearly 75 percent within 5 feet of the injection wells (CH2M, 2015b).

3.5.3 Progress Since the 2015 Five-Year Review

Issues, recommendations, and follow-up actions from the 2015 FYR are summarized in **Table 3-3**. The current understanding of the conceptual site model (CSM) including potential risk pathways, approximate extent of COCs, and potential sources is shown on **Figure 3-2**. The OU 1 RA components and expected outcomes are summarized in **Table 3-4**.

Table 3-3. 2015 FYR OU 1 Issues, Recommendations, and Follow-up Actions

Issues	Recommendations (Milestones)	Date Complete/Current Status
Cleanup levels were met and LTM is complete at Site 24, but remedy completion has not been formally documented	Prepare a RACR to document remedy completion at Site 24. (June 30, 2016)	Completed December 31, 2016. A RACR was prepared to document completion of LTM and RC at Site 24. The RACR was finalized on December 31, 2016 and signed in March 2017 (CH2M, 2016b).
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI). (June 30, 2016)	Completed June 30, 2016. The LUCIP to add the Industrial/Non-Industrial Use Control (VI) boundary was finalized in January 2016 (CH2M, 2016a). The Draft ESD was submitted June 30, 2016, finalized March 30, 2017, and signed on June 1, 2017 (CH2M, 2017), and documented the following updates at Site 78: • Updated RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary for VI. • Include the VIMS installed and operating at Building 902. • Updated the groundwater COCs to reflect post-ROD additions during LTM and/or other post-ROD investigations.
An RSL was established for 1,4-dioxane and indicator constituents are present in groundwater	Collect groundwater samples for 1,4-dioxane. (September 30, 2018)	Completed September 14, 2017. Groundwater sampling for 1,4-dioxane was completed on August 24, and September 14, 2017 and results in the surficial, UCH, and MCH aquifers were below laboratory detection limits (CH2M, 2019a).
The remedy is not functioning as designed and RAOs will not be met within a reasonable timeframe because recently discovered source areas and deeper groundwater contamination are not being addressed	Continue groundwater remedy evaluation to determine what changes are needed and refine the CSM to evaluate extent of groundwater contamination and exposure pathways. Develop a Revised Proposed Plan and ROD Amendment or ESD as necessary. (December 31, 2020)	Currently in progress. The FS Amendment field investigation was initiated in 2017 to collect data to refine the CSM and support remedial alternative evaluation (CH2M, 2018a). An air sparging (AS) pilot study was initiated in 2017 and completed in February 2019. A GWTP evaluation was conducted from 2017 to 2018 (CH2M, 2018b) and an enhanced pump and treat test was also completed in 2018 (CH2M, 2019b). Data collected during these investigations and studies is being incorporated into an FS Amendment, currently under preparation, which will present an updated CSM, re-evaluate risks, and re-evaluate remedial alternatives.

3.6 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

No. While the treatment system was designed to treat the extent of VOCs understood at the time of the ROD, supplemental investigations have identified VOCs more widespread and deeper than initially understood;

therefore, the remedy is not functioning as intended by the ROD. However, current protectiveness is not affected because LUCs are in place to prevent exposure to groundwater COCs and soil COCs at concentrations above cleanup levels and to evaluate the VI pathway as necessary.

Groundwater Extraction and Treatment System

From October 2015 to December 2018, the system treated an average of 204,150 gallons per month at 78 North and 138,167 gallons of groundwater per month at 78 South. Influent flow rates are limited because the recovery wells are screened across the water table and groundwater is extracted only when the water level rises above the pump intake. On average, the 78 North system removes 0.13 pounds of VOCs per month and the 78 South system removes 0.33 pounds of VOCs per month. This is consistent with the previous ten years, suggesting asymptotic conditions. Cumulative mass removed graphs for each system are shown on **Figures 3-3** and **3-4**; approximately 90 percent of the mass removal occurred by 2005 for both systems.

An evaluation of the groundwater treatment systems was conducted in 2017 to support ongoing efforts to optimize the remedy and evaluate alternative remediation strategies to address the more widespread contamination identified during supplemental investigations. The evaluation concluded that the treatment systems are underutilized with respect to both hydraulic and contaminant mass loading. Each system was designed to accommodate up to 80 gallons per minute, but only receives approximately 3.5 gallons per minute, due to the shallow placement of pump intakes. Recovery wells are located in the less contaminated surficial and shallow UCH aquifers and average plant influent VOC concentrations are typically less than the effluent discharge level of 100 µg/L. VOCs in the final effluent from both GWTPs are generally not detected. Consequently, each GWTP can accommodate additional groundwater with higher contaminant concentrations with modifications (CH2M, 2018b).

The understanding of the extent of contamination at Site 78 has been updated based on ongoing supplemental investigations to encompass deeper and more widespread occurrences of COCs. **Figures 3-5** through **3-8** depict the well network that has expanded since the ROD to reflect the current understanding of the groundwater CVOC and benzene, toluene, ethylbenzene, and xylene (BTEX) plumes. These figures demonstrate the magnitude of change, particularly in the deeper aquifer zones that are not covered by the recovery well network.

Long-Term Monitoring

Based on the most recent data collected in support of the 2019 LTM and FS Amendment, the extent of COCs has been defined, and MK statistical analysis was performed to evaluate the significance of historical COC concentration trends. For locations in the surficial, UCH, MCH, and LCH aquifers, MK statistical analysis was performed where four or more rounds of data were available and COCs that were detected more than 50 percent of the time. Trends by aquifer for CVOC and BTEX compounds are presented in **Table 3-5** and **3-6** and are discussed below.

- In the surficial aquifer, CVOCs were all decreasing, stable, or in some locations there were no statistical trends (typically occurring when concentrations fluctuate). BTEX compounds were generally stable or decreasing.
- In the UCH aquifer, CVOCs were predominantly stable or decreasing, with no statistical trends for PCE, TCE, and total 1,2-DCE at IR78-GW117UCH (Site 78 North) and total 1,2-DCE at IR78-GW52R (Site 78 South), and increasing trends for cis-1,2-DCE in IR78-GW79IW (Site 78 North) and IR78-GW83IW (Site 78 South). Increasing degradation products is typically a sign of reductive dechlorination and parent products were not detected frequently enough to calculate trends. BTEX in the UCH aquifer were stable, decreasing, or no statistical trend was observed with the exception of increasing benzene in two locations in Site 78 North (IR78-GW82IW and IR78-MW139UCH).
- In the MCH aquifer, CVOCs were either stable, decreasing, or increasing. At IR78-GW101MCH (located in Site 78 North) and IR78-GW112MCH (located in Site 78 South) all CVOCs were increasing, including TCE. Two other locations at Site 78 North show increasing cis-1,2-DCE and total 1,2-DCE concentrations (IR78-GW103MCH and IR78-MW138MCH). BTEX in the MCH aquifer was stable to decreasing in all locations with the exception of increasing benzene and toluene at IR78-GW101MCH, where CVOCs were also increasing.

Overall, as discussed in the groundwater extraction and treatment system section, the extent of COCs is more widespread than understood at the time of the ROD (**Figures 3-5** through **3-8**) and the recovery well network does not fully address the extent of COCs in groundwater. In general, decreasing and stable trends of both parent and degradation CVOC compounds are observed and, where increasing trends are observed they are typically degradation products, which is indicative of natural attenuation. While increasing trends are observed in the MCH aquifer, alternate treatment technologies are being evaluated to address COCs in all aquifer zones in the pending FS Amendment.

Metals are collected every 5 years in preparation of the FYR. Concentrations in groundwater were consistent with previous results for Site 78 (**Table 3-7**). Arsenic, beryllium, chromium, manganese, and vanadium exceeded cleanup levels at least once in the last four sampling rounds; however, the exceedances were isolated at one or two locations. Barium has not exceeded its cleanup level during the last five monitoring events.

VIMS O&M

Based on the VIMS performance monitoring report for June 2019 data, design operating parameters indicate the VIMS system is operating effectively to mitigate the VI pathway. Indoor air and exhaust concentrations collected in 2019 indicate that the VIMS is effectively removing VOCs from the subsurface as evidenced by PCE and TCE detections in exhaust (**Figure 3-9**). Vacuum pressure from 9 nodes did not meet system operating parameters, likely because of a high water table and as a result, a VIMS operational evaluation is currently underway to monitor how high water table impacts the VIMS effectiveness and will be used to modify the VIMS at Building 902 if needed (CH2M, 2019d).

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. Exposure assumptions, cleanup levels, and RAOs used at the time of the ROD and/or ESD are still valid. Although toxicity data has changed, these changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to groundwater or soil. Groundwater cleanup levels were updated in the 2017 ESD (CH2M, 2017) and there have been no changes to the standards that the cleanup levels are based on since the update.

Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs identified in the ROD and since the 2015 FYR, the majority of changes would result in decreased risk, with the exception of the noncancer hazard for benzo(a)pyrene, 4,4’-dichlorodiphenyldichloroethane (DDD), and 4,4’-dichlorodiphenyldichloroethylene (DDE), which increased (**Table 2-1**). These constituents were identified in soil and RAs were completed to industrial levels. Although toxicity values have changed, the area was restored with clean fill following the RA, and LUCs for non-industrial use remain in-place and are protective.

Cleanup Levels: The cleanup levels for pesticides in soil were identified as the USEPA Region III risk-based concentrations (RBCs) for industrial soil. The confirmation soil sample results documenting the removal of the pesticide and PCB-contaminated soil indicate that the cleanup levels identified in the ROD were met (OHM, 1996). Although the recent USEPA RSL for industrial soil for 4,4’-DDD is more conservative (**Table 3-1**), the area was restored with clean fill following the RA, and LUCs for non-industrial use remain in place and are protective.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 1 remedy with respect to extreme weather events, primarily hurricanes, was completed. The risks at OU 1 are from potable use of groundwater, VI, and non-industrial use. Hurricane damage could potentially affect the performance of the VIMS at Building 902 if the system is damaged and occupancy of the building continues. At Site 78, damage to monitoring wells from fallen trees is a possibility but would not affect protectiveness of human health or the environment. LUCs and VIMS are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

3.7 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 1 are summarized in **Table 3-8**.

Table 3-8. OU 1 Recommendations and Follow-up Actions

Issue	Recommendations/ Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	Future
VOCs in groundwater are present in deeper aquifer zones, at higher concentrations, are more widespread than the existing remedy was designed to address, and RAOs are not likely to be met in a reasonable timeframe. A formal evaluation of remedial alternatives to address this contamination has not been completed.	Complete the Site 78 FS Amendment to reevaluate alternatives to address VOCs in groundwater.	Navy/Base	USEPA/ State	December 31, 2020	No	Yes

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Site 24 was evaluated in the Basewide PFAS PA as a potential PFAS release area based on its designation as a dump. The dump received WWTP sludge from the former Hadnot Point WWTP that serviced the area as early as 1959. The former Hadnot Point WWTP serviced the Print Shop, Furniture Shop, Central Heating Plant, and the Building 18 Hadnot Point Fire Station. There is potential for the industrial WWTP sludge to contain PFAS and further evaluation was recommended (CH2M, 2019e).
- Building 1400, the Dogwood Street Fire Station is an active fire station within the boundary of Site 78 that was evaluated in the Basewide PFAS PA. Due to the presence of AFFF-containing fire engines, there is a potential for AFFF to have been released and further evaluation was recommended (CH2M, 2019e).

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release areas identified; therefore, there is no current exposure pathway (CH2M, 2019e). These areas will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

3.8 Statement of Protectiveness

The remedy at OU 1 is currently protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled. LUCs are in place to prohibit aquifer use, non-industrial use, restrict intrusive activities, and evaluate and/or mitigate potential VI pathways. Groundwater performance monitoring will be conducted to monitor COCs until cleanup levels are achieved.

However, in order to ensure the remedy is protective in the long-term, the Navy is preparing an FS Amendment for Site 78 to reevaluate RAOs and remedial alternatives.

3.9 References

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Table 3-1. Cleanup Levels for OU 1 (Sites 21, 24, and 78)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (Baker, 1994, Navy, 1995, and CH2M, 2017)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	Benzene	1	1	NCGWQS
	1,2-Dibromo-3-chloropropane	0.04	0.04	NCGWQS
	1,2-Dibromoethane	0.02	0.02	NCGWQS
	1,1-Dichloroethane	6	6	NCGWQS
	1,2-Dichloroethane	0.4	0.4	NCGWQS
	1,1-Dichloroethene	7	7	MCL
	1,2-Dichloroethene	60	60	NCGWQS/IMAC/MCL
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL
	Ethylbenzene	600	600	NCGWQS
	Isopropylbenzene	70	70	NCGWQS
	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS
	Methylene chloride	5	5	NCGWQS
	Tetrachloroethene	0.7	0.7	NCGWQS
	Toluene	600	600	NCGWQS
	Trichloroethene	3	3	NCGWQS
	Vinyl chloride	0.03	0.03	NCGWQS
	Xylenes (total)	500	500	NCGWQS
	Pesticides			
	Heptachlor epoxide	0.2	0.004	NCGWQS
	Metals			
	Arsenic	10	10	NCGWQS/MCL
	Barium	700	700	NCGWQS
	Beryllium	4	4	NCGWQS
	Cadmium	2	2	NCGWQS
	Chromium	16.9	16.9	BTV
	Cobalt	3.38	3.38	BTV
	Iron	16,100	16,100	BTV
	Lead	15	15	NCGWQS
	Manganese	176	176	BTV
	Vanadium	26.7	26.7	BTV

Table 3-1. Cleanup Levels for OU 1 (Sites 21, 24, and 78)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (Baker, 1994, Navy, 1995, and CH2M, 2017)	Current Standard	
			Concentration	Reference
Soil (µg/kg)	**Polychlorinated Biphenyls**			
	Polychlorinated Biphenyls	10,000	10,000	Action Level for Low Occupancy Land Use (USEPA, 1990)
	Pesticides			
	4,4-DDD	12,000	2,500	RSL-Industrial Soil
Soil (µg/kg)	4,4-DDT	8,400	8,500	RSL-Industrial Soil
	Chlordane (total)	2,200	7,700	RSL-Industrial Soil

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value. Cleanup level is the surficial aquifer Base BTV when the BTV is higher than the NCGWQS or MCL. Cleanup levels for polychlorinated biphenyls in soil were updated in the 1995 ESD, groundwater VOCs and metals were updated in the 2017 ESD, all others listed are ROD cleanup levels.

Notes:

Shading indicates cleanup levels achieved/remain protective for soil per Closeout Report (OHM, 1996) and for groundwater per Notice of Non-Significant Changes (USMC, 1997) and four rounds of data below cleanup levels (CH2M, 2010, 2015)

Current Standard Reference Dates:

BTV (CH2M, 2012)
MCL (March 2018)
NCGWQS (February 2016)
RSL (May 2019) lower of RSL based on cancer risk of 10-6 and noncancer hazard index of 0.1

µg/L = microgram per liter
µg/kg = microgram per kilogram
BTV = background threshold value
COC = constituent of concern
DDD = dichlorodiphenyldichloroethane
DDT = dichlorodiphenyltrichloroethane
MCL = maximum contaminant level
NCGWQS = North Carolina Groundwater Quality Standard
NS = not specified
RSL = Regional Screening Level
ROD = Record of Decision
VOC = volatile organic compound

Table 3-4. OU 1 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
21 78	Soil	Potential unacceptable ecological risks from pesticides in soil (Sites 78 and 21). PCBs exceeded industrial standards at isolated locations (Site 21 only).	Industrial	Treat or remove contaminated soil from designated areas of concern.	Soil Removal	Pesticide and PCB-contaminated soil removal to meet industrial standards.	Industrial Land Use
				Prevent current or future exposure to contaminated soils.	LUCs	Maintain non-industrial land use controls and conduct quarterly monitoring of LUCs.	
21 24 78	Groundwater	Potential unacceptable risks to future residents from exposure to metals and VOCs in groundwater.		Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. To prevent current or future exposure to the contaminated groundwater.	Groundwater Extraction and Treatment System	Operate until after groundwater COCs are at or below respective cleanup levels. Perform routine maintenance. Monitor VOC mass removal in conjunction with LTM data to evaluate system effectiveness.	UU/UE
					LTM	Groundwater LTM to monitor treatment system performance and COC concentration trends over time until groundwater COCs are at or below cleanup levels for four consecutive monitoring events. LTM at Site 24 is complete and documented in a RACR.	
					LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	

Table 3-4. OU 1 Remedial Action Summary and Expected Outcomes

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
78	Groundwater	Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	UU/UE
					VIMS	Operate VIMS at Building 902 until groundwater VOCs are at or below respective cleanup levels within 100 feet of the building. Perform periodic inspections, indoor air and exhaust sampling, and routine maintenance as needed.	

Notes:

COC = constituent of concern

LUC = land use control

NCAC = North Carolina Administrative Code

NCDEQ = North Carolina Department of Environmental Quality

RACR = remedial action completion report

UU/UE = unlimited use and unrestricted exposure

VI = vapor intrusion

VIMS = vapor intrusion mitigation system

VOC = volatile organic compound

Table 3-5. Mann-Kendall Evaluation Summary Table - Site 78 CVOCs

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	COC	Trend
Site 78 North - Surficial Aquifer		
IR78-GW24-1	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
	trans-1,2-Dichloroethene	**Decreasing**
	Trichloroethene	**Decreasing**
	Vinyl chloride	**Decreasing**
IR78-GW46	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
IR78-GW47	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
	Trichloroethene	**Decreasing**
IR78-GW113	1,2-Dichloroethene (total)	**Stable**
	cis-1,2-Dichloroethene	**Stable**
	Trichloroethene	**Stable**
IR78-GW114	1,2-Dichloroethene (total)	**No Trend**
	cis-1,2-Dichloroethene	**Decreasing**
	Tetrachloroethene	**Decreasing**
	trans-1,2-Dichloroethene	**No Trend**
	Trichloroethene	**No Trend**
	Vinyl chloride	**Stable**
Site 78 South - Surficial Aquifer		
IR78-GW04-1	Trichloroethene	**Decreasing**
IR78-GW42	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
	trans-1,2-Dichloroethene	**Decreasing**
	Trichloroethene	**Decreasing**
	Vinyl chloride	**Stable**
IR78-GW56	1,2-Dichloroethene (total)	**Stable**
	cis-1,2-Dichloroethene	**No Trend**
	Trichloroethene	**Decreasing**
IR78-GW60	1,2-Dichloroethene (total)	**Stable**
	cis-1,2-Dichloroethene	**Stable**
	Trichloroethene	**Decreasing**
IR78-GW64	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**No Trend**
IR78-GW73	Tetrachloroethene	**Decreasing**
IR78-MW144	1,2-Dichloroethene (total)	**Stable**
	cis-1,2-Dichloroethene	**Stable**

Table 3-5. Mann-Kendall Evaluation Summary Table - Site 78 CVOCs
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	COC	Trend
IR78-MW144	trans-1,2-Dichloroethene	Stable
	Trichloroethene	Stable
	Vinyl chloride	Stable
UST1613-MW03	Tetrachloroethene	Decreasing
Site 78 North - UCH Aquifer		
IR78-GW44	1,2-Dichloroethene (total)	Decreasing
	cis-1,2-Dichloroethene	Decreasing
	trans-1,2-Dichloroethene	Decreasing
	Vinyl chloride	Decreasing
IR78-GW79IW	1,2-Dichloroethene (total)	Stable
	cis-1,2-Dichloroethene	Increasing
IR78-GW80IW	1,2-Dichloroethene (total)	Decreasing
	cis-1,2-Dichloroethene	Decreasing
	Trichloroethene	Decreasing
IR78-GW84IW	1,2-Dichloroethene (total)	Stable
	cis-1,2-Dichloroethene	Stable
	trans-1,2-Dichloroethene	Stable
	Vinyl chloride	Stable
IR78-GW85IW	1,2-Dichloroethene (total)	Stable
	cis-1,2-Dichloroethene	Stable
IR78-GW117UCH	1,2-Dichloroethene (total)	No Trend
	cis-1,2-Dichloroethene	Stable
	Tetrachloroethene	No Trend
	Trichloroethene	No Trend
IR78-MW139UCH	1,2-Dichloroethene (total)	Stable
	cis-1,2-Dichloroethene	Stable
	Trichloroethene	Stable
	Vinyl chloride	Stable
Site 78 South - UCH Aquifer		
IR78-GW52R	1,2-Dichloroethene (total)	Decreasing
	cis-1,2-Dichloroethene	Decreasing
	Vinyl chloride	Decreasing
IR78-GW74	1,2-Dichloroethene (total)	No Trend
	cis-1,2-Dichloroethene	Decreasing
IR78-GW83IW	1,2-Dichloroethene (total)	Stable
	cis-1,2-Dichloroethene	Increasing
IR94-MW02IW	1,2-Dichloroethene (total)	Stable
	cis-1,2-Dichloroethene	Decreasing

Table 3-5. Mann-Kendall Evaluation Summary Table - Site 78 CVOCs
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	COC	Trend
IR94-MW02IW	Trichloroethene	**Stable**
IR94-MW03IW	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
	trans-1,2-Dichloroethene	**Stable**
	Trichloroethene	**Decreasing**
	Vinyl chloride	**Stable**
UST1613-MW13	Trichloroethene	**Decreasing**
Site 78 North - MCH Aquifer		
IR78-GW80DW	1,2-Dichloroethene (total)	**Stable**
	cis-1,2-Dichloroethene	**Stable**
	Trichloroethene	**Stable**
IR78-GW101MCH	1,2-Dichloroethene (total)	**Increasing**
	cis-1,2-Dichloroethene	**Increasing**
	trans-1,2-Dichloroethene	**Increasing**
	Trichloroethene	**Increasing**
	Vinyl chloride	**Increasing**
IR78-GW103MCH	1,2-Dichloroethene (total)	**Increasing**
	cis-1,2-Dichloroethene	**Increasing**
IR78-GW116MCH	1,2-Dichloroethene (total)	**Stable**
	cis-1,2-Dichloroethene	**Stable**
	Tetrachloroethene	**Stable**
	trans-1,2-Dichloroethene	**Stable**
	Trichloroethene	**Decreasing**
	Vinyl chloride	**Stable**
IR78-MW131MCH	1,2-Dichloroethene (total)	**Increasing**
	cis-1,2-Dichloroethene	**Increasing**
IR78-MW136MCH	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
	trans-1,2-Dichloroethene	**Decreasing**
	Trichloroethene	**Decreasing**
	Vinyl chloride	**Decreasing**
IR78-MW138MCH	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
	Vinyl chloride	**Increasing**
Site 78 South - MCH Aquifer		
IR78-GW105MCH	1,2-Dichloroethene (total)	**Decreasing**
	cis-1,2-Dichloroethene	**Decreasing**
	trans-1,2-Dichloroethene	**Stable**

Table 3-5. Mann-Kendall Evaluation Summary Table - Site 78 CVOCs

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	COC	Trend
IR78-GW105MCH	Trichloroethene	**Decreasing**
IR78-GW112MCH	1,2-Dichloroethene (total)	**Increasing**
	cis-1,2-Dichloroethene	**Increasing**
	Trichloroethene	**Increasing**
	Vinyl chloride	**Increasing**

Table 3-6. Mann-Kendall Evaluation Summary Table - Site 78 BTEX

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	COC	Trend
Site 78 North - Surficial Aquifer		
IR78-GW46	Benzene	**Decreasing**
	Ethylbenzene	**Decreasing**
	Xylene, total	**Decreasing**
IR78-GW47	Benzene	**Decreasing**
Site 78 South - Surficial Aquifer		
IR78-GW42	Benzene	**Decreasing**
	Toluene	**Stable**
IR78-GW53R	Benzene	**Stable**
	Toluene	**No Trend**
	Ethylbenzene	**Stable**
	Xylene, total	**Stable**
IR78-GW60	Toluene	**Decreasing**
	Ethylbenzene	**Stable**
	Xylene, total	**Stable**
UST1613-MW17	Benzene	**Decreasing**
	Toluene	**Decreasing**
	Ethylbenzene	**Decreasing**
	Xylene, total	**Decreasing**
Site 78 North - UCH Aquifer		
IR78-GW79IW	Benzene	**Stable**
IR78-GW80IW	Benzene	**Decreasing**
IR78-GW82IW	Benzene	**Increasing**
IR78-GW84IW	Benzene	**Decreasing**
IR78-MW139UCH	Benzene	**Increasing**
Site 78 South - UCH Aquifer		
IR78-GW52R	Benzene	**Decreasing**
IR78-GW74	Benzene	**No Trend**
	Toluene	**No Trend**
	Ethylbenzene	**Stable**
	Xylene, total	**Stable**
Site 78 North - MCH Aquifer		
IR78-GW80DW	Benzene	**Decreasing**
IR78-GW101MCH	Benzene	**Increasing**
	Toluene	**Increasing**
IR78-GW30-2	Benzene	**Stable**
	Toluene	**Decreasing**

Table 3-6. Mann-Kendall Evaluation Summary Table - Site 78 BTEX

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	COC	Trend
IR78-GW30-2	Ethylbenzene	**Stable**
	Xylene, total	**Decreasing**
IR78-MW138MCH	Benzene	**Stable**
	Toluene	**Stable**
Site 78 South - MCH Aquifer: No Trends		

Table 3-7. Metals Concentrations in Surficial Aquifer Groundwater - Site 78

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Station ID		IR78-GW04-1											
Sample ID	**Cleanup Level**	IR78-GW04-01/11/1991	R78-GW04D-01/11/199	IR78-GW04-07/10/1995	IR78-GW04-10/25/1995	IR78-GW04-01/17/1996	IR78-GW04-04/12/1996	IR78-GW04-07/15/1996	MR08-GW04-1-07A	MR08-GW04-1D-07A	IR78-GW04-1-12B	IR78-GW04-1-15A	IR78-GW04-1-19B
Sample Date		01/11/91	01/11/91	07/10/95	10/25/95	01/17/96	04/12/96	07/15/96	01/08/07	01/08/07	04/20/12	03/15/15	04/18/19
Chemical Name													
Total Metals (µg/L)													
Arsenic	10	**15.5**	**19.4**	0.5 U	0.5 U	0.5 U	**0.8**	1.4 U	**3.8 J**	**3.1 J**	100 U	**9.1 J**	**3.4 J**
Barium	700	**268**	**273**	NA	NA	NA	NA	NA	**55.8 J**	**55 J**	**78.8 J**	**169**	**78.1**
Beryllium	4	**6.7**	**6.4**	0.5 U	0.5 U	0.5 U	**3.1**	0.7 U	5 U	5 U	3.7 U	**4.96 J**	**0.926 J**
Chromium	16.9	**187**	**195**	5 U	5 U	5 U	**11**	**5.3**	10 U	**2.4 J**	30 U	**47.6 J**	**16.4**
Manganese	176	**425**	**436**	**5**	5 U	5 U	**30**	**24.7**	**74.4**	**74**	**148**	**177**	**77.5**
Vanadium	26.7	**213**	**222**	NA	NA	NA	NA	NA	50 U	50 U	**2.46 J**	**52.3**	**21.4**

Station ID		IR78-GW10								IR78-GW10		
Sample ID	**Cleanup Level**	IR78-GW10-01/09/1991	IR78-GW10-07/09/1995	IR78-GW10-10/25/1995	IR78-GW10-01/17/1996	IR78-GW10-04/12/1996	IR78-GW10-07/16/1996	IR78-GW10-12B	IR78-GW10D-12B	IR78-GW10-15A	IR78-GW10D-15A	IR78-GW10-19B
Sample Date		01/09/91	07/09/95	10/25/95	01/17/96	04/12/96	07/16/96	04/20/12	04/20/12	03/14/15	03/14/15	04/10/19
Chemical Name												
Total Metals (µg/L)												
Arsenic	10	**39.9**	0.5 U	0.5 U	0.5 U	**0.2**	1.4 U	100 U	100 U	10 U	10 U	4 U
Barium	700	**492**	NA	NA	NA	NA	NA	80 U	80 U	**8.06 J**	**7.99 J**	**11.8**
Beryllium	4	**5.6**	0.5 U	0.5 U	0.5 U	0.2 U	0.7 U	3.7 U	3.7 U	0.37 U	0.37 U	0.2 U
Chromium	16.9	**310**	5 U	5 U	5 U	**1.2**	3.3 U	30 U	30 U	3 U	3 U	4 U
Manganese	176	**255**	5 U	5 U	5 U	**2.7**	**1.8**	12.8 U	12.8 U	1.28 U	1.28 U	1.5 U
Vanadium	26.7	**376**	NA	NA	NA	NA	NA	8 U	8 U	**0.279 J**	**0.282 J**	**0.76 J**

Station ID		IR78-GW11								IR78-GW11					
Sample ID	**Cleanup Level**	IR78-GW11-01/09/1991	IR78-GW11-07/10/1995	IR78-GW11-10/25/1995	IR78-GW11-01/17/1996	IR78-GW11-04/12/1996	IR78-GW11-07/15/1996	MR08-GW11-07A	IR78-GW11-08D	IR78-GW11-12B	IR78-GW11D-12B	IR78-GW11-15A	IR78-GW11D-15A	IR78-GW11-19B	IR78-GW11-19B-DUP
Sample Date		01/09/91	07/10/95	10/25/95	01/17/96	04/12/96	07/15/96	01/09/07	11/14/08	04/20/12	04/20/12	03/14/15	03/14/15	04/10/19	04/10/19
Chemical Name															
Total Metals (µg/L)															
Arsenic	10	9.1 B	0.5 U	**0.6**	0.5 U	**0.2**	1.4 U	10 U	0.25 U	100 U	100 U	10 U	10 U	4 U	4 U
Barium	700	**298**	NA	NA	NA	NA	NA	**21.5 J**	**23.5**	80 U	80 U	**8.79 J**	**8.8 J**	**6.6**	**6.61**
Beryllium	4	2.1 U	0.5 U	0.5 U	0.5 U	0.2 U	0.7 U	5 U	NA	3.7 U	3.7 U	0.37 U	0.37 U	0.2 U	0.2 U
Chromium	16.9	**140**	5 U	5 U	5 U	**2.5**	3.3 U	10 U	2.5 U	30 U	30 U	3 U	3 U	4 U	4 U
Manganese	176	**103**	5 U	**10**	5 U	**1.5**	**4**	15 U	NA	12.8 U	12.8 U	1.28 U	1.28 U	1 U	1.1 U
Vanadium	26.7	**166**	NA	NA	NA	NA	NA	50 U	NA	8 U	8 U	**0.358 J**	**0.311 J**	**0.82 J**	**1 J**

Shading indicates the result exceeded Cleanup Level

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

µg/L - Micrograms per liter

Table 3-7. Metals Concentrations in Surficial Aquifer Groundwater - Site 78

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Station ID		IR78-GW113		IR78-GW114		IR78-GW22									
Sample ID	Cleanup Level	IR78-GW113-15A	IR78-GW113-19B	IR78-GW114-15A	IR78-GW114-19B	IR78-GW22-01/18/1991	IR78-GW22A-07/09/1995	IR78-GW22A-10/25/1995	IR78-GW22A-01/17/1996	IR78-GW22A-04/09/1996	IR78-GW22A-07/17/1996	IR78-GW22-09B	IR78-GW22-12B	IR78-GW22-15A	IR78-GW22-19B
Sample Date		03/15/15	04/16/19	03/15/15	04/18/19	01/18/91	07/09/95	10/25/95	01/17/96	04/09/96	07/17/96	04/07/09	04/23/12	03/16/15	04/11/19
Chemical Name															
Total Metals (µg/L)															
Arsenic	10	10 U	4 U	**0.715 J**	4 U	7.2 B	0.5 U	0.5 U	0.5 U	0.1 U	1.4 U	8 U	100 U	10 U	4 U
Barium	700	**55**	**37**	**358**	**126**	102 B	NA	NA	NA	NA	NA	**7.4 J**	80 U	**11.2**	**15.4**
Beryllium	4	**0.525 J**	**0.388 J**	**0.367 J**	**0.17 J**	0.6 B	0.5 U	0.5 U	0.5 U	**0.3**	0.7 U	NA	3.7 U	0.37 U	**0.035 J**
Chromium	16.9	**0.61 J**	4 U	**1.7 J**	4 U	**79.8**	5 U	5 U	5 U	1 U	3.3 U	**0.82 J**	30 U	**0.54 J**	4 U
Manganese	176	**15.6**	**11.8**	**38.4**	**9.22**	**94.1**	**6**	5 U	5 U	1 U	**16.3**	NA	**16.8 J**	**6.4**	7.09 U
Vanadium	26.7	0.8 U	**0.55 J**	0.8 U	**1.9 J**	**100**	NA	NA	NA	NA	NA	NA	8 U	**1.77**	**1.6 J**

Station ID		IR78-GW24-1								
Sample ID	Cleanup Level	IR78-GW24-01/08/1991	IR78-GW24-07/09/1995	IR78-GW24-10/25/1995	IR78-GW24-01/21/1996	IR78-GW24-04/09/1996	IR78-GW24-07/16/1996	IR78-GW24-1-12B	IR78-GW24-1-15A	IR78-GW24-1-19B
Sample Date		01/08/91	07/09/95	10/25/95	01/21/96	04/09/96	07/16/96	04/20/12	03/14/15	04/11/19
Chemical Name										
Total Metals (µg/L)										
Arsenic	10	4.2 B	0.5 U	0.5 U	0.5 U	0.1 U	1.4 U	**0.74 J**	100 U	4 U
Barium	700	60.1 B	NA	NA	NA	NA	NA	**60.6**	**53.9 J**	**43.2**
Beryllium	4	2.1 U	0.5 U	0.5 U	0.5 U	**0.3**	0.7 U	**0.0946 J**	3.7 U	**0.046 J**
Chromium	16.9	**26.3**	5 U	5 U	5 U	**1**	3.3 U	3 U	30 U	4 U
Manganese	176	**54.8**	**6**	5 U	5 U	**3.2**	**35.3**	**78.1 J**	**46**	**43.4**
Vanadium	26.7	39.2 B	NA	NA	NA	NA	NA	**2.51**	**2.83 J**	**1.9 J**

Station ID		IR78-GW42					IR78-GW46			IR78-GW47			IR78-GW53R	
Sample ID	Cleanup Level	MR08-GW42-07A	IR78-GW42-08D-2	IR78-GW42-12B	IR78-GW42-15A	IR78-GW42-19B	IR78-GW46-12B	IR78-GW46-15A	IR78-GW46-19B	IR78-GW47-12B	IR78-GW47-15A	IR78-GW47-19B	IR78-GW53R-15A	IR78-GW53R-19B
Sample Date		01/08/07	11/11/08	04/20/12	03/14/15	04/12/19	04/20/12	03/14/15	04/16/19	04/23/12	03/14/15	04/16/19	03/14/15	04/11/19
Chemical Name														
Total Metals (µg/L)														
Arsenic	10	10 U	**0.547 J**	100 U	10 U	4 U	100 U	30 U	4 U	**3.45 J**	30 U	**3.6 J**	50 U	4 U
Barium	700	**92.2 J**	**62.6**	**37.7 J**	**49.3**	**40.3**	**172**	**100**	**87.7**	**60.1**	**41.1**	**55.3**	**71.6**	**51.7**
Beryllium	4	5 U	NA	3.7 U	**0.225 J**	**0.24 J**	3.7 U	1.11 U	**0.15 J**	**0.247 J**	**0.373 J**	**0.17 J**	1.85 U	**0.1 J**
Chromium	16.9	10 U	2.5 U	30 U	**0.519 J**	4 U	30 U	9 U	4 U	**1.05 J**	**4.53 J**	4 U	15 U	4 U
Manganese	176	**71.7**	NA	**67.2**	**57.9**	**47.6**	**50**	**24.1**	**37.9**	**23.1**	**36.4**	**21.8**	**61.2**	**54.1**
Vanadium	26.7	**8.8 J**	NA	**6.14 J**	**2.86**	**2.2 J**	**2.61 J**	**5.63**	**4.9 J**	**3.18**	**8.93**	**3.2 J**	**1.05 J**	**1.7 J**

Shading indicates the result exceeded Cleanup Level

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

µg/L - Micrograms per liter

Table 3-7. Metals Concentrations in Surficial Aquifer Groundwater - Site 78
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	**Site-Specific Cleanup Level[a]**	IR78-GW56					IR78-GW60				IR78-GW64			
Sample ID		MR08-GW56-07A	IR78-GW56-08C	IR78-GW56-08D	IR78-GW56-15A	IR78-GW56-19B	IR78-GW60-12B	IR78-GW60D-12B	IR78-GW60-15A	IR78-GW60-19B	IR78-GW64-08C	IR78-GW64-12B	IR78-GW64-15A	IR78-GW64-19B
Sample Date		01/09/06	07/09/08	11/13/08	03/13/15	04/12/19	04/20/12	04/20/12	03/14/15	04/11/19	07/08/08	04/20/12	03/14/15	04/15/19
Chemical Name														
Total Metals (µg/L)														
Arsenic	10	10 U	10 U	**0.723 J**	50 U	4 U	100 U	100 U	**0.631 J**	4 U	**11.8**	**9.22 J**	**11 J**	**18**
Barium	700	**37.4 J**	200 U	**32.9**	**37.3 J**	**42.9**	80 U	80 U	**16.2**	**7.65**	200 U	**30.4 J**	**44.4 J**	**64.3**
Beryllium	4	5 U	5 U	NA	1.85 U	0.2 U	3.7 U	3.7 U	0.37 U	0.2 U	5 U	3.7 U	1.85 U	0.2 U
Chromium	16.9	10 U	10 U	2.5 U	15 U	4 U	30 U	30 U	3 U	4 U	10 U	30 U	15 U	4 U
Manganese	176	**14.3 J**	**15.1**	NA	**18.3**	**36.7**	12.8 U	12.8 U	**8.18**	5.4 U	**54.1**	**49.3**	**61.8**	**73.8**
Vanadium	26.7	50 U	50 U	NA	4 U	4 U	8 U	8 U	**0.795 J**	**0.69 J**	50 U	8 U	4 U	4 U

Station ID	**Cleanup Level**	IR78-GW73				IR78-GW85			IR78-MW144	IR78-MW147	IR78-MWVI01		
Sample ID		IR78-GW73-12B	IR78-GW73-15A	IR78-GW73D-15A	IR78-GW73-19B	IR78-GW85-12B	IR78-GW85-15A	IR78-GW85-19B	IR78-GW144-19B	IR78-GW147-19B	IR78-GWVI01-12B	IR78-MWVI01-15A	IR78-GWVI01-19B
Sample Date		04/22/12	03/14/15	03/14/15	04/23/19	04/22/12	03/14/15	04/16/19	04/15/19	04/15/19	04/22/12	03/14/15	04/11/19
Chemical Name													
Total Metals (µg/L)													
Arsenic	10	100 U	10 U	10 U	4 U	100 U	**5.64 J**	**6.9**	**4.4 J**	4 U	100 U	100 U	**2.8 J**
Barium	700	**26.1 J**	**41.8**	**42.1**	**24.6**	80 U	**36.4**	**34.2**	**89.9**	**99.7**	**51.7 J**	**51.7 J**	**37.2**
Beryllium	4	3.7 U	**0.122 J**	**0.124 J**	**0.044 J**	3.7 U	1.11 U	0.2 U	0.2 U	**0.23 J**	3.7 U	3.7 U	0.2 U
Chromium	16.9	30 U	3 U	3 U	4 U	30 U	9 U	4 U	4 U	4 U	30 U	30 U	4 U
Manganese	176	12.8 U	**12.8**	**13**	**17.8**	**64.1**	**56.4**	**40.8**	**192**	**25.8**	**89.4**	31.8 U	**41**
Vanadium	26.7	8 U	**0.372 J**	**0.334 J**	**0.89 J**	8 U	**2 J**	**6.37**	4 U	4 U	4 U	8 U	**0.82 J**

Station ID	**Cleanup Level**	IR78-RW06			IR78-RW08					UST1613-MW03			UST1613-MW17		
Sample ID		IR78-EXW06-01/19/1996	IR78-EXW06-04/09/1996	IR78-RW06-19B	IR78-EXW08-01/19/1996	IR78-EXW08-04/09/1996	IR78-RW08-12B	IR78-RW08-15A	IR78-RW08-19B	UST1613-GW03-04D	UST1613-GW03-15A	UST1613-GW03-19B	UST1613-GW17-04D	UST1613-GW17-15A	UST1613-GW17-19B
Sample Date		01/19/96	04/09/96	04/22/19	01/19/96	04/09/96	04/21/12	03/14/15	04/22/19	10/06/04	03/15/15	04/12/19	10/06/04	03/14/15	04/11/19
Chemical Name															
Total Metals (µg/L)															
Arsenic	10	0.5 U	0.1 U	**6.3**	**0.7**	**0.5**	100 U	100 U	**9.9**	1.8 U	10 U	4 U	1.8 U	10 U	4 U
Barium	700	NA	NA	**42.5**	NA	NA	**50.9 J**	**54.7 J**	**53.1**	**35.2 J**	**21.1**	**18.9**	**12.4 J**	**24.7**	**29.1**
Beryllium	4	0.5 U	**0.6**	**0.76 J**	0.5 U	**0.6**	3.7 U	3.7 U	**0.805 J**	0.29 U	**0.154 J**	**0.13 J**	0.1 U	0.37 U	**0.048 J**
Chromium	16.9	5 U	**1.3**	**5.97**	**8**	**2.4**	30 U	30 U	**15.7**	0.5 U	3 U	4 U	0.91 U	3 U	4 U
Manganese	176	**8**	**8.1**	**145**	**11**	**61**	**565**	**103**	**208**	**42.9**	**11.5**	4.8 U	**5.4 J**	**6.18**	6.06 U
Vanadium	26.7	NA	NA	**7.41**	NA	NA	8 U	8 U	**27.3**	0.4 U	0.8 U	4 U	**7.8 J**	**0.695 J**	**1.5 J**

Shading indicates the result exceeded Cleanup Level
Bold indicates detections
NA - Not analyzed
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/L - Micrograms per liter

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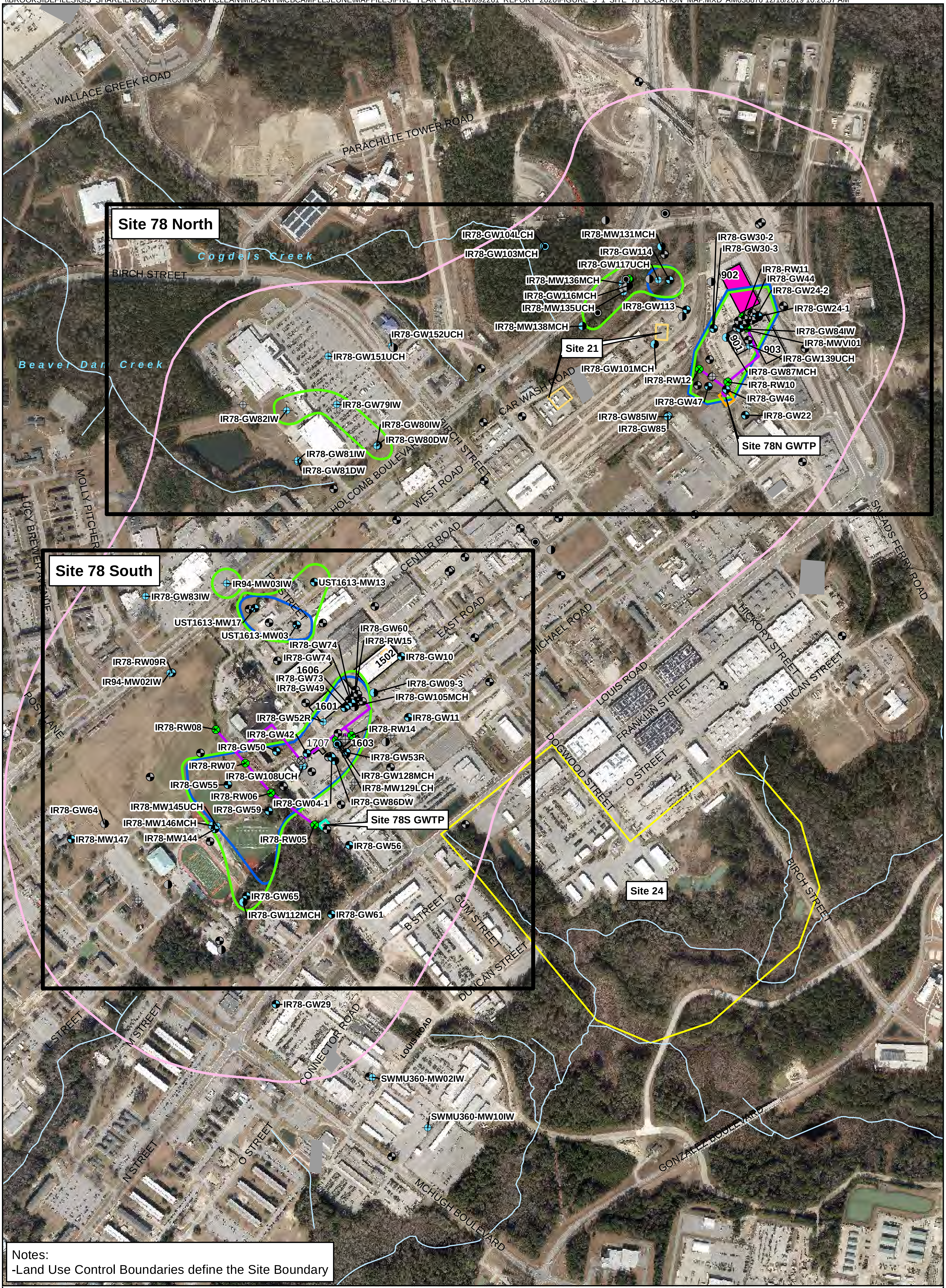


Legend

Monitoring Wells

- Surficial Aquifer
- Middle Castle Hayne Aquifer
- Upper Castle Hayne Aquifer
- Lower Castle Hayne Aquifer
- Surficial Aquifer - not in LTM
- Middle Castle Hayne Aquifer - not in LTM
- Upper Castle Hayne Aquifer - not in LTM
- Lower Castle Hayne Aquifer - not in LTM
- Recovery Well - not in LTM
- Recovery Well - Surficial/Upper Castle Hayne Aquifer

- Surface Water Centerline
- Groundwater Treatment System Piping
- Site 78N GWTP
- Site 78S GWTP
- Site Boundary
- VIMS System Installed

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

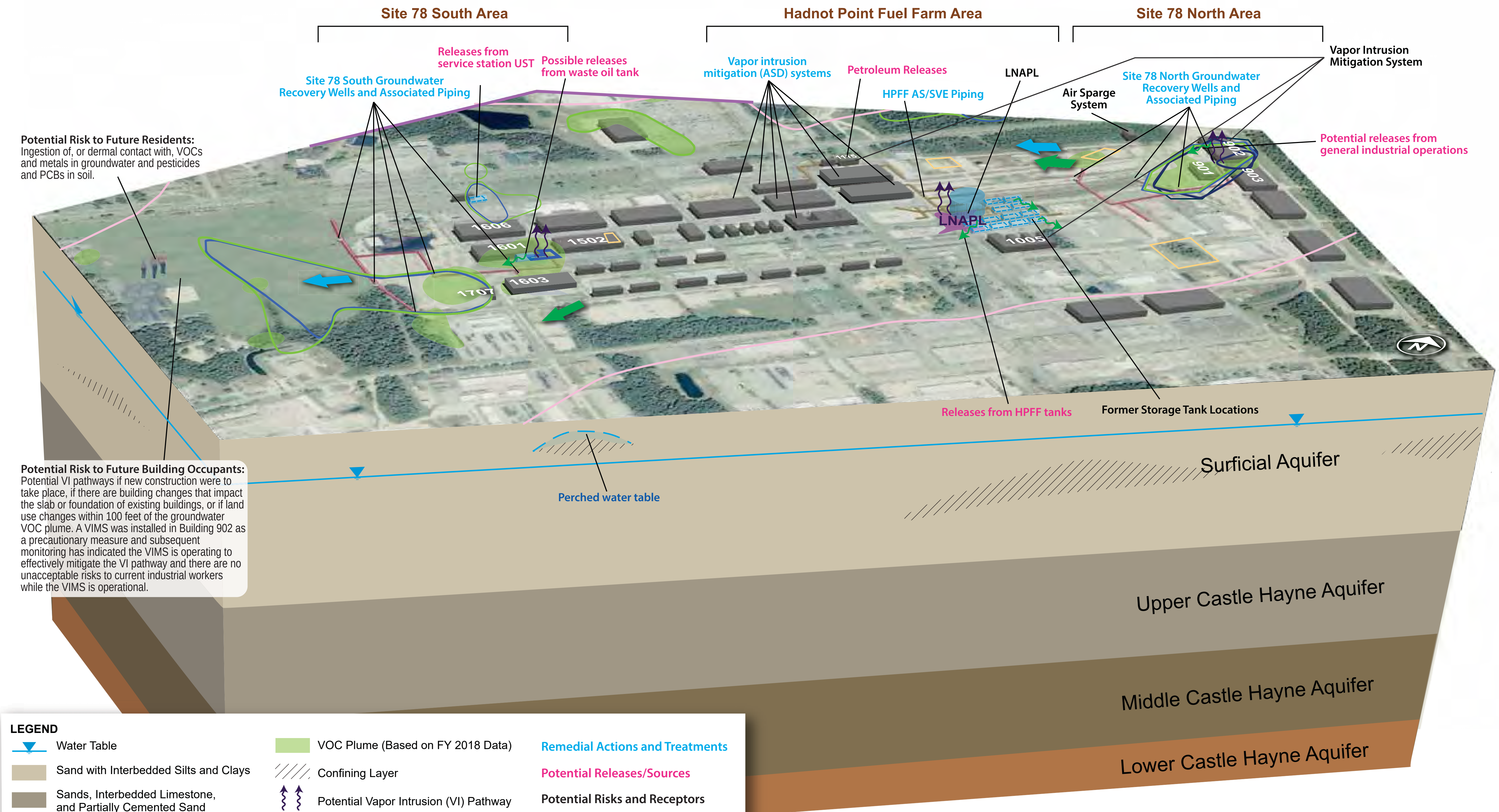
N

0 375 750 Feet

1 inch = 750 feet

Figure 3-1
OU 1 (Sites 21, 24, and 78)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.



LEGEND

- Water Table
- Sand with Interbedded Silts and Clays
- Sands, Interbedded Limestone, and Partially Cemented Sand

Groundwater Flow Direction

- Surficial Aquifer
- Castle Hayne Aquifer

- VOC Plume (Based on FY 2018 Data)
- Confining Layer
- Potential Vapor Intrusion (VI) Pathway

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Non-Industrial Use Control Boundary

Remedial Actions and Treatments

Potential Releases/Sources

Potential Risks and Receptors

ORC – Oxygen Release Compound
HRC – Hydrogen Release Compound
HPFF – Hadnot Point Fuel Farm
AS/SVE – Air Sparge/Soil Vapor Extraction
UST – Underground Storage Tank
ASD – Active Sub-slab Depressurization
VIMS – Vapor Intrusion Mitigation System

Note:
The locations of site conditions are intended to be graphic visuals and not exact replications of site conditions.

FIGURE 3-2
Site 78 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

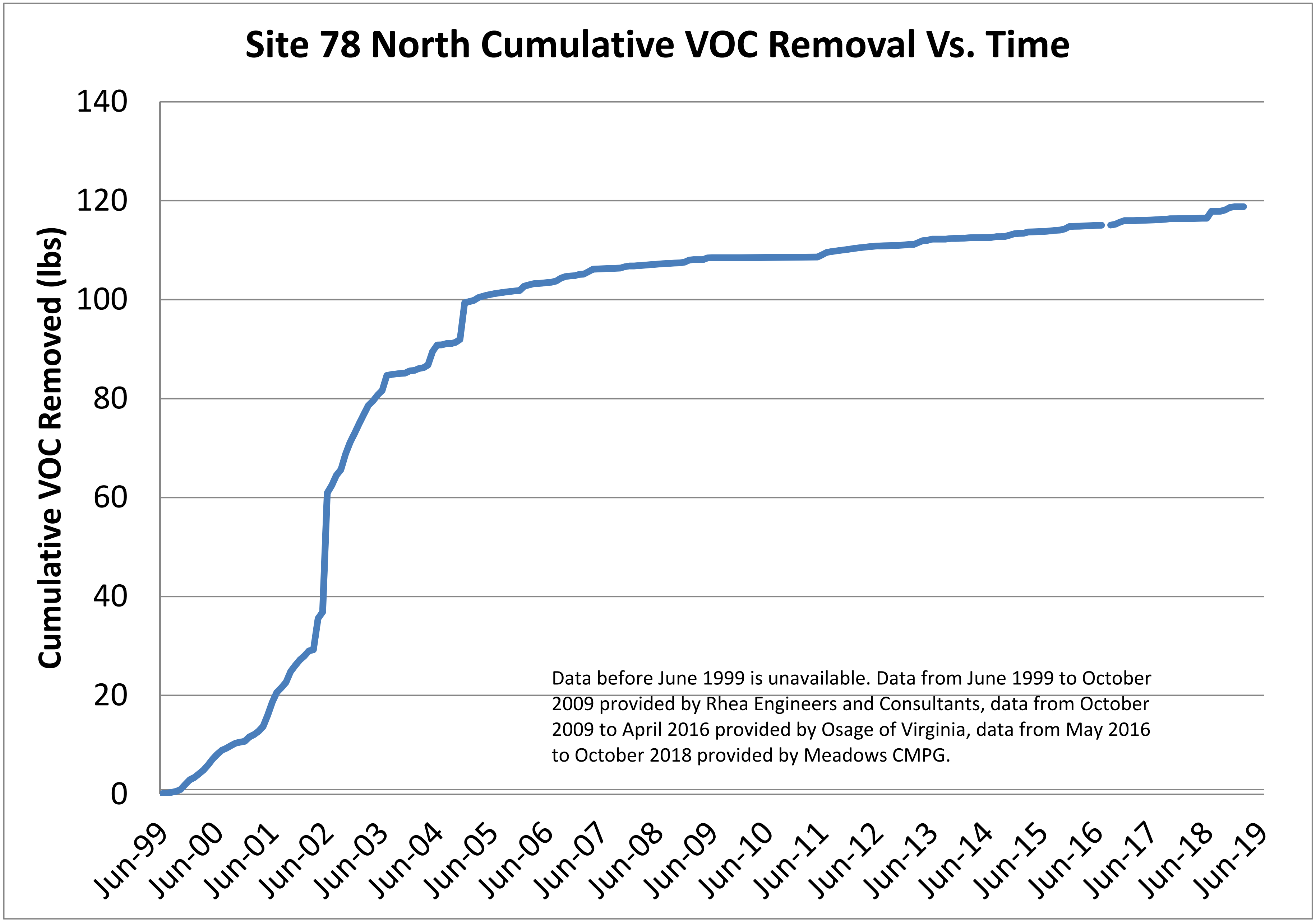


Figure 3-3
Cumulative VOC Removal Site 78 North
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

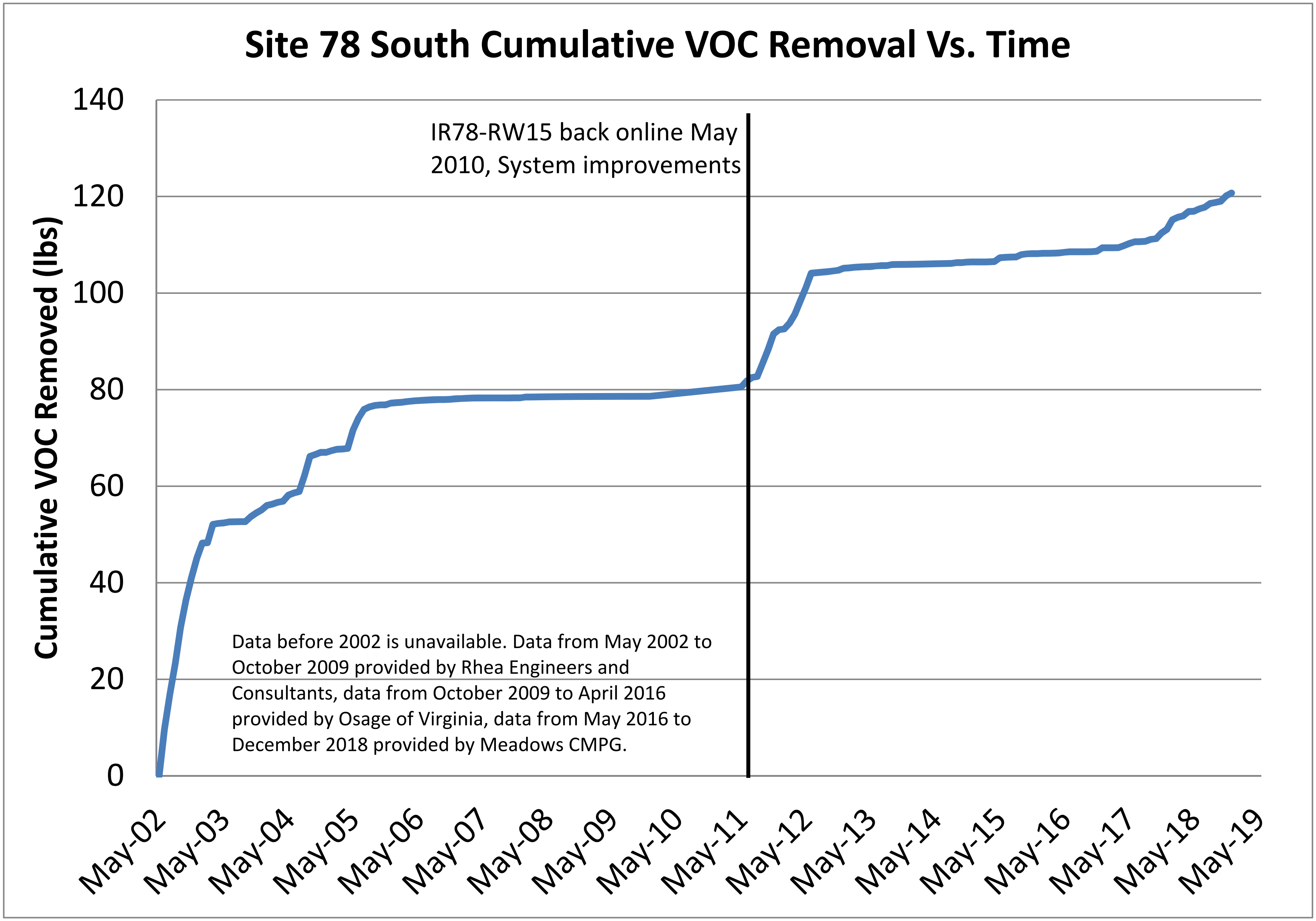


Figure 3-4
Cumulative VOC Removal Site 78 South
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\N\NAVY\CLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\FIVE_YEAR_REVIEW\692261_REPORT_2020\FIGURE_3_5_SURFICIAL_CVOC_AND_BTEX.MXD CE075706 2/18/2020 11:09:55 AM

Note:
CVOC extent based on PCE, TCE, DCE, and VC.
BTEX extent based on Benzene and Xylene.
Highlighted wells are the original monitoring well network at the time of the ROD.
Contaminant extents are based on the most recent data collected from each monitoring well during groundwater sampling events conducted at Site 78 from 2017-2019

Legend

- Surficial Aquifer Monitoring Well
- UCH/Surficial Aquifer Recovery Well
- Surficial Aquifer Monitoring Well - not in LTM
- Recovery Well UCH/surficial - not in LTM
- BTEX extent above cleanup levels
- CVOC extent above cleanup levels

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N

0 300 600 1,200 Feet

1 inch = 600 feet

Figure 3-5
CVOC and BTEX Extents in Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

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Note:
CVOC extent based on PCE, TCE, DCE, and VC.
BTEX extent based on Benzene and Xylene.
Highlighted wells are the original monitoring well network at the time of the ROD.
Contaminant extents are based on the most recent data collected from each monitoring well during groundwater sampling events conducted at Site 78 from 2017-2019

Legend

- Upper Castle Hayne Aquifer Monitoring Well
- UCH/Surficial Aquifer Recovery Well
- Upper Castle Hayne Aquifer Monitoring Well - not in LTM
- Recovery Well UCH/surficial - not in LTM
- BTEX extent above cleanup levels
- CVOC extent above cleanup levels

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

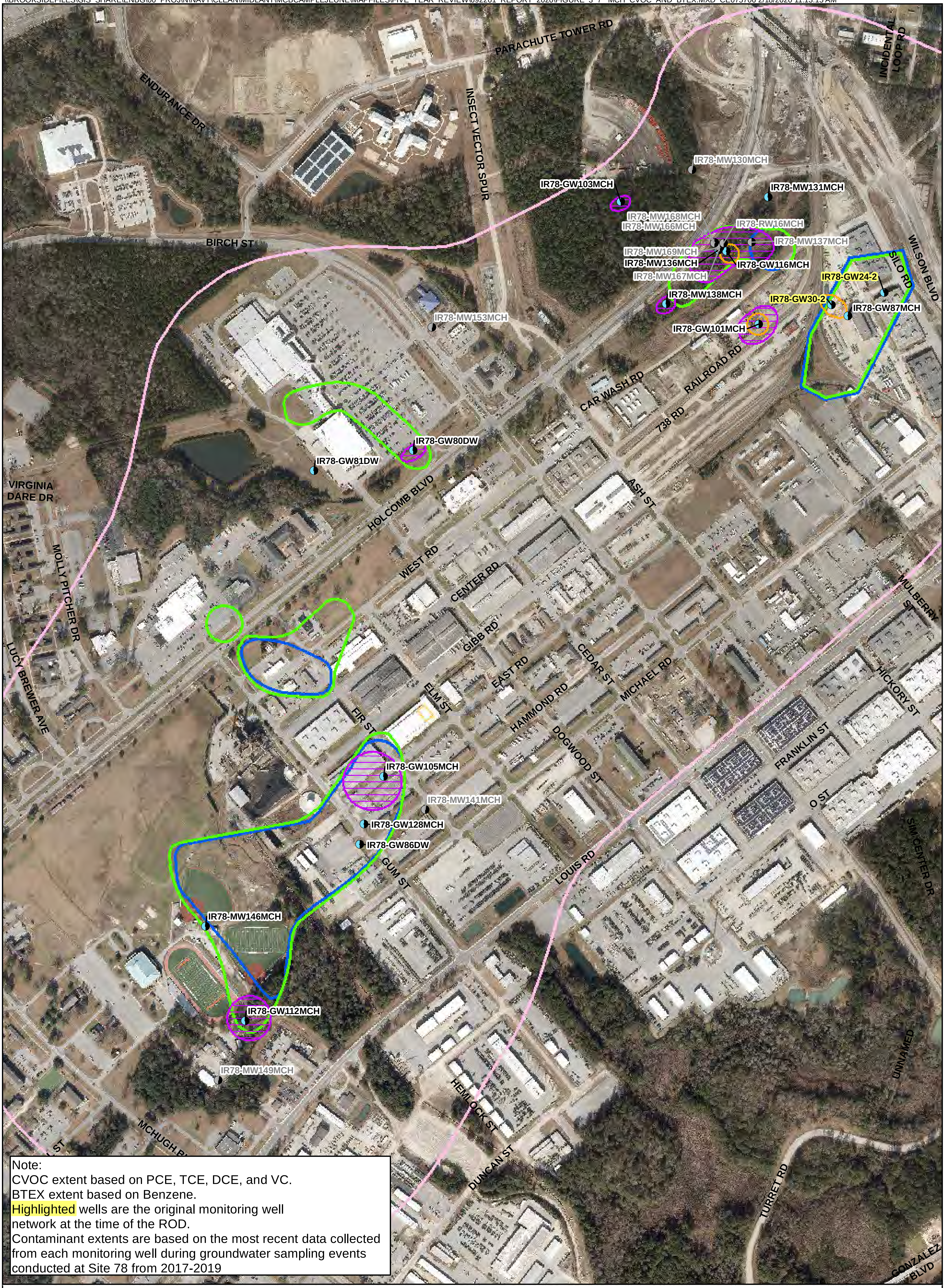
0 300 600 1,200 Feet

N

1 inch = 600 feet

Figure 3-6
CVOC and BTEX Extents in UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.



Note:
CVOC extent based on PCE, TCE, DCE, and VC.
BTEX extent based on Benzene.
Highlighted wells are the original monitoring well network at the time of the ROD.
Contaminant extents are based on the most recent data collected from each monitoring well during groundwater sampling events conducted at Site 78 from 2017-2019

Legend

- Middle Castle Hayne Aquifer Monitoring Well
- Middle Castle Hayne Aquifer Monitoring Well -not in LTM
- BTEX extent above cleanup levels
- CVOC extent above cleanup levels

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N

0 300 600 1,200 Feet

1 inch = 600 feet

Figure 3-7
CVOC and BTEX Extents in MCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Note:
BTEX extent based on Benzene.
Highlighted wells are the original monitoring well network at the time of the ROD.
Contaminant extents are based on the most recent data collected from each monitoring well during groundwater sampling events conducted at Site 78 from 2017-2019

Legend
- Lower Castle Hayne Aquifer Monitoring Well
- BTEX extent above cleanup levels

Land Use Control Boundaries
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

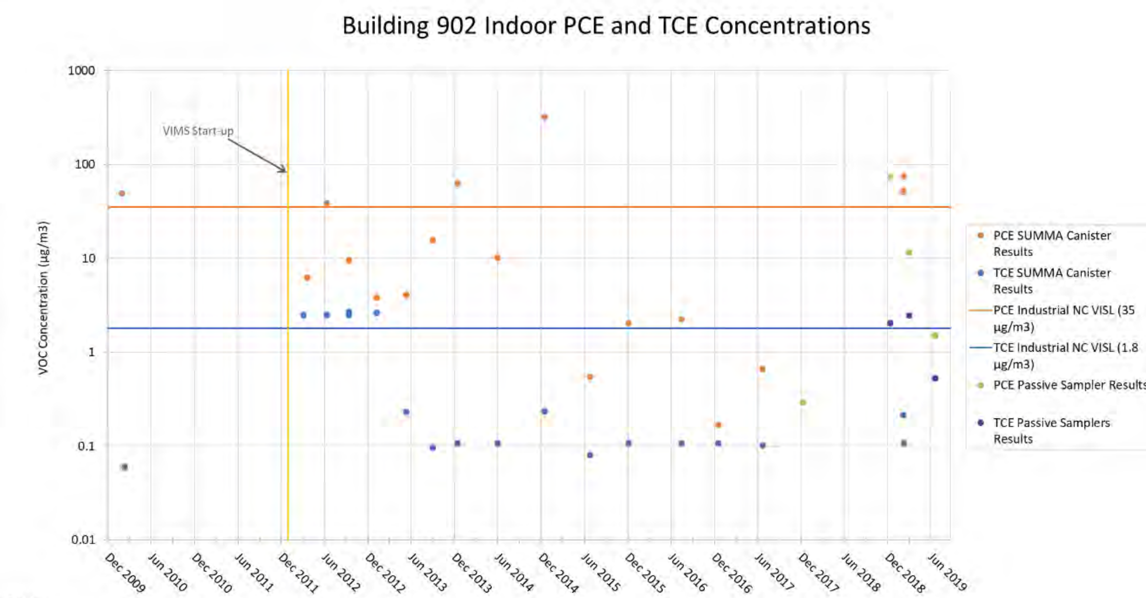
N

0 300 600 1,200 Feet

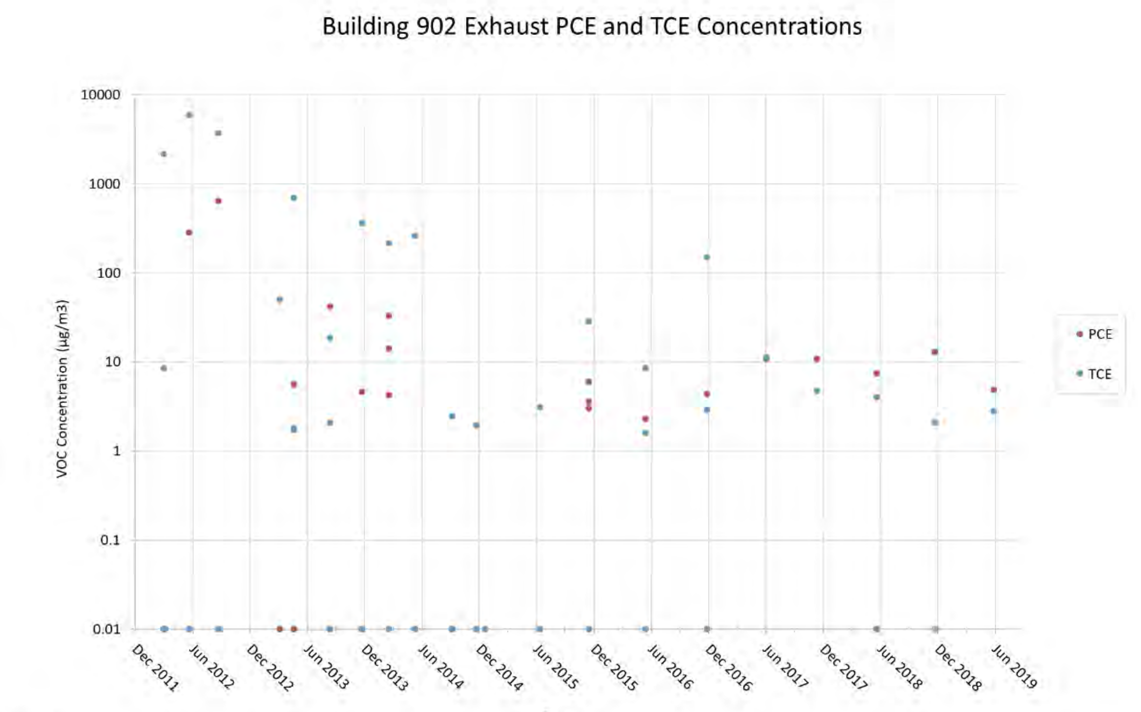
1 inch = 600 feet

Figure 3-8
BTEX Extent in LCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m



Notes:
1. Non-detect results are shown as 0.1 µg/m3
2. PCE concentrations above the VISL in December 2013 and December 2014 identified to be due to an indoor source (CH2M, 2014).
3. PCE concentrations above the VISL in December 2018 and February 2019 were likely the result of an indoor source.
4. Following the September 2017 (Round 22) performance monitoring event, the MCB Camp Lejeune Partnering Team concurred to collect passive samples with sorbent tubes over a 2-week period to evaluate longer-term indoor air concentrations in future performance monitoring events. Previous indoor air samples were collected over a 24-hour period with Summa canisters.



Notes:
Non-detect results are shown as 0.01 µg/m3
Samples may be collected from different nodes during each round

Figure 3-9
Building 902 Indoor Air and Exhaust VOC Concentrations
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

Operable Unit 2 (Sites 6, 9, and 82)

4.1 Site History and Background

OU 2 is within the Mainside area of the Base, approximately 2 miles east of the New River and 2 miles south of North Carolina Highway 24 (**Figure 1-2**). OU 2 consists of four sites (Sites 6, 9, 82, and UXO-22) that have been grouped together because of their proximity to one another. Site 9 was closed with NFA in the OU 2 ROD. However, post-ROD investigations have identified chemicals in soil and groundwater that may require additional action. Therefore, Site 9 is included in this FYR.

Site 6 — Lots 201, 202, and 203 cover an area of approximately 400 acres (**Figure 4-1**). From the 1940s to the late 1980s, Site 6 was used for disposal and storage of wastes and supplies, including pesticides, transformers containing PCBs, solvents, electrolytes, waste oils, and munitions items. Lot 201 is used to store military equipment, vehicles, hydraulic oils, and other "nonhazardous" supplies. Lot 202 has been used to store a variety of shipping containers and other surplus equipment. Most of Lot 203 remains an open field; 21 acres were temporarily used by the Defense Reutilization and Marketing Office (DRMO) for metal staging operations between 2001 and 2012.

Site 9 – The **Piney Green Road Fire Fighting Training Pit** is approximately 2.6 acres located between Piney Green Road and Snead Ferry Road (**Figure 4-1**). The site has been used to conduct training exercises for extinguishing fires caused by flammable liquids from the early 1960s through the present. It was unlined until 1981, when it was lined with asphalt and outfitted with an OWS (Baker, 1993a). Flammable liquids including used oil, solvents, and fuels (unleaded) were used as accelerants during training exercises and it is likely that fires were extinguished onsite using AFFF. The OWS located next to the fire training pit collects water used in the training exercises, as well as stormwater that enters the pit and discharges water to the sanitary sewer. The product collected in the OWS is disposed of offsite.

Site 82 — The Piney Green VOC Area is in the northern portion of OU 2 (**Figure 4-1**). Before the late 1980s, much of the site was reportedly used for storage, disposal, and handling of potentially hazardous waste and material. Site 82 was identified during the Confirmation Study at Site 6 in 1986, when debris, including spent ammunition casings and empty or rusted drums, was discovered on the ground surface. Some of the drums were marked as "lubrication oil" and "anti-freeze."

OU 2 Timeline	
Year	**Event**
1983	IAS (Sites 6 & 9)
1984-1987	Confirmation Study (Sites 6 & 9)
1989	Soil Gas Survey (Site 6)
1991	SI (Site 82)
1992-1993	RI/FS/PRAP/ROD (Sites 6, 9, & 82), NFA (Site 9)
1994-1995	TCRA – Soil and Drum Removal (Sites 6 & 82)
1995	SVE (Site 82)
1996-Present	GW treatment (Site 82) LTM (Sites 6 & 82)
2001-2002	LUCs (Sites 6 & 82)
2002-2012	Chlorobenzene Investigation (Site 6)
2007-2008	ERD Pilot Study (Site 82)
2008-2011	Supplemental Source Investigations (Site 82)
2011	TCRA – Chlorobenzene Drum Removal (Site 6)
2011-2013	PA/SI (Site UXO-22)
2012	Historical Metals Evaluation (Sites 6 & 82)
2012-2015	Supplemental Investigation (Sites 6 & 82)
2013-2016	Expanded SI (Site UXO-22)
2016-Present	SRI (Sites 6 & 82)
2017	ESD (Sites 6, 82, & UXO-22)
2017-Present	Biosparging Pilot Study (Site 6)
2017-2018	PFAS SI (Site 9)
2017	ESD (Site 6, 82, & UXO-22)
2018	Initial Site Assessment (Site 9) GWTP evaluation (Site 82)
2019	LUCIP Update (Sites 6, 82, & UXO-22) Basewide PFAS PA (Sites 6, 9, & 82)

Site UXO-22 – Sites 6 and 82 covers approximately 112 acres and encompasses portions of Sites 6 and 82 where munitions and explosives of concern (MEC) and material potentially presenting an explosive hazard (MPPEH) were found co-located within the waste disposal areas. No former range activities are known to have occurred.

4.2 Site Characterization

The findings from various investigations at OU 2 that are pertinent to the FYR are summarized in this section.

4.2.1 Physical Characteristics

- **Surface Features –**Sites 6, 82, and UXO-22 are relatively flat in the southern and central portion and consists of unpaved storage lots in the central area with wooded areas in the northern and southern areas of the site. An ephemeral drainage feature is in the northwest section of Site 6 and runs through Site 82 to discharge into Wallace Creek. There is a steep drop in elevation leading toward Wallace Creek. Bearhead Creek, a tributary of Wallace Creek, lies within the southern portion of Site 6.

  Site 9 is relatively flat with maintained grass inside of a fenced area. Bearhead Creek is located approximately 500 feet to the north of Site 9.

- **Geology and Hydrogeology –** The subsurface at OU 2 generally consists of Coastal Plain deposits comprising silty sands, clays, and poorly to moderately indurated sandy limestone, with varying amounts of shell fragments. Groundwater is a medium of concern and affected aquifers include the surficial aquifer which extends from ground surface to approximately 25 feet bgs, UCH aquifer from 25 to approximately 90 feet bgs, and LCH aquifer from 90 to approximately 310 feet bgs. Groundwater is influenced by the recovery well system in each aquifer; however, when the system is off, groundwater in the surficial, UCH, and LCH aquifers flow to the north and northwest toward Wallace Creek (**Figure 4-1**). The horizontal hydraulic gradient at Site 6 ranges from 0.0032 to 0.0168 ft/ft in the surficial aquifer, 0.0010 to 0.0128 ft/ft in the UCH aquifer and 0.0037 to 0.0061 ft/ft in the LCH aquifer. In the LCH aquifer, the average hydraulic conductivity ranges from 1.58 to 15.56 ft/day. The hydraulic gradient at Site 82 ranges from 0.0053 to 0.0370 ft/ft in the surficial aquifer, 0.0041 to 0.0093 ft/ft in the UCH aquifer and 0.0011 to 0.0156 ft/ft in the LCH aquifer.

4.2.2 Land Use

- **Current Land Use –** Lot 201 is used to store military equipment, vehicles, hydraulic oils, and other "non-hazardous" supplies. Lot 202 (adjacent to Lot 201) is a storage area for shipping containers and other surplus equipment. Most of Lot 203 and the area to the north to Wallace Creek is vacant and consists of open fields and wooded areas; a portion of Lot 203 is also used for Navy contractor field trailers and the GWTP (**Figure 4-1**). Site 9 is currently used by the MCB Camp Lejeune Fire Department to conduct training exercises for extinguishing fires caused by flammable liquids.
- **Future Land Use –** There are no anticipated changes in land use.

4.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 2. Details are in the OU 2 RI report (Baker, 1993a) and ROD (Baker, 1993c). No human health risk or potential sources of contamination were identified at Site 9 during the RI and ROD and the site was not carried forward for remediation.

Sites 6, 82 and UXO-22

Soil, groundwater, surface soil, surface water and sediment in Wallace and Bearhead Creeks, and biota in Wallace Creek were investigated. A geophysical survey was also conducted to investigate buried debris. The HHRA evaluated current military personnel, potential future adult and child residents, and potential future construction worker scenarios. Based on the results of the RI, unacceptable human health risks were identified for current Base personnel and future residents from exposure to metals and VOCs in surficial aquifer groundwater. Potential unacceptable human health risks were identified for ingestion of fish due to Aroclor-1260 detected in one fish from Wallace Creek. Waste material and metallic debris was identified during geophysical and test pit investigations and presents a potential unacceptable risk to human receptors. Although no unacceptable risks were identified from exposure to contaminants in soil, several areas were identified for RAs in the ROD. One area of soil, AOC 1 (**Figure 4-1**), was identified as being a potential source of VOCs in groundwater and one area, AOC 2, contained waste materials and elevated levels of polycyclic aromatic hydrocarbons (PAHs), PCBs, and metals in soil and sediment (Baker, 1993b). Four areas AOCs 3, 4, 5, and 6 (**Figure 4-1**) were identified for pesticide and PCB-contaminated soil removal based on comparison to remedial goals selected during the FS (Baker, 1993b).

The ERA evaluated terrestrial and aquatic receptors and concluded that concentrations of inorganics in surface water and inorganics and organics in sediment in Bearhead Creek, Wallace Creek, and a ravine leading to Wallace Creek presented a moderate to high risk to ecological receptors if they were representative of long-term conditions. However, based on ecological studies conducted, there did not appear to be any impact on the fish or benthic communities due to site contamination (Baker, 1993a).

Sites 6 and 82 were included in a Basewide VI evaluation from 2007 to 2009 to assess the potential for site COCs to impact VI in existing buildings within 100 feet of the groundwater plume (AGVIQ/CH2M, 2009; CH2M, 2011). Although the evaluation concluded that the VI pathway is not currently significant, based on site-specific COCs, indoor air concentrations could exceed VISLs should VI occur in the future if new construction were to take place or if future building or land use changes within 100 feet of the groundwater VOC plume. Additionally, MEC and MPPEH were discovered during previous investigations at Sites 6 and 82. As a result, a portion of OU 2 was designated as Site UXO-22, which was added to the Military Munitions Response Program (MMRP) in 2010. The nature and extent of MEC/MPPEH was characterized during investigations conducted from 2010 to 2015. The MEC/MPPEH items encountered on the surface and in the subsurface had no apparent pattern of distribution and are not reflective of range activities but of historical waste disposal areas (CH2M, 2013, 2016b).

4.3 Remedial Action Objectives

The ROD for OU 2 was signed in 1993 (Baker, 1993c) and the ESD was signed in June 2017 (CH2M, 2017a). The current RAOs are as follows:

- Prevent current and future exposure to contaminated soil and groundwater.
- Treat or remove contaminated soil.
- Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.
- Reduce or prevent the potential for direct physical contact with MEC/MPPEH which can present unacceptable risk to human health and safety due to the explosive nature of the items/materials.
- Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.

The COCs and cleanup levels for OU 2 are presented in **Table 4-1**.

4.4 Remedial Actions

The RA for OU 2 includes the following major components:

- Excavation and offsite disposal of PCB, PAH, metal, and pesticide-contaminated soil to industrial levels.
- Installation and operation of a GWTP to remove VOCs in the surficial and Castle Hayne aquifers at Site 82.

- LTM of groundwater and surface water in Wallace Creek and the nearby active water supply wells to monitor the effectiveness of the GWTP at Site 82.
- LTM of groundwater to evaluate COC concentrations at Site 6.
- Soil vapor extraction (SVE) to treat approximately 16,500 cubic yards of VOC-contaminated soils at Site 82.
- LUCs to prevent exposure to COCs in soil and groundwater, VOCs indoor air via the VI pathway, and explosive hazards from MEC/MPPEH.

4.4.1 Remedy Implementation

Soil and Debris Removal – Sites 6 and 82

A time-critical removal action (TCRA) was conducted in 1994 and 1995 to remove aboveground storage tanks (ASTs), drums, and other containers that presented potential ongoing sources to soil and groundwater before the ROD was finalized. Approximately 2,655 cubic yards of contaminated soil and debris, including drums containing 4,4'-dichlorodiphenyltrichloroethane (DDT), empty drums, communication wire, spent munitions casings, and batteries, were removed from trenches excavated at both sites (OHM, 1997). The approximate locations of removal trenches are shown on **Figure 4-1**.

Based on a summary update letter to the Navy dated December 1994, soil and debris were removed and disposed of offsite from AOC 2 and PCB-contaminated soil was removed and disposed of offsite from AOCs 3, 4, and 6. The total volume of soil and debris removed is unknown; however, the letter states that 181 tons of non-hazardous debris were removed from AOC 2 and 57 tons of PCB-contaminated soil were removed from AOCs 3, 4, and 6 and test results were clean (Navy, 1994). The AOCs are shown on **Figure 4-1**. There is no documentation of RA completion at AOC 5.

Soil Vapor Extraction – Site 82

SVE was conducted in 1995 to treat approximately 16,500 cubic yards of VOC-contaminated soils (**Figure 4-1**). The system consisted of a single horizontal injection well, an array of eight vertical extraction wells, a piping and manifold system, a vapor/liquid separator, a vacuum blower sized to produce 1,500 actual cubic feet per minute at 15 inches of mercury, and a vapor phase granular activated carbon filter (OHM, 1995a). The SVE system at Site 82 operated for 6 months, from April to November 1995. The confirmation sampling results indicated that remedial goals were reached for all constituents except for PCE at one location in the 60-day post-system shutdown sampling event. However, the previous two rounds at that location and depth were below the laboratory detection limit for PCE and it was concluded that the system had successfully remediated the area to the RAOs. The system was decontaminated and decommissioned in March and April 1996 (OHM, 1996).

Groundwater Extraction and Treatment Plant – Site 82

Full-scale operation of the GWTP began in July 1996. In 2016 and 2017, the system was optimized to address COCs identified post-ROD and expansions to the recovery well network (CH2M, 2016a; Meadows, 2017). The GWTP currently treats groundwater from ten recovery wells: surficial aquifer recovery well IR06-SRW01, surficial/shallow UCH aquifer recovery wells IR06-SRW02 through IR06-SRW06; UCH aquifer recovery wells IR06-DRW01, IR06-DRW02 and IR06-DRW04 and LCH aquifer recovery well IR06-DRW03 (**Figure 4-1**). In June 2018, three recovery wells IR82-DRW05, IR82-DRW06, and IR82-SRW07 were installed and IR82-DRW05 and IR82-DRW06 were incorporated into the GWTP system.

Groundwater from recovery wells and sump is currently treated in the sequential order as follows (**Figure 4-2)**:

1. Surficial and shallow UCH aquifer wells, IR82-DRW06, and sump enter the Holding Tank/Reactivation Tank
2. Clarifier
3. 145 Tank
4. Sand Filters
5. Shallow Well Tray Air Stripper

6. 146 Pump
7. 110 Tank (influent from the deep UCH and LCH aquifer wells enters the system here)
8. Sand Filters
9. Tower Air Stripper
10. 220 Tank
11. Cartridge Filters (in parallel)
12. Carbon Vessels (in parallel)
13. Effluent Holding Tank
14. Effluent to Wallace Creek

Sludge collected from the clarifier is passed through filter socks and the filtered fluid is recirculated through the treatment system via the sump. Effluent levels for COCs are listed in **Table 4-2**.

Long-term Monitoring and Land Use Controls – OU 2

LTM was initiated in 1996 and is ongoing as described in the following section. LUCs were implemented at OU 2 in 2001 and updated in 2002 (Baker, 2002) and 2019 (CH2M, 2019b). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in Base GIS and Master Plan:

- **Aquifer Use Control Boundary:** Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 1,000 feet of groundwater within the surficial and Castle Hayne aquifers with concentrations of VOCs exceeding NCGWQS/MCLs.
- **Non-industrial Use Control Boundary (Soil):** Prohibit non-industrial land use, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, schools, and day care facilities. This LUC boundary is based on the estimated extent of suspected buried materials and associated soil from historical use of Lots 201 and 203 as trench and fill disposal area.
- **Intrusive Activities Control Boundary (Soil):** Prohibit intrusive activities in areas within the extent of suspected buried materials and associated soil based on historical use of Lots 201 and 203 as trench and fill disposal areas.
- **Intrusive Activities Control Boundary (Groundwater):** Restrict intrusive activities within 100 feet of the extent of groundwater contamination within the surficial aquifer with concentrations the NCGWQS/MCLs.
- **Industrial/Non-Industrial Use Control (VI):** Before construction of new buildings or structural modifications to existing buildings, the potential for VI will be evaluated by assessing multiple lines of evidence. If the results of the evaluation indicate that VI could result in unacceptable indoor air concentrations, then engineering controls or an action to address the source will be considered to mitigate the unacceptable exposure. The LUC boundary encompasses the area that is within 100 feet of groundwater within the surficial and Castle Hayne aquifers that contains or potentially could contain concentrations of VOCs exceeding cleanup levels.
- **Intrusive Activities Control (MEC/MPPEH)** – Require site approval and determination of need for unexploded ordnance (UXO) construction support[1] for any intrusive activities within the LUC boundary. Provide educational support to inform personnel and contractors on the implemented LUCs at the site. Require 3Rs (recognize, retreat, report) Explosives Safety Education for all non-UXO-qualified Base personnel and contractors working within the LUC boundary. Restrict access using engineering controls, such as warning signs, to reduce the potential for Base personnel, recreational users, and trespassers to encounter MEC/MPPEH that may be onsite.
- **Industrial/Non-Industrial Use Control (MEC/MPPEH)**: Require site approval if new buildings are to be constructed or if land use changes; this includes evaluating the need for MEC clearance and/or UXO

[1] Actual construction support requirements will be determined by the Installation's Explosives Safety Officer, Marine Corps Systems Command, and the Department of Defense Explosives Safety Board. Construction support shall be determined by submission of an Explosives Safety Submission and/or an Explosives Safety Submission Determination Request, in accordance with appropriate Navy and Marine Corps regulations.

construction support. Prohibit non-industrial land use; this includes prohibiting the construction of residential housing, hospitals, hotels, nursing homes, schools, and day care facilities.

4.4.2 Remedy Operation and Maintenance

Ongoing operations at Site 6 includes LTM and LUCs. Ongoing operations at Site 82 include operation of the GWTP, LTM, and LUCs. The total annual cost is approximately $380,000.

Groundwater Extraction and Treatment Plant – Site 82

The GWTP has been in operation continuously, except for routine downtime or unexpected repairs. Extended periods of downtime since the 2015 FYR include system upgrades from November 2016 until April 2017, the month of September 2018 during Hurricane Florence and subsequent repairs, and the month of December 2019 to replace the tower air stripper for tray strippers. Daily and weekly GWTP inspections include recording system totalizer and pressure readings; recording pressure readings for the process pumps, cartridge filters, and carbon filters; and observing the condition of other plant and health and safety equipment. Routine maintenance consists of system checks, bag filter replacement, sump cleaning, and backwashing the carbon vessel. Other maintenance includes servicing and replacing pumps, cleaning tank floats, and other as-needed repairs. Influent and effluent samples are collected monthly and compared with the effluent levels listed in **Table 4-2**. There have not been any exceedances of effluent levels since carbon changeouts occurred in October 2018. Monthly O&M reports are included as attachments to the annual LTM reports.

Long-term Monitoring - OU 2

LTM at Site 6 began in 1996 and initially consisted of collecting groundwater samples from seven surficial, two UCH, and one LCH aquifer monitoring wells quarterly for VOCs, metals, TSS and TDS. Metals, TSS, and TDS were removed from the sampling protocol in 1997 but metals were re-included in 2015 based on an evaluation of metals in groundwater (CH2M, 2015). The ROD also specified collecting samples from nearby active supply wells; however, the supply wells were deactivated as a result of the aquifer use restrictions established in the ROD and were therefore not included in the LTM protocol (Baker, 1998). In 2000, groundwater samples collected from monitoring well IR06-GW16 contained chlorobenzene at a concentration of 57,000 μg/L (previous detections were several orders of magnitude lower). A series of investigations and RAs were completed from 2002 to present and the LTM network was updated to reflect the current plume configuration to include two surficial, six UCH, and five LCH aquifer monitoring wells. Groundwater samples are collected annually from all monitoring wells for VOCs and every 5 years from surficial aquifer monitoring wells for metals (CH2M, 2019c).

LTM was initiated at Site 82 in 1996 and included annual groundwater sampling of seven surficial, six UCH, and seven LCH aquifer monitoring wells quarterly for VOCs, metals, TSS, and TDS analysis. Since 1999, three co-located surface water and sediment samples have been collected semiannually for VOC analysis. Metals, TDS, and TSS were discontinued in 1997 but metals were added back into the sampling protocol in 2015 based on an evaluation of metals in groundwater (CH2M, 2015). Based on additional post-ROD investigations, the LTM network was updated to reflect the current extent of contamination and currently includes 19 surficial, 17 UCH, and 8 LCH aquifer monitoring wells; 13 recovery wells; and 3 co-located surface water and sediment sample locations. Groundwater samples are collected annually from all monitoring and recovery wells for VOCs and every five years from surficial aquifer monitoring wells for metals. Surface water and sediment samples are collected semiannually for VOCs (CH2M, 2019c).

In addition to comparison with the cleanup levels (**Table 4-1**), all surficial aquifer VOC data are screened against the non-residential NC VISLs, consistent with overall site use to evaluate whether concentrations indicate potential for a complete VI pathway. Surface water data from Site 82 is compared with the human health North Carolina Surface Water Quality Standard (NCSWQS) and sediment is compared to the most current residential RSL. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends.

Land Use Controls - OU 2

The LUCs are shown on **Figure 4-1** and summarized in **Table 4-3**. Lots 202 and 203 are currently surrounded by a chain-link fence to restrict access. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. One violation was observed at Site 6 in October 2015, when previously approved construction work was being conducted, but environmental requirements to have a 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER)-trained personnel complete intrusive activities, equipment decontamination, and sampling excess soil for disposal were not met. While some soil was disposed at the Base landfill, composite sampling was conducted on remaining soil by properly trained contractors to verify that the excess soil was nonhazardous. The soil was characterized as nonhazardous based on the sampling results. USEPA and NCDEQ were notified via email in November 2015 and by a follow-up letter in December 2015.

In September 2018, a post-hurricane inspection was conducted and fallen trees were observed throughout the wooded areas blocking access to several monitoring and recovery wells. Damage to the GWTP included damage to the electrical breaker from a power outage caused by a fallen tree that detached electrical service to recovery well IR06-SRW03. Trees were cleared, a new breaker was installed, and the electrical line was repaired between October 2018 and March 2019.

The FYR site inspection, conducted in March 2019, did not identify any issues affecting protectiveness (**Appendix B**). An interview with the treatment plant operator indicated that the O&M manual on file was outdated as many of the components had been replaced with newer or different models. The OU is currently undergoing a comprehensive remedy evaluation and the O&M manual will be updated if necessary, based on the conclusion of the evaluation.

Table 4-3. OU 2 Land Use Control Summary

LUC Boundary	Area (Acres)	Most Recent LUCIP	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	394.04	May 2019	April 16, 2019
Non-Industrial Use Control Boundary (Soil)	206.75		February 15, 2002
Intrusive Activities Control Boundary (Soil)	206.75		February 15, 2002
Intrusive Activities Control Boundary (Groundwater)	147.90		April 16, 2019
Industrial/Non-Industrial Use Control Boundary (VI)	147.90		April 16, 2019
Intrusive Activities Control (MEC/MPPEH)	112.12		April 16, 2019
Industrial/Non-Industrial Use Control Boundary (MEC/MPPEH)	112.12		April 16, 2019

4.4.3 Post-ROD Removal Actions and Pilot Studies

Site 82 ERD Pilot Study

In December 2005, a pilot study was initiated to evaluate the use of ERD to remediate groundwater as an alternative to pump and treat. Groundwater recovery well IR06-DRW01 was selected as the injection well and 6 new monitoring wells were installed to evaluate the radius of influence and effectiveness of the pilot study. A total volume of 374 gallons of 42 percent lactate/emulsified oil blend was diluted to 1.3 percent in water and 28,140 gallons of solution were injected into the subsurface over 3 days. Degradation daughter products were detected in post-injection samples from three locations and changes in groundwater geochemistry (low dissolved oxygen [DO] and negative oxidation-reduction potential [ORP]) indicated a shift toward a more reducing environment for dechlorination. Prior to injection, the recovery well was turned off for 12 months, during which time the concentration of TCE decreased from 9,200 to 160 µg/L. This indicates that the recovery well was capturing impacted groundwater during operation but may not have been ideally located to remove the source of groundwater contamination (CH2M, 2008).

Site 6 Time-Critical Removal Action Chlorobenzene Drum Removal

Based on elevated and fluctuating concentrations of chlorobenzene reported in samples collected from IR06-GW16, additional investigations were conducted from 2002 to 2010 to assess the source and extent of contamination (CH2M, 2010). From 2010 to 2011, a digital geophysical mapping and follow up test pit investigation were completed in the area upgradient of the well and drums containing chlorobenzene were uncovered (CH2M, 2012). In May 2011, a TCRA was completed to remove the drums and associated surrounding soils. Approximately 42 cubic yards of soil, buried debris, and two 55-gallon drums were removed, and the site was restored with clean fill. Chlorobenzene concentrations in the confirmation samples from the removal area ranged from 170 to 2,600,000 µg/kg, indicating that residual contamination was still present in soil. Follow up investigations were recommended to evaluate the extent of contamination in soil and revisit the remedy in place to evaluate protectiveness of human health and the environment (CH2M, 2011).

Site 6 Biosparging Pilot Study

Investigations to evaluate the extent of chlorobenzene in soil and groundwater were completed from 2012 to 2015 (CH2M, 2015, 2017b). Based on the results, a pilot study was conducted from October 2017 to May 2019 to evaluate the effectiveness of biosparging to treat remaining chlorobenzene in the soil and groundwater at Site 6. The biosparge system was installed and was in operation from November 2017 through February 2018. Chlorobenzene was not detected in the initial performance monitoring samples; however, chlorobenzene was detected at concentrations above screening criteria in a soil sample collected in June 2018 and the biosparge system was restarted in July 2018. The last round of performance monitoring samples was collected, and results will be presented in the third and final Supplemental Remedial Investigation (SRI) technical memorandum and will be used to determine the path forward.

Site 82 Subgrade Biogeochemical Reactor Pilot Study

A pilot study was initiated in late 2018 and is ongoing to evaluate the use of subgrade biogeochemical reactors (SBGRs) to treat areas with elevated CVOC concentrations in soil and groundwater that were identified during the SRI (CH2M, 2020). Three SBGRs were constructed in test pit locations that exhibited source concentrations of VOCs and are comprised of a gravel, straw, mulch backfill amended with a sand/zero-valent iron (ZVI) mixture and soybean oil. Groundwater is recirculated through the treatment media using an extraction well and infiltration gallery (CH2M, 2019a, 2020). The pilot study is ongoing through 2020.

4.4.4 Progress Since the 2015 Five-Year Review

Issues identified during the 2015 FYR and follow-up actions are summarized in **Table 4-4**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figures 4-3** (Site 6) and **4-4** (Site 82). The OU 2 RA components and expected outcomes are summarized in **Table 4-5**.

Table 4-4. 2015 FYR OU 2 Issues, Recommendations, and Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI) (6/30/2016)	Completed June 30, 2016. The Draft ESD was submitted June 30, 2016, finalized March 30, 2017, and signed on June 1, 2017 to update the RAOs for OU 2 to include VI, to add an industrial/non-industrial use control for VI, add intrusive controls due to MEC/MPPEH associated with UXO-22, and to update the groundwater LUCs based on current extent of groundwater contamination (CH2M, 2017a). The LUCIP update was finalized in May 2019 (CH2M, 2019b).
Explosive hazards may be present within the boundary of UXO-22	Prepare a Master ESD to update the OU 2 ROD to include UXO-22 and add LUCs to include an intrusive activities control for MEC (6/30/2016)	
Effluent standards for the treatment system were selected in 1993 based on State and Federal criteria that has since been updated	Re-evaluate effluent standards based on current State and Federal criteria (12/31/2016)	Completed June 30, 2016. A review of current State and Federal criteria for surface water was completed and updated effluent standards were documented in the ESD. The Draft ESD was submitted June 30, 2016, finalized March 30, 2017, and signed on June 1, 2017 (CH2M, 2017a).
COCs were detected in surficial groundwater and porewater leading to Wallace Creek indicating a potential transport pathway from groundwater to surface water	Re-evaluate human health and ecological risks based on updated data (12/31/2016)	Completed June 28, 2016. Preliminary human health and ecological risk assessments were completed as part of the SRI, presented to the USEPA and NCDEQ during the June 2016 Partnering meeting, and documented in the first update technical memorandum, submitted as draft in January 2017 and finalized in May 2017. Initial results indicated that there is a potential for unacceptable risks to human receptors from VOCs, metals, pesticides, and PCBs in fish tissue. However, these risks were based on modeling using concentrations in surface water and sediment and an additional investigation is underway to collect fish tissue samples that will be used to re-evaluate risks. There were no unacceptable ecological risks (CH2M, 2017b). An investigation was conducted from May 2018 to May 2019 to identify whether the source of pesticides and PCBs in surface water and sediment was from GWTP effluent (CH2M, 2018a). Monthly samples were collected from the GWTP effluent outfall for pesticides and PCBs. All data collected were below laboratory detections indicating that the GWTP is not the source of the pesticides and PCBs.

Table 4-4. 2015 FYR OU 2 Issues, Recommendations, and Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Current extent of COCs in site media is not fully assessed at Sites 6 and 82	Complete assessment of the extent of COCs in site media (12/31/2016)	Completed June 28, 2016. Groundwater COCs and constituents in soil at Site 6 and the majority of Site 82 were investigated as part of the SRI at OU 2 in 2016. Results were presented to the USEPA and NCDEQ during the June 2016 Partnering meeting and documented in the first SRI Update memorandum (CH2M, 2017b). The results of the investigation indicated the need for additional groundwater delineation at Site 82 which was completed in 2017 and documented in the second SRI update (CH2M, 2020). Soil sampling was conducted to confirm a removal action occurred at AOC 5, as identified in the ROD. Additionally, although RAs occurred at AOCs 1 and 2, impacted soil and waste is still present at these AOCs based on source removal and supplemental investigations since the ROD. Therefore, soil sampling was performed at AOCs 1 (PAHs), 2 (PAHs and select metals), and 5 (pesticides) in May 2019 and data will be used to evaluate whether unacceptable risks to human health and/or ecological receptors are present (CH2M, 2019a).
	Update groundwater LUCs as applicable (12/31/2018)	Completed June 30, 2016. The Draft ESD was submitted June 30, 2016, finalized March 30, 2017, and signed on June 1, 2017 to update the groundwater LUCs based on current extent of groundwater contamination (CH2M, 2017a). The LUCIP update was finalized in May 2019 (CH2M, 2019b).
An RSL was established for 1,4-dioxane and indicator constituents are present in groundwater at Sites 6 and 82	Collect groundwater samples for 1,4-dioxane to evaluate presence/absence (9/30/2018)	Completed April 12, 2017. Groundwater samples were collected on February 15, March 1 and 15, and April 12, 2017 for 1,4-dioxane analysis from select monitoring and recovery wells in the surficial, UCH, MCH, and LCH aquifers. There were no detections above laboratory detection limits in any samples collected (CH2M, 2018a).
Existing treatment system does not encompass recently discovered source areas at Site 82 or groundwater contamination at Site 6	Evaluate expanding or modifying the existing treatment system at Site 82 and evaluate alternative treatment technologies at Site 6 and/or Site 82 to remediate source areas and minimize degradation of Wallace Creek and develop a revised Proposed Plan and ROD Amendment or ESD as necessary (12/31/2020)	Currently in progress. The GWTP was evaluated in 2016 to assess current effectiveness to treat COCs and future ability to treat an expanded recovery well network (CH2M, 2016). Additional groundwater recovery wells were installed, and hydraulic testing was completed to evaluate capture zones and potential removal effectiveness (CH2M, 2020). A pilot study was initiated at Site 6 in November 2017 to evaluate biosparging to treat chlorobenzene in the soil and groundwater (CH2M, 2020). A pilot study was initiated at Site 82 in late 2018 to evaluate the use of SBGRs to treat VOC source areas (CH2M, 2020). Results from these evaluations and studies will be used to re-evaluate the overall site remedy.

Site Inspection for PFAS Investigation in Groundwater

A SI was conducted at Site 9 to identify the presence or absence of PFAS in groundwater resulting from historical site activities as a firefighting training area. Groundwater samples were collected from three newly installed surficial aquifer monitoring wells and one existing monitoring well. Concentrations of PFOS and PFOA were detected in surficial aquifer groundwater above USEPA lifetime health advisory concentration (0.07 µg/L), tapwater RSL based on a hazard quotient of 1 (0.4 µg/L), and the North Carolina IMAC for PFOA (2 µg/L) with the highest concentrations detected in the monitoring well nearest to and downgradient of the fire training pit. The elevated concentrations of PFOS (maximum of 35.1 µg/L) and PFOA (maximum of 3.46 µg/L) in the groundwater indicate historical fire training activities have resulted in a release of PFAS to the groundwater in the surficial aquifer. During groundwater sampling, a sheen and strong odor was observed at the monitoring well nearest to and downgradient of the fire training pit. There were also elevated total petroleum hydrocarbons results in the investigation-derived waste soil samples from this same well. An additional investigation and removal action were conducted under the UST Program and PCE was reported in groundwater above the NCGWQS and soil samples at concentrations above residential maximum soil contamination concentration and/or the soil to groundwater maximum contamination concentration. Based on the confirmatory soil sample results, a total of 225.8 tons of soil were removed and replaced with clean backfill. The lateral limits of the excavation extended to the four soil sample locations that did not exceed the North Carolina Action Limit. The vertical limit of the excavation extended to just above the water table where groundwater contamination above the NCGWQS was confirmed. As a result of these findings, additional investigation under the IRP were recommended to further develop the CSM and define the nature and extent of PFAS and PCE contamination at Site 9 (CH2M, 2018c).

4.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

No. RAs were implemented at OU 2 to address RAOs based on the site conditions at the time of the ROD. Supplemental investigations have been conducted that indicate there are additional sources of contamination, COCs are more widespread and deeper than initially understood, and the recovery well network is not optimal to address all contamination sources. However, current protectiveness is not affected because LUCs are in place to prevent exposure to COCs in site media at Sites 6 and 82 and all groundwater plumes, including the estimated extent of PCE at Site 9, are included in the Base GIS and Master Plan and all construction projects go through environmental review.

Site 6

The ongoing remedy at Site 6 is LTM and LUCs. Based on most recent data collected in support of FY 2019 LTM, chlorobenzene treatability study, and the SRI (CH2M, 2020), LTM is functioning as intended by the decision document. As discussed in **Section 4.4.3**, a pilot study was conducted from 2018 to 2019 to evaluate the effectiveness of biosparging to treat chlorobenzene in soil and groundwater. Preliminary results indicate that the pilot study was effective, and chlorobenzene is below cleanup levels in groundwater in the surficial aquifer and is isolated to four locations in the UCH aquifer (**Figures 4-5** and **4-6**). Other site COCs are below cleanup levels in the surficial aquifer but continue to be present in the UCH aquifer within the Site 6 area (**Figure 4-7**).

In January 2019, groundwater samples were collected for metals evaluation from surficial aquifer monitoring wells. Metals concentrations were consistent with historical concentrations at most locations. Manganese was the only metal that exceeded the cleanup level during the last 3 rounds of sampling (**Table 4-6**).

Site 9

The remedy at Site 9 is NFA. Since the last FYR, PCE and PFAS were identified in groundwater at Site 9 and additional investigation is planned to determine the extent of contamination, potential risks to human and ecological receptors, and, if applicable, identify RAs needed to protect human health and the environment.

Site 82

The remedy at Site 82 is soil removal, operation of the GWTP, LTM, and LUCs. Supplemental investigations have been conducted that indicate there are additional sources of contamination, COCs are more widespread and deeper than initially understood, and the recovery well and LTM network is not optimal to address all contamination sources. The comprehensive SRI, conducted from 2014 to 2019, identified four additional VOC source areas (**Figure 4-8**) (CH2M, 2020). During test pit excavation as part of the SRI, general radioactive material in the form of commodities such as dials, gauges, and compasses were identified above local gross gamma radiation background during health and safety monitoring. The waste and soil were stockpiled, sampled, and will be appropriately disposed of by a US Navy qualified broker.

From October 2015 to May 2019, the GWTP treated an average of 9.4 million gallons per month, removing an average of 144 pounds of VOCs per month. The GWTP appears to be functioning as designed, although trends indicate that the monthly mass removal has decreased since the system start up (**Figure 4-9**). The recovery well network performance was evaluated by sampling during system operation and shutdown to identify if the wells are located in higher concentration areas of the plume. Additionally, hydraulic testing was completed to evaluate the optimal capture zones to treat the groundwater plumes (CH2M, 2020). Two new recovery wells (IR82-DRW05 and IR82-DRW06) were added to the recovery well network and pumping rates were reduced at IR06-DRW03 and IR06-DRW04 to prevent downward migration of COCs.

Based on FY 2018 LTM data reported in the SRI second technical memorandum update, VOCs are present in groundwater at and near the source areas and along the active recovery wells near Wallace Creek in all aquifer depths (**Figure 4-7**). Significant updates to the LTM network were recommended and incorporated into the FY 2020 LTM sampling protocol. LUCs continue to encompass the extent of COCs in groundwater. There were no COCs exceeding cleanup levels in surface water (CH2M, 2020).

In January 2019, groundwater samples were collected for metals evaluation from surficial aquifer monitoring wells at Site 82. Metals concentrations were consistent with historical concentrations at most locations and manganese was the only metal that continues to exceed the cleanup level (**Table 4-7**).

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. Although the RAOs are still valid; exposure assumptions, toxicity data, and standards on which cleanup levels are based have changed. These changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to groundwater, waste, or soil. New potential VOC contaminant sources were identified at OU 2, Site 9 was confirmed as a PFAS release area, and general radioactive material was identified at Site 82.

Exposure Assumptions: While changes in land use have not occurred, investigations at Site 9 have identified new contaminants in groundwater (PCE and PFOA/PFOS) at concentrations above above the USEPA Lifetime Health Advisory, tapwater RSL based on a hazard quotient of 1, and the North Carolina IMAC for PFOA and human health risks have not been quantified. However, groundwater in the area is not currently used; therefore, there is no current exposure pathway.

Toxicity and Other Contaminant Characteristics: There have been changes to toxicity criteria for COCs since the HHRA was conducted and the ROD was signed, and since the 2015 FYR (**Table 2-1**). Groundwater monitoring and remediation will continue and LUCs will continue to be maintained to prevent exposure to contaminated groundwater and waste. No unacceptable risks were identified for surface soil at the time of the ROD; however, soil removal was conducted for hot spots to industrial based or leaching to groundwater-based remediation goals. Although toxicity values have changed, the area was restored with clean fill following the RAs and LUCs for non-industrial use remain in place and are protective. Thus, toxicity changes for any of the chemicals detected at the site would not affect the protectiveness of the remedy.

Cleanup Levels: The cleanup levels for groundwater were identified as the more conservative of the NCGWQS and MCL. Since the ROD was signed, the standards for arsenic, barium, mercury, and vanadium have decreased and are more conservative; however, the most up to date standards, or BTV if the standard is lower than the BTV for metals, are used to evaluate LTM data (**Table 4-1**).

The cleanup levels for pesticides, VOCs, and metals in soil were identified as risk-based levels calculated in the ROD (Baker, 1993b). The confirmation soil sample results documenting the contaminated soil removal indicate that the cleanup levels identified in the ROD were met (OHM, 1997, Navy, 1994) and soil sampling data collected at AOCs 1, 2, and 5 in 2019 is currently being evaluated for potential risks. LUCs restricting intrusive activities and prohibiting non-industrial use remain in place and are protective.

The NCSWQS have been updated since the ESD documented effluent levels for the GWTP (**Table 4-2**). The effluent level for chlorobenzene, trans-1,2-DCE, lead, and manganese are more conservative; however, these constituents are consistently below laboratory detection limits during monthly effluent sampling.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 2 remedy with respect to extreme weather events, primarily hurricanes, was completed. Effects of hurricane damage have been observed at OU 2 with damage to recovery wells and the GWTP and fallen trees blocking access to monitoring and recovery wells. Damage to the system would not affect protectiveness because it would not create a complete exposure pathway to contaminated groundwater. If erosion were to uncover subsurface MEC/MPPEH or buried waste a complete exposure pathway may occur. However, 3Rs Explosives Safety Education is a component of the remedy so if an item were to be exposed, personnel are trained to respond. LUCs are inspected quarterly and following major storm events and the O&M of the GWTP requires daily system checks. Repairs are conducted as needed to maintain protectiveness.

4.6 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 2 are summarized in **Table 4-8**.

Table 4-8. OU 2 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	Future
Site 9 was identified as a potential PFAS release area based on historical site use. Presence of PFAS compounds has been identified in groundwater at Site 9.	Refine the extent of PFAS in site media at Site 9 and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors.	Navy/Base	USEPA/ State	December 31, 2025	No	Yes
PCE was identified in soil and groundwater at concentrations above NCGWQS and the maximum soil contamination concentration at Site 9.	Refine the extent of PCE in site media at Site 9 and evaluate potential risks to human health and the environment and potential future actions if necessary.	Navy/Base	USEPA/ State	December 31, 2025	No	Yes
General radioactive materials were identified in buried waste materials at Site 82.	Determine if radionuclides are present in groundwater above background.	Navy/Base	USEPA/ State	December 31, 2025	No	Yes

Table 4-8. OU 2 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	Future
New contaminant sources have been identified and VOCs in groundwater are more widespread than the existing remedy was designed to address and RAOs are not likely to be met in a reasonable timeframe. A formal evaluation of RAs to address this contamination has not been completed.	Complete the SRI and conduct an FS Amendment to reevaluate alternatives to address new contaminant sources and COCs in groundwater.	Navy/Base	USEPA/ State	December 31, 2025	No	Yes

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Sites 6 and 82 were evaluated as potential PFAS release areas based on use as a former DRMO lot and waste disposal area. The sites were used for the disposal and storage of materials including expired AFFF concentrate and/or empty AFFF containers. There is potential for release of PFAS from the disposal areas based on storage and handling of AFFF. Therefore, further evaluation was recommended (CH2M, 2019d).

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release areas identified; therefore, there is no current exposure pathway (CH2M, 2019d). These areas will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

4.7 Statement of Protectiveness

The remedy at OU 2 is currently protective of human health and the environment. Exposure pathways that could result in an unacceptable risk are being controlled. LUCs are in place to prohibit aquifer use, non-industrial use, restrict intrusive activities, and evaluate and/or mitigate potential VI pathways. Active treatment of groundwater and LTM is ongoing at Sites 6 and 82 until cleanup levels are achieved.

However, to ensure the remedy is protective in the long term, the Navy intends to refine the extent of PFAS and PCE in site media and evaluate the potential for unacceptable risks and/or potential complete exposure pathways at Site 9; complete the SRI and conduct an FS Amendment at Site 82; and evaluate radionuclides in groundwater at Site 82. In the interim, to facilitate protectiveness at Site 9, the Base GIS and Master Plan maintains current VOC plume data and all construction projects go through environmental review.

4.8 References

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Table 4-1. Cleanup Levels for OU 2 (Sites 6 and 82)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (Baker, 1993, CH2M, 2017)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	***VOCs***			
	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS
	1,1,2-Trichloroethane	0.6	0.6	NCGWQS/IMAC
	1,1-Dichloroethene	7	7	NCGWQS/MCL
	1,2-Dichloroethane	0.4	0.4	NCGWQS
	1,2-Dichloropropane	0.6	0.6	NCGWQS
	1,4-Dichlorobenzene	6	6	NCGWQS
	Benzene	1	1	NCGWQS
	Chlorobenzene	50	50	NCGWQS
	Chloroform	70	70	NCGWQS/MCL
	Chloromethane	3	3	NCGWQS
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	Ethylbenzene	600	600	NCGWQS
	Tetrachloroethene	0.7	0.7	NCGWQS
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL
	Trichloroethene	3	3	NCGWQS
	Vinyl chloride	0.03	0.03	NCGWQS
	Metals			
	Aluminum	14,000	14,000	BTV
	Arsenic	10	10	NCGWQS/MCL
	Barium	700	700	NCGWQS
	Beryllium	4	4	NCGWQS
	Chromium	16.9	16.9	BTV
	Cobalt	3.38	3.38	BTV
	Iron	16,100	16,100	BTV
	Lead	15	15	NCGWQS
	Manganese	176	176	BTV
	Mercury	1	1	NCGWQS
	Thallium	0.2	0.2	NCGWQS
	Vanadium	26.7	26.7	BTV

Table 4-1. Cleanup Levels for OU 2 (Sites 6 and 82)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (Baker, 1993, CH2M, 2017)	Current Standard	
			Concentration	Reference
Soil (µg/kg)	Polychlorinated Biphenyls	10,000	10,000	Action Level for Low Occupancy Land Use (USEPA, 1990)
	Pesticides			
	4,4-DDT	60,000	8,500	RSL-Industrial Soil
	VOCs			
	Benzene	5.4	5,100	RSL-Industrial Soil
	Tetrachloroethene	10.5	39,000	RSL-Industrial Soil
	Trichloroethene	32.2	1,900	RSL-Industrial Soil
Soil (µg/kg)	***Metals***			
	Arsenic	23,000	3,000	RSL-Industrial Soil
	Cadmium	39,000	98,000	RSL-Industrial Soil
	Manganese	390,000	2,600,000	RSL-Industrial Soil

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value. Cleanup level is the surficial aquifer Base BTV when the BTV is higher than the NCGWQS or MCL. Cleanup Levels for groundwater were updated in the 2017 ESD, all others listed are ROD cleanup levels.

Notes:

Shading indicates cleanup levels achieved/remain protective per Closeout Report (OHM, 1997)

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS/IMAC (February 2016)

RSL (May 2019) lower of RSL based on cancer risk of 10-6 and noncancer hazard index of 0.1

µg/L = microgram per liter

BTV = background threshold value ethylbenzene

COC = constituent of concern

DDT = dichlorodiphenyltrichloroethane

IMAC = Interim Maximum Allowable Concentration

MCL = maximum contaminant level

NCGWQS = North Carolina Groundwater Quality Standard

RSL = Regional Screening Level

ROD = Record of Decision

Table 4-2. Site 82 Groundwater Treatment Plant Effluent Levels
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

COCs	ROD Effluent Levels (Baker, 1993)	ESD Effluent Levels (CH2M, 2017)	Current NCSWQS	Source of Current NCSWQS[a]
VOCs (µg/L)				
1,1,2,2-Tetrachloroethane	--	4	4	HH
1,1,2-Trichloroethane	--	16	8.9	HH - NRWQC
1,1-Dichloroethene	--	7,100	20,000	HH
1,2-Dichloroethane	113,000	37	650	HH
1,2-Dichloropropane	--	15	31	HH
1,4-Dichlorobenzene	--	190	900	HH
Benzene	--	51	51	HH
Chlorobenzene	--	1,600	800	HH
Chloroform	--	170	2,000	HH - NRWQC
Chloromethane	--	96	96	HH
cis-1,2-Dichloroethene	--	720	720	HH
Ethylbenzene	430	25	130	Saltwater Aquatic Life
Tetrachloroethene	0.8	3.3	3.3	HH
trans-1,2-Dichloroethene	100	10,000	4,000	HH
Trichloroethene	92.4	3	30	HH
Vinyl chloride	525	2.4	2.4	HH
Metals (µg/L)				
Aluminum	--	8,000	8,000	HH
Arsenic	50	10	10	HH
Barium	1,000	1,000	1,000	Water Supply
Beryllium	0.117	6.5	6.5	Freshwater Aquatic Life
Chromium	20	24	50	Saltwater Aquatic Life
Cobalt	--	4	4	HH
Iron	--	NS	1,000	Freshwater Aquatic Life – NRWQC
Lead	25	25	8.1	Saltwater Aquatic Life
Manganese	50	NS	100	HH –NRWQC
Mercury	0.025	0.025	0.025	Saltwater Aquatic Life
Thallium	--	0.47	0.47	HH - NRWQC

Table 4-2. Site 82 Groundwater Treatment Plant Effluent Levels

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

COCs	ROD Effluent Levels (Baker, 1993)	ESD Effluent Levels (CH2M, 2017)	Current NCSWQS	Source of Current NCSWQS[a]
Vanadium	NS	NS	NS	No standard established

[a] Wallace Creek is classified as Primary Recreation, Salt Water; Nutrient Sensitive Waters (SB; NSW). The applicable NCSWQS was selected as the most stringent between saltwater aquatic life or human health criteria from the North Carolina and EPA Criteria table (June 2019). If neither standard is available, then the most stringent available standard is used.

Notes:

-- = COC identified post-ROD based on LTM exceedances of cleanup levels

µg/L = microgram per liter

COC = constituent of concern

ESD = Explanation of Significant Differences

HH = human health

LTM = long-term monitoring

NCSWQS - North Carolina Surface Water Quality Standard

NRWQC – National Recommended Water Quality Criteria (used for constituents for which NC does not have a standard)

NS = No standard established

ROD = Record of Decision

VOC = volatile organic compound

Table 4-5. OU 2 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
6	Soil	Potential unacceptable risks to current Base personnel and future residents due to exposure to pesticides and PCBs in soil.	Industrial/Vacant/ Storage	Treat or remove contaminated soil.	Soil Removal	Excavation and offsite disposal of soil [and debris] from areas of concern to meet industrial levels.	Industrial Land Use
				Prevent current and future exposure to contaminated soil.	LUCs	Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring of LUCs.	
	Groundwater	Potential unacceptable risks to current Base personnel and future residents due to exposure to VOCs and metals in groundwater.		Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.	LTM	Groundwater LTM to monitor natural attenuation of COCs. Will be continued until all groundwater COCs are at or below cleanup levels for 4 consecutive monitoring events.	UU/UE
				Prevent current and future exposure to contaminated groundwater.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
82	Soil	Potential unacceptable risks to current Base personnel and future site residents due to exposure to metals and VOCs in soil.		Treat or remove contaminated soil.	Soil Removal	Excavation and offsite disposal of soil [and debris] from areas of concern to meet industrial levels.	Industrial Land Use
					SVE	SVE to remove VOCs in soil. System operated for 6 months when soil cleanup levels were met.	
				Prevent current and future exposure to contaminated soil.	LUCs	Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring.	
	Groundwater	Potential unacceptable risks to current Base personnel and future site residents due to exposure to VOCs and metals in groundwater.	Industrial/Vacant/ Storage	Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.	Groundwater extraction and treatment system	Operate until groundwater COCs are at or below respective cleanup levels. Perform routine maintenance to mitigate the potential for exceedances of effluent levels. Monitor VOC mass removal in conjunction with LTM data to evaluate system effectiveness.	UU/UE
					LTM	Groundwater and surface water LTM to monitor treatment system performance, migration, and COC concentration trends over time until after groundwater COCs are at or below cleanup levels for four consecutive monitoring events.	
				Prevent current and future exposure to contaminated groundwater.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
UXO-22	MEC/MPPEH	Potential explosive hazard from contact with MEC/MPPEH within the Site UXO-22 boundary.		Reduce or prevent the potential for direct physical contact with MEC/MPPEH.	LUCs	Maintain industrial/non-industrial use and intrusive activities control for MEC/MPPEH and conduct quarterly monitoring.	Restricted Use

Notes:
COC = constituent of concern
LTM = long-term monitoring
LUC = land use control
MEC = munitions and explosives of concern
MPPEH = material potential presenting an explosive hazard
RAO = remedial alternative objective
SVE = soil vapor extraction
UU/UE = unlimited use/unrestricted exposure
VI = vapor intrusion
VOC = volatile organic compound

Table 4-6. Metals Concentrations in Surficial Aquifer Groundwater - Site 6
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	**Site-Specific**	IR06-GW16												IR06-GW04				
Sample Date	**Cleanup Level**	10/21/92	07/27/97	10/23/97	01/19/98	05/20/05	05/20/05	03/02/11	03/02/11	04/18/12	04/18/12	03/10/15	01/15/19	11/19/86	10/21/92	03/03/11	03/09/15	03/09/15
Chemical Name																		
Total Metals (µg/L)																		
Arsenic	10	3 U	2.5 U	10 U	10 U	1.6 U	1.6 U	NA	NA	100 U	100 U	10 U	4 U	8.4 B	3 U	NA	10 U	10 U
Barium	700	84.2 B	**36.6**	**45.3 J**	24.7 B	**27.4 J**	**27.8 J**	NA	NA	80 UJ	80 UJ	**10.2**	**20.7**	**564**	**209**	NA	**15.9**	**15.6**
Beryllium	4	0.3 U	0.3 U	5 U	5 U	NA	NA	NA	NA	3.7 U	3.7 U	0.37 U	0.2 U	1.7 B	0.58 B	NA	0.37 U	0.37 U
Chromium	16.9	**15.6 J**	**1.1**	10 U	10 U	**1.1 J**	**1.1 J**	**3 J**	**2.5 J**	30 U	30 U	**1.88 J**	4 U	**41.6**	**26.4**	**1.3 J**	**2.38 J**	**2.17 J**
Lead	15	5.9 U	**2.1**	3 U	2.3 B	**1.2 J**	**1.6 J**	**1.2 J**	**1.6 J**	6 U	6 U	**0.289 J**	**1.01**	**12**	**9.6**	**1.6 J**	**0.381 J**	**0.343 J**
Manganese	176	**67.9**	**88.2**	**124**	**63**	NA	NA	**225**	**228**	**455**	**420**	**254**	**12.7**	**73.5**	**57.3**	**5**	8.71 U	8.65 U
Mercury	1	0.05 U	0.1 U	0.2 U	0.08 B	0.1 U	0.1 U	NA	NA	0.069 UJ	0.069 UJ	0.069 U	0.1 U	0.1 U	0.07 U	NA	0.069 U	0.069 U
Vanadium	26.7	13.7 B	**1.6**	50 U	16.9 B	NA	NA	NA	NA	8 U	8 U	**4.12 J**	4.7 U	**106**	26.7 B	NA	**2.56 J**	**2.01 J**

Station ID	**Site-Specific**	IR06-GW31							IR06-MW55			IR06-MW64			IR06-MW80	
Sample Date	**Cleanup Level**	03/06/93	03/04/11	12/16/11	04/18/12	03/10/15	01/15/19	01/15/19	03/01/11	03/09/15	01/15/19	10/18/12	03/10/15	01/15/19	03/10/15	01/15/19
Chemical Name																
Total Metals (µg/L)																
Arsenic	10	**11.4**	NA	1.5 U	100 U	**1.02 J**	**4.1 J**	**3.1 J**	NA	10 U	4 U	10 U	10 U	4 U	10 U	4 U
Barium	700	51.2 B	NA	**48.3**	**33.5 J**	**36.7**	**31.8**	**29.7**	NA	**87.5**	**33.6**	**18.4**	**10.5**	**17.9**	**62.9**	**132**
Beryllium	4	1 U	NA	0.5 U	3.7 U	0.37 U	0.2 U	0.2 U	NA	0.37 U	0.2 U	0.37 U	0.37 U	0.2 U	0.37 U	0.2 U
Chromium	16.9	6 U	**0.66 J**	1 U	30 U	3 U	4 U	4 U	**2.8 J**	**1.82 J**	4 U	**9.94**	**6.53**	4.36 U	**1.61 J**	4 U
Lead	15	2.4 U	4 U	0.75 U	6 U	0.6 U	0.5 U	0.5 U	4 U	**0.177 J**	**0.68 J**	**0.207 J**	**0.362 J**	**0.6 J**	0.6 U	**0.24 J**
Manganese	176	**126**	**108**	**17.1**	**13.9 J**	**339**	**568**	**422**	**1,010**	**872**	**49.9**	**170**	**65.3**	**79.5**	**239**	**922**
Mercury	1	0.12 U	NA	0.2 U	0.069 UJ	0.069 U	0.1 U	0.1 U	NA	0.069 U	0.1 U	0.069 U	0.069 U	0.1 U	0.069 U	0.1 U
Vanadium	26.7	14 B	NA	2.5 U	8 U	**0.819 J**	4 U	4 U	NA	**3.68 J**	5.04 U	**0.739 J**	**1.91 J**	4 U	**2.1 J**	4 U

Notes:
Shading indicates the result exceeded Site Specific screening criteria
Bold indicates detections
NA - Not analyzed
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/L - Micrograms per liter

Table 4-7. Metals Concentrations in Surficial Aquifer Groundwater - Site 82
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	Site-Specific	IR06-82MW02								IR06-82MW03							
Sample Date	Cleanup Level	10/24/92	07/27/97	10/25/97	01/17/98	04/18/98	04/20/12	03/12/15	01/23/19	10/23/92	07/23/97	10/28/97	01/17/98	04/15/98	04/19/12	03/12/15	01/23/19
Chemical Name																	
Total Metals (µg/L)																	
Arsenic	10	3 B	2.5 U	10 U	10 B	10 U	10 U	10 U	4 U	**24.4**	2.5 U	**2.5 J**	10 U	10 U	10 U	10 U	4 U
Barium	700	74.6 B	**36.3**	**33.4 J**	40.4 U	30.5 B	**10.3**	**65.1 J**	**46.5**	**540**	**66.3**	**69.3 J**	55.6 B	41.5 B	**48.6**	**29.3 J**	**24.6**
Beryllium	4	0.3 U	0.3 U	5 U	5 U	5 U	0.37 U	0.37 U	**0.05 J**	2.6 B	**0.58**	**0.78 J**	0.99 B	5 U	**1.05**	**0.114 J**	**0.074 J**
Chromium	16.9	**15.4**	**1**	10 U	6.2 B	3.3 B	3 U	**1.44 J**	4 U	**174**	0.7 U	10 U	10 U	10 U	3 U	3 U	4 U
Lead	15	**10.4**	1.5 U	**1.7 J**	3 U	3 U	0.6 U	0.6 U	**0.14 J**	**88.9**	1.5 U	**1.5 J**	1.4 B	1.7 B	**2.6**	**0.49 J**	**0.66 J**
Manganese	176	**55**	**46.7**	**58.4**	**63.8**	**50.4**	**5.5**	**70.5**	**112**	**160**	**122**	**116**	**87**	**53.6**	**91.5**	**17**	**9.02**
Mercury	1	**0.66**	0.1 U	0.2 U	0.07 B	0.2 U	0.069 U	0.069 U	**0.053 J**	**0.27**	0.1 U	0.2 U	0.08 B	0.2 U	0.069 U	0.069 U	0.1 U
Vanadium	26.7	19.6 B	0.8 U	**13.5 J**	26.5 B	20.8 B	0.8 U	**1.6**	**2 J**	**215**	0.8 U	50 U	11.1 B	7.4 B	0.8 U	0.8 U	4 U

Station ID	Site-Specific	IR06-GW28									IR06-GW30						
Sample Date	Cleanup Level	10/23/92	03/18/93	07/25/97	10/26/97	01/16/98	04/18/98	04/19/12	03/11/15	01/24/19	10/23/92	07/24/97	10/25/97	01/17/98	04/18/98	03/11/15	01/23/19
Chemical Name																	
Total Metals (µg/L)																	
Arsenic	10	3 U	2.3 U	2.5 U	10 U	10 U	10 U	10 U	10 U	4 U	5.6 B	2.5 U	10 U	10 U	10 U	10 U	4 U
Barium	700	26.2 BJ	80.8 B	**17.4**	**23.8 J**	20.3 B	32.6 B	**26.9**	**26.2 J**	**35.4**	48.6 B	**7.6**	**12.8 J**	7.7 B	7.6 B	**16.6 J**	**7.55**
Beryllium	4	0.3 U	1 U	0.3 U	5 U	5 U	5 U	0.37 U	0.37 U	**0.064 J**	2.2 B	0.3 U	**0.51 J**	5 U	5 U	**0.405 J**	**0.22 J**
Chromium	16.9	3.6 U	**18.4**	0.7 U	10 U	10 U	10 U	3 U	3 U	4 U	24.2 U	0.7 U	10 U	10 U	10 U	**1.56 J**	4 U
Lead	15	1.8 B	2.3 B	**1.6**	**6.2**	3 U	3 U	0.6 U	0.6 U	0.5 U	**4.1**	1.5 U	3 U	3 U	3 U	0.6 U	0.5 U
Manganese	176	**26.9**	12.9 B	**8.2**	**11.4 J**	9.9 B	2.9 B	**6.54**	2.05 U	2.1 U	**44**	**21.8**	**24.4**	**27.2**	**18.2**	**19.9**	**23.4**
Mercury	1	0.05 U	0.17 UJ	0.1 U	0.2 U	0.09 B	0.2 U	0.069 U	0.069 U	0.1 U	0.05 U	0.1 U	0.2 U	0.08 B	0.2 U	0.069 U	0.1 U
Vanadium	26.7	1.8 UJ	15.8 B	0.8 U	50 U	12.4 B	50 U	0.8 U	0.8 U	4 U	14.6 B	0.8 U	**6.4 J**	15.7 B	6.6 B	**0.232 J**	4 U

Station ID	Site-Specific	IR06-GW32									IR82-MW07		IR82-MW04			IR06-GW41	
Sample Date	Cleanup Level	03/06/93	03/18/93	07/27/97	10/26/97	01/16/98	04/16/98	04/19/12	03/10/15	01/23/19	03/10/15	01/23/19	03/10/15	01/23/19	01/23/19	03/12/15	01/22/19
Chemical Name																	
Total Metals (µg/L)																	
Arsenic	10	**24**	**24**	2.5 U	10 U	10 U	10 U	**0.664 J**	10 U	4 U	10 U	4 U	10 U	4 U	4 U	10 U	4 U
Barium	700	**796**	**796**	**18.5**	**17.3 J**	23 B	21.7 B	**21.4**	**25.2 J**	**25**	**9.34 J**	**8.96**	**11.9 J**	**12.7**	**12.2**	**65 J**	**36.3**
Beryllium	4	**54.1**	**54.1**	0.3 U	5 U	5 U	5 U	**0.462 J**	**0.315 J**	**0.23 J**	**0.0981 J**	**0.066 J**	0.37 U	0.2 U	0.2 U	0.37 U	**0.069 J**
Chromium	16.9	**385**	**385**	0.7 U	10 U	10 U	10 U	**1.01 J**	**0.908 J**	4 U	**1.48 J**	4 U	3 U	4 U	4 U	**0.924 J**	4 U
Lead	15	**18.8**	**18.8**	**11.4**	3 U	3 U	3 U	**0.333 J**	0.6 U	**0.13 J**	0.6 U	0.5 U	0.6 U	0.5 U	0.5 U	0.6 U	**0.35 J**
Manganese	176	**1,170**	**1,170**	**6**	**8.7 J**	5.7 B	5 B	**8.65**	**12.7**	**6.84**	**6.74**	**6.5**	**32.1**	**37.9**	**35.7**	33.4 U	**7.98**
Mercury	1	0.33 U	0.33 U	0.1 U	0.2 U	0.08 B	0.2 U	0.069 U	0.069 U	0.1 U	0.069 U	0.1 U	0.069 U	0.1 U	0.1 U	0.069 U	0.1 U
Vanadium	26.7	**305**	**305**	**0.84**	50 U	9.8 B	50 U	**1.29**	**0.342 J**	**0.8 J**	**0.6 J**	4 U	0.8 U	4 U	4 U	**0.263 J**	4 U

Table 4-7. Metals Concentrations in Surficial Aquifer Groundwater - Site 82

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Station ID	**Site-Specific**	IR06-GW01								IR82-MW13			IR06-GW42			IR06-GW33	
Sample Date	**Cleanup Level**	10/24/92	07/26/97	10/24/97	01/15/98	04/16/98	04/18/12	03/11/15	01/23/19	10/18/12	03/12/15	01/22/19	04/18/12	03/12/15	01/23/19	03/06/93	03/18/93
Chemical Name																	
Total Metals (µg/L)																	
Arsenic	10	**11.2**	2.5 U	10 U	10 U	10 U	10 U	10 U	4 U	**0.846 J**	**2.52 J**	4 U	10 U	10 U	4 U	8.8 B	8.8 B
Barium	700	161 B	**22.1**	**23.9 J**	45.4 B	29.4 B	**11.4**	**16.3 J**	**19.8**	**97**	**89.4 J**	**77.7**	**100**	**77.7 J**	**62**	**484**	**484**
Beryllium	4	1.9 UJ	0.3 U	5 U	5 U	5 U	0.37 U	0.37 U	0.2 U	**0.392 J**	**0.995**	**1.14**	**0.58 J**	**0.55 J**	**0.39 J**	3.4 B	3.4 B
Chromium	16.9	**175**	0.7 U	10 U	5.9 B	4.6 B	**0.512 J**	**0.526 J**	4 U	3 U	**0.803 J**	4 U	3 U	3 U	4 U	**139**	**139**
Lead	15	**37.8**	1.5 U	**2.2 J**	3 U	3 U	0.6 U	0.6 U	0.5 U	0.6 U	0.6 U	0.5 U	**0.5 J**	**0.391 J**	**0.36 J**	**57.2**	**57.2**
Manganese	176	**49.9**	**3.6**	**4.4 J**	1.5 B	15 U	**1.25 J**	1.28 U	1.2 U	**202**	**313**	**254**	**33.4**	36.8 U	**20.7**	**31.8**	**31.8**
Mercury	1	0.17 B	0.1 U	0.2 U	0.07 B	0.2 U	0.069 U	0.069 U	0.1 U	0.069 U	0.069 U	0.1 U	0.069 U	0.069 U	0.1 U	**0.59**	**0.59**
Vanadium	26.7	**330**	**0.94**	**6.4 J**	24.7 B	18.7 B	**0.62 J**	**0.583 J**	**1.1 J**	**1.04**	**0.418 J**	**0.79 J**	**0.365 J**	0.8 U	4 U	**96.6**	**96.6**

Station ID	**Site-Specific**	IR06-GW33 (continued)							IR06-GW34								
Sample Date	**Cleanup Level**	07/27/97	10/24/97	01/16/98	04/15/98	04/18/12	03/12/15	01/22/19	03/06/93	03/18/93	07/24/97	10/24/97	01/16/98	04/16/98	10/17/12	03/12/15	01/22/19
Chemical Name																	
Total Metals (µg/L)																	
Arsenic	10	2.5 U	10 U	10 U	10 U	10 U	10 U	4 U	**15.6**	**15.6**	2.5 U	10 U	10 U	10 U	10 U	10 U	4 U
Barium	700	**73.6**	**80.1 J**	61.1 B	36.3 B	**50.8**	**35.1 J**	**35.2**	**311**	**311**	**77.6**	**97.9 J**	96.8 B	99.3 B	**72.7**	**57.2 J**	**50.8**
Beryllium	4	0.3 U	5 U	5 U	5 U	0.37 U	0.37 U	**0.057 J**	2.8 B	2.8 B	0.3 U	**0.42 J**	5 U	5 U	**0.343 J**	**0.225 J**	**0.13 J**
Chromium	16.9	0.7 U	10 U	10 U	10 U	**0.659 J**	**0.662 J**	4 U	**259**	**259**	0.7 U	10 U	10 U	10 U	3 U	3 U	4 U
Lead	15	1.5 U	3 U	3 U	3 U	0.6 U	0.6 U	**0.55 J**	**41.9**	**41.9**	**4.2**	**4.6**	3 U	1.2 B	**0.26 J**	**0.167 J**	**0.26 J**
Manganese	176	**8.7**	**10.9 J**	10.6 B	8.1 B	**6.25**	2.43 U	3.88 U	**171**	**171**	**20.7**	**30.8**	**37.2**	**31.5**	**30.4**	**7.38**	3.6 U
Mercury	1	0.1 U	0.2 U	0.08 B	0.2 U	0.069 U	0.069 U	0.1 U	0.42 U	0.42 U	0.1 U	0.2 U	0.18 B	0.2 U	0.069 U	0.069 U	0.1 U
Vanadium	26.7	0.8 U	50 U	10.6 B	50 U	**0.867 J**	**0.664 J**	4 U	**316**	**316**	0.8 U	50 U	11.5 B	50 U	0.8 U	0.8 U	4 U

Notes:

Shading indicates the result exceeded Site Specific screening criteria

Bold indicates detections

NA - Not analyzed

B - Analyte not detected above the level reported in blanks

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

µg/L - Micrograms per liter

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Legend

Monitoring Wells
- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Lower Castle Hayne Aquifer

Recovery Wells
- Surficial Aquifer
- Surficial/Upper Castle Hayne Aquifer
- Upper Castle Hayne Aquifer
- Lower Castle Hayne Aquifer

- Site Boundary
- Approximate Location of Soil Vapor Extraction System
- ERD Pilot Study Area
- Source Removal Trenches (OHM, 1997)
- TCRA Excavation Area (CH2M HILL, 2011)
- AOC Boundary (Baker, 1993a)
- Ephemeral Drainage Feature
- Stream

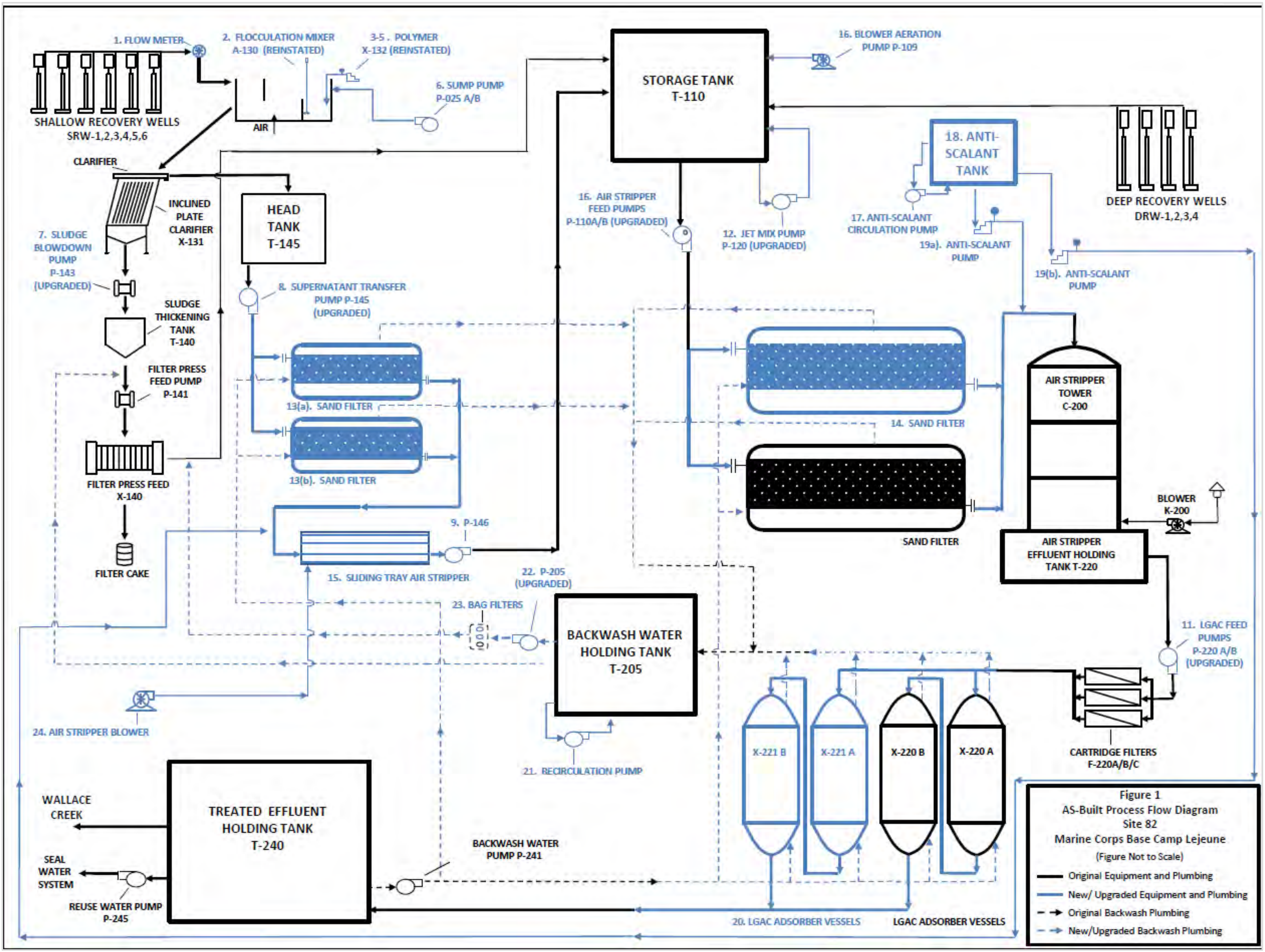
N

0 300 600 1,200 Feet

1 inch = 600 feet

Figure 4-1
OU 2 (Sites 6, 9, 82, and UXO-22)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:



Process flow diagram from Meadows CPMG showing conditions current as of June 2018. Deep recovery wells IR82-DRW05 and IR82-DRW06 were installed in 2019 and enter the system with Shallow Recovery Wells at (2) Flocculation Mixer A.130.

Figure 4-2
GWTP Process Flow Diagram – Site 82
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

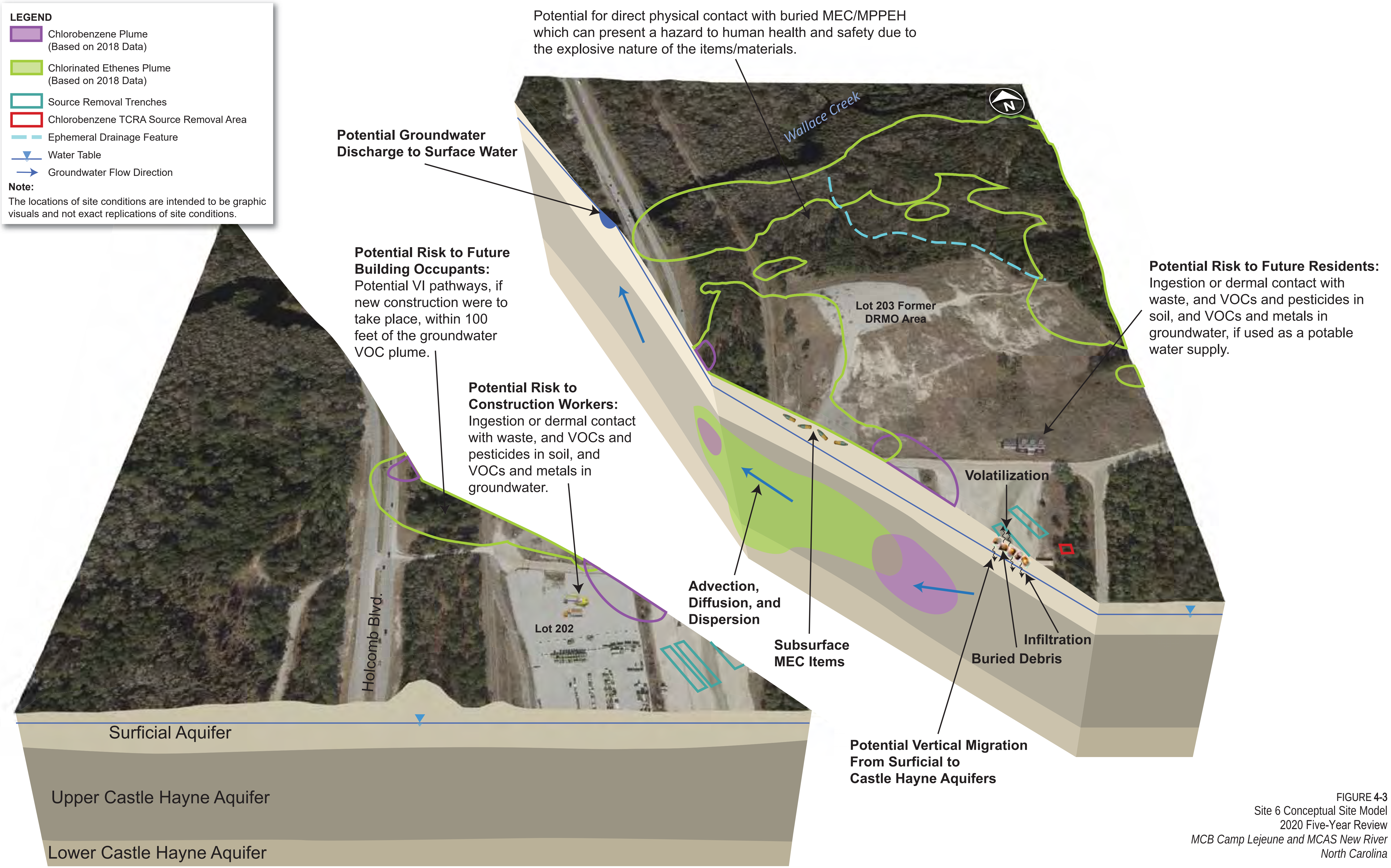


FIGURE 4-3
Site 6 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.

BI0613180714WDC MCB_CamLej_Site_6_CSM_v8.ai 8-13-19 tdaus

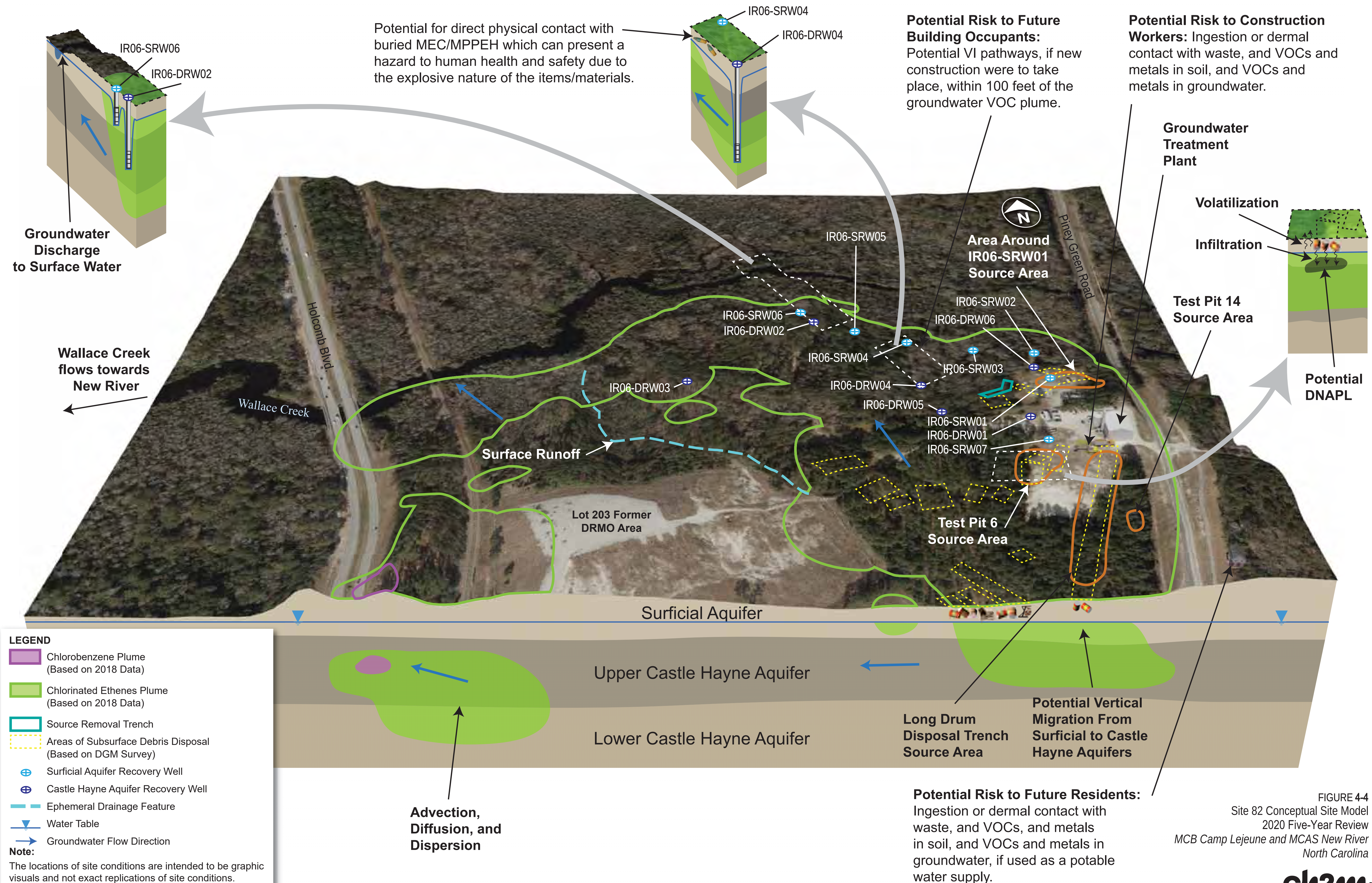


FIGURE 4-4
Site 82 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

BI0613180714WDC MCB_CamLej_Site_82_CSM_v8.ai 8-13-19 tdaus

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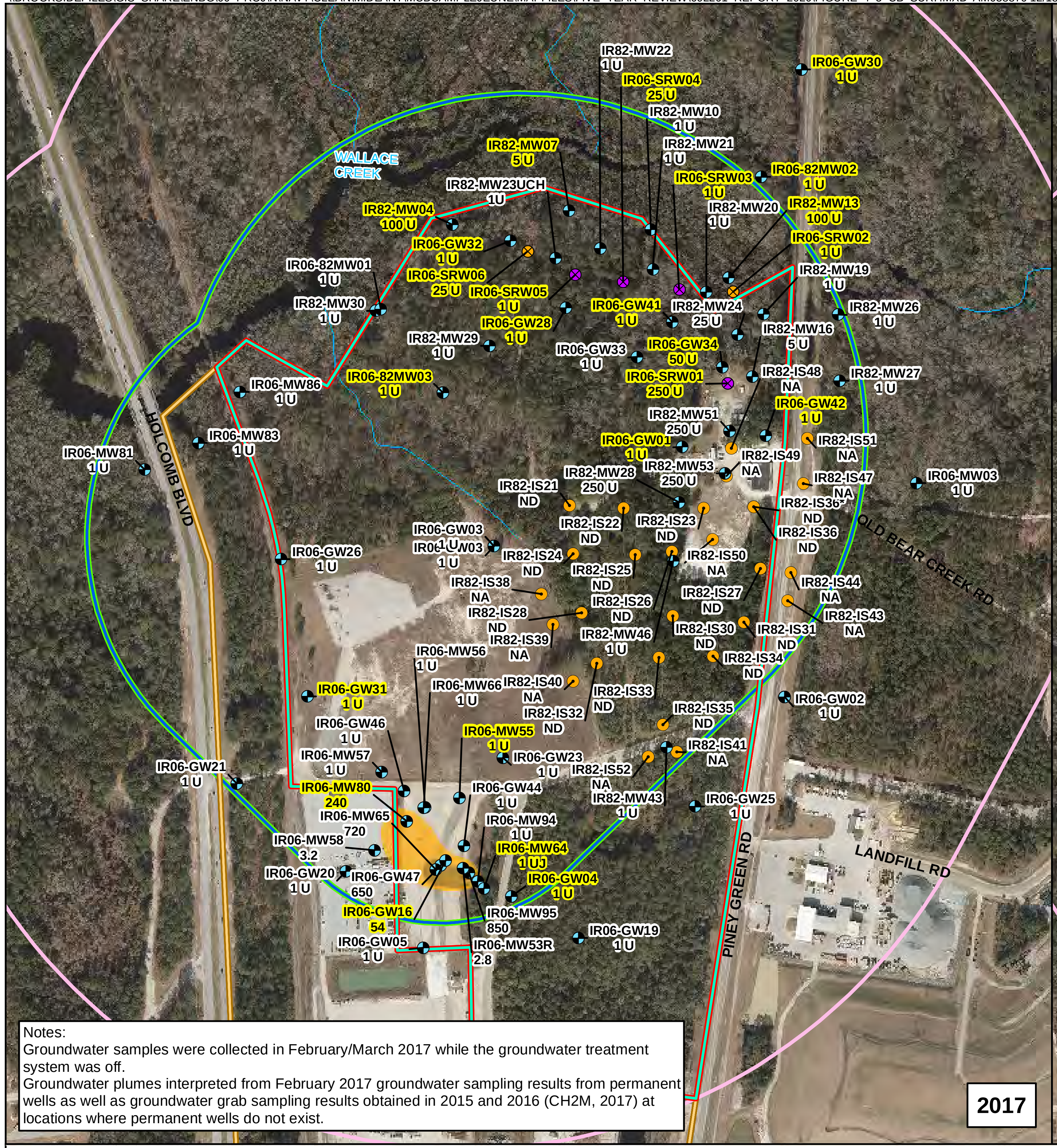
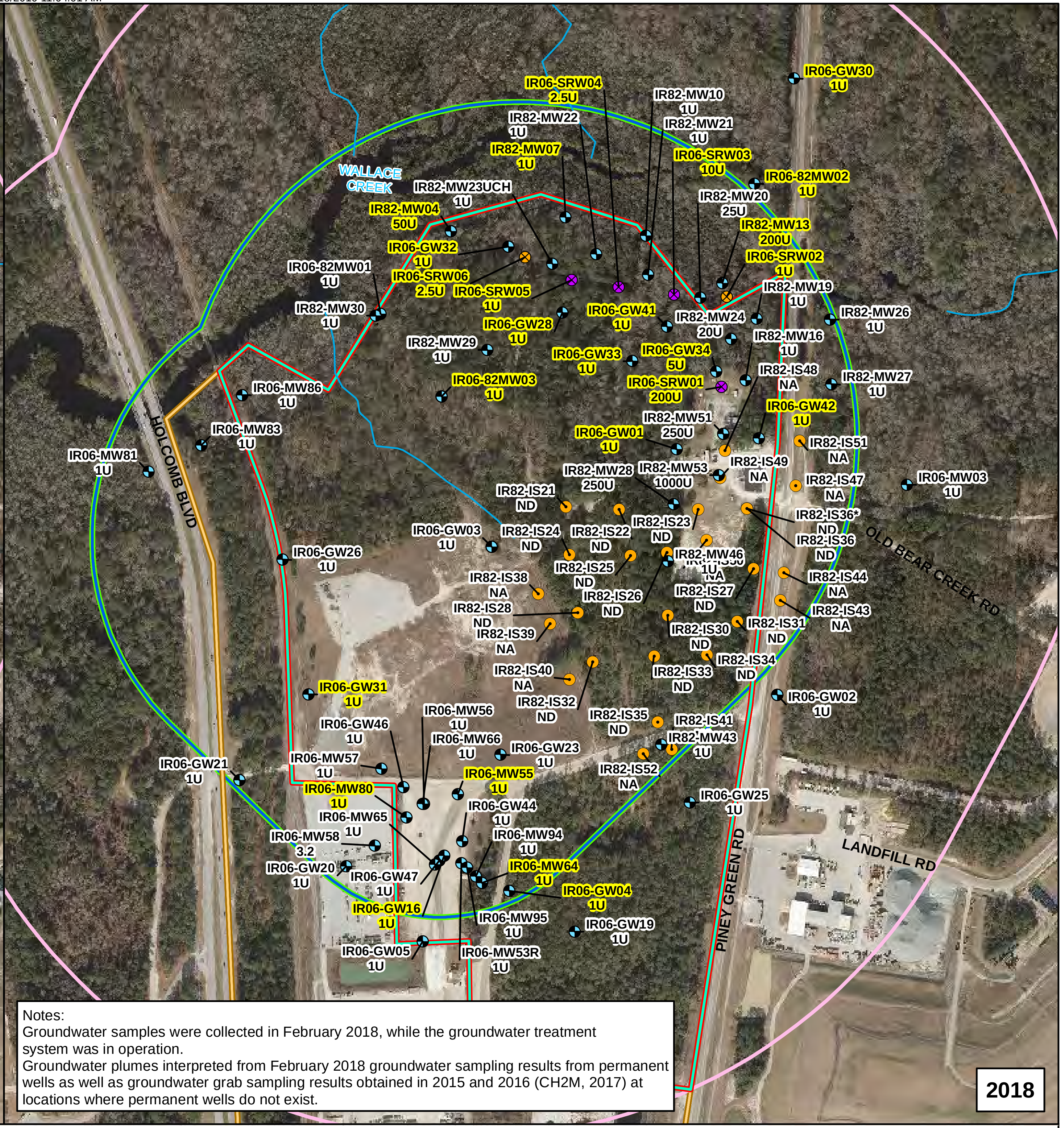


Notes:
Groundwater samples were collected in February/March 2017 while the groundwater treatment system was off.
Groundwater plumes interpreted from February 2017 groundwater sampling results from permanent wells as well as groundwater grab sampling results obtained in 2015 and 2016 (CH2M, 2017) at locations where permanent wells do not exist.

2017



Notes:
Groundwater samples were collected in February 2018, while the groundwater treatment system was in operation.
Groundwater plumes interpreted from February 2018 groundwater sampling results from permanent wells as well as groundwater grab sampling results obtained in 2015 and 2016 (CH2M, 2017) at locations where permanent wells do not exist.

2018

Legend
- Surficial Aquifer Monitoring Well
- Surficial Aquifer Recovery Well
- Surficial/Upper Castle Hayne Aquifer Monitoring Well
- DPT Groundwater Grab Sample (CH2M, 2017)

Extent of Chlorobenzene in Groundwater
NCGWQS = 50 µg/L
- 50-500
- 500-5,000

LUCs
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activites Control Boundary (Soil)
- Intrusive Activites Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (MEC/MPPEH)
- Intrusive Activities Control Boundary (MEC/MPPEH)

Note:
* Shallower sample from 12-16 ft bgs
ND - Not detected
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/l - Micrograms per liter
Highlighted wells are in LTM.

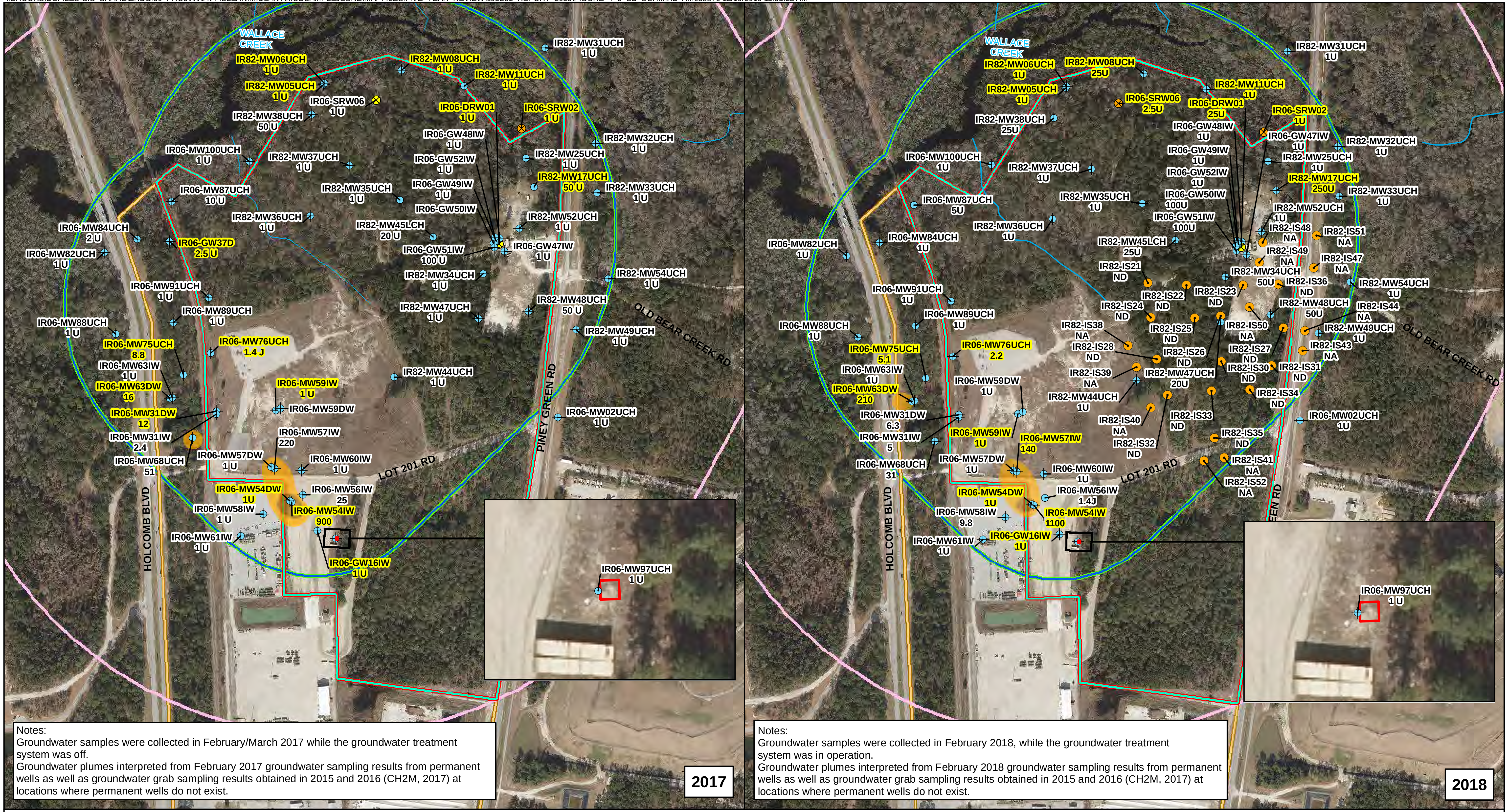
N

0 250 500
Feet

1 inch = 500 feet

Figure 4-5
Extent of Chlorobenzene in Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:



Legend

- Upper Castle Hayne Aquifer Monitoring Well
- Surficial/Upper Castle Hayne Aquifer Recovery Well
- Upper Castle Hayne Aquifer Recovery Well
- DPT Groundwater Grab Sample (CH2M, 2017)
- TCRA Boundary

Extent of Chlorobenzene in Groundwater

NCGWQS = 50 µg/L

- 50-500 µg/L
- 500-5000 µg/L

LUCs

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activites Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (MEC/MPPEH)
- Intrusive Activities Control Boundary (MEC/MPPEH)

Note:
ND - Not detected
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/l - Micrograms per liter
Highlighted wells are in LTM.

N

0 250 500 Feet

1 inch = 500 feet

Figure 4-6
Extent of Chlorobenzene in UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

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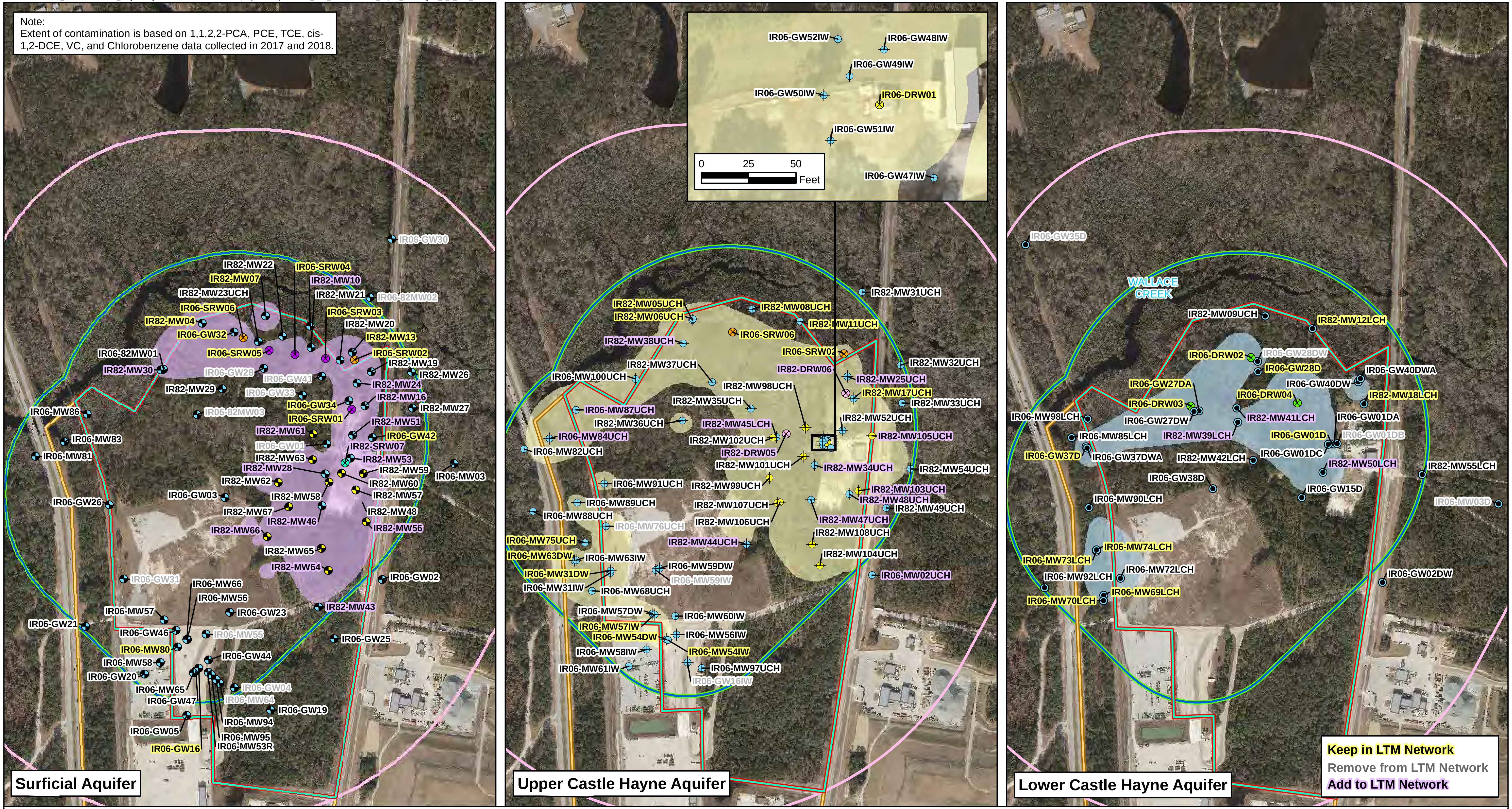

Legend

- Surficial Aquifer Monitoring Well
- Upper Castle Hayne Aquifer Monitoring Well
- Lower Castle Hayne Aquifer Monitoring Well
- Surficial Aquifer Recovery Well
- Surficial/Upper Castle Hayne Aquifer Recovery Well
- Upper Castle Hayne Aquifer Recovery Well
- Lower Castle Hayne Aquifer Recovery Well
- Newly Installed Surficial Aquifer Recovery Well
- Newly Installed Upper Castle Hayne Aquifer Recovery Well
- Proposed Surficial Aquifer Monitoring Well
- Proposed Upper Castle Hayne Aquifer Monitoring Well
- Extent of Contaminants in Surficial Aquifer
- Extent of Contaminants in UCH Aquifer
- Extent of Contaminants in LCH Aquifer

LUCs

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary
- Intrusive Activites Control Boundary (Soil)
- Intrusive Activites Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (MEC/MPPEH)
- Intrusive Activities Control Boundary (MEC/MPPEH)

N

0 325 650
Feet
1 inch = 650 feet

Figure 4-7
LTM Recommendations
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\N\NAVY\CLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\FIVE_YEAR_REVIEW\692261_REPORT_2020\FIGURE_4_8_SITE_82_PCA_AND_PCE_SOURCE_AREAS.MXD AM038876 12/16/2019 11:02:57 AM

Legend

- Historical Soil Sample Location
- MIP Boring Location
- MIP Boring Location/Soil Sample Location
- Soil Sample Location
- Test Pit Location
- Test Pit/Soil Sample Location
- Test Pit Sample Location (Rhea, 2011)
- As-Dug Test Pit Location (Rhea, 2011)
- Ephemeral Drainage Feature
- DGM anomaly investigated by GPR
- PCA in soil exceeds the PSRG by one to two orders of magnitude
- PCE in soil exceeds the PSRG by one to two orders of magnitude
- Source Area

N

0 80 160 Feet

1 inch = 160 feet

Figure 4-8
Site 82 PCA and PCE Source Areas
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

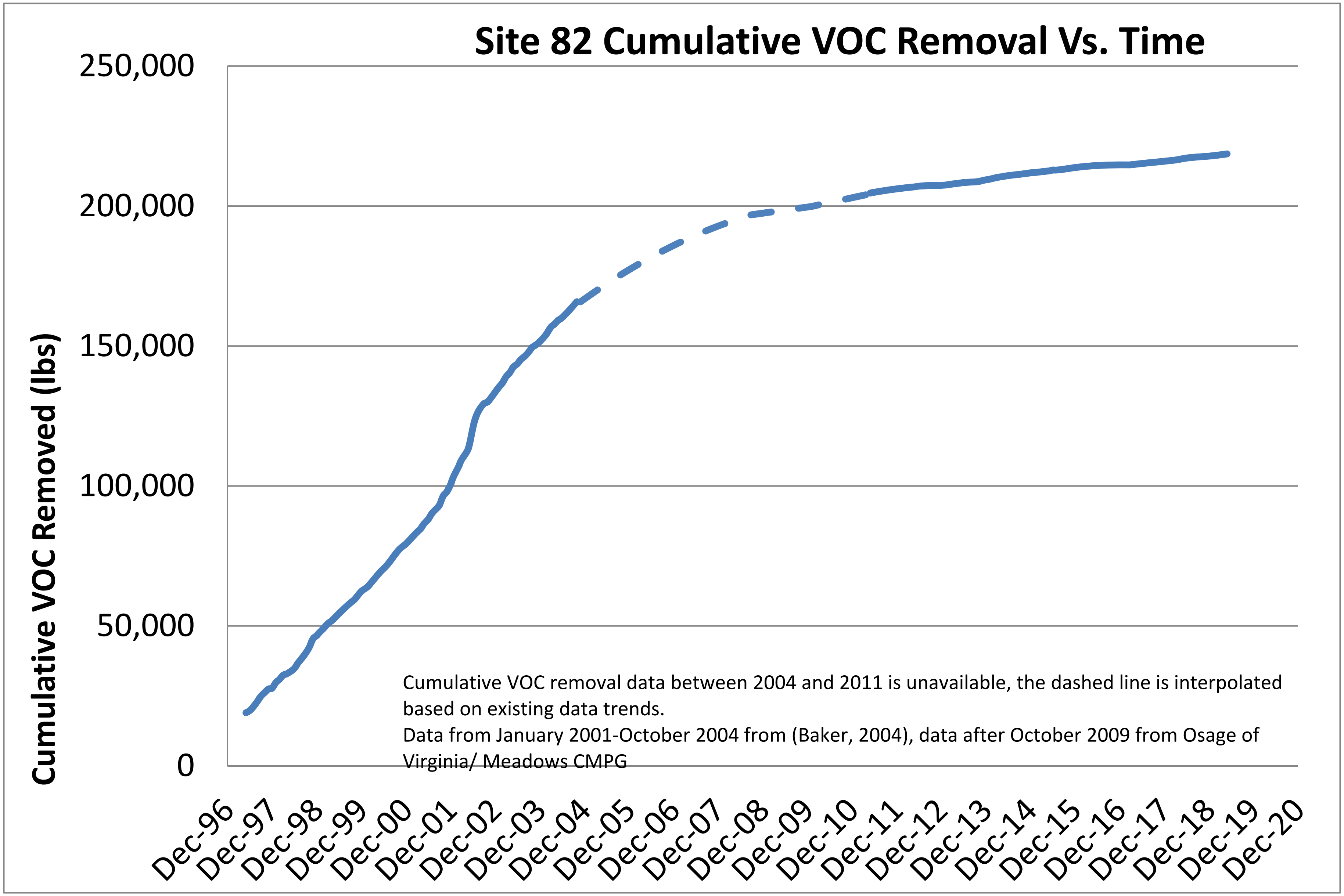

Figure 4-9
Cumulative VOC Removal Site 82 Groundwater Treatment Plant
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Operable Unit 4 (Sites 41 and 74)

5.1 Site History and Background

OU 4 is within the Mainside area of the Base and the MCAS New River (**Figure 1-2**). OU 4 consists of two sites (Sites 41 and 74) that have been grouped together based on the unique characteristic of suspected waste (chemical agent).

OU 4 Timeline	
Year	**Event**
1983	IAS (Sites 41 and 74)
1984-1990	Confirmation Study (Sites 41 and 74)
1993-1995	RI/FS (Sites 41 and 74)
1995	PRAP and ROD (Sites 41 and 74)
1997-1998	LTM (Site 74)
1997-2004	LTM (Site 41)
2001	RIP (LUCs) (Sites 41 and 74)
2002	LUCs Updated (Sites 41 and 74)
2006	Closeout Report (Sites 41 and 74)
2012-2013	Henderson and Hickory Ponds Investigation
2019	Basewide PFAS PA (Sites 41 and 74)

Site 41 — The Camp Geiger Dump near Former Trailer Park covers approximately 37 acres (**Figure 5-1**). Site 41 was used as a dump from 1946 to 1970. Construction debris, petroleum, oil, and lubricant (POL) compounds, solvents, batteries, ordnance, chemical training agents, and, in 1964, mirex (a pesticide), were reportedly disposed of at Site 41. The debris was reportedly burned and graded over with soil. The dump area contains an estimated 110,000 cubic yards of waste. The amount of solvents and oil disposed of was estimated to be between 10,000 and 15,000 gallons; and the quantity of mirex was estimated at several tons.

Site 74 — The Mess Hall Grease Dump covers approximately 24 acres (**Figure 5-2**). Site 74 was used from the early 1950s through the early 1960s. Grease from the mess hall at Site 74 was reportedly disposed of in trenches. It was also reported that drums containing PCBs and pesticide-soaked bags were buried near the grease pit. Estimates of quantities include 1,100 gallons of PCB oil, 50 to 500 gallons of DDT, and 2,200 gallons of drummed pesticides. One internal memorandum reports chemical agents in the form of test kits were reportedly disposed of at Site 74. A former Pest Control Area was also reportedly located in the southeastern portion of the site.

5.2 Site Characterization

The findings from various investigations at OU 4 that are pertinent to the FYR are summarized in this section.

5.2.1 Physical Characteristics

- **Surface Features –** Both sites within OU 4 are densely vegetated.

  Site 41 is located on a hill and construction and demolition debris is present on the ground surface. Site surface water drains to Tank Creek to the south and an unnamed tributary to the north. Two seeps are located along the northern and eastern boundaries of the disposal area.

  Site 74 is primarily flat. Surface water drains toward Henderson and Hickory Ponds, located approximately one quarter mile to the south/southeast of the site.

- **Geology and Hydrogeology –** OU 4 is underlain by silty sand with discontinuous layers of sand, clayey sand, sandy clay, silt, and clay. The upper unit of the Castle Hayne aquifer, consisting of shelly sand, was encountered beneath the silty sands. Surficial aquifer groundwater flows south-southeast at Site 41 (**Figure 5-1**) and east-northeast at Site 74 (**Figure 5-2**).

5.2.2 Land Use

- **Current Land Use –** Both sites are currently not in use and access is restricted by chain-link perimeter fencing. An access road leading to the Henderson Pond recreation area with fencing along each side runs through the center of Site 74.
- **Future Land Use –** There are no anticipated changes in land use.

5.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 4. Details are located in the RI report (Baker, 1995a) and the ROD (Baker, 1995d).

Site 41

Soil, groundwater, surface water, seeps, sediment, and buried waste was investigated. The HHRA evaluated current military personnel, and potential future adult and child resident and construction worker scenarios. Unacceptable risk to potential future adult and child residents was identified from consumption of metals in groundwater. Unacceptable risk to future construction workers or residents was presumed from exposure to landfill debris and soil, particularly from the suspected presence of chemical agent and the possibility of UXO if the ordnance burned at the site was not fully destroyed. The ERA evaluated aquatic and terrestrial habitats and concluded that, although metals were identified in seeps at concentrations above applicable screening levels, the overall potential adverse impacts to ecological receptors was low due to the absence of critical habitats and low levels of contaminants. Despite the ERA conclusions, the North Carolina Department of Environmental Health and Natural Resources (now NCDEQ) expressed concerns about elevated metals in surface water and shallow groundwater discharging to surface water.

Site 74

Soil, groundwater, and buried waste was investigated. The HHRA evaluated current military personnel, and potential future adult and child resident and construction worker scenarios. Unacceptable risk to potential future adult and child residents was identified from consumption of metals in groundwater. Unacceptable risk to future construction workers or residents was presumed from exposure to landfill debris and soil, particularly from the suspected presence of chemical agent.

5.3 Remedial Action Objectives

The ROD for OU 4 was signed in December 1995 with the following RAOs:

Site 41

- Prevent future potential exposure to contaminated groundwater.
- Protect ecological receptors from future potential exposure to contaminated surface water.
- Prevent future potential exposure to buried contaminated soil and waste.

Site 74

- Prevent future potential use of the shallow groundwater.
- Prevent future potential exposure to buried contaminated soil and waste.

The COCs and cleanup levels for OU 4 groundwater, applicable for Site 41, are presented in **Table 5-1**. No cleanup levels were selected for Site 74.

5.4 Remedial Actions

The RA for OU 4 includes the following major components:

Site 41

- Surface water and sediment sampling program to track contaminant migration.

Site 41 and 74

- Groundwater sampling program to assess trends in COC concentrations.
- LUCs to prevent exposure to contaminated groundwater, soil, and waste.

5.4.1 Remedy Implementation

The groundwater (Sites 41 and 74) and surface water and sediment sampling (Site 41) programs were initiated at OU 4 in 1997 as described in the following section. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring, from the surficial aquifer within 500 feet of the estimated impacted groundwater extent.
- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use within the extent of the estimated impacted soil/waste, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.
- **Intrusive Activities Control (Soil):** Restrict intrusive activities within the vicinity of the estimated impacted soil/waste extent.
- **Intrusive Activities Control (Groundwater):** Restrict intrusive activities within the vicinity of the estimated impacted groundwater.

5.4.2 Remedy Operation and Maintenance

Long-term Monitoring

In 1997, the groundwater, surface water, and sediment sampling program at Site 41 was initiated and included semi-annual sampling of five monitoring wells and eight surface water and sediment locations for VOCs, metals, TDS, and TSS analysis. In 2004, groundwater samples were collected for explosives residues, chemical agent constituents, and breakdown products, and there were no detections. In 2005, LTM was discontinued at Site 41 because the groundwater cleanup levels (**Table 5-1**) were achieved and surface water and sediment data indicated that site COCs were not migrating offsite. No cleanup levels were established for surface water and sediment. However, VOCs were not detected in surface water or sediment during LTM and metals did not exceed comparison criteria during the later rounds of LTM (CH2M, 2006).

In 1997, the LTM Program at Site 74 was initiated and included semi-annual sampling of four monitoring wells metals analysis. In 1998, LTM at Site 74 was discontinued because detected metal concentrations were indicative of naturally occurring metals in the presence of acidic soils (CH2M/Baker, 2001).

Land Use Controls

The LUCs are shown on **Figures 5-1** and **5-2** and summarized in **Table 5-2**. While not specified as part of the remedy in the ROD, access controls in the form of fencing and “Keep Out” signs around Site 41 were installed in 1996. Fencing was in place at Site 74 before the ROD. Additional fencing was installed around the perimeter of Site 74 in 2008 and again in 2011 to restrict access. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In October 2018, a post-hurricane inspection was completed and damage to the fence around each site from fallen trees was observed. Between November 2018 and March 2019, repairs were made to the fence at Site 74. Because Site 41 is remote and access to the Hicks Run Road is restricted, repairs to the fence were not completed.

During the FYR site inspections, completed in March 2019, one area of damage to the fence at Site 74 and minor damage to fencing around Site 41 was observed. Several lengths of fence at Site 74 were newly repaired, particularly along access roads. In addition, at Site 74, a gate accessing the dirt road bisecting the northern portion of the site was found to be open and unlocked; inner fencing was intact along the road with some vegetation beginning to encroach (**Appendix B**).

Table 5-2. OU 4 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Site 41			
Aquifer Use Control Boundary (500 feet)	86.44	July 2002	February 15, 2002
Non-Industrial Use Control Boundary (Soil)	36.63		
Intrusive Activities Control Boundary (Soil)	36.63		
Intrusive Activities Control Boundary (Groundwater)	16.47		
Access Control Boundary	30	Not applicable	Not applicable
Site 74			
Aquifer Use Control Boundary (500 feet)	71.27	July 2002	February 15, 2002
Non-Industrial Use Control Boundary (Soil)	23.81		
Intrusive Activities Control Boundary (Soil)	23.81		
Intrusive Activities Control Boundary (Groundwater)	13.93		
Access Control Boundary	20.5	Not applicable	Not applicable

5.4.3 Progress Since the 2015 Five-Year Review

No issues were identified for OU 4 during the 2015 FYR. LUCs continue to be monitored to ensure they remain properly implemented, and no deficiencies or inconsistent uses were observed. The current status of OU 4 RA components and expected outcomes are summarized in **Table 5-3**.

5.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. LUCs remain in place to prohibit non-industrial land use, restrict unauthorized intrusive activities, and restrict aquifer use. Although damage to fencing at each site was noted during the inspection, access continues to be restricted by chain-link perimeter fencing.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. While the exposure pathways and RAOs are still valid, toxicity data and standards that cleanup levels are based on have changed since the ROD. These changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to buried materials and/or groundwater.

Toxicity and Other Contaminant Characteristics: There have been some changes to toxicity criteria for COCs since the HHRA was conducted and the ROD was signed however, there have been no changes since the last FYR which concluded that the remedy at OU 4 was protective of human health and the environment (**Table 2-1**).

Cleanup Levels: The cleanup levels for groundwater were identified as the more conservative of the NCGWQS and MCL. Since the ROD was signed, the standards for arsenic, cadmium, and chromium have been updated to more conservative values as listed in **Table 5-1**. LTM had been discontinued previously as documented in the closeout report (CH2M, 2006). The maximum concentrations of arsenic, cadmium, and chromium for Site 41 listed in the closeout report (CH2M, 2006) were 8.6, 0.55, and 2 µg/L, respectively, which are below the updated standards (10 µg/L for arsenic and chromium, and 2 µg/L for cadmium).

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 4 remedy with respect to extreme weather events, primarily hurricanes, was completed. Damage to the Site 41 fencing is in a remote area, so potential exposure is less likely to occur. However, Site 74 is located within an area used frequently for recreational purposes, so missing or downed fencing may allow site access and subsequent exposure. With respect to flooding damage, if the creek that runs through Site 41 overflows during significant rainfall events, buried debris may be exposed. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

5.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 4 during this FYR.

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Site 41 was evaluated in the Basewide PFAS PA as a potential PFAS release area based on its designation as a chemical dump site/waste disposal area. The site received industrial wastes and munitions, including two reported instances when a fire truck was present during dumping. While there are no documented releases of AFFF, based on presence of the fire truck and timeframe of use (1946 to 1970) overlapping with use of AFFF starting in 1960, there is potential for PFAS-containing materials to have been used or disposed of at Site 41. Therefore, further evaluation was recommended (CH2M, 2019).
- Site 74 was also evaluated in the Basewide PFAS PA as a potential PFAS release area based on its designation as a chemical dump site. However, no documentation or institutional knowledge of AFFF, or other PFAS-containing material, being used, released, or transferred was identified at Site 74. Therefore, no further evaluation was recommended (CH2M, 2019).

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release areas identified; therefore, there is no current exposure pathway (CH2M, 2019). Site 41 will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

5.7 Statement of Protectiveness

The remedy at OU 4 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial use, and to restrict access and intrusive activities.

5.8 References

Baker Environmental Inc. (Baker). 1995a. *Remedial Investigation Report, Operable Unit No. 4 (Sites 41 and 74).* Marine Corps Base Camp Lejeune, North Carolina.

Baker. 1995b. *Feasibility Study Report, Operable Unit No 4. (Sites 41 and 74), Marine Corps Base Camp Lejeune, North Carolina.* May.

Baker. 1995c. *Proposed Remedial Action Plan, Operable Unit No. 4 (Sites 41 and 74), Marine Corps Base Camp Lejeune, North Carolina.* May.

Baker. 1995d. *Record of Decision for Operable Unit No. 4 (Sites 41 and 74), Marine Corps Base Lejeune, North Carolina.* October.

Baker. 2002. *Land Use Control Implementation Plans. Marine Corps Base Camp Lejeune, North Carolina*. July.

CH2M HILL, Inc. (CH2M)/Baker. 2001. *Long-Term Monitoring Report, OU No.4, Site 74. Marine Corps Base Camp Lejeune, North Carolina*. August

CH2M. 2006. *Closeout Report, Operable Unit No. 4 – Sites 41 and 74. Marine Corps Base Camp Lejeune, North Carolina*. July.

CH2M. 2010. *Five-Year Review. Marine Corps Base Camp Lejeune, North Carolina*. August.

CH2M. 2012. *Technical Memorandum, Confirmatory Sampling Investigation, IR Site 74 – Henderson Pond, Marine Corps Base Camp Lejeune, North Carolina*. February.

CH2M. 2013. *Henderson Pond/Hickory Pond Investigation Report. Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina*. January.

CH2M. 2015. *Five-Year Review. Marine Corps Base Camp Lejeune, North Carolina*. August.

CH2M. 2019. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* December.

Environmental Science and Engineering, Inc. (ESE). 1990. *Site Summary Report Final, Marine Corps Base Camp Lejeune, North Carolina.* September.

Water and Air Research, Inc. (WAR). 1983. *Initial Assessment Study for MCB Camp Lejeune, North Carolina.*

Table 5-1. Cleanup Levels for OU 4 (Site 41)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs [a]	Cleanup Levels[b] (Baker, 1995)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	Arsenic	50	10	NCGWQS/MCL
	Beryllium	4	4	MCL
	Cadmium	5	2	NCGWQS
	Chromium	50	10	NCGWQS
	Lead	15	15	NCGWQS/MCL
	Nickel	100	100	NCGWQS

Notes:

[a] Metals were identified as COCs at Site 74. No cleanup levels were established in the OU 4 ROD. LTM was discontinued after three rounds because the metals concentrations were indicative of naturally occurring metals.

[b] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Shading indicates cleanup levels achieved per Closeout Report (CH2M, 2006)

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

µg/L = microgram(s) per liter

COC = constituent of concern

MCL = maximum contaminant level

NCGWQS = North Carolina Groundwater Quality Standard

ROD = Record of Decision

Table 5-3. OU 4 Remedial Action Summary and Expected Outcomes

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
41	Soil/waste	Potential exposure to suspected UXO or chemical agent in waste left in place.	Vacant/ Industrial	Prevent future potential exposure to buried contaminated soil and waste.	LUCs	Maintain access control, non-industrial land use, and intrusive activities control; conduct quarterly monitoring.	Restricted Land Use
	Surface Water/ Sediment	Potential for groundwater contaminants to discharge to surface water through seeps.		Protect ecological receptors from future potential exposure to contaminated surface water.	LTM	LTM completed. Groundwater cleanup levels were achieved, and surface water and seeps data indicated no offsite migration.	
	Groundwater	Potential unacceptable risks to future residents from exposure to metals through potable use of groundwater.		Prevent future potential exposure to contaminated groundwater.	LTM	LTM completed. Groundwater cleanup levels were achieved.	
					LUCs	Maintain intrusive activities and aquifer use controls; conduct quarterly monitoring. LUCs are in effect because waste remains in place.	
74	Soil/waste	Potential exposure to chemical agent in waste left in place.	Vacant/ Industrial	Prevent future potential exposure to buried contaminated soil and waste.	LUCs	Maintain access control, non-industrial land use, and intrusive activities control; conduct quarterly monitoring.	
	Groundwater	Potential unacceptable risks to future residents from exposure to metals through potable use of groundwater.		Prevent future potential use of the shallow groundwater.	LTM	LTM completed. Groundwater concentrations were indicative of naturally occurring metals.	
					LUCs	Maintain intrusive activities and aquifer use controls; conduct quarterly monitoring. LUCs are in effect because waste remains in place.	

Notes:

LTM = long-term monitoring; LUC = land use control; RAO = remedial action objectives; UXO = unexploded ordnance

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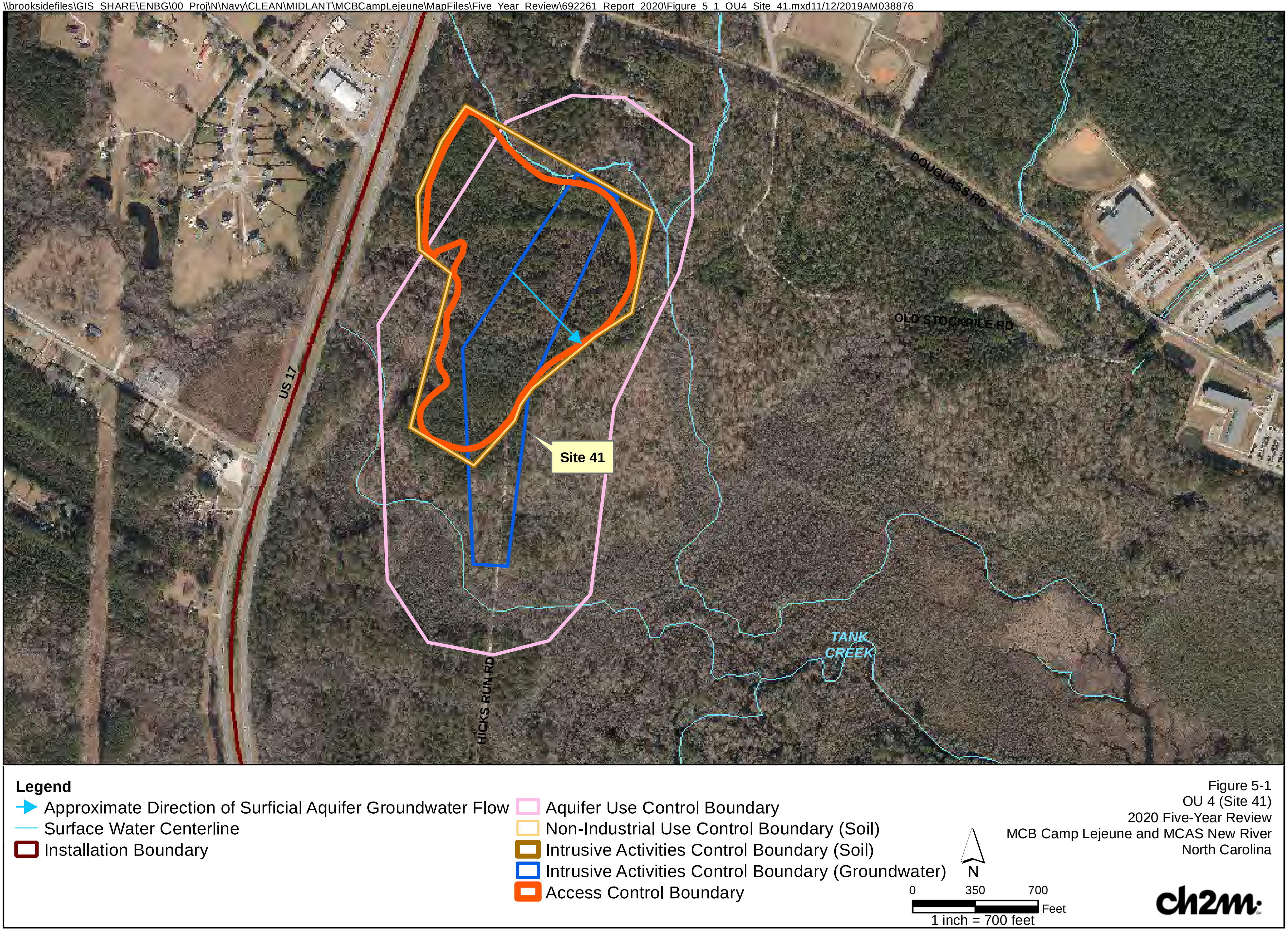

Figure 5-1
OU 4 (Site 41)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Legend

- Approximate Direction of Surficial Aquifer Groundwater Flow
- Surface Water Centerline
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Access Control Boundary

N

0 400 800 Feet

1 inch = 800 feet

Figure 5-2
OU 4 (Site 74)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

Operable Unit 5 (Site 2)

6.1 Site History and Background

OU 5 is within the Mainside of the Base (**Figure 1-2**) and consists of Site 2.

Site 2 — the Former Nursery/Day Care Center is approximately 5 acres just inside the Main Gate in the northeast portion of the Base (**Figure 6-1**). From 1945 to 1958, an onsite building (Building 712) was used for storing, handling, and dispensing pesticides, and was later used as a day care center. Chemicals known to have been used at Site 2 include chlordane, DDT, diazinon, and 4,4'-DDD, dieldrin, lindane, malathion, and silvex. A preliminary soil sampling investigation, conducted in 1982, indicated the presence of pesticides, resulting in the transfer of the day care center to another location.

OU 5 Timeline	
Year	**Event**
1983	IAS
1984-1990	Confirmation Study
1991-1992	Geophysical Investigation
1993-1994	RI/FS
1994	PRAP and ROD
1994-1995	TCRA
1995-2008	LTM
1997	Notice of Non-Significant Change
2001	LUCs
2008	Closeout Report
2011	Closeout Report Update
2017-2018	Groundwater Investigation
2019	Basewide PFAS PA
2019	Memorandum to Site File: Non-Significant Changes to the Remedy

6.2 Site Characterization

The findings from various investigations at OU 5 that are pertinent to the FYR are summarized in this section.

6.2.1 Physical Characteristics

- **Surface Features –** The site is located at the intersection of Holcomb Boulevard and Brewster Boulevard and is bordered to the north by a wooded area; to the west by Holcomb Boulevard; to the south by Brewster Boulevard; and to the east by a water treatment plant. OU 5 is primarily flat, but dips sharply at drainage ditches which run parallel to the Camp Lejeune Railroad. Stormwater flow generally drains north towards Overs Creek, located approximately 1,000 feet north of Building 712, and is limited over most of the site due to the flat topography.

- **Geology and Hydrogeology –** OU 5 is underlain by unconsolidated deposits of sand, silt, and clay. The surficial aquifer is encountered from approximately 2 to 25 feet bgs in this area. Surficial aquifer groundwater flows north towards Overs Creek.

6.2.2 Land Use

- **Current Land Use –** Building 712 is currently used as administrative offices and the surrounding area is vacant.
- **Future Land Use –** There are no anticipated changes in land use.

6.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 5. Details are located in the OU 5 RI report (Baker, 1994a) and the OU 5 ROD (Baker, 1994d).

Soil, groundwater, sediment, and surface water was investigated. The HHRA evaluated current military personnel, potential future adult and child resident, and potential future construction worker exposure scenarios. Based on the results of the RI, unacceptable risks to current military personnel from exposure to pesticides in soil and sediment, and unacceptable risks to potential future residents were identified from exposure to pesticides in soil and sediment, and pesticides, VOCs, semi-volatile organic compounds (SVOCs), and metals in groundwater. The

ERA identified potential unacceptable risks to ecological receptors from presence of pesticides in soil and sediment.

A TCRA to remove soil and sediment with concentrations of pesticides presenting unacceptable human health risks (residential) and ecological risks was implemented. In 1994 to 1995, a total of 1,048 tons of soil and sediment were excavated from three areas and disposed of as hazardous waste. All confirmation samples were below the risk-based cleanup levels for residential use established for the TCRA (Baker, 1994d; OHM, 1995).

Risks for post-TCRA conditions were evaluated by removing the data associated with samples that exceeded a residential risk-based preliminary remedial goal from the dataset. No unacceptable risks to ecological receptors were identified under post-TCRA conditions. Unacceptable risks to potential future residents from VOCs, SVOCs, pesticides, and metals in groundwater remained.

6.3 Remedial Action Objectives

The ROD for OU 5 was signed in September 1994 (Baker, 1994d) with the following RAOs:

- Prevent future human exposure to the contaminated groundwater.
- Ensure, through monitoring, that there are no human or environmental exposures due to migration of the contaminant plume off site.

The COCs and cleanup levels for OU 5 are presented in **Table 6-1** (groundwater).

6.4 Remedial Actions

The RA for OU 5 includes the following major components:

- LTM of groundwater to monitor on-site wells and nearby potable water supply wells.
- LUCs to restrict installation of new potable water supply wells in the vicinity of Site 2.

6.4.1 Remedy Implementation

LTM at Site 2 was initiated in 1995 and completed in 2007 as described in the following section. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002) and again in 2009 (CH2M, 2011[2]). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site:

- **Aquifer Use Control:** Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring, from the surficial aquifer within 1,000 feet of the estimated impacted groundwater extent.
- **Intrusive Activities Control (Groundwater):** Restrict intrusive activities within the vicinity of the estimated impacted groundwater.

Although there were no unacceptable risks from exposure to site soils, the following LUC was also recorded:

- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use within the extent of the former removal areas, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.

LUCs for groundwater were removed in 2009 (CH2M, 2011). The Non-Industrial Use Control (Soil) LUC is currently in-place and included in the Base GIS and Master Plan.

[2] Aquifer Use Control and Intrusive Activities Control (Groundwater) were recommended for removal in the Closeout Report (CH2M, 2008), the updated plat removing the LUCs was recorded in June 2009 and the final plat was included as an attachment with the Closeout Report Update (CH2M, 2011).

6.4.2 Remedy Operation and Maintenance

Long-term Monitoring

In 1995, the LTM Program at Site 2 was initiated and included quarterly sampling of six shallow monitoring wells and three active supply wells for VOCs, metals, TDS, and TSS analysis. In 1997, as documented in a Notice of Non-Significant Changes, the sampling protocol was modified to remove the supply wells, update the monitoring well network to better define the extent of contamination, and remove metals, TDS, and TSS from the sampling protocol because there was no history of metals disposal at the site and concentrations were indicative of natural geological conditions (USMC, 1997). After 1997, the sampling protocol consisted of annual sampling of groundwater from six surficial aquifer monitoring wells for analysis of VOCs. In 2007, groundwater VOC concentrations were below cleanup levels for four consecutive events. As a result, LTM was discontinued and a Closeout Report was submitted in 2008 (CH2M, 2008). Because the Closeout Report addressed VOCs only, the 2010 FYR recommended issuing a correction to the Closeout Report to include and explain the removal of metals as groundwater COCs documented in the 1997 Notice of Non-Significant Changes. The Closeout Report Update was submitted in 2011 (CH2M, 2011).

Land Use Controls

LUCs restricting groundwater intrusive activities and aquifer use were removed in accordance with the Closeout Report (CH2M, 2006, 2011). LUCs remain in place to prohibit non-industrial use within the extent of the former soil RAs. The LUCs are shown on **Figure 6-1** and summarized in **Table 6-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**.

In September 2018, a post-hurricane inspection was completed, and no damage was observed. During the FYR site inspections conducted in March 2019, no issues affecting protectiveness were observed (**Appendix B**).

Table 6-2. OU 5 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Non-Industrial Use Control Boundary (Soil)	3.29	July 2002	June 6, 2009

6.4.3 Progress Since the 2015 Five-Year Review

Issues identified during the 2015 FYR and follow-up actions are summarized in **Table 6-3**. LUCs continue to be monitored to ensure they remain properly implemented, and no deficiencies or inconsistent uses were observed. The OU 5 RA components and expected outcomes are summarized in **Table 6-4**.

Table 6-3. 2015 FYR OU 5 Issues, Recommendations, and Follow-up Actions

Issues	Recommendations (Milestone)	Date Completed/Current Status
Confirmation soil and sediment data does not exceed residential RSLs	Remove non-industrial use LUC and prepare a RACR (2016)	Initiated in 2016. During preparation of the RACR, a comprehensive data and HHRA review was conducted for soil sediment, and groundwater to confirm that conditions were acceptable for UU/UE and support removal of the LUC. Soil and sediment data did not present unacceptable risks to human health and the environment based on a revised HHRA using post-TCRA and RI data (CH2M, 2019a). However, several COCs identified in groundwater were not included in the 2008 closeout report and 2011 closeout report update. Based on a review of available data, from the 1993 RI, 4,4'-DDD and 4,4'-DDT in groundwater did present potential unacceptable risks if used as a potable source in the RI and was never addressed by the remedy. Groundwater sampling for 4,4'-DDD and 4,4'-DDT was conducted in 2017 and 2018 and both pesticides were detected and 4,4'-DDD exceeded the NCGWQS (Meadows, 2017, 2018). Based on the groundwater investigation results, LTM of groundwater for 4,4'-DDD and 4,4'-DDT will be conducted every 5 years and an aquifer use LUC will be reinstated. Although 4,4'-DDT did not exceed the NCGWQS during confirmation sampling, it will be included in LTM until 4 rounds of data below the NCGWQS have been collected. The HHRA review concluded that there were no unacceptable risks to future residents from exposure to soil or sediment. Therefore, the non-industrial use control LUC will be removed. A Memorandum to Site File was issued documenting this non-significant change to the remedy (CH2M, 2019a).

6.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

No. Based on data identified during RACR preparation, 4,4'-DDD and 4,4'-DDT in groundwater present an unacceptable risk to human health if used as a drinking water source (CH2M, 2019a). Aquifer use controls were removed in 2011; however, protectiveness is not affected because groundwater is not currently used as a potable source and there are no current exposure pathways.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. While the exposure assumptions and RAOs are still valid, the toxicity data and standards on which cleanup levels are based have changed since the ROD was signed. Additonally, cleanup levels were not identified for several groundwater COCs listed in the ROD; however, there are currently MCLs or NCGWQS available.

Toxicity and Other Contaminant Characteristics: There have been some changes in toxicity values and regulatory levels of some contaminants detected in groundwater and soil since the HHRA was conducted and the ROD was signed and the 2015 FYR, particularly 4,4'-DDD (**Table 2-1**). As presented in **Section 6.4.3**, risks from COCs in groundwater, soil, and sediment were reevaluated using current toxicity data and only 4,4'-DDD, and 4,4'-DDT in groundwater presented unacceptable risks (CH2M, 2019a).

Cleanup Levels: The cleanup levels for groundwater were identified as the more conservative of the NCGWQS and MCL at the time the ROD was signed. However, cleanup levels were not identified for SVOCs or pesticides in the ROD because risk-based remediation goals calculated during the FS were not exceeded and these contaminants were not included in LTM (Baker, 1994c). The more conservative value between the NCGWQS and MCL available for the SVOC and pesticide COCs and are included in **Table 6-1**. An HHRA was completed to reevaluate risks from the remaining COCs and there were no unacceptable risks from SVOCs but there were unacceptable risks from 4,4'-DDD and 4,4'-DDT (CH2M, 2019a).

Cleanup levels for VOCs have been achieved and LTM was discontinued (CH2M, 2008). LTM for metals was discontinued based on the Notice of Non-Significant Change, which concluded there is no history of metals disposal at the site and metals were a product of natural geologic conditions (USMC, 1997; CH2M, 2011).

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 5 remedy with respect to extreme weather events, primarily hurricanes, was completed. The effects of extreme weather events are most likely limited to fallen trees; however, the only well installed in wooded are is flush-mounted and would not likely be damaged. Further, damage to monitoring wells would not significantly affect protectiveness of the remedy because the only potential risk at OU 5 is from potable use of groundwater which will be restricted through LUCs. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

6.6 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 5 are summarized in **Table 6-5**.

Table 6-5. OU 5 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	Future
4,4'-DDD and 4,4'-DDT are present in groundwater and present potential unacceptable risk to human receptors.	Reinstate groundwater LTM for 4,4'-DDD and 4,4'-DDT and an aquifer use control boundary 500 feet from groundwater containing 4,4'-DDD and 4,4'-DDT.	Navy/Base	USEPA/ State	December 31, 2023	No	Yes

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Site 2 was identified in the Basewide PFAS PA as an area with potential to use PFAS-containing materials (other than AFFF), but where use of these materials is not well documented or unknown (such as hobby shops, paint shops, car washes, and pesticide shops). No further evaluation was recommended at this time, and Site 2 has been cataloged should information later indicate operations at these areas could result in a potential PFAS release (CH2M, 2019b).

6.7 Statement of Protectiveness

The remedy at OU 5 will be protective of human health and the environment when aquifer LUCs are reinstated. There are currently no complete exposure pathways because groundwater is not used as a potable source as there are no active supply wells within 500 feet of the site. In the interim, until the LUCs are reinstated, the Base GIS and Master Plan maintain existing and proposed LUCs and all construction projects go through environmental review. Groundwater LTM will be conducted to monitor COCs until cleanup levels are achieved.

6.8 References

Baker Environmental Inc. (Baker). 1994a. *Remedial Investigation Report, Operable Unit No. 5, Site 2*. Marine Corp Base, Camp Lejeune, North Carolina. June.

Baker. 1994b. *Feasibility Study, Operable Unit No. 5, Site 2.* Marine Corp Base, Camp Lejeune, North Carolina. May.

Baker. 1994c. *Proposed Remedial Action Plan, Operable Unit No. 5 (Site 2), Marine Corps Base, MCB Camp Lejeune, North Carolina.* May.

Baker. 1994d. *Record of Decision, Operable Unit Number 5 – Site 2.* Marine Corp Base Camp Lejeune. September.

Baker. 2002. *Land Use Control Implementation Plans.* Marine Corps Base Camp Lejeune, North Carolina. July 2002.

CH2M. 2008. *Closeout Report, Operable Unit No. 5 – Site 2, Marine Corps Base Camp Lejeune*. September.

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CH2M. 2015. *Five-Year Review, Marine Corps Base Camp Lejeune*. August.

CH2M. 2019a. *Draft Memorandum to the Site File Documenting Non-Significant Changes to Remedy, Operable Unit 5, Site 2.* October.

CH2M. 2019b. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* December.

Meadows. 2017. *Completion Report, Operable Unit No. 5 - Site 2 Groundwater Investigation, Marine Corps Base Camp Lejeune, North Carolina.* August.

Meadows. 2018. Technical Memorandum - *Operable Unit No. 5 - Site 2 Groundwater Investigation, Marine Corps Base Camp Lejeune, North Carolina.* December.

OHM Remediation Services (OHM). 1995. *Contractor's Closeout Report Time Critical Removal Action for Pesticide Contaminated Soil Operable Unit 5, Site 2, Marine Corps Base, Marine Corps Base Camp Lejeune, North Carolina*.

United States Marine Corps (USMC). 1997. *Notice of Non-Significant Changes: OU 1 (Sites 24 and 78) and OU 5 (Site 2), Marine Corps Base Camp Lejeune*. July.

Water and Air Research, Inc. (WAR). 1983. *Initial Assessment Study for MCB Camp Lejeune, North Carolina.*

Table 6-1. Groundwater Cleanup Levels for OU 5 (Site 2)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (Baker, 1994)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	Ethylbenzene	29	600	NCGWQS
	Trichloroethene	2.8	3	NCGWQS
	Xylene (total)	530	500	NCGWQS
	SVOCs			
	Acenaphthene	NS	80	NCGWQS
	2,4-Dimethyphenol	NS	100	NCGWQS
	2-Methylnaphthalene	NS	30	NCGWQS
	Naphthalene	NS	6	NCGWQS
	Phenol	NS	30	NCGWQS
	Pesticides			
	4,4'-DDD	NS	0.1	NCGWQS
	4,4'-DDT	NS	0.1	NCGWQS
	Metals			
	Arsenic	50	10	NCGWQS/MCL
	Barium	2,000	700	NCGWQS
	Beryllium	4	4	MCL
	Lead	15	15	NCGWQS/MCL
	Vanadium	NS	8.6	RSL-Tapwater

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Shading indicates cleanup levels achieved per Notice of Non-Significant Changes ([metals] Navy, 1997) and Closeout Report ([VOCs] CH2M, 2008; 2011) or risk re-evaluation ([SVOCs] CH2M, 2019b).

Notes:

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

RSL (April 2019), lower of RSL based on cancer risk of 10-6 or non-cancer hazard index of 0.1.

µg/L = microgram per liter

COC = constituent of concern

DDD = dichlorodiphenyldichloroethane

DDT = dichlorodiphenyltrichloroethane

MCL = maximum contaminant level

NCGWQS = North Carolina Groundwater Quality Standard

NS = not specified

RSL = Regional Screening Level

ROD = Record of Decision

SVOC = semivolatile organic compound

VOC = volatile organic compound

Table 6-4. OU 5 Remedial Action Summary and Expected Outcomes

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
2	Groundwater	Potential unacceptable risks to future residents from exposure to pesticides, VOCs, SVOCs, and metals in groundwater.	Industrial	Ensure, through monitoring, that there are no human or environmental exposures due to migration of the contaminant plume offsite.	LTM	LTM for metals discontinued in 1997 notice of non-significant changes and for VOCs in 2007 after four consecutive rounds were below cleanup levels. Risks from SVOCs were re-evaluated and within acceptable range. LTM for 4,4'-DDD and 4,4'-DDT is to be reinstated.	UU/UE
				Prevent future human exposure to contaminated groundwater.	LUCs	Aquifer use restrictions to be reinstated and will be in place until cleanup levels have been achieved.	
	Soil	Potential unacceptable risks to future resident, current Base personnel, and ecological receptors from pesticides in soil.		Remove soil with concentrations of pesticides that present a potential risk to human health and the environment (TCRA).	Soil Removal	TCRA to remove soil above cleanup levels is complete.	
					LUCs	HHRA identified no unacceptable risks to potential future residents, nonindustrial use controls can be removed.	
	Sediment	Potential unacceptable risks to future resident, current Base personnel, and ecological receptors from pesticides in sediment.		Remove sediment with concentrations of pesticides that present a potential risk to human health and the environment (TCRA).	Sediment Removal	TCRA to remove sediment above cleanup levels is complete.	
					LUCs	HHRA identified no unacceptable risks to potential future residents, nonindustrial use controls can be removed.	

Notes:

COC = constituent of concern

DDD = dichlorodiphenyldichloroethane

DDT = dichlorodiphenyltrichloroethane

HHRA = human health risk assessment

LTM = long-term monitoring

LUC = land use control

RAO = remedial action objective

SVOC = semivolatile organic compound

TCRA = time-critical removal action

UU/UE = unlimited use/unrestricted exposure

VOC = volatile organic compound

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Figure 6-1
OU 5 (Site 2)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

Operable Unit 6 (Sites 36, 43, 44, and 54)

7.1 Site History and Background

OU 6 is within the Camp Geiger and MCAS New River portions of the Base (**Figure 1-2**). OU 6 consists of four sites (Sites 36, 43, 44, and 54) that have been grouped together because of the similar characteristics of material disposed, contaminants detected, and geographic location.

Site 36 — the **Camp Geiger Area Dump** covers approximately 65 acres in the northwest portion of the Base (**Figure 7-1**). Site 36 is reported to have been used for the disposal of municipal wastes and mixed industrial wastes including trash, waste oils, solvents, and hydraulic fluids that were generated at MCAS New River. The dump was active from the late 1940s to the late 1950s. Most of the material was burned and buried.

Site 43 — the **Agan Street Dump** covers approximately 14 acres and reportedly received inert material such as construction debris and trash (**Figure 7-1**). Sludge from the former sewer treatment plant was also reportedly dumped onto the ground surface; however, it is not clear when disposal operations took place.

Site 44 — the **Jones Street Dump** covers approximately 6 acres and was reportedly in operation during the 1950s (**Figure 7-1**). Although the quantity of waste is not known, debris, cloth, lumber, and paint cans were reportedly disposed of at the site.

Site 54 — the **Crash Crew Fire Training Burn Pit** covers approximately 1 acre and has served as the fire training area since the mid-1950s (**Figure 7-1**). The former Crash Crew Fire Training Burn Pit was 90 feet in diameter and situated at the center of this site. Originally, fire training was conducted on the ground surface within a bermed area using JP-type fuel, which was stored in an 8,000-gallon UST northwest of the burn pit. An OWS, located approximately 100 feet southeast of the burn pit, was used for temporary storage and collection of the spent fuel. In 1975, a lined burn pit was constructed and was used until 1999. Beginning in August 2000, the burn pit was converted to a fire training area that employs clean-burning fuels with operational and engineering controls. It is estimated that nearly 500,000 gallons of POL may have been used at Site 54. In 2015, most of Site 54 (including the burn pit) was paved with concrete and is currently used for MCAS New River operations.

OU 6 Timeline	
Year	**Event**
1983	IAS (Sites 36, 43, 44, & 54)
1984-1990	Confirmation Study (Sites 36 & 54)
1991-1994	Site Investigation (Sites 43 & 44)
1994-1996	RI (Site 36)
1995-2002	RI/FS (Sites 43, 44, & 54)
1995	TCRA (Site 43)
1997	TCRA (Site 36)
1998-Present	MNA (Site 36)
1998-2002	LTM (Site 54)
2002	FS (Site 36)
2001	Soil Removal (Site 54)
2002	PRAP (Sites 36 & 54)
2003	Interim RA (Sites 36 & 43)
2005	ROD (Sites 36, 43, 44, & 54)
2007	Interim RACR (Sites 36, 43, 44, & 54)
2015-2016	ERD Pilot Study (Site 36)
2015	Construction at MCAS New River (Site 54)
2017	ESD (Site 36)
2017-2018	PFAS SI (Site 54)
2019	LUCIP Update (Site 36) Basewide PFAS PA (Sites 36, 43, 44, & 54)

7.2 Site Characterization

The findings from various investigations at OU 6 that are pertinent to the FYR are summarized in this section.

7.2.1 Physical Characteristics

- **Surface Features –** Sites 36, 43, and 44 are primarily wooded. Site 36 is bisected by an access road to a recreational area on the New River, and Brinson Creek is located along the northeast boundary. Stormwater from Site 36 flows toward Brinson Creek. Site 44 and 43 are bounded by Edwards Creek to the north and the ground slopes steeply toward the creek. Stormwater flows toward Edwards Creek at Site 43 and 44. Site 54 is primarily paved and flat.
- **Geology and Hydrogeology –** Subsurface conditions at OU 6 sites generally consist of Coastal Plain deposits comprising layers of sand, silt, and clay. Groundwater is currently a medium of concern at Site 36 and is also relevant as a potential medium of concern at Sites 43 and 54. The affected aquifers at Site 36 include the surficial aquifer, which extends from 2 to 40 feet bgs; the UCH aquifer, which extends from 40 to 60 feet bgs; and the MCH aquifer, which extends from greater than 60 feet bgs. In the surficial aquifer, the average hydraulic conductivity is 2.4 ft/day, and the average groundwater velocity is 0.1 ft/day. In the UCH aquifer, the average hydraulic conductivity is 5.7 ft/day and the average groundwater velocity is 0.3 ft/day. Groundwater in the surficial and UCH aquifers typically flows to the north and northeast across Site 36, where it is expected to discharge to Brinson Creek. Groundwater in the surficial aquifer at Sites 43 and 44 is expected to flow to the north and discharge to Edwards Creek. Groundwater in the surficial aquifer at Site 54 is expected to flow south and discharge to a tributary of South West Creek. Groundwater in the Castle Hayne aquifer typically flows toward the northeast and the New River. Groundwater flow is shown on **Figure 7-1**.

7.2.2 Land Use

- **Current Land Use –** There are no ongoing operations at Sites 36, 43, and 44. The access road at Site 36 is used by military personnel for recreation and to access a picnic area located adjacent to the New River. Fishing may occur in Brinson Creek and the New River. Site 54 is located within MCAS New River and is accessed by military personnel who work at the air station. Site 54 is no longer used as a firefighting training area but is used for MCAS New River operations.
- **Future Land Use –** There are no anticipated changes in land use.

7.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 6. Details are in the OU 6 RI report (Baker, 1996) and the OU 6 ROD (CH2M and Baker, 2005).

Site 36

Soil, groundwater, surface water, sediment, and fish and crab tissue were investigated. The HHRA evaluated current military personnel, trespassers, recreational users (fishing), and construction workers, and future adult and child residents. Potential unacceptable human health risks were initially identified for potential current and future recreational fishermen from ingestion of fish or crab containing arsenic and mercury. However, additional fish tissue sampling was conducted by the NCDEQ in April 1998, and the results did not exceed USEPA and North Carolinas limits for mercury; arsenic was not detected, and other metals were either not detected or were present at background levels (Hale, 1998). Potential unacceptable human health risks were also identified for future child residents based on exposure to iron in groundwater and subsurface soil and future adult residents based on exposure to iron in groundwater. However, iron was considered to be naturally occurring at the site and not related to site activities; therefore, was not retained as a groundwater COC.

Potential unacceptable human health risks (blood lead levels above target blood lead levels) were identified for current or future child trespassers and future child residents from exposure to the maximum detected concentrations of lead in surface soil, subsurface soil, and crab tissue. Although no unacceptable risks were identified from exposure to VOCs in groundwater, the concentrations exceeded the NCGWQS and/or MCL and VOCs were retained as COCs.

The RI results also identified isolated areas with PCBs, PAHs, and pesticides exceeding risk-based screening levels that were targeted for RAs before the ROD. In 1997, approximately 92 tons of regulated PCB-contaminated soil and 148 tons of non-regulated PCB-contaminated soil were removed from Site 36 during a TCRA. Confirmation samples exhibited PCB concentrations below the industrial action level (10 milligrams per kilogram [mg/kg]) (Baker, 2002). In 2003, a TCRA was implemented to remove "hot spot" areas that exceeded residential levels for PAHs and pesticides. A total of 1,630 tons of PAH- and pesticide-contaminated soil was removed from four areas within the south-central portion of the site (Shaw, 2003). Based on historical dumping activities conducted at the site, unacceptable risks were presumed for potential future residents and construction workers from exposure to contaminants in buried waste and affected soil remaining onsite.

The ERA evaluated terrestrial and aquatic receptors and a slight potential for decrease in terrestrial vertebrate population from exposure to site contamination was identified.

A phased Basewide VI evaluation was conducted from 2007 through 2015 to evaluate sites with VOCs as COCs for potential VI pathways. Although Site 36 was not included in the evaluation because there are no buildings within 100 feet of VOC-impacted groundwater, indoor air concentrations could exceed VISLs should VI occur in the future if new construction were to take place or land use changes within 100 feet of the groundwater VOC plume (CH2M, 2017a).

Site 43

Soil, groundwater, surface water, and sediment were investigated. The HHRA evaluated current military personnel and adult and child trespassers, and potential future adult and child residents. Potential unacceptable risks were identified for future residents from exposure to iron and aluminum in groundwater. However, based on geochemical conditions (neutral pH) and background concentrations, the metals were considered to be naturally occurring and not likely a result of leaching from buried debris. The ERA evaluated aquatic and terrestrial receptors and concluded that there were no unacceptable ecological risks.

Several debris items that could potentially present a hazard to human health or the environment were observed on the ground surface during the RI prompting a TCRA. In 1995, 14,660 pounds of metallic debris were removed from the surface and recycled, and four drums containing paint cans were disposed of offsite as hazardous waste (OHM, 1995). In 2003, although the HHRA indicated no unacceptable risks, a TCRA was implemented to remove PAHs in soil that exceeded residential levels. A total of 1,478 tons of PAH-contaminated soil was excavated and disposed offsite (Shaw, 2003). Based on historical dumping activities conducted at the site, unacceptable risks were presumed for potential future residents and construction workers from exposure to contaminants in buried waste and affected soil remaining onsite.

Site 44

Soil, groundwater, surface water, and sediment were investigated. The HHRA evaluated current military personnel and adult and child trespassers, and potential future adult and child residents and construction workers. Potential unacceptable risks were identified for future residents from exposure to VC and iron in groundwater. However, the VC was considered to be related to an upgradient source (Site 89) and iron is naturally occurring and not related to site activities. Based on historical dumping activities conducted at the site, unacceptable risks were presumed for potential future residents and construction workers from exposure to contaminants in buried waste and affected soil remaining onsite. The ERA evaluated aquatic and terrestrial receptors and there were no unacceptable ecological risks.

Site 54

Soil, groundwater, and sediment were investigated. The HHRA evaluated current military personnel and adult and child trespassers and potential future residents and construction workers. Potential unacceptable risks were identified for future residents based on exposure to VOCs, SVOCs, and lead in groundwater. However, post-RI groundwater monitoring results showed VOCs, SVOCs, and metals were below NCGWQS and monitoring was discontinued in 2002, before the ROD was signed. The ERA evaluated terrestrial receptors and potential risks to soil invertebrates and plants were identified from SVOCs and metals; however, there were no unacceptable ecological risks to terrestrial vertebrates and the site is not considered an ecological habitat.

In 2001, the UST and associated POL-contaminated soil and construction debris were removed from the former burn pit area to industrial levels. The excavation was 9 feet deep and roughly oval in shape, with a length of 128 feet and a width of 96.5 feet (OHM, 2001). A new concrete-lined fire training area and two propane tanks were constructed onsite. Soil contamination above the residential cleanup levels remain in place in the former burn pit area.

7.3 Remedial Action Objectives

The ROD for OU 6 was signed in July 2005 (CH2M and Baker, 2005) and the ESD for Site 36 was signed in June 2017 (CH2M, 2017a) with the following RAOs:

Site 36

- Protect human health by preventing exposure to surface and subsurface soil within the following areas: lead contaminated areas, and unknown disposal materials within the former dump, and the previous soil removal action areas (i.e., PCB, PAH, and pesticide removal action areas).
- Protect uncontaminated groundwater for future potential beneficial use.
- Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.

Site 43

- Prevent future exposure to the surface and subsurface soil within the former sitewide dump from unknown disposed materials and the previous soil removal action area (i.e., PAH removal action area).

Site 44

- Prevent future exposure to the surface and subsurface soil due to unknown disposed materials within the former sitewide dump.

Site 54

- Prevent future exposure to the surface and subsurface soil within the former burn pit area.

The COCs and cleanup levels for OU 6 (Site 36) are presented in **Table 7-1**.

7.4 Remedial Actions

The RA for OU 6 includes the following major components:

Site 36

- MNA of VOCs in groundwater
- LTM of surface water to assess potential discharge to Brinson Creek
- Annual groundwater modeling to evaluate natural attenuation
- LUCs to prevent exposure to waste materials, and contaminants in soil, groundwater, and indoor air via the VI pathway.

Sites 43 and 44, and 54

- LUCs to prevent exposure to waste materials and soil

Site 54

- LUCs to prevent exposure to contaminated soil

7.5 Remedy Implementation

Site 36

Site 36 was included in the Basewide LTM program beginning in 1998, after the RI was completed. Groundwater and surface water LTM was conducted until the ROD was signed in 2005 when it continued as MNA, the selected remedy. Groundwater MNA and surface water monitoring is ongoing as described in the following section. Groundwater modeling was also conducted during the Basewide LTM beginning in 1998 and was discontinued in 2015 based on recommendations made in the 2015 FYR. LUCs for OU 6 were implemented in 2005 and updated at Site 36 in 2019 (CH2M, 2019a). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring, from the surficial aquifer within 1,000 feet of the estimated impacted groundwater extent.
- **Intrusive Activities Control (Groundwater):** Restrict intrusive activities within the vicinity of the estimated impacted groundwater. This LUC boundary encompasses the area within 100 feet of groundwater in the surficial and Castle Hayne aquifers that contains or potentially could contain concentrations of VOCs exceeding cleanup levels.
- **Industrial and Non-Industrial Use Control (VI)** – Before construction of new buildings or structural modifications to existing buildings, the potential for VI will be evaluated by assessing multiple lines of evidence. If the results of the evaluation indicate that VI could result in unacceptable indoor air concentrations, then engineering controls or an action to address the source will be considered to mitigate the unacceptable exposure. This LUC boundary encompasses the area within 100 feet of groundwater in the surficial and Castle Hayne aquifers that contains or potentially could contain concentrations of VOCs exceeding cleanup levels.

Site 36, 43, 44, and 54

- **Intrusive Activities Control (Soil):** Restrict intrusive activities within the vicinity of the estimated impacted soil/waste extent.
- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use within the extent of the estimated impacted soil/waste extent, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.

7.5.1 Remedy Operation and Maintenance

Remedy O&M consists of MNA (Site 36) and LUC monitoring (all sites). The total cost of MNA every 5 years at Site 36 is approximately $20,000 or approximately $4,000 annually.

Monitored Natural Attenuation and Surface Water Sampling (Site 36)

Groundwater and surface water sampling was initiated in 1998 as a post-RI MNA evaluation. The protocol initially consisted of quarterly groundwater sampling from 5 surficial, 6 UCH, and 1 MCH aquifer monitoring wells, and 4 surface water locations for VOCs and natural attenuation indicator parameters (NAIPs) (methane, ethane, ethene [MEE], alkalinity, chloride, iron, sulfate, sulfide, and total organic carbon [TOC]) in groundwater. The monitoring protocol was modified after a Basewide LTM optimization effort was completed (CH2M, 2005) and when post-

ROD groundwater MNA and surface water LTM began in 2005, the protocol consisted of annual groundwater sampling of three surficial, four UCH, and one MCH aquifer monitoring well for VOCs and NAIPs, and semi-annual surface water sampling from four locations in Brinson Creek for VOCs. Based on the results over time, surface water sampling was discontinued unless groundwater samples exceeded 10 times the NCSWQS for human health to determine the potential for groundwater to affect surface water (CH2M, 2015).

The sampling protocol currently consists of collecting samples from three surficial, six UCH, and one MCH aquifer monitoring wells. Groundwater samples are analyzed for VOCs and for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and TOC) every 5 years to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs. LTM will continue until groundwater meets cleanup levels.

In addition to comparing to cleanup levels (**Table 7-1**), data in the surficial aquifer are also compared to the NC VISLs, consistent with the overall site use, to evaluate whether concentrations indicate the potential for a complete VI pathway if buildings were constructed within 100 feet of the groundwater plume. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of the MNA component of the remedy.

Groundwater Modeling

Groundwater modeling of natural attenuation was completed using the BIOCHLOR model from 1998 until 2014. It was discontinued in 2015 because LTM data indicated that groundwater modeling was not appropriate for evaluating MNA and protection of Brinson Creek as site COCs were not detected in surface water samples (CH2M, 2015). This decision was documented in the 2017 ESD (CH2M, 2017a).

Land Use Controls

The LUCs are shown on **Figure 7-1** and summarized in **Table 7-2**. While not specified as part of the remedy in the ROD, Site 44 is currently surrounded by a chain-link fence with “Keep Out” signs to restrict access because of its location near residential housing. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed and damage from to the fence around Site 44 from fallen trees was observed. Between November 2018 and March 2019, repairs were made to the fence.

During the FYR site inspections, the White Street access road to Site 36 was deeply rutted causing water ponding, and paths to monitoring wells were also rutted and too soft for vehicle access. A sign that was present at the entrance to Site 43 in 2015 appears to have been removed. No issues affecting protectiveness were observed (**Appendix B**).

Table 7-2. OU 6 Land Use Control Summary

<table>
<tr><th>LUC Boundary</th><th>Estimated Area (Acres)</th><th>Most Current LUCIP Date</th><th>Onslow County Registration Date</th></tr>
<tr><td colspan="4">Site 36</td></tr>
<tr><td>Aquifer Use Control Boundary (1,000 feet)</td><td>64.8</td><td rowspan="5">May 2019</td><td rowspan="3">February 8, 2007</td></tr>
<tr><td>Non-Industrial Use Control Boundary (Soil)</td><td>4.8</td></tr>
<tr><td>Intrusive Activities Control Boundary (Soil)</td><td>4.8</td></tr>
<tr><td>Intrusive Activities Control Boundary (Groundwater)</td><td>4.73</td><td rowspan="2">April 16, 2019</td></tr>
<tr><td>Industrial/Non-Industrial Use Control Boundary (VI)</td><td>4.73</td></tr>
<tr><td colspan="4">Site 43</td></tr>
<tr><td>Non-Industrial Use Control Boundary (Soil)</td><td>0.14</td><td rowspan="2">September 2005</td><td rowspan="2">February 8,2007</td></tr>
<tr><td>Intrusive Activities Control Boundary (Soil)</td><td>13.2</td></tr>
</table>

Table 7-2. OU 6 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Site 44			
Non-Industrial Use Control Boundary (Soil)	5.6	September 2005	February 8, 2007
Intrusive Activities Control Boundary (Soil)	5.6		
Site 54			
Non-Industrial Use Control Boundary (Soil)	0.29	September 2005	February 8, 2007
Intrusive Activities Control Boundary (Soil)	0.29		

7.5.2 Post-ROD Removal Actions and Pilot Studies

Site 36 ERD Pilot Study

A pilot study was implemented in May 2015 to evaluate the effectiveness of ERD using SRS and a commercial bioaugmentation culture (TSI-DC) to accelerate the natural attenuation process and reduce the time to achieve site closure. The pilot study also evaluated the effectiveness of red yeast rice extract (Provect-CH4) to inhibit the generation of methane. The pilot study injections successfully stimulated biodegradation and reduced COC concentrations (in some instances, greater than 80 percent reduction) but was limited by distribution of the substrate in the subsurface. Based on limited distribution of the substrate in the treatment zone where the methane inhibitor was applied, no conclusions were drawn on the effectiveness of the methane inhibitor. If full-scale application were to occur, the emulsified vegetable oil (EVO) dose, permanent injection wells, and/or the quantity and injection location spacing would need to be adjusted (CH2M, 2017b).

7.5.3 Progress Since the 2015 Five-Year Review

Issues identified during the 2015 FYR and follow-up actions are summarized in **Table 7-3**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources at Site 36 is shown on **Figure 7-2**. The OU 6 RA components and expected outcomes are summarized in **Table 7-4**.

Table 7-3. 2015 FYR OU 6 Issues, Recommendations, and Follow-up Actions

Issue	Recommendation (Milestone)	Date Completed/Current Status
Groundwater modeling, as defined by the ROD, may not be appropriate for evaluating MNA and protection of Brinson Creek at Site 36	Discontinue BIOCHLOR modeling and surface water sampling as part of LTM; compare groundwater data collected from the most downgradient locations closest to Brinson Creek to 10 times the NCSWQS to monitor future protectiveness of Brinson Creek. If there are exceedances, surface water will be sampled. (9/30/2016)	Completed June 2, 2015. The decision to discontinue modeling and to collect surface water only when the farthest downgradient groundwater data exceeds 10 times the NCSWQS was agreed upon during the June 2015 Partnering meeting and documented in the ESD (CH2M, 2017b). Groundwater modeling using BIOCHLOR was discontinued. Groundwater data from the most downgradient locations are screened against 10 times the NCSWQS. LTM data were below this level during the most recent sampling event conducted in 2019 (CH2M, 2019b).
VI potential at Site 36	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI) at Site 36 (6/30/2016)	Completed June 30, 2016. The Draft ESD was submitted June 30, 2016, finalized March 30, 2017, and signed on June 1, 2017 to update the RAOs for OU 6 to include an industrial/non-industrial use control boundary for VI (CH2M, 2017a). The LUCIP update was finalized in May 2019 (CH2M, 2019a).

Table 7-3. 2015 FYR OU 6 Issues, Recommendations, and Follow-up Actions

Perfluorinated compounds (PFCs)[a] are an emerging contaminant group for former firefighting/burn pits and Site 54 is a former firefighting training area	Collect groundwater samples for PFCs at Site 54 (12/31/2017)	Completed November 19, 2017. Groundwater sampling for PFAS in the surficial aquifer was completed on November 19, 2017. Concentrations of PFOS and PFOA were detected in surficial aquifer groundwater above USEPA lifetime health advisory concentration (0.07 µg/L), tapwater RSL based on a hazard quotient of 1 (0.4 µg/L), and the North Carolina IMAC for PFOA (2 µg/L) with the highest concentrations detected just downgradient of the former Crash Crew Fire Training Burn Pit. The elevated concentrations of PFOS (maximum concentration of 30 µg/L) and PFOA (maximum concentration of 25.1 µg/L) in the groundwater indicate historical fire training activities have resulted in a release of PFAS to the groundwater in the surficial aquifer. Additional investigations were recommended to evaluate the nature and extent of PFAS contamination (CH2M, 2018).

[a] The present terminology for PFCs is PFAS.

7.6 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Site 36

Yes. The remedy is functioning as intended at Site 36.

The extent of TCE over time in the UCH aquifer is shown on **Figure 7-3** and the extent of VC over time in the surficial and UCH aquifers are found on **Figures 7-4** and **7-5**. TCE was not present in the surficial aquifer during the FY 2019 sampling. Results of the MK statistical analysis are shown in the 2018 frame on **Figures 7-3** through **7-5**. All locations were decreasing or stable except locations that did not have enough detections for the evaluation. No COCs exceeded 10 times the Human Health NCSQWS in the surficial aquifer and, although there are no buildings in the vicinity of the site, VOCs did not exceed the non-residential NC VISL. COCs were not detected above laboratory detection limits in the MCH aquifer sample (CH2M, 2019b).

NAIP data was collected from LTM monitoring wells in December 2018, and conditions do not appear to be optimal for reductive dechlorination (**Table 7-5**). In both the surficial and UCH aquifers, TOC concentrations were generally low (unfavorable for microbial growth), and sulfate concentrations were elevated, which may inhibit reductive dechlorination. Although NAIPs were not optimal for reductive dechlorination, MK statistical analysis indicates that COCs are stable or decreasing, suggesting that COCs may be attenuating through other pathways. Based on stable or decreasing concentrations, and continued evidence that COCs are not migrating vertically or laterally to Brinson Creek, the remedy is functioning as intended by the decision document.

LUCs remain in place to prevent exposure to groundwater COCs and soil COCs at concentrations above cleanup levels and to evaluate the VI pathway, as necessary.

Sites 43, 44, and 54

Yes, the remedy is functioning as intended at Sites 43, 44, and 54. LUCs remain in place to restrict non-industrial land-use and intrusive activities in soil. Additionally, fencing and signs were installed to restrict access. No issues concerning the protectiveness of the remedies in place were noted at Sites 43, 44, and 54 during the site inspections. It is recommended to add a sign at the entrance of Site 43.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. While exposure assumptions, cleanup levels, and RAOs used at the time of the ROD and ESD are still valid; toxicity data has changed, and a new potential contaminant source was identified at OU 6: the presence of select PFAS compounds was identified at concentrations above the USEPA lifetime health advisory, tapwater RSL based on a hazard quotient of 1, and the North Carolina IMAC for PFOA in surficial aquifer groundwater at Site 54. These changes do not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to buried materials and/or groundwater.

Toxicity and Other Contaminant Characteristics: There have been some changes in toxicity values for the COCs since the HHRA was conducted and the ROD was signed, however, there have been no changes since the last FYR which concluded that the remedy at OU 6 was protective of human health and the environment (**Table 2-1**).

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 6 remedy with respect to extreme weather events, primarily hurricanes, was completed. Effects of hurricane damage include erosion, potentially exposing debris, or damage to perimeter fencing at Site 44, potentially allowing access to the site. At Site 36, damage to monitoring wells from fallen trees is also a possibility but would not affect protectiveness. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

7.7 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 6 are summarized in **Table 7-6.**

Table 7-6. OU 6 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	Future
Site 54 was identified as a potential PFAS release area based on historical site use. Presence of PFAS compounds has been identified in groundwater at Site 54.	Refine the extent of PFAS in site media at Site 54 and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors.	Navy/Base	USEPA/ State	December 31, 2025	No	Yes

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Sites 36, 43, and 44 were evaluated in the Basewide PFAS PA as potential PFAS release areas based on designation as landfill/disposal sites and the following conclusions were made:
  - The former Camp Geiger WWTP is a demolished plant that once serviced Camp Geiger at MCB Camp Lejeune. This area is located within the IR Site 36 boundary. AFFF reportedly engulfed the main WWTP building at least one time. Additionally, there is a potential for a PFAS release in the wastewater from the industrial area at Camp Geiger and the presence of sludge drying beds. Therefore, further evaluation was recommended (CH2M, 2019b).

- Site 43 received WWTP sludge from the Former Agan Street WWTP that serviced the area as early as 1959 until the Advanced WWTP became operational in 1998. There is potential for the WWTP sludge to contain PFAS. Therefore, further evaluation is recommended (CH2M, 2019b).
- No documentation or institutional knowledge of AFFF, or other PFAS-containing materials, being used, released, or transferred was identified for Site 44. Additionally, the operational timeframe for Site 44 predates the use of AFFF; therefore, no further evaluation is recommended.

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release areas identified; therefore, there is no current exposure pathway (CH2M, 2019b). The former Camp Geiger WWTP area and Site 43 will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

7.8 Statement of Protectiveness

The remedy at OU 6 is currently protective of human health and the environment. Exposure pathways that could result in an unacceptable risk are being controlled. LUCs are in place to prohibit non-industrial use and restrict intrusive activities at Sites 36, 43, 44, and 54, and prohibit aquifer use and evaluate and/or mitigate potential VI pathways at Site 36. MNA is ongoing at Site 36 until cleanup levels are achieved.

However, to ensure the remedy is protective in the long term, the Navy intends to refine the extent of PFAS in site media and evaluate the potential for unacceptable risks and/or potential complete exposure pathway at Site 54.

7.9 References

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Table 7-1. Cleanup Levels for OU 6 (Site 36)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2017)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	Benzene	1	1	NCGWQS
	1,1-Dichloroethane	6	6	NCGWQS
	1,2-Dichloroethane[b]	--	0.4	NCGWQS
	1,1-Dichloroethene	7	7	NCGWQS/MCL
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL
	Trichloroethene	3	3	NCGWQS
	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS
	Tetrachloroethene	0.7	0.7	NCGWQS
	Vinyl Chloride	0.03	0.03	NCGWQS

[a] Cleanup Level is the more conservative between the NCGWQS and MCL; NCGWQS/MCL denotes NCGWQS and MCL are the same value.

[b] 1,2-Dichloroethane was added to the sampling protocol when it was detected above the NCGWQS in FY2019 (CH2M, 2019b)

Notes:

Shading indicates cleanup level achieved per LTM Reports (CH2M, 2014, 2019b)

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

NCSWQS (Sept 2017)

-- = COC identified post-ROD based on exceedances of current standard during MNA

µg/L = microgram(s) per liter

COC = constituent of concern

ESD = Explanation of Significant Differences

MCL = Maximum Contaminant Level

MNA = monitored natural attenuation

NCGWQS = North Carolina Groundwater Quality Standard

ROD = Record of Decision

VOC = volatile organic compound

Table 7-4. OU 6 Remedial Action Summary and Expected Outcomes

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
36	Groundwater	VOCs present in groundwater above drinking water standards. Potential migration of VOCs in groundwater to indoor air via the VI pathway. Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.	Vacant/Industrial	Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Protect uncontaminated groundwater for future beneficial use. Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.	MNA	Groundwater MNA to monitor VOC concentration trends over time until groundwater VOCs are at or below cleanup levels for four consecutive monitoring events.	UU/UE
					LUCs	Maintain intrusive activities (VI) and aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
						Maintain industrial/non-industrial use controls (VI) and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
	Surface Water	Potential migration of VOCs into surface water.		Prevent future exposure to VOC-contaminated groundwater.	LTM	Surface water LTM will be conducted if groundwater collected from the most downgradient surficial aquifer locations contain concentrations greater than 10 times the NCSWQS.	
	Soil and Waste	Potential unacceptable risks to child trespassers and future residents from lead in soil. Potential exposure to contaminants from buried waste.		Protect human health by preventing exposure to surface and subsurface soil within the following areas: lead contaminated areas, unknown disposal materials within the former dump, and the previous soil removal action areas (i.e., PCB, PAH, and pesticide removal action areas).	LUCs	Waste debris remains onsite and soil removal were completed to industrial levels. Maintain nonindustrial land use and intrusive activities controls and conduct quarterly monitoring of LUCs.	Industrial Land Use
43	Soil and Waste	Potential exposure to contaminants from buried waste.		Prevent future exposure to the surface and subsurface soil within the former site-wide dump from unknown disposed materials and the previous soil removal action area (i.e., PAH removal action area).	LUCs		
44	Soil and Waste	Potential exposure to contaminants from buried waste.		Prevent future exposure to the surface and subsurface soil due to unknown disposed materials within the former site wide dump.	LUCs		
54	Soil	Potential unacceptable risks to future residents from exposure to PAHs in soil.		Prevent future exposure to the surface and subsurface soil within the former burn pit area.	LUCs		

Notes:

LTM = long-term monitoring
LUC = land use control
MNA = monitored natural attenuation
NCAC = North Carolina Administrative Code
NCDEQ = North Carolina Department of Environmental Quality
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
RAO = remedial action objective
UU/UE = unlimited use/unrestricted exposure
VI = vapor intrusion
VOC = volatile organic compound

Table 7-5. Natural Attenuation Indicator Parameters - Site 36
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Parameter	Project Indicator Levels		Surficial Aquifer		UCH Aquifer	
	Description	Favorable Condition[a]	Range of Results	Conclusion	Range of Results	Conclusion
DO (mg/L)	DO is the most thermodynamically favored electron acceptor used by microbes for the biodegradation of organic carbon. However, low levels of DO are generally favorable for natural attenuation of chlorinated VOCs.	< 1	0 to 6.44	Yes, unfavorable result isolated	0 to 2.73	Yes, unfavorable result isolated
ORP (mV)	The ORP of groundwater is a measure of electron activity and is an indicator of the relative tendency of a solution to accept or transfer electrons. However, lower ORPs are generally favorable for natural attenuation of chlorinated VOCs.	< 0	-14 to 116	No, favorable result isolated	-103 to 76	Yes, unfavorable result isolated
Nitrate (mg/L)	Low levels of nitrate, compared to background, are indicative of nitrate-reducing conditions, which are generally favorable for natural attenuation of chlorinated VOCs.	< 1	0.01 U to 8.88	No, favorable result isolated	0.01 U to 4.4	Yes, unfavorable result isolated
Nitrite (mg/L)	The presence of nitrite generally indicates that nitrate-reducing conditions are present, which are generally favorable for natural attenuation of chlorinated VOCs.	Detectable Concentrations	0.01 U to 8.8	No, favorable result isolated	0.01 U to 0.133	Yes
Ferrous Iron (mg/L)	The presence of dissolved iron indicates that iron-reducing conditions are present, which are favorable for natural attenuation of chlorinated VOCs.	> 1	0.01 U to 1	No, favorable result isolated	0.01 U to 4.5	Yes
Sulfate (mg/L)	If sulfur compounds are present in the aquifer, higher concentrations of sulfate may compete with the reductive dechlorination pathway. Therefore, ideal conditions will maintain low sulfate levels. Depleted sulfate concentrations are also an indicator that sulfate-reduction is proceeding, which is a positive indication that conditions are favorable for natural attenuation of chlorinated VOCs.	< 20	68 to 290	No	55 to 220	No
Sulfide (mg/L)	The presence of sulfide is a geochemical footprint for sulfate reduction, which indicates that conditions are favorable for natural attenuation of chlorinated VOCs.	Detectable Concentrations	ND	Neutral	0.8 U to 3	Yes
Methane (mg/L)	Elevated methane levels are a geochemical footprint for methanogenesis and suggest that highly reducing conditions are present in the subsurface. This is a favorable indicator for natural attenuation of chlorinated VOCs.	> 0.5	0.0039 J to 0.029	No	0.015 to 16	No, favorable results isolated
TOC (mg/L)	TOC is an indicator of the total amount of organic matter available to microbial communities to use as a carbon source for biodegradation of COCs that are used as an electron acceptor. Elevated TOC concentrations are a positive indicator of natural attenuation potential.	< 20	1.3 to 5	No	1 to 1.3	No
Ethane (mg/L)	Ethane is an ultimate daughter product of chlorinated ethanes and ethenes. These parameters are an indicator of complete dechlorination. Detectable concentrations of ethane are a favorable indicator natural attenuation of chlorinated VOCs.	Detectable Concentrations	Not Detected	No	Not Detected	No
Ethene	Ethene is an ultimate daughter product of chlorinated ethanes and ethenes. These parameters are an indicator of complete dechlorination. Detectable concentrations of ethene are a favorable indicator natural attenuation of chlorinated VOCs.	Detectable Concentrations	Not Detected	No	0.005 U to 0.0023	No, favorable result isolated
Chloride (mg/L)	Chloride is generated during the reductive dechlorination of chlorinated VOCs. Concentrations of chloride above background levels indicate that chlorinated compounds are being degraded.	Greater than Background	10 to 18	Neutral	18 to 41	Neutral
pH (SU)	The pH of groundwater affects the presence and activity of microbial populations in groundwater. The pH for optimal growth of the bacteria for reductive dechlorination generally falls between pH 6 and 8 SUs.	6 - 8	6.17 to 6.79	Yes	6.36 to 7.02	Yes
Alkalinity (mg/L)	Alkalinity is a measurement of the available buffering capacity against pH change, which can affect the rate of degradation of chemicals. Moderate to elevated alkalinity levels are generally favorable for natural attenuation of chlorinated VOCs.	> 50	200 to 420	Yes	310 to 430	Yes

[a] If readings are near the Project Indicator Level, engineering judgment may be used to determine favorability.

Notes:
< = less than
> = greater than
COC = constituent of concern
DO = dissolved oxygen
J = Analyte present, value may or may not be accurate or precise
mg/L = milligram(s) per liter
mV = millivolt(s)
ORP = oxidation=reduction potential
SU = standard unit
TOC = total organic carbon
U = The material was analyzed for, but not detected
UCH = Upper Castle Hayne

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Legend

Monitoring Wells
- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Middle Castle Hayne Aquifer
- LTM Surface Water Sample Location
- Surface Water Centerline
- Approximate Direction of Surficial Aquifer Groundwater Flow
- Approximate Direction of UCH Aquifer Groundwater Flow

- Installation Boundary

Land Use Control Boundaries
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (soil)
- Intrusive Activities Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control (Vapor Intrusion)

N

0 1,000 2,000 Feet

1 inch = 1,000 feet

Figure 7-1
OU 6 (Sites 36, 43, 44, and 54)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

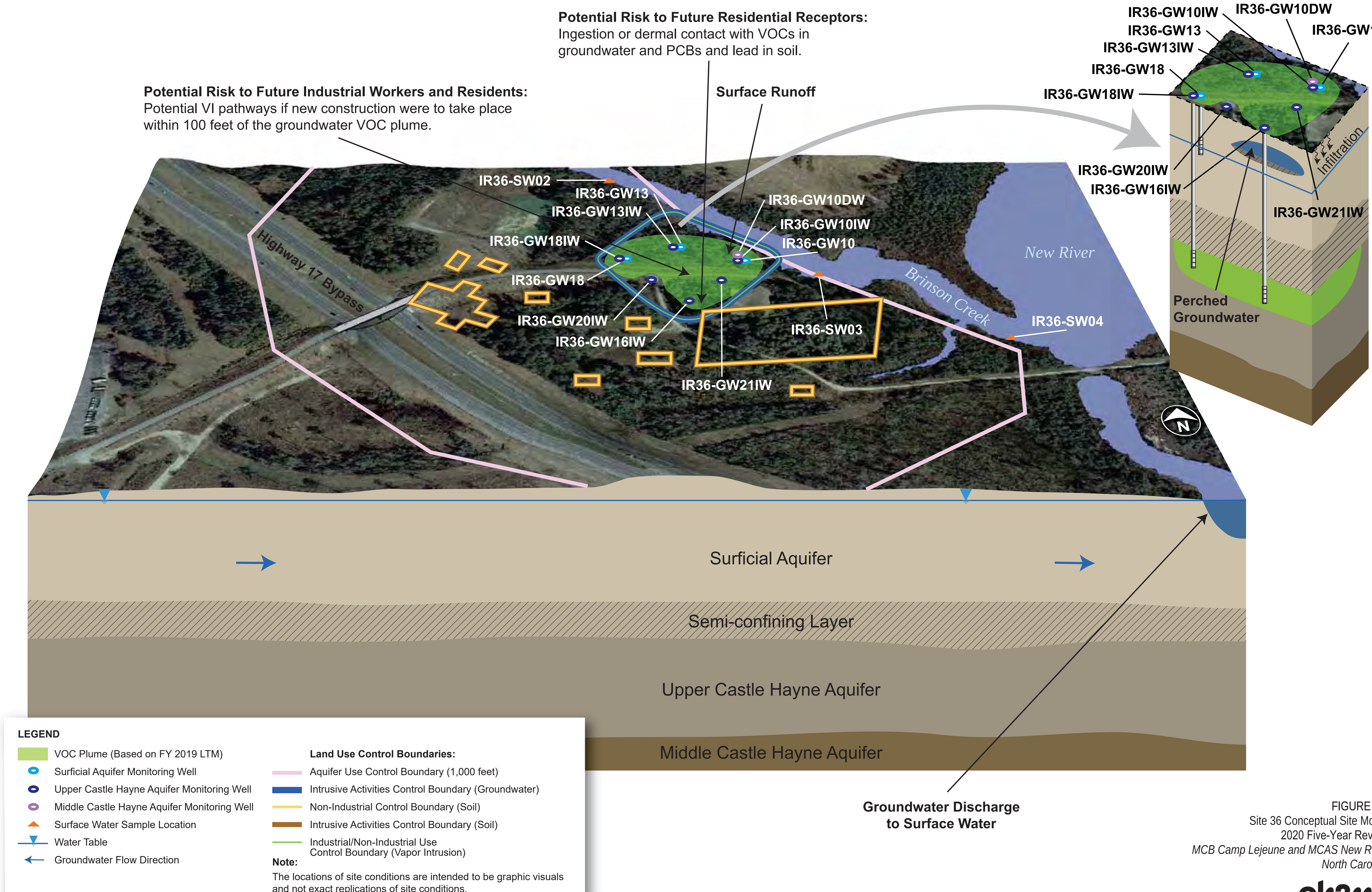

FIGURE 7-2
Site 36 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

Legend

- Installation Boundary
- Upper Castle Hayne (UCH) Aquifer Monitoring Well

TCE Extent (dashed where inferred)

- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

Land Use Control Boundary

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N

0 225 450
Feet

1 inch = 450 feet

Figure 7-3
Site 36 Approximate Extent of TCE Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Legend

Installation Boundary

Surficial Aquifer Monitoring Well

VC Extent

0.03 µg/L - 0.3 µg/L

0.3 µg/L - 3 µg/L

Land Use Control Boundary

Aquifer Use Control Boundary

Non-Industrial Use Control Boundary (Soil)

Intrusive Activities Control Boundary (Soil)

Intrusive Activities Control Boundary (Groundwater)

Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N

0 225 450 Feet

1 inch = 450 feet

Figure 7-4
Site 36 Approximate Extent of VC Exceedances in the Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.

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Legend

- Installation Boundary
- Upper Castle Hayne (UCH) Aquifer Monitoring Well

VC Extent (dashed where inferred)

- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L

Land Use Control Boundary

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

Figure 7-5
Site 36 Approximate Extent of VC Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

N

0 225 450
Feet

1 inch = 450 feet

ch2m.

Operable Unit 7 (Sites 1, 28, and 30)

8.1 Site History and Background

OU 7 is within the Mainside area of the Base (**Figure 1-2**). OU 7 consists of three sites (Sites 1, 28, and 30) that have been grouped together into one OU because of their unique characteristics of suspected waste (POL, oil and gas, and metals) and geographic location. The Site 1, French Creek Liquids Disposal Area, RACR was submitted in 2015 to document the RA was complete with NFA (CH2M, 2015). The closure was included during the 2015 FYR; therefore, Site 1 is not evaluated in this FYR. Site 30, Sneads Ferry Road Fuel Tank Sludge Area, was closed with NFA in 1996 and is not evaluated in the FYR.

OU 7 Timeline	
Year	**Event**
1983	IAS (Sites 1, 28, and 30)
1984-1990	Confirmation Study (Sites 1, 28, & 30)
1991	Soil Assessment (Site 1)
1993	Groundwater Study (Site 1)
1994-1995	RI/FS (Sites 1, 28, & 30)
1995-1996	PRAP and ROD (Sites 1, 28, & 30)
1996	NFA (Site 30)
1996-2002	LTM, LUCs (Sites 1 & 28)
2014	LUCIP Update (Site 28)
2015	RACR (Site 1)
2019	Basewide PFAS PA (Sites 1, 28, & 30)[3]

Site 28 — the **Hadnot Point Burn Dump** is approximately 17 acres and operated from 1946 to 1971 as a burn area for a variety of solid wastes generated on the Base (**Figure 8-1**). Industrial waste, trash, oil-based paint, and construction debris were reportedly burned and then covered with soil. In 1971, the burn dump ceased operations and was graded and seeded with grass. The total volume of fill within the dump is estimated to be between 185,000 and 375,000 cubic yards.

8.2 Site Characterization

The findings from various investigations at OU 7 pertinent to the FYR are summarized in this section.

8.2.1 Physical Characteristics

- **Surface Features –** Site 28 is located along the eastern bank of the New River and consists of two lawn and recreation areas. Picnic pavilions, playground equipment, and a stocked fish pond are located within the recreation area (Baker, 1995a). The site is surrounded by wooded, marshy areas and Orde Pond to the north and east, and the New River to the south and west. The site is bisected by Cogdels Creek before it discharges into the New River.

- **Geology and Hydrogeology –** Subsurface conditions at Site 28 generally consist of Coastal Plain deposits consisting of silty sands with thinly interbedded discontinuous layers of clay and silty clay. Groundwater is not currently a medium of concern at Site 28 and historically only the surficial aquifer has been impacted. Based on proximity to surface water, surficial groundwater is assumed to flow toward the New River (**Figure 8-1**).

8.2.2 Land Use

- **Current Land Use –** Most of Site 28 is used for recreation and physical training exercises and the area north of Julian C. Smith Road is currently used as a construction material staging area.

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3 Sites 1 and 30 were evaluated in the Basewide PFAS PA as potential PFAS release areas based on designations as disposal sites. No documentation or institutional knowledge of AFFF, or other PFAS-containing materials, being used, released, or transferred was identified at Sites 1 and 30; therefore, no further evaluation was recommended (CH2M, 2019).

- **Future Land Use –** There are no anticipated changes in land use.

8.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at Site 28. Details are located in the OU 7 RI report (Baker, 1995a) and the OU 7 ROD (Baker, 1996).

Soil, groundwater, surface water, sediment, and fish tissue were investigated. The HHRA evaluated current military personnel and adult and child residents, and potential future adult and child resident and construction worker scenarios. Unacceptable risks to current and potential future child receptors were identified from exposure to metals in soil, groundwater, and sediment from the New River. However, concentrations of metals in soil were just above the screening criteria; therefore, the risks associated with exposure to soils were deemed to be low and metals were not retained as COCs in soil. Additionally, the ROD identified a nearby firing range as a potential source of metals contamination to the New River, rather than Site 28. Unacceptable risks to future adult residents were identified from exposure to metals in groundwater. The ERA evaluated terrestrial and aquatic receptor scenarios and habitats and concluded that risks were not significant.

8.3 Remedial Action Objectives

The OU 7 ROD was signed in 1996 (Baker, 1996) with the following RAOs:

- Prevent current and future exposure to contaminated groundwater.
- Protect uncontaminated water for future potential use.

The COCs and cleanup levels for Site 28 are presented in **Table 8-1**.

8.4 Remedial Actions

The RA for OU 7 includes the following major components:

- LTM of metals in groundwater.
- LUCs to prevent exposure to and use of contaminated groundwater and limit future land use.

8.4.1 Remedy Implementation

LTM at Site 28 was implemented in July 1996 and monitoring was discontinued in 2001 as discussed in the following section. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002). While not identified as an unacceptable risk in the ROD, buried waste was uncovered during utilities installation activities in 2012 and additional LUCs to prevent exposure to waste material were added in 2014 (CH2M, 2014). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and use of groundwater, except for environmental monitoring, within the extent of waste. This boundary was a 1,000-foot radius from the original extent of groundwater contamination and was maintained when the non-industrial and intrusive activities controls were updated.

- **Non-Industrial Use Control (Waste) -** Prohibit non-industrial land use (i.e., residential housing, hospitals, hotels, nursing homes, and daycare facilities) within the extent of waste remaining in-place.

- **Intrusive Activities Control (Waste):** Restrict intrusive activities within the extent of waste remaining in-place.

8.4.2 Remedy Operation and Maintenance

Long-term Monitoring

In 1996, the LTM program at Site 28 was initiated and included semi-annual sampling of seven monitoring wells for metals analysis. In 1998, LTM was discontinued after four rounds because lead concentrations fluctuated seasonally above and below the cleanup level and manganese consistently exceeded the cleanup level. A confirmatory sampling program was initiated which involved quarterly sampling of three monitoring wells for lead and manganese. In 2002, groundwater monitoring was discontinued, and Site 28 was recommended for removal from the LTM program because lead and manganese were attributed to naturally occurring metals. The fluctuating concentrations observed for lead were attributed to low pH levels in the groundwater from peat material which causes leaching of lead from soil and organic matter into groundwater during higher water table conditions. A close-out report was prepared to document completion of LTM (CH2M and Baker, 2002).

Land Use Controls

The LUCs are shown on **Figure 8-1** and summarized in **Table 8-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There was one unauthorized intrusion recorded in April 2016 by Base Telephone personnel to reroute base telephone utility lines. No waste or debris was reportedly observed, and proper protocol was communicated to Base Telephone. The intrusion was reported to USEPA and NCDEQ in a letter dated April 20, 2016.

In September 2018, a post-hurricane inspection was completed and no damage or issues that could affect protectiveness were observed.

During the FYR site inspections completed in March 2019, a sandy depression with scattered pieces of construction debris (rebar and concrete) was observed immediately outside of the northern edge of the intrusive and non-industrial use control boundaries (**Figure 8-1**). The area north of Julian C Smith Road has historically been used to store construction materials. No other issues were observed (**Appendix B**).

Table 8-2. OU 7 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
	Site 28		
Aquifer Use Control Boundary (1,000 feet)	79.57	October 2014	October 15, 2014
Non-Industrial Use Control Boundary (Waste)	25.73		
Intrusive Activities Control Boundary (Waste)	25.73		

8.4.3 Progress Since the 2015 Five-Year Review

No issues were identified at OU 7 during the 2015 FYR. LUCs continue to be monitored to ensure they remain properly implemented, and violations were promptly addressed. The OU 7 RA components and expected outcomes are summarized in **Table 8-3**.

8.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. Ongoing quarterly inspections have documented that the LUCs are functioning as intended and the remedy remains protective. The intrusive LUC violation that was observed in April 2016 was addressed and no violations have been observed since. Groundwater LTM was discontinued in accordance with the Closeout Report and aquifer use controls are in place to prevent exposure to groundwater (CH2M and Baker, 2002).

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. While the exposure assumptions, cleanup levels, and RAOs used at the time of the ROD are still valid, toxicity data has changed, these changes would not adversely affect the protectiveness of the selected remedy because

LUCs remain in place that restrict unauthorized activities which could result in exposure to waste and groundwater.

Toxicity and Other Contaminant Characteristics: There have been changes in toxicity values for constituents detected in site media since the HHRA was completed and the ROD was signed, however, there have been no changes since the last FYR, which concluded the remedy at Site 28 was protective of human health and the environment (**Table 2-1**).

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 7 remedy with respect to extreme weather events, primarily hurricanes, was completed. Fallen trees may expose buried waste entangled in root systems and potential flooding in Cogdels Creek, Orde Pond, or the New River, or erosion of surface soils from overland flows may also expose waste. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

8.6 Issues, Recommendations, and Follow-up Actions

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Site 28 was evaluated in the Basewide PFAS PA as a potential release area based on designation as a disposal site. There are limited disposal records and based on the burning activities and disposal of industrial waste, there is the potential for AFFF or other PFAS-containing materials to have been used or disposed of at Site 28. Additionally, the former Hadnot Point WWTP and sludge drying beds are located within the Site 28 aquifer use control boundary. There is a potential for a PFAS release in the wastewater and associated sludge from the industrial area at Hadnot Point. Therefore, further evaluation was recommended (CH2M, 2019).

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release area; therefore, there is no current exposure pathway (CH2M, 2019). Site 28 will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

8.7 Statement of Protectiveness

The remedy at OU 7 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial land use, and to restrict intrusive activities.

8.8 References

Baker Environmental, Inc. (Baker). 1991. *Final Site Assessment Report for Site 1 French Creek Liquids Disposal Area, Marine Corps Base Camp Lejeune, North Carolina.* December.

Baker. 1993. *Remedial Investigation/Feasibility Study Work Plan for Operable Unit 7 (OU 7) Sites 1, 28, and 30. Marine Corps Base Camp Lejeune. North Carolina.* December.

Baker. 1995a. *Remedial Investigation, Operable Unit No. 7 (Sites 1, 28, and 30). Marine Corps Base, Camp Lejeune. North Carolina.* June.

Baker. 1995b. *Feasibility Study Report, Operable Unit No. 7 (Sites 1, 28, and 30). Marine Corps Base, Camp Lejeune, North Carolina.* July.

Baker. 1995c. *Proposed Remedial Action Plan, Operable Unit No. 7 (Sites 1, 28 and 30). Marine Corps Base, Camp Lejeune, North Carolina.* July.

Baker. 1996. *Record of Decision, Operable Unit No. 7, Sites 1, 28, and 30. Marine Corps Base, Camp Lejeune. North Carolina.* October.

Baker. 2002. *Land Use Control Implementation Plans. Marine Corps Base Camp Lejeune, North Carolina*. July.

CH2M HILL, Inc. (CH2M) and Baker. 2002. *Closeout Report. Operable Unit No. 7, Sites 1 & 28, Marine Corps Base Camp Lejeune, North Carolina.* September.

CH2M. 2014. *Land Use Control Implementation Plan Update, Site 28, Operable Unit No. 7. Marine Corps Installation East – Marine Corps Base Camp Lejeune, North Carolina*. October.

CH2M. 2015. *Remedial Action Completion Report, Operable Unit 7, Site 1. Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina.* February.

CH2M. 2019. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* December.

Environmental Science and Engineering, Inc. (ESE). 1990. *Site Summary Report Final, Marine Corps Base Camp Lejeune, North Carolina.* September.

Water and Air Research, Inc. (WAR). 1983. *Initial Assessment Study for MCB Camp Lejeune, North Carolina.*

Table 8-1. Cleanup Levels for OU 7 (Site 28)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (Baker, 1996)	Current Standard	
			Concentration	Reference
Metals				
Groundwater (µg/L)	Lead	15	15	NCGWQS/MCL
	Manganese	50	50	NCGWQS

[a] Cleanup Level is the more conservative between the NCGWQS and MCL; NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Shading indicates groundwater monitoring complete per Closeout Report (CH2M and Baker, 2002)

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

µg/L = microgram(s) per liter

COC = constituent of concern

NCGWQS = North Carolina Groundwater Quality Standard

Table 8-3. OU 7 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
28	Groundwater	Potential unacceptable risks to future residential adult and children from exposure to metals in groundwater.	Industrial/ Recreational	Prevent current and future exposure to groundwater that may be contaminated by waste-in-place.	LTM	LTM was discontinued because metals concentrations were indicative of natural conditions.	Non-Residential Land Use
					LUCs	Maintain aquifer use controls and monitor quarterly. Aquifer use restrictions will continue to be implemented because waste remains in-place and groundwater cleanup levels will not be achieved.	
	Waste	Potential unacceptable exposure to waste-in-place.		Prevent exposure to waste-in-place.	LUCs	Maintain non-industrial and intrusive activities controls and monitor quarterly.	

Notes:

LTM = long-term monitoring

LUC = land use control

RAO = remedial action objective

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Legend

- Sandy depression observed during March 2019 inspection
- Surface Water Centerline
- Groundwater Flow Direction Inferred
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Waste)
- Intrusive Activities Control Boundary (Waste)

N

0 250 500 Feet

1 inch = 500 feet

Figure 8-1
OU 7 (Site 28)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Operable Unit 8 (Site 16)

9.1 Site History and Background

OU 8 consists of Site 16 in the Montford Point area of the Base (**Figure 1-2**).

Site 16 — The **Former Montford Point Burn Dump** is approximately 4 acres (**Figure 9-1**). The dump was open from approximately 1958 to 1972; although unauthorized dumping subsequently occurred. Trash from the surrounding housing area and buildings is suspected to have been burned and then covered with soil. Records indicate building debris, garbage, tires, and small amounts of waste oils were disposed at the site. Materials, including asbestos insulating material for pipes, were also dumped on the surface. The quantity of asbestos material was estimated at less than 1 cubic yard and mitigation was completed.

OU 8 Timeline	
Year	**Event**
1983	IAS
1994-1996	RI
1996	PRAP/ROD
2001-2002	RIP (LUCs)
2012	ESD
2014	LUCIP Update
2019	Basewide PFAS PA

9.2 Site Characterization

The findings from various investigations at OU 8 that are pertinent to the FYR are summarized in this section.

9.2.1 Physical Characteristics

- **Surface Features –** Site 16 is relatively flat. The area surrounding the site is heavily wooded with pine and hardwood forest. Northeast Creek is approximately 400 feet southeast of the site and flows in the southwesterly directions toward the New River. Surface drainage is to the southeast toward Northeast Creek.

- **Geology and Hydrogeology –** Site 16 is primarily underlain by sands and silty sands with lenses and/or discontinuous layers of sand and clay, clay, and sandy clay. Groundwater at Site 16 flows southeast, in the direction of Northeast Creek (**Figure 9-1**).

9.2.2 Land Use

- **Current Land Use –** Site 16 is vacant and access by vehicles is prevented by a gate at the entrance to the site.
- **Future Land Use –** There are no anticipated changes in land use.

9.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 8. Details are located in the OU 8 RI (Baker, 1996a) and the OU 8 ROD (Baker, 1996b).

Soil, groundwater, surface water, and sediment were investigated. The HHRA evaluated current military personnel and potential future adult and child residents and construction workers. Potential unacceptable human health risks were identified for future child residents due to the presence of PCBs, specifically Aroclor-1254, in soil. However, the maximum detected PCB concentration (2.1 parts per million [ppm]) was below the recommended cleanup level for PCBs of 10 to 25 ppm for industrial areas and no action was recommended. Although there were no risks from contaminants in groundwater, a single detection of benzene exceeded the MCL. The ERA evaluated terrestrial and aquatic receptors and no unacceptable ecological risks were identified.

Although risks were considered minimal, LUCs were implemented by the Base in 2001 for planning purposes, due to the site's past use as a disposal area (CH2M, 2012).

9.3 Remedial Action Objectives

The ROD for OU 8 was signed in September 1996 (Baker, 1996b). The selected remedy in the ROD was NFA because risks were considered minimal.

An ESD for OU 8 was signed in November 2012 (CH2M, 2012) with the following RAO:

- Prevent exposure to waste due to the uncertainty of whether it would present unacceptable risk should exposure occur.

9.4 Remedial Actions

The RA selected in the ESD for OU 8 includes the following major component:

- LUCs to prevent exposure to waste and potentially contaminated groundwater and soil.

9.4.1 Remedy Implementation

LUCs were implemented in 2001 and updated in 2002 (Baker, 2002) and in 2014 to add an intrusive activities control for soil (CH2M, 2014). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** To prohibit the withdrawal and use of groundwater, except for environmental monitoring, from the surficial and Castle Hayne aquifers within 1,000 feet of the groundwater contamination.
- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use within the extent of soil contamination remaining in-place above concentrations that allow for UU/UE. This includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and daycare facilities.
- **Intrusive Activities Control (Soil):** To restrict intrusive activities within the waste disposal area. This boundary is based on the estimated extent of buried waste.
- **Intrusive Activities Control (Groundwater):** To restrict intrusive activities into groundwater within contaminated groundwater. This boundary is based on the single detection of benzene in groundwater above the MCL.

9.4.2 Remedy Operation and Maintenance

The LUCs are shown on **Figure 9-1** and summarized in **Table 9-1**. LUCs shall be maintained based on the potential presence of buried waste. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations reported during this review cycle.

In September 2018, a post-hurricane inspection was completed and no damage or issues that could affect protectiveness were observed. No unauthorized intrusions or issues affecting protectiveness were observed during the FYR site inspections conducted in March 2019 (**Appendix B**).

Table 9-1. OU 8 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	63.26	August 2014	August 14, 2014
Non-Industrial Use Activities Control Boundary (Soil)	2.12		
Intrusive Activities Control Boundary (Soil)	2.12		
Intrusive Activities Control Boundary (Groundwater)	0.17		

9.4.3 Progress Since the 2015 Five-Year Review

No issues were identified at OU 8 during the 2015 FYR. LUCs continue to be monitored to ensure they remain properly implemented, and no deficiencies or inconsistent use were observed. The current status of OU 8 RA components and expected outcomes are summarized in **Table 9-2**.

9.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. No RA was required; however, LUCs were implemented and remain in place to prohibit non-industrial land use, restrict intrusive activities within the extent of waste and within an area of groundwater contamination above the MCL, and prohibit aquifer use.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. The exposure assumptions and RAOs used in the ESD are still valid. Because there were no unacceptable risks to human health or the environment there were no COCs identified; therefore, changes in toxicity data or cleanup levels are not applicable to this site.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 8 remedy with respect to extreme weather events, primarily hurricanes, was completed. Fallen trees may expose buried waste entangled in root systems and overland flow or potential flooding of Northwest Creek could cause erosion and expose buried waste. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

9.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 8 during this FYR.

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness:

- Site 16 was evaluated in the Basewide PFAS PA as a potential PFAS release area based on past use as a dump. While the site reportedly received WWTP sludge from the Montford Point WWTP, the plant is not suspected to have received PFAS-containing wastewater because the WWTP only received waste from residential, non-industrial activities and did not receive industrial wastewater. Therefore, no further evaluation was recommended (CH2M, 2019).

9.7 Statement of Protectiveness

The remedy at OU 8 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use, non-industrial land use, and restrict intrusive activities within the extent of waste and within an area of groundwater contamination above the MCL.

9.8 References

Baker Environmental Inc. (Baker). 1996a. *Remedial Investigation Report, Operable Unit No. 8 (Site 16)*. *Marine Corps Base Camp Lejeune, North Carolina.* January.

Baker. 1996b. *Record of Decision, Operable Unit No. 8 (Site 16)*. *Marine Corps Base Camp Lejeune, North Carolina*. April.

CH2M HILL, Inc. (CH2M). 2010. *Five-Year Review*. Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. August.

CH2M. 2012. *Explanation of Significant Difference Operable Units 8 (Site 16), 11 (Site 80), and 13 (Site 63). Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina.* July.

CH2M. 2014. *Land Use Control Implementation Plan Site 16, Operable Unit No. 8. Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina.* August.

CH2M. 2019. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances. Marine Corps Base Camp Lejeune and Marine Corps Air Station New River.* December.

Water and Air Research, Inc. (WAR). 1983. *Initial Assessment Study for MCB Camp Lejeune, North Carolina.*

Table 9-2. OU 8 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
16	Soil	Potential unacceptable risks from exposure to site media based on site history as a waste disposal area.	Vacant/Industrial	Prevent exposure to waste due to the uncertainty of whether it would present unacceptable risk should exposure occur.	LUCs	Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring.	Industrial Land Use
	Groundwater	Detected concentration of benzene in groundwater exceeded the MCL.		Prevent exposure to, and use of, groundwater.		Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring.	

Notes:

LUC = land use controls

MCL = maximum contaminant level

RAO = remedial action objective

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Legend

- Approximate Direction of Surficial Aquifer Groundwater Flow
- Surface Water Centerline
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)

N

0 250 500 Feet

1 inch = 500 feet

Figure 9-1
OU 8 (Site 16)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

Operable Unit 10 (Site 35)

10.1 Site History and Background

OU 10 is within the Camp Geiger operations area of MCAS New River (**Figure 1-2**) and consists of Site 35.

Site 35 — The **Former Camp Geiger Fuel Farm** covers approximately 178 acres (**Figure 10-1**). The fuel farm was composed of five 15,000-gallon ASTs, underground fuel transmission lines, a pump house, a fuel unloading pad, an OWS, and a distribution island. The ASTs were installed in 1945 as part of the original Camp Geiger construction. The fuel farm was active until it was decommissioned in the spring of 1995 to make way for the construction of the U.S. Highway 17 Bypass. During the active life of the fuel farm, several releases of fuel occurred. A vehicle maintenance garage (former Building TC474) and weapons cleaning area were also present at Site 35.

OU 10 Timeline	
Year	**Event**
1983	IAS
1984-1987	Confirmation Study
1990	Focused FS
1992-1993	Comprehensive Site Assessment
1993-1994	Interim RA Investigation
1994	Interim ROD
1995	RI, Interim FS and Interim ROD
1995-1997	Interim RA
1996	AS Pilot Study
1999-2004	LTM
1998-2003	Natural Attenuation Evaluation
2002-2003	Hot Spot Characterization
2003	Technical Evaluation
2003-2006	ISCO Pilot Study
2005-2008	SRI
2006-2008	ERD NTCRA
2009	FS/PRAP/ROD
2010-2011	RIP (AS, LUCs) and Interim RACR
2011-Present	LTM
2013	AS System Shutdown
2017	ESD
2018-Present	ERD Pilot Study
2019	LUCIP Update
2019-Present	AS Pilot Study

10.2 Site Characterization

The findings from various investigations at OU 10 that are pertinent to the FYR are summarized in this section.

10.2.1 Physical Characteristics

- **Surface Features –** With the exception of the Bypass, which is at a higher elevation than the rest of the site, the ground surface at Site 35 is generally flat. The majority of the site consists of roadways, buildings, former building foundations, and several large parking areas. The eastern portion of the site, beginning at the Bypass, is heavily wooded and slopes down towards Brinson Creek. Stormwater across the developed portion of the site is conveyed via manmade drainage ditches, storm drains, and catch basins, and discharges to Brinson Creek and its tributaries in the northern portion of the site, and Edwards Creek in the southern portion of the site.
- **Geology and Hydrogeology –** Subsurface conditions consist of typical Coastal Plain deposits, including fine-to-medium grained sands, clayey sands, and partially indurated sediments. Groundwater is a medium of concern and the affected aquifers include the surficial aquifer, which is encountered at approximately 1 to 11 feet bgs and extends to a depth of approximately 25 feet bgs; the UCH aquifer, which extends from approximately 25 to 45 feet bgs; and the MCH aquifer, which extends from 45 to 65 feet bgs. In general, the groundwater flow direction within the surficial, UCH, and MCH aquifers is to the northeast towards Brinson Creek and the New River (**Figure 10-1**). The Castle Hayne aquifer confining unit observed between the surficial and Castle Hayne aquifers across much of the Base is either not present or is laterally discontinuous at Site 35 and a hydraulic connection exists between the surficial and UCH aquifers. In the surficial aquifer, the average hydraulic

conductivity is 0.63 ft/day, the average horizontal hydraulic gradient is 0.00615 ft/ft, and the average groundwater velocity is 0.00387 ft/day. In the UCH aquifer, the average hydraulic conductivity ranges from 1.9 ft/day to 7.9 ft/day, the average horizontal hydraulic gradient is 0.00679 ft/ft, and the average groundwater velocity is 0.333 ft/day. The MCH aquifer has an average hydraulic conductivity of 6.5 ft/day with a horizontal hydraulic gradient of 0.00501 ft/ft and a velocity of 0.0325 ft/day (CH2M, 2019b). In the area of impacted groundwater, the vertical gradient between the surficial and UCH aquifers is 0.0818 ft/ft downwards and, similarly, between the UCH and MCH aquifers it is 0.0860 ft/ft downwards. In the wetland area adjacent to Brinson Creek, the vertical gradient between the surficial and UCH aquifers is 0.0373 ft/ft upwards, and between the UCH and MCH aquifers it is 0.0501 ft/ft upwards (CH2M, 2019b).

10.2.2 Land Use

- **Current Land Use** – Portions of Site 35 are currently used by the Camp Geiger School of Infantry for training exercises. Several warehouses, general storage buildings, and troop barracks also occupy the site.
- **Future Land Use** – There are no anticipated changes in land use.

10.2.3 Basis for Taking Action

This section describes the site investigations and risk assessments that provide the basis for taking action at OU 10. Details are in the SRI (CH2M, 2009a) and ROD (CH2M, 2009b).

Soil, groundwater, surface water, sediment, and fish tissue were investigated. HHRAs during the RI and SRI evaluated the current military personnel, and potential future adult and child residents and construction worker scenarios. Unacceptable risks were identified for future residents from ingestion of VOCs in groundwater. Although no unacceptable risks were identified from contaminants in soil, petroleum hydrocarbons exceeded screening levels and a removal action was recommended. The ERAs evaluated terrestrial and aquatic receptors and identified minimal potential risks associated with pesticides and metals in Brinson Creek sediment; however, they were determined not to be site-related as they were not attributed to historical site activities. Therefore, it was concluded that there were no site-related risks to terrestrial and aquatic receptors related to Site 35.

Interim RODs to address soil and surficial aquifer groundwater were signed in September 1994 (Baker, 1994), and September 1995 (Baker, 1995), respectively. The interim RAs for Site 35 included the following major components (**Figure 10-2**):

- Excavation and offsite disposal of VOC-contaminated soil: From September 1995 to May 1996, approximately 15,700 tons of petroleum-contaminated soil were excavated for offsite disposal (OHM, 1997). Concentrations of COCs in soil confirmation samples were below cleanup levels.
- AS using a vertical trench to address VOCs in surficial aquifer groundwater: An AS trench was installed in 1998 to address the northeast portion of surficial aquifer groundwater plume near the former fuel farm. The AS trench operated until 2009 when the final RA was implemented to address sitewide groundwater and it was dismantled.

Pre-ROD Pilot Studies and Actions

Additional RAs and pilot studies were completed in preparation of the FS to address sitewide groundwater, as follows (**Figure 10-2**):

- From December 2003 to July 2005, a pilot study was conducted to evaluate the effectiveness of ISCO in an area of groundwater near the former Fuel Farm. The pilot study involved injection of approximately 26,000 gallons of modified Fenton's reagent followed by injection of approximately 19,400 gallons of potassium permanganate solution. The pilot study achieved 80 to 98 percent reduction of TCE and 72 to 85 percent total VOC reduction within the study area (CH2M, 2006).
- From May 2007 to June 2008 a non-time-critical removal action (NTCRA) consisting of approximately 50,520 pounds of an ERD substrate (50:50 EVO and lactate mix) was injected via DPT in an area of

groundwater with concentrations of TCE greater than 100 µg/L, bounded by Fifth, F, Fourth, and C Streets. The target depth was 20 to 47 feet bgs. Results of the NTCRA monitoring indicated that TCE in surficial aquifer groundwater was decreased by 54 percent and DCE decreased by 69 percent. However, deeper concentrations of TCE and DCE were not reduced significantly (CH2M, 2008).

After completion of these interim RAs and pilot studies, the remaining COCs were chlorinated VOCs in groundwater above NCGWQS and/or MCLs.

Site 35 was included in a Basewide VI evaluation from 2007 to 2015 to assess the potential for site COCs to impact VI in existing buildings within 100 feet of the groundwater plume. Although the evaluation concluded that the VI pathway is not currently significant, based on site-specific COCs, indoor air concentrations could exceed the VISLs should VI occur in the future if new construction were to take place or if future building or land use changes within 100 feet of the groundwater VOC plume (CH2M, 2017a).

10.3 Remedial Action Objectives

The ROD for OU 10 was signed in November 2009 (CH2M, 2009b) and the ESD was signed in June 2017 (CH2M, 2017a). The current RAOs are as follows:

- Restore groundwater quality at Site 35 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201, and to prevent human ingestion of water containing COCs (benzene, 1,1,2,2-tetrachloroethane [PCA], PCE, TCE, cis-1,2-DCE, and VC) at concentrations exceeding NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained.
- Minimize migration of COCs in groundwater to surface water.
- Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk to human health.

The COCs and cleanup levels for OU 10 are presented in **Table 10-1**.

10.4 Remedial Actions

The RA for OU 10 includes the following major components:

- AS using a horizontal directionally drilled (HDD) well to address COCs.
- LTM, consisting of performance monitoring for groundwater to evaluate the effectiveness of the AS system and MNA outside of the active treatment area and sitewide after active treatment is complete.
- LUCs to prevent exposure to contaminants in groundwater and indoor air via the VI pathway.

10.4.1 Remedy Implementation

Air Sparging

The AS system and horizontal well was installed in August 2010 and consists of a 1,080-foot long HDD well with a 500-foot well screen, installed to 50 feet bgs. The AS HDD well was designed to deliver air at a rate of approximately 180 standard cubic feet per minute (scfm) across the well screen, promoting mass transfer of VOCs and/or aerobic biodegradation of benzene and VC. Construction details for the AS system can be found in the IRACR (Shaw, 2011).

Long-term Monitoring and Land Use Controls

LTM began in 2011 and is ongoing as described in the following section. LUCs were implemented at OU 10 in 2010 (CH2M, 2010) and updated in 2019 (CH2M, 2019b). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the land area within 1,000 feet of groundwater with COC concentrations exceeding cleanup levels.
- **Industrial/Non-Industrial Use Control (VI):** Before construction of new buildings or structural modifications to existing buildings and/or land use, the potential for VI will be evaluated by assessing multiple lines of evidence. If the results of the evaluation indicate that VI could result in unacceptable indoor air concentrations, then engineering controls or an action to address the source will be considered to mitigate the unacceptable exposure. This LUC boundary encompasses the area within 100 feet of groundwater within the surficial aquifer with VOC concentrations exceeding cleanup levels.

10.4.2 Remedy Operation and Maintenance

Remedy O&M currently consists of MNA and LUC monitoring. The total annual cost is approximately $40,000.

Air Sparging

The AS system operated from August 2010 to February 2013. The system operated at 180 scfm, except for down times during sampling and system repairs in October 2012. The system was shut down when 71 percent total VOC reduction in source area wells and 75 percent total VOC reduction in UCH aquifer monitoring wells within 100 feet of the sparging well were achieved and BIOCHLOR modeling showed current concentrations to be protective of Brinson Creek. The system was prepared for a period of inactivity and left in place in case it needed to be reactivated (e.g., if rebound occurred). While the AS was operating, performance monitoring included quarterly sampling of three surficial, six UCH, and one MCH aquifer monitoring well for VOC analysis. A soil gas probe was installed and sampled quarterly for VOC analysis during operation to monitor potential VI impacts to the nearest building, Building G560. During AS operation, soil gas data did not exceed the VI screening levels.

Monitored Natural Attenuation

When MNA began in 2011, the sampling protocol consisted of collecting groundwater samples from 14 surficial, 18 UCH, and 5 MCH aquifer monitoring wells. Samples were collected annually for all COCs listed in **Table 10-1**. After the AS system was turned off, the MNA network was optimized and currently includes 12 surficial, 15 UCH, and 3 MCH aquifer monitoring wells. Groundwater samples are collected annually from 7 surficial, 11 UCH, and 1 MCH aquifer monitoring well and every 5 years from 4 surficial, 4 UCH, and 2 MCH aquifer wells for COCs to monitor progress toward achieving cleanup levels. Groundwater samples are also collected every 5 years from all wells for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and TOC) to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs.

In addition to comparing to cleanup levels (**Table 10-1**), data in the surficial aquifer are compared to the residential and non-residential NC VISLs consistent with the overall site use, to evaluate whether concentrations indicate the potential for a complete VI pathway. Groundwater data in the surficial aquifer nearest to Brinson Creek are also compared with 10 times the NCSWQS to determine the potential for groundwater to affect surface water. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of the MNA component of the remedy.

Based on MNA data, two studies were initiated to reduce the timeframe to remediation: a bioremediation treatability study to refine the extent of COCs and reduce concentrations in the southern plume around IR35-MW92IW, and an AS treatability study to evaluate restarting the AS system to treat lingering VC concentrations in the northern plume area (**Figure 10-1**) (CH2M, 2017c). These studies are discussed in **Section 10.4.3**.

Land Use Controls

LUCs are shown on **Figure 10-1** and summarized in **Table 10-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed and no damage to the site was observed. During the FYR site inspection conducted in March 2019, the outer casing on monitoring well IR35-MW30IW was damaged, preventing it from being locked; however, the inner expansion cap was locked (**Appendix B**).

Table 10-2. OU 10 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary	178.6	May 2019	August 16, 2010
Industrial/Non-Industrial Control Boundary (VI)	61.6		April 16, 2019

10.4.3 Post-ROD Removal Actions and Pilot Studies

South Plume Bioremediation Treatability Study

In 2018, a treatability study was initiated to address COCs in the southern plume. The objectives of the study were to refine the extent of the COCs in the UCH aquifer in the southern plume and evaluate the effectiveness of ERD using EVO, bioaugmentation, and red yeast rice extract (a methane inhibitor) to treat COCs (CH2M, 2019a).

Three new monitoring wells (IR35-MW95IW, IR35-MW96IW, and IR35-MW97IW) were installed in December 2017 and sampled in January 2018 to confirm the area of highest concentration. Consistent with historical results, the highest concentrations of PCE and TCE were found at IR35-MW92IW and IR35-MW94IW. Based on these results, six injection wells, three at IR35-MW92IW and three at IR35-MW94IW, were installed in April 2019 (**Figure 10-1**). Injections took place in July and August 2019 and three quarters of performance monitoring are planned.

Air Sparging Treatability Study

In 2019, a treatability study was initiated to restart the existing AS system to reduce concentrations of lingering VC in the surficial and UCH aquifers in the northern plume. The Uniform Federal Policy Sampling and Analysis Plan was finalized in August 2019 and the system restart is planned for Fall 2019. Performance monitoring including groundwater and soil gas sampling will be conducted monthly for the first three months of operations and quarterly thereafter (CH2M, 2019d).

10.4.4 Progress since the 2015 Five-Year Review

Issues identified during the 2015 FYR and follow-up actions are summarized in **Table 10-3**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 10-2**. The OU 10 RA components and expected outcomes are summarized in **Table 10-4**.

Table 10-3. 2015 FYR OU 10 Issues, Recommendations, and Follow-up Actions

Issues	Recommendations (Milestones)	Date Complete/Current Status
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI) (6/30/2016)	Completed June 30, 2016. The Draft ESD was submitted June 30, 2016, finalized March 30, 2017, and signed on June 1, 2017 to update the RAOs for OU 10 to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI) (CH2M, 2017a). The LUCIP Update was finalized in May 2019 (CH2M, 2019b).

10.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?

Yes. Shutdown criteria for AS were met in 2013 and MNA results indicate that natural attenuation is occurring, as discussed in the following sections. LUCs are in place to prevent exposure to groundwater COCs at concentrations above cleanup levels and evaluate the VI pathway, as necessary.

Air Sparging

The horizontal AS well operated from August 2010 to February 2013 until shutdown criteria were met. COCs were reduced to levels protective of Brinson Creek, and total VOCs concentrations decreased by 75 percent in monitoring wells located within 100 feet of the AS well. The AS system will be restarted in 2020 to further reduce lingering VC concentrations and reduce the timeframe to remediation (CH2M, 2019d).

Monitored Natural Attenuation

Based on data reported in the FY 2018 report and data collected in support of the FY 2019 report, MNA is effective. MK statistical analysis was completed for each COC in each aquifer using post-AS data to evaluate MNA after active treatment was completed. The following is a summary from the FY 2018 report and included FY 2019 data (CH2M, 2019c).

In the surficial aquifer, benzene, TCE, and VC were the only COCs detected above cleanup levels during the most recent round of sampling at two, one, and five locations, respectively. Based on MK statistical analysis, benzene and TCE are stable at locations that continue to exceed cleanup levels. VC is the most widely detected COC in the surficial aquifer and the extent, historical and most recent concentrations, and MK statistical analysis results are shown on **Figure 10-3**. The MK statistical analysis indicated that VC trends are stable except for IR35-MW10, which had no trend (fluctuating concentrations) and was reported at the highest concentration (52 µg/L) in 2018. VC was the only COC that exceeded the residential NC VISL within 100 feet of a building (**Figure 10-3**). This building will be evaluated in the upcoming VI FYR (CH2M, 2019e).

Surficial aquifer groundwater near Brinson Creek is monitored for exceedances of 10 times the NCSWQS as an indicator for potential impacts to the creek. One location, IR35-MW62, reported sporadic exceedances of 10 times the NCSWQS for VC (24 µg/L) during this 5-year cycle and the monitoring frequency was increased to quarterly and then to semi-annually based on results. Concentrations ranged from 15.1 to 33 µg/L and exceeded 10 times the NCSWQS in six out of the nine most recent rounds of sampling (CH2M, 2017c, 2019c). VC is stable in groundwater according to the MK statistical analysis. During the most recent LTM sampling event in December 2018, IR35-MW62 appeared to be compromised and was abandoned. The FY 2018 report recommended considering additional investigation of Brinson Creek to determine if groundwater is impacting surface water (CH2M, 2019c).

In the UCH aquifer, all COCs were detected above cleanup levels except 1,1,2,2-PCA (not detected) and trans-1,2-DCE (detected below cleanup levels). Of these, PCE and cis-1,2-DCE exceeded cleanup levels at one location each, both with stable trends, and benzene was detected above cleanup levels at 3 locations with stable to decreasing trends (CH2M, 2019c). The current and historical extent, concentrations, and MK statistical analysis results for TCE, cis-1,2-DCE, and VC are shown on **Figures 10-4** through **10-6**. MK statistical results indicate that COC concentrations have also generally remained stable or decreasing in the UCH aquifer except for increasing VC at IR35-MW80IW (**Figure 10-6**). Increasing daughter products is an indicator that degradation is occurring. In the southern plume, MK statistical results indicate that concentrations of COCs were generally stable. Natural attenuation does not appear to be occurring, and two COCs remain at concentrations that exceed cleanup levels.

In the MCH aquifer, TCE, cis-1,2-DCE, and VC were detected above cleanup levels. MK statistical evaluations were only able to be conducted for VC as insufficient detected data were available for TCE and cis-1,2-DCE (at least 4 data points are required). VC is increasing in IR35-MW03DW (**Figure 10-7**) indicating that degradation is occurring.

A summary of NAIP data is provided in **Table 10-5**. Conditions in the surficial, UCH, and MCH aquifers are generally favorable for reductive dechlorination. Favorable indicators for reductive dechlorination included DO (generally low), ORP (generally negative), ferrous iron (measurable levels), and methane (measurable to moderate levels). Elevated alkalinity in the surficial, UCH, and MCH aquifers provides buffering capacity during degradation. TOC in both aquifer zones was low, which may limit microbial growth.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. While the exposure assumptions and RAOs are still valid since the ROD (CH2M, 2009d) and ESD (CH2M, 2017a), the toxicity data, and standards on which the cleanup levels are based have changed. These changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to groundwater.

Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs and other constituents detected in site media since the HHRA and ROD, there have been no changes since the 2015 FYR, which concluded that the remedy at OU 10 is protective of human health and the environment (**Table 2-1**).

Cleanup Levels: The cleanup levels for groundwater were identified as the more conservative of the NCGWQS and MCL. Since the ROD was signed, the standards for 1,1,2,2- PCA, TCE, and VC have increased; however, the most up to date standards are used to evaluate LTM data (**Table 10-1**).

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 10 remedy with respect to extreme weather events, primarily hurricanes, was completed. The effects of extreme weather events are most likely limited to damage to monitoring wells from fallen trees or damage to the AS system from winds or flooding. However, protectiveness would not be affected because the only risks at OU 10 are from potable use of groundwater and VI. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

10.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 10 during this FYR.

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- As part of the LTM program, surficial aquifer groundwater nearest to Brinson Creek is monitored for exceedances of 10 times the NCSWQS as an indicator for potential impacts to the creek. Concentrations of VC in groundwater nearest to Brinson Creek exceeded 10 times the NCSWQS and an investigation of the groundwater to surface water pathway was recommended in the FY 2018 LTM report (CH2M, 2019c).

The Navy will complete an evaluation of the groundwater to surface water pathway to determine whether groundwater is affecting surface water at concentrations above the NCSWQS and determine whether additional action is warranted as part of the LTM program.

10.7 Statement of Protectiveness

The remedy at OU 10 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and evaluate and/or mitigate potential VI pathways. MNA for groundwater COCs will continue until cleanup levels are achieved.

10.8 References

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Table 10-1. Cleanup Levels for OU 10 (Site 35)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2009)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	***VOCs***			
	1,1,2,2-Tetrachloroethane	0.17	0.2	NCGWQS
	Benzene	1	1	NCGWQS
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	Tetrachloroethene	0.7	0.7	NCGWQS
	Trichloroethene	2.8	3	NCGWQS
	Vinyl chloride	0.015	0.03	NCGWQS

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

µg/L = microgram(s) per liter

COC = constituent of concern

MCL = Maximum Contaminant Level

NCGWQS = North Carolina Groundwater Quality Standard

ROD = Record of Decision

VOC = volatile organic compound

Table 10-4. OU 10 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
35	Groundwater	Potential unacceptable risks to future residents from exposure to VOCs in groundwater.	Industrial	Restore groundwater quality at Site 35 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Prevent human ingestion of water containing COCs (benzene, 1,1,2,2-PCA, PCE, TCE, cis-1,2-DCE, and VC) at concentrations exceeding NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained. Minimize migration of COCs in groundwater to surface water.	AS	AS until a reduction of COC concentrations of 75% in source area wells, COC reductions in source area wells demonstrating an asymptotic trend prior to achieving the target 75% reduction, and/or protectiveness of Brinson Creek is demonstrated through fate and transport modeling, or operation of the system for 3 years. Performance metrics were met and AS was discontinued in February 2013.	UU/UE
					MNA	Implement groundwater MNA to monitor VOC concentrations and migration to surface water until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	
					LUCs	Maintain aquifer use controls and conduct quarterly monitoring until groundwater cleanup levels are achieved.	
		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent future exposure to COCs in indoor air via the VI pathway.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	

Notes:
AS = air sparging
COC = constituent of concern
DCE = dichloroethene
LUC = land use control
MCL = maximum contaminant level
MNA = monitored natural attenuation
NCGWQS = North Carolina Groundwater Quality Standard
PCA = tetrachloroethane
PCE = tetrachlroethene
RAO = remedial action objective
TCE = trichloroethene
UU/UE = unlimited use/unrestricted exposure
VC = vinyl chloride
VI = vapor intrusion
VOC = volatile organic compound

Table 10-5. Natural Attenuation Indicator Parameters Summary - Site 35
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			MCH Aquifer			UCH Aquifer - South (One Location)	
	Description	Favorable Condition[a]	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion	Result	Conclusion
DO (mg/L)	DO is the most thermodynamically favored electron acceptor used by microbes for the biodegradation of organic carbon. However, low levels of DO are generally favorable for reductive dechlorination of chlorinated VOCs.	< 1	0 to 4.43	6 / 8	Yes, unfavorable results isolated	0 to 1.38	8 / 10	Yes, unfavorable results isolated	0.04 to 2.04	1 / 2	Favorable result at one location	0	Yes
ORP (mV)	The ORP of groundwater is a measure of electron activity and is an indicator of the relative tendency of a solution to accept or transfer electrons. However, lower ORPs are generally favorable for natural attenuation of chlorinated VOCs.	< 0	-110 to 274	6 / 8	Yes, unfavorable results isolated	-143 to -47	10 / 10	Yes	-118 to -113	2 / 2	Yes	-80	Yes
Nitrate (mg/L)	Nitrate and nitrite data will be collected to assess whether nitrate-reducing conditions are present because reducing conditions are favorable for natural attenuation.	< 1	0 to 8.8	1 / 8	Yes, unfavorable result isolated	0 to 0	0 / 10	Yes	0 to 0	0 / 2	Yes	0	No
Nitrite (mg/L)	Nitrate and nitrite data will be collected to assess whether nitrate-reducing conditions are present because reducing conditions are favorable for natural attenuation.	Detectable Concentrations	0 to 0	0 / 8	NA	0 to 0	0 / 10	NA	0 to 0	0 / 2	NA	0	No
Ferrous Iron (mg/L)	The presence of dissolved iron indicates that iron-reducing conditions are present, which are favorable for natural attenuation of chlorinated VOCs.	> 1	0 to 2.75	5 / 8	Yes, unfavorable results isolated	1 to 3.75	10 / 10	Yes	0 to 0.25	0 / 2	No	1.5	Yes
Sulfate (mg/L)	If sulfur compounds are present in the aquifer, higher concentrations of sulfate may compete with the reductive dechlorination pathway. Therefore, ideal conditions will maintain low sulfate levels. Depleted sulfate concentrations are also an indicator that sulfate reduction is proceeding, which is a positive indication that conditions are favorable for anaerobic biodegradation.	< 20	5 to 260	4 / 8	Favorable results in 4/8 locations	7.6 to 570	5 / 10	Favorable results in 5/10 locations	2 to 2.1	2 / 2	Yes	25	Yes
Sulfide (mg/L)	The presence of sulfide is a geochemical footprint for sulfate reduction. This is a positive indication that conditions are favorable for anaerobic biodegradation.	Detectable Concentrations	0.8 U to 2.8	1 / 8	No, favorable result isolated	0.8 U to 0.8 U	0 / 10	No	0.8 U to 9.7	1 / 2	Favorable result at one location	0.8 U	No
Methane (mg/L)	Elevated methane levels are geochemical footprint for methanogenesis and suggest that highly reducing conditions are present in the subsurface. This is a favorable indicator for anaerobic biodegradation.	> 0.	0.0066 to 8.3	5 / 8	Favorable results in 5/8 locations	0.026 to 0.81	4 / 10	Favorable results in 4/10 locations	0.049 to 0.079	0 / 2	No	0.019	No
TOC (mg/L)	TOC is an indicator of the total amount of organic matter available to microbial communities to use as a carbon source for biodegradation of COCs used as an electron acceptor. Elevated TOC concentrations are a positive indicator of natural attenuation potential.	< 20	1.2 to 7	0 / 8	No	0.9 J to 3	0 / 10	No	0.89 J to 0.92 J	0 / 2	No	0.77 J	No
Ethane (mg/L)	Ethane is an ultimate daughter product of chlorinated ethanes and ethenes. These parameters are an indicator of complete dechlorination. Increasing concentrations are a positive indicator of reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 8	No	0.005 U to 0.005 U	0 / 10	No	0.005 U to 0.005 U	0 / 2	No	0.005 U	No
Ethene (mg/L)	Ethene is an ultimate daughter product of chlorinated ethanes and ethenes. These parameters are an indicator of complete dechlorination. Increasing concentrations are a positive indicator of reductive dechlorination.	Detectable Concentrations	0.005 U to 0.035	1 / 8	No, favorable result isolated	0.005 U to 0.0038	2 / 10	No, favorable results isolated	0.005 U to 0.005 U	0 / 2	No	0.005 U	No

Table 10-5. Natural Attenuation Indicator Parameters Summary - Site 35
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			MCH Aquifer			UCH Aquifer - South (One Location)	
	Description	**Favorable Condition[a]**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Result**	**Conclusion**
Chloride (mg/L)	Chloride data will be collected if a natural attenuation or enhanced biological remedy is later needed for the site. Enhanced biological treatment methods that reduce aquifer conditions are generally expected to result in increasing concentrations of chloride, if chlorinated compounds are being degraded.	Increasing Values	4.6 to 17	8 / 8	--	7.7 to 72	10 / 10	--	17 to 22	2 / 2	--	9.9	--
pH (SU)	The pH of groundwater affects the presence and activity of microbial populations in groundwater. However, the pH for optimal growth of the bacteria that perform reductive dechlorination generally falls between pH 6 and 8 SUs (Yang, 2017).	6 - 8	3.73 to 7.21	6 / 8	Yes, unfavorable results isolated	6.83 to 7.87	10 / 10	Yes	6.83 to 7.39	2 / 2	Yes	7.03	Yes
Alkalinity (mg/L)	A measurement of the available buffering capacity against pH change, which can affect the rate of degradation of chemicals. Decreasing alkalinity may indicate that pH conditions would be highly influenced by acidity from reductive dechlorination.	> 50	39 to 430	7 / 8	Yes, unfavorable result isolated	260 to 390	10 / 10	Yes	190 to 200	2 / 2	Yes	250	Yes

[a] If readings are near the Project Indicator Level, engineering judgment may be used to determine favorability.

Notes:

< = less than

> = greater than -- = Count not performed; see Project Indicator Level description for rationale.

DO = dissolved oxygen

J = Analyte present, value may or may not be accurate or precise

MCH = Middle Castle Hayne

mg/L = milligram(s) per liter

mV = millivolt(s)

ORP = oxidation-reduction potential

SU = standard unit

TOC = total organic carbon

U = The material was analyzed for, but not detected

UCH = Upper Castle Hayne

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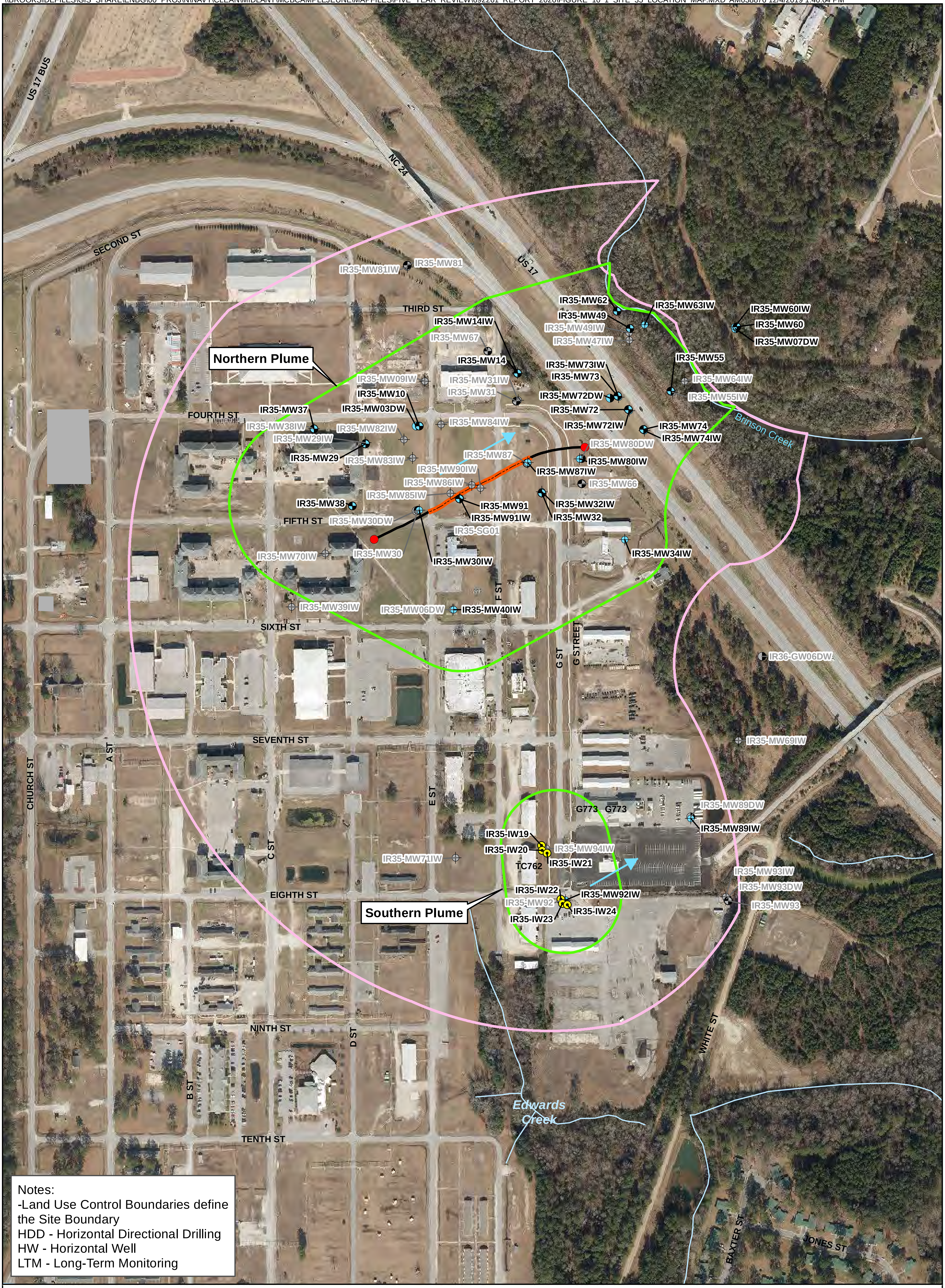

Legend

Monitoring Well
- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Middle Castle Hayne Aquifer
- Surficial Aquifer - not in LTM
- Upper Castle Hayne Aquifer - not in LTM
- Middle Castle Hayne Aquifer - not in LTM
- Injection Well
- HDD Well Entry/Exit Point
- HW and Screened Interval

- Surface Water Centerline
- Groundwater Flow Direction

Land Use Control Boundaries
- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N

0 200 400 800 Feet

1 inch = 400 feet

Figure 10-1
OU 10 (Site 35)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

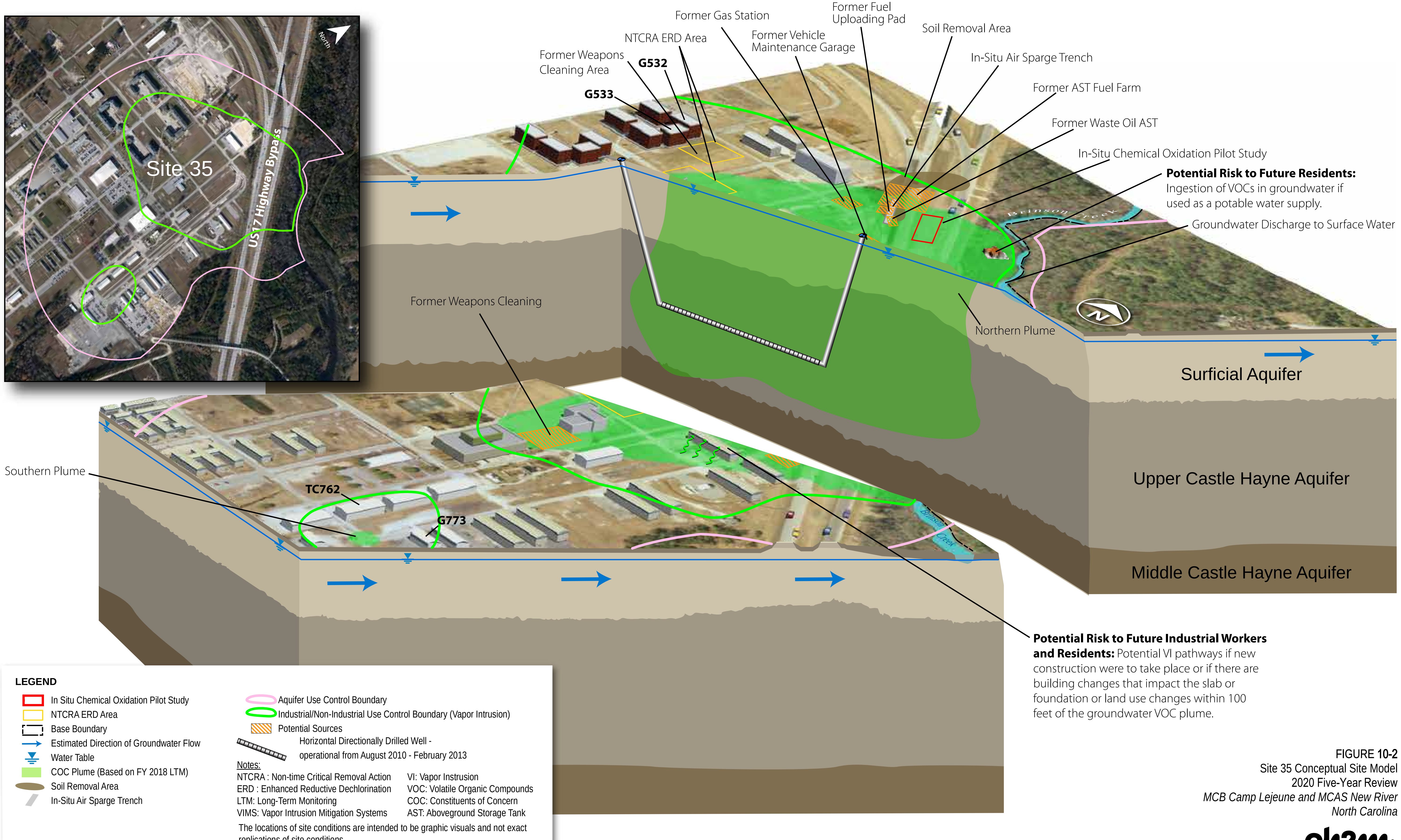

FIGURE 10-2
Site 35 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

ES070313105727GNV MCB_CamLej_Site_35_CSM_v4.ai 8-09-19 tdaus

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Legend

- Surficial Aquifer Monitoring Well
- HDD Well Entry/Exit Point
- Surface Water Centerline
- HW and Screened Interval
- Residential NC VISL Exceedance within 100 Feet of Building

VC Extents

- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

Notes:
VC - Vinyl Chloride
HDD - Horizontal Directional Drilling
HW - Horizontal Well
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/L - Micrograms per liter
MK - Mann Kendall
ND - non-detect

N

0 400 800 Feet

1 inch = 800 feet

Figure 10-3
Approximate Extent of VC Exceedances in the Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Legend

Monitoring Wells
- Upper Castle Hayne Aquifer
- HDD Well Entry/Exit Point
- Surface Water Centerline
- HW and Screened Interval

TCE Extents
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

Notes:
TCE - Trichlorethene
HDD - Horizontal Directional Drilling
HW - Horizontal Well
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/L - Micrograms per liter
MK - Mann Kendall
ND - non-detect

N

0 400 800 Feet

1 inch = 800 feet

Figure 10-4
Approximate Extent of TCE Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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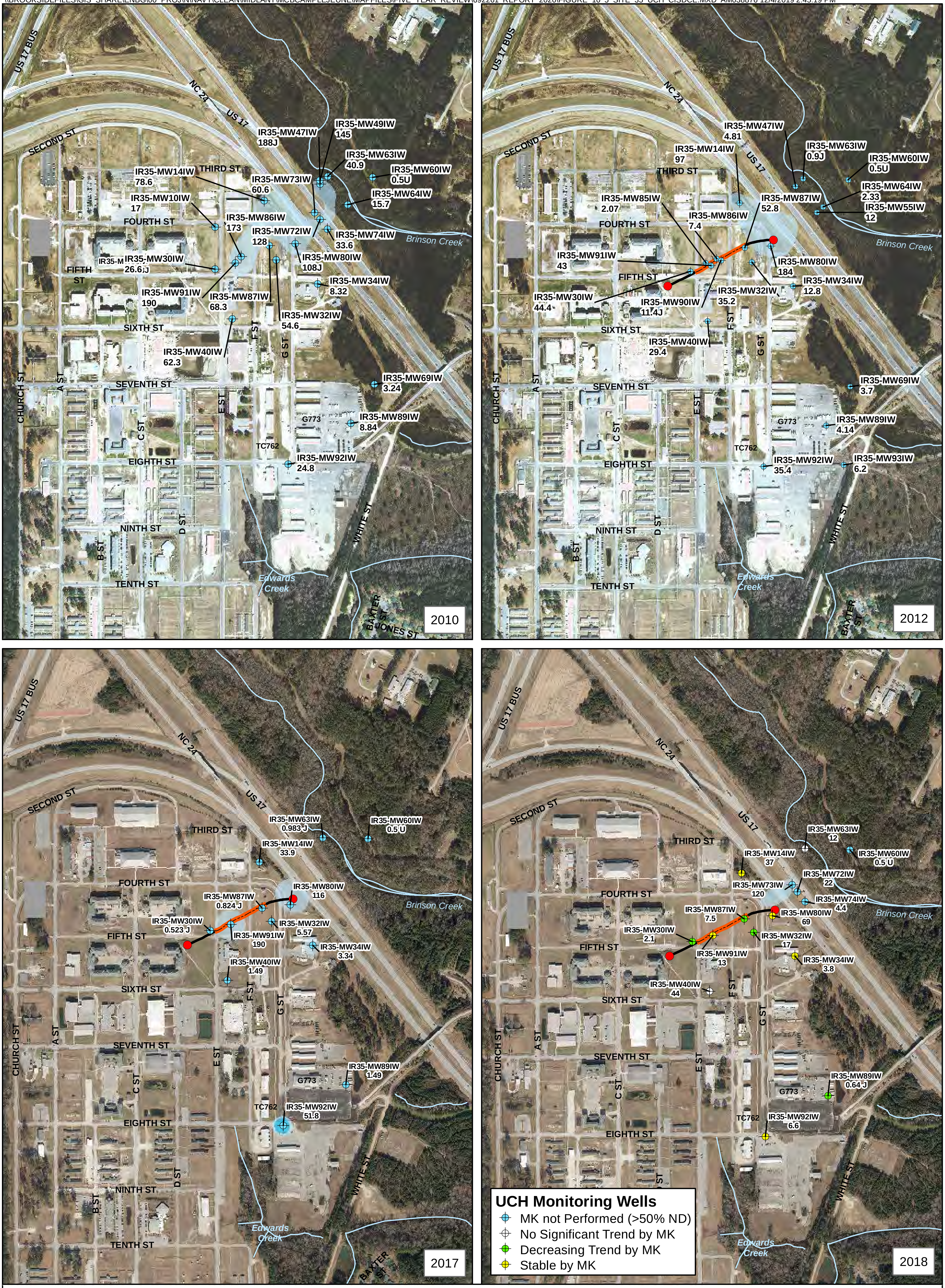

Legend

Monitoring Wells
- Upper Castle Hayne Aquifer
- HDD Well Entry/Exit Point
- Surface Water Centerline
- HW and Screened Interval

cis-1,2-DCE Extents
- 70 µg/L - 700 µg/L

Notes:
cis-1,2-DCE - cis-1,2-Dichloroethene
HDD - Horizontal Directional Drilling
HW - Horizontal Well
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/L - Micrograms per liter
MK - Mann Kendall
ND - non-detect

N

0 400 800
Feet
1 inch = 800 feet

Figure 10-5
Approximate Extent of cis-1,2-DCE Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Legend

Monitoring Wells

- Upper Castle Hayne Aquifer
- HDD Well Entry/Exit Point
- Surface Water Centerline
- HW and Screened Interval

VC Extents

- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

Notes:
VC - Vinyl Chloride
HDD - Horizontal Directional Drilling
HW - Horizontal Well
NS - Not Sampled
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/L - Micrograms per liter
MK - Mann Kendall
ND - non-detect

N

0 400 800 Feet

1 inch = 800 feet

Figure 10-6
Approximate Extent of VC Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\N\NAVY\CLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\FIVE_YEAR_REVIEW\692261_REPORT_2020\FIGURE_10_7_SITE_35_MCH_VC.MXD AM038876 12/4/2019 3:17:19 PM

Legend

Monitoring Wells
- Middle Castle Hayne Aquifer
- HDD Well Entry/Exit Point
- Surface Water Centerline
- HW and Screened Interval

VC Extents
- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

Notes:
VC - Vinyl Chloride
HDD - Horizontal Directional Drilling
HW - Horizontal Well
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
µg/L - Micrograms per liter
MK - Mann Kendall
ND - non-detect

N

0 400 800
Feet

1 inch = 800 feet

Figure 10-7
Approximate Extent of VC Exceedances in the MCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.

Operable Unit 11 (Sites 7 and 80)

11.1 Site History and Background

OU 11 is within the northeast portion of the Base, adjacent to the Northeast Creek (**Figure 1-2**). OU 11 consists of two sites (Sites 7 and 80) that have been grouped together because of their similar disposal history and proximity to one another. Site 7, the Tarawa Terrace Dump was closed with NFA in 1997 and will not be evaluated in this FYR.

Site 80 — Paradise Point Golf Course Maintenance Area is approximately 3 acres within the Paradise Point Golf Course (**Figure 11-1**). Information regarding past maintenance procedures at Site 80 is unknown; however, the facility is currently in operation. Golf course maintenance operations, which include the machine shop (a potential source of waste oils) and the routine spraying of pesticides and herbicides, may have contributed to potential contamination at this site. It is unknown when the wash pad was constructed, and what the exact procedure was for cleaning the maintenance equipment prior to the construction of the wash pad.

OU 11 Timeline	
Year	**Event**
1983	IAS (Site 7)
1991-1992	SI (Sites 7 and 80)
1994-1996	RI (Sites 7 and 80)
1996	TCRA (Soil, Site 80)
1996-1997	PRAP/ROD (Site 7 and 80), NFA (Site 7)
2007-Present	RIP (LUCs) (Site 80)
2012	ESD for LUCs (Site 80)
2019	Basewide PFAS PA (Site 7)[4]

11.2 Site Characterization

The findings from various investigations at Site 80 that are pertinent to the FYR are summarized in this section.

11.2.1 Physical Characteristics

- **Surface Features –** Site 80 is relatively flat, with a slight slope to the northeast, and is partially wooded. A machine shop, a maintenance building, and a maintenance wash down area is present, surrounded by gravel parking and access roads. A drainage ditch is located east of the wash down area.
- **Geology and Hydrogeology –** Subsurface conditions at Site 80 primarily consist of silty sand, sand, and silty clay. The estimated groundwater flow direction is north-northwest towards Northeast Creek (**Figure 11-1**).

11.2.2 Land Use

- **Current Land Use –** Site 80 operates as the maintenance facility for Paradise Point Golf Course.
- **Future Land Use –** There are no anticipated changes in land use.

11.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at Site 80. Details are in the OU 11 RI report (Baker, 1996a) and the ROD (Baker, 1997).

Soil and groundwater were investigated. The HHRA evaluated current Base personnel, and potential future residential children and adults, and construction workers. Potential unacceptable risks were identified for current Base personnel and future residents from pesticides and metals in soil. Potential unacceptable risks were

[4] Site 7 was evaluated in the Basewide PFAS PA as potential PFAS release area based on its designation as a dump. The dump received WWTP filter media, which was assumed to originate from the adjacent former Tarawa Terrace WWTP, which was not suspected to have received PFAS because it serviced the residential housing complex and did not receive any industrial wastewater. Therefore, no further evaluation was recommended (CH2M, 2019).

identified for future residents if exposed to arsenic in the groundwater. The human health risks from exposure to groundwater were considered to be minimal since arsenic was only detected in one monitoring well at a concentration above the then current state and federal drinking water standard of 50 µg/L, the well was observed to have poor groundwater recharge, samples collected from the well were silty, and the TSS were relatively high, which may have contributed to the elevated arsenic detection.

Based on the potential human health risk from exposure to pesticides in soil, a TCRA was completed to remove soil contaminated with pesticides to industrial levels. From March to August 1996, approximately 988 tons of contaminated soil was excavated and transported offsite to a disposal facility. Pesticide concentrations in soil confirmation samples collected from each excavation site did not exceed the risk-based cleanup levels that were based on an industrial worker scenario (OHM, 1996). As part of the HHRA, a post-TCRA scenario where all pesticide-contaminated soil above industrial risk-based cleanup levels was removed was completed and, although metals, particularly arsenic, were expected to remain in soil at concentrations above risk-based levels at some locations, there was no unacceptable risk remaining for all risk scenarios.

Although the ROD did not require RA, LUCs were implemented by the Base in 2007 to encompass the entire site boundary, including the previous soil removal action area where pesticides remain in soil above levels that allow for UU/UE (CH2M, 2012).

11.3 Remedial Action Objectives

The ROD addressing soil and groundwater at OU 11 was signed in August 1997 (Baker, 1997) and the selected remedy was “no action.”

An ESD for OU 11 was signed in November 2012 (CH2M, 2012) with the following RAO:

- Prevent exposure to pesticides in soil.

The cleanup levels for pesticides in soil used in the TCRA are presented in **Table 11-1**.

11.4 Remedial Actions

The RA for OU 11 includes:

- LUCs to prevent potential exposure to COCs in surface soil.

11.4.1 Remedy Implementation

LUCs were implemented at Site 80 in 2007 (CH2M, 2007). The following LUCs were recorded with Onslow County as a Notice of a Contaminated Site and are included in the Base GIS and Master Plan:

- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use, which includes restrictions on the construction of residential housing, elementary and secondary schools, day care facilities, and recreational areas within the site boundary.
- **Intrusive Activities Control (Soil):** Restrict intrusive activities within the site boundary.

11.4.2 Remedy Operation and Maintenance

LUCs are shown on **Figure 11-1** and summarized in **Table 11-2**. LUCs shall be maintained based on the presence of pesticides in soil above residential levels. Monitoring of the LUCs is performed quarterly by the Base; annual reports sent to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In October 2018, a post-hurricane inspection was completed and no damage affecting protectiveness was identified. During the FYR site inspections completed in March 2019, some fallen trees were observed in the wooded areas surrounding the site, but no damage or intrusive activities were observed (**Appendix B**).

Table 11-2. OU 11 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Non-Industrial Use Control Boundary (Soil)	2.93	May 2007	February 8, 2007
Intrusive Activities Control Boundary (Soil)	2.93		

11.4.3 Progress Since the 2015 Five-Year Review

No issues were identified for OU 11 during the 2015 FYR. LUCs continue to be monitored to ensure they remain properly implemented, and no deficiencies or inconsistent uses were observed. The OU 11 RA components and expected outcomes are summarized in **Table 11-3**.

11.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. The TCRA removed potential unacceptable risks to current and reasonably anticipated future receptors and LUCs have been implemented to prohibit non-industrial land use and restrict intrusive activities.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. While the exposure assumptions and RAOs in the ESD are still valid; cleanup levels and toxicity data have changed since the TCRA; however, these changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to soil.

Cleanup Levels: The cleanup levels for pesticides in soil were identified as the USEPA Region III RBCs for industrial soil in the TCRA. The current 2018 industrial soil RSLs are lower for aldrin and dieldrin, and higher for 4,4’-DDD and 4,4’-DDT compared to the cleanup levels identified for the TCRA (**Table 11-1**). The confirmation soil sample results documenting the removal of the pesticide-contaminated soil indicate that the cleanup levels identified in the ROD were met (OHM, 1996). However, the maximum concentration of dieldrin from confirmation samples exceeds the current RSL (**Table 11-1**). Therefore, a risk screening was completed using the maximum concentrations from the TCRA and the risks were within the acceptable risk management range of 10^{-4} to 10^{-6} for cancer risks and below a hazard index of 1 for noncancer hazards for industrial workers (**Table 11-4**).

Toxicity and Other Contaminant Characteristics: There have been some changes in toxicity values since the HHRA was conducted and the ROD was signed, and since the last FYR (**Table 2-1**). However, based on the risk screening discussed above and presented in **Table 11-4**, these changes would not adversely affect the protectiveness of the selected remedy.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 11 remedy with respect to extreme weather events, primarily hurricanes, was completed. No damage or adverse effects of hurricane damage were noted that would affect the protectiveness or performance of the LUCs. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

11.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified for OU 11 during this review.

11.7 Statement of Protectiveness

The remedy at OU 11 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to restrict soil intrusive activities and prohibit non-industrial use within the site boundary, including removal areas where pesticides remain in soil above levels that allow for UU/UE.

11.8 References

Baker Environmental Inc. (Baker). 1996a. *Remedial Investigation Report Operable Unit No. 11 (Site 80). Marine Corps Base Camp Lejeune, North Carolina.* April.

Baker. 1996b. *Proposed Remedial Action Plan Operable Unit No. 11 Site 80, Marine Corps Base Camp Lejeune, North Carolina.* November.

Baker. 1997. *Record of Decision Operable Unit No. 11 (Sites 7 and 80). Marine Corps Base Camp Lejeune, North Carolina*. April.

CH2M HILL, Inc. (CH2M). 2007. *Land Use Control Implementation Plan, Operable Unit Number 11, Site 80. Marine Corps Base Camp Lejeune, North Carolina*. May.

CH2M. 2012. *Explanation of Significant Different Operable Units 8 (Site 16), 11 (Site 80), and 13 (Site 63). Marine Corps Installations East – Marine Corps Base Camp Lejeune, Jacksonville, North Carolina*. July.

Halliburton/NUS. 1992. *Site Inspection Report for Site 80 Paradise Point Golf Course, Marine Corps Base, Camp Lejeune, North Carolina* (DRAFT ACTING AS FINAL). October.

OHM Remediation Services (OHM). 1996. *Contractor's Closeout Report Time Critical Removal Action for Pesticide Contaminated Soil Operable Unit No. 11, Site 80. Marine Corps Base Camp Lejeune, North Carolina*.

Water and Air Research, Inc. (WAR). 1983. *Initial Assessment Study for MCB Camp Lejeune, North Carolina.*

Table 11-1. Cleanup Levels for OU 11 (Site 80)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	TCRA Cleanup Levels (Baker, 1996)	May 2019 Industrial Soil RSL[1]	May 2019 Residential Soil RSL[1]	Maximum Concentration[2]
Soil (µg/kg)	***Pesticides***				
	Aldrin	340	180	39	Not detected
	Alpha-Chlordane	4,400	7,700	1,700	220
	Dieldrin	360	140	34	260
	4,4-DDD	2,400	2,500	190	1,300
	4,4-DDT	1,700	8,500	1,900	610
	Gamma-Chlordane	4,400	7,700	1,700	230

[a] RSLs based on noncarcinogenic endpoints based on hazard index of 0.1 to account for cumulative effects from exposure to multiple chemicals. RSLs based on carcinogenic risks based on carcinogenic risk of 1 x 10^{-6}

[b] Contractor's Closeout Report, TCRA Soil Remediation (OHM, 1996)

Notes:

Shading indicates cleanup levels achieved or no unacceptable risks based on risk screening (Table 11-4)

µg/kg = microgram(s) per kilogram

COC = constituent of concern

DDD = dichlorodiphenyldichloroethane

DDT = dichlorodiphenyltrichloroethane

RSL = Regional Screening Level

TCRA = Time-Critical Removal Action

Table 11-3. OU 11 Remedial Action Summary and Expected Outcomes

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
80	Soil	Potential risk to future residents from exposure to pesticides in soil.	Golf course and maintenance area	Prevent exposure to pesticides in soil.	LUCs	Maintain intrusive and non-industrial use controls and monitor quarterly.	Industrial/ Recreational Land Use

Notes:

LUC = land use control

RAO = remedial action objective

Table 11-4. OU 11 Surface and Subsurface Soil Screening, Industrial Scenario - Risk Ratio, Maximum Detected Concentration

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Maximum Detected Concentration (mg/kg)	Noncarcinogenic Industrial Soil RSL HQ=1 (mg/kg)	Carcinogenic Industrial Soil RSL Excess Lifetime Cancer Risk = 1.0E-6 (mg/kg)	HI[a]	Cancer Risk[b]	Target Organ
Aldrin	Not detected	3.5E+01	1.8E-01	Not detected	Not detected	Liver
Alpha-Chlordane	2.2E-01	4.5E+02	7.7E+00	0.0005	3E-08	Liver
Dieldrin	2.6E-01	4.1E+01	1.4E-01	0.006	2E-06	Liver
4,4-DDD	1.3E+00	2.5E+01	9.6E+00	0.05	1E-07	Liver
4,4-DDT	6.1E-01	5.2E+02	8.5E+00	0.001	7E-08	Liver
Gamma-Chlordane	2.3E-01	4.5E+02	7.7E+00	0.0005	3E-08	Liver
Cumulative Hazard Index[c]				**0.06**		
Cumulative Cancer Risk[d]					**2E-06**	
					Total Liver HI =	0.06

[a] Hazard Index equals maximum detected concentration divided by the noncarcinogenic RSL divided by the acceptable hazard level of 1.

[b] Cancer Risk equals maximum detected concentration divided by the carcinogenic RSL divided by the acceptable risk level of 1 x 10^{-6}.

[c] Cumulative Hazard Index equals sum of Hazard Indices for each constituent.

[d] Cumulative Cancer Risk equals sum of Cancer Risks for each constituent.

Notes:

Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05, otherwise, constituent not selected as COPC.

Constituents selected as COPCs are indicated by shading.

COPC = Constituent of Potential Concern

HI = Hazard Index

mg/kg = milligram(s) per kilogram

RSL = Regional Screening Level, Industrial Soil Screening Level (April 2019)

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Legend

- Estimated groundwater flow
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Soil)

N

0 150 300 Feet

1 inch = 300 feet

Figure 11-1
OU 11 (Sites 80)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

Operable Unit 12 (Site 3)

12.1 Site History and Background

OU 12 is within the Mainside area of the Base (**Figure 1-2**) and consists of Site 3.

Site 3 — the Old Creosote Plant is approximately 5 acres (**Figure 12-1**). The site reportedly operated from 1951 to 1952 to supply treated lumber during construction of the Base Railroad. An onsite sawmill, reportedly located in the northern portion of the site, supplied cut timbers for the creosote treatment.

OU 12 Timeline	
Year	**Event**
1983	IAS
1991-1992	Site Investigation
1994-1996	RI/FS
1996-1999	PRAP/ROD
1997-Present	RIP (LTM)
1997	NTCRA: Soil Removal, Amended ROD
2001-2002	RIP (LUCs)
2015-2017	ORC Pilot Study
2018-Present	Groundwater Extraction Pilot Study

12.2 Site Characterization

The findings from various investigations at OU 12 that are pertinent to the FYR are summarized in this section.

12.2.1 Physical Characteristics

- **Surface Features –** Site 3 is relatively flat, unpaved, and covered with unmaintained grass. The site is bordered by wooded areas to the north, east, and south. Old Sawmill road bisects the site from west to east and the Camp Lejeune Railroad line runs parallel to the site's western edge and intersects an old railroad spur line at the site's southern boundary. Stormwater runoff flows toward drainage swales located along the eastern and western boundaries of the site, ultimately discharging to Wallace Creek to the south.

- **Geology and Hydrogeology –** Site 3 is primarily underlain by sand and silty sand with occasional discontinuous layers of silt and clay. Groundwater is a medium of concern at Site 3 and the affected aquifers include the surficial aquifer which is encountered at depths of approximately 4 to 21 feet bgs and extends to a depth of approximately 30 feet bgs, and the UCH aquifer which extends from approximately 30 to 90 feet bgs. Localized areas of perched groundwater also appear to be present. Groundwater in both aquifers flows to the west, towards an unnamed tributary of Wallace Creek (**Figure 12-1**). In the surficial aquifer, the average hydraulic conductivity is 3.2 ft/day, the average hydraulic gradient is 0.45 ft/day, and the average groundwater velocity is 0.41 ft/day. In the UCH aquifer, the average hydraulic conductivity is 4 ft/day, the average hydraulic gradient is 0.002 ft/ft, and the average groundwater velocity is 0.02 ft/day. A downward vertical gradient exists between the surficial and UCH aquifers.

12.2.2 Land Use

- **Current Land Use –** There are no ongoing operations at Site 3 and the area is currently vacant.
- **Future Land Use –** There are no anticipated changes in land use.

12.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 12. Details are in the OU 12 RI report (Baker, 1996a) and the ROD (Baker, 1997).

Soil and groundwater were investigated. The HHRA evaluated current military personnel, future child and adult residents, and future construction workers. Potential unacceptable risks were identified for future residents from VOCs, SVOCs (primarily PAHs), and metals in groundwater if used as a potable water supply. The metals that were identified in groundwater were aluminum and iron and, although they were present at concentrations above risk-based levels, active remediation was not considered necessary because there did not appear to be a site-related source of either metal and concentrations were similar to background levels (Baker, 1996b). There were no unacceptable ecological risks identified.

Although there were no unacceptable risks associated with exposure to soil, concentrations of some of the analytes detected in subsurface soil exceeded the USEPA Region III soil to groundwater soil screening levels, potentially presenting a source of contamination to groundwater.

12.3 Remedial Action Objectives

The ROD for OU 12 was signed in April 1997 (Baker, 1997) with the following RAOs:

- Prevent leaching of SVOCs from subsurface soil to groundwater.
- Remediate subsurface soil and shallow groundwater.
- Prevent exposure to VOC and SVOC-contaminated groundwater.

The COCs and cleanup levels for OU 12 groundwater and soil are presented in **Tables 12-1** and **12-2**, respectively.

12.4 Remedial Actions

The RA for OU 12 includes the following major components:

- Source removal with onsite biological treatment of soil with SVOC concentrations above the North Carolina soil screening levels (NC SSLs).
- LTM to monitor changes in VOC and SVOC concentrations and extent in groundwater.
- LUC to prevent exposure to COCs in groundwater and restrict site use until soil is remediated.

12.4.1 Remedy Implementation

Source Removal

A pilot-scale treatability study was conducted in 1998 and results indicated that biological treatment of the soil was not effective. As a result, an Amended ROD was signed in 2000 and included excavation of soil with offsite disposal. An NTCRA to remove SVOC-contaminated soil above NC SSLs was completed in 2000. Approximately 3,300 tons of contaminated soil was removed to the depth of the water table and disposed of offsite (OHM, 2001).

Long-term Monitoring and Land Use Controls

LTM at Site 3 was initiated in 1997 and is ongoing as described in the following section. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002a). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the land area within 1,000 feet of groundwater with COC concentrations exceeding cleanup levels.
- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use within the extent of the estimated impacted soil, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.
- **Intrusive Activities Control (Groundwater):** Restrict intrusive activities within the vicinity of the estimated impacted groundwater.

12.4.2 Remedy Operation and Maintenance

Ongoing operations at Site 3 include LTM sampling and LUCs. The annual cost of LTM is approximately $30,000.

Long-term Monitoring

LTM at Site 3 initially consisted of collecting groundwater samples from three surficial and one UCH aquifer monitoring wells for VOCs and SVOCs annually. Over time the monitoring well network and analyte list was optimized as cleanup levels were met for four consecutive sampling events (CH2M, 2013, 2017, 2018).

LTM currently consists of collecting samples from one UCH aquifer monitoring well quarterly for the remaining COCs listed on **Table 12-1**.

Land Use Controls

The LUCs are shown on **Figure 12-1** and summarized in **Table 12-3**. Although not a ROD requirement, a wire fence also restricts access to the site and hazardous waste warning signs are posted. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed, and no damage was noted. During the FYR site inspection completed in March 2019, damage to one sign was noted; however, no issues affecting protectiveness were observed (**Appendix B**).

Table 12-3. OU 12 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	85.21	July 2002	February 15, 2002
Non-Industrial Use Control Boundary (Soil)	0.14		
Intrusive Activities Control Boundary (Groundwater)	4.09		

12.4.3 Post-ROD Removal Actions and Pilot Studies

Oxygen-Releasing Compound and Groundwater Extraction Pilot Studies

To reduce time to site closure and address lingering concentrations of COCs, a pilot study was initiated in 2015 to accelerate the natural attenuation process using an ORC reagent. ORC injections were conducted in the surficial aquifer and ORC socks were installed in the UCH aquifer. Results of the 2015 pilot study indicated that COCs in the surficial aquifer had been reduced to concentrations below cleanup levels. The ORC socks had a limited zone of influence in the UCH aquifer (CH2M, 2017). Thus, a groundwater extraction pilot study was implemented in August 2018 to extract groundwater from IR03-GW02IW to increase the zone of ORC distribution in the UCH aquifer and evaluate COC reductions. Results of this study are pending (CH2M, 2019).

12.4.4 Progress since the 2015 Five-Year Review

No issues were identified for OU 12 during the 2015 FYR. Pilot studies and LTM have been ongoing since the last FYR. LUCs continue to be monitored to ensure they remain properly implemented, and no deficiencies or inconsistent uses were observed.

The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 12-2**. The current status of OU 12 RA components and expected outcomes are summarized in **Table 12-3**.

12.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes, the OU 12 remedy is functioning as designed. The TCRA removed the contaminated soil that was the source of SVOC contamination to groundwater, LTM is ongoing, and LUCs are in place to prevent exposure to COCs at concentrations above cleanup levels.

Long-term Monitoring

Cleanup levels were met in the surficial aquifer groundwater in August 2017 after four rounds of sampling were completed (CH2M, 2018). Three COCs remain in the UCH aquifer above cleanup levels in one or more round out of the previous four rounds (**Figure 12-3**). Groundwater geochemistry changes during the pilot study (DO and pH) and subsequent decrease in COC concentrations indicate the groundwater extraction pilot study aided DO distribution and removed contaminant mass. Performance monitoring is ongoing.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. While exposure assumptions and RAOs used at the time of selection are still valid, toxicity data and the standards on which cleanup levels are based have changed since the ROD. These changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to groundwater and/or soil.

Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs and chemicals detected at the site since the ROD and last FYR (**Table 2-1**), most of the changes would result in a decreased risk, except for an increase in benzo(a)pyrene noncancer hazard. LTM is ongoing to monitor COCs, including benzo(a)pyrene, in groundwater and the LUCs prevent exposure to groundwater until the most current cleanup levels are achieved. Thus, toxicity changes would not affect the protectiveness of the remedy.

Cleanup Levels: The groundwater cleanup levels were identified as the more conservative of the NCGWQS and MCL. Since the ROD was signed, the groundwater standards have been updated as listed in **Table 12-1**. The most current NCGWQS/MCLs are used for comparison in the LTM program, and groundwater COCs remain in the LTM program until they are detected at or below cleanup levels for four consecutive events. Cleanup levels for COCs that were previously removed from LTM have more conservative standards than at the time of the ROD. The cleanup levels that were met for each COC are listed in **Table 12-1** and are either equal to or lower than current standards (CH2M, 2012, 2017, 2018). Aluminum and iron were initially identified as COCs in groundwater; however, the concentrations reported in the RI would not exceed respective BTVs and there were no site-related sources of these metals identified in the RI.

The cleanup levels for SVOCs in soil were identified as the NC SSLs. The recent (February 2018) NC SSL for naphthalene is more conservative than the cleanup level identified in the ROD (**Table 12-2**). However, there were no unacceptable risks from exposure to soil and the soil removal action was implemented to remove a potential source to groundwater, and the maximum detected soil concentrations of all the soil COCs (as presented in the RA Contractor's Closeout Report [OHM, 2000]) were below the current NC SSL. Therefore, changes in the NC SSL do not affect protectiveness and soil LUCs are in-place until all groundwater COCs are below cleanup levels.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 12 remedy with respect to extreme weather events, primarily hurricanes, was completed. The effects of extreme weather events are most likely limited to damage to monitoring wells from fallen trees which does not significantly affect protectiveness of the remedy because the only risk at OU 12 is from potable use of groundwater. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

12.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified for OU 12 during this review.

12.7 Statement of Protectiveness

The remedy at OU 12 protective of human health and the environment.

Exposures that could result in unacceptable risks are being controlled. LUCs are in place to restrict intrusive activities, non-industrial land use, and aquifer use, and LTM is ongoing to monitor the COC concentrations until groundwater cleanup levels are achieved.

12.8 References

Baker Environmental Inc. (Baker). 1996a. *Remedial Investigation Report, Operable Unit No. 12 (Site 3). Marine Corps Base, Camp Lejeune, North Carolina.* July.

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Table 12-1. Groundwater Cleanup Levels for OU 12 (Site 3)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Level[a] (Baker, 1997)	Standard Achieved[b]	Current Standard	
				Concentration	Reference
Groundwater (µg/L)	**VOCs**				
	Benzene	1	1	1	NCGWQS
	Chloroform	0.19	0.19	70	NCGWQS
	Vinyl chloride	--	0.03	0.03	NCGWQS
	SVOCs				
	Acenaphthene	--	80	80	NCGWQS
	Benzo(a)anthracene	0.05	not achieved	0.05	NCGWQS
	Benzo(a)pyrene	2	not achieved	0.005	NCGWQS
	Benzo(b)fluoranthene	0.12	not achieved	0.05	NCGWQS
	Benzo(k)fluoranthene	1	0.5	0.5	NCGWQS
	Bis(2-ethylheyxl)phthalate	--	3	3	NCGWQS
	Carbazole	4	2	2	NCGWQS[c]
	Chrysene	5	5	5	NCGWQS
	Dibenzofuran	6	6	28	NCGWQS[c]
	2,4-Dimethylphenol	31	31	100	NCGWQS
	2-Methylnaphthalene	63	30	30	NCGWQS
	2-Methylphenol	78	78	93	RSL-Tapwater
	Naphthalene	21	6	6	NCGWQS
	Phenanthrene	210	200	200	NCGWQS
	Phenol	300	30	30	NCGWQS
	Metals[d]				
	Aluminum	50	below BTV	2,000	RSL-Tapwater
	Iron	300	below BTV	300	NCGWQS

[a] Cleanup Level is based on the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.
[b] Standard used in the LTM program at the time that the COC concentrations were below for four consecutive sampling events.
[c] Interim Maximum Allowable Concentration
[d] Maximum aluminum concentration (4,030 µg/L) and iron concentration (2,190 µg/L) from 1996 Remedial Investigation do not exceed the respective BTV for surficial aquifer groundwater (14,000 µg/L and 16,100 µg/L).

Notes:
Shading indicates cleanup levels achieved per LTM Report (CH2M, 2013, 2017, 2018)
Current Standard Reference Dates:
NCGWQS (February 2016)
RSL (May 2019)
-- = COC identified post-ROD based on exceedances of current cleanup levels during LTM
µg/L = microgram(s) per liter
BTV = background threshold value
COC = constituent of concern
LTM = long-term monitoring
MCL = maximum contaminant level
NCGWQS = North Carolina Groundwater Quality Standard
ROD = Record of Decision
RSL = regional screening level
SVOC = semivolatile organic compound
VOC = volatile organic compound

Table 12-2. Soil Cleanup Levels for OU 12 (Site 3)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels (Baker, 1997)	2018 NC SSL	Maximum Concentration[a]
Soil (µg/kg)	**SVOCs**			
	Benzo(a)anthracene	343	350	180
	Carbazole	273	740	Not Detected
	Chrysene	3,810	36,000	410
	2-Methylnaphthalene	4,900	3,100	Not Detected
	Naphthalene	585	390	88

[a] Maximum concentration: Remedial Action Contractor's Closeout Report (OHM, 2000)

Notes:

Shading indicates cleanup levels achieved

µg/kg = microgram(s) per kilogram

COC = constituent of concern

NC SSL = North Carolina Soil Screening Level

ROD = Record of Decision

Table 12-4. OU 12 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
3	Soil	SVOCs in soil are a potential source of groundwater contamination.	Vacant/Industrial	Remediate subsurface soil.	Soil Removal	Excavation and offsite disposal of soil to the NC SSL to remove potential source of SVOCs to groundwater.	UU/UE
	Groundwater	Potential unacceptable risks to future residents from exposure to VOCs and SVOCs in groundwater.		Remediate shallow groundwater.	LTM	Implement groundwater LTM to monitor COC concentrations until each groundwater COC is at or below its respective cleanup level for 4 consecutive sampling events.	
				Prevent leaching of SVOCs from subsurface soil to groundwater.	LUCs	Maintain intrusive activities, aquifer use, and non-industrial use controls and monitor quarterly until groundwater cleanup levels are achieved.	
				Prevent exposure to SVOC-contaminated groundwater.			

Notes:
COC = constituent of concern
LTM = long-term monitoring
LUC = land use control
NC SSL = North Carolina Soil Screening Level
RAO = remedial alternative objective
SVOC = semi-volatile organic compound
UU/UE = unlimited use/unrestricted exposure
VOC = volatile organic compound

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Legend
- Upper Castle Hayne Aquifer Monitoring Well
- Surficial Aquifer Monitoring Well - not in LTM
- Upper Castle Hayne Aquifer Monitoring Well - not in LTM
- Middle Castle Hayne Aquifer Monitoring Well - not in LTM
- Direction of Groundwater Flow
- Surface Water

Land Use Control Boundaries
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)

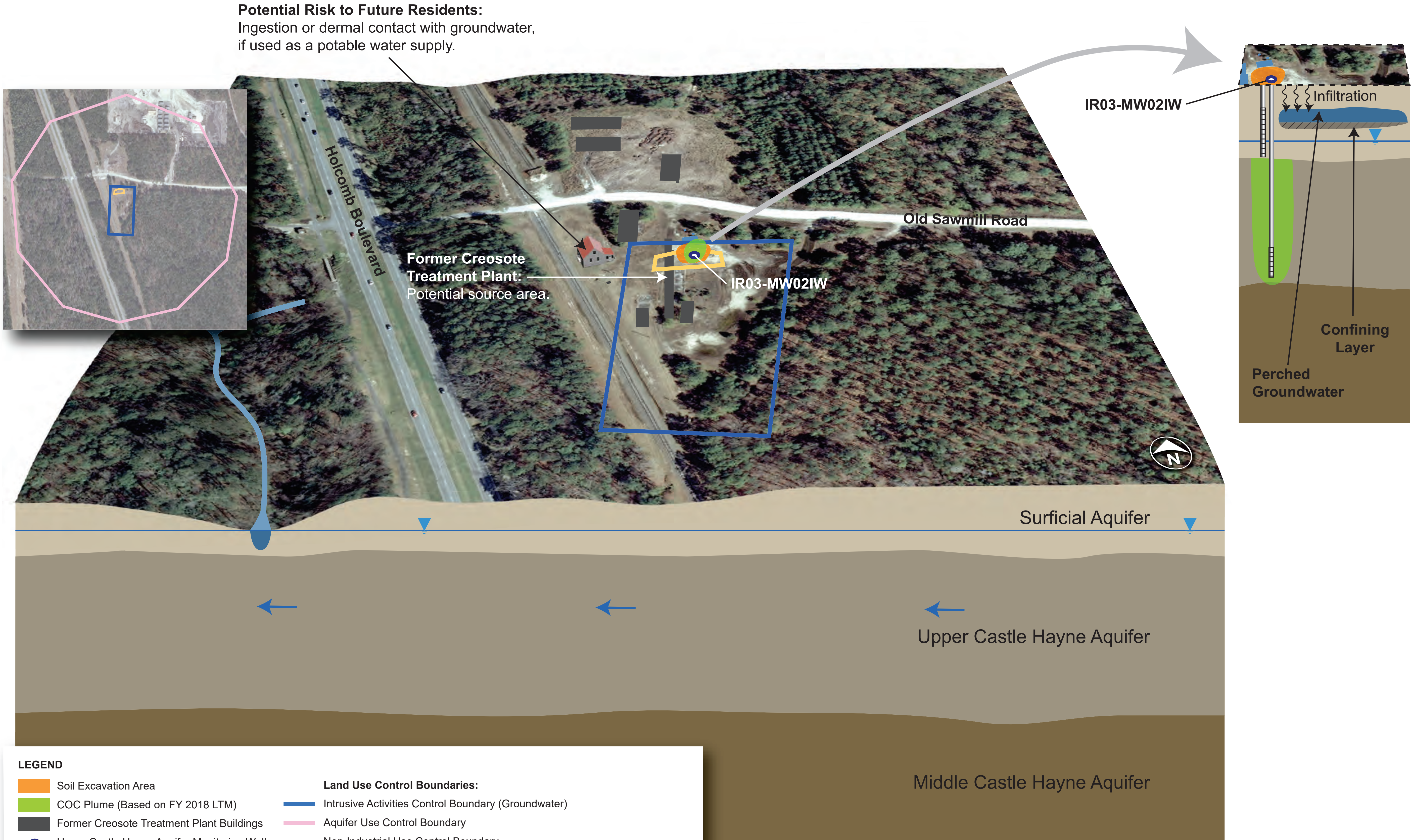
N

0 100 200 Feet

1 inch = 200 feet

Figure 12-1
OU 12 (Site 3)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m



LEGEND

- Soil Excavation Area
- COC Plume (Based on FY 2018 LTM)
- Former Creosote Treatment Plant Buildings
- Upper Castle Hayne Aquifer Monitoring Well
- Water Table
- Estimated Direction of Groundwater Flow

Land Use Control Boundaries:

- Intrusive Activities Control Boundary (Groundwater)
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary

Notes:

Non-industrial use and intrusive activities LUCs were put in place to prevent activities that may enhance possible migration of contaminants. Once the groundwater concentrations are below cleanup levels, all LUCs may be removed.

The locations of site conditions are intended to be graphic visuals and not exact replications of site conditions.

FIGURE 12-2
Site 3 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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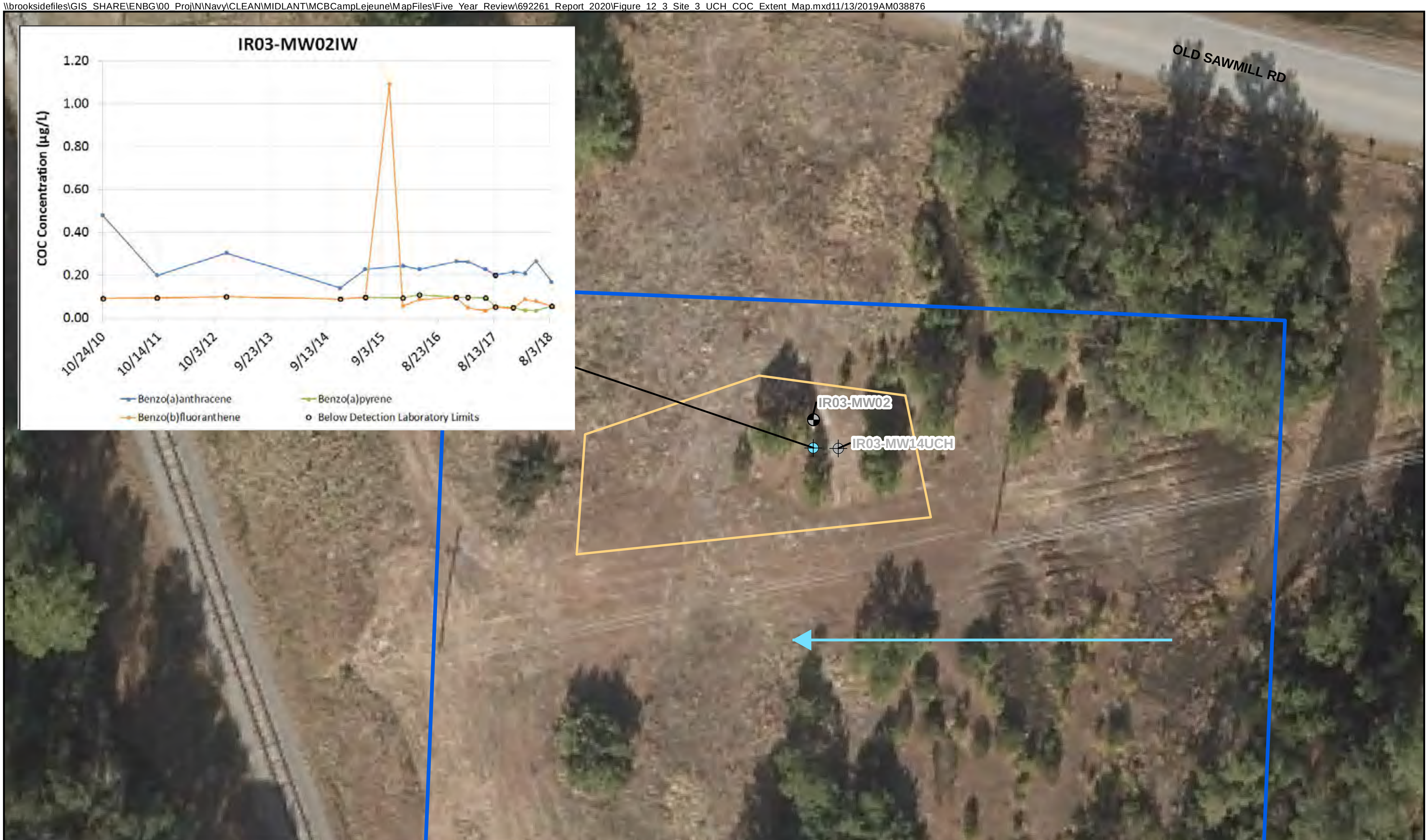

Legend

Upper Castle Hayne Aquifer Monitoring Well
Surficial Aquifer - Pilot Study
Upper Castle Hayne Aquifer Monitoring Well - Pilot Study
GW_Flow

Land Use Control Boundaries

Non-Industrial Use Control Boundary
Intrusive Activities Control Boundary (Groundwater)

Notes:
µg/L - micrograms per liter

N

0 25 50
Feet
1 inch = 50 feet

Figure 12-3
COC Exceedance Map
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

Operable Unit 13 (Site 63)

13.1 Site History and Background

OU 13 is south of the MCAS New River (**Figure 1-2**) and consists of Site 63.

Site 63 — the Verona Loop Dump is approximately 5 acres (**Figure 13-1**). It is nearly 2 miles south of the MCAS New River operations area. The area reportedly received bivouac wastes generated during training exercises. No hazardous wastes were reportedly disposed of at Site 63.

OU 13 Timeline	
Year	**Event**
1983	IAS
1994	Site Investigation
1995-1996	RI
1996-1997	PRAP/ROD
2001-2002	RIP (LUCs)
2012	ESD for LUCs
2014	LUCIP Update
2019	Basewide PFAS PA

13.2 Site Characterization

The findings from various investigations at OU 13 that are pertinent to the FYR are summarized in this section.

13.2.1 Physical Characteristics

- **Surface Features –** Site 63 is relatively flat and heavily vegetated. The eastern portion of the site slopes towards an unnamed tributary that discharges into Mill Run approximately 2,000 feet south of the site. A drainage ditch along Verona Road receives surface water runoff from the extreme southern portion of the site and the asphalt road surface.

- **Geology and Hydrogeology –** Subsurface conditions at the site generally consist of Coastal Plain deposits comprising layers of sand, silt, and clay. Site 63 appears to be located on a groundwater divide with flow to the west and to the east (**Figure 13-1**).

13.2.2 Land Use

- **Current Land Use –** Site 63 is currently used for training exercises, maneuvers, and recreational hunting.
- **Future Land Use –** There are no anticipated changes in land use.

13.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 13. Details are in the OU 13 RI report (Baker, 1996) and the ROD (Baker, 1997).

Soil, groundwater, surface water, and sediment were investigated. The HHRA evaluated current military personnel and adult and child trespassers, and potential future adult and child residents and construction workers. Potential unacceptable risks to future residents were identified from metals, primarily iron and zinc, in groundwater. However, iron is an essential human nutrient and the risks associated with zinc were driven by one groundwater sample and concentrations of zinc were lower or below laboratory detection limits in other site media. Further, groundwater was not used as a potable supply and there were no future plans for use as a potable supply. Therefore, risks from iron and zinc were considered conservative and the current site conditions (non-residential/non-potable use) were considered protective of human health in the ROD. The ERA evaluated terrestrial and aquatic receptors and concluded that there were no unacceptable risks to ecological receptors.

However, waste remains in place and unacceptable risks were assumed from exposure to waste-in-place or impacted soil (CH2M, 2012).

13.3 Remedial Action Objectives

The ROD for OU 13 was signed in 1997 (Baker, 1997) and an ESD was signed in November 2012 (CH2M, 2012). The RAOs are as follows:

- Prevent exposure to, and future use of, groundwater.
- Prevent exposure to waste in place due to the uncertainty of whether it would present unacceptable risk should exposure occur.

13.4 Remedial Actions

The RA for OU 13 consists of the following component:

- LUCs to prevent exposure to soil and groundwater that may be impacted by waste.

13.4.1 Remedy Implementation

LUCs were implemented in 2001 and updated in 2002 (Baker, 2002a) and 2014 (CH2M, 2014) to add intrusive and non-industrial use controls for soil. The following LUCs were recorded with Onslow County as a Notice of a Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and any use of contaminated groundwater, except for environmental monitoring, from the surficial aquifer within 1,000 feet of the area where metals presented a potential unacceptable risk in groundwater.
- **Non-Industrial Use Control (Soil):** Prohibit non-industrial land use within the waste disposal area, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities.
- **Intrusive Activities Control (Groundwater):** Restrict intrusive activities within the area where metals presented a potential unacceptable risk in groundwater.
- **Intrusive Activities Control (Soil):** Restrict intrusive activities within the vicinity of the waste disposal area.

13.4.2 Remedy Operation and Maintenance

The current LUCs are shown on **Figure 13-1** and summarized in **Table 13-1**. LUCs shall be maintained based on the potential presence of buried waste and contaminated groundwater. Monitoring of the LUCs is performed quarterly by the Base; annual reports sent to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations reported during this review cycle.

In October 2018, a post-hurricane inspection was completed and evidence of fallen trees that had been recently cleared from the access road was observed. During the FYR site inspections, completed in March 2019, evidence of possible tree-clearing/cutting activities was observed (**Appendix B**). No unauthorized intrusions or issues affecting protectiveness were observed during inspections.

Table 13-1. OU 13 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	110.28	August 2014	August 14, 2014
Non-Industrial Use Control Boundary (Soil)	5.16		
Intrusive Activities Control Boundary (Soil)	5.16		
Intrusive Activities Control Boundary (Groundwater)	2.05		

13.4.3 Progress Since the 2015 Five-Year Review

No issues were identified at OU 13 during the 2015 FYR. LUCs continue to be monitored to ensure they remain properly implemented, and no deficiencies or inconsistent uses were observed. The current status of OU 13 RA components and expected outcomes are summarized in **Table 13-2**.

13.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. LUCs are in place to prohibit aquifer use, restrict intrusive activities, and prohibit non-industrial land use.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. The exposure assumptions and RAOs used in the ROD and ESD are still valid. No COCs were identified; therefore, changes in toxicity data or cleanup levels are not applicable.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 13 remedy with respect to extreme weather events, primarily hurricanes, was completed. No damage or adverse effects of hurricane damage were noted that would affect the protectiveness or performance of the LUCs. However, overland flow and flooding may cause erosion, potentially exposing buried waste at the surface. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

13.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 13 during this FYR.

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness:

- Site 63 was evaluated in the Basewide PFAS PA as a potential PFAS release area based on its designation as a dump site/waste disposal area. Based on the known use of the area (bivouac waste dump), it is not likely that industrial or consumer materials containing PFAS were disposed at Site 63. Therefore, no further evaluation was recommended (CH2M, 2019).

13.7 Statement of Protectiveness

The remedy at OU 13 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial use and restrict intrusive activities in areas of contaminated groundwater and buried waste.

13.8 References

Baker Environmental Inc. (Baker). 1994. *Site Inspection Report, Site 63, Verona Loop Dump, Marine Corps Base, MCB Camp Lejeune, North Carolina.* January.

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Table 13-2. OU 13 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/ Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
63	Groundwater	Potential unacceptable risks from exposure to metals in groundwater if used as a potable source.	Military Training/Vacant	Prevent exposure to, and future use of, groundwater.	LUCs	Maintain intrusive activities and aquifer use controls and conduct quarterly monitoring.	Military Training/ Industrial
	Soil	Potential unacceptable risks from exposure to site media based on site history as a waste disposal area.		Prevent exposure to waste due to the uncertainty of whether it would present unacceptable risk should exposure occur.		Maintain non-industrial land use and intrusive activities controls and conduct quarterly monitoring.	

Notes:

LUC = land use control

RAO = remedial action objective

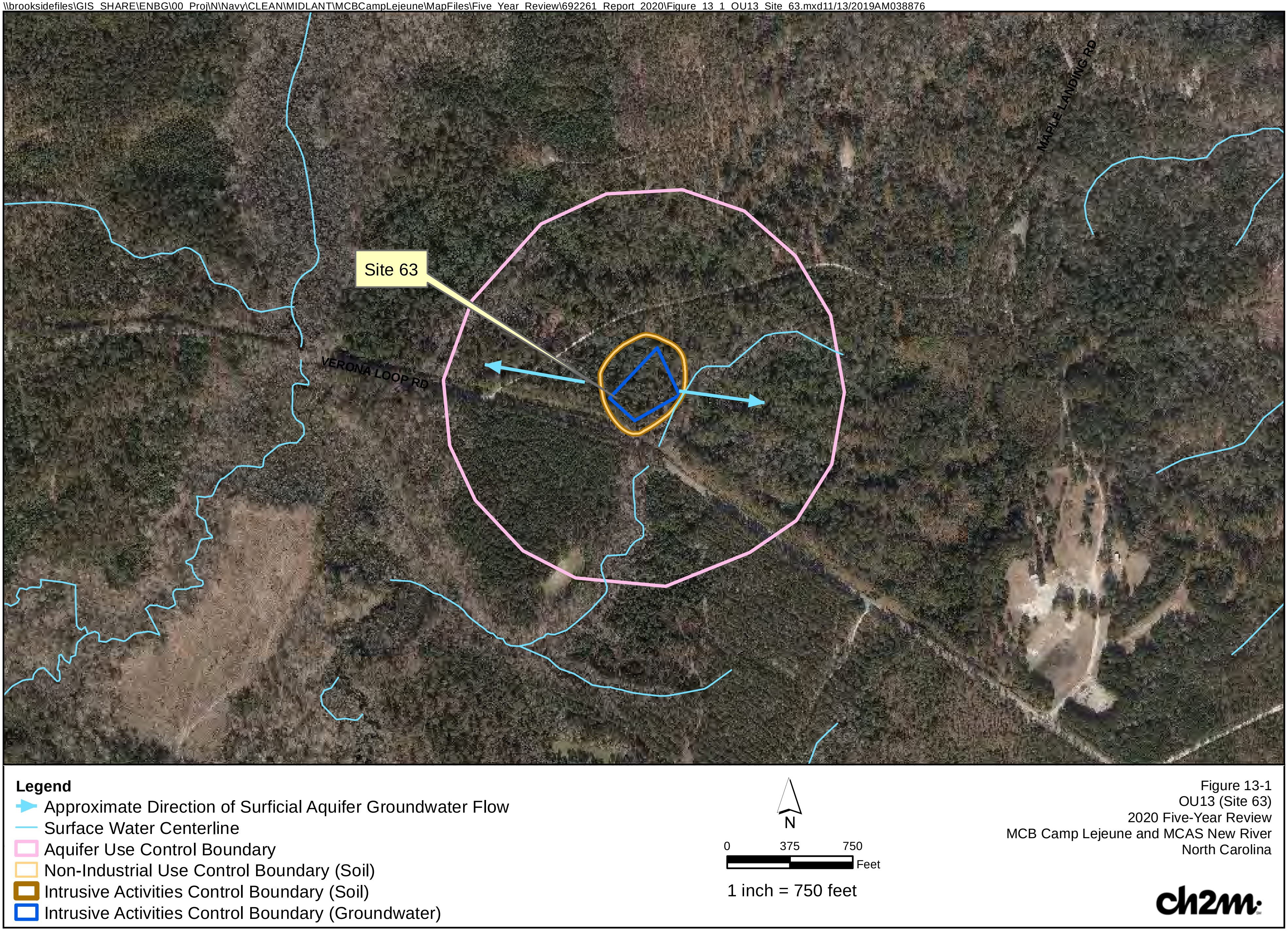

Figure 13-1
OU13 (Site 63)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

Operable Unit 14 (Site 69)

14.1 Site History and Background

OU 14 is within the Rifle Range operations area near Sneads Ferry (**Figure 1-2**) and consists of Site 69.

Site 69 — the Rifle Range Chemical Dump is approximately 14 acres located west of the New River in the Rifle Range area (**Figure 14-1**). From 1950 to 1976, Site 69 was reportedly used to dispose of chemical wastes including PCBs, solvents, pesticides, and drums of gas that possibly contained cyanide (i.e., tear gas) or other training agents, also known as chemical agents. Site 69 is within a former explosive range, UXO-02, which was reportedly used from 1973 to 2002. UXO-02 was investigated under the MMRP and was granted NFA in July 2013 (CH2M, 2013a).

OU 14 Timeline	
Year	**Event**
1980-1981	Radiation Survey and Soil Sampling
1983	IAS
1984-1987	Confirmation Study
1995-1997	RI
1996-1998	Pilot Study – In-Well Aeration
1998	PRAP
1998-2005	LTM
2000	Interim ROD
2001	LUCs
2007	Radiation Survey
2008-2009	Supplemental Investigation
2011-2012	UXO-02 PA/SI, Expanded SI Feasibility Study (Site 69)
2012-2013	PRAP/ROD UXO-02 NFA
2013	RD
2014	RIP (Cap)
2015-Present	LTM and LUCs
2019	Basewide PFAS PA

14.2 Site Characterization

The findings from various investigations at OU 14 that are pertinent to the FYR are summarized in this section.

14.2.1 Physical Characteristics

- **Surface Features –** OU 14 is on a west-east-trending ridge that gently slopes toward the east and the New River. The suspected disposal areas were covered with a multi-layered cap in 2014. Outside of the cap area, the site is heavily wooded with primarily pine, dogwood, and oak trees. The perimeter of Site 69 is surrounded by a 6-foot-high chain-link fence with a locked access gate.
- **Geology and Hydrogeology –** Subsurface conditions generally consist of Coastal Plain deposits consisting of mostly fine-grained, loose, poorly graded sand, with lesser amounts of silt and clay with depth. Groundwater is a medium of concern and the affected aquifers include the surficial aquifer which is encountered at approximately 5 to 22 feet bgs and extends to a depth of approximately 30 feet bgs, the UCH aquifer which extends from approximately 30 to 70 feet bgs, and the MCH aquifer which extends from 70 to approximately 220 feet bgs. A semi-confining unit is present at the OU separating the surficial and UCH aquifers. Beneath the semi-confining unit, the formation is composed of sands, silts, shell, and fossil fragments. Groundwater in the surficial aquifer flows radially outward from the center of Site 69, and groundwater in the UCH and MCH aquifers generally flows to the northeast (**Figure 14-1**). Groundwater velocities calculated based on 2019 data in the surficial, UCH, and MCH aquifers are 31, 25, and 24 feet per year, respectively.

14.2.2 Land Use

- **Current Land Use –** The site is currently vacant and undeveloped. The perimeter of the disposal area is secured by a 6-foot high chain-link fence with a locked access gate. Military training exercises are periodically conducted throughout the area outside of the fence.
- **Future Land Use –** There are no anticipated changes in land use.

14.2.3 Basis for Taking Action

This section describes the site characterization and risk assessments that led to the ROD. Details are in the Site 69 Supplemental Investigation Report (CH2M, 2011) and the OU 14 ROD (CH2M, 2013c).

Soil (outside of the suspected waste area), groundwater, surface water, and sediment were investigated. Because of the potential for chemical agents at Site 69, soil samples were not collected within the suspected disposal area. The HHRA evaluated current or potential future military personnel and adult or child trespasser/visitors, and potential future adult and child residents, industrial workers, and construction workers. Unacceptable risks to potential future industrial workers or residents were identified from exposure to CVOCs, pesticides, PCBs, and metals in groundwater and VOCs in indoor air through the VI pathway. Unacceptable risks were assumed from exposure to waste and soil within the suspected disposal area. The ERA evaluated terrestrial and aquatic receptors. Ecological risks were assumed to be present as a result of waste left in place and the associated soil present in the disposal trenches and burial pits.

14.3 Remedial Action Objectives

An interim ROD was signed in June 2000 and included LUCs to mitigate human health risks from exposure to waste and impacted groundwater, and LTM to monitor plume stability (Baker, 2000). The interim ROD was superseded by the final ROD (CH2M, 2013c) addressing soil, waste in place, and groundwater at OU 14, which was signed in June 2013 with the following RAOs:

- Restore groundwater quality to meet NCDEQ and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Minimize potential exposure to chemical agent and chemical waste to the maximum extent practicable.
- Reduce infiltration and leaching of contaminants from waste into groundwater to the maximum extent practicable.
- Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for UU/UE.
- Minimize potential degradation of the New River by COC-affected groundwater.

The COCs and cleanup levels for OU 14 are presented in **Table 14-1**.

14.4 Remedial Actions

The RA for OU 14 includes the following major components:

- Constructing a multi-layered cap to prevent potential exposure to buried wastes and contaminated soil and provide a barrier to minimize infiltration of surface water.
- Groundwater MNA for VOCs and LTM for pesticides, PCBs, and metals.
- LUCs to prevent exposure to buried waste, soil, and groundwater and mitigate VI.

14.4.1 Remedy Implementation

Multi-Layer Cap

Installation of the 4.6-acre multi-layer cap was completed in September 2014. The components of the cap consist of low-permeability soil and geosynthetics layers and a stormwater management system. The stormwater management system consists of riprap placement on the cap at the base of mounds and around the perimeter for dissipating water conveyance onto the surrounding soils. The cap was vegetated using native grass species to provide long-term erosion protection. The capped area is shown on **Figure 14-1**.

Long-term Monitoring and Land Use Controls

Groundwater MNA and LTM was initiated in 2015 and is currently ongoing as described in the following section. LUCs were implemented in 2001 and updated in 2002 (Baker, 2002) and were updated again in 2015 (CH2M, 2013b). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control –** To prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in-place above concentrations that allow for UU/UE. This LUC boundary, which encompasses the area within 1,000 feet of groundwater within the surficial and Castle Hayne aquifers with concentrations of COCs exceeding cleanup levels.
- **Intrusive Activities Control (Soil, Groundwater, and MEC) –** To restrict intrusive activities within the waste disposal area. This LUC boundary is defined by the perimeter fence at the site. Provide UXO support for any intrusive activities and/or munitions safety awareness training for anyone working in the area.
- **Industrial/Non-Industrial Use Control (VI) –** To evaluate future buildings and land use for potential VI pathways, prior to construction. This LUC boundary encompasses the waste disposal area and within 100 feet of surficial and Castle Hayne groundwater COCs exceeding cleanup levels.
- **Access Control –** Fencing and signs around the perimeter of the site to protect Base personnel, recreational users, or trespassers from encountering site hazards.

14.4.2 Remedy Operation and Maintenance

Remedy O&M currently consists of cap maintenance, groundwater MNA and LTM, and LUC monitoring. The cost of annual cap O&M is $55,000 and MNA and LTM is $95,000.

Multi-Layer Cap

O&M of the cap is conducted quarterly and consists of site inspections to evaluate general conditions and maintenance needs. Maintenance activities included mowing or reseeding; repairing access and controls such as entrance road, fencing, and signs; and repairing cap conditions such as settlement, cracks, erosion, holes, bulges, vegetation, and wet areas indicating poor drainage. The topsoil is tested for agronomic conditions to guide fertilizer and conditioning application.

The most recent inspection conducted in May 2018, identified no issues with the soil cover system; however, in comparing the 2018 and 2014 as-builts, the cap appears to have settled throughout by 2 inches. The vegetative cover was in good condition and continued quarterly monitoring and weed clearing was recommended. In addition, the 2018 O&M summary report recommended applying herbicide to control weeds in the riprap area. The gas venting system, stormwater management system, fencing, signs, and access roads were in good condition (Tetra Tech, 2018).

Monitored Natural Attenuation and Long-term Monitoring

Post-ROD MNA and LTM activities were initiated in 2015. MNA consists of annual groundwater sampling of 9 surficial, 12 UCH, and 6 MCH aquifer monitoring wells for VOC COCs and a subset of these wells every 5 years for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and TOC). LTM consists of groundwater sampling every 5 years for PCB and pesticide COCs (all MNA wells) and a subset of the MNA network for chemical agent and metals.

There have been no changes in the COCs or monitoring well network since the initiation of MNA.

In addition to comparing to cleanup levels (**Table 14-1**), data in the surficial aquifer are compared to the non-residential NC VISL consistent with the overall site use, to evaluate whether concentrations indicate the potential for a complete VI pathway. Data in the downgradient surficial aquifer wells are also compared with 10 times the NCSWQS to determine the potential for groundwater to affect surface water. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of the MNA component of the remedy.

Land Use Controls

The LUCs are shown on **Figure 14-1** and are summarized in **Table 14-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In October 2018, a post-hurricane inspection was completed, and several trees had fallen within the site boundary damaging a monitoring well (IR69-MW09IW), blocking access to transects, and damaging the perimeter fencing. No damage was observed to the cap. Repairs were made to the fence at Site 69 between November 2018 and March 2019.

During the FYR site inspections, completed in April 2019, a fallen tree blocked access to one well cluster, and bollards were in poor condition around monitoring well IR69-MW13DW (**Appendix B**). No issues affecting protectiveness were observed.

Table 14-2. OU 14 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	LUCIP	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	126.31	February 2013 (RD)	September 1, 2015
Intrusive Activities Control Boundary (Soil, Groundwater, and MEC)	14.20		
Industrial/Non-Industrial Use Control Boundary (VI)	16.33		
Access Control Boundary	14.20		

14.4.3 Progress Since the 2015 Five-Year Review

No issues were identified at OU 14 during the 2015 FYR. LUCs continue to be monitored to ensure they remain properly implemented, and any issues identified were addressed. MNA and LTM are ongoing and the current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 14-2**. The OU 14 RAs and expected outcomes are summarized in **Table 14-3**.

14.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. The cap installation was completed in September 2014 (Tetra Tech, 2015). Five rounds of MNA and one round of LTM sampling have been completed and LUCs are in place to prevent exposure to buried waste and COCs in site media.

Multi-Layer Cap

No issues were observed during this review period, with respect to the multi-layer cap and associated systems (Tetra Tech, 2018). While settling was observed, it was uniform throughout the cap and the cap was in good condition. Monitoring of the cap condition and settling will continue as part of routine O&M.

Monitored Natural Attenuation and Long-term Monitoring

Based on data reported in the FY 2019 report, MNA is effective. MK statistical analysis was completed for each COC in each aquifer, if enough data (over four samples) was available, to evaluate concentration trends. The following is a summary from the FY 2019 report (CH2M, 2019a).

In the surficial aquifer, 1,1,2,2-PCA (**Figure 14-3**) was the only COC that exceeded its cleanup level in only one monitoring well and MK statistical results indicate that concentrations are stable. VOC concentrations of other detected COCs are generally stable and detections are limited to areas north and south of the cap in the surficial aquifer. Stable VOC concentrations demonstrate that the plume is not expanding beyond its current bounds, suggesting there is no indication of a recent release, and that concentrations are attenuating on the plume fringe. There were no exceedances of the non-residential NC VISL nor 10 times the NCSWQS. Additionally, pesticides and PCB COCs were not detected above cleanup levels, and chemical agents were not detected in the surficial aquifer. Metals analysis is not conducted in the surficial aquifer groundwater samples. Since cap installation, the average groundwater velocity in the surficial aquifer has decreased from 56 feet per year to approximately 31 feet per year, indicating that the cap is working as designed to limit infiltration through the residual waste materials.

In the UCH aquifer, TCE, cis-1,2-DCE, and VC exceeded cleanup levels (**Figures 14-4** through **14-6**). MK statistical results indicate that TCE concentrations are stable to decreasing, cis-1,2-DCE concentrations are stable, and VC concentrations are stable to decreasing. No pesticides, PCBs, or chemical agents were detected in the UCH aquifer. Samples were collected from all UCH aquifer wells for metals COCs and only chromium was detected at two monitoring wells (IR69-MW28IW and IR69-MW29IW) at concentrations above the cleanup level. Chromium concentrations have fluctuated between 11.6 and 108 J µg/L in IR69-MW28IW and 3.21 J to 101 µg/L in IR69-MW29IW. The groundwater velocity for the UCH aquifer has increased from approximately 13 feet per year, before cap installation, to approximately 24 feet per year in December 2018, indicating a greater potential for plume migration (CH2M, 2019a). Based on this value, groundwater from the waste disposal area would require approximately 30 years to migrate to the New River.

In the MCH aquifer, VC exceeded the cleanup level (**Figure 14-7**). MK statistical results indicate VC concentrations are stable to increasing and overall plume geometry indicates the plume may be migrating southeast and north. Chemical agents were not detected in MCH aquifer groundwater. Aroclor-1260 was the only PCB detected, but concentrations were below the cleanup level and no pesticides were detected. Samples were collected from all MCH aquifer wells for metals COCs and only chromium was detected above the cleanup level in samples collected from one monitoring well (IR69-GW14DW) and concentrations ranged from 14.5 to 16.9 µg/L.

A summary of NAIP data is provided in **Table 14-4**. Conditions in the surficial aquifer are generally unfavorable for natural attenuation with only DO (generally low), nitrate (low), and sulfate (low) being generally favorable. Conditions in the UCH, and MCH aquifers are generally favorable for reductive dechlorination. Favorable indicators for reductive dechlorination included DO (generally low), ORP (generally negative), nitrate (generally low), ferrous iron (measurable levels), and sulfate (generally low). Elevated alkalinity in the UCH and MCH aquifers provide buffering capacity during degradation. TOC in all aquifer zones was low, which may limit microbial growth.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. The exposure pathways, toxicity data, cleanup levels, and RAOs are still valid from the time of selection.

The ROD was signed in 2013 and there have been no changes in toxicity values since the ROD that would impact the protectiveness of the remedy. Additionally, there have been no changes in toxicity values for the COCs identified in the HHRA since the last five-year review which concluded that the remedy at OU 14 is protective of human health and the environment (**Table 2-1**). There have been no changes in regulatory standards, and risk characteristics of COCs at OU 14 identified in the ROD. Additionally, any changes would not affect the protectiveness of the remedy, as LUCs prevent exposure to site media and limit site use.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 14 remedy with respect to extreme weather events, primarily hurricanes, was completed. Effects of hurricane damage include flooding, erosion, and fallen trees that could damage the perimeter fencing and the cap. LUC inspections are conducted quarterly, and general site conditions inspections are conducted after major storms, tropical storms, and hurricanes and repairs are conducted as needed to maintain protectiveness.

14.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 14 during this FYR.

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Site 69 was evaluated in the Basewide PFAS PA as a potential PFAS release area based on its designation as a chemical dump site and timeframe of use from 1950 to 1976. The dump was designated as a disposal area for hazardous chemicals including fire retardants. In 1970, an explosion and fire occurred that was responded to by a fire truck. It is unknown if water or AFFF was used to extinguish the fire. Therefore, further evaluation is recommended (CH2M, 2019b).

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release areas identified; therefore, there is no current exposure pathway (CH2M, 2019b). Site 69 will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

14.7 Statement of Protectiveness

The remedy at OU 14 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and non-industrial land use, restrict access, intrusive activities where impacted soil, groundwater or MEC may be present, and evaluate and/or mitigate potential VI pathways. The multi-layer cap is in-place to reduce infiltration and leaching of contaminants from waste into groundwater and prevents direct exposure to the soil and buried waste. MNA and LTM is ongoing to monitor plume stability and confirm that there are no releases from the waste disposal area or potential impacts to surface water.

14.8 References

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Table 14-1. Cleanup Levels for OU 14 (Site 69)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2013c)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS
	1,1,2-Trichloroethane	5	5	MCL
	1,2-Dichloroethane	0.4	0.4	NCGWQS
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL
	Trichloroethene	3	3	NCGWQS
	Vinyl chloride	0.03	0.03	NCGWQS
	Pesticides			
	Alpha-BHC	0.02	0.02	NCGWQS
	Dieldrin	0.002	0.002	NCGWQS
	Heptachlor epoxide	0.004	0.004	NCGWQS
	PCBs			
	Aroclor-1260	0.5	0.5	MCL
	Metals			
	Chromium	10	10	NCGWQS
	Thallium	2	2	MCL

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Cleanup Level Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

RSL (November 2018)

µg/L = microgram(s) per liter

COC = constituent of concern

MCL = maximum contaminant level

NCGWQS = North Carolina Groundwater Quality Standard

PCB = polychlorinated biphenyl

ROD = Record of Decision

VOC = volatile organic compound

Table 14-3 OU 14 Remedial Action Summary and Expected Outcomes
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Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
69	Waste and associated soil	Potential unacceptable risks to human health and the environment from exposure to contaminants (chemical agent) in buried waste and associated soil.	Industrial/ Vacant	Prevent exposure to buried waste and associated soil and groundwater until concentrations meet levels that allow for unlimited use/unrestricted exposure. Minimize exposure to potential chemical agent and chemical waste to the maximum extent practicable.	LUCs	Maintain non-industrial and intrusive activities controls and monitor quarterly.	Restricted/ Industrial Land Use
					Capping	Maintain multi-layered cap to provide a barrier for receptors and evaluate effectiveness annually by comparison of current COC concentrations in downgradient monitoring wells to preconstruction concentrations and the cleanup levels.	
	Groundwater	Potential unacceptable risks to future industrial or residential receptors from exposure to VOCs, pesticides, PCBs, and metals in groundwater and VOCs in indoor air through vapor intrusion.		Reduce infiltration and leaching of contaminants from waste into groundwater to the maximum extent practicable.	Capping	Maintain multi-layered cap to provide a barrier for receptors and evaluate effectiveness annually by comparison of current COC concentrations in downgradient monitoring wells to preconstruction concentrations and the cleanup levels.	
				Restore groundwater quality at Site 69 to meet North Carolina Department of Environmental Quality and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A North Carolina Administrative Code 02L.0201. Minimize potential degradation of the New River by COC-affected groundwater.	MNA/LTM	Implement MNA/LTM to monitor COC concentrations and migration until each groundwater COC is at or below its respective cleanup level for four consecutive monitoring events. Compare concentrations of COCs at locations adjacent to surface water bodies with ten times the NCSWQS to to determine the potential for groundwater to affect surface water.	
					LUCs	Maintain industrial/non-industrial use VI, intrusive activities, and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	

Notes:
COC = constituent of concern
LTM = long-term monitoring
LUC = land use control
MNA = monitored natural attenuation
NCSWQS = North Carolina Surface Water Quality Standard
PCB = polychlorinated biphynyl
RAO = remedial action objective
VOC = volatile organic compound

Table 14-4. Natural Attenuation Indicator Parameters Summary - Site 69
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			MCH Aquifer		
	Description	Favorable Condition[a]	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion
DO (mg/L)	DO is the most thermodynamically favorable electron acceptor used by microbes. High levels of DO are indicative of aerobic conditions, and low levels of DO are indicative of anaerobic conditions. As reductive dechlorination takes place under anaerobic conditions, low levels of DO are generally favorable for reductive dechlorination.	< 1	0 to 1.82	3 / 4	Yes, unfavorable result isolated	0 to 1	5 / 5	Yes	0 to 0	4 / 4	Yes
ORP (mV)	ORP measures the degree to which aquifer conditions are reducing or oxidizing. As reductive dechlorination takes place under reducing conditions, lower ORPs are generally favorable for reductive dechlorination.	< 0	129 to 376	0 / 4	No	-173 to -11	5 / 5	Yes	-160 to -90	4 / 4	Yes
Nitrate (mg/L)	After DO is depleted, nitrate may be used as an electron acceptor (i.e., denitrification). As nitrate may compete with the reductive dechlorination pathway, depleted nitrate concentrations are generally favorable for reductive dechlorination. Depleted nitrate concentrations alone do not conclusively indicate favorable conditions for reductive dechlorination.	< 1	0 to 2	3 / 4	Yes, unfavorable result isolated	0 to 0	5 / 5	Yes	0 to 0	3 / 3	Yes
Nitrite (mg/L)	During denitrification, nitrate is converted into nitrite. Therefore, the presence of nitrite indicates the geochemical footprint of denitrification. If nitrate is absent from a monitoring location, denitrifying conditions may exist if nitrite is not observed. Denitrifying conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	Detectable Concentrations	0 to 0	0 / 1	No	0 to 0	--	Neutral	0 to 0	--	Neutral
Ferrous Iron (mg/L)	The presence of ferrous iron indicates the geochemical footprint of iron-reduction, which takes place under more reducing conditions than denitrification. Iron reducing conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	> 1	0 to 2.75	3 / 4	No, favorable result isolated	0.25 to 4.75	4 / 5	Yes, unfavorable result isolated	2.25 to 4.5	3 / 3	Yes
Sulfate (mg/L)	Sulfate may be used as an electron acceptor under more reducing conditions than iron-reducing conditions. As higher concentrations of sulfate may compete with the reductive dechlorination pathway, low levels of sulfate are favorable for reductive dechlorination. Depleted sulfate concentrations are also an indicator that sulfate reduction is proceeding, which generally indicates that conditions are favorable for reductive dechlorination.	< 20	0.57 to 21	4 / 4	Yes	11 to 50	1 / 5	No, favorable result isolated	1.1 to 8.5	4 / 4	Yes
Sulfide (mg/L)	During sulfate reduction, sulfate is converted into sulfide. Therefore, the presence of sulfide indicates the geochemical footprint for sulfate reduction. When detected, sulfide indicates that sulfate reduction is taking place and that conditions are generally favorable for reductive dechlorination. However, the absence of sulfide does not conclusively indicate that conditions are unfavorable for reductive dechlorination, as sulfide is highly reactive and readily forms precipitates with ferrous iron.	Detectable Concentrations	0.8 U to 0.8 U	--	Neutral	0.8 U to 0.8 U	--	Neutral	0.8 U to 0.8 U	--	Neutral
Methane (mg/L)	The presence of methane in groundwater is indicative of the strongly reducing conditions required to support reductive dechlorination. Therefore, the presence of moderate concentrations of methane is a favorable indicator for reductive dechlorination.	> 0.5	0.003 J to 0.7	1 / 4	No, favorable result isolated	0.003 J to 0.24	0 / 5	No	0.0059 J to 0.45	1 / 4	No
TOC (mg/L)	TOC is an indicator of the total amount of organic matter available to microbial communities to use as source of carbon and energy. Elevated TOC concentrations are a positive indicator of natural attenuation potential.	< 20	0.64 J to 4	0 / 4	No	0.45 J to 2.3	0 / 5	No	0.71 J to 4.4	0 / 4	No
Ethane (mg/L)	Ethane is a nonhazardous end product of reductive dechlorination. As the presence of ethane indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethane are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 4	No	0.005 U to 0.005 U	0 / 5	No	0.005U to 0.005U	0 / 4	No
Ethene (mg/L)	Ethene is a nonhazardous end product of reductive dechlorination. As the presence of ethene indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethene are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 4	No	0.005 U to 0.005 U	0 / 5	No	0.005U to 0.005U	0 / 4	No

Table 14-4. Natural Attenuation Indicator Parameters Summary - Site 69

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			MCH Aquifer		
	Description	**Favorable Condition[a]**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**
Chloride (mg/L)	Chloride is a daughter product of reductive dechlorination. If elevated concentrations of chlorinated VOCs are present (e.g., greater than 1 mg/L), chloride concentrations may increase as biodegradation occurs. Appreciable changes in chloride concentrations are not expected for natural attenuation sites with lower concentrations of chlorinated VOCs.	Greater than Background	20 to 55	--	Neutral	12 to 24	--	Neutral	10 to 41	--	Neutral
pH (SU)	The pH of groundwater affects the presence and activity of microbial populations in groundwater. The optimal pH range for dechlorinating bacteria generally falls between pH 6 and 8 SU (Yang, 2017).	6 - 8	4.15 to 5.41	0 / 4	No	7.10 to 7.58	5 / 5	Yes	7.68 to 12.01	2 / 4	Favorable results in 2 of 4 wells
Alkalinity (mg/L)	Alkalinity measures the capacity of groundwater to resist changes in pH. As biodegradation processes increase aquifer acidity, higher concentrations of alkalinity indicate that pH values are more likely to remain stable.	> 50	4 U to 0.72	0 / 4	No	100 to 250	5 / 5	Yes	170 to 220	4 / 4	Yes

[a] If readings are near the Project Indicator Level, engineering judgment may be used to determine favorability.

Notes:

< = less than

> = greater than

-- = Count not performed; see Project Indicator Level description for rationale.

DO = dissolved oxygen

J = Analyte present, value may or may not be accurate or precise

MCH = Middle Castle Hayne

mg/L = milligram(s) per liter

mV = millivolt(s)

ORP = oxidation-reduction potential

SU = standard units

U = The material was analyzed for, but not detected

UCH = Upper Castle Hayne

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Legend

- Creeks
- Surficial Groundwater Flow Direction
- UCH Groundwater Flow Direction
- Waste Disposal Area

Monitoring Wells

- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Middle Castle Hayne Aquifer
- Surficial Aquifer - not in LTM
- Upper Castle Hayne Aquifer - not in LTM
- Middle Castle Hayne Aquifer - not in LTM
- Lower Castle Hayne Aquifer - not in LTM

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Soil and MEC)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Land Use Boundary (Vapor Intrusion)
- Access Control Boundary

N

0 75 150 Feet

1 inch = 150 feet

Figure 14-1
OU 14 (Site 69)
2020 Five Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

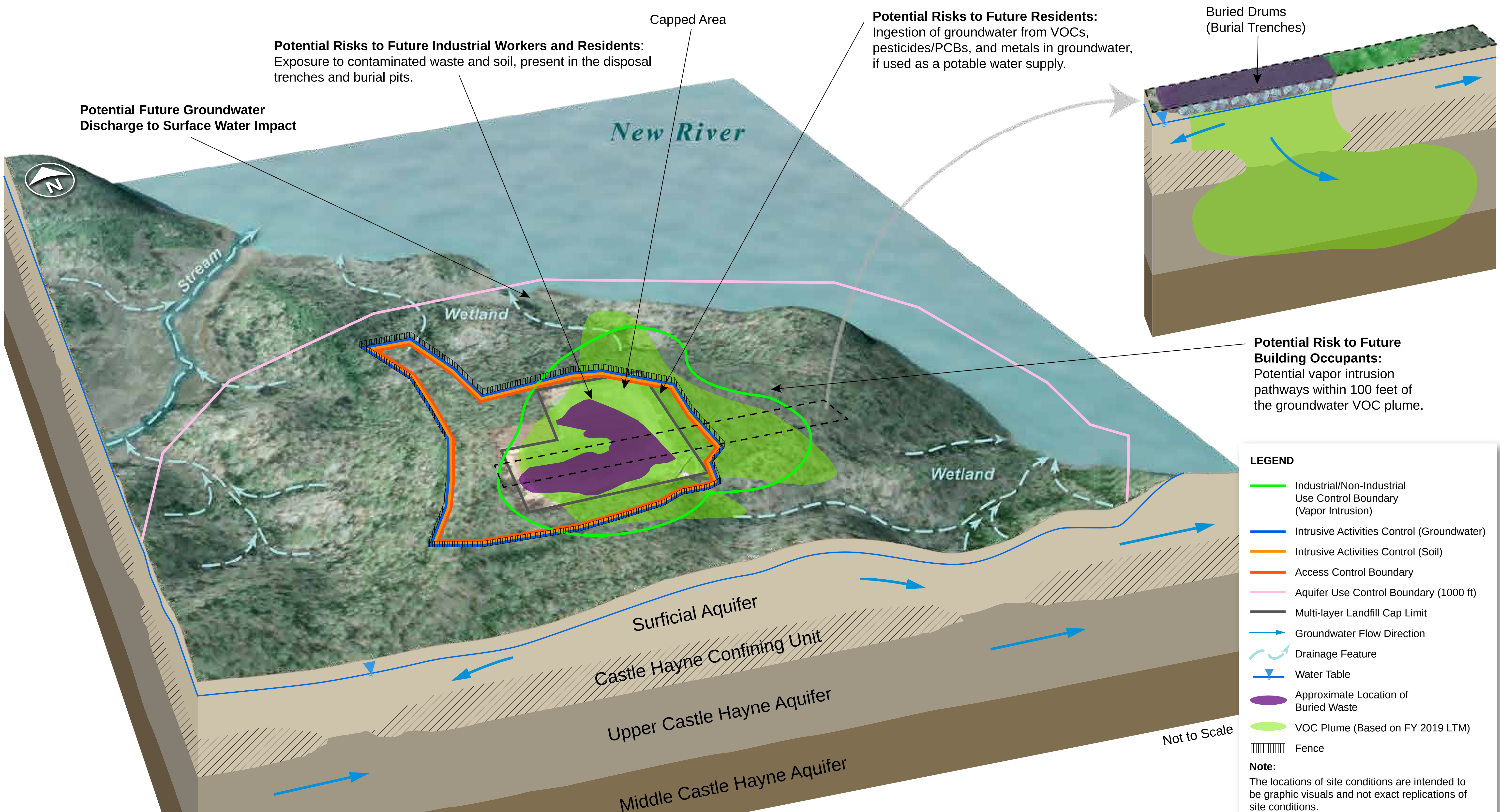

FIGURE 14-2
Site 69 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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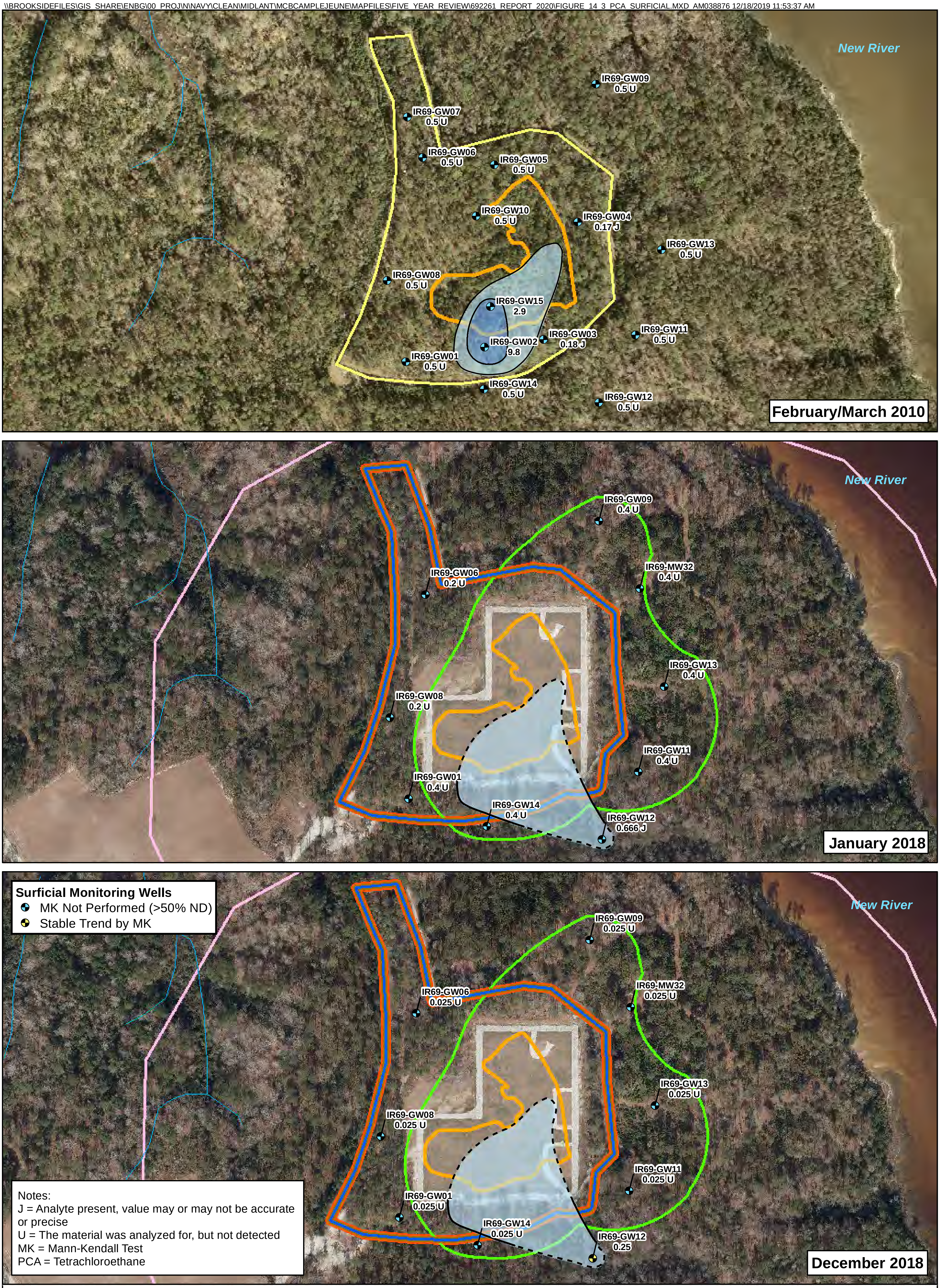

Legend

- Surficial Aquifer Monitoring Well
- Waste Disposal Area
- Site 69 Boundary
- Surface Water Centerline

1,1,2,2-PCA Concentration (dashed where inferred)

- 0.2 µg/L - 2 µg/L
- 2 µg/L - 20 µg/L

Land Use Control Boundary

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Soil and MEC)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Land Use Boundary (Vapor Intrusion)
- Access Control Boundary

N

0 150 300 Feet

1 inch = 300 feet

Figure 14-3
Extent of 1,1,2,2-PCA - UCH Aquifer
2020 Five Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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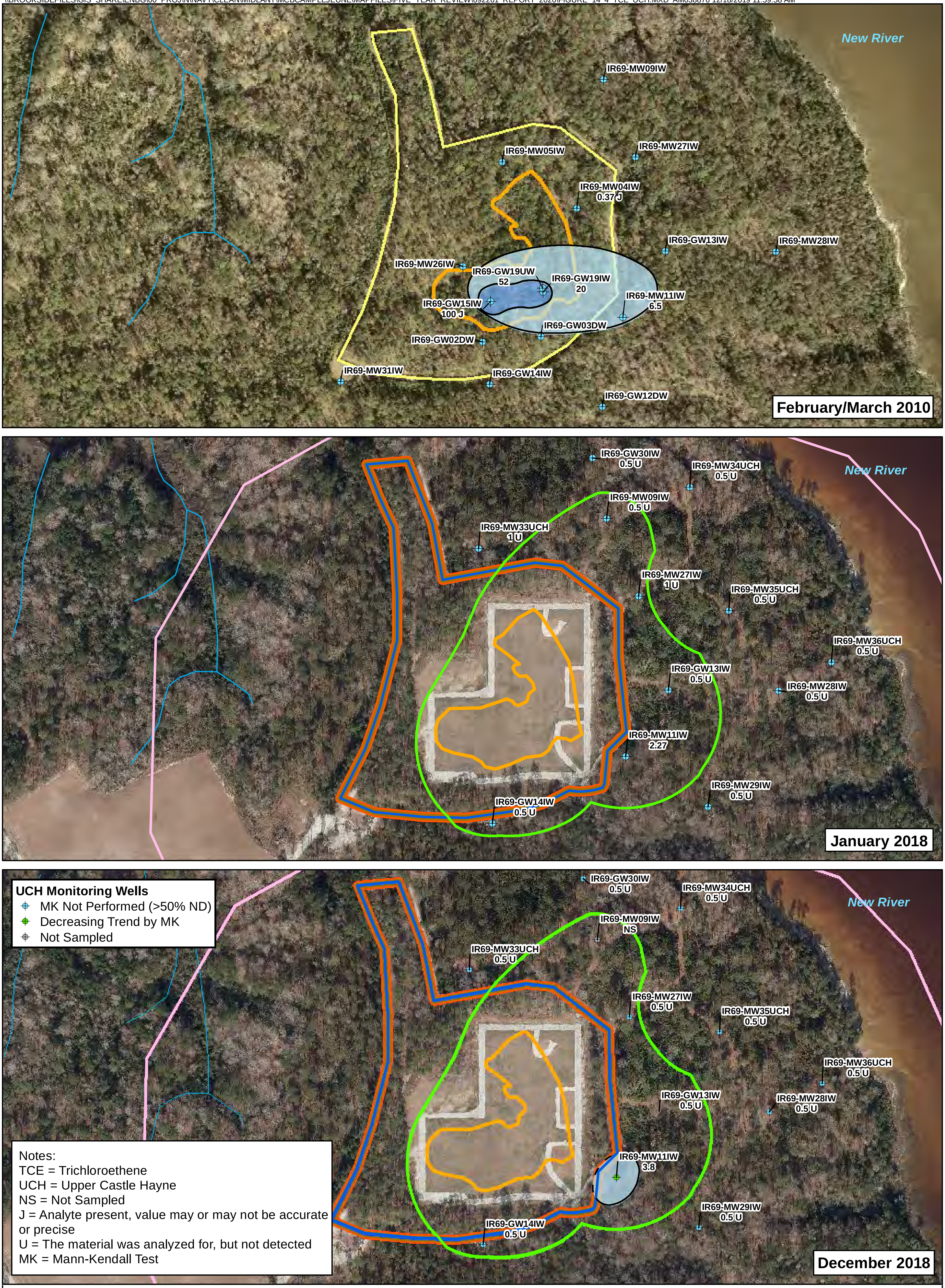


Legend

- UCH Aquifer Monitoring Well
- Waste Disposal Area
- Site 69 Boundary
- Surface Water Centerline

TCE Concentration (dashed where inferred)

- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

Land Use Control Boundary

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Soil and MEC)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Land Use Boundary (Vapor Intrusion)
- Access Control Boundary

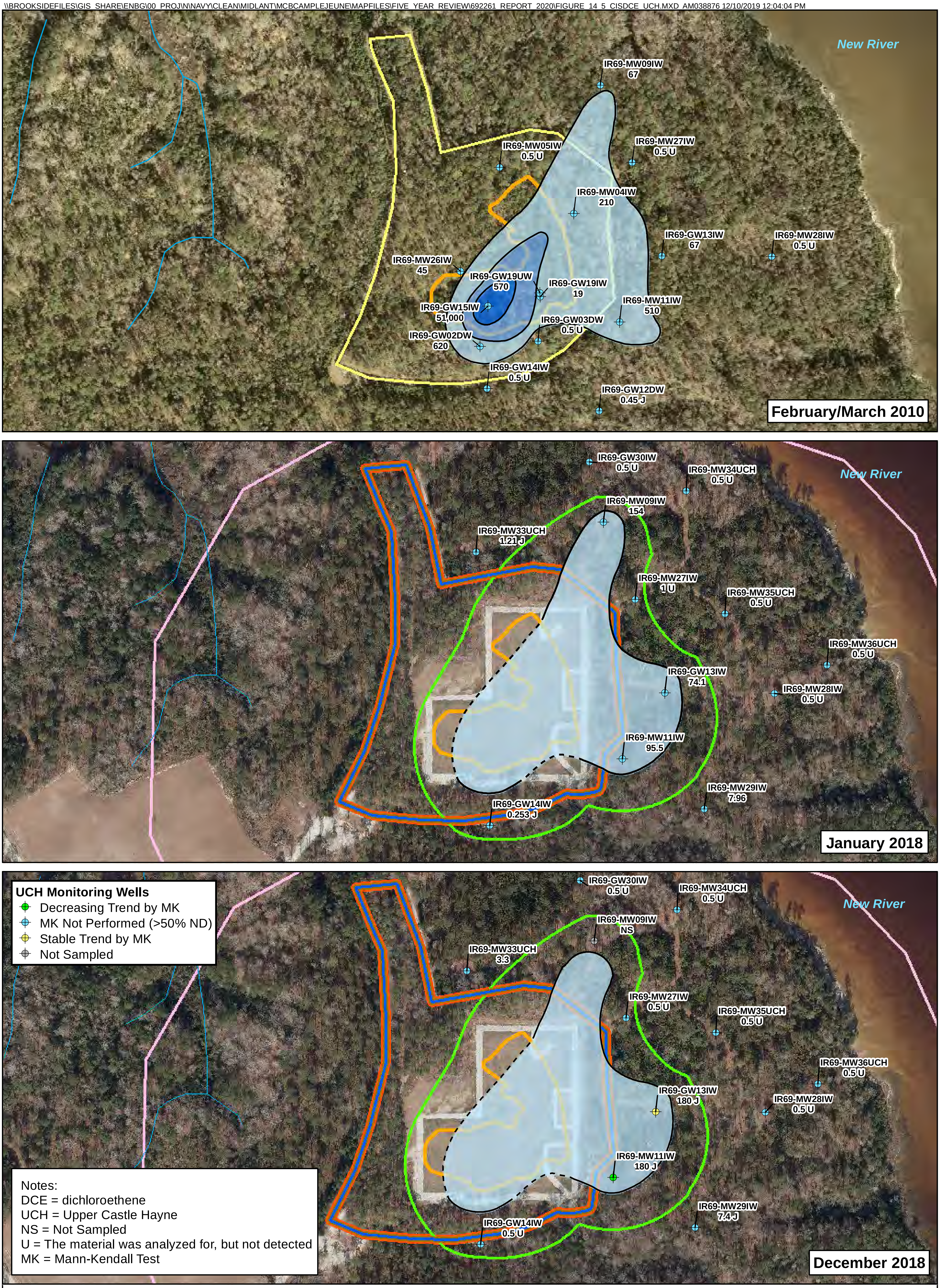
N

0 150 300 Feet

1 inch = 300 feet

Figure 14-4
Extent of TCE - UCH Aquifer
2020 Five Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.



Legend

- UCH Aquifer Monitoring Well
- Waste Disposal Area
- Site 69 Boundary
- Surface Water Centerline

cis-1,2-DCE Concentration (dashed where inferred)

- 70 µg/L- 700 µg/L
- 700 µg/L - 7,000 µg/L
- 7,000 µg/L - 70,000 µg/L

Land Use Control Boundary

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Soil and MEC)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Land Use Boundary (Vapor Intrusion)
- Access Control Boundary

N

0 150 300 Feet

1 inch = 300 feet

Figure 14-5
Extent of cis-1,2-DCE - UCH Aquifer
2020 Five Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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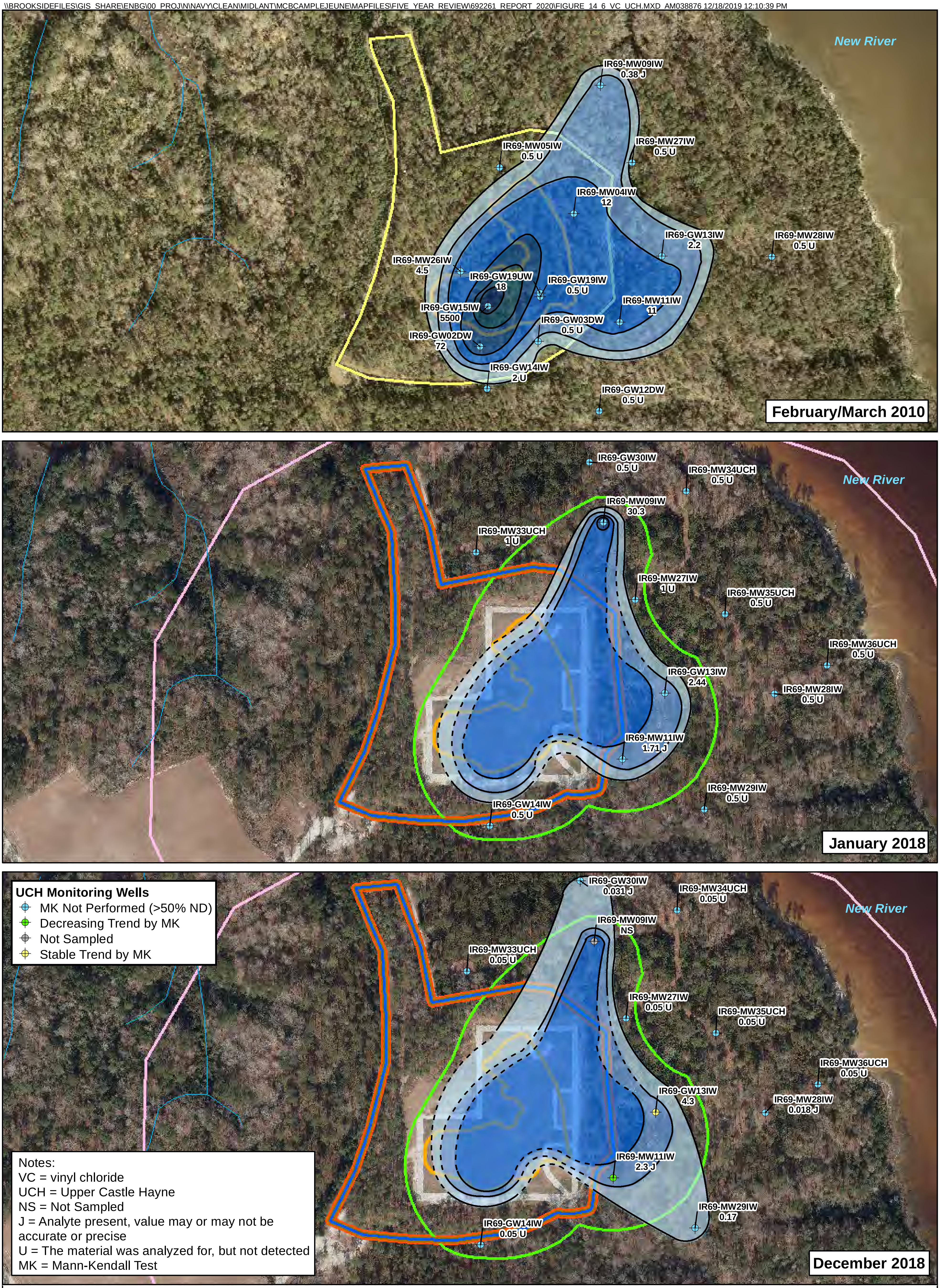

Legend

- UCH Aquifer Monitoring Well

VC Concentration (dashed where inferred)

- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L
- 300 µg/L - 3,000 µg/L
- 3,000 µg/L - 30,000 µg/L

- Surface Water Centerline
- Waste Disposal Area
- Site 69 Boundary

Land Use Control Boundary

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Soil and MEC)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Land Use Boundary (Vapor Intrusion)
- Access Control Boundary

Figure 14-6
Extent of VC - UCH Aquifer
2020 Five Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

N

0 150 300
Feet

1 inch = 300 feet

ch2m:

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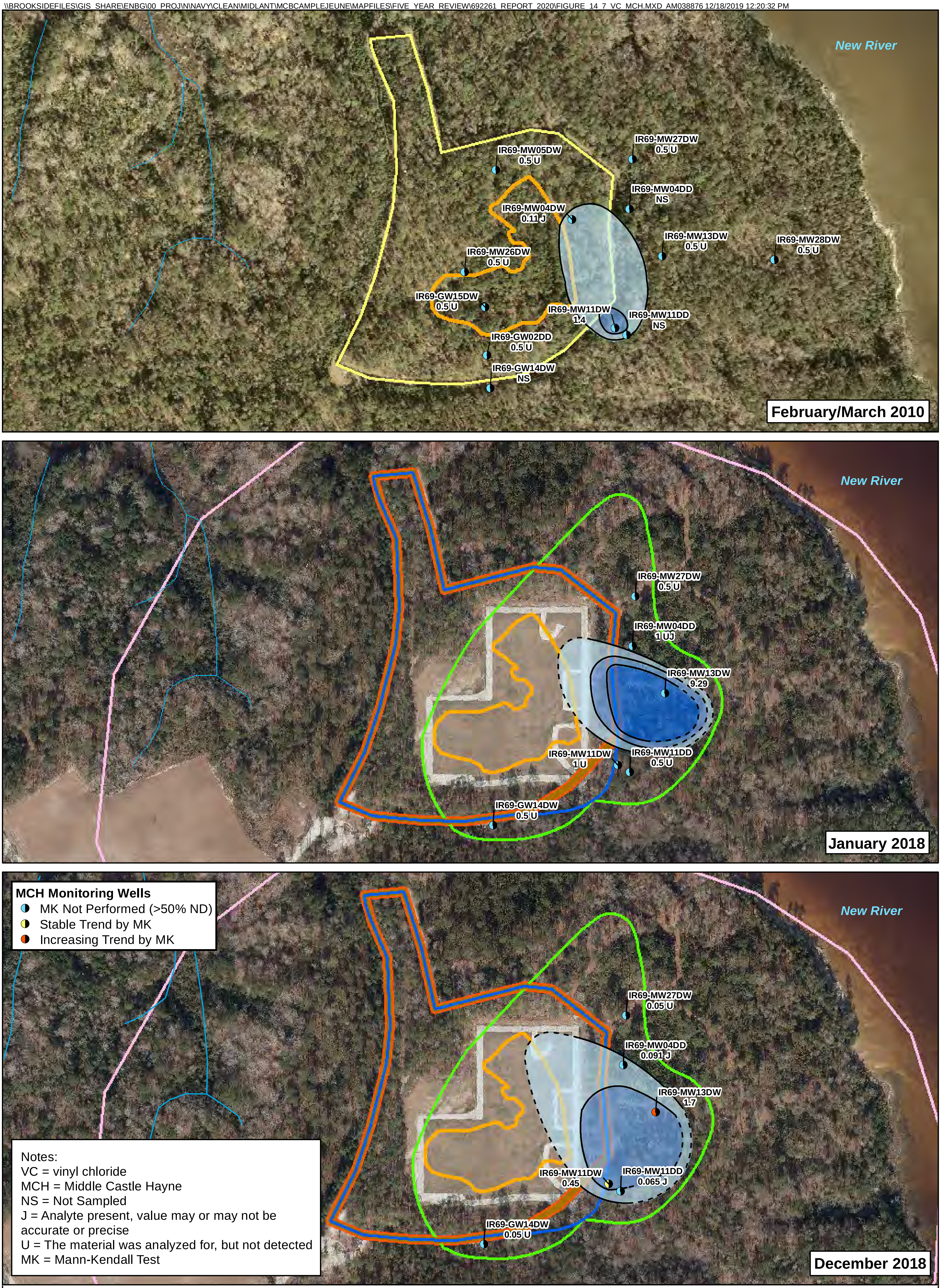

Legend

- MCH Aquifer Monitoring Well
- Waste Disposal Area
- Site 69 Boundary
- Surface Water Centerline

VC Concentration (dashed where inferred)

- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L

Land Use Control Boundary

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Soil)
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Land Use Boundary (Vapor Intrusion)
- Access Control Boundary

N

0 150 300 Feet

1 inch = 300 feet

Figure 14-7
Extent of VC - MCH Aquifer
2020 Five Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.

Operable Unit 15 (Site 88)

15.1 Site History and Background

OU 15 is within the HPIA of MCB Camp Lejeune (**Figure 2-1**) and consists of Site 88.

Site 88 – the **former Base Dry-Cleaning Facility Building 25** encompasses approximately 41 acres located east of the New River in the HPIA (**Figure 15-1**) and began operating as a dry-cleaning facility in the 1940s. Five 750-gallon USTs were installed on the north side of the building to store dry cleaning fluids. Initially, Varsol was used in dry cleaning operations. Because of flammability concerns, Varsol's use was discontinued in the 1970s and it was replaced with PCE. The PCE was stored in one 150-gallon AST adjacent to the north wall of Building 25, in the same vicinity as the USTs. PCE was reportedly stored in the AST from the 1970s until 1995. Spent PCE was reportedly disposed of in floor drains during this time. In December 1986 and March 1995, self-contained dry-cleaning machines were installed in Building 25, eliminating the need for bulk storage of PCE. The USTs and AST were removed in November 1995. The dry-cleaning operations ceased in January 2004, and the building was demolished to slab in August 2004.

OU 15 Timeline	
Year	**Event**
1996-1998	Focused RI
1998-1999	DNAPL Recovery Demonstration
1999-2002	LTM
2000-2001	In situ Bioremediation Treatability Study
2002	Supplemental Site Investigation
2004	Membrane Interface Probe Investigation
2004-2006	EE/CA and NTCRA –ZVI Soil Mixing
2005-2008	RI
2010-2011	ISCO, ERD Bio-barrier Treatability Study
2007-2015	Basewide VI Evaluation
2012 - Present	VIMS installation and monitoring– Buildings 3, 3B, 37, and 43
2014-2015	Building HP57 VI Investigation
2017	FS
2016-2018	Building HP57 Sewer Ventilation Pilot Study
2018-Present	ISCO, ERD Treatability Study
2018	Proposed Plan
2019	ROD, RD

15.2 Site Characterization

The findings from various investigations at OU 15 that are pertinent to the FYR are summarized in this section.

15.2.1 Physical Characteristics

- **Surface Features –** Site 88 is located within the HPIA of the Base, with little topographic relief. Ground surface elevations range from approximately 20 to 30 feet above mean sea level. Site 88 is primarily covered by asphalt or concrete, with smaller areas of maintained grass between the buildings, roads, and parking areas. Infiltration is limited at the site and the surface water drainage is conveyed through a series of storm sewers, located along the roads, to the New River. An underground sanitary sewer system emanates from the former dry-cleaning facility, connecting several of the buildings in this area.

- **Geology and Hydrogeology –** Subsurface conditions generally consist of Coastal Plain deposits consisting of fine-grained, loose, poorly graded sand with lesser amounts of silt and clay with depths. Groundwater is a medium of concern at Site 88 and aquifers affected include the surficial aquifer, which is encountered at approximately 5 feet bgs extending to 25 feet bgs, the UCH aquifer from approximately 25 to 75 feet bgs, the MCH aquifer extending from 75 to 125 feet bgs, and the LCH aquifer from 125 to 180 feet bgs. A semi-confining unit is present separating the surficial aquifer from the UCH aquifer. This unit is present beneath former Building 25 at approximately 20 feet bgs and with a variable thickness of approximately 14 to 16 feet and appears to decrease in thickness significantly to the northeast and again to the southwest. Groundwater flow in the surficial aquifer is highly variable and is likely influenced by differing hydraulic conductivity of the undifferentiated sediments. The UCH and MCH aquifers flow to the west and northwest toward the New

River. Based on the limited data, the inferred groundwater flow direction in the LCH aquifer is to the southwest (**Figure 15-1**). In the surficial aquifer, the average hydraulic conductivity is 4.1 ft/day and the average seepage velocity is 0.19 ft/day. In the UCH aquifer, the average hydraulic conductivity is 14.7 ft/day and the average seepage velocity is 0.06 ft/day. In the MCH aquifer, the average hydraulic conductivity is 7.9 ft/day and the average seepage velocity is 0.05 ft/day.

15.2.2 Land Use

- **Current Land Use** – Site 88 is in a developed area of MCB Camp Lejeune and is surrounded by buildings, parking lots, streets, and sidewalks. Buildings surrounding former Building 25 include administrative offices and barracks.
- **Future Land Use** – There are no anticipated changes in land use.

15.2.3 Basis for Taking Action

This section describes the site characterization and risk assessments that provide the basis for taking action at OU 15. Details are in the RI (CH2M, 2008), FS (CH2M, 2018), and ROD (CH2M, 2019).

Soil, groundwater, soil gas, and indoor air were investigated. An HHRA was completed during the 2008 RI and updated in the FS using more recent data and current risk assessment methodology. The HHRA evaluated current industrial workers and adult residents and potential future adult and child residents, industrial workers, and construction workers. Based on the HHRA, exposure to VOCs at Site 88 poses an unacceptable future risk to human health via potable use of groundwater, dermal exposure to groundwater and inhalation of vapors from groundwater and soil gas in an excavation, and in indoor air via the VI pathway. In addition, under North Carolina's groundwater classification, the surficial and Castle Hayne aquifers are considered Class GA, a potential source of drinking water. Additionally, NCDEQ identified NCGWQS as a 'relevant and appropriate' requirement for groundwater remediation and benzene and naphthalene are present in groundwater at concentrations exceeding NCGWQS.

While, dense nonaqueous phase liquid (DNAPL) in the shallow soils immediately surrounding former Building 25 was addressed during a ZVI soil mixing NTCRA (AGVIQ/CH2M JV, 2006), DNAPL was also identified as a principle threat waste (PTW) in deeper zones of the UCH aquifer in the ROD. Although there are no soil COCs, it is noted that PCE, aliphatics C9-C18, aromatics C9-C10, and aromatics C11-C22 remain in soil within the ZVI soil mixing area at concentrations exceeding soil-to-groundwater maximum soil contaminant concentrations, suggesting that contaminated soil could serve as a continuing source to groundwater. However, there is evidence of ongoing treatment occurring within the ZVI soil mixing area that will continue to benefit groundwater remediation; therefore, until residual treatment is complete, disturbance of the soil mixing area should be limited.

The ERA evaluated future terrestrial and aquatic receptors through the groundwater to surface water pathway and there were no unacceptable risks identified.

From 2007 to 2011, Site 88 was included in the phased Basewide VI evaluation that was conducted to determine whether a complete or significant exposure pathway for VI existed into buildings. Several buildings were evaluated and VI was identified as a pathway of concern at Building 3B and a VIMS was installed in 2012. Although VI was not a significant pathway of concern at Buildings 3, 37 and 43, VIMS were installed because there was a potential for indoor air concentrations to exceed the VISLs should VI occur in the future (AGVIQ/CH2M JV, 2009; CH2M, 2011, 2012). In 2014, additional VI investigation was conducted at Building HP57 that identified the sewer lines as a preferential pathway allowing TCE into indoor air. As a result, a sewer ventilation system was installed to mitigate the VI pathway through the sewer line (CH2M, 2018).

15.3 Remedial Action Objectives

The ROD for OU 15 was signed in May 2019 (CH2M, 2019) with the following RAOs:

- Restore groundwater quality to meet NCDEQ and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Reduce groundwater contaminant source mass to the maximum extent practicable within a reasonable timeframe to inhibit migration of COCs to the New River.
- Prevent human ingestion of and contact with groundwater containing COCs at concentrations above NCGWQS or MCLs, whichever is more stringent.
- Prevent exposure to COCs in groundwater and soil gas during construction, and through the VI pathway that could result in an unacceptable risk to human health.
- Restrict intrusive activities and prevent residential use near the ZVI soil mixing treatment area.

The COCs and cleanup levels for OU 15 groundwater and soil gas are presented in **Table 15-1**.

15.4 Remedial Actions

The RA for OU 15 includes the following major components:

- ERD via vertical injection wells to treat areas with PTW and groundwater with COC concentrations at depths from 5 to 60 feet bgs near the initial source area, former Building 25 (referred to as Zone 1).
- ISCO via horizontal injection wells to treat areas with suspected PTW and groundwater with COC concentrations downgradient from the initial source area at depths from approximately 40 to 180 feet bgs (referred to as Zone 2).
- Bio-barrier via vertical injection wells treat the downgradient groundwater with COC concentrations at depths from approximately 40 to 60 feet bgs (referred to as Zone 3).
- Continued operation and monitoring of the VIMS at Building 3B and the sewer ventilation system at Building HP57 to mitigate the VI pathway. As a precautionary measure, continued operation and monitoring of VIMS at Buildings 3, 37, and 43 will mitigate VI .
- Performance monitoring during active treatment and MNA after active treatment is complete.
- LUCs to prevent exposure to COCs in soil, groundwater, and soil gas.

15.4.1 Remedy Implementation

Remedy components for Site 88 are shown on **Figure 15-1**. The remedy at Site 88 is currently in design and treatability studies are ongoing to evaluate design parameters (CH2M, 2019c). The following is a summary of the remedy and treatability study progress reported in the RD.

ERD

ERD near the source/PTW area involves the installation of 21 surficial aquifer and 78 UCH aquifer vertical injection wells, for a total of 99 injection wells. Substrate injections are expected to be required every two years until active treatment objectives are achieved. During active treatment, groundwater performance monitoring will be conducted to measure the effectiveness of ERD and changes in COC concentrations.

A treatability study was initiated in 2018 to further evaluate the effectiveness of ERD as a treatment alternative and to obtain additional design parameters needed for full-scale implementation. The surficial and UCH aquifer injection wells were installed, baseline groundwater and VI sampling was conducted, and LactOil and water, followed by bioaugmentation culture, were injected into the surficial and UCH aquifers. Performance monitoring will include semiannual groundwater sampling from five surficial and five UCH aquifer monitoring wells as described in the RD (CH2M, 2019c). While ERD is active, TCE and VC will be analyzed in VIMS exhaust and indoor air samples at Building 37 and 43 and VC will be analyzed in the exhaust, sewer gas, and indoor air at Building HP57.

ISCO

ISCO near the source/PTW and deeper downgradient area involves the installation of nine horizontal injection wells and five vertical extraction wells, for a total of 10 injection wells and 8 extraction wells. It is estimated that two permanganate injection events will be needed, and operation of a recirculation system will continue for approximately one year post-injection. During active treatment, groundwater performance monitoring will be conducted to measure the effectiveness of ISCO and changes in COC concentrations. Performance monitoring will include semiannual groundwater sampling from two UCH, four MCH, and three LCH aquifer monitoring wells as described in the RD (CH2M, 2019c).

Bio-barrier

The downgradient bio-barrier involves the installation of ten new vertical injection wells near the four existing injection wells, creating a bio-barrier that is approximately 280 feet long. Substrate injections are expected to be required every two years until groundwater COC concentrations are protective of downgradient receptors, based on fate and transport modeling, or until it is determined that biodegradation can be maintained naturally and further enhancements are not required. During active treatment, groundwater performance monitoring will be conducted to measure the effectiveness of ERD and changes in COC concentrations.

A treatability study was initiated in 2018 to further evaluate the effectiveness of ERD and obtain additional design parameters for full-scale implementation and to mitigate offsite migration of COCs. The additional injection wells were installed, baseline groundwater sampling was conducted, and LactOil and water, followed by bioaugmentation culture, were injected into the UCH aquifer. Performance monitoring will consist of semiannual groundwater sampling from 13 UCH aquifer monitoring wells as described in the RD (CH2M, 2019c).

VIMS

The VIMS at Buildings 3, 3B, 37, and 43 are active subslab depressurization systems that use fans to place a negative pressure beneath the floor slab under the footprint of the building. The negative pressure reverses the flow of contaminants into the indoor space and removes subslab VOCs. The sewer ventilation system associated with Building HP57 was installed in the adjacent sewer system to vent gases before reaching the building and consists of conveyance piping and a blower, tied into a manhole between the source area and Building HP57. VIMS were installed in Buildings 3, 3B, 37, and 43 in 2012, and the sewer ventilation system was installed at Building HP57 in 2018. O&M is conducted as described in the following section.

Monitored Natural Attenuation

Once active treatment is complete, MNA will take effect to monitor the plume until contaminant concentrations are such that would allow for UU/UE. Monitoring details such as specific sampling locations, frequency, and natural attenuation data to collect are presented in the RD (CH2M, 2019c).

Land Use Controls

The following LUCs are planned for Site 88 (**Figure 15-1**):

- **Aquifer Use Control Boundary**: Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 1,000 feet of groundwater within the surficial and Castle Hayne aquifers with concentrations of COCs exceeding the more conservative values between the NCGWQS or the federal MCLs.
- **Intrusive Activities Control Boundary (Groundwater and Soil Gas)**: Restrict intrusive activities within 100 feet of the extent of groundwater contamination with concentrations above the cleanup levels.
- **Industrial/Non-Industrial Use Control (VI)**: Before construction of new buildings or structural modifications to existing buildings, the potential for VI will be evaluated by assessing multiple lines of evidence. If the results of the evaluation indicate that VI could result in unacceptable indoor air concentrations, then engineering controls or an action to address the source will be considered to mitigate the unacceptable exposure. This LUC

boundary encompasses the area within 100 feet of groundwater with concentrations of VOCs exceeding the cleanup levels.

- **Intrusive Activities Control Boundary (Soil):** Prohibit intrusive activities within the former ZVI soil mixing treatment area.
- **Non-industrial Use Control Boundary (Soil):** Prohibit non-industrial land use within the ZVI soil mixing treatment area.

15.4.2 Remedy Operation and Maintenance

The VIMS are operational at Site 88 and the approximate annual cost of O&M and performance monitoring is $70,000.

VIMS O&M at Buildings 3, 3B, 37, and 43 was initiated in 2012 and consists of weekly inspections of VIMS components (fan/blower, piping, gauges), quarterly monitoring of system operating parameters (flow rate, riser vacuum, and short-term differential pressure), and semi-annual collection of exhaust and indoor and outdoor air samples for PCE analysis only at Buildings 3, 37, and 43, and PCE and TCE analysis at Building 3B. Indoor air data are compared to outdoor air data and screened against the non-residential indoor air NC VISLs. Due to damage sustained during Hurricane Florence (September 2018), Building 3 and 3B are unoccupied. These buildings are slated for demolition in the future; however, the VIMS in Building 3B is still operating.

Sewer ventilation system O&M for Building HP57 was initiated in December 2016 and consists of weekly inspections of system components (blower, piping, gauges), quarterly monitoring of differential pressure measurements in sewer manholes and discharge vapor sampling using a portable gas detector, and semi-annual system exhaust, sewer gas, and indoor and outdoor air samples for PCE and TCE analysis. Indoor air data are compared to outdoor air data and screened against the residential indoor air NC VISLs.

15.5 Progress Since the 2015 Five-Year Review

Site 88 was not included in the 2015 FYR. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 15-2**. The OU 15 RA components and expected outcomes are summarized in **Table 15-2**.

15.6 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

The remedy, with the exception of VIMS, has not been fully implemented.

Based on the VIMS performance monitoring report for June 2019 data, the VIMS are operating consistently and mitigating the VI pathway within Buildings 37 and 43. Buildings 3 and 3B were damaged during Hurricane Florence and have been unoccupied since September 2018; however, the VIMS in Building 3B is still in operation (CH2M, 2019b). Short-term differential pressure measurements in Buildings 3B, 37, and 43 were all -0.01 inch water column or less, indicating that the subslab is being depressurized. Indoor air samples at each building contained COCs at less than the non-residential indoor air NC VISLs during the most recent rounds of data and exhaust samples contained COCs, indicating that the system is removing subslab COCs (**Figure 15-3** through **15-5**). The sewer ventilation system at Building HP57 is operating consistently based on vacuum and flow rate measurements and sewer vapor and exhaust samples indicate that the system is removing COCs before entry into the building. Indoor air samples at Building HP57 contained COCs at less than the residential indoor air NC VISLs (**Figure 15-6**) (CH2M, 2019b).

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes, all exposure assumptions, toxicity data, cleanup levels, and RAOs are still valid based on the ROD signed in 2019.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the proposed OU 15 remedy with respect to extreme weather events, primarily hurricanes, was completed. The effects of extreme weather events are most likely limited to flooding close to the New River, raised water levels which could prevent effectiveness of the VIMS, and damage to infrastructure (VIMS or recirculation system components). VIMS components are inspected weekly and LUCs are inspected quarterly and following major storm evens and repairs are conducted as needed to maintain protectiveness.

15.7 Issues, Recommendations, and Follow-up Actions

There are no issues, recommendations, and follow-up actions for OU 15.

15.8 Statement of Protectiveness

The remedy at OU 15 will be protective of human health and the environment when the remedy is fully implemented. Exposure pathways that could result in unacceptable risks will be controlled by LUCs to prohibit aquifer use, non-industrial use, and restrict intrusive activities where groundwater, soil, and soil gas present unacceptable risks, and evaluate and/or mitigate potential VI pathways. VIMS are currently operational and prevent exposure to COCs through the VI pathway. Groundwater is not currently used as a potable supply. To facilitate protectiveness until LUCs are put in-place, the Base GIS and Master Plan maintain existing and proposed LUCs and all construction projects go through environmental review. Groundwater performance monitoring and/or MNA will be conducted to monitor COCs until cleanup levels are achieved.

15.9 References

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CH2M. 2018b. *Phase I and II Building HP57 Sewer Ventilation Pilot Study Technical Memorandum, Site 88, Marine Corps Base Camp Lejeune, North Carolina*. July.

CH2M. 2019a. *Record of Decision Operable Unit 15, Site 88. Marine Corps Base Camp Lejeune, North Carolina.* April.

CH2M. 2019b. *Draft Vapor Intrusion Mitigation System Performance Monitoring – December 2018 Data, Marine Corps Base Camp Lejeune, North Carolina.* August.

CH2M. 2019c. *Draft Remedial Design Site 88, Operable Unit 15, Marine Corps Base Camp Lejeune, North Carolina.* November.

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Table 15-1. Cleanup Levels for OU 15 (Site 88)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2019a)	Reference
Groundwater (µg/L)	**VOCs**		
	Benzene	1	NCGWQS
	Naphthalene	6	NCGWQS
	Tetrachloroethene	0.7	NCGWQS/MCL
	Trichlorethene	3	NCGWQS/MCL
	cis-1,2-dichloroethene	70	NCGWQS
	Vinyl chloride	0.03	NCGWQS
Soil Gas (µg/m^3)	**VOCs**		
	Tetrachloroethene	1,390	USEPA VISL[b]
	Trichlorethene	69.5	USEPA VISL[b]
	Vinyl chloride	559	USEPA VISL[b]

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

[b] USEPA VISL Calculator for a target cancer risk of $1x10^{-4}$ and hazard quotient of 1.0 for a residential use scenario.

Notes:

Cleanup Level Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

USEPA VISL (February 2019)

µg/L = microgram(s) per liter

µg/m^3 = microgram(s) per cubic meter

COC = constituent of concern

MCL = maximum contaminant level

NCGWQS = North Carolina Groundwater Quality Standard

ROD = Record of Decision

USEPA = United States Environmental Protection Agency

VISL = vapor intrusion screening level

VOC = volatile organic compound

Table 15-2. OU 15 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
88	Groundwater Soil Gas	Potential unacceptable risks to future residents exposed to COCs in groundwater and soil gas. Potential unacceptable risks to future construction workers exposed to COCs in groundwater and soil gas.	Industrial/ Barracks	Reduce groundwater contaminant source mass to the maximum extent practicable within a reasonable timeframe to inhibit migration of COCs to the New River	ERD	For Zones 1 and 2, continue treatment applications as described in the RD or multiple lines of evidence of MNA are observed including: • Plume stability • Mass reduction • Elimination of NAPL to the extent practicable, based on groundwater concentrations exceeding 1 percent of the solubility of PCE • Groundwater fate and transport modeling indicating protectiveness of the New River • Sustained favorable MNA conditions	MNA
					ISCO		
					Biobarrier	Maintain until COC concentrations in groundwater are protective of downgradient receptors (based on fate and transport modeling) and aquifer conditions suggest that biodegradation can be maintained naturally, and further enhancements are not required.	
				Restore groundwater quality to meet NCDEQ and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A North Carolina Administrative Code 02L.0201.	MNA	Implement until each groundwater COC is at or below the more conservative values between the NCGWQS or the federal MCLs for four consecutive monitoring events.	UU/UE
				Prevent human ingestion of and contact with groundwater containing COCs at concentrations above NCGWQS or MCLs, whichever is more stringent.	LUCs	Implement LUCs and monitor quarterly until each groundwater COC is at or below the more conservative values between the NCGWQS or the federal MCLs for four consecutive monitoring events.	
				Prevent exposure to COCs in groundwater and soil gas during construction, and through the vapor intrusion pathway that could result in an unacceptable risk to human health.	LUCs/VIMS	Implement LUCs until each groundwater COC is at or below its respective cleanup level for four consecutive monitoring events. Once groundwater concentrations are below the cleanup levels, soil gas concentrations are expected to be below concentrations likely to result in a complete VI pathway or unacceptable risk to construction workers. Soil gas confirmation samples will be collected and compared to soil gas cleanup levels. While LUCs are in place, if groundwater concentrations are detected above cleanup levels within 100 feet of a building without a VIMS or sewer ventilation system, a VI evaluation will be conducted. This evaluation will determine whether the potential for a complete VI pathway has changed from previous assessments and whether additional sampling is required. Operate the Building 3B VIMS and Building HP57 sewer ventilation system until active treatment in Zones 1 and 2 are complete and shutdown criteria, as established in the RD, are met. The following lines of evidence may be considered to evaluate VIMS and sewer ventilation system shutdown: • Results of rebound testing • Additional indoor air and soil gas sampling • Building-specific attenuation factors • Other empirical evidence	
		Although there are no soil COCs, VOCs remain in soil within the ZVI soil mixing area at concentrations exceeding soil-to-groundwater MSCCs, suggesting that contaminated soil could serve as a continuing source to groundwater.		Restrict intrusive activities and prevent residential use within the ZVI soil mixing treatment area.	LUCs	Maintain and monitor LUCs quarterly. If the groundwater remedy cannot achieve the RAOs and data suggest that contaminated soil is acting as a continuing source of groundwater contamination, then additional soil remediation actions will be evaluated.	Parking Lot

Notes:
COC = constituent of concern
ERD = enhanced reductive dechlorination
ISCO = in situ chemical oxidation
LUC = land use control
MCL = maximum contaminant level
MNA = monitored natural attenuation
MSCC = maximum soil contaminant concentration
NCGWQS = North Carolina Groundwater Quality Standard
RD = remedial design
RAO = remedial action objective
UU/UE = unlimited use/unrestricted exposure
VIMS = vapor intrusion mitigation system
VOC = volatile organic compound
ZVI = zero valent iron

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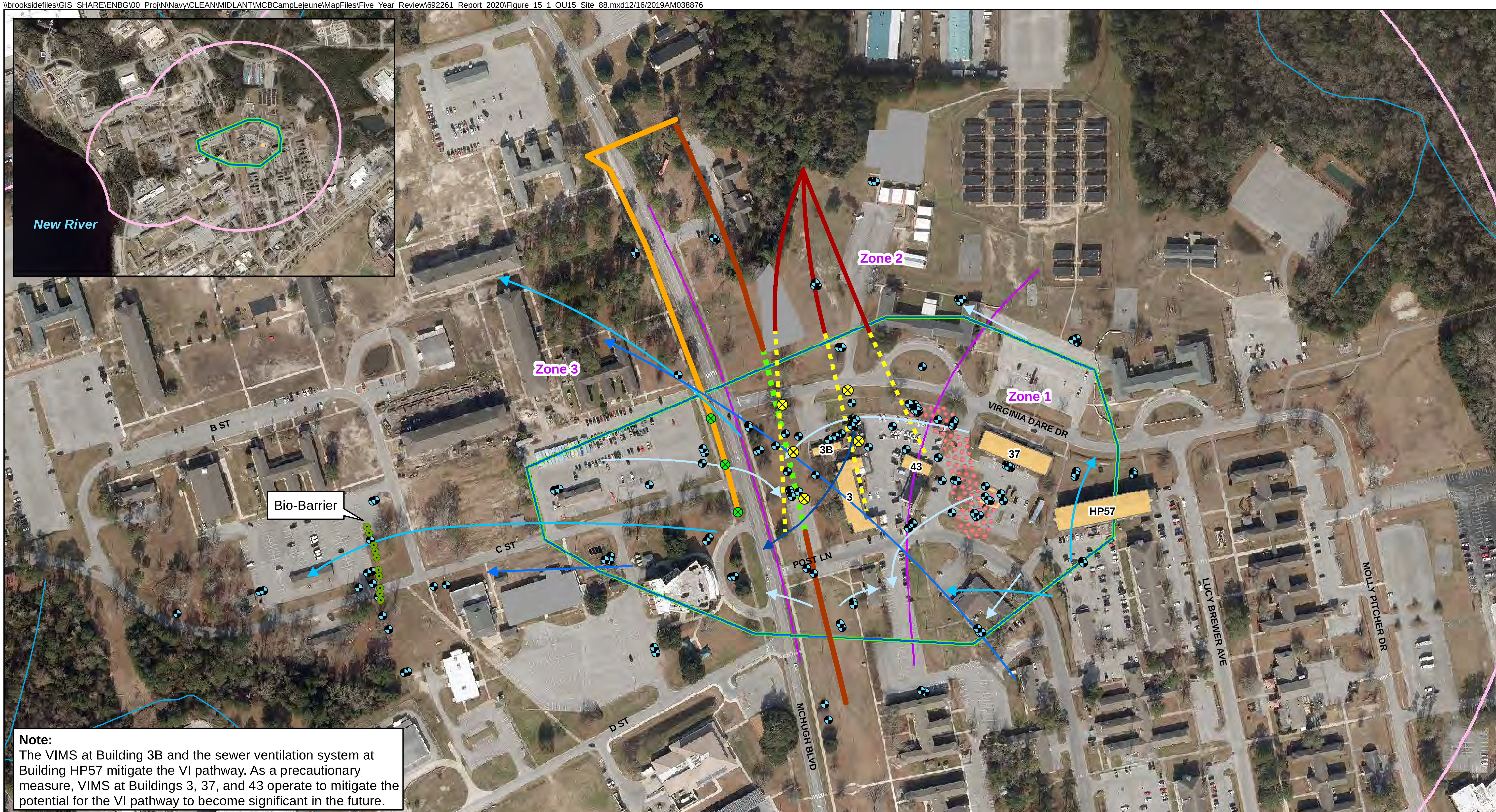


Legend

- Monitoring Well Location
- Vertical Extraction Well
- Proposed Vertical Extraction Well
- Proposed ERD Injection Wells
- Proposed Injection Wells
- Existing Horizontal Injection Well Screened Interval
- Proposed Horizontal Injection Well Screened Interval
- Horizontal Injection Well Casing
- Extraction Conveyance Line
- Zone Boundary
- Buildings with Vapor Intrusion Mitigation Systems
- Surface Water Centerline
- Surficial Groundwater Flow
- UCH Groundwater Flow
- MCH Groundwater Flow
- LCH Groundwater Flow

Land Use Control Boundary

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrustion)

N

0 125 250 500 Feet

1 inch = 250 feet

Figure 15-1
OU 15 (Site 88)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

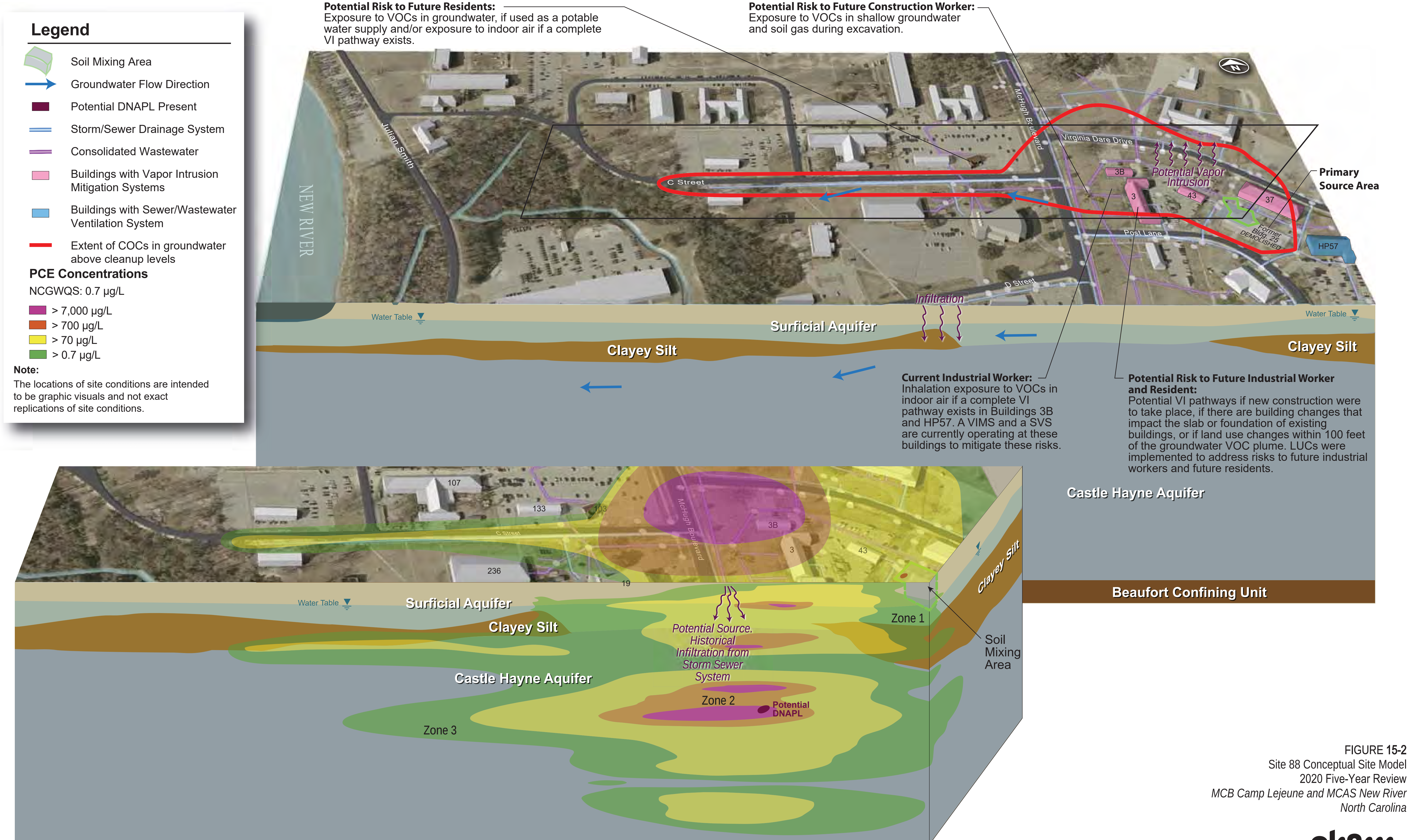
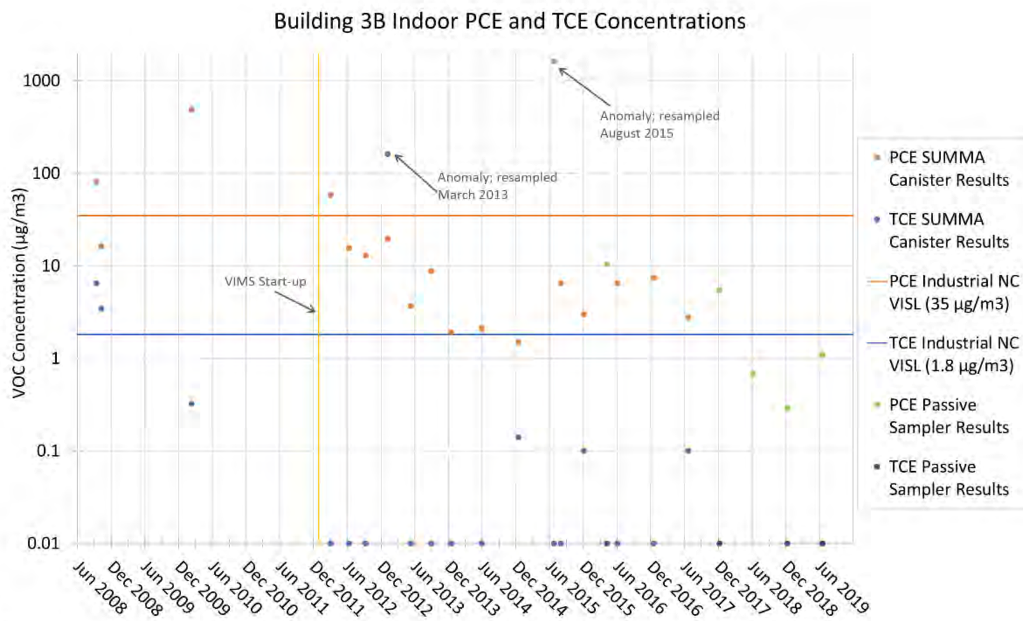
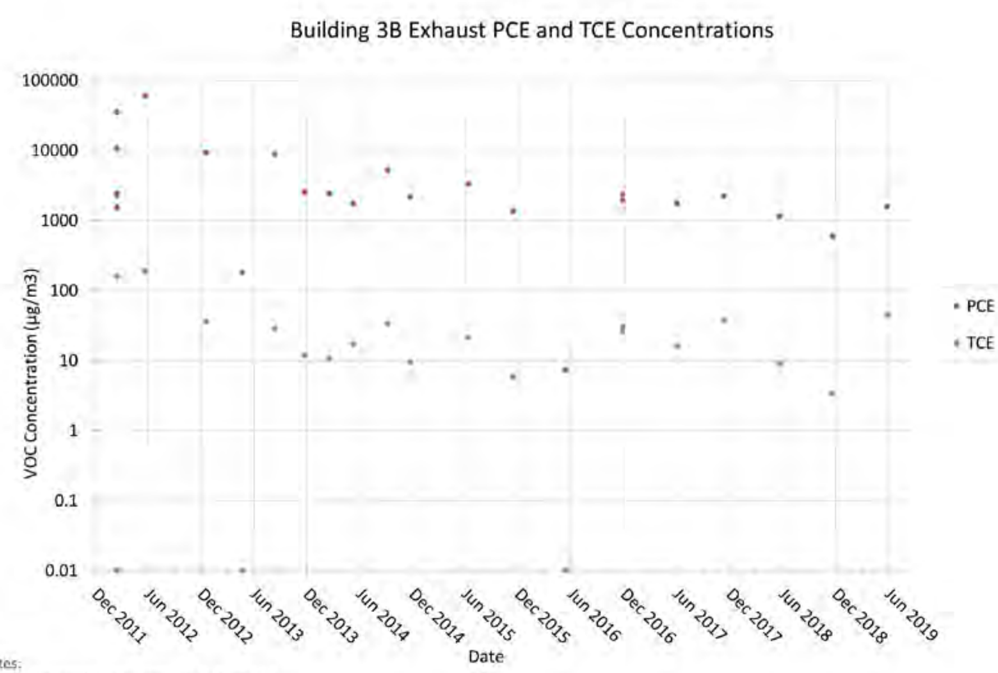


FIGURE 15-2
Site 88 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ES100611223359MKE MCB_CamLej_Site_88_CSM_v5.ai 8-13-19 tdaus

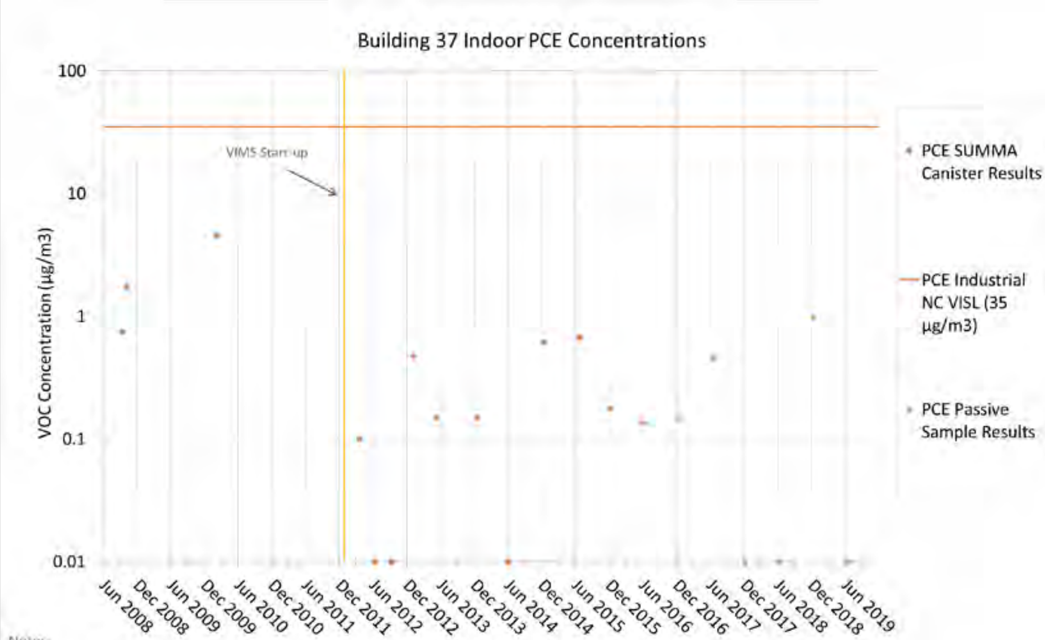


Notes:
1. Non-detect results are shown as 0.01 µg/m3
2. Following the September 2017 (Round 22) performance monitoring event, the MCB Camp Lejeune Partnering Team concurred to collect passive samples with sorbent tubes over a 2-week period to evaluate longer-term indoor air concentrations in future performance monitoring events. Previous indoor air samples were collected over a 24-hour period with Summa canisters.

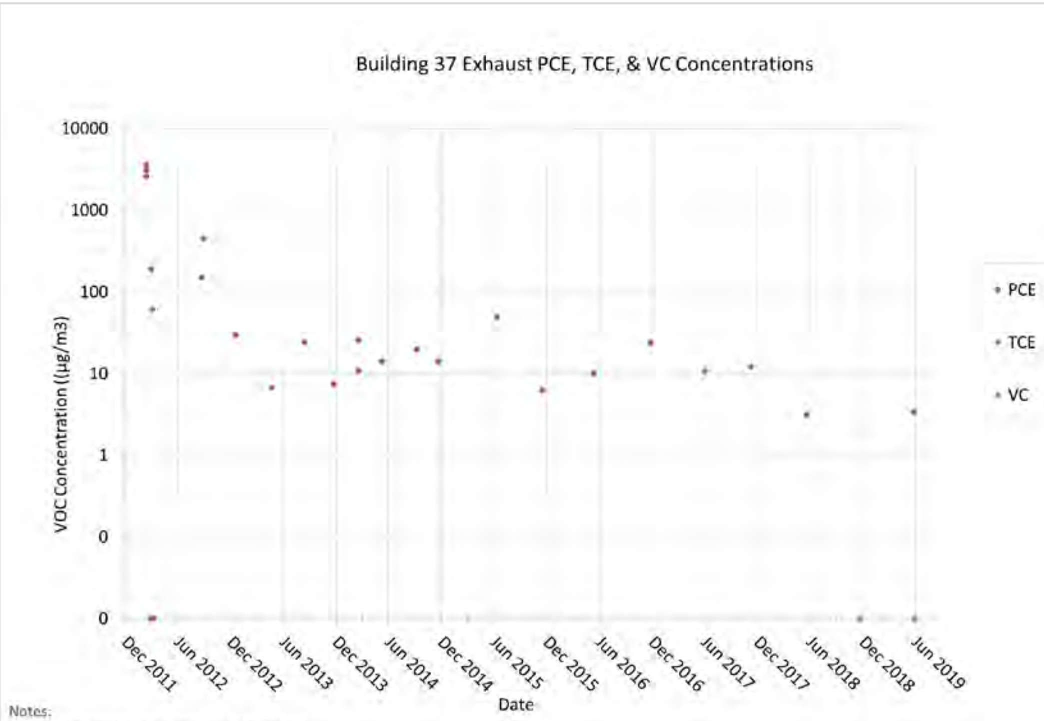


Notes:
Non-detect results are shown as 0.01 µg/m3
Samples may be collected from different nodes during each round

Figure 15-3
Building 3B Indoor Air and Exhaust VOC Concentrations
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

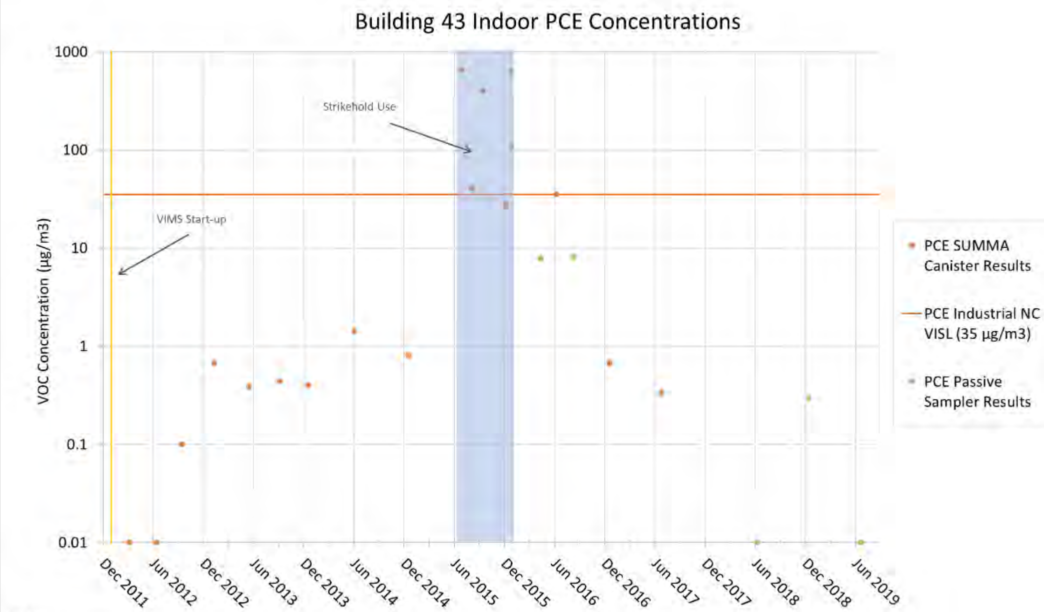


Notes:
1. Non-detect results are shown as 0.01 µg/m3.
2. Following the September 2017 (Round 22) performance monitoring event, the MCB Camp Lejeune Partnering Team concurred to collect passive samples with sorbent tubes over a 2-week period to evaluate longer-term indoor air concentrations in future performance monitoring events. Previous indoor air samples were collected over a 24-hour period with Summa canisters.

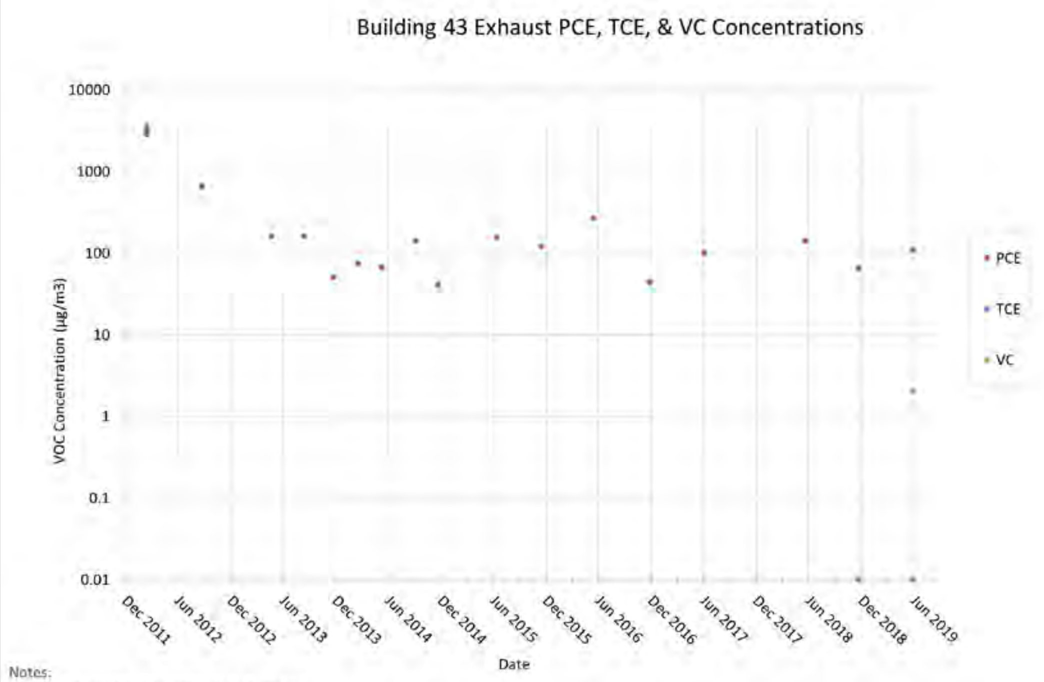


Notes:
Non-detect results are shown as 0.01 µg/m3
Samples may be collected from different nodes during each round

Figure 15-4
Building 37 Indoor Air and Exhaust VOC Concentrations
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

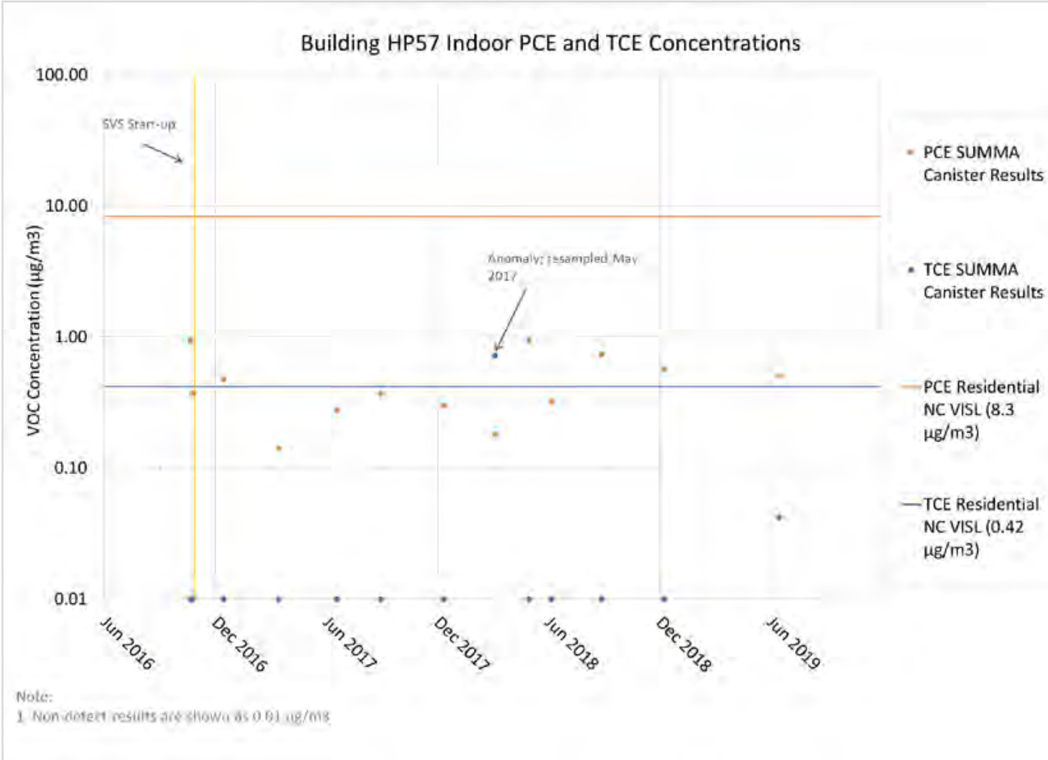


Notes:
1. Non-detect results are shown as 0.01 µg/m3
2. Following the September 2017 (Round 22) performance monitoring event, the MCB Camp Lejeune Partnering Team concurred to collect passive samples with sorbent tubes over a 2-week period to evaluate longer-term indoor air concentrations in future performance monitoring events. Previous indoor air samples were collected over a 24-hour period with Summa canisters.
3. The Building 43 VIMS was off in December 2017 due to building construction.



Notes:
Non-detect results are shown as 0.01 µg/m3
Samples may be collected from different nodes during each round

Figure 15-5
Building 43 Indoor Air and Exhaust VOC Concentrations
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina



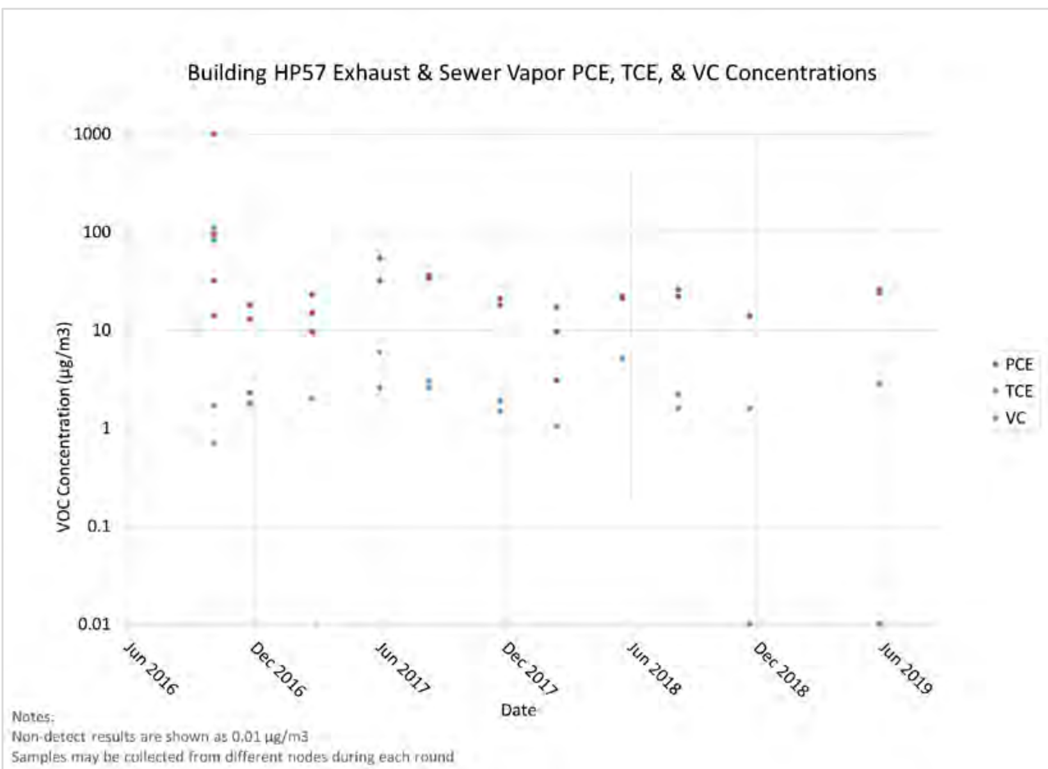


Figure 15-6
Building HP57 Indoor Air, Exhaust, and Sewer Gas VOC Concentrations
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

Operable Unit 16 (Sites 89 and 93)

16.1 Site History and Background

OU 16 is within in the Camp Geiger operations area at MCAS New River and covers approximately 66 acres (**Figure 1-2**). OU 16 consists of two sites (Sites 89 and 93) that have been grouped together because of their proximity to one another and unique characteristic of suspected waste (solvents).

Site 89 — the former DRMO is approximately 50 acres and is located west of the New River, near the intersection of 8th and G Streets (**Figure 16-1**). The Base motor pool operated on the site until 1988 and reportedly used solvents such as acetone, TCE, and 2-butanone (methyl-ethyl-ketone) for cleaning parts and equipment. A steel 550-gallon UST was used to store waste oil from 1983 until its removal in 1993. During removal, visible signs of contamination were observed, and the contaminated soil was removed until groundwater was encountered. Other structures historically located in the former UST area include Building STC-867, which was reportedly used to store soil piles from various on-Base sources, and a wash rack with an associated drain and OWS. The DRMO was operated by the Defense Logistics Agency on the site from 1988 until 2000. The area was used as a storage yard for items such as scrap and surplus metal, electronic equipment, vehicles, rubber tires, and fuel bladders. The site has been vacant since the DRMO relocated in 2000. Four USTs containing various petroleum hydrocarbon products were formerly located at Site 89 to support the operations.

Site 93 — Building TC942 is approximately 16 acres located at the intersection of 9th and E Streets (**Figure 16-1**). Historical records indicate that a 550-gallon UST storing waste oil was previously located on Site 93, off the southwest corner of Building TC-942. Previous investigations identified VOCs in groundwater following the UST removal (Law, 1994).

OU 16 Timeline	
Year	**Event**
1994	UST Investigation (Site 89)
1995-1996	Geotechnical Investigation (Site 93)
1996-1998	RI (Site 89 & 93)
1999-2003	Groundwater Monitoring (Site 89)
1999	Post RI CVOC Sampling (Site 89)
2000	TCRA – Thermal Treatment (Site 89)
2001	Supplemental Investigation, Natural Attenuation Evaluation (Site 89)
2002	Additional Plume Characterization (Site 93)
2003-2005	Pilot Study – ERH (Site 89)
2004-2005	Supplemental Investigation (Site 93)
2005	FS (Site 93)
2006	PRAP and ROD (Site 93)
2006-2008	Comprehensive RI, Treatability Study (Site 89) RD/RA – ISCO (Site 93)
2007-2010	NTCRA – Soil Mixing (Site 89)
2007-2011	Basewide VI Evaluation
2008-Present	LTM (Site 93)
2008	Baseline ERA Addendum (Site 89)
2009	RIP and IRACR (Site 93)
2009-2010	NTCRA –Wetland Soil Removal (Site 89)
2011-2012	FS (Site 89)
2012	PRAP, ROD, RD (Site 89)
2013	RA - AS, Aerator, PRB (Site 89) LUCIP Update (Site 93)
2014-Present	LTM (Site 89)
2015-Present	Pilot Study – SBGR (Site 93)
2017-Present	SRI (Site 89)
2019	Basewide PFAS PA (Site 89)

16.2 Site Characterization

The findings from various investigations at OU 16 that are pertinent to the FYR are summarized as follows:

16.2.1 Physical Characteristics

- **Surface Features –** At Site 89, the former DRMO area is surrounded by a fence with an access gate, and the ground surface is covered with asphalt pavement, gravel, or grass. The area north of the former DRMO is developed, with buildings, asphalt pavement, and maintained grass. The area to the west and south of the former DRMO is primarily wetland along Edwards Creek. The eastern portion of Site 89 is generally undeveloped and covered in grass, wetland, and forest.

  Site 93 is developed and covered with asphalt pavement, gravel, and grass. Several buildings and training areas are present in the vicinity of the site. The eastern portion of the site is wooded and slopes gently toward Edwards Creek. Storm water from Camp Geiger is conveyed by manmade drainage ditches into the headwaters of Edwards Creek.

- **Geology and Hydrogeology** – Subsurface conditions generally consist of Coastal Plain deposits including silts, clays, fine sands, and limestone. A discontinuous layer of dense fine sands, silts, and clays provides localized areas of confinement of the Castle Hayne aquifer. Where the confining layer is absent, the surficial and Castle Hayne aquifers are in direct hydraulic communication. At Site 89, groundwater is a medium of concern and the affected aquifers include the surficial aquifer, which is encountered at depths ranging from 1 to 14 feet bgs and extends to a depth of approximately 35 feet bgs, the UCH aquifer which extends to a depth of 70 feet bgs, and the MCH aquifer which extends to at least 125 feet bgs. In the surficial aquifer, the average hydraulic conductivity is 5.1 ft/day, the average gradient is 0.027 ft/ft, and the average groundwater seepage velocity is 0.136 ft/day. There is an upward vertical gradient of 0.016 foot per foot between the surficial and UCH aquifers. In the UCH aquifer, the average hydraulic conductivity is 64.6 ft/day, the average gradient is 0.003 ft/ft, and the average groundwater velocity is 0.205 ft/day. Between the UCH and MCH aquifer there is a downward vertical gradient of approximately 0.35 ft/ft. In the MCH aquifer, the average gradient is 0.006 ft/ft. At Site 93, groundwater is a medium of concern and the affected aquifer is the surficial aquifer which is encountered at depths ranging from approximately 1 to 4 feet bgs and extends to a depth of approximately 25 feet bgs. The hydraulic conductivity was estimated to be 8.4 ft/day, the horizontal hydraulic gradient ranges from 0.011 ft/ft to 0.018 ft/ft, and the average groundwater velocity is 0.34 ft/day. In general, the groundwater flow direction within the surficial and Castle Hayne aquifers at both sites is to the southeast towards Edwards Creek and the New River (**Figure 16-1**).

16.2.2 Land Use

- **Current Land Use** – There are no ongoing operations at Site 89 and the area is categorized as supply/storage, training, and administrative use. The eastern portion of the aquifer use boundary encompasses residential housing. An access road that bisects the site is used by military personnel for recreation, training, and to access a picnic area located adjacent to the New River. Buildings in the vicinity of Site 93 currently function as classrooms, barracks, and supply rooms for the Marine Infantry School.
- **Future Land Use -** There are no anticipated changes in land use.

16.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 16.

Site 89

This section summarizes the basis for taking action at Site 89 when the ROD was signed. Details are in the RI (Baker, 1998), Comprehensive RI (CH2M, 2008a), FS (CH2M, 2012a), and ROD (CH2M, 2012d).

Soil, groundwater, surface water, sediment, and pore water were investigated from 1994 to 2012 and identified chlorinated solvents, PAHs, and pesticides in soil and sediment and chlorinated solvents in groundwater and surface water. After completion of the 1998 RI, groundwater monitoring was implemented and a sudden increase in VOCs triggered an immediate response investigation (Baker, 1999), which identified DNAPL in soil and groundwater. Several RAs and studies were completed to reduce or eliminate risks and contaminant volume, particularly the DNAPL in soil and groundwater, prior to the ROD (CH2M, 2012d) (**Figure 16-2**).

- Low Temperature Thermal Desorption TCRA (OHM, 2000): Based on the results of the immediate response investigation and supplemental sampling (Baker, 1999), DNAPL in shallow soil in the southern portion of the DRMO area was identified as a source of VOC contamination in the surficial aquifer groundwater and Edwards Creek. In 2000, a TCRA consisting of low-temperature thermal desorption was completed in the southern portion of the former DRMO for the removal and treatment of vadose zone soils contaminated with chlorinated solvents. Roughly 32,000 tons of DNAPL-impacted soil were treated. In addition, an aeration system was installed in Edwards Creek to assist in the remediation of VOCs. The aeration system remains in place and is operational.
- Electrical Resistive Heating (ERH) Pilot Study (Shaw, 2005): Based on the results of supplemental investigations conducted in 2000 and 2001 (Baker, 1999 and CH2M, Baker, and CDM, 2001), an ERH pilot study was conducted from 2003 to 2004 to treat the DNAPL in surficial groundwater and soil in the southern area of the DRMO. The total treatment area was approximately 15,900 square feet, and the approximate quantity of soil treated was 14,700 cubic yards, based on an estimated conductive zone of 25 feet. An estimated 48,000 pounds of VOCs were removed from the subsurface. Confirmatory sampling indicated that the free-phase DNAPL in the treatment zone was removed.
- Treatability Studies (AGVIQ-CH2M Joint Venture, 2008): From 2006 to 2008, treatability studies were completed to evaluate the performance and effectiveness of four technologies to remove CVOCs from surficial aquifer groundwater, including: AS using a HDD well; permeable reactive barriers (PRBs) using mulch and compost as backfill; chemical reduction via ZVI injection through pneumatic fractures; and ERD using a combination of sodium lactate and EVO using DPT injection methods. Evaluation of the four pilot studies concluded that AS is the optimal treatment when considering effectiveness, implementability, and cost.
- NTCRA – Soil Mixing (AGVIQ/CH2M, 2010): Unacceptable risks were identified in the 2008 RI based on concentrations of CVOCs in subsurface soil and surficial aquifer groundwater. From 2008 to 2010, an NTCRA consisting of soil mixing with ZVI and clay was conducted in the southern portion of the former DRMO, outside of the ERH treatment area, to remove chlorinated solvents in the soil and surficial aquifer groundwater. The area treated was 32,000 square feet at a depth of 25 feet, resulting in a total treated volume of 30,000 cubic yards. Follow-up monitoring indicated significant reduction in VOC concentrations in the soil, groundwater, and adjacent creek.
- NTCRA – Western Wetland (CH2M, 2010): A baseline ERA addendum was completed in 2008 (CH2M, 2008b) to evaluate potential ecological risks in the wetland area of Site 89. Potential unacceptable risks were identified from PAHs and pesticides at two isolated locations. In 2010, an NTCRA consisting of soil and sediment excavation and offsite disposal was completed in the western wetland to remove ecological risks associated with PAHs and pesticides. After excavation, confirmation sampling was conducted, and the results were below cleanup levels. Excavated soil and sediment was disposed of offsite. There were no remaining ecological risks after completion of the 2010 Western Wetland NTCRA.

The ROD was prepared based on the site conditions after these RAs and studies were completed. The HHRA evaluated potential future maintenance and industrial workers, recreational users, adult and child residents, and construction workers. Unacceptable risks to future industrial workers, residents, and construction workers were identified from exposure to CVOCs in surficial and UCH aquifer groundwater from direct exposure and/or use as a potable supply. Although no unacceptable risks were identified from exposure to concentrations of VOCs in surface water at the time of evaluation; groundwater migration to surface water was identified as a potential migration pathway for VOCs.

Site 89 was included in the phased Basewide VI evaluation, conducted from 2007-2015 to determine if complete or significant exposure pathways exist for VI into buildings. Although the evaluation concluded that the VI pathway is not currently significant, based on site-specific COCs, indoor air concentrations could exceed the VISLs should VI occur in the future if new construction were to take place or if future building or land use changes within 100 feet of the groundwater VOC plume.

Site 93

This section summarizes the basis for taking action at Site 93. Details are in the RI (Baker, 1998), Supplemental Investigation (CH2M, 2005), and ROD (CH2M, 2006b).

Soil, groundwater, and surface water were investigated. The HHRA evaluated current military personnel and potential future adult and child residents, military personnel, and construction workers. Unacceptable risks to potential future adult and child residents were identified from exposure to CVOCs and metals in groundwater. Metals were not retained as COCs because detected concentrations were attributed to natural geologic conditions and sampling method (CH2M, 2006b). The ERA evaluated terrestrial and aquatic receptors. No unacceptable ecological risks were identified.

Site 93 was included in the phased Basewide VI evaluation, conducted from 2007 to 2015, to determine if complete or significant exposure pathways exist for VI into buildings because of the presence of VOCs in the surficial aquifer. Although the evaluation concluded that the VI pathway is not currently significant, based on site-specific COCs, indoor air concentrations could exceed the VISLs should VI occur in the future if new construction were to take place or if future building or land use changes within 100 feet of the groundwater VOC plume.

16.3 Remedial Action Objectives

Site 89

The ROD for Site 89 was signed in December 2012 (CH2M, 2012d). The RAOs identified for Site 89 are:

- Restore groundwater quality at Site 89 to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water [Class GA or Class GSA] under 15A NCAC 02L.0201.
- Minimize degradation of Edwards Creek from COC-impacted groundwater discharging into surface water until surface water COC concentrations meet the NCSWQS.
- Control exposure to COCs in groundwater and VI from COCs in groundwater.

The COCs and cleanup levels for Site 89 are presented in **Table 16-1**.

Site 93

The ROD for Site 93 was signed in October 2006 (CH2M, 2006b). The RAOs identified for Site 93 are:

- Reduce COC concentrations in the highest concentration areas and reduce exceedances of COCs to meet the NCGWQS or MCLs, whichever is more conservative.
- Prevent human exposure of water containing COCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC) at concentrations above NCGWQS or MCLs, whichever is more conservative.
- Achieve suitability of Site 93 groundwater for unlimited use with a reasonable approach and within a reasonable timeframe.

The COCs and cleanup levels for Site 93 are presented in **Table 16-2**.

16.4 Remedial Actions

Site 89

The RA at Site 89 includes the following major components:

- AS using horizontal and vertical wells to treat areas of groundwater with high contaminant concentrations (1,1,2,2-PCA greater than 2,000 µg/L, TCE greater than 3,000 µg/L, and VC greater than 3,000 µg/L) and associated performance monitoring.
- PRBs to treat the downgradient groundwater prior to migration offsite or discharge to Edwards Creek and associated performance monitoring.
- Aerators to treat groundwater discharge to surface water and associated performance monitoring.
- MNA to monitor plume stability and natural attenuation processes in groundwater across the site outside of the active treatment area and after active treatment is completed.
- LUCs to prevent exposure to VOCs in groundwater and indoor air via the VI pathway.

Site 93

The RA for Site 93 includes the following major components:

- ISCO via permanganate injection to treat the highest concentration area of the plume.
- MNA to monitor plume stability and natural attenuation processes in groundwater.
- LUCs to prevent exposure to VOCs in groundwater and indoor air via the VI pathway.

16.4.1 Remedy Implementation

Remedy components for both Site 89 and 93 are shown on **Figure 16-1**.

Site 89

Air Sparging

In March 2013, two HDD AS wells (HAS-A and HAS-B), and three vertical AS wells (VAS-1, VAS-2, and VAS-3) were installed in the former DRMO (Osage, 2014) as follows:

Well	Type	Depth (feet bgs)	Total Length (feet)	Screen Length (feet)	Air Flow Rate (scfm)
HAS-A	HDD	45	910	700	420
HAS-B	HDD	45	840	600	360
VAS-1	Vertical	85	—	2.5	30
VAS-2	Vertical	85	—	2.5	30
VAS-3	Vertical	85	—	2.5	30

Construction details for the AS system are provided in the Construction Completion Report (Osage, 2014). The AS system start-up began in September 2013, and performance monitoring began in May 2013 and is ongoing.

Permeable Reactive Barriers

In July 2013, two PRBs were installed east of White Street. PRB A, oriented parallel to White Street, was installed to 35 feet deep to treat groundwater migrating from the former DRMO area. PRB B, oriented parallel to Edwards Creek, was installed to 23 feet deep to treat surficial aquifer groundwater before discharging into the creek. The PRB media consisted of a mix of 40 percent mulch and 60 percent gravel (SEPI, 2014). PRB performance monitoring began in December 2013 and is ongoing.

Surface Water Aerators

In January 2014, five in-creek aerators were installed in Edwards Creek to treat VOCs in surface water. Air is delivered at a rate of 50 cubic feet per minute and 6 pounds per square inch via 2,100 feet of conveyance piping to the five aerators. The aerators use air stripping technology to transfer contaminants from aqueous solutions to air (SEPI, 2014). Performance monitoring of the six in-creek aerators (one existing, five newly installed) began in December 2013 and is ongoing.

Monitored Natural Attenuation and Land Use Controls

MNA of groundwater at Site 89 was initiated in 2014 and is ongoing as described in the following section. LUCs for Site 89 were implemented in 2013 (CH2M, 2012c). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control** – To prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in-place above concentrations that allow for UU/UE. This LUC boundary encompasses the area 500 feet from the surficial and Castle Hayne aquifer groundwater with COCs exceeding cleanup levels.
- **Intrusive Activities Control (Groundwater)** – To restrict intrusive activities within the extent of groundwater contamination. This LUC boundary is defined as the area with concentrations of COCs contributing to construction worker risks and is conservatively assumed to include the area within 100 feet of the entire extent of surficial aquifer groundwater COCs exceeding cleanup levels.
- **Industrial/Non-Industrial Use Control (Vapor Intrusion)** – To evaluate future buildings and land use for potential VI pathways, prior to construction, within the extent of groundwater contamination remaining in-place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 100 feet of surficial and Castle Hayne aquifer groundwater COCs exceeding cleanup levels.
- **Access Control** – To prevent exposure to surface water in Edwards Creek, fencing and signs around the perimeter of the site will be maintained.

Site 93

In Situ Chemical Oxidation

The ISCO injections were conducted at Site 93 from 2006 through 2007. The initial phase was conducted from October 2006 to February 2007 and the second phase was conducted from June to December 2007. The injections were suspended due to wet conditions and low actual injection rates compared with the design. During the interval between the first and second phase, pump testing was completed and the injection method was re-evaluated and gravity-feed via injection points was initiated during the second phase. A total of 92,000 and 144,000 gallons of permanganate solution were injected during the first and second phases, respectively, which is approximately 60 percent of the design. Performance monitoring indicated that only a slight reduction in COC concentrations was observed within the treatment area (Shaw, 2009). Additional ISCO injections were not considered cost-effective and MNA was initiated.

Monitored Natural Attenuation and Land Use Controls

MNA at Site 93 was initiated in 2008, upon completion of the ISCO injections, and is ongoing as described in the following section. LUCs for Site 93 were implemented in 2009 and updated in 2014 to include VI considerations (CH2M, 2014a). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control:** Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 1,000 feet of groundwater within the surficial and UCH aquifers with concentrations of CVOCs exceeding cleanup levels.
- **Intrusive Activities Control (Groundwater):** Restrict intrusive activities within the extent of groundwater contamination. This LUC boundary encompasses the area within 100 feet of surficial aquifer groundwater CVOCs exceeding cleanup levels.

- **Industrial/Non-Industrial Use Control (VI):** Evaluate future buildings and land use for potential VI pathways, prior to construction, within the extent of groundwater contamination remaining in place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 100 feet of surficial aquifer groundwater CVOCs exceeding cleanup levels.

16.4.2 Remedy Operation and Maintenance

Site 89

Ongoing operations at Site 89 include operation of the AS system, PRBs, surface water aerators, MNA, and LUCs. The total annual cost is approximately $160,000.

Air Sparging

O&M of the AS system is conducted weekly; monthly reports are provided in annual LTM reports. The AS system has been in operation approximately 88 percent of the time with periods of planned (routine sampling and maintenance, and drilling operations) and unplanned (power outages, non-routine repairs) shutdowns (CH2M, 2019c). **Figure 16-3** summarizes AS operating parameters in comparison to the design since implementation. The system consistently operates below design flow rates.

AS performance monitoring initially consisted of collecting groundwater samples quarterly for COCs from 19 surficial, 15 UCH, and 1 MCH aquifer monitoring wells located within 60 feet of the horizontal AS wells and 20 feet of the vertical AS wells. As specified in the RD, the sampling frequency was changed to annual after the first two years of operation. Soil gas samples were collected in Building TC-864 quarterly for three quarters (December 2016, February 2017, and April 2017). Building TC-864 was demolished after the April 2017 sampling event and there are no other buildings within 100 feet of the VOC plume.

Permeable Reactive Barriers

Performance monitoring for the PRBs was initiated in 2013 and initially consisted of quarterly groundwater sampling from 20 surficial and 2 UCH aquifer monitoring wells for COCs and TOC. Based on performance data indicating the PRB was effective over multiple quarters, the monitoring frequency was reduced to semi-annually.

PRB effectiveness is evaluated quarterly by comparing COC and TOC concentrations and ORP to baseline conditions. Performance data collected during FYs 2015 and 2016 indicated that while COCs still appeared to be decreasing within and downgradient from the PRB, TOC levels decreased from baseline in samples collected from within both PRB A and B, indicating that the PRB was depleted. ORP levels increased slightly in PRB B, also indicating that the PRB is depleted (CH2M, 2017b). Two replenishment events injecting EVO into each PRB were conducted. The first event was attempted in 2017 using DPT methods but was generally unsuccessful due to daylighting and relatively high water levels. The second event was completed in 2018 by installing permanent injection point and gravity feeding EVO over the course of several weeks to allow the formation to accept the substrate more slowly and limit daylighting. Injections were completed on March 1, 2018 (CH2M, 2019c).

Surface Water Aerators

O&M of the surface water aerators consists of daily visual inspection of pond aerators, creek blower, flow cycle recording, weekly visual inspection of pond aerator’s timer set points, individual creek aerators, and air supply lines. Monthly reports are provided in annual LTM reports. Aerator performance monitoring initially consisted of quarterly sampling of three surface water sample locations and currently consists of semi-annual sampling of three surface water sample locations for VOC COCs. The aerators operated the majority of the time during this five-year cycle with the exception of a blower breakdown from January to April 2016 and a 2-week shutdown due to Hurricane Florence (CH2M, 2017, 2019c).

Monitored Natural Attenuation

MNA for Site 89 initially consisted of collection of groundwater samples from 20 surficial, 12 UCH, and 4 MCH aquifer monitoring wells and surface water samples from 5 locations in Edwards Creek. Samples are collected annually for COCs (**Table 16-2**) and every 5 years groundwater samples are also collected for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and TOC) to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs. Based on monitoring results over time, the groundwater MNA network was modified to reflect the plume extents and currently consists of 18 surficial, 13 UCH, and 5 MCH aquifer monitoring wells. No changes have been made to the surface water sampling locations and protocol.

In addition to comparing to cleanup levels (**Table 16-2**), data in the surficial aquifer are compared to the non-residential NC VISLs, consistent with overall site use, to evaluate whether concentrations indicate the potential for a complete VI pathway. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of the MNA component of the remedy.

Land Use Controls

The LUCs for Site 89 are shown on **Figure 16-1** and are summarized in **Table 16-3**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed and damage to the fence around the former DRMO area and high water in Edwards Creek was noted. The fence was repaired between November 2018 and March 2019. During the FYR site inspection conducted in March 2019, damage to the fencing along Edwards Creek was noted east of White Street and south of the PRBs. Ponding was also observed along the southern boundary of the PRB area adjacent to Edwards Creek. There appeared to be evidence of off-road driving not related to sampling in the open field where PRBs are present (**Appendix B**). No issues affecting protectiveness were observed.

Table 16-3. OU 16 (Site 89) Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (500 feet)	105.17	November 2012 (RD)	November 14, 2013
Intrusive Activities Control Boundary (Groundwater)	29.06		
Industrial/Non-Industrial Use Control Boundary (VI)	29.06		
Access Control	1,600 feet of fence line		

Site 93

Ongoing operations at Site 93 consist of MNA and LUCs. The total annual cost Site 93 is approximately $35,000.

Monitored Natural Attenuation

MNA for Site 93 initially consisted of quarterly sampling of 11 surficial, 5 UCH, and 1 MCH aquifer monitoring well for VOCs. Based on results over time, the MNA protocol was optimized and currently includes annual sampling of 11 surficial and 3 UCH aquifer monitoring wells for COCs listed in **Table 16-2**. Samples are analyzed every 5 years for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and TOC) to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs. Sampling locations are shown on **Figure 16-1**.

In addition to comparing to cleanup levels, all surficial aquifer groundwater data is screened against non-residential NC VISLs consistent with overall site use to evaluate whether concentrations indicate potential for a complete VI pathway. Downgradient surficial aquifer data is also compared to 10 times the human health NCSWQS to assess the potential for groundwater to affect surface water. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of MNA.

Land Use Controls

The LUCs for Site 93 are shown on **Figure 16-1** and are summarized in **Table 16-4**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In October 2018, a post-hurricane inspection was completed and no damage at Site 93 was observed. No issues affecting protectiveness were observed during the FYR site inspection conducted in March 2019 (**Appendix B**).

Table 16-4. OU 16 (Site 93) Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	114.76	October 2014	October 15, 2014
Intrusive Activities Control Boundary (Groundwater)	8.63		
Industrial/Non-Industrial Use Control Boundary (VI)	8.63		

16.4.3 Post-ROD Removal Actions and Pilot Studies

Site 93 – Subgrade Biogeochemical Reactor Pilot Study

To reduce the time to site closure, a pilot study was initiated in 2015 to assess the effectiveness of using a SBGR to facilitate ERD of VOCs in the surficial aquifer (CH2M, 2017). The SBGR is comprised of mulch, gravel, and vegetable oil, and equipped with a solar-powered recirculation pump. Performance monitoring of the SBGR consisted of semiannual sampling of one monitoring well, one piezometer, and one extraction well. Based on the first 9 rounds of samples, the pilot study resulted in decreasing trends of parent products and increasing daughter products that are indicative of an active ERD system at IR93-PZ01 (99 percent reduction of TCE and 87 reduction of VC) and IR93-MW06 (96 percent reduction of TCE and 69 percent reduction of cis-1,2-DCE), both located within the zone of influence (**Figure 16-4**). These results indicated that the SBGR has created conditions within its zone of influence conducive to reductive dechlorination (CH2M, 2019a).

The SBGR was replenished with EVO and commercial dechlorinating bacteria in August 2018 based on reduced TOC and microbial populations and persistent elevated VC concentrations (CH2M, 2019a). Following the system enhancements, operation of the SBGR continued for 1 year and the final round of groundwater performance monitoring was conducted in May of 2019. Results indicated that VOC concentrations within the SBGR have decreased significantly except for VC, which remains at concentrations above its cleanup level. Based on the results, an enhancement to the pilot study is planned to expand the solar-powered SBGR and extraction well network to evaluate the potential to use ERD to further reduce VC concentrations in the surficial aquifer (CH2M, 2019e).

16.4.4 Progress Since the 2015 Five-Year Review

The OU 16 RA components and expected outcomes are summarized in **Table 16-5**.

Site 89

No issues were identified at Site 89 during the 2015 FYR. AS operation, PRB maintenance, surface water aeration, MNA, and LUCs inspections are ongoing as described above. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 16-2**. Investigations completed since the 2015 FYR are summarized in the following sections.

Supplemental Investigation

Supplemental Investigations were conducted in 2018 and 2019 to refine the CSM based on the discovery of CVOCs at concentrations indicative of DNAPL in the surficial aquifer and elevated concentrations of TCE in the

UCH aquifer in the vicinity of IR89-MW80DW (CH2M, 2017a). The investigations were conducted using a membrane interface probe and hydraulic profiling tool, soil screening using DPT, and soil and groundwater sampling in the surficial, UCH, and MCH aquifers. The investigation concluded that there are previously unidentified source areas in the surficial aquifer: one near the VAS area with 1,1,2,2-PCA, PCE, and TCE concentrations indicative of DNAPL near the AS area and one area near MNA monitoring well IR89-MW11 that continues to exhibit cis-1,2-dichloroethane (DCA) and VC concentrations several orders of magnitude higher than the cleanup level (**Figure 16-5**). A semi-confining dense sand unit appears to vertically confine this material at approximately 25 feet bgs. However, a limited area of elevated concentrations of CVOCs is present in the UCH and MCH aquifers up to a depth of 110 feet bgs, apparently due to migration of surficial CVOCs through damage sustained to IR89-MW80DW and IR89-MW80DW2 (**Figure 16-5**).

Site 93

No issues were identified at Site 93 during the 2015 FYR. MNA and LUCs inspections are ongoing and a pilot study was initiated and is also ongoing, as described above. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and suspected sources, is shown on **Figure 16-6**.

16.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Site 89

No. While the AS system was designed to treat the extent of VOCs in the former DRMO area understood at the time of the ROD, supplemental investigations have identified VOCs outside of the target treatment zone at concentrations indicative of DNAPL; therefore, the remedy is not functioning as intended by the ROD. However, current protectiveness is not affected because PRBs, aerators, and MNA are functioning as intended and LUCs are in place to prevent exposure to groundwater COCs at concentrations above cleanup levels and evaluate the VI pathway as necessary. The following is a summary of the remedy performance presented in the FY 2018 LTM report (CH2M, 2019c).

AS – COC concentrations from baseline to December 2017 are shown on **Figures 16-7** to **16-11**. Concentrations of COCs in surficial aquifer samples are stable to decreasing in the northern (proximal) area of the horizontal AS well (**Figures 16-7** and **16-8**). Similarly, concentrations in the UCH aquifer appear predominantly stable with isolated areas of increasing trends (**Figures 16-9** and **16-10**). Concentrations in the MCH aquifer vertical AS performance monitoring well (IR89-MW80DWR) appear to be decreasing (**Figure 16-11**). The system has been in operation for over 5 years, flow rate is consistently below design flow rate, and concentrations continue to be one to three orders of magnitude above cleanup levels. Additionally, the recent identification of new source areas within the surficial aquifer and elevated CVOCs deeper than the vertical AS system was designed to treat may warrant re-evaluating the remedial technology in this area (**Section 16.4.4**).

PRB – COC concentrations decrease as groundwater flows through the PRBs and only VC continues to exceed cleanup levels downgradient from PRB A (**Figure 16-12** and **16-13**) and only cis-1,2-DCE and VC continue to exceed cleanup levels downgradient from PRB B (**Figures 16-14** through **16-16**). Post-replenishing geochemical parameters (low ORP and DO) and decreasing concentrations of COCs indicate that the PRBs are still effective and functioning as designed.

Surface Water Aerators – COCs detected in Edwards Creek at concentrations exceeding the cleanup levels indicate that groundwater from Site 89 is discharging to the creek. As the surface water migrates downstream and passes through the series of aerators, the concentrations are decreasing (**Figure 16-17**). No COCs are detected in exceedance of the cleanup level in the most downstream sampling location indicating that the aerators are functioning as designed and contaminated groundwater is not migrating from Edwards Creek to the New River.

MNA – The majority of Site 89 is being impacted by the active treatment systems. COCs have generally remained stable or decreasing at locations that are not affected by the AS system or PRBs, with the exception of IR89-

MW11 and IR89-MW36IW where data show increasing trends for some COCs (**Figures 16-18** and **16-19**) (CH2M, 2019c). The presence of daughter products in the surficial, UCH, and MCH aquifers indicates that COCs are attenuating in the subsurface.

The NAIP data, collected from outside of the treatment areas but within the plume in the surficial, UCH, and MCH aquifers are summarized in **Table 16-6**. Although concentrations of TOC are generally low throughout the surficial, UCH, and MCH aquifers, geochemical conditions appear to be moderately favorable for reductive dechlorination of COCs. Favorable indicators for reductive dechlorination include, generally low concentrations of sulfate (near or below 20 milligrams per liter), detectable to moderate (in some cases elevated) concentrations of methane, and generally neutral pH (6 to 8 standard units). Elevated alkalinity provides buffering capacity during degradation. Non-harmful end products ethane and ethene suggest that complete reductive dechlorination to non-harmful end products is taking place in portions of the surficial aquifer. COCs may also be attenuating through other pathways, including aerobic oxidation, aerobic co-metabolism, abiotic dechlorination, and physical processes (dilution, dispersion, volatilization, and adsorption).

Site 93

Yes. Although ISCO was not successful, MNA is functioning as intended and LUCs are in place to prevent exposure to groundwater COCs at concentrations above cleanup levels and evaluate the VI pathway as necessary. The following is a summary from the FY 2018 LTM report (CH2M, 2019a).

MNA – In the surficial aquifer, TCE, cis-1,2-DCE, and VC are the only COCs remaining in groundwater above cleanup levels and concentrations are stable to decreasing (**Figures 16-20** through **16-22**). Data in monitoring wells located adjacent to Edwards Creek are compared to 10 times the NCSWQS and VC continues to exceed in the samples collected from IR93-MW14; however, surface water is actively treated downstream for CVOCs at Site 89. The NAIP data collected in 2019 for the surficial and UCH aquifers are summarized in **Table 16-7**. In the surficial aquifer, the data indicate that conditions are not optimal for reductive dechlorination. There is only one location in the UCH aquifer that continues to exceed cleanup levels (VC in IR93-MW11IW) and conditions at that location are also not optimal for reductive dechlorination. Based on decreasing trends and presence of daughter products in both aquifers, natural attenuation may be occurring through other pathways.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. While exposure assumptions, cleanup levels, and RAOs are still valid from the time of selection, toxicity data has changed since the ROD. These changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities which could result in exposure to buried materials and/or groundwater.

Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs since the ROD, there have been no changes since the 2015 FYR which concluded that the remedy at OU 16 is protective of human health and the environment (**Table 2-1**).

Cleanup Levels: The groundwater cleanup levels were identified as the more conservative of the NCGWQS and MCL. Since the Site 89 ROD was signed, the groundwater standards have not changed (**Table 16-1**). Since the Site 93 ROD was signed, the groundwater standards for 1,1,2,2-PCA and TCE have slightly increased (**Table 16-2**) which does not affect protectiveness. The most up to date standards are used to evaluate LTM data.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 16 remedy with respect to extreme weather events, primarily hurricanes, was completed. Effects of hurricane damage include flooding, erosion, and fallen trees that could damage the access control fencing and cause power outages to the AS or aeration systems. Sudden flooding could also damage the aeration system within the creek. LUC inspections are conducted quarterly, and general site conditions inspections are conducted after major storms, tropical storms, and hurricanes and repairs are conducted as needed to maintain protectiveness.

16.6 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 16 are summarized in **Table 16-8**. There were no issues identified for Site 93.

Table 16-8. OU 16 Recommendations and Follow-up Actions

Issue	Recommendations/ Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	Future
The remedy is not functioning as intended because recently discovered source areas and deeper groundwater contamination are not being addressed and RAOs are not expected to be met in a reasonable timeframe.	Complete the supplemental investigation and re-evaluate the remedial strategy.	Navy/Base	USEPA/ State	December 31, 2025	No	Yes

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Site 89 was evaluated as a potential PFAS release area in the Basewide PFAS PA based on the historical use as a waste storage site. Materials stored at the site included expired AFFF concentrate and/or empty AFFF containers for processing. Therefore, further evaluation was recommended (CH2M, 2019d).

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release areas identified; therefore, there is no current exposure pathway (CH2M, 2019d). Site 89 will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

16.7 Statement of Protectiveness

The remedy at OU 16 is currently protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use, restrict intrusive activities, and evaluate and/or mitigate potential VI pathways at both sites.

At Site 89, active remediation is being conducted to address the VOCs in former DRMO area groundwater (AS) and minimize offsite migration of COCs in downgradient groundwater and surface water (PRB and surface water aerators) and MNA will be conducted until cleanup levels are achieved. However, to ensure that the remedy remains protective in the long term, the Navy intends to revisit the site remediation strategy to address the current extent of CVOC concentrations indicative of DNAPL and impacted groundwater.

At Site 93, a pilot study is being implemented to evaluate ERD to reduce the timeframe to remediation and MNA is ongoing until cleanup levels are met.

16.8 References

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Table 16-1. Cleanup Levels for OU 16 (Site 89)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2012)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL
	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS
	1,1,2-Trichloroethane	5	5	MCL
	Tetrachloroethene	0.7	0.7	NCGWQS
	Trichloroethene	3	3	NCGWQS
	Vinyl chloride	0.03	0.03	NCGWQS
Surface Water (µg/L)	**VOCs**			
	1,1,2,2-Tetrachloroethane	4	4	NCSWQS
	Trichloroethene	30	30	NCSWQS
	Vinyl chloride	2.4	2.4	NCSWQS

[a] Cleanup Level for groundwater is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

NCSWQS (September 2017)

µg/L = micrograms per liter

COC = constituent of concern

MCL = Maximum Contaminant Level

NCGWQS = North Carolina Groundwater Quality Standard

NCSWQS = North Carolina Surface Water Quality Standard

ROD = Record of Decision

VOC = volatile organic compound

Table 16-2. Cleanup Levels for OU 16 (Site 93)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2006)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	1,2-Dichloroethane	--	0.4	NCGWQS
	1,2-Dichloroethene	--	60	NCGWQS (IMAC)
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	trans-1,2-Dichloroethene	70	100	NCGWQS/MCL
	1,1,2,2-Tetrachloroethane	0.17	0.2	NCGWQS
	Tetrachloroethene	0.7	0.7	NCGWQS
	Trichloroethene	2.8	3	NCGWQS
	Vinyl chloride	0.015	0.03	NCGWQS

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Shading indicates cleanup level achieved per Fiscal Year 2018 Long-term Monitoring Report (CH2M, 2019)

Cleanup Level Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

-- COC identified post-ROD based on exceedances of current standard during Long-term Monitoring

µg/L = micrograms per liter

COC = constituent of concern

IMAC = interim maximum allowable concentration

MCL = Maximum Contaminant Level

NCGWQS = North Carolina Groundwater Quality Standard

ROD = Record of Decision

VOC = volatile organic compound

Table 16-5. OU 16 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
89	Groundwater	Potential unacceptable risks to future industrial workers and future residents from exposure to VOCs in groundwater and indoor air through vapor intrusion.	Industrial/Vacant	Restore groundwater quality at Site 89 to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water [Class GA or Class GSA] under 15A North Carolina Administrative Code 02L.0201.	AS	Install and operate the AS system until VOC concentrations are at 100 µg/L in samples collected from wells within 50 feet of the AS radius of influence, or average COC reductions in these wells demonstrate an asymptotic trend prior to achieving the target reduction.	UU/UE
					MNA	Implement groundwater MNA to monitor VOC concentrations and migration until each groundwater VOC is at or below its respective cleanup level for four consecutive sampling events.	
				Control exposure to COCs in groundwater and vapor intrusion from COCs in groundwater.	LUCs	Maintain intrusive activities, industrial/non-industrial use (VI) and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	
	Surface water	VOCs in surface water exceed cleanup levels.		Minimize degradation of Edwards Creek from COC-impacted groundwater discharging into surface water until surface water COC concentrations meet the NCSWQS.	PRB	Maintain, and monitor PRB mulch walls to treat groundwater prior to migration offsite or discharge to Edwards Creek until cleanup levels are met for 4 consecutive sampling events. Until cleanup levels are met, the PRBs will be replenished when concentrations in downgradient groundwater begin to increase or exceed cleanup levels, conditions in the PRB are no longer reducing, and/or TOC within the PRB has been depleted.	
					Aerators	Install, maintain, and monitor surface water aerators within Edwards Creek until surface water VOCs are below surface water cleanup levels.	
					LTM	Implement surface water LTM to monitor the effectiveness of the PRB and aerators and VOC concentrations until groundwater LTM/MNA is complete.	
					LUCs	Maintain access controls around Edwards Creek and monitor quarterly until groundwater cleanup levels are achieved.	
93	Groundwater	Potential unacceptable risks to future industrial workers and future residents from exposure to VOCs in groundwater and indoor air through vapor intrusion.	Marine Infantry School/Industrial	Reduce COC concentrations in the highest concentration areas and reduce exceedances of COCs to meet the NCGWQS or MCLs, whichever is more conservative.Achieve suitability of Site 93 groundwater for unlimited use with a reasonable approach and within a reasonable timeframe.	ISCO	Permanganate injections to treat the highest concentration area of the plume. ISCO injections were conducted from October 2006 to December 2007.	UU/UE
					MNA	Implement groundwater MNA until each VOC is at or below its respective cleanup level for 4 consecutive sampling events.	
				Prevent human exposure to water containing COCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) at concentrations above NCGWQS or MCLs, whichever is more conservative.	LUCs	Maintain intrusive activities, industrial/non-industrial use (VI) and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	

Notes:

µg/L = microgram(s) per liter
AS = air sparging
COC = constituent of concern
DCE = dichloroethene
ISCO = in situ chemical oxidation
LTM = long-term monitoring
LUCs = land use controls
MCL = maximum contaminant level
MNA = monitored natural attenuation
NCGWQS = North Carolina Groundwater Quality Standard
NCSWQS = North Carolina Surface Water Quality Standards
PCE = tetrachloroethene
PRB = permeable reactive barrier
RAO = remedial action objective
TCE = trichloroethene
UU/UE = unlimited use/unrestricted exposure
VC = vinyl chloride
VI = vapor intrusion
VOC = volatile organic compound

Table 16-6. Natural Attenuation Indicator Parameters Summary - Site 89
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			MCH Aquifer		
	Description	Favorable Condition[a]	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion
DO (mg/L)	DO is the most thermodynamically favorable electron acceptor used by microbes. High levels of DO are indicative of aerobic conditions, and low levels of DO are indicative of anaerobic conditions. As reductive dechlorination takes place under anaerobic conditions, low levels of DO are generally favorable for reductive dechlorination.	< 1	0 to 5.42	9 / 12	Favorable results in more than half of surficial wells	0 to 0.88	9 / 9	Yes	0 to 0	4 / 4	Yes
ORP (mV)	ORP measures the degree to which aquifer conditions are reducing or oxidizing. As reductive dechlorination takes place under reducing conditions, lower ORPs are generally favorable for reductive dechlorination.	< 0	-150 to 163	8 / 12	Favorable results in more than half of surficial wells	-139 to -26	9 / 9	Yes	-179 to 155	3 / 4	Yes, unfavorable result isolated
Nitrate (mg/L)	After DO is depleted, nitrate may be used as an electron acceptor (i.e., denitrification). As nitrate may compete with the reductive dechlorination pathway, depleted nitrate concentrations are generally favorable for reductive dechlorination. Depleted nitrate concentrations alone do not conclusively indicate favorable conditions for reductive dechlorination.	< 1	0 to 0	0 / 12	Yes	0 to 0	0 / 8	Yes	0 to 0	0 / 4	Yes
Nitrite (mg/L)	During denitrification, nitrate is converted into nitrite. Therefore, the presence of nitrite indicates the geochemical footprint of denitrification. If nitrate is absent from a monitoring location, denitrifying conditions may exist if nitrite is not observed. Denitrifying conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	Detectable Concentrations	0 to 0	0 / 12	Neutral	0 to 0	0 / 8	Neutral	0 to 0	0 / 4	Neutral
Ferrous Iron (mg/L)	The presence of ferrous iron indicates the geochemical footprint of iron-reduction, which takes place under more reducing conditions than denitrification. Iron reducing conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	> 1	0 to 7	9 / 12	Favorable results in more than half of surficial wells	0 to 2	6 / 8	Yes, unfavorable results isolated	0 to 1.5	1 / 4	Yes, unfavorable result isolated
Sulfate (mg/L)	Sulfate may be used as an electron acceptor under more reducing conditions than iron-reducing conditions. As higher concentrations of sulfate may compete with the reductive dechlorination pathway, low levels of sulfate are favorable for reductive dechlorination. Depleted sulfate concentrations are also an indicator that sulfate reduction is proceeding, which generally indicates that conditions are favorable for reductive dechlorination.	< 20	0.5 U to 110	10 / 12	Favorable results in more than half of surficial wells	0.5 U to 24	9 / 9	Yes	1.3 to 28	4 / 4	Yes
Sulfide (mg/L)	During sulfate reduction, sulfate is converted into sulfide. Therefore, the presence of sulfide indicates the geochemical footprint for sulfate reduction. When detected, sulfide indicates that sulfate reduction is taking place and that conditions are generally favorable for reductive dechlorination. However, the absence of sulfide does not conclusively indicate that conditions are unfavorable for reductive dechlorination, as sulfide is highly reactive and readily forms precipitates with ferrous iron.	Detectable Concentrations	0.8 U	0 / 12	Neutral	0.8 U to 2	1 / 9	Favorable result observed in one well	0.8 U	0 / 4	Neutral
Methane (mg/L)	The presence of methane in groundwater is indicative of the strongly reducing conditions required to support reductive dechlorination. Therefore, the presence of moderate concentrations of methane is a favorable indicator for reductive dechlorination.	> 0.5	0.0064 J to 11	8 / 12	Favorable results in more than half of surficial wells	0.0034 to 0.47	5 / 9	Favorable results in more than half of surficial wells	0.011 to 0.023	0 / 4	No
TOC (mg/L)	TOC is an indicator of the total amount of organic matter available to microbial communities to use as source of carbon and energy. Elevated TOC concentrations are a positive indicator of natural attenuation potential.	< 20	1.6 to 740	1 / 12	No, favorable result isolated	0.67 to 4.6	0 / 9	No	1 to 2.5	0 / 4	No
Ethane (mg/L)	Ethane is a nonhazardous end product of reductive dechlorination. As the presence of ethane indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethane are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.84	4 / 12	Favorable results in less than half of surficial wells	0.005 U	0 / 9	No	0.005 U	0 / 4	No

Table 16-6. Natural Attenuation Indicator Parameters Summary - Site 89
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			MCH Aquifer		
	Description	**Favorable Condition[a]**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**
Ethene (mg/L)	Ethene is a non-hazardous end product of reductive dechlorination. As the presence of ethene indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethene are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 3.8	3 / 12	Favorable results in less than half of surficial wells	0.005 U	0 / 9	No	0.005 U	0 / 4	No
Chloride (mg/L)	Chloride is a daughter product of reductive dechlorination. If elevated concentrations of chlorinated VOCs are present (e.g., greater than 1 mg/L), chloride concentrations may increase as biodegradation occurs. Appreciable changes in chloride concentrations are not expected for natural attenuation sites with lower concentrations of chlorinated VOCs.	Greater than Background	2 to 3400	12 / 12	Neutral	7.6 to 46	9 / 9	Neutral	35 to 180	4 / 4	Neutral
pH (SU)	The pH of groundwater affects the presence and activity of microbial populations in groundwater. The optimal pH range for dechlorinating bacteria generally falls between pH 6 and 8 SU (Yang, 2017).	6 - 8	4.48 to 9.4	9 / 12	Favorable results in more than half of surficial wells	6.67 to 8.57	8 / 9	Yes, unfavorable result isolated	7.03 to 7.42	4 / 4	Yes
Alkalinity (mg/L)	Alkalinity measures the capacity of groundwater to resist changes in pH. As biodegradation processes increase aquifer acidity, higher concentrations of alkalinity indicate that pH values are more likely to remain stable.	> 50	1.1 to 860	9 / 12	Yes, unfavorable results isolated	160 to 300	9 / 9	Yes	250 to 330	4 / 4	Yes

[a] If readings are near the Project Indicator Level, engineering judgment may be used to determine favorability.

Notes:

DO - dissolved oxygen

J - Analyte present, value may or may not be accurate or precise

MCH - Middle Castle Hayne

mg/L - milligrams per liter

mV - millivolts

ORP - oxidation-reduction potential

SU - standard units

U - The material was analyzed for, but not detected

UCH - Upper Castle Hayne

Table 16-7. Natural Attenuation Indicator Parameters Summary - Site 93

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer		
	Description	Favorable Condition[a]	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion
DO (mg/L)	DO is the most thermodynamically favorable electron acceptor used by microbes. High levels of DO are indicative of aerobic conditions, and low levels of DO are indicative of anaerobic conditions. As reductive dechlorination takes place under anaerobic conditions, low levels of DO are generally favorable for reductive dechlorination.	< 1	0 to 0	9 / 9	Yes	0 to 0.11	3 / 3	Yes
ORP (mV)	ORP measures the degree to which aquifer conditions are reducing or oxidizing. As reductive dechlorination takes place under reducing conditions, lower ORPs are generally favorable for reductive dechlorination.	< 50	-162 to 100	8 / 9	Yes, unfavorable result isolated	-121 to -79	3 / 3	Yes
Nitrate (mg/L)	After DO is depleted, nitrate may be used as an electron acceptor (i.e., denitrification). As nitrate may compete with the reductive dechlorination pathway, depleted nitrate concentrations are generally favorable for reductive dechlorination. Depleted nitrate concentrations alone do not conclusively indicate favorable conditions for reductive dechlorination.	< 1	0 to 0	9 / 9	Yes	0 to 0	3 / 3	Yes
Nitrite (mg/L)	During denitrification, nitrate is converted into nitrite. Therefore, the presence of nitrite indicates the geochemical footprint of denitrification. If nitrate is absent from a monitoring location, denitrifying conditions may exist if nitrite is not observed. Denitrifying conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	Detectable Concentrations	0 to 0	--	Inconclusive	0 to 0	--	Inconclusive
Ferrous Iron (mg/L)	The presence of ferrous iron indicates the geochemical footprint of iron-reduction, which takes place under more reducing conditions than denitrification. Iron reducing conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	> 1	1 to 5.5	9 / 9	Yes	2 to 3	3 / 3	Yes
Sulfate (mg/L)	Sulfate may be used as an electron acceptor under more reducing conditions than iron-reducing conditions. As higher concentrations of sulfate may compete with the reductive dechlorination pathway, low levels of sulfate are favorable for reductive dechlorination. Depleted sulfate concentrations are also an indicator that sulfate reduction is proceeding, which generally indicates that conditions are favorable for reductive dechlorination.	< 20	16 to 89	3 / 9[a]	Favorable results in 3 of 9 wells	1.6 to 32	1 / 3	No, favorable result isolated
Sulfide (mg/L)	During sulfate reduction, sulfate is converted into sulfide. Therefore, the presence of sulfide indicates the geochemical footprint for sulfate reduction. When detected, sulfide indicates that sulfate reduction is taking place and that conditions are generally favorable for reductive dechlorination. However, the absence of sulfide does not conclusively indicate that conditions are unfavorable for reductive dechlorination , as sulfide is highly reactive and readily forms precipitates with ferrous iron.	Detectable Concentrations	0.8 U to 0.8 U	0 / 9	Inconclusive	0.8 U to 0.8 U	0 / 3	Inconclusive
Methane (mg/L)	The presence of methane in groundwater is indicative of the strongly reducing conditions required to support reductive dechlorination. Therefore, the presence of moderate concentrations of methane is a favorable indicator for reductive dechlorination.	> 0.5	0.071 to 0.44	1 / 9[a]	No, favorable result isolated	0.23 to 0.41	2 / 3[a]	No

Table 16-7. Natural Attenuation Indicator Parameters Summary - Site 93
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer		
	Description	Favorable Condition[a]	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion
TOC (mg/L)	TOC is an indicator of the total amount of organic matter available to microbial communities to use as source of carbon and energy. Elevated TOC concentrations are a positive indicator of natural attenuation potential.	> 20	0.85 to 2.4	0 / 9	No	2.2 to 3	0 / 3	No
Ethane (mg/L)	Ethane is a non-hazardous end product of reductive dechlorination. As the presence of ethane indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethane are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 9	No	0.005 U to 0.005 U	0 / 3	No
Ethene (mg/L)	Ethene is a non-hazardous end product of reductive dechlorination. As the presence of ethene indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethene are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 9	No	0.005 U to 0.005 U	0 / 3	No
Chloride (mg/L)	Chloride is a daughter product of reductive dechlorination. If elevated concentrations of chlorinated VOCs are present (e.g., greater than 1 mg/L), chloride concentrations may increase as biodegradation occurs. Appreciable changes in chloride concentrations are not expected for natural attenuation sites with lower concentrations of chlorinated VOCs.	Increasing Concentrations	8.4 to 8.5	--	NA	9.4 to 9.4	--	NA
pH (SU)	The pH of groundwater affects the presence and activity of microbial populations in groundwater. The optimal pH range for dechlorinating bacteria generally falls between pH 6 and 8 SU (Yang, 2017).	6 to 8	4.93 to 7.46	6 / 9	Yes, unfavorable results isolated	7.09 to 12.65	2 / 3	Yes, unfavorable result isolated
Alkalinity (mg/L)	Alkalinity measures the capacity of groundwater to resist changes in pH. As biodegradation processes increase aquifer acidity, higher concentrations of alkalinity indicate that pH values are more likely to remain stable.	> 50	29 to 240	7 / 9	Yes, unfavorable results isolated	200 to 240	3 / 3	Yes

a - If readings are near the Project Indiciator Level, engineering judgment may be used to determine favorability.
-- Count not performed; see PIL description for rationale.
DO - dissolved oxygen
J - Analyte present, value may or may not be accurate or precise
MCH - Middle Castle Hayne
mg/L - milligrams per liter
mV - millvolts
ORP - oxidation-reduction potential
SU - standard units
ND - not detected
NA - not applicable
U - The material was analyzed for, but not detected
UCH - Upper Castle Hayne

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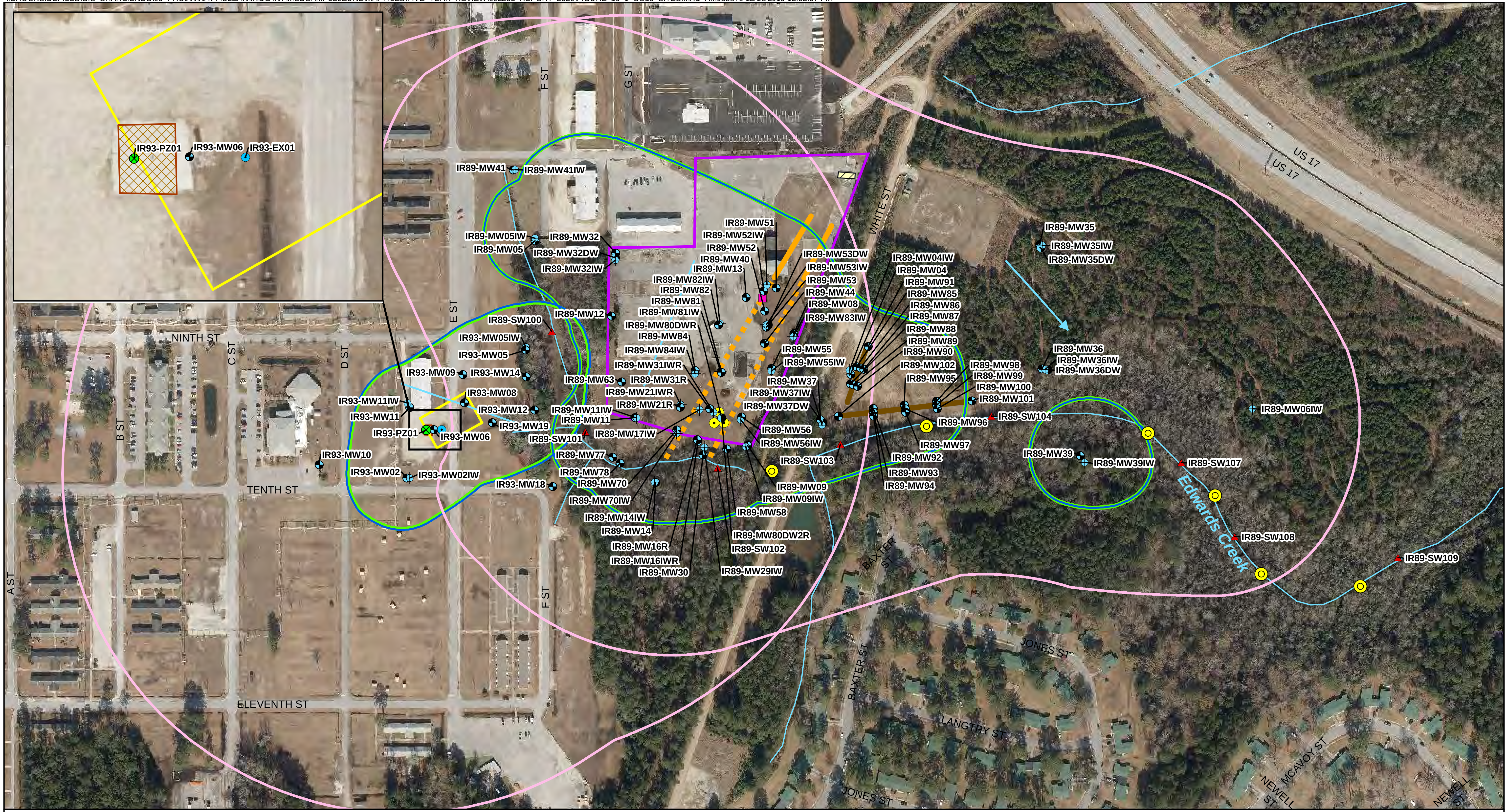

Legend

LTM Monitoring Wells
- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Middle Castle Hayne Aquifer

Land Use Control Boundaries
- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

- LTM Surface Water Sampling Locations
- Vertical Sparging Points
- Surface Water Aerator Locations
- Approximate Direction of Groundwater Flow
- Surface Water Centerline
- Horizontal Air Sparging Wells (dash representing screen interval)
- PRB

- Former UST Locations
- Bioreactor Piezometer
- Extraction Well
- AS Compressor Compound
- Former Defense Reutilization and Marketing Office Area
- Mulch/Gravel Bioreactor
- Permanganate Treatment Area

N

0 150 300 Feet

1 inch = 300 feet

Figure 16-1
OU 16 (Sites 89 and 93)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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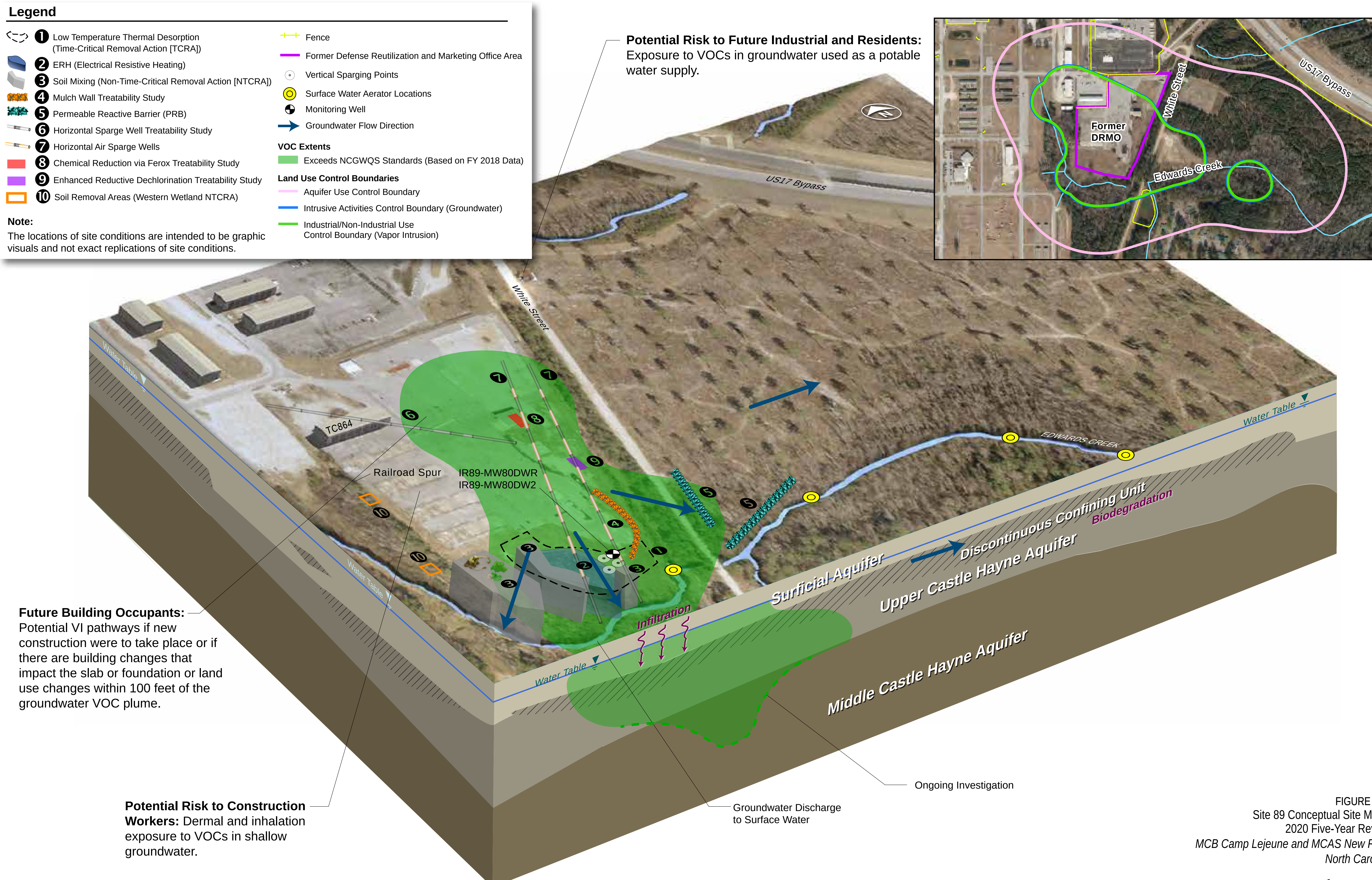
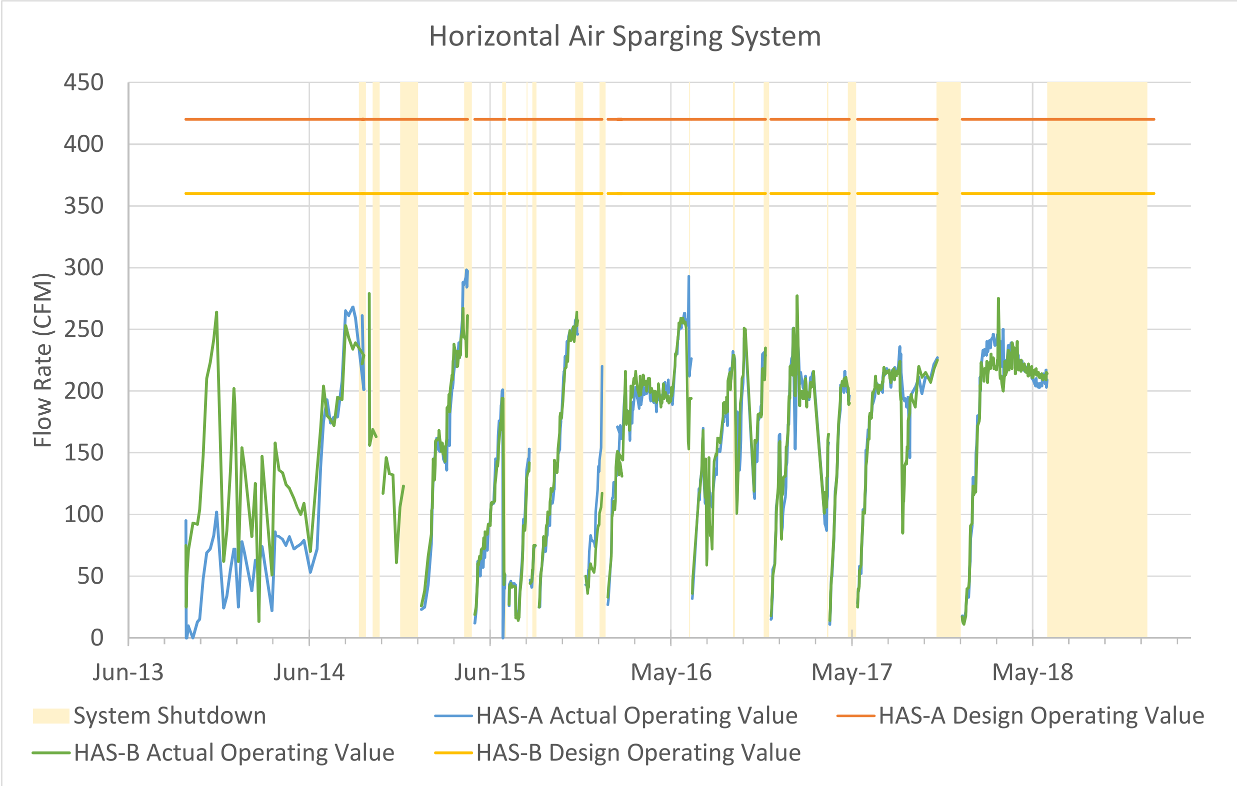
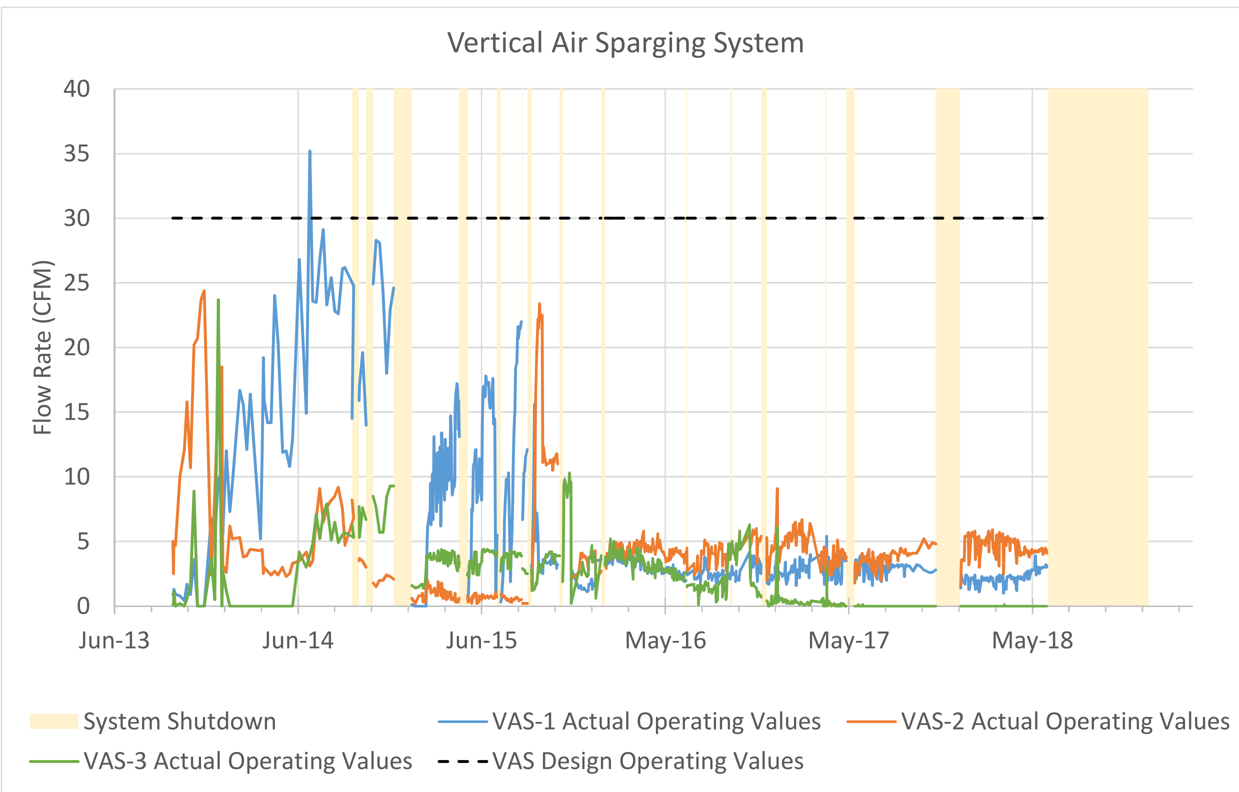


FIGURE 16-2
Site 89 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina





Note: The extended shutdown period was due to supplemental investigations.

Figure 16-3
HAS and VAS Operating Parameters
2020 Five Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

Legend

- Surficial Aquifer Monitoring Well
- Upper Castle Hayne Aquifer Monitoring Well
- Bioreactor Piezometer
- Extraction Well
- Groundwater Flow Direction
- Mulch/Gravel Bioreactor

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Intrusive Activities Control Boundary (Groundwater)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N

0 7.5 15 Feet

1 inch = 15 feet

Figure 16-4
Analytical Data Trends - Bioreactor Performance Monitoring
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

Legend

- DPT Location
- MIHPT Points
- Surficial Aquifer Monitoring
- Upper Castle Hayne Monitoring Well
- Middle Castle Hayne Monitoring Well
- Abandoned Middle Castle Hayne Aquifer Monitoring
- Vertical Sparging Points
- Horizontal Air Sparging Wells
- PRB
- Surface Water
- Groundwater Flow Direction
- Site 89 Boundary
- Soil Mixing Treatment Areas
- ERH Treatment Area

Total VOCs(December 2017 data based on LTM Network and Supplemental Investigation Data)

- 10 to 100 µg/L
- 100 to 1,000 µg/L
- 1,000 to 10,000 µg/L
- 10,000 to 100,000 µg/L
- 100,000 to 1,000,000 µg/L
- 1,000,000 to 10,000,000 µg/L

N

0 45 90 Feet

1 inch = 80 feet

Figure 16-5
Site 89 VOC Plumes by Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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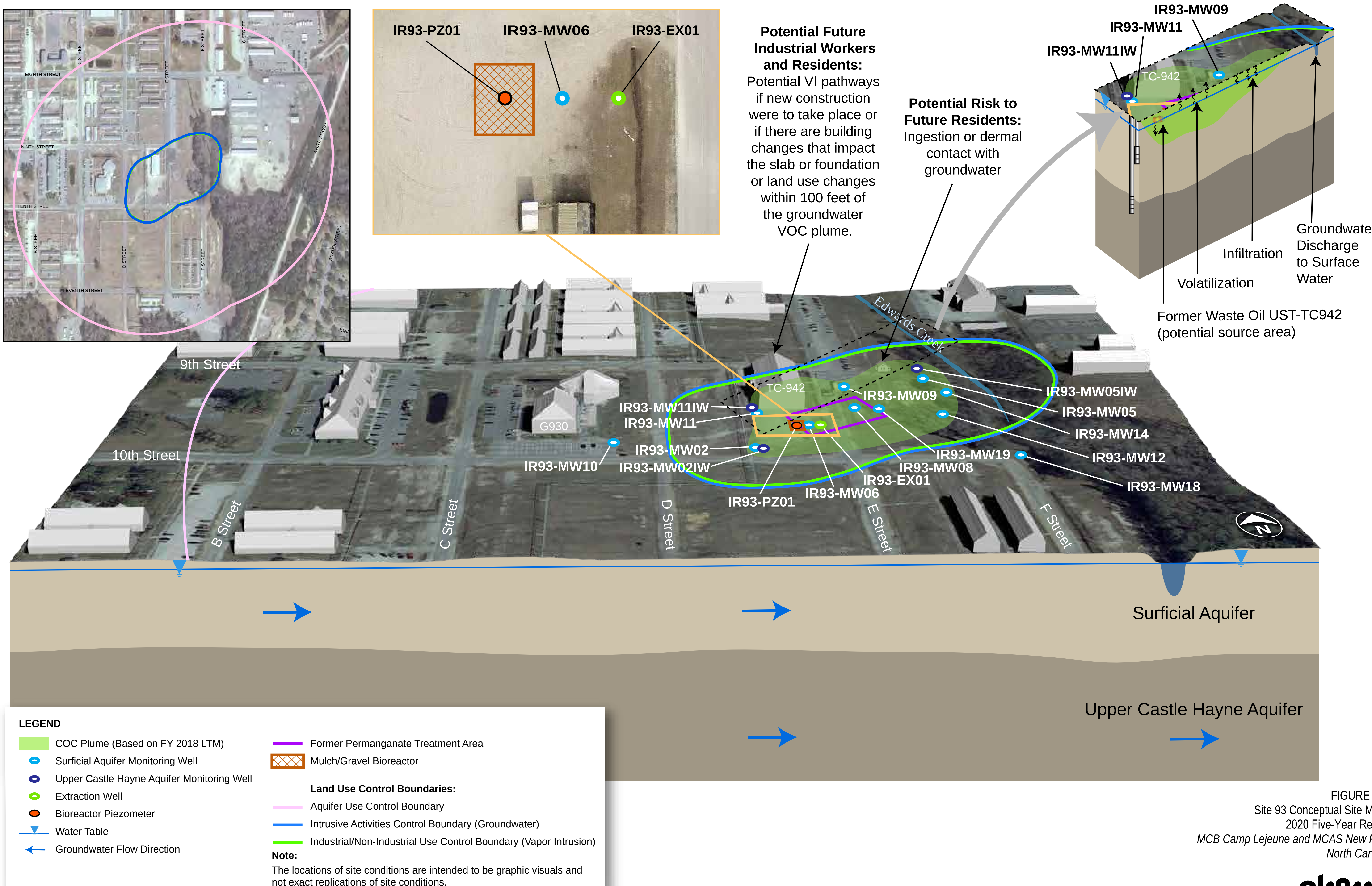

FIGURE 16-6
Site 93 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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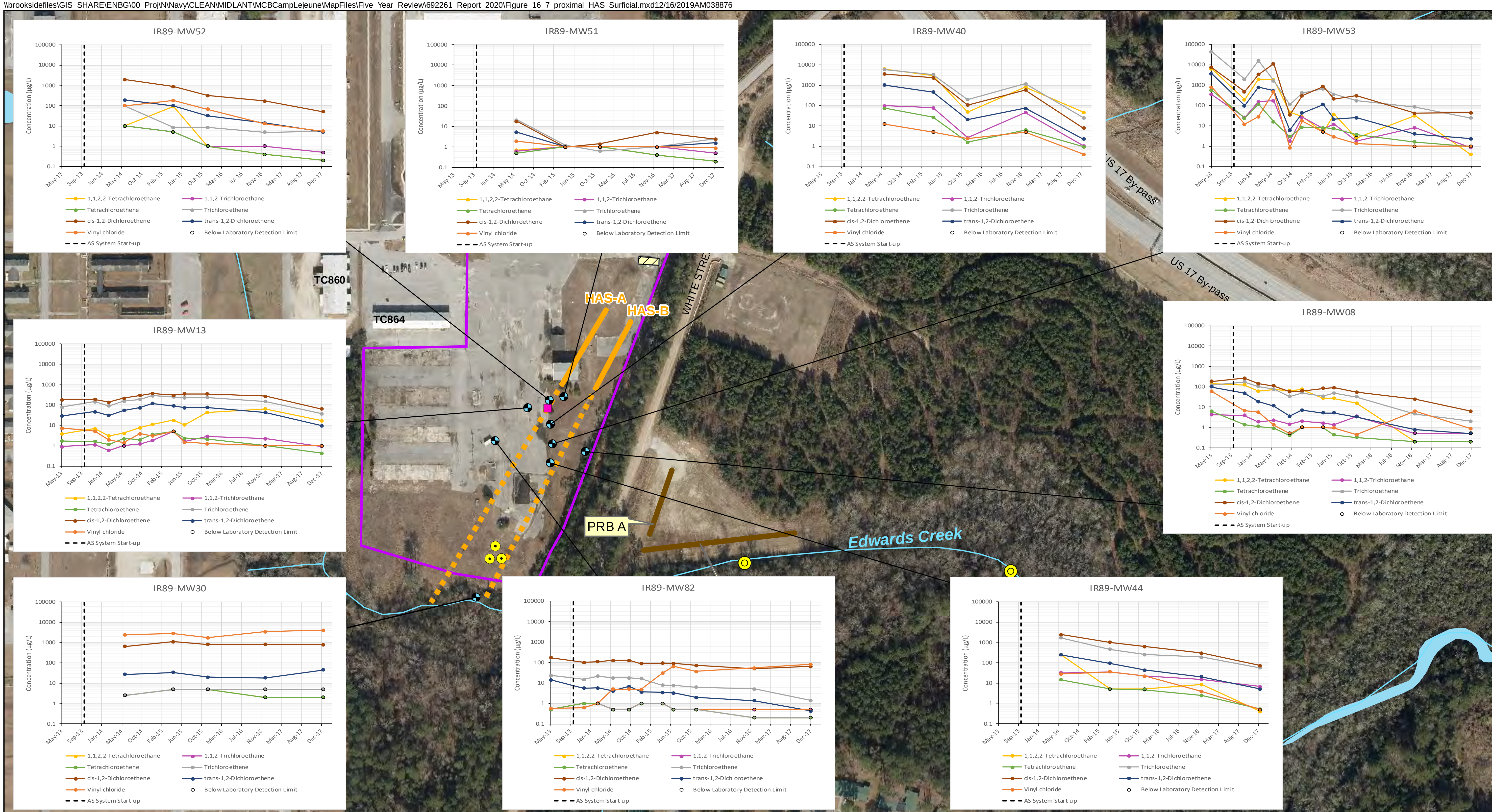

Legend

- Surficial Aquifer Monitoring Well
- Former Underground Storage Tank Location
- Vertical Sparging Points
- Horizontal Air Sparging (HAS) Wells
- Permeable Reactive Barrier (PRB)
- AS Compressor Compound
- Former Defense Reutilization and Marketing Office Area
- Water Bodies
- Surface Water Centerline

Note:
µg/L - micrograms per liter
UST - underground storage tank
AS - air sparging
PRB - permeable reactive barrier

N

0 125 250 Feet

1 inch = 250 feet

Figure 16-7
Select Proximal HAS Monitoring Wells - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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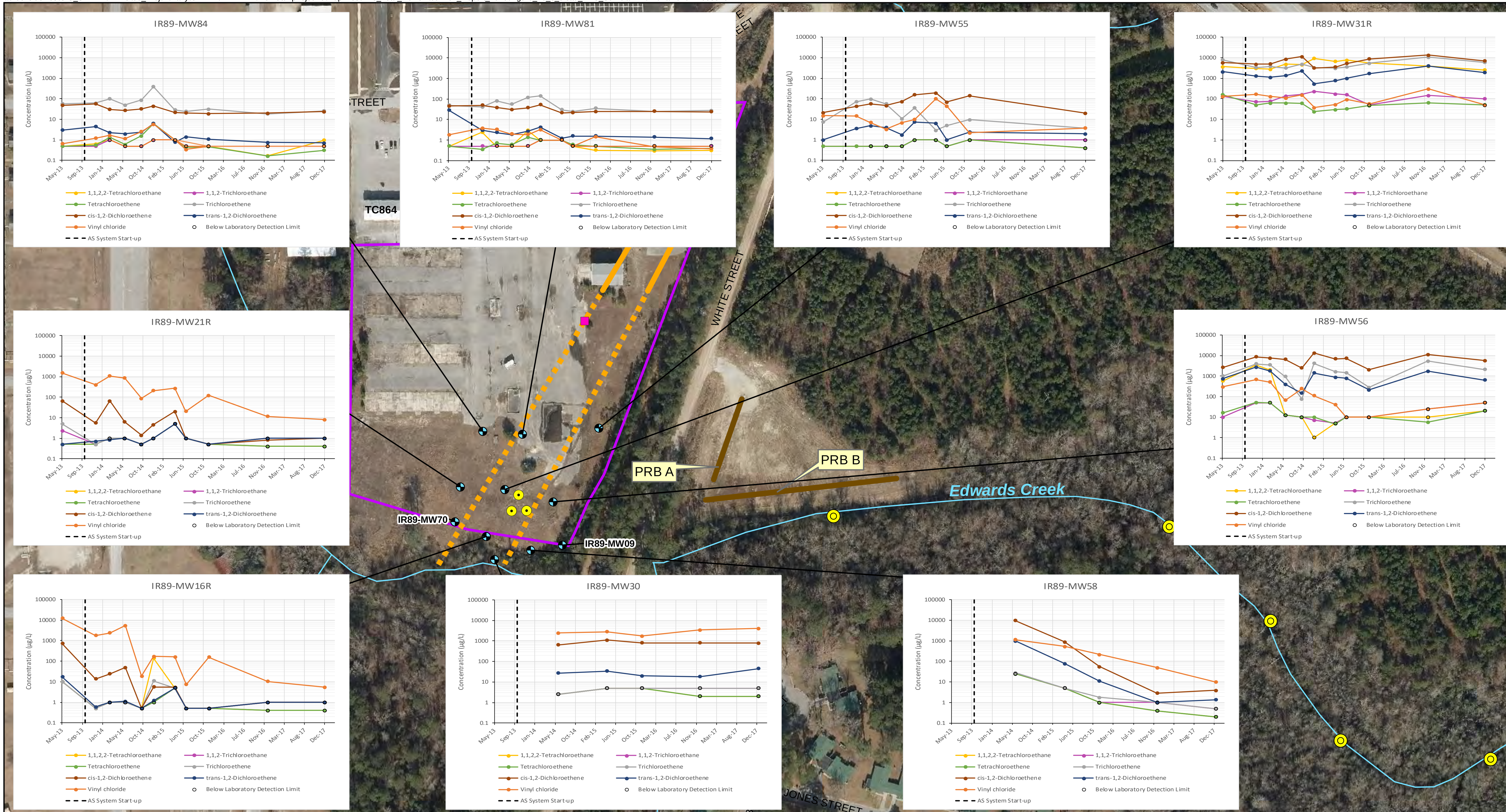

Legend

- Surficial Aquifer Monitoring Well
- Former UST Locations
- Vertical Sparging Points
- Approximate Surface Water Aerator Locations
- Horizontal Air Sparging Wells (dash represents screen interval)
- Permeable Reactive Barrier
- Former Defense Reutilization and Marketing Office Area
- AS Compressor Compound
- Surface Water Centerline
- Water Bodies

Note:
µg/L - micrograms per liter
UST - underground storage tank
AS - air sparging
PRB - permeable reactive barrier

N

0 100 200 Feet
1 inch = 200 feet

Figure 16-8
Select Distal HAS and VAS Monitoring Wells - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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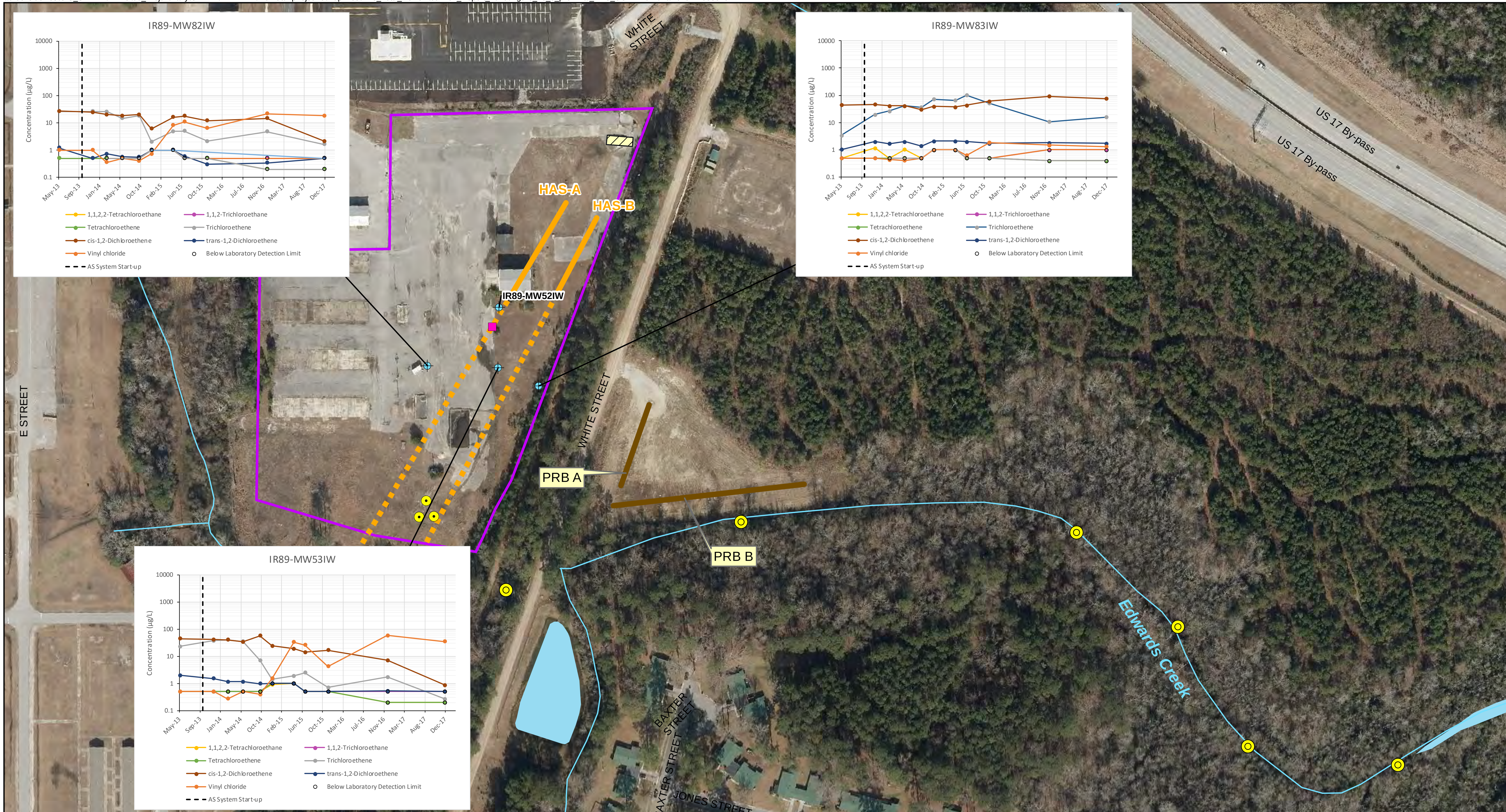

Legend

- Upper Castle Hayne Monitoring Well
- Former Underground Storage Tank Location
- Vertical Sparging Points
- Approximate Surface Water Aerator Locations
- Horizontal Air Sparging (HAS) Wells
- Permeable Reactive Barrier (PRB)
- Former Defense Reutilization and Marketing Office Area
- AS Compressor Compound
- Surface Water Centerline
- Water Bodies

Note:
µg/L - micrograms per liter
UST - underground storage tank
AS - air sparging
PRB - permeable reactive barrier

N

0 100 200 Feet
1 inch = 200 feet

Figure 16-9
Select Proximal HAS Monitoring Wells - UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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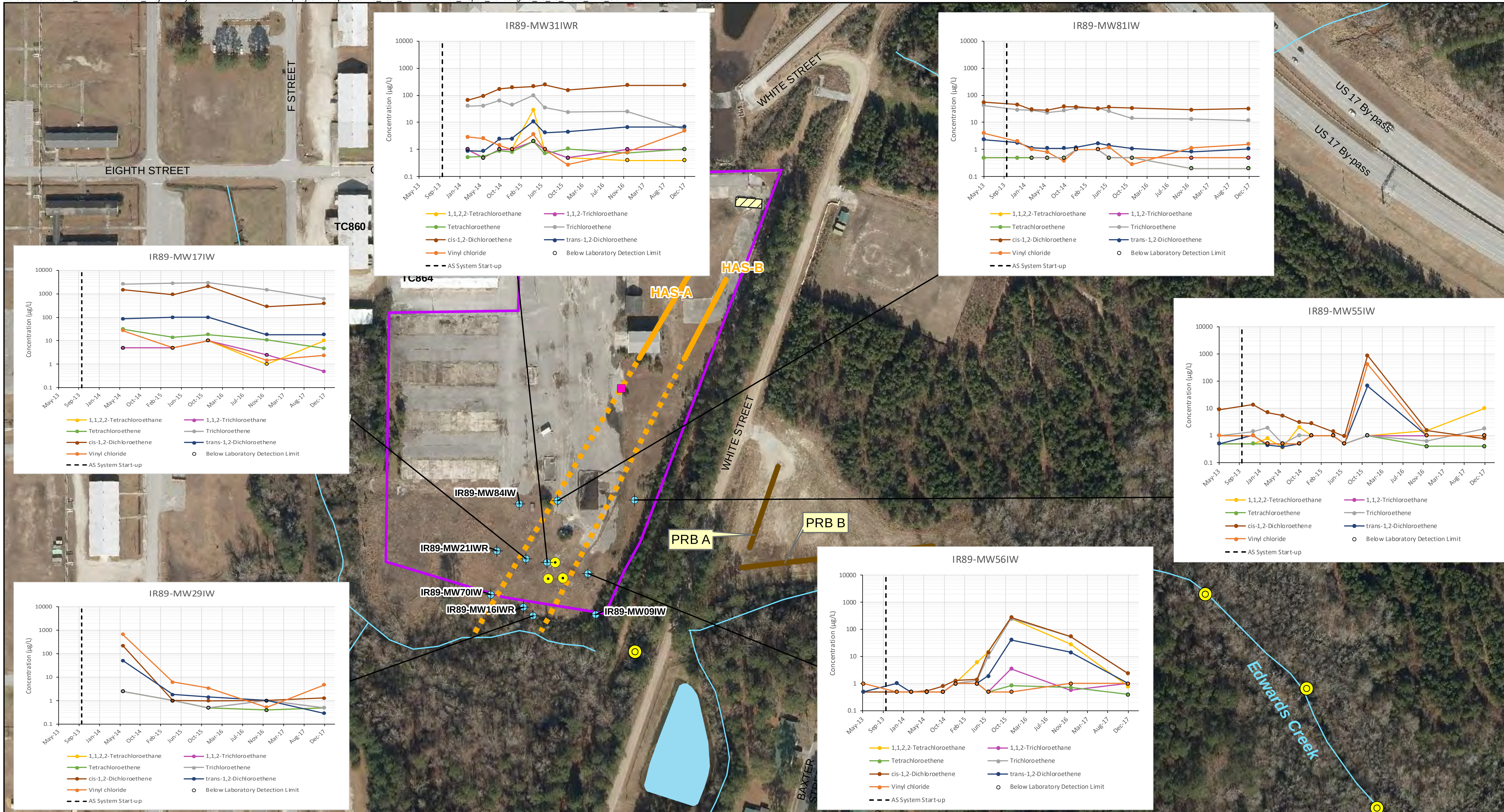

Legend

- Upper Castle Hayne Monitoring Well
- Former UST Locations
- Vertical Sparging Points
- Approximate Surface Water Aerator Locations
- Horizontal Air Sparging Wells (dash represents screen interval)
- Permeable Reactive Barrier
- Former Defense Reutilization and Marketing Office Area
- AS Compressor Compound
- Surface Water Canterline
- Water Bodies

Note:
µg/L - micrograms per liter
UST - underground storage tank
AS - air sparging
PRB - permeable reactive barrier

N

0 100 200 Feet

1 inch = 200 feet

Figure 16-10
Select Distal HAS and VAS Monitoring Wells - UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

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Legend

- Middle Castle Hayne Monitoring Well
- Former Underground Storage Tank Location
- Vertical Sparging Points
- Approximate Surface Water Aerator Locations
- Horizontal Air Sparging (HAS) Wells
- Permeable Reactive Barrier (PRB)
- Former Defense Reutilization and Marketing Office Area
- AS Compressor Compound
- Surface Water Centerline
- Water Bodies

Note:
µg/L - micrograms per liter
UST - underground storage tank
AS - air sparging
PRB - permeable reactive barrier

N

0 100 200 Feet

1 inch = 200 feet

Figure 16-11
VAS Monitoring Well - MCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

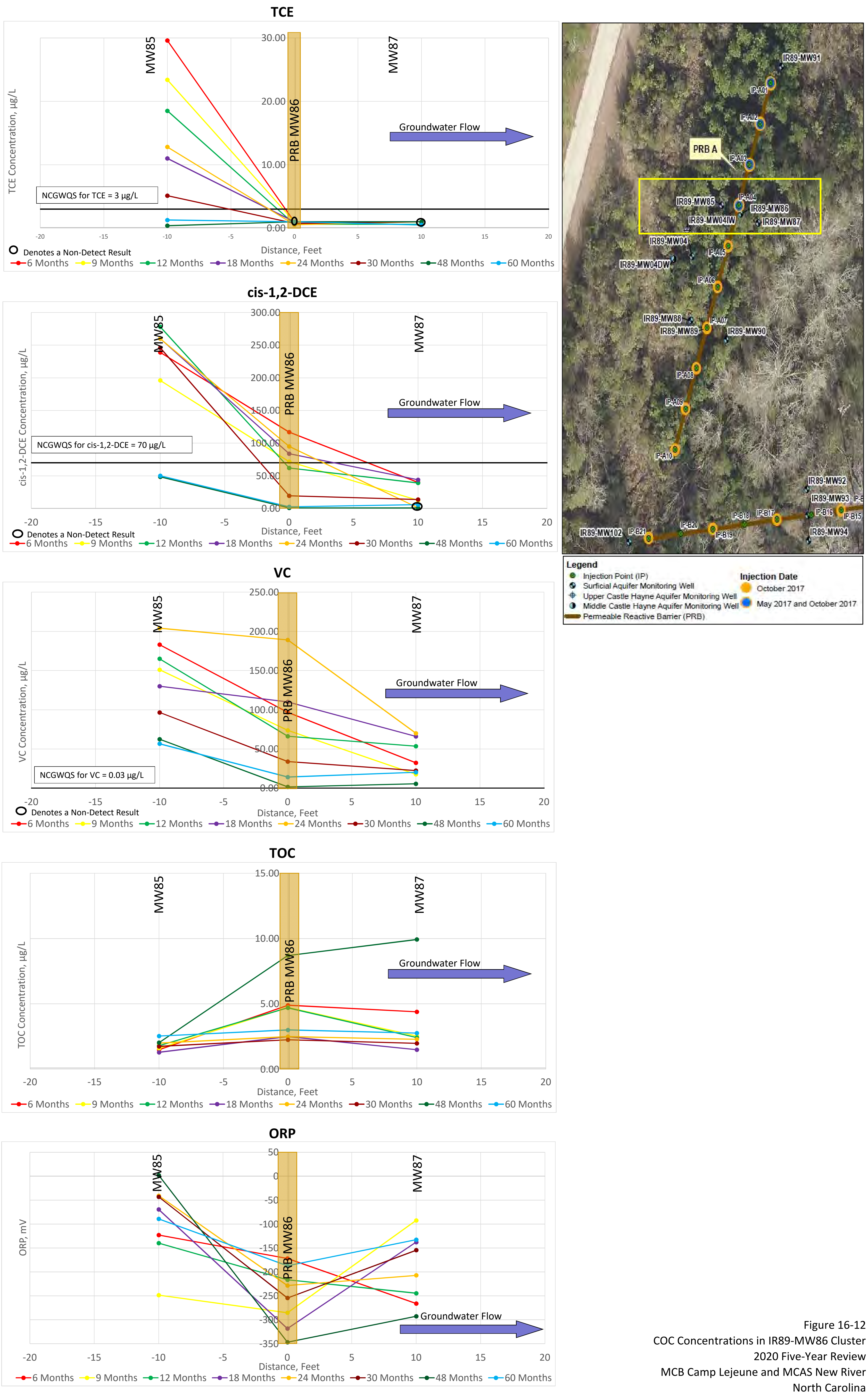
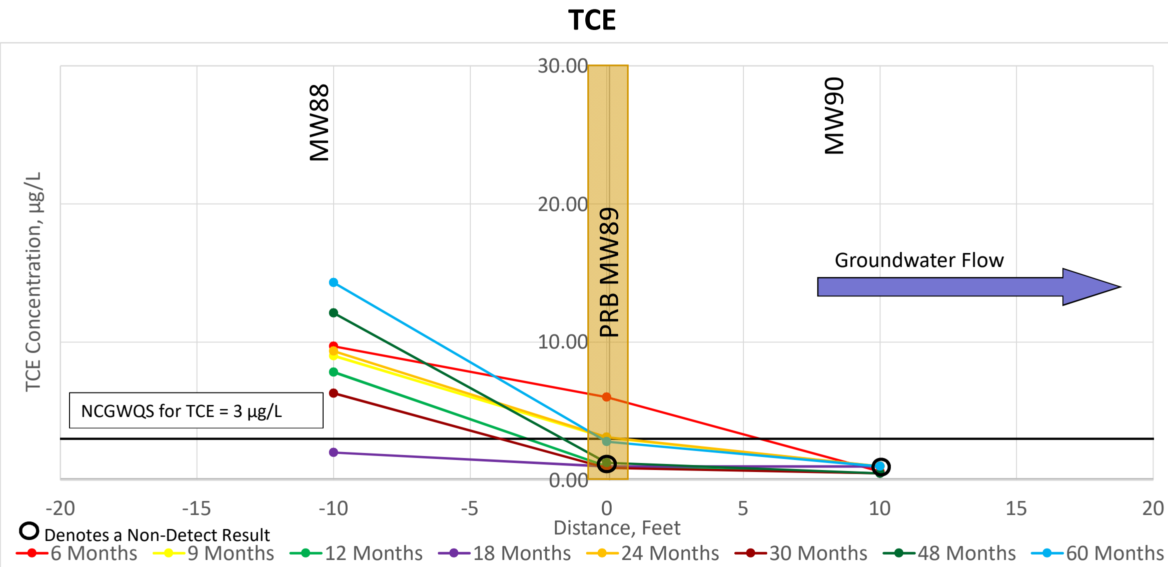
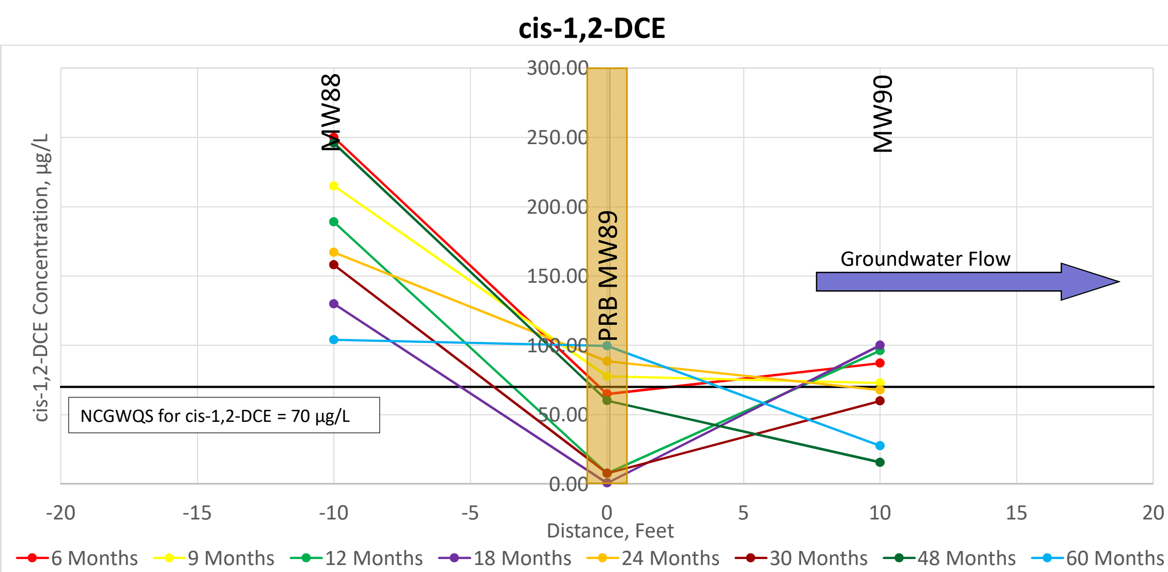
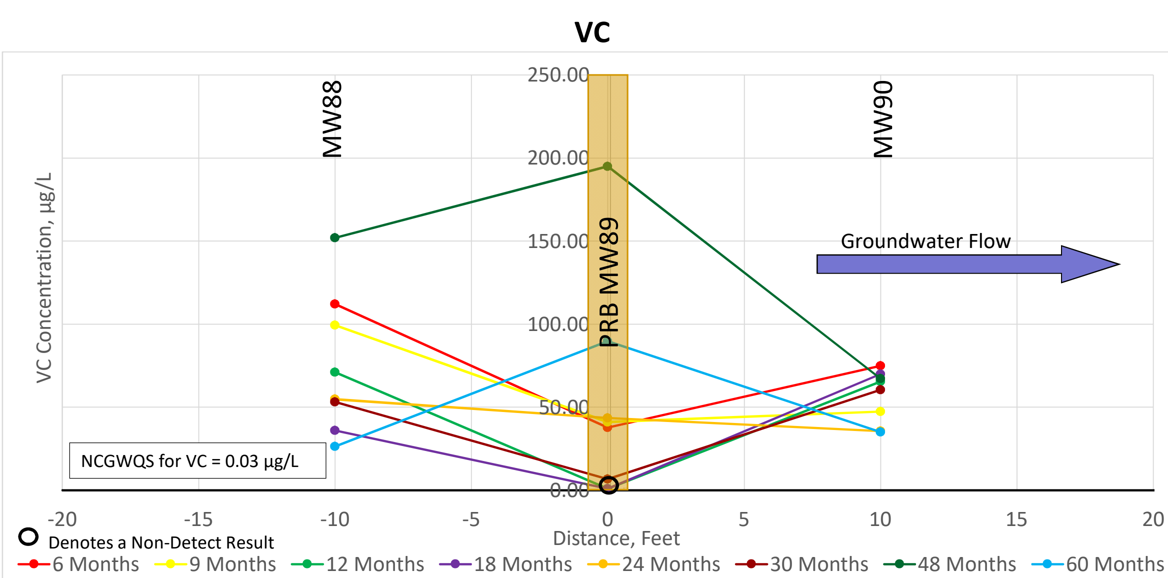
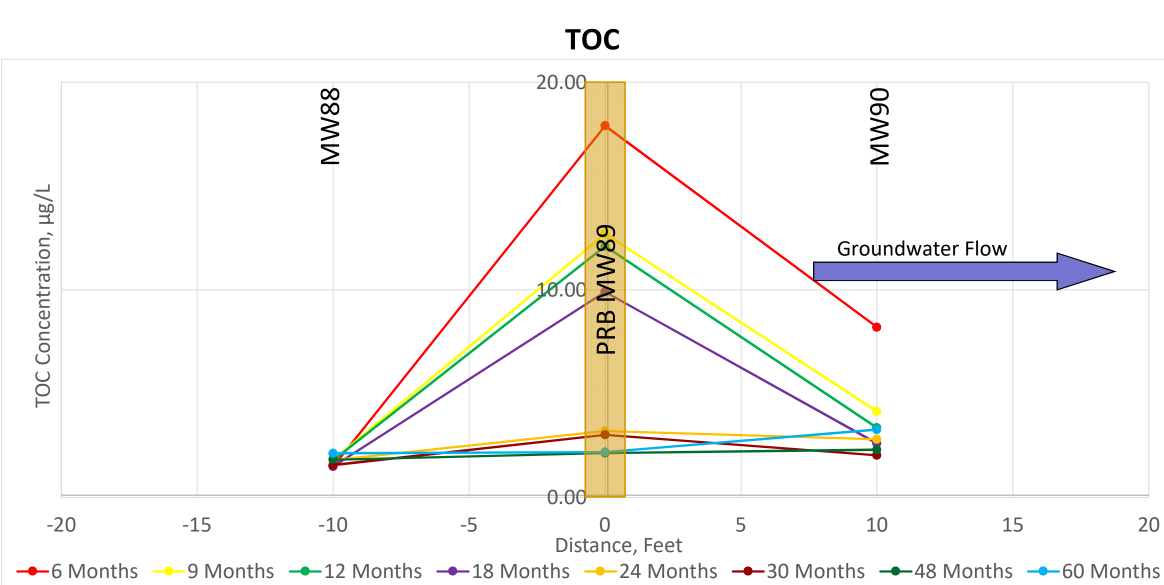


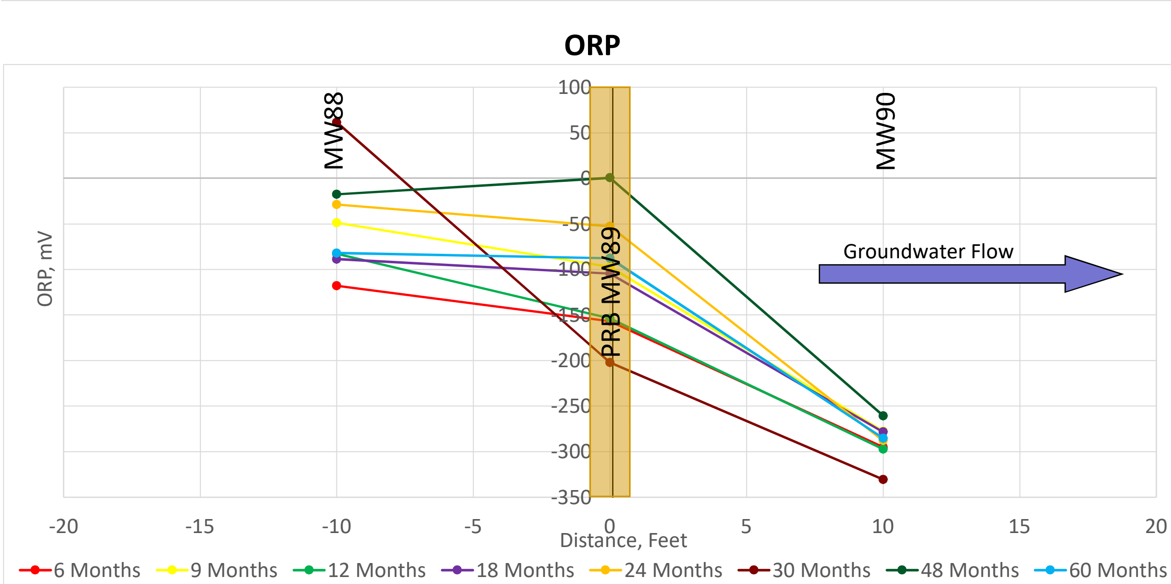
Figure 16-12
COC Concentrations in IR89-MW86 Cluster
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina











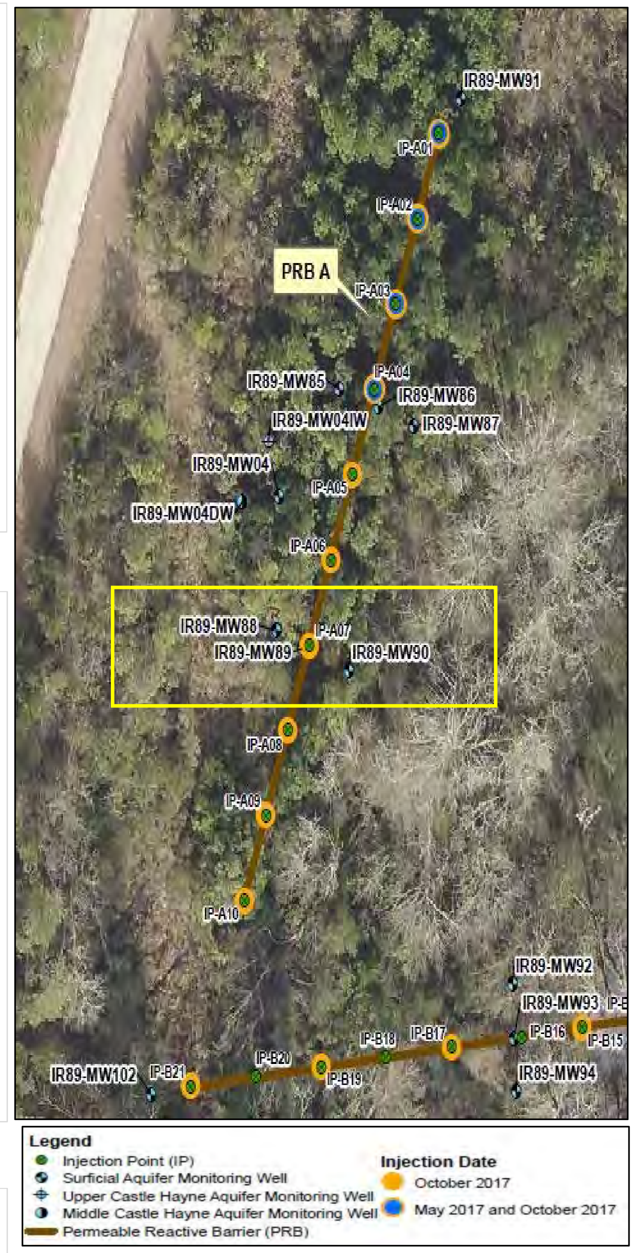
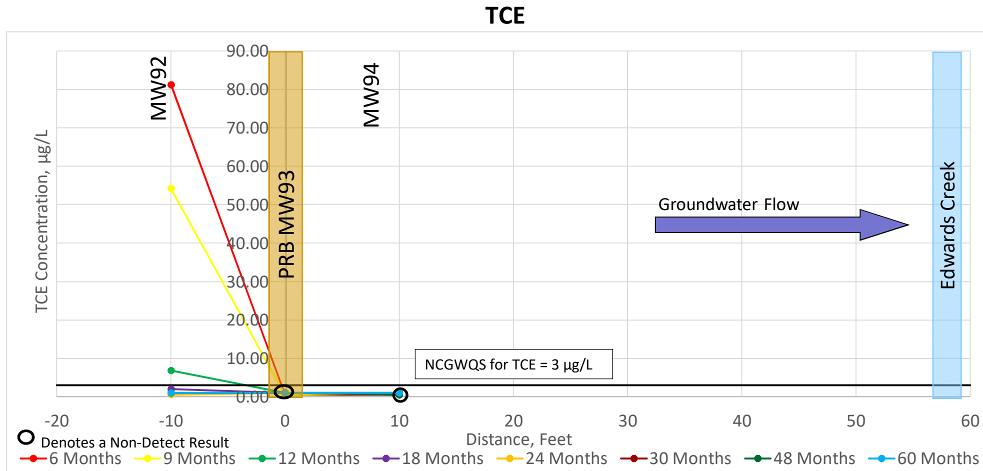
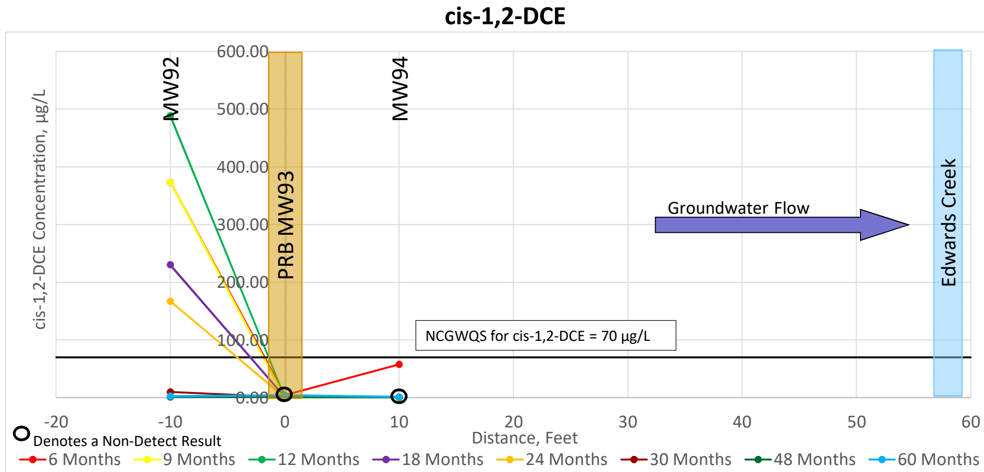


Figure 16-13
COC Concentrations in IR89-MW89 Cluster
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

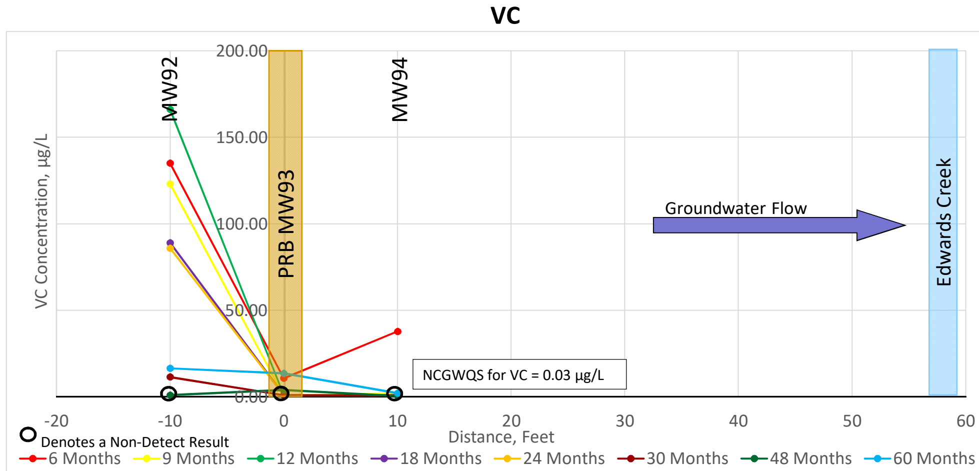
TCE



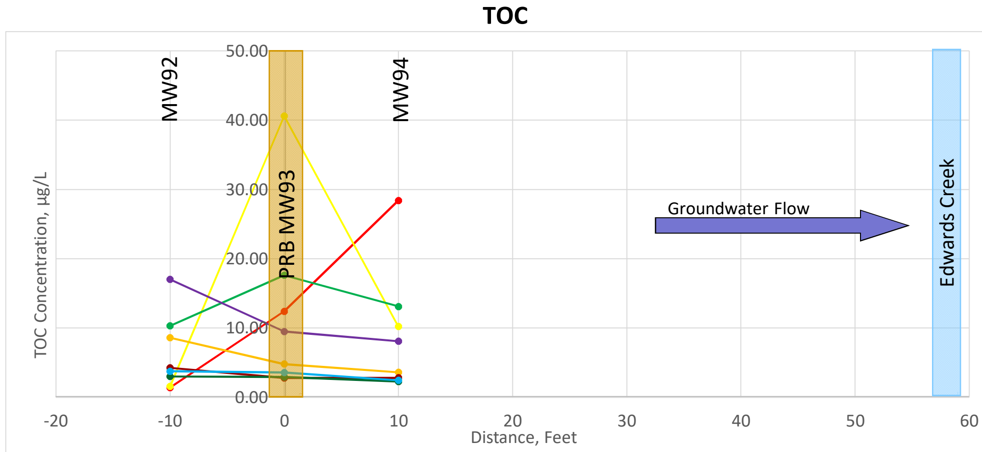
cis-1,2-DCE



VC



TOC



ORP

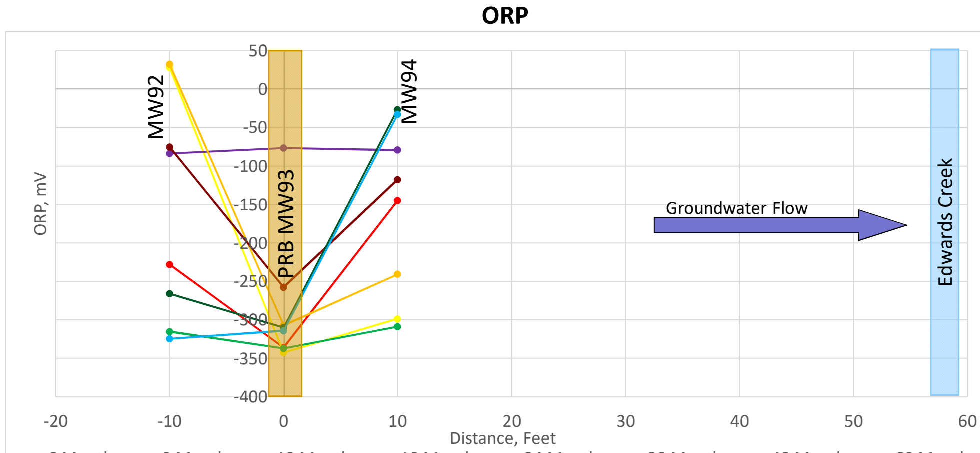


Figure 16-14
COC Concentrations in IR89-MW93 Cluster
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

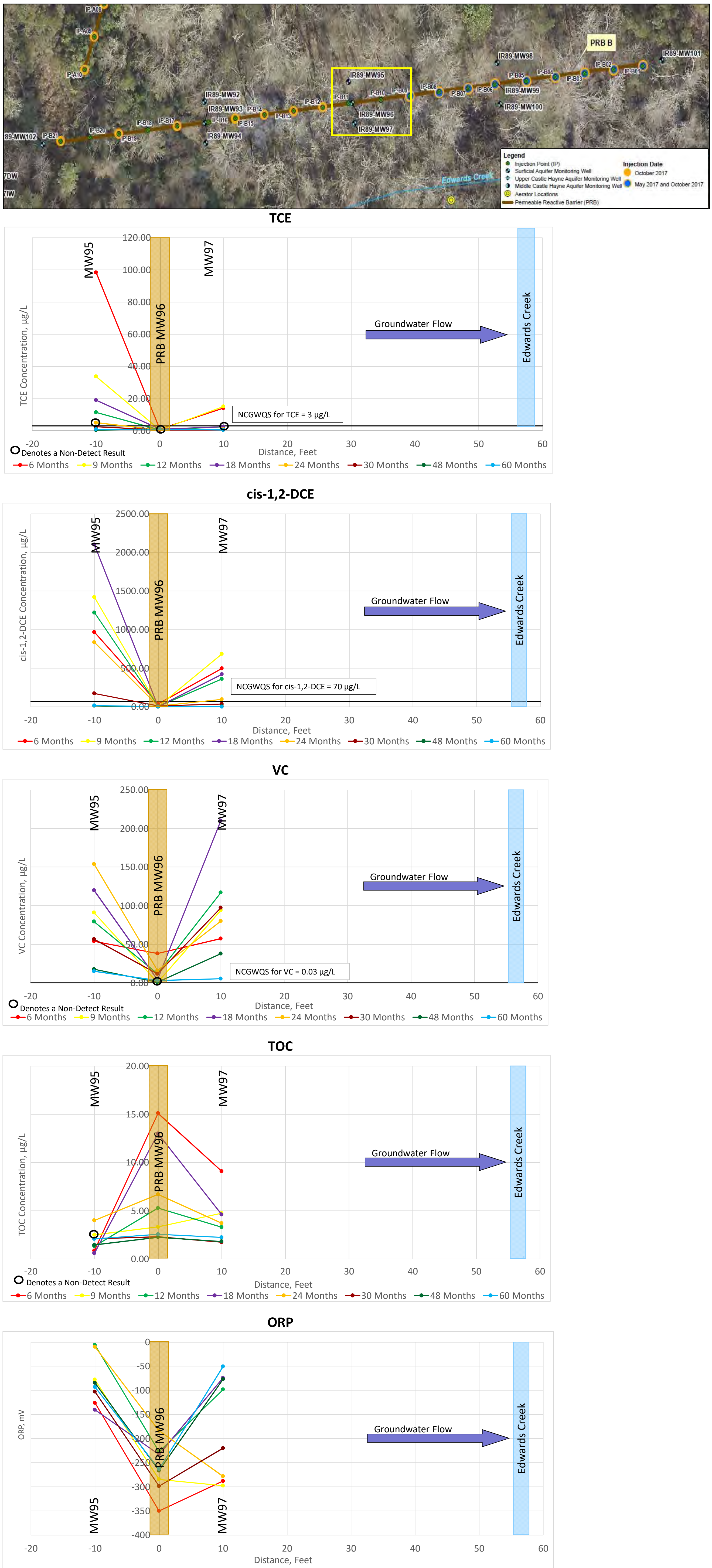
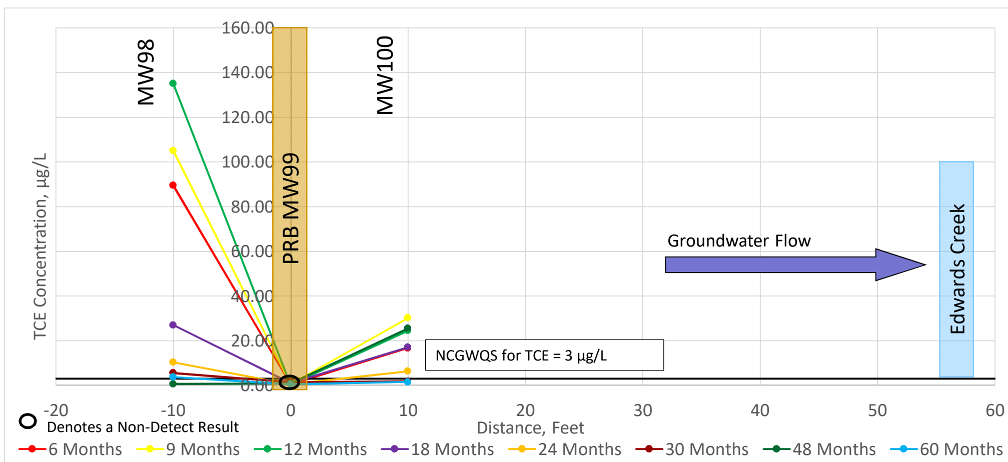
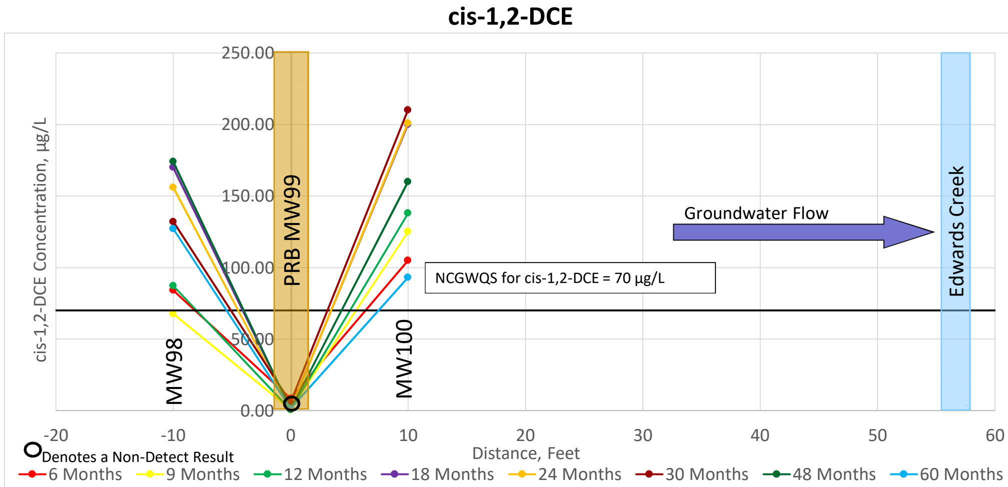


Figure 16-15
COC Concentrations in IR89-MW96 Cluster
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

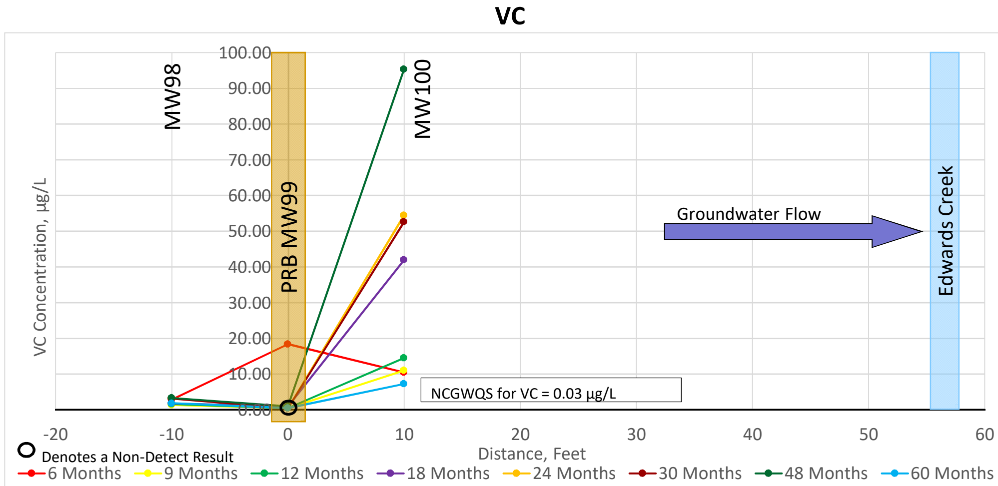
TCE



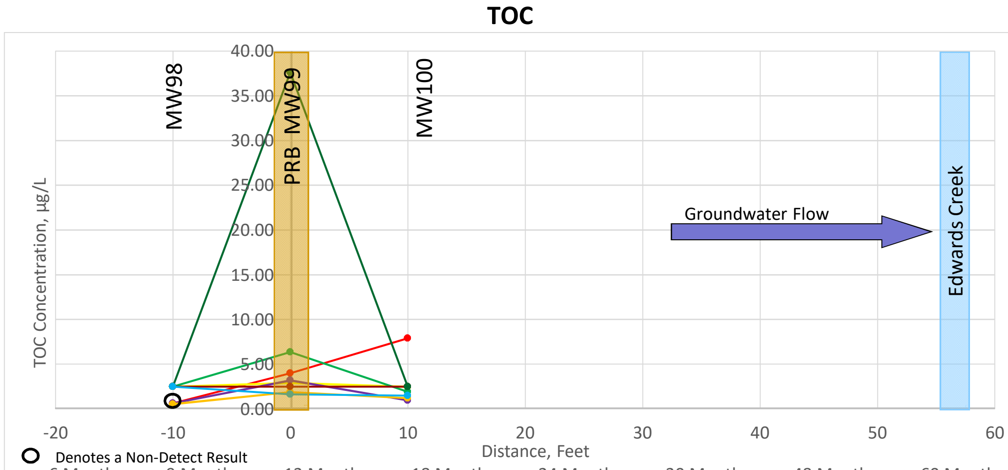
cis-1,2-DCE



VC



TOC



ORP

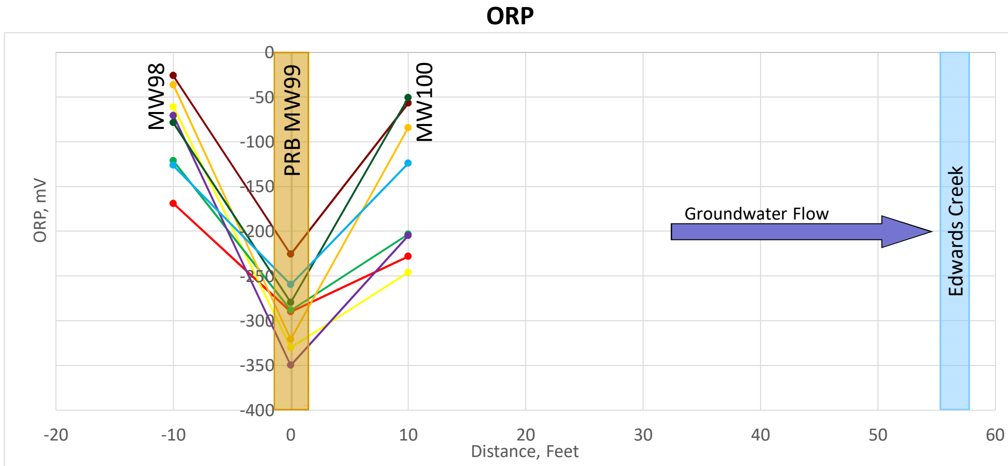
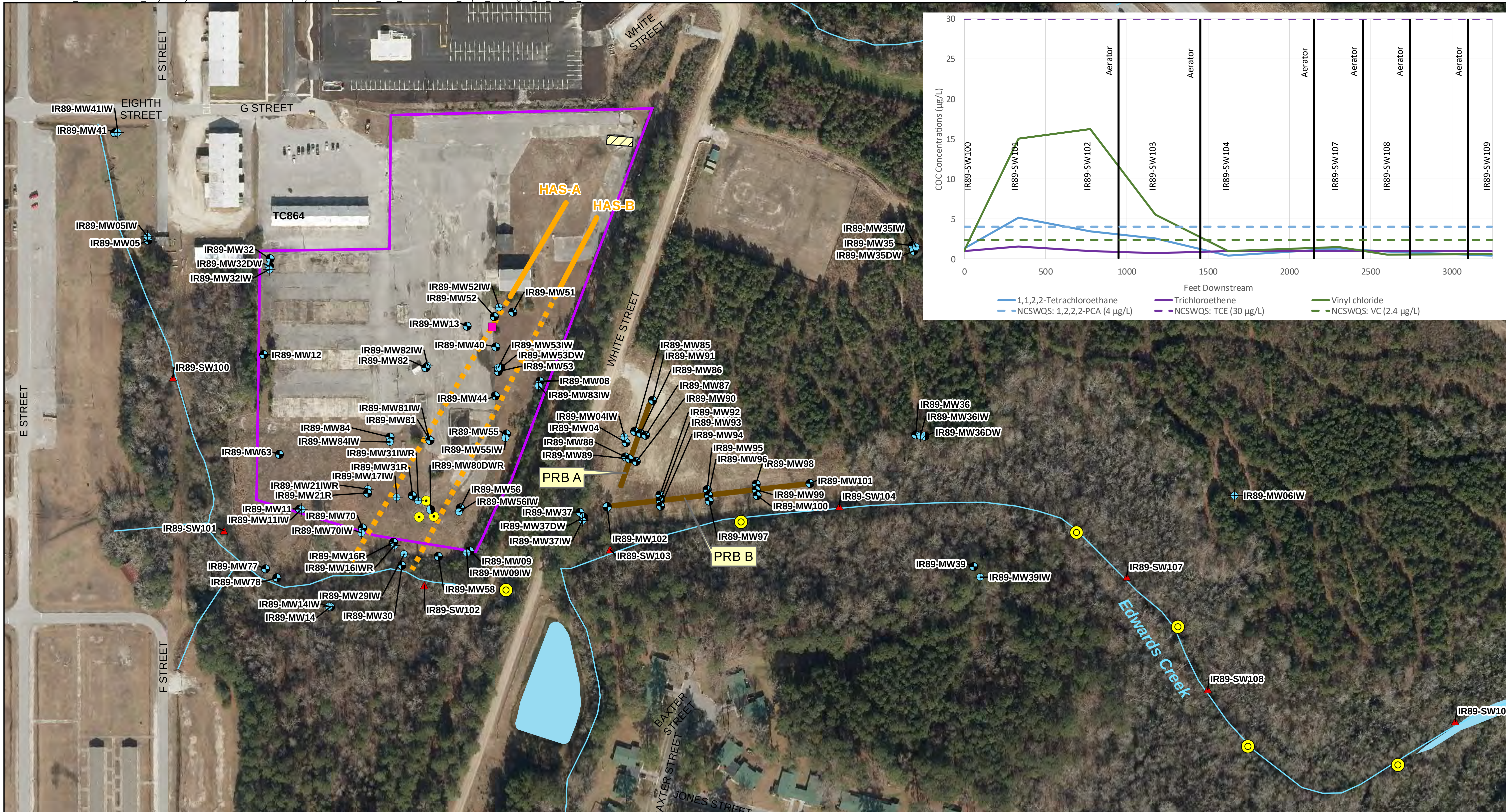


Figure 16-16
COC Concentrations in IR89-MW99 Cluster
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina



Legend

- Surficial Aquifer Monitoring Well
- Upper Castle Hayne Monitoring Well
- Middle Castle Hayne Monitoring Well
- Surface Water Sampling Location
- Former Underground Storage Tank Location
- Vertical Sparging Points
- Approximate Surface Water Aerator Locations
- Horizontal Air Sparging (HAS) Wells
- Permeable Reactive Barrier (PRB)
- Former Defense Reutilization and Marketing Office Area
- Water Bodies

Note:
UST = underground storage tank
AS = air sparging
PRB = permeable reactive barrier

N

0 100 200 Feet
1 inch = 200 feet

Figure 16-17
Surface Water Trends
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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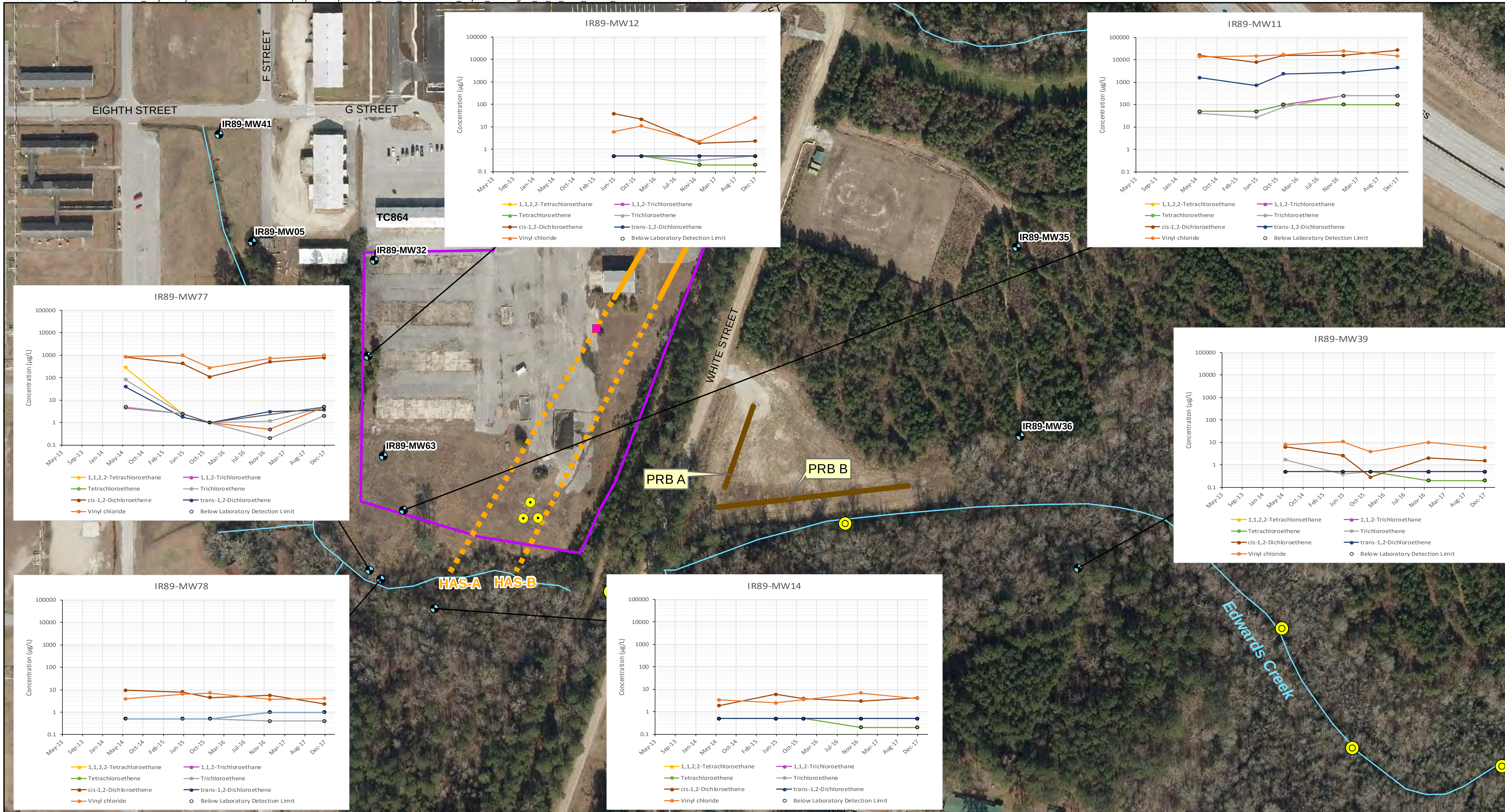

Legend

- Surficial Aquifer Monitoring Well
- Former Underground Storage Tank Location
- Vertical Sparging Points
- Approximate Surface Water Aerator Locations
- Horizontal Air Sparging (HAS) Wells
- Permeable Reactive Barrier
- Former Defense Reutilization and Marketing Office Area
- AS Compressor Compound
- Surface Water Centerline
- Water Bodies

Note:
µg/L - micrograms per liter
UST - underground storage tank
AS - air sparging
PRB - permeable reactive barrier

N

0 100 200 Feet
1 inch = 200 feet

Figure 16-18
Select MNA Trends - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Legend

- Upper Castle Hayne Monitoring Well
- Former Underground Storage Tank Location
- Vertical Sparging Points
- Approximate Surface Water Aerator Locations
- Horizontal Air Sparging (HAS) Wells
- Permeable Reactive Barrier (PRB)
- Former Defense Reutilization and Marketing Office Area
- AS Compressor Compound
- Surface Water Centerline
- Water Bodies

Note:
µg/L - micrograms per liter
UST - underground storage tank
AS - air sparging
PRB - permeable reactive barrier

N

0 100 200 Feet
1 inch = 200 feet

Figure 16-19
Select MNA Trends - UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

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Notes:
TCE - Trichloroethene
µg/L - micrograms per liter
U - analyte not detected above detection limit
J - concentration is estimated
Plumes are based on the current LTM network at the time of each respective sampling event

Legend
- Surficial Aquifer Monitoring Well
- Bioreactor Piezometer
- Extraction Well
- Industrial NC VISL Exceedance within 100 Feet of Building
- Former Permanganate Treatment Area (performed 2006-2008)
- Surface Water Centerline

TCE Extent
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

N

0 162.5 325 Feet

1 inch = 325 feet

Figure 16-20
Approximate Extent of TCE
Exceedances in the Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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Legend

- Surficial Aquifer Monitoring Well
- Bioreactor Piezometer
- Extraction Well
- Former Permanganate Treatment Area (performed 2006-2008)
- Surface Water Centerline

cis-1,2-DCE Extent

70 µg/L - 700 µg/L

N

0 162.5 325 Feet

1 inch = 325 feet

Figure 16-21
Approximate Extent of cis-1,2-DCE Exceedances in the Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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Notes:
VC - Vinyl Chloride
µg/L - micrograms per liter
U - analyte not detected above detection limit
J - concentration is estimated
Plumes are based on the current LTM network at the time of each respective sampling event

Legend
- Surficial Aquifer Monitoring Well
- Bioreactor Piezometer
- Extraction Well
- Industrial NC VISL Exceedance within 100 Feet of Building
- Former Permanganate Treatment Area (performed 2006-2008)
- Surface Water Centerline

VC Extent
- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

N

0 162.5 325 Feet

1 inch = 325 feet

Figure 16-22
Approximate Extent of Vinyl Chloride Exceedances in the Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

SECTION 17

Operable Unit 19 (Site 84)

17.1 Site History and Background

OU 19 is within Mainside (**Figure 1-2**) and consists of Site 84.

Site 84 — Former Building 45 covers approximately 5 acres (**Figure 17-1**). The property located one mile west of the Main Gate, south of State Route 24, was purchased by the federal government in 1941 and Building 45 was a former electric substation, where transformers reportedly containing PCBs were used and possibly stored. The building was constructed by the Navy soon after purchasing the property, and leased to Tidewater Electric, who operated the building through 1965. In 1965, Building 45 was converted to a maintenance facility for large machinery. While no official operational history exists for the building and the surrounding property, former employees recalled that site activities included PCB transformer maintenance, recycling, and onsite disposal of spent transformer casings. A transformer was discovered near a wooded area and additional transformers (approximately 20), potentially containing PCB dielectric oil, were discovered near the woods of the powerhouse. Maintenance personnel at Building 45 previously indicated that additional transformers may still be buried in areas near a former lagoon; however, an excavation is reported to have been performed by Public Works Center personnel and no waste materials were discovered. In 2012, portions of the site were developed with a photovoltaic farm.

OU 19 Timeline	
Year	**Event**
1992	UST Investigation
1996	Corrective Action Plan
1995-1998	Pre-RI Study
2001-2002	RI and FS
2002	PRAP, EE/CA, Action Memorandum
2002	Phase I NTCRA (Soil)
2002-2005	Phase II NTCRA (Soil)
2002-2010	RIP LUCs and RACR
2005-2006	Supplemental Investigation
2006-2007	Phase III NTCRA (Soil)
2007	Closeout Report
2008	Amended FS and PRAP
2009	ROD
2011	Supplemental Assessment – AST45-S781

17.2 Site Characterization

The findings from various investigations at OU 19 that are pertinent to the FYR are summarized in this section.

17.2.1 Physical Characteristics

- **Surface Features –** The ground surface at Site 84 is generally flat. The northeast edge of the site runs along a pedestrian pathway, and the northwest edge is bordered by Northeast Creek. The site is primarily wooded to the east and wetland areas are present adjacent to the creek.
- **Geology and Hydrogeology –** Subsurface conditions generally consist of Coastal Plain deposits consisting of layers of sand, silt, and clay. Groundwater is not a medium of concern at Site 84; however, the surficial aquifer is encountered from approximately 2 to 40 feet bgs and groundwater flows toward the Northeast Creek.

17.2.2 Land Use

- **Current Land Use –** Current land use is classified as low occupancy industrial. A portion of the site is currently part of a leased utility corridor and a photovoltaic farm was installed within the OU boundary.
- **Future Land Use –** There are no anticipated changes in land use. However, when the utility corridor lease agreements are scheduled for renewal in 2026, the companies with utilities within the PCB AOC, where intrusive or access controls are required, will be notified of the contaminated area and given the option to

either properly excavate and dispose of PCB-contaminated and waste soil or relocate their utilities outside of the PCB AOC.

17.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 19. Details in the OU 19 RI report (Baker, 1996) and the ROD (Rhēa, 2009).

Soil, groundwater, and sediment were investigated. PCBs were widespread at low concentrations (1 to 10 mg/kg) with three "hot spot" areas that were recommended for removal as a NTCRA. Three NTCRAs, discussed as follows, were conducted to remove PCB-contaminated soil and sediment. A 24-inch soil cover was put in place across the site.

- **Phase I** (2002) was completed to remove the remaining building foundation at Building 45 and some surrounding PCB-contaminated soil. 4,857 tons of nonhazardous PCB-contaminated soil and 142 tons of petroleum-contaminated soil were removed from the site (CH2M, 2002).
- **Phase II** (2004) was completed to remove contaminated soil and lagoon sediments. Approximately 12,000 tons of contaminated soil/sediment were removed from the site. However, remediation goals were not met because the Phase II NTCRA uncovered additional areas of contamination (TMS Envirocon and Baker, 2005).
- **Phase III** (2006-2007) was completed to remove additional PCB-contaminated soil to the south and west of the previous NTCRA locations. Complete excavation was deemed impractical in areas with buried, active utility, and communication lines. In these areas, a 2-foot-thick vegetative soil cover was placed over the PCB-contaminated soil (Rhēa, 2007b).

The HHRA completed as part of the RI evaluated current Base personnel and potential future adult and child residents, industrial/commercial site workers, and construction workers for both pre- and post-NTCRA scenarios. Post-NTCRA, unacceptable risks were identified for future adult and child residents from PCBs in surface and subsurface soils and future construction workers from exposure to PCBs in subsurface soils. Unacceptable risks from pesticides were identified in groundwater during the RI; however, results of post-RI sampling for pesticides were below the NCGWQS and groundwater was not considered a medium of concern in the ROD.

The ERA evaluated terrestrial and aquatic receptors for a post-NTCRA scenario and concluded that there were no remaining unacceptable risks after the soil and sediment was removed.

17.3 Remedial Action Objectives

The ROD for OU 19 was signed in January 2009 (Rhēa, 2009) with the following RAO:

- Remove contaminated surface and subsurface soils that contain PCBs in excess of the selected remediation goal (i.e., cleanup level) and prevent exposure to remaining PCB-contaminated soil consistent with the requirements for a low occupancy industrial area.

The COCs and cleanup levels for OU 19 are presented in **Table 17-1**.

17.4 Remedial Actions

The RA for OU 19 includes the following major components:

- Removal of PCB-contaminated soil (completed via NTCRA, **Section 17.2.3**)
- LUC to prevent exposure to PCB-contaminated surface and subsurface soil.
- Maintain the 24-inch vegetative cover within former removal areas to limit exposure to subsurface soils with PCB contamination greater than 10 ppm.

17.4.1 Remedy Implementation

LUCs were implemented in 2009 (Rhēa, 2009). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Intrusive Activities Control (Soil):** Restrict intrusive activities within the area of PCB contamination greater than 10 ppm in subsurface soils greater than 2 feet bgs.
- **Non-Industrial Use Control:** Prohibit development and use of the site for residential housing, elementary and secondary schools, child care facilities, and recreational areas within the area of PCB contamination greater than 1 ppm in surface soil.

A fence restricts access and warning signs are posted around the areas of PCB contamination greater than 10 ppm in subsurface soils.

17.4.2 Remedy Operation and Maintenance

The LUCs are shown on **Figure 17-1** and summarized in **Table 17-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed and no damage was observed. During the FYR site inspection completed in March 2019, a small debris pile containing soil, concrete, and brush was observed at the end of the access road that leads to the Northeast Creek, while not a violation of intrusive or non-industrial LUCs, it is an indicator that the area may be in use (**Appendix B**).

Table 17-2. OU 19 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Non-Industrial Use Control Boundary (Soil)	4.6	May 2009 (RD)	March 19, 2010
Intrusive Activities Control Boundary (Soil)	0.55		
Access Control Boundary	0.136		

17.4.3 Progress Since the 2015 Five-Year Review

No issues were identified at OU 19 during the 2015 FYR. The OU 19 RA components and expected outcomes are summarized in **Table 17-3**.

17.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. LUCs have been implemented to prohibit non-industrial land use and restrict intrusive activities. A fence restricts access and warning signs are posted.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. The exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time the final ROD was signed are still valid (**Table 17-1**).

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 19 remedy with respect to extreme weather events, primarily hurricanes, was completed. Effects of hurricane damage are most likely limited to flooding or erosion. Although the fencing could be damaged, allowing unauthorized access, the unacceptable risks to general site workers and trespassers are from subsurface soils so damage to fencing and significant erosion would need to occur to complete the exposure pathway. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

17.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified at OU 19 during this FYR.

Other Findings

When the utility corridor lease agreements that are scheduled for renewal in 2026 occur, the Navy and MCB Camp Lejeune EMD will notify the companies with utilities within the PCB AOC and give the option to either properly excavate and dispose of the PCB-contaminated soil or relocate utilities outside of the AOC so that the Base can properly address the contamination.

17.7 Statement of Protectiveness

The remedy at OU 19 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit soil intrusive activities and prohibit non-industrial use within the extent of the former soil removal action areas where PCBs remain in soil above levels that allow for UU/UE. A fence was also installed to restrict access within the areas of PCB contamination greater than 10 mg/kg in subsurface soils and warning signs are posted.

17.8 References

Baker Environmental Inc. (Baker). 1998. *Pre-Remedial Investigation Screening Study, Sites 12, 68, 75, 76, 84, 85, and 87 Marine Corps Base Camp Lejeune, North Carolina.* November.

Baker. 2002. *Remedial Investigation, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, North Carolina.* May.

CH2M HILL, Inc. (CH2M). 2002*. Non-Time Critical Removal Action, Operable Unit 19 (OU 19) Site 84, Building 45 Area, Marine Corps Base Camp Lejeune, North Carolina*. January.

Marine Corps Base (MCB) Camp Lejeune. 2002. *Proposed Remedial Action Plan for Operable Unit 19 (OU 19) Site 84 Building 45 Area, MCB Camp Lejeune, NC*. June.

Rhēa Engineers and Consultants (Rhēa). 2006. *Supplemental Investigation – Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, North Carolina.*

Rhēa. 2007a. *Non-time-critical Removal* Action *Report, Site 84, Operable Unit 19. Marine Corps Base Camp Lejeune, North Carolina.*

Rhēa. 2007b. *Project Closeout Report: Review, Recommendations and Removal Action, Site 84, Operable Unit 19. Marine Corps Base Camp Lejeune, North Carolina.* November.

Rhēa. 2008a. *Proposed Remedial Action Plan, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* April.

Rhēa. 2008b. *Feasibility Study Amendment, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, North Carolina.* May.

Rhēa. 2009. *Record of Decision, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* January.

Rhēa. 2010. *Remedial Action Completion Report, Site 84, Operable Unit No. 19, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.*

TMS Envirocon and Baker. 2005. *Site 84, Operable Unit 19 Phase II Interim Removal Action Closeout Report, Marine Corps Base, Camp Lejeune, North Carolina*. March.

Table 17-1. Cleanup Levels for OU 19 (Site 84)

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	ROD Cleanup Levels for Intrusive Activities (RHEA, 2009)	Cleanup Level Reference	ROD Cleanup Levels for Industrial Land Use (RHEA, 2009)	Cleanup Level Reference
Soil (mg/kg)	PCBs	10	Action Level for Low Occupancy Land Use (USEPA, 1990)	1	Action Level for High Occupancy Land Use (USEPA & TSCA)

Notes:

Shading indicates cleanup levels achieved/remedy protective (Rhēa, 2010)

COC = constituent of concern

mg/kg = milligram(s) per kilogram

PCB = polychlorinated biphenyl

ROD = Record of Decision

TSCA = Toxic Substances Control Act

USEPA = United States Environmental Protection Agency

Table 17-3. OU 19 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
84	Soil	Potential exposure to residents and industrial workers to PCBs in soil.	Utilities[a]/ vacant	Remove contaminated surface and subsurface soils that contain PCBs exceeding the selected remediation goal (i.e., cleanup level) and prevent exposure to remaining PCB-contaminated soil consistent with the requirements for a low occupancy industrial area.	Soil Removal	Excavation and offsite disposal of PCB-contaminated soil from areas of concern was conducted to meet industrial levels.	Utilities/ Industrial Land Use
					LUCs	Maintain non-industrial use, intrusive activities, and access controls and monitor quarterly.	

[a] When the utility corridor lease agreements are scheduled for renewal in 2026, the companies with utilities within the PCB AOC, where intrusive or access controls are required, will be notified of the contaminated area and given the option to either properly excavate and dispose of PCB-contaminated soil and PCB waste soil, or relocate their utilities outside of the PCB AOC.

Notes:

AOC = area of concern

LUC = land use control

PCB = polychlorinated biphenyl

RAO = remedial action objective

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Legend

- Surface Water Centerline
- Non-Industrial Use Control Boundary (Soil)
- Intrusive Activities Control Boundary (Soil)
- Access Control Boundary
- Installation Boundary

N

0 225 450 Feet

1 inch = 450 feet

Figure 17-1
OU19 (Site 84)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

Operable Unit 20 (Site 86)

18.1 Site History and Background

OU 20 is within the operations area of MCAS New River (**Figure 1-2**) and consists of Site 86.

Site 86 — Tank Area AS419-AS421 is approximately 500 acres and consists of a VOC groundwater plume that underlies an area of approximately 100 acres (**Figure 18-1**). The potential sources of contamination are shown include the following:

OU 20 Timeline	
Year	**Event**
1990	Preliminary Site Investigation
1992	UST Assessment
1995-1996	RI
1997-2000	Post-RI Fieldwork
1998-2005	LTM
2001-2003	Amended RI
2004-2006	Air/Ozone Sparging Pilot Study
2007-2011	Expanded SRI
2011-2012	ERD and ISCO Pilot Study
2012-2013	FS
2014	PRAP, ROD, & RD
2015	RACR
2015-Present	MNA
2018	SI for PFAS
2019	Basewide PFAS PA

- AST area—Contained three 25,000-gallon ASTs that held fuel oil from 1954 until 1974 and waste oil from 1979 to 1988. The tanks were contained within an earthen berm. A small pump house was used to transfer oil to and from the ASTs. The tanks were emptied and removed in 1992.
- Helicopter Wash Pad—Used nozzles embedded in the tarmac to clean aircraft from 1968 until abandonment in 2001.
- Several hangars—Housed carburetor, battery, and engine buildup shops used for aircraft maintenance.
- Solid Waste Management Unit (SWMU) 303—Consisted of two former steel ASTs that were contained within a concrete, bermed structure.
- SWMU 318—Consisted of a concrete, multichambered OWS and grit chamber associated with the former Helicopter Wash Pad.
- Gas station and garage.
- UST AS-510—Located near the footprints of three former buildings used for various activities, including a steam power plant and waste storage.

Investigations were initially conducted under the UST program and the original site boundary encompassed the AST area. Based on the presence of CVOC impacts, the site was transferred to the IRP and designated as Site 86. The site was expanded overtime to encompass the potential sources listed above.

18.2 Site Characterization

The findings from various investigations at OU 20 that are pertinent to the FYR are summarized in this section.

18.2.1 Physical Characteristics

- **Surface Features –** Site 86 is located on an active military flight line with multiple areas of limited or restricted access. Approximately half of the site is developed with buildings, parking lots, landscaped areas, and the flight line. Stormwater runoff from the western portion of the site flows east through storm drains that discharge to a drainage ditch and ultimately to the New River. Stormwater from the northern portion of the site flows to a retention pond.

- **Geology and Hydrogeology –** Subsurface conditions generally consist of Coastal Plain deposits including silts, clays, fine sands, and limestone. Groundwater is a medium of concern and the affected aquifers include the surficial aquifer which is encountered at approximately 3 to 10 feet bgs and extends to a depth of approximately 25 feet bgs and the UCH aquifer which extends to approximately 60 feet bgs. The MCH aquifer is present below the UCH aquifer. In general, the groundwater flow direction within the surficial and Castle Hayne aquifers is to the east-northeast towards the New River (**Figure 18-1**). In the surficial aquifer, the average hydraulic conductivity is 3.4 ft/day and the average hydraulic gradient is 0.004 ft/ft, with an average groundwater velocity of 0.057 ft/day. In the UCH aquifer, the average hydraulic conductivity is 10 ft/day and the average hydraulic gradient is 0.0034 ft/ft, with an average groundwater velocity of 0.139 ft/day. Vertical hydraulic gradients from the surficial to the UCH aquifer were downward with a gradient of approximately 0.03197 ft/ft. A downward gradient of 0.01335 ft/ft from the UCH to the MCH aquifer was also observed.

18.2.2 Land Use

- **Current Land Use –** The majority of Site 86 consists of the MCAS New River flight line and supporting operations.
- **Future Land Use –** There are no anticipated changes in land use.

18.2.3 Basis for Taking Action

This section describes the site investigations and risk assessments that provide the basis for taking action at OU 20. Details are in the RI (Baker, 1996), Expanded SRI (CH2M, 2011), FS (CH2M, 2013a), pilot studies (AGVIQ/CH2M JV, 2006; CH2M, 2013a, 2013b), and ROD (CH2M, 2014b).

Soil, groundwater, surface water, and sediment were investigated. The HHRAs conducted during the RI and Expanded SRI evaluated risks to current military and industrial personnel and potential future adult and child residents and construction worker scenarios. Unacceptable risks to potential future industrial workers and residents were identified from VOCs, PAHs, and chromium in groundwater if used as a potable source. The unacceptable risk for one VOC (chloroform), the PAHs, and chromium was driven by a single groundwater sample; confirmation sampling was completed, and results were below laboratory detection limits (CH2M, 2013b). Unacceptable risks to potential future residents was identified from exposure to chromium in surface soil. Additional evaluation and a Base background study indicated exposure to chromium in soil would not result in unacceptable risks based on applying a base-specific hexavalent chromium to total chromium ratio and reevaluating risks (CH2M, 2013b). Additionally, for future building occupants, indoor air concentrations could exceed the VISLs should VI occur in the future if new construction were to take place, or if there are building changes that impact the slab or foundation, or land use changes within 100 feet of the groundwater VOC plume. The ERA evaluated terrestrial and aquatic receptors and did not identify any unacceptable ecological risks.

Several pilot studies were implemented to evaluate potential treatment options and reduce VOC mass in the areas with the highest historical concentrations identified during the RI (Baker, 1996) and the Expanded SRI (CH2M, 2011) (**Figure 18-2**):

- AS/ozone injection pilot study: From 2005 to 2006 ozone was injected via an HDD well installed in an area with elevated TCE concentrations in groundwater (28 to 1,200 µg/L). The well was 950 feet long with 350 feet of screen at approximately 60 feet bgs. The pilot study system reduced concentrations of TCE by approximately 99 percent in the target treatment area (AGVIQ/CH2M, 2006).

- ERD recirculation pilot study: From 2011 to 2012 approximately 30,000 pounds of sodium lactate were injected through a series of injection wells and further distributed by extracting and re-injecting groundwater to treat approximately 330,000 cubic feet of impacted aquifer. The study reduced concentrations of VOCs by approximately 80 percent near the eastern end of the industrial portion of Site 86 (CH2M, 2013a).

- ISCO pilot study: From 2011 to 2012, a downgradient study consisting of 60 slow-release permanganate candles were placed 27 to 33 feet bgs in 30 locations along two 80-foot-long transects. Follow-up monitoring indicated initial VOC concentrations were reduced by 81 percent and subsequent monitoring results were variable (CH2M, 2013b). Distribution of the permanganate in the formation was limited.

These pilot studies treated the highest concentrations of VOCs, leaving diffuse plumes of benzene, PCE, TCE, cis-1,2-DCE, and VC at concentrations above the NCGWQS in the surficial and UCH aquifers. The ROD was prepared based on site conditions after the pilot studies were completed.

18.3 Remedial Action Objectives

The ROD addressing groundwater at OU 20 was signed in October 2014 (CH2M, 2014b). The RAOs identified for OU 20 are to:

- Restore groundwater quality to meet NCDEQ and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE.

The COCs and cleanup levels for OU 20 are presented in **Table 18-1**.

18.4 Remedial Actions

The RA for OU 20 includes the following major components:

- MNA to monitor plume stability and natural attenuation processes in groundwater.
- LUCs to prevent exposure to contaminated groundwater and mitigate VI.

18.4.1 Remedy Implementation

MNA was initiated in 2015 and is ongoing as described in the following section. LUCs were implemented in 2014 (CH2M, 2014c). The following LUCs were filed with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control** – To prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the land area within at least 1,000 feet of groundwater with COC concentrations exceeding cleanup levels.
- **Industrial and Non-Industrial Use Control (VI)** – To evaluate future buildings and land use for potential VI pathways, prior to construction, within the extent of groundwater contamination remaining in-place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 100 feet of groundwater within the surficial and Castle Hayne aquifers with COC concentrations exceeding cleanup levels.

18.4.2 Remedy Operation and Maintenance

Remedy O&M currently consists of MNA and LUC monitoring. The total annual cost is approximately $55,000.

Monitored Natural Attenuation

When MNA began in 2015, the sampling protocol consisted of collecting groundwater samples from 27 surficial, 30 UCH, and 1 MCH aquifer monitoring wells. The monitoring well network is reviewed and updated annually and currently consists of 21 surficial, 25 UCH, and 1 MCH aquifer monitoring wells. Groundwater samples are collected from all monitoring wells and analyzed annually for COCs (**Table 18-1**) and every 5 years for NAIPs (alkalinity, chloride, MEE, sulfate, sulfide, and TOC) to monitor natural attenuation.

In addition to comparing to cleanup levels (**Table 18-1**), data in the surficial aquifer are compared to the non-residential NC VISL consistent with the overall site use, to evaluate whether concentrations indicate the potential for a complete VI pathway. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of MNA.

Land Use Controls

LUCs are shown on **Figure 18-1** and summarized in **Table 18-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports sent to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed and no damage to the site was observed. There were no issues affecting protectiveness observed during the FYR site inspection conducted in March 2019 (**Appendix B**).

Table 18-2. OU 20 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	500.9	December 2014 (RD)	September 23, 2015
Industrial/Non-Industrial Use Control Boundary (VI)	96.4		

18.4.3 Progress Since the 2015 Five-Year Review

Issues identified during the 2015 FYR and follow-up actions are summarized in **Table 18-3**. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 18-2**. The OU 20 RA components and expected outcomes are summarized in **Table 18-4**.

Table 18-3. 2015 FYR OU 20 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Current Status
An RSL was established for 1,4-dioxane and indicator constituents are present in groundwater.	Collect groundwater samples for 1,4-dioxane to evaluate presence/absence (September 30, 2018).	Completed June 23, 2017. Groundwater sampling for 1,4-dioxane was completed on June 21 and 23, 2017 as part of the FY 2017 MNA sampling and there were no exceedances of screening criteria (CH2M, 2018).

Site Inspection for PFAS in Groundwater

An SI to evaluate the presence of PFAS in groundwater was conducted in 2017 based on known use of AFFF at fire stations and hangars (Buildings AS502, AS508, AS3900, and AS3905) located within the Site 86 boundary. Concentrations of PFOS and PFOA were detected in groundwater and exceeded the USEPA lifetime health advisory (0.07 µg/L), and tapwater RSL based on a hazard quotient of 1 (0.4 µg/L), with the highest concentrations detected near Building AS502 (Fire Station #1). The elevated concentrations of PFOS (maximum concentration of 22.1 µg/L) and PFOA (maximum concentration of 1.62 µg/L) in the groundwater indicate historical AFFF releases have resulted in a release of PFAS to the groundwater in the surficial aquifer. Additional investigations were recommended to evaluate the nature and extent of PFAS contamination (CH2M, 2018).

Basewide Preliminary Assessment for Per- and Polyfluoroalkyl Substances

The four areas identified in the PFAS SI (Buildings AS502, AS508, AS3900, and AS3905) were all identified as confirmed PFAS release areas based on historical use of AFFF and reported concentrations of PFOS and PFOA in groundwater from the SI. Additionally, a MV-22B Osprey experienced a maintenance-related fire that was extinguished using AFFF within the Site 86 aquifer use control boundary. Therefore, additional investigation to evaluate the nature and extent of PFAS contamination was recommended (CH2M, 2019b).

18.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. MNA results indicate that natural attenuation is occurring and LUCs are in place to prevent aquifer use and evaluate the VI pathway. The following is a summary of the FY 2019 LTM findings (CH2M, 2020).

In the surficial aquifer, MK statistical analyses indicate that concentrations of COCs are generally stable to decreasing, indicating that natural attenuation appears to be occurring (**Figures 18-3** through **18-7**). TCE exceeded the non-residential NC VISL at three locations and one exceedance was within 100 feet of a building (Building AS545), which is being evaluated in the upcoming VI FYR (CH2M, 2019a).

In the UCH aquifer, MK statistical analyses indicate that concentrations of benzene were stable to increasing. Concentrations of TCE were generally decreasing, while concentrations of daughter products (cis-1,2-DCE and VC) were generally stable or increasing at isolated locations (**Figures 18-8** through **18-11**). Collectively, these results indicate that natural attenuation is taking place in the UCH aquifer. Overall COCs are still contained within LUCs and increasing degradation daughter products are a sign of natural attenuation.

NAIP data was collected in FY 2019 and summarized on **Table 18-5**. NAIPs indicate that conditions in the surficial aquifer are generally not optimal for reductive dechlorination. Concentrations of TOC are low, and pH readings are generally below the range where dechlorinating bacteria are most active. NAIPs indicate that conditions are generally favorable for reductive dechlorination in portions of the UCH aquifer. Although concentrations of TOC are low, pH readings mostly fall in the range where dechlorinating bacteria are most active, and low concentrations of sulfate often coincided with moderate to elevated concentrations of methane. Reductive dechlorination end products were detected, indicating that complete degradation of chlorinated ethenes is taking place in the UCH aquifer.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

No. While exposure assumptions, toxicity data, cleanup levels, and RAOs are still valid from the time of selection, a new potential contaminant source has been identified. Surficial aquifer groundwater within the LUC boundaries at Site 86 was evaluated in a SI and PFAS compounds were detected at concentrations above the USEPA lifetime health advisory and tapwater RSL based on a hazard quotient of 1.

The ROD was signed in 2014 and there have been no changes in toxicity values since the ROD that would impact the protectiveness of the remedy. Additionally, there have been no changes in toxicity values for the COCs identified in the HHRA since the last five-year review which concluded that the remedy at OU 20 is protective of human health and the environment (**Table 2-1**). There have been no changes in regulatory standards, and risk characteristics of COCs at OU 20 identified in the ROD. Additionally, any changes would not affect the protectiveness of the remedy, as LUCs prevent exposure to groundwater.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 20 remedy with respect to extreme weather events, primarily hurricanes, was completed. The effects of extreme weather events would be damage to monitoring wells and are most likely limited because there are very few trees or structures that would be subject to high winds as the flightline controls and minimizes any potential debris during regular operations. LUCs, are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

18.6 Issues, Recommendations, and Follow-up Actions

Issues, recommendations, and follow-up actions for OU 20 are summarized in **Table 18-6**.

Table 18-6. OU 20 Recommendations and Follow-up Actions

Issue	Recommendations/Actions	Party Responsible	Oversight Agency	Milestone Date	Affects Protectiveness (Yes/No)	
					Current	Future
Areas within the Site 86 boundary have been identified as potential PFAS release areas based on historical use and PFAS has been detected in surficial aquifer groundwater at concentrations above the USEPA lifetime health advisory.	Refine the extent of PFAS in site media near Buildings AS502, AS508, AS3900, AS3905 and the MV-22B Osprey crash and evaluate whether there is a potentially unacceptable risk to human health and/or a potential complete exposure pathway to drinking water receptors.	Navy/Base	USEPA/ State	December 31, 2025	No	Yes

18.7 Statement of Protectiveness

The remedy at OU 20 is currently protective of human health and the environment. Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and evaluate and/or mitigate potential VI pathways and MNA is ongoing until cleanup levels are achieved. However, to ensure that the remedy remains protective in the long term, the Navy intends to refine the the extent, potential for unacceptable risks and/or potential complete exposure pathway from PFAS in groundwater from Buildings AS502 AS508, AS3900, AS3905, and the MV-22B Osprey crash.

18.8 References

AGVIQ and CH2M HILL, Inc. Joint Venture (AGVIQ/CH2M). 2006. *Pilot Study Report, Site 86, Operable Unit No. 20, Marine Corps Base Camp Lejeune, North Carolina.* September.

Baker Environmental Inc. (Baker). 1996. *Remedial Investigation Report, Operable Unit No. 20 (Site 86), Marine Corps Base Camp Lejeune, North Carolina.* August.

CH2M HILL, Inc. (CH2M). 2011. *Expanded Supplemental Remedial Investigation, Site 86-Operable Unit No. 20, Marine Corps Base, Camp Lejeune, North Carolina.* February.

CH2M. 2013a. *Pilot Study Report Site 86, Operable Unit No. 20. Marine Corps Installations East – Marine Corps Base Camp Lejeune, Jacksonville, North Carolina*. September.

CH2M. 2013b. *Feasibility Study, Site 86 Operable Unit No. 20 Marine Corps Installations East – Marine Corps Base Camp Lejeune, Jacksonville, North Carolina. October.*

CH2M. 2014a. *Proposed Remedial Action Plan Site 86 Operable Unit 20. Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina.* January.

CH2M. 2014b. *Record of Decision Operable Unit No. 20 Site 86 Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* October.

CH2M. 2014c. *Remedial Design, Operable Unit 20, Site 86, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina*. December.

CH2M. 2015. *Remedial Action Completion Report, Operable Unit 20, Site 86, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina*. September.

CH2M. 2018. *Site Inspection for PFAS in Groundwater at Sites 9, 54, 86, and Tactical Landing Zone Phoenix, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* November.

CH2M. 2019a. *Draft Sampling and Analysis Plan Vapor Intrusion Monitoring Installation Restoration Program Five-Year Update, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* October.

CH2M. 2019b. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* December.

CH2M. 2020. *Draft Long-Term Monitoring Report Installation Restoration Program Site 86, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* January.

CH2M, Baker, and CDM. 2003. *Amended Remedial Investigation, Operable Unit No. 20, Site 86 – Tank Area AS419 – AS421, MCB Camp Lejeune, North Carolina*. May.

Environmental Science and Engineering, Inc. (ESE). 1990. *Site Summary Report Final, Marine Corps Base Camp Lejeune, North Carolina.* September.

O'Brien and Gere. 1992. *Site Assessment Tanks AS419 – A421. New River, North Carolina. June.*

Table 18-1. Cleanup Levels for OU 20 (Site 86)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2014)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	Benzene	1	1	NCGWQS
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	Tetrachloroethene	0.7	0.7	NCGWQS
	Trichloroethene	3	3	NCGWQS
	Vinyl chloride	0.03	0.03	NCGWQS

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Current Standard Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

µg/L = microgram(s) per liter

COC = constituent of concern

MCL = maximum contaminant level

NCGWQS = North Carolina Groundwater Quality Standard

ROD = Record of Decision

VOC = volatile organic compound

Table 18-4. OU 20 Remedial Action Summary and Expected Outcomes

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/ Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
86	Groundwater	Potential unacceptable risks to future residents from exposure to VOCs in groundwater.	Industrial	Restore groundwater quality to meet North Carolina Department of Environmental Quality and federal primary drinking water standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A North Carolina Administrative Code 02L.0201.	MNA	Implement groundwater MNA to monitor COC concentrations and migration until each groundwater VOC is at or below its respective cleanup level for four consecutive sampling events.	UU/UE
				Prevent exposure to COCs in groundwater and vapor intrusion from COCs in groundwater until such time as groundwater concentrations or vapor intrusion mitigation measures allow for UU/UE.	LUCs	Maintain industrial/non-industrial use (VI) and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	

Notes:

COC = constituent of concern

LUC = land use control

MNA = monitored natural attenuation

RAO = remedial action objective

UU/UE = unlimited use/unrestricted exposure

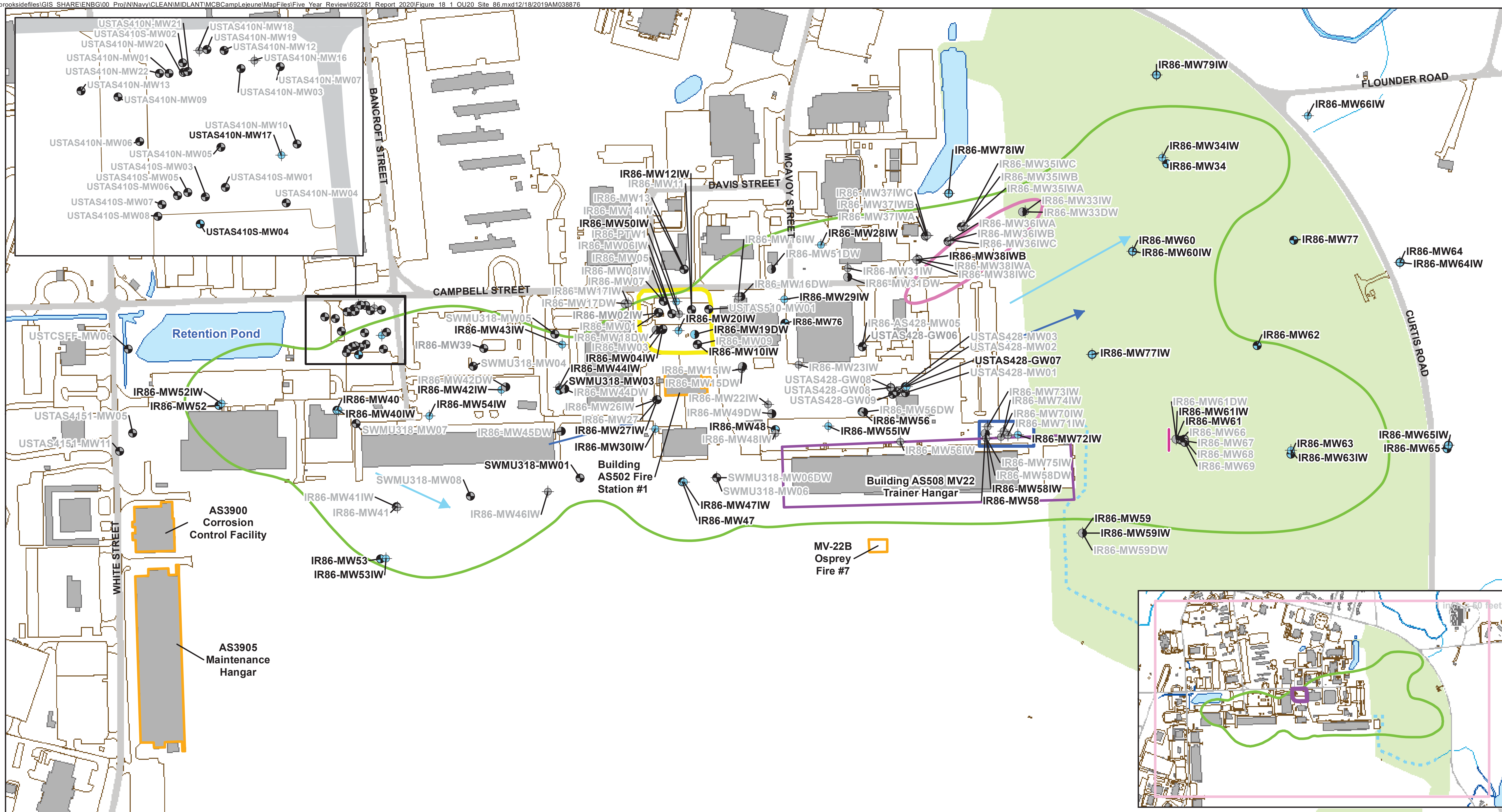
VI = vapor intrusion

VOC = volatile organic compound

Table 18-5. Natural Attenuation Indicator Parameters Summary - Site 86
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer		
	Description	Favorable Condition[a]	Range of Results	Frequency of Favorable Results	Conclusion	Range of Results	Frequency of Favorable Results	Conclusion
DO (mg/L)	DO is the most thermodynamically favorable electron acceptor used by microbes. High levels of DO are indicative of aerobic conditions, and low levels of DO are indicative of anaerobic conditions. As reductive dechlorination takes place under anaerobic conditions, low levels of DO are generally favorable for reductive dechlorination.	< 1	0 to 1.5	23 / 24	Yes, unfavorable result isolated	0 to 1.04	29 / 29	Yes
ORP (mV)	ORP measures the degree to which aquifer conditions are reducing or oxidizing. As reductive dechlorination takes place under reducing conditions, lower ORPs are generally favorable for reductive dechlorination.	< 50	-95 to 315	17 / 24	Favorable results in more than half of surficial wells	-160 to 23	29 / 29	Yes
Nitrate (mg/L)	After DO is depleted, nitrate may be used as an electron acceptor (i.e., denitrification). As nitrate may compete with the reductive dechlorination pathway, depleted nitrate concentrations are generally favorable for reductive dechlorination. Depleted nitrate concentrations alone do not conclusively indicate favorable conditions for reductive dechlorination.	< 1	0 to 0	23 / 23[b]	Yes	0 to 0	28 / 28	Yes
Nitrite[b] (mg/L)	During denitrification, nitrate is converted into nitrite. Therefore, the presence of nitrite indicates the geochemical footprint of denitrification. If nitrate is absent from a monitoring location, denitrifying conditions may exist if nitrite is not observed. Denitrifying conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	Detectable Concentrations	0 to 0	--	Neutral	0 to 0.5	1 / 1	Favorable result at one location. Otherwise, inconclusive.
Ferrous Iron (mg/L)	The presence of ferrous iron indicates the geochemical footprint of iron-reduction, which takes place under more reducing conditions than denitrification. Iron reducing conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	> 1	0 to 7.5	22 / 24	Yes, unfavorable results isolated	0 to 7	26 / 29	Yes, unfavorable results isolated
Sulfate (mg/L)	Sulfate may be used as an electron acceptor under more reducing conditions than iron-reducing conditions. As higher concentrations of sulfate may compete with the reductive dechlorination pathway, low levels of sulfate are favorable for reductive dechlorination. Depleted sulfate concentrations are also an indicator that sulfate reduction is proceeding, which generally indicates that conditions are favorable for reductive dechlorination.	< 20	0.42 J to 210	11 / 24	Favorable results in approximately half of surficial wells	0.38 J to 1500	21 / 29	Yes, favorable results in more than half of UCH wells.
Sulfide[b] (mg/L)	During sulfate reduction, sulfate is converted into sulfide. Therefore, the presence of sulfide indicates the geochemical footprint for sulfate reduction. When detected, sulfide indicates that sulfate reduction is taking place and that conditions are generally favorable for reductive dechlorination. However, the absence of sulfide does not conclusively indicate that conditions are unfavorable for reductive dechlorination, as sulfide is highly reactive and readily forms precipitates with ferrous iron.	Detectable Concentrations	0.78 J to 9.2	6 / 6	Favorable results in six surficial wells. Otherwise, inconclusive.	0.7 J to 0.84 J	3 / 3	Favorable results in three UCH wells. Otherwise, inconclusive.
Methane (mg/L)	The presence of methane in groundwater is indicative of the strongly reducing conditions required to support reductive dechlorination. Therefore, the presence of moderate concentrations of methane is a favorable indicator for reductive dechlorination.	> 0.5	0.0028 J to 2.9	11 / 24	Favorable results in approximately half of surficial wells	0.0034 to 4	15 / 29[a]	Favorable result in approximately half of UCH wells
TOC (mg/L)	TOC is an indicator of the total amount of organic matter available to microbial communities to use as source of carbon and energy. Elevated TOC concentrations are a positive indicator of natural attenuation potential.	> 20	0.42 J to 12	0 / 24	No	0.47 J to 27	1 / 32	No, favorable result isolated
Ethane (mg/L)	Ethane is a nonhazardous end product of reductive dechlorination. As the presence of ethane indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethane are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 24	No	0.003 J to 0.015	4 / 29	No, favorable results isolated
Ethene (mg/L)	Ethene is a nonhazardous end product of reductive dechlorination. As the presence of ethene indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethene are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 24	No	0.0023 J to 0.026	6 / 29	No, favorable results isolated
pH (SU)	The pH of groundwater affects the presence and activity of microbial populations in groundwater. The optimal pH range for dechlorinating bacteria generally falls between pH 6 and 8 SUs (Yang, 2017).	6 - 8	4.17 to 7.62	9 / 24	Favorable results in 9 surficial wells.	6.37 to 10.01	28 / 29	Yes, unfavorable result isolated
Alkalinity (mg/L)	Alkalinity measures the capacity of groundwater to resist changes in pH. As biodegradation processes increase aquifer acidity, higher concentrations of alkalinity indicate that pH values are more likely to remain stable.	> 50	1.9 J to 550	12 / 24	Favorable results in half of surficial wells	57 to 610	29 / 29	Yes

[a] If readings are near the Project Indicator Level, engineering judgment may be used to determine favorability.
[b] Only locations where nitrite or sulfide were detected were included for this evaluation.
Notes:
< = less than
> = more than
-- = Count not performed; see Project Indicator Level description for rationale.
DO = dissolved oxygen
J = Analyte present, value may or may not be accurate or precise
mg/L = milligram(s) per liter
mV = millivolt(s)
ORP = oxidation-reduction potential
SU = standard unit
ND = not detected
TOC = total organic carbon
U = The material was analyzed for, but not detected
UCH = Upper Castle Hayne



Legend

Monitoring Wells

- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Middle Castle Hayne Aquifer
- Surficial Aquifer - not in LTM
- Upper Castle Hayne Aquifer - not in LTM
- Middle Castle Hayne Aquifer - not in LTM
- ERD and Bioaugmentation Pilot Study
- Horizontal AS Well Pilot Study
- Original Site 86 Boundary
- Drainage Ditch
- Slow-Release Permanganate Candles
- Surface Water Centerline
- Surface Water Body Area
- Northeast Grass Area
- Building
- Road
- Pavement Parking and Driveway Area
- Surficial Groundwater Flow Direction
- UCH Groundwater Flow Direction
- Potential PFAS Release Area
- Area Previously Investigated

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

N

0 175 350 Feet

1 inch = 350 feet

Figure 18-1
OU 20 (Site 86)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

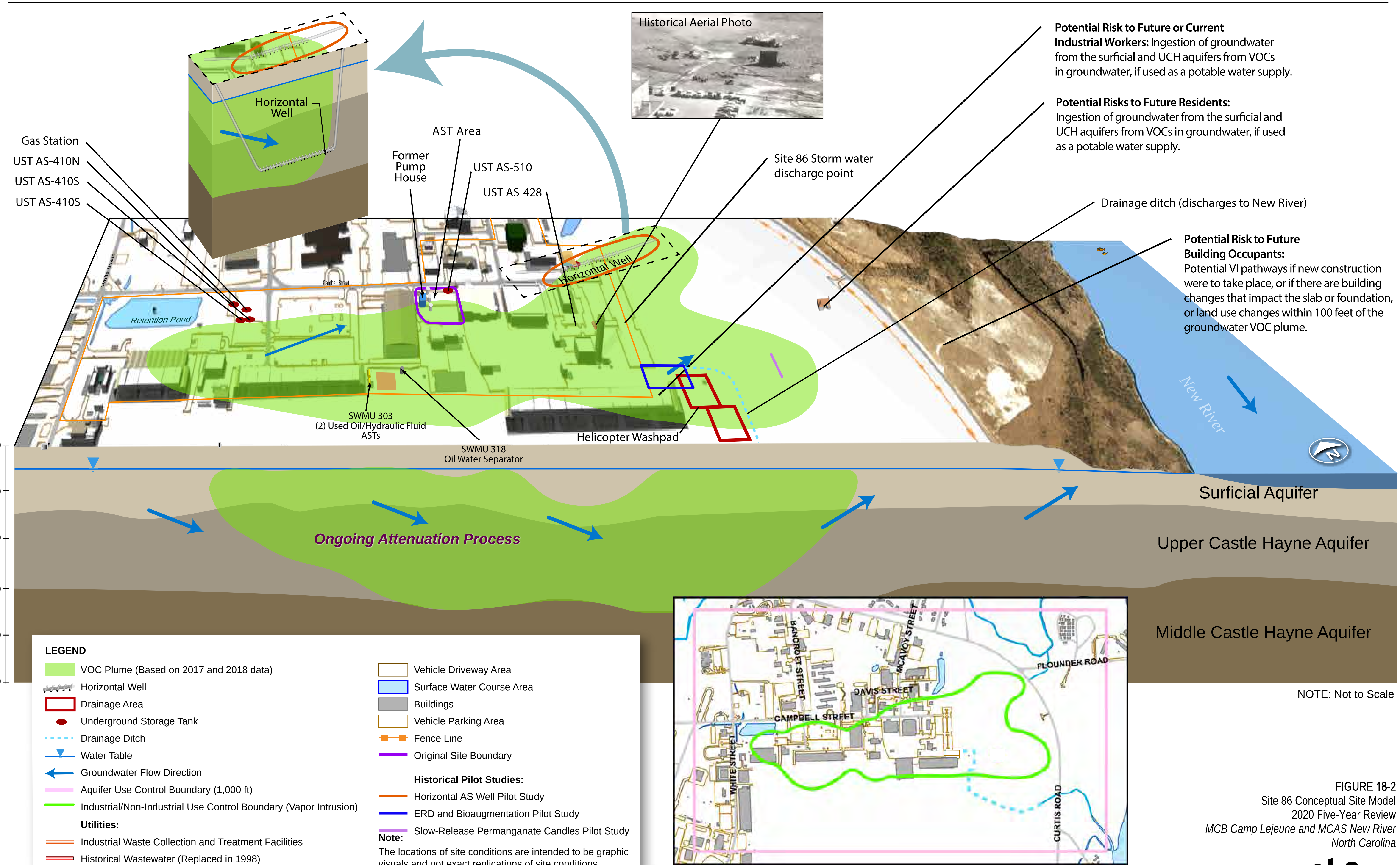


FIGURE 18-2
Site 86 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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Legend

- Surficial Aquifer Monitoring Well
- Drainage Ditch
- Surface Water Centerline
- Surface Water Body Area
- Buildings
- Road
- Vehicle Parking Area
- Northeast Grass Area

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

Benzene Extent

- 1 - 10 µg/L
- 10 - 100 µg/L

Note:
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 210 420 Feet

1 inch = 420 feet

Figure 18-3
Approximate Extent of Benzene Exceedances - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

\\brooksidefiles\GIS_SHARE\ENBG\00_Proj\N\Navy\CLEAN\MIDLANT\MCBCampLejeune\MapFiles\Five_Year_Review\692261_Report_2020\Figure_18_4_PCE_Surficial_Stacked.mxd12/10/2019AM038876

Legend

- Surficial Aquifer Monitoring Well
- Drainage Ditch
- Surface Water Centerline
- Surface Water Body Area
- Buildings
- Road
- Vehicle Parking Area
- Northeast Grass Area

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

PCE Extent

- 0.7 µg/L - 7 µg/L

Note:
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 210 420
Feet
1 inch = 420 feet

Figure 18-4
Approximate Extent of PCE Exceedances - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Legend

Surficial Aquifer Monitoring Well
Industrial NC VISL Exceedance within 100 Feet of Building
Drainage Ditch
Surface Water Body Area
Surface Water Centerline

Buildings
Road
Vehicle Parking Area
Northeast Grass Area

Land Use Control Boundaries

Aquifer Use Control Boundary
Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

TCE Extent

3 - 30 µg/L
30 - 300 µg/L

Note:
NC VISL - North Carolina Vapor Intrusion Screening Level
TCE - Trichloroethene
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 210 420 Feet

1 inch = 420 feet

Figure 18-5
Approximate Extent of TCE Exceedances - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.

Legend

- Surficial Aquifer Monitoring Well
- Drainage Ditch
- Surface Water Centerline
- Surface Water Body Area
- Buildings
- Road
- Vehicle Parking Area
- Northeast Grass Area

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

cis-1,2-DCE Extent

- 70 µg/L - 700 µg/L

Note:
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter
NS - not sampled

N

0 210 420 Feet

1 inch = 420 feet

Figure 18-6
Approximate Extent of cis-1,2-DCE Exceedances - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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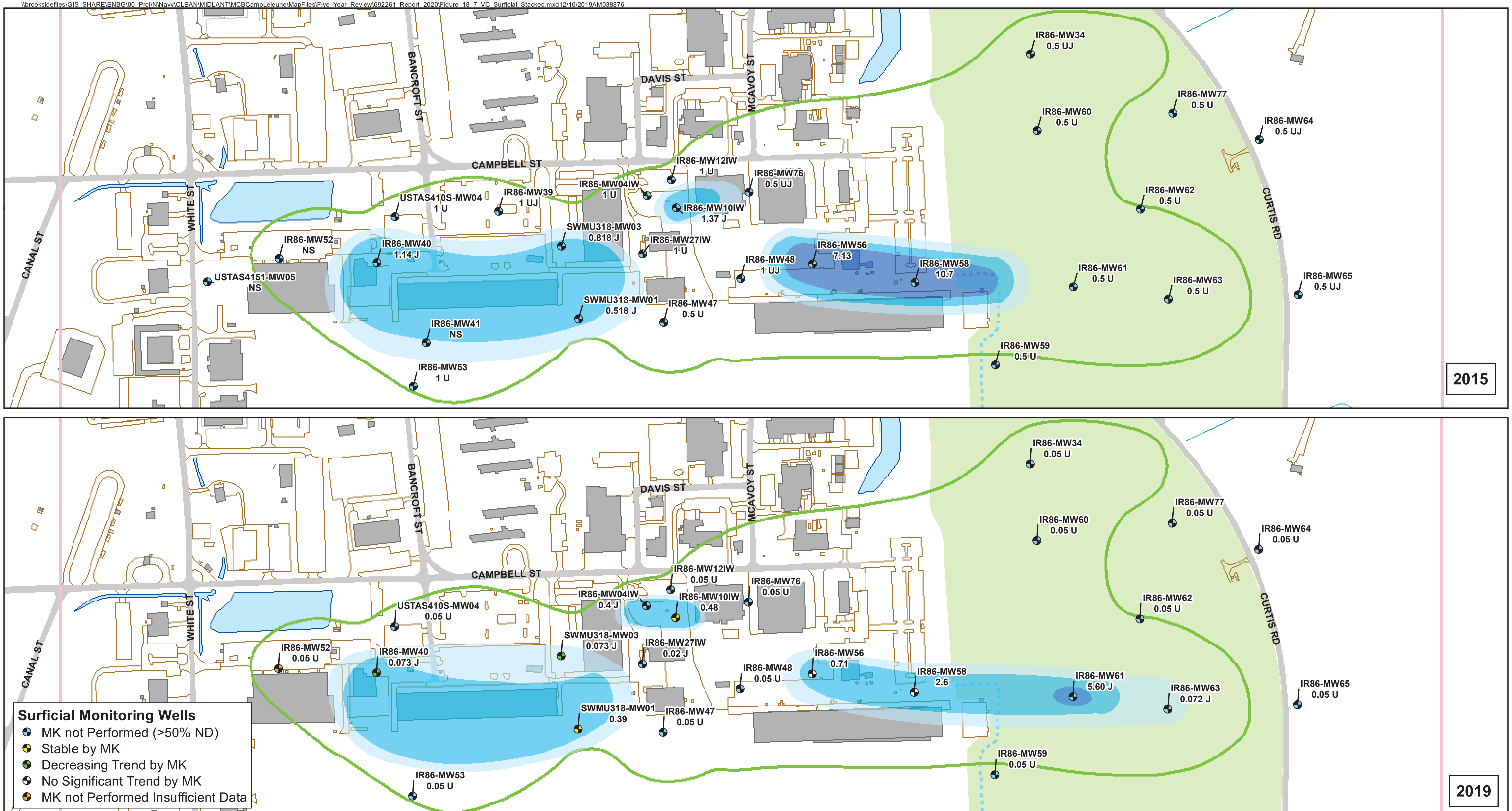

Legend

- Surficial Aquifer Monitoring Well
- Drainage Ditch
- Surface Water Centerline
- Surface Water Body Area
- Buildings
- Road
- Vehicle Parking Area
- Northeast Grass Area

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

VC Extent

- 0.03 - 0.3 µg/L
- 0.3 - 3 µg/L
- 3 - 30 µg/L
- 30 - 300 µg/L

Note:
VC - Vinyl chloride
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 210 420
Feet

1 inch = 420 feet

Figure 18-7
Approximate Extent of VC Exceedances - Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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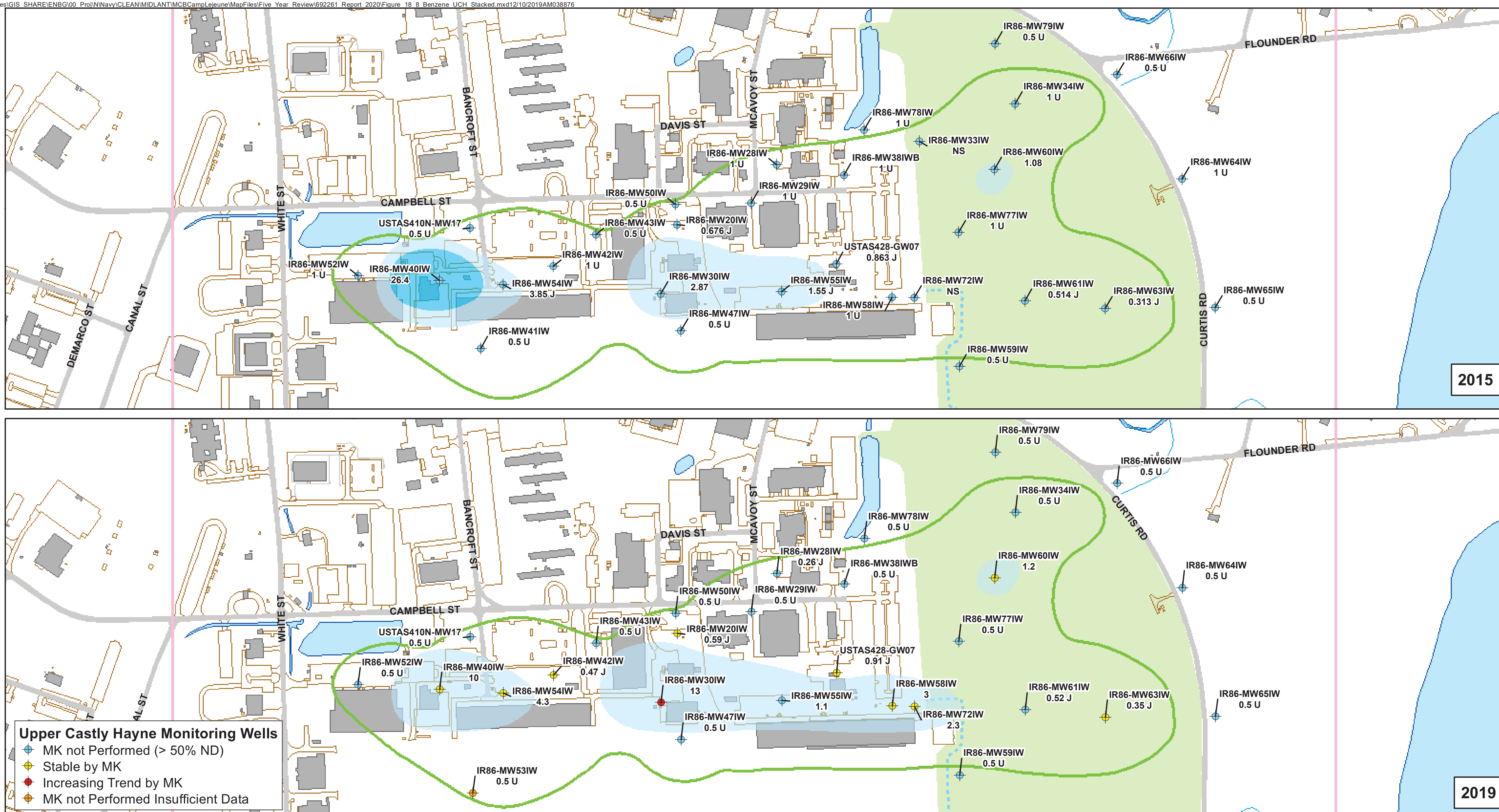

Legend

- Upper Castle Hayne Aquifer Monitoring Well
- Drainage Ditch
- Surface Water Centerline
- Surface Water Body Area
- Buildings
- Road
- Vehicle Parking Area
- Northeast Grass Area

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

Benzene Extent

- 1 - 10 µg/L
- 10 - 100 µg/L

Notes:
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 250 500 Feet

1 inch = 500 feet

Figure 18-8
Approximate Extent of Benzene Exceedances - UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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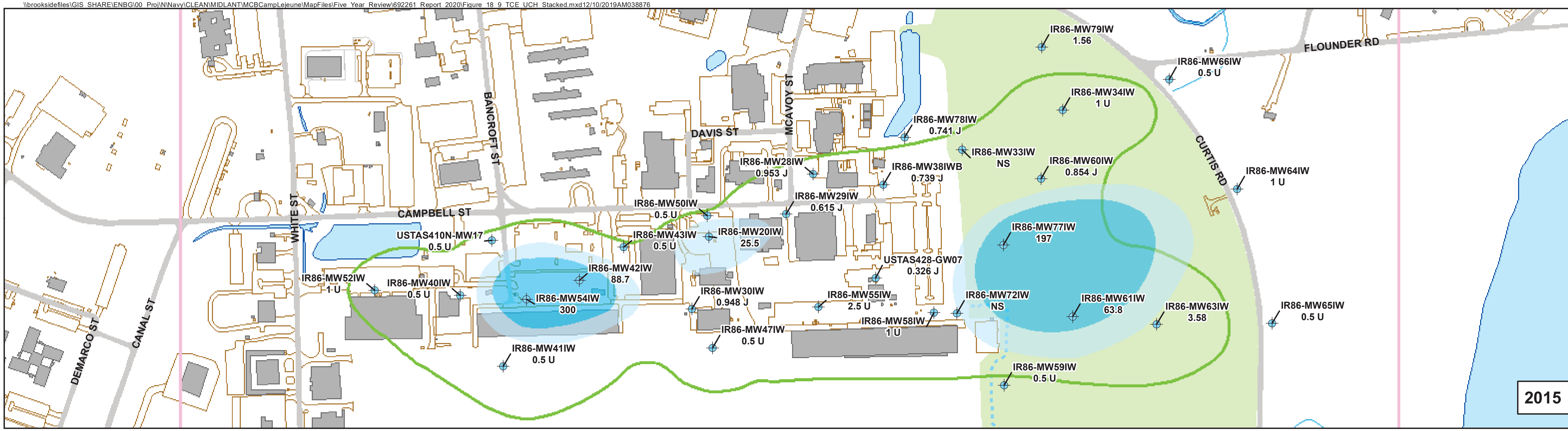

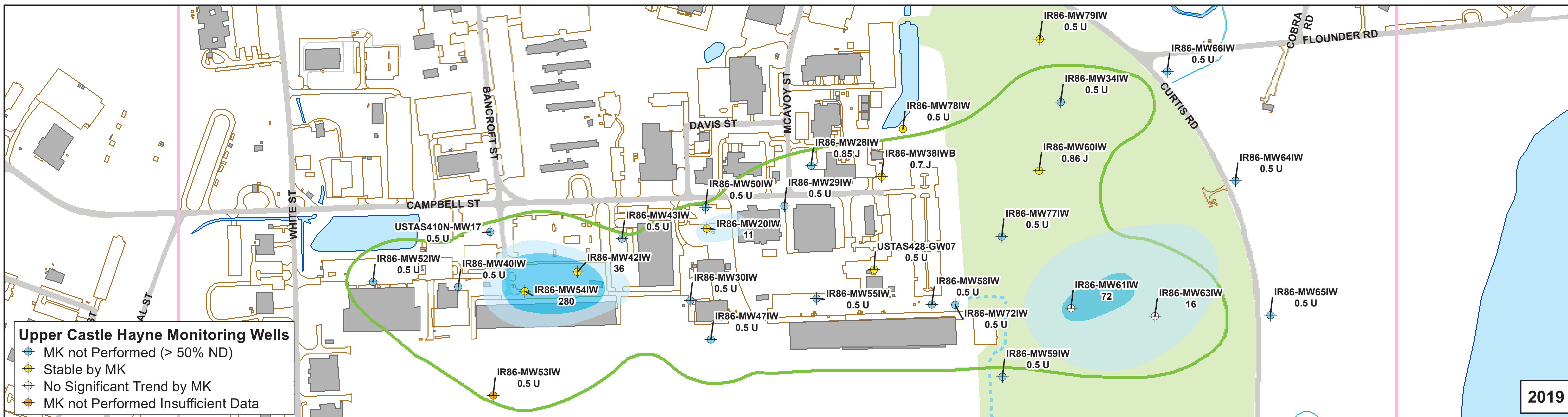

Legend

- Upper Castle Hayne Aquifer Monitoring Well
- Drainage Ditch
- Surface Water Centerline
- Surface Water Body Area
- Buildings
- Road
- Vehicle Parking Area
- Northeast Grass Area

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

TCE Extent

- 3 - 30 µg/L
- 30 - 300 µg/L

Note:
TCE - Trichloroethene
NS - not sampled
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 250 500
Feet
1 inch = 500 feet

Figure 18-9
Approximate Extent of TCE Exceedances - UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:

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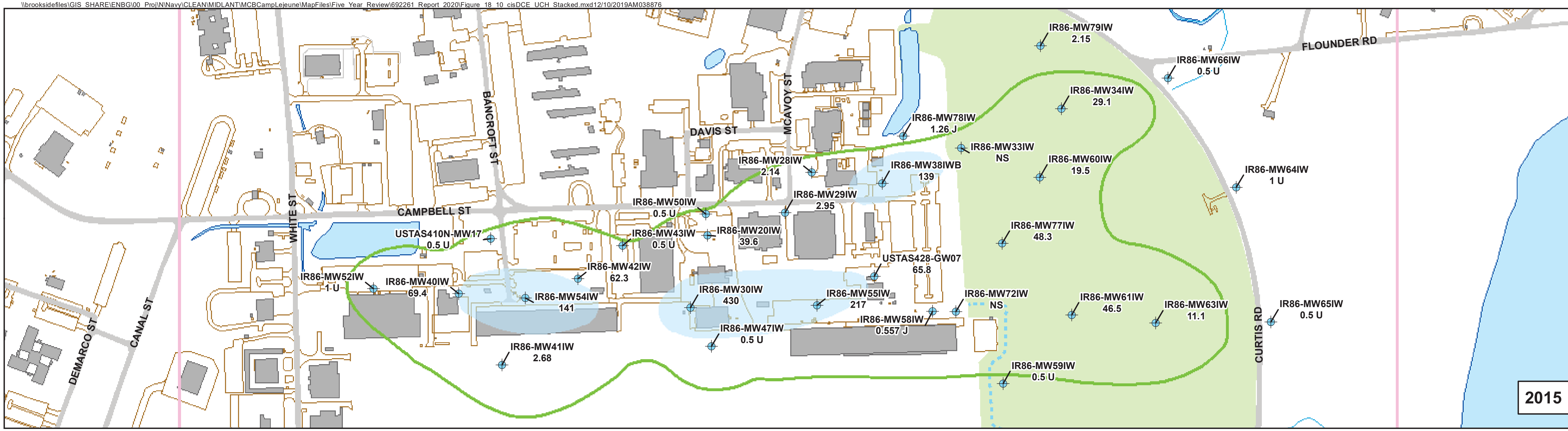

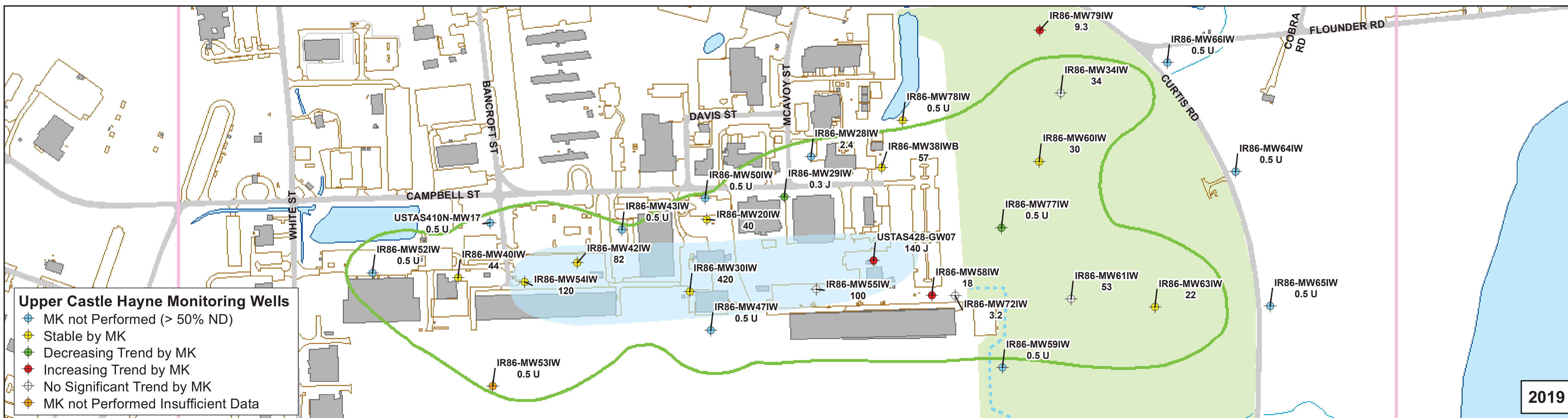

Legend

- Upper Castle Hayne Aquifer Monitoring Well
- Drainage Ditch
- Surface Water Centerline
- Surface Water Body Area
- Buildings
- Road
- Vehicle Parking Area
- Northeast Grass Area

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

cis-1,2-DCE Extent

- 70 - 700 µg/L

Note:
DCE - Dichloroethene
NS - not sampled
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 250 500 Feet

1 inch = 500 feet

Figure 18-10
Approximate Extent of cis-1,2-DCE Exceedances - UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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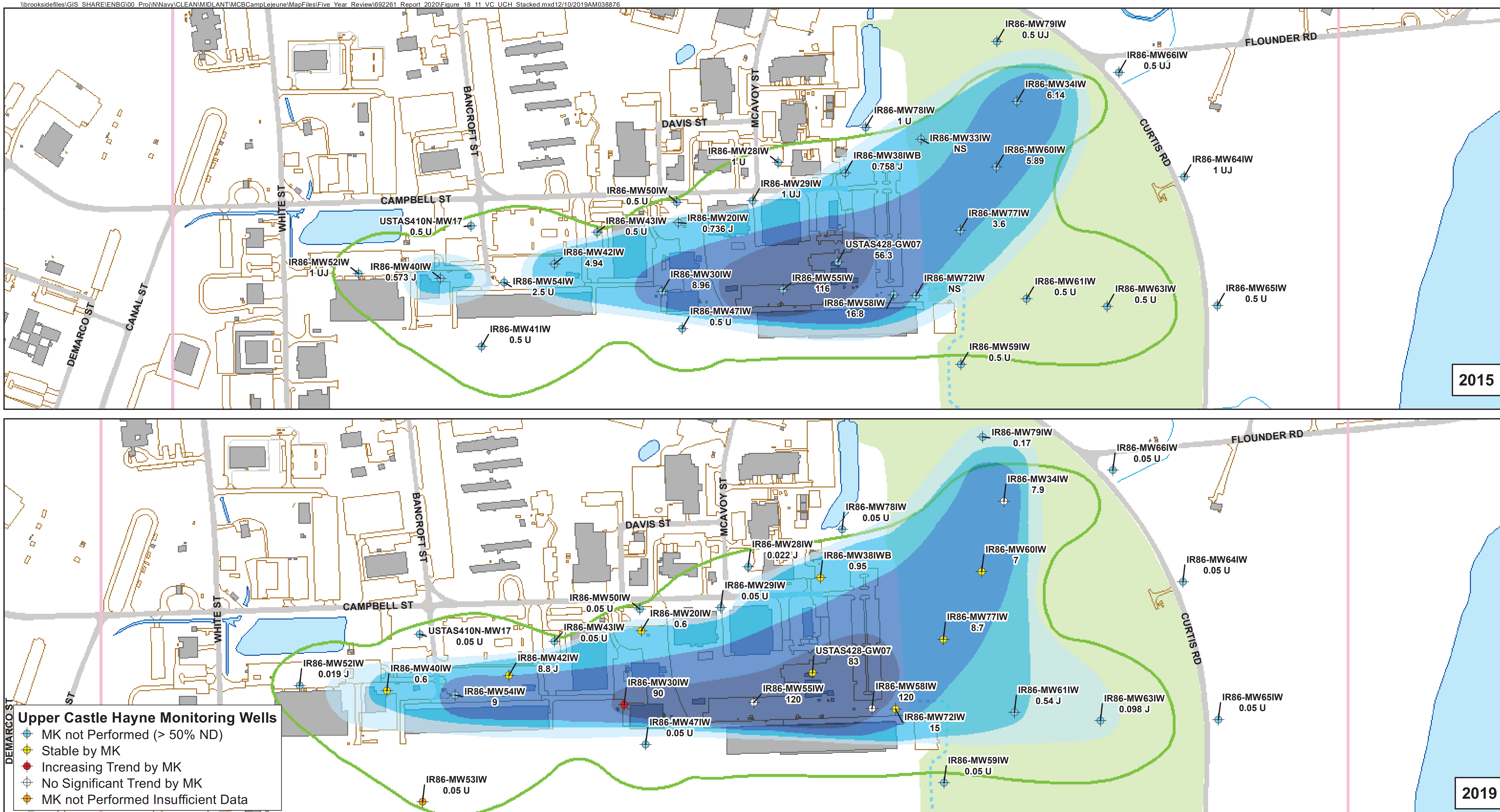

Legend

Upper Castle Hayne Aquifer
Drainage Ditch
Surface Water Centerline
Surface Water Body Area
Buildings
Road
Vehicle Parking Area
Northeast Grass Area

Land Use Control Boundaries

Aquifer Use Control Boundary
Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

VC Extent

0.03 - 0.3 µg/L
0.3 - 3 µg/L
3 - 30 µg/L
30 - 300 µg/L

Note:
VC - Vinyl chloride
NS - not sampled
U - analyte not detected above detection limit
J - concentration is estimated
µg/L - micrograms per liter

N

0 250 500 Feet

1 inch = 500 feet

Figure 18-11
Approximate Extent of VC Exceedances - UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

Operable Unit 21 (Site 73)

19.1 Site History and Background

OU 21 is within the Courthouse Bay area on the Mainside of the Base (**Figure 1-2**) and consists of Site 73.

Site 73 — the **Amphibious Vehicle Maintenance Facility** covers approximately 47 acres, located along the northwest shore of Courthouse Bay (**Figure 19-1**). The facility was constructed in 1946. Maintenance activities were historically conducted in the former Building A3 located southeast of the current Building A47. Used motor oil and battery acid resulting from maintenance activities were reportedly discharged directly to the ground surface northeast of former Building A3. Between 1983 and 1989, Building A3 was demolished and a new building was constructed. Based on the nature of maintenance activities conducted and CVOCs identified in groundwater, it is likely that other hazardous substances including chlorinated solvents, were also disposed of in this area. Ten USTs containing various petroleum hydrocarbon products (diesel fuel, gasoline, and/or waste oil) were formerly located at Site 73 to support the operations. All USTs except A47-1 have been removed (approximate location of A47-1 is within the footprint of the former maintenance building). UST A47-1 is currently not in use and is believed to be closed in-place.

OU 21 Timeline	
Year	**Event**
1983	IAS
1985	Confirmation Study
1991-1993	UST Investigations
1994	Preliminary Investigation
1997	RI
1998	Supplemental Groundwater Investigation and FS
2000-2005	LTM
2002	Natural Attenuation Evaluation Study
2003	Technology Evaluation
2003-2006	Pilot Study – Hydrogen Sparging
2008	Pilot Study – Air/Ozone Sparging
2006-2009	SRI
2009	FS, PRAP, & ROD
2009-Present	MNA
2009-2011	RIP and Interim RACR (AS, Bio-barrier, MNA, LUCs)
2012	AS Complete
2013	Bio-barrier Injections
2017	ESD
2017-2018	Pilot Study – Biostimulation and Bioaugmentation
2019	LUCIP Update, Bio-barrier Injections Basewide PFAS PA

19.2 Site Characterization

The findings from various investigations at OU 21 that are pertinent to the FYR are summarized in this section.

19.2.1 Physical Characteristics

- **Surface Features –** OU 21 is primarily paved and contains maintenance and storage buildings. Ground surface elevation ranges from approximately 5 to 10 feet above mean sea level, with a gentle slope towards Courthouse Bay. There are two small unnamed tributaries to the east and west, and retention ponds to the west, all ultimately discharging to Courthouse Bay.

- **Geology and Hydrogeology –** Subsurface conditions generally consist of Coastal Plain deposits that include sands, silts, clays, and cemented sands (Baker, 1997). A laterally discontinuous semi-confining dense silty layer overlies the Castle Hayne aquifer. Where the semi-confining layer is absent, the surficial and Castle Hayne aquifers are in direct hydraulic communication. Groundwater is a medium of concern and the affected aquifers include the surficial aquifer, which is encountered at approximately 1 to 12 feet bgs and extends to a depth of approximately 25 feet bgs and the UCH aquifer which extends to approximately 90 feet bgs. The MCH aquifer is present below the UCH aquifer and extends to approximately 150 feet bgs. In general, the groundwater flow direction within the surficial and Castle Hayne aquifers is to the south and southeast toward Courthouse Bay (**Figure 19-1**). In the surficial aquifer, the hydraulic conductivity is 1.3 ft/day, the average horizontal hydraulic gradient is 0.0094 ft/ft, and the average groundwater velocity is 0.041 ft/day. In the UCH aquifer, the average hydraulic conductivity is 3.6 ft/day, the average horizontal hydraulic gradient is 0.00026 ft/ft, and the average groundwater velocity is 0.026 ft/day. In the upgradient area of the site, the vertical gradient is downward at approximately 0.04299 ft/ft. Closer to Courthouse Bay, the vertical gradient changes to a slightly upward gradient.

19.2.2 Land Use

- **Current Land Use –** Current land use consists of the Amphibious Vehicle Maintenance Facility and supporting operations.
- **Future Land Use –** There are no anticipated changes in land use.

19.2.3 Basis for Taking Action

This section describes the site characterization and risk assessments that provide the basis for taking action at OU 21. The most comprehensive site characterization took place during the original RI (Baker, 1997). Further characterization was completed as part of the Supplemental Groundwater Investigation and FS (Baker, 1998), the Natural Attenuation Evaluation Study (CH2M, 2002), SRI (CH2M, 2009a), pilot studies (MicroPact/Baker, 2006; AGVIQ/CH2M JV, 2008) and ROD (CH2M, 2009d).

Soil, groundwater, surface water, sediment, and fish and crab tissue were investigated. The HHRAs conducted during the RI and SRI evaluated risks to current military personnel, adult and child trespassers, adult fishermen, and future adult and child residents and construction workers. Between the RI and SRI, pilot studies addressing areas of concern in groundwater were completed as described below, and remaining unacceptable risks identified during the SRI HHRA provide the basis for action for Site 73. Unacceptable risks to potential future residents were identified from ingestion of VC in groundwater and inhalation/incidental ingestion of petroleum hydrocarbon-fraction class C11-C22 in subsurface soils. Other VOCs exceeded the NCGWQS or MCL and contributed to overall site risk. The ERAs conducted during the RI and SRI evaluated terrestrial and aquatic communities and no site-related unacceptable risks were identified.

The following pilot studies were completed at Site 73 to address areas of concern and evaluate treatment technologies for full-scale implementation.

- From March 2004 through May 2005, a pilot study was conducted to address a groundwater TCE “hot spot” located near Building A47 to evaluate the effectiveness of hydrogen sparging for the remediation of dissolved-phase CVOCs. An HDD well, with a 400-foot long screen, was installed to treat groundwater at a depth of approximately 75 feet bgs (**Figure 19-2**). The goal of the pilot study was to achieve an order-of-magnitude reduction in dissolved phase TCE concentrations (MicroPact/Baker, 2006). However, groundwater results were variable with increasing, decreasing, and static concentrations in the study area. The average TCE concentration decreased approximately 35 percent over the 15-month study period, while the average total VOC concentration decreased by approximately 8 percent.
- In 2007, a pilot study was initiated to evaluate the effectiveness of air and ozone sparging for removal of TCE and associated daughter products from groundwater near the former maintenance Building A3, southeast of Building A47. The pilot test was performed using the existing HDD well. Assessment of ozone sparging proved inconclusive due to limited period of continuous ozone generation; however, TCE concentrations were reduced 75 percent in groundwater samples collected from monitoring wells with baseline concentrations exceeding 1,100 µg/L and the pilot study indicated that an HDD well is effective for distributing gas phase reagents at Site 73. Results of the groundwater sampling events indicated a combined effect of mass transfer (air stripping) with some degree of biodegradation (ERD) appears to have occurred based on decreasing TCE and increasing in cis-1,2-DCE concentrations within the study area (AGVIQ/CH2M JV, 2008).

The ROD was prepared based on site conditions after the pilot studies were completed.

Site 73 was included in a Basewide VI evaluation from 2007 to 2015 to assess the potential for site COCs to impact VI in existing buildings within 100 feet of the groundwater plume (AGVIQ/CH2M, 2009; CH2M, 2011, 2015a). Although the evaluation concluded that the VI pathway is not currently significant, based on site-specific COCs, indoor air concentrations could exceed the VISLs should VI occur in the future if new construction were to take place or if future building or land use changes within 100 feet of the groundwater VOC plume or within 30 feet of the petroleum impacted soil.

19.3 Remedial Action Objectives

The ROD for OU 21 was signed in November 2009 (CH2M, 2009d) and the ESD was signed in June 2017 (CH2M, 2017a). The current RAOs are as follows:

- Restore groundwater quality at Site 73 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Prevent human ingestion of water containing COCs (benzene, TCE, cis-1,2-DCE, 1,1-DCE, and VC) at concentrations above NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained.
- Prevent future residential exposure to petroleum hydrocarbon-contaminated soils above the NC SSL and minimize transport to groundwater.
- Minimize migration of COCs in groundwater to surface water.
- Prevent exposure to petroleum in soil[5]; and prevent VI from petroleum in soil and soil gas that could result in an unacceptable risk to human health.
- Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk.

The COCs and cleanup levels for OU 21 are presented in **Table 19-1**.

19.4 Remedial Actions

The RA for OU 21 includes the following major components:

- AS using the existing HDD well to address COCs in groundwater.
- Substrate injections to create an ERD bio-barrier to treat downgradient groundwater migrating toward Courthouse Bay.
- LTM, consisting of performance monitoring for groundwater to evaluate effectiveness of AS and the bio-barrier, and MNA outside of active treatment areas and sitewide after active treatment is complete.
- LUCs to prevent exposure to contaminants in groundwater and soil and mitigate VI.

19.4.1 Remedy Implementation

Air Sparging

The AS system includes a 1,170-foot long HDD well with a 400-foot well screen. The estimated depth of the screen is 75 feet bgs. The AS compressor was designed to deliver air at a rate of approximately 140 scfm across the well screen, promoting mass transfer and/or aerobic biological degradation of CVOCs. Construction details for the AS system can be found in the RD (CH2M, 2010) and the IRACR (Shaw, 2011).

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[5] Refers to petroleum hydrocarbon-contaminated soils.

Bio-barrier

The downgradient ERD bio-barrier was installed in 2011 and consists of 17 vertical injection wells, spaced 40 feet apart, each located between 100 and 150 feet from Courthouse Bay and screened within the partially cemented sandy horizon UCH aquifer (approximately 55 to 65 feet bgs). The initial injection event was completed in June 2011. The amendments injected into each of the injection wells consisted of 484 gallons of a 10 percent three-dimensional microemulsion (3DMe) substrate solution, 13,600 gallons of anaerobic chase water, approximately 1.2 liters of SDC-9 bioaugmentation culture at a concentration of 1×10^{10} cells per milliliter, and another 14,000 gallons of anaerobic chase water (Shaw, 2011).

Long-term Monitoring and Land Use Controls

LTM began in 2010 and is ongoing as described in the following section. LUCs were implemented at OU 21 in 2010 (CH2M, 2010) and were updated in 2019 (CH2M, 2019a). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control Boundary:** Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the area of land within 1,000 feet of groundwater within the surficial and Castle Hayne aquifers containing concentrations of VOCs exceeding cleanup levels. The southeastern boundary is defined by the Courthouse Bay coastline.
- **Non-Industrial Use Control:** Prohibit non-industrial land use, which includes restrictions on the construction of residential housing, hospitals, hotels, nursing homes, and day care facilities within the extent of the soil where petroleum hydrocarbons exceed the NC SSL. This LUC boundary superseded the intrusive activities control LUC recorded in 2010.
- **Industrial/Non-Industrial Use Control (Groundwater and Soil VI):** Before construction of new buildings or structural modifications to existing buildings, the potential for VI will be evaluated by assessing multiple lines of evidence. If the results of the evaluation indicate that VI could result in unacceptable indoor air concentrations, then engineering controls or an action to address the source will be considered to mitigate the unacceptable exposure. The groundwater VI LUC boundary encompasses the area within 100 feet of groundwater within the surficial and Castle Hayne aquifers that contains or potentially could contain concentrations of VOCs exceeding cleanup levels. The VI LUC boundary associated with soil encompasses the area within 30 feet of soil containing petroleum hydrocarbons above the NC SSL.

19.4.2 Remedy Operation and Maintenance

Remedy O&M currently consists of bio-barrier maintenance and associated performance monitoring, MNA, and LUC monitoring. The total annual cost is approximately $90,000.

Air Sparging

The AS system operated from October 2010 to March 2012. The system operated at 120 scfm, except for down times during sampling, power outages, and storm preparation. The system was shut down when cleanup levels for TCE were met within the zone of influence (100 feet of the AS well) (CH2M, 2013). After completion of AS, the air compressor and associated components were removed from the site and reused for a Treatability Study at a Resource Conservation and Recovery Act site on-Base. The HDD well remains intact. While the AS was operating, performance monitoring included quarterly sampling of three surficial, seven UCH, and two MCH aquifer monitoring wells for VOC analysis. Subslab soil gas samples were collected from four locations within Building A-47 during operation of the AS system to evaluate potential VI pathways. During operation, TCE concentrations exceeded non-residential soil gas screening levels in one location. After shut-down, all COCs were detected below screening levels during one year of quarterly post-operation monitoring, indicating that VI is not currently a complete pathway and will not likely be a complete pathway if the AS system remains shut down (CH2M, 2015c).

Bio-barrier

Bio-barrier performance monitoring includes semiannual collection of groundwater samples from nine UCH aquifer performance monitoring wells for site-specific COCs and NAIPs, including TOC, volatile fatty acids, and *Dehalocoiccoides* (DHC) to evaluate the effectiveness of the bio-barrier. When performance monitoring indicates the substrate is depleted (TOC, volatile fatty acids, and DHC are depleted compared with post-injection baseline data), and detections of COCs are reported in downgradient monitoring wells (IR73-MW69DW, IR73-MW71DW, and IR73-MW73DW), substrate reinjections will be evaluated. If concentrations in the downgradient monitoring wells exceed cleanup levels or if concentrations in upgradient monitoring wells (IR73-MW39DW and IR73-MW65DW) return to within 50 percent of its concentration at the beginning of bio-barrier implementation, then reinjections will be completed. Reinjections will continue to be necessary until COC concentrations upgradient are reduced to below the cleanup levels or until groundwater modeling indicates that COC concentrations have been reduced to levels that are protective of public health and the environment.

The first substrate and bioaugmentation reinjection event was completed in December 2013. The injections were conducted to closely replicate the first round of injection with slight modifications based on product availability. The amendments injected into each of the injection wells included 1.3 L of SDC-9 bioaugmentation culture, 73 gallons of 3DMe substrate concentrate, 660 gallons of dilute chase water, and 150 gallons of anaerobic chase. Additional chase water ranged from 0 to 27,198 gallons based on low injection rates. A total of 11 injection wells did not receive any chase water due to low flow rates during the substrate and initial chase water injections (Osage, 2014).

The FY 2017 performance monitoring results indicated that the bio-barrier substrate had depleted, and a second reinjection event was recommended. The second substrate and bioaugmentation reinjection event was initiated in August 2019 as a treatability study to evaluate the effectiveness of redeveloping injection wells and recirculating groundwater to replenish the bio-barrier with EVO, ERD, and decrease downgradient COC concentrations (CH2M, 2019b). The study targeted the five southwest-most injection wells where VC concentrations were highest. Well development and injections were completed in August 2019 and performance monitoring is ongoing.

Monitored Natural Attenuation

MNA at Site 73 initially consisted of collecting groundwater samples from 7 surficial, 14 UCH, and 3 MCH aquifer monitoring wells for COCs. After the AS system was turned off, the MNA network was expanded to include the former AS performance monitoring wells which included 10 surficial, 23 UCH, and 4 MCH aquifer monitoring wells. Monitoring of the MCH aquifer was discontinued after FY 2015 because COCs were not detected above laboratory detection limits (CH2M, 2017b). The LTM program currently includes annual sampling for COCs at 7 surficial and 23 UCH aquifer wells and sampling for NAIPs (MEE, alkalinity, chloride, iron, sulfate, sulfide, and TOC) every 5 years to evaluate subsurface conditions for biodegradation and reductive dechlorination of COCs. Sampling locations are shown on **Figure 19-1**.

In addition to comparison with cleanup levels (**Table 19-1**), all surficial aquifer data are screened against the non-residential NC VISLs, consistent with overall site use, to evaluate whether concentrations indicate potential for a complete VI pathway. Select surficial aquifer monitoring well data is compared to 10 times the NCSWQS to determine the potential for groundwater to affect surface water. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of the MNA component of the remedy.

Light non-aqueous phase liquid (LNAPL) is periodically measured in IR73-MW14 with no discernable trend; however, historical groundwater samples collected when LNAPL was not measured have not been shown to contain elevated concentrations of VOCs or SVOCs, suggesting that the LNAPL does not appear to contain appreciable concentrations of VOCs. Free product monitoring and recovery (using an oil-absorbent sock) is being conducted monthly and will continue to be conducted until no LNAPL is observed.

A pilot study was recommended in the FY 2015-2016 report to address residual VC in the AS area and was initiated in 2017 (**Section 19.4.3**).

Land Use Controls

LUCs are shown on **Figure 19-1** and summarized in **Table 19-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In September 2018, a post-hurricane inspection was completed and no damage to the site was observed but evidence of a storm surge was apparent as debris was observed at the high water mark on the ground surface. During the FYR site inspection conducted in March 2019, the protective casing on monitoring wells in the IR73-MW52 cluster were damaged and not all injection wells were bolted; the bolts were replaced and tightened during the inspection (**Appendix B**). No issues affecting protectiveness were observed; however, outer casings of some monitoring wells were in disrepair and labels were either missing or difficult to read.

Table 19-2. OU 21 Land Use Control Summary

LUC Boundary	Area (Acres)	Most Current LUCIP Date	Onslow County Registration Date
Aquifer Use Control (1,000 feet)	47.06	May 2019	August 16, 2010
Non-Industrial Use Control Boundary (Soil)	0.81		April 16, 2019
Industrial/Non-Industrial Control Boundary (Groundwater VI)	15.83		
Industrial/Non-Industrial Control Boundary (Soil VI)	0.81		

19.4.3 Post-ROD Removal Actions and Pilot Studies

Biostimulation and Bioaugmentation Pilot Study

A pilot study was initiated in October 2017 to evaluate biostimulation and bioaugmentation to enhance degradation of VC in the UCH aquifer (CH2M, 2017c). The pilot study was conducted in the area where highest VC concentrations have consistently been reported. Groundwater samples were collected from IR73-MW27DW, IR73-MW44DW, IR73-MW49IW, IR73-MW49DW, and IR73-MW63DW (**Figure 19-3**) to monitor the radius of influence, effectiveness of injections, and downgradient changes during the pilot study. Groundwater samples were analyzed for COCs, NAIPs, and microbials and functional genes.

To initially evaluate the effectiveness of potential substrates, three in situ microcosms (Bio-Traps) were installed in IR73-MW27DW in October 2017. One unit contained no amendment as a control; one unit contained 3DME, to serve as the biostimulation unit; and one unit contained the microbial culture SDC-9 to serve as the bioaugmentation unit. The Bio-Traps were collected in December 2017 for analysis of COCs, NAIPs, and microbials and functional genes. Concentrations in the control unit were similar to baseline and concentrations in the biostimulation ,and bioaugmentation units showed an 89 and 92 percent reduction from baseline, respectively. Based on these results, bioaugmentation was selected as the preferred approach for the pilot study.

Six injection wells were installed in November 2018 to target the elevated concentrations of VC at wells IR73-MW27DW and IR73-MW49IW (**Figure 19-3**). Approximately, 4 gallons of bioaugmentation culture (SDC-9), 225 gallons of anaerobic water, and 1 gallon of Newman Zone oxygen scavenger (to create anaerobic conditions) were introduced to the subsurface via the new injection wells in February 2019. Three quarters of post-injection groundwater monitoring were performed in June, September, and November 2019 to assess the effectiveness of the bioaugmentation. Results are being evaluated and will be included in the FY 2020 LTM report.

19.4.4 Progress since the 2015 Five-Year Review

Issues identified during the 2015 FYR and follow-up actions are summarized in **Table 19-3**. LTM, bio-barrier maintenance, and LUC enforcement is ongoing. The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 19-2.** The OU 21 RA components and expected outcomes are summarized in **Table 19-4**.

Table 19-3. 2015 FYR OU 21 Recommendations/Follow-up Actions

Issues	Recommendations (Milestone)	Current Status
Potential for VI pathway	Prepare a Master ESD to update RAOs to include VI and add an Industrial/Non-Industrial Use Control Boundary (VI) (June 30, 2016)	Completed June 30, 2016. The Draft ESD was submitted June 30, 2016, finalized March 30, 2017, and signed on June 1, 2017 to update the RAOs for OU 21 to include VI and add an industrial/non-industrial use control boundary for VI from VOCs in soil and groundwater (CH2M, 2017a). The LUCIP was finalized in May 2019 (CH2M, 2019a).

19.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. Shutdown criteria for AS were met in 2012, MNA results indicate that natural attenuation is occurring, and the bio-barrier is being replenished and is protective of Courthouse Bay, as discussed in the following sections. LUCs are in place to prevent exposure to groundwater COCs at concentrations above cleanup levels and evaluate the VI pathway.

Monitored Natural Attenuation

Based on data reported in the FY 2018 report and NAIP data collected in support of the FYR report, MNA is effective. The following is a summary from the FY 2018 report (CH2M, 2019a).

In the surficial aquifer, VC was the only COC that exceeded cleanup levels in 2018 (**Figure 19-4**). Concentrations appear to be decreasing at two locations (IR73-MW13 and IR73-MW27) and continue to fluctuate at IR73-MW29 and IR73-A47/3-8 (CH2M, 2019c). Concentrations are higher than at the time of the ROD but lower than 2012 levels, indicating that reductive dechlorination has occurred and is continuing.

In the UCH aquifer, TCE, cis-1,2-DCE, VC, and benzene exceeded their respective cleanup levels. TCE concentrations are within the same order of magnitude as the cleanup level and are isolated to two locations within the former AS area; TCE concentrations are lower than at the time of the ROD (**Figure 19-5**). Cis-1,2-DCE exceeded the cleanup level in one location, downgradient of the former AS system and upgradient from the bio-barrier; concentrations were generally stable to decreasing at this location (**Figure 19-6**). VC was the most widespread in the UCH aquifer with the highest concentrations upgradient and downgradient from the AS system; concentrations appear to be stable to increasing (**Figure 19-7**). A pilot study is ongoing to address VC in the UCH aquifer (CH2M, 2017c). Benzene was widespread throughout the site at concentrations within the same order of magnitude as the cleanup level and appear to be stable to decreasing (**Figure 19-8**).

None of the COCs exceed 10 times the NCSWQS in the farthest downgradient surficial aquifer groundwater samples.

A summary of NAIP data collected in February 2019 is provided in **Table 19-5**. Conditions in the surficial and UCH aquifer are generally favorable for reductive dechlorination. Favorable indicators for reductive dechlorination include DO (generally below 1 milligram per liter), ORP (negative), nitrate (not detected), ferrous iron (measurable levels), and sulfate in the surficial aquifer (low concentrations), and methane (detectable to moderate concentrations). TOC in both aquifer zones was low, which may be unfavorable for microbial growth.

Bio-barrier

Re-injection trigger criteria for the bio-barrier were met both in March 2017 and February 2018 at IR73-MW65DW based on increases in VC to within 50 percent of its concentration at the beginning of the bio-barrier implementation. As groundwater flows through the bio-barrier, VC and benzene are the only remaining COCs above cleanup levels downgradient but remain below 10 times the NCSWQS. A bio-barrier treatability study is underway to evaluate the effectiveness of injection well redevelopment, use of a recirculation system to deliver the substrate to the subsurface, and radius of influence enhancement.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. Although exposure assumptions and RAOs are still applicable since the ROD and ESD, toxicity data and the standards on which cleanup levels are based have changed slightly. These changes would not adversely affect the protectiveness of the selected remedy because LUCs remain in place that restrict unauthorized activities that could result in exposure to groundwater.

Cleanup Levels: The ROD (CH2M, 2009d) identified the cleanup levels for groundwater as the more conservative of the NCGWQS or MCL and NCDEQ soil-to-groundwater protection concentration for petroleum hydrocarbon-fraction class C11-C22 in subsurface soil, which have changed slightly (**Table 19-1**). In groundwater, the updated standard is higher than the ROD cleanup level. The most current values are used for comparison in LTM reports. The soil cleanup level has decreased; however, LUCs are in place to prevent potential exposure and changes in cleanup levels do not affect protectiveness.

Toxicity and Other Contaminant Characteristics: Although there have been some changes to toxicity criteria for COCs since the ROD, there have been no changes since the 2015 FYR which concluded that the remedy at OU 21 is protective of human health and the environment (**Table 2-1**).

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 21 remedy with respect to extreme weather events, primarily hurricanes, was completed. The effects of extreme weather events are most likely limited to damage to monitoring wells from fallen trees or through debris migration during flooding events. However, protectiveness would not be affected because the only risks at OU 21 are from potable use of groundwater, non-industrial use, and VI. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

19.6 Issues, Recommendations, and Follow-up Actions

No issues affecting protectiveness have been identified for OU 21 during this review.

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Monitoring wells that are currently not in use for LTM or other onsite monitoring are not routinely inspected or repaired. If there are plans to use these wells, routine inspection or repairs should be conducted. If there are no future plans for use and appropriate lines of evidence are presented (trends, redundancy, or condition), then these wells will be proposed for abandonment.
- Although Site 73 was not identified as a potential PFAS release area based on site use, a high mobility multi-purpose wheeled vehicle fire occurred near Building A66 on October 15, 2015, within the aquifer use control boundary. It was identified as a potential PFAS release area because AFFF was used to extinguish the fire. Therefore, further evaluation is recommended (CH2M, 2019b).There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release areas identified; therefore, there is no current exposure pathway (CH2M, 2019b). This area will be included in a Basewide SI to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

19.7 Statement of Protectiveness

The remedy at OU 21 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use, non-industrial use, and evaluate and/or mitigate potential VI pathways. MNA for groundwater COCs and maintenance of the bio-barrier are ongoing until cleanup levels are achieved.

19.8 References

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Table 19-1. Cleanup Levels for OU 21 (Site 73)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2009)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	1,1-Dichloroethene	7	7	NCGWQS/MCL
	Benzene	1	1	NCGWQS
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	Trichloroethene	2.8	3	NCGWQS
	Vinyl chloride	0.015	0.03	NCGWQS
Soil (mg/kg)	Petroleum Aromatic Carbon Fraction Class C9-C22	33.6	31	UST Program Soil to Groundwater Maximum Soil Contaminant Concentration (April 2012)

[a] Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.

Notes:

Cleanup Level Reference Dates:

MCL (March 2018)

NCGWQS (February 2016)

µg/L = microgram(s) per liter

COC = constituent of concern

MCL = Maximum Contaminant Level

mg/kg = milligram per kilogram

NCGWQS = North Carolina Groundwater Quality Standard

ROD = Record of Decision

UST = underground storage tank

VOC = volatile organic compound

Table 19-4. OU 21 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
73	Soil	Potential unacceptable risks to future adult and child residents from exposure to petroleum hydrocarbons in soil and indoor air through the VI pathway.	Industrial/ Maintenance	Prevent future residential exposure to petroleum hydrocarbon-contaminated soils above the NC SSL and minimize transport to groundwater.	LUCs	Maintain intrusive activities controls and monitor quarterly.	Industrial Land Use
				Prevent exposure to petroleum in soil; and prevent VI from petroleum in soil and soil gas that could result in an unacceptable risk to human health.		Maintain industrial/non-industrial use controls for VI and monitor quarterly.	
	Groundwater	Potential unacceptable risk to future residents from exposure to VOCs in groundwater.		Restore groundwater quality at Site 73 to the NCGWQS and MCL standards based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A North Carolina Administrative Code 02L.0201.	Air Sparging	AS until average COC concentrations in monitoring wells within 100 feet of the sparge well are less than cleanup levels, groundwater modeling indicates contaminant levels have been reduced to levels protective of Courthouse Bay or system has operated for 5 years. The AS system was shut down in March 2012 when TCE cleanup levels were met.	UU/UE
					MNA	Implement groundwater MNA to monitor VOC concentrations and migration until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	
				Minimize migration of COCs in groundwater to surface water.	Bio-barrier	Inject ERD substrate to create a bio-barrier upgradient to the New River. The bio-barrier will be maintained until VOCs are below cleanup levels or modeling indicates concentrations are protective of the New River. If COCs are detected in downgradient monitoring wells, reinjection will be evaluated. If COCs are detected above cleanup levels in downgradient monitoring wells or return to within 50 percent of concentrations at the initiation of the biobarrier in upgradient monitoring wells, reinjection will be completed. Maintenance of the bio-barrier is ongoing.	
				Prevent human ingestion of water containing COCs (benzene, TCE, cis-1,2-DCE, 1,1-DCE, and VC) at concentrations above NCGWQS or MCL standards, whichever is more stringent, until the remediation goals have been obtained.	LUCs	Maintain aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	
		Potential unacceptable risks to future Base personnel and residents from exposure to VOCs in indoor air from the VI pathway.		Prevent exposure to VOCs in groundwater; and prevent VI from VOCs in groundwater and soil gas that could result in an unacceptable risk.	LUCs	Maintain industrial/non-industrial use controls for VI and conduct quarterly monitoring until groundwater cleanup levels are achieved.	

Notes:
AS = air sparging
COC = constituent of concern
ERD = enhanced reductive dechlorination
DCE = dichloroethene
LUC = land use control
MCL = maximum contaminant level
MNA = monitored natural attenuation
NCGWQS = North Carolina Groundwater Quality Standard
NC SSL = North Carolina Soil Screening Level
RAO = remedial action objective
TCE = trichloroethene
UU/UE = unlimited use/unrestricted exposure
VC = vinyl chloride
VI = vapor intrusion
VOC = volatile organic compound

Table 19-5. Natural Attenuation Indicator Parameters Summary - Site 73
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			UCH Aquifer - Bio-Barrier		
	Description	**Favorable Condition[a]**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**
DO (mg/L)	DO is the most thermodynamically favorable electron acceptor used by microbes. High levels of DO are indicative of aerobic conditions, and low levels of DO are indicative of anaerobic conditions. As reductive dechlorination takes place under anaerobic conditions, low levels of DO are generally favorable for reductive dechlorination.	< 1	0 to 4.8	5 / 6	Yes, unfavorable result isolated	0 to 0.4	16 / 16	Yes	0 to 0	6 / 6	Yes
ORP (mV)	ORP measures the degree to which aquifer conditions are reducing or oxidizing. As reductive dechlorination takes place under reducing conditions, lower ORPs are generally favorable for reductive dechlorination.	< 0	-142 to 97	4 / 6	Yes, unfavorable results isolated	-144 to -36	16 / 16	Yes	-167 to -74	6 / 6	Yes
Nitrate (mg/L)	After DO is depleted, nitrate may be used as an electron acceptor (i.e., denitrification). As nitrate may compete with the reductive dechlorination pathway, depleted nitrate concentrations are generally favorable for reductive dechlorination. Depleted nitrate concentrations alone do not conclusively indicate favorable conditions for reductive dechlorination.	< 1	0	0 / 5[b]	Yes	0	15 / 15[b]	Yes	0	6 / 6	Yes
Nitrite (mg/L)	During denitrification, nitrate is converted into nitrite. Therefore, the presence of nitrite indicates the geochemical footprint of denitrification. If nitrate is absent from a monitoring location, denitrifying conditions may exist if nitrite is not observed. Denitrifying conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	Detectable Concentrations	0 to 4	1 / 6	Favorable result in one well	0	0 / 16	Neutral	0	0 / 6	Neutral
Ferrous Iron (mg/L)	The presence of ferrous iron indicates the geochemical footprint of iron-reduction, which takes place under more reducing conditions than denitrification. Iron reducing conditions alone do not conclusively indicate favorable conditions for reductive dechlorination.	> 1	0 to 7	5 / 6	Yes, unfavorable result isolated	0.5 to 7	16 / 16	Yes	2 to 4.25	6 / 6	Yes
Sulfate (mg/L)	Sulfate may be used as an electron acceptor under more reducing conditions than iron-reducing conditions. As higher concentrations of sulfate may compete with the reductive dechlorination pathway, low levels of sulfate are favorable for reductive dechlorination. Depleted sulfate concentrations are also an indicator that sulfate reduction is proceeding, which generally indicates that conditions are favorable for reductive dechlorination.	< 20	5.6 to 1200	3 / 6	Favorable resultsin half the wells	0.5 U to 2100	3 / 16	No, favorableresults isolated	0.5 U to 170	4 / 6	Yes, unfavorableresults isolated
Sulfide (mg/L)	During sulfate reduction, sulfate is converted into sulfide. Therefore, the presence of sulfide indicates the geochemical footprint for sulfate reduction. When detected, sulfide indicates that sulfate reduction is taking place and that conditions are generally favorable for reductive dechlorination. However, the absence of sulfide does not conclusively indicate that conditions are unfavorable for reductive dechlorination, as sulfide is highly reactive and readily forms precipitates with ferrous iron.	Detectable Concentrations	0.8 U to 2.7	4 / 6	Yes, unfavorable results isolated	0.8 U to 0.98	2 / 16	Favorable result in two wells	0.8 U to 1.5	1 / 6	Favorable result in one well
Methane (mg/L)	The presence of methane in groundwater is indicative of the strongly reducing conditions required to support reductive dechlorination. Therefore, the presence of moderate concentrations of methane is a favorable indicator for reductive dechlorination.	> 0.5	0.45 to 3.6	6 / 6	Yes	0.014 to 31	13 / 16	Yes, unfavorable results isolated	1.2 to 30	6 / 6	Yes
TOC (mg/L)	TOC is an indicator of the total amount of organic matter available to microbial communities to use as source of carbon and energy. Elevated TOC concentrations are a positive indicator of natural attenuation potential.	< 20	5.1 to 37	2 / 6	Yes, unfavorable results isolated	1.4 to 14	0 / 16	No	1.9 to 4.1	0 / 6	No
Ethane (mg/L)	Ethane is a nonhazardous end product of reductive dechlorination. As the presence of ethane indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethane are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 6	No	0.005 U to 0.01	2 / 16	No, favorable results isolated	0.005 U to 0.09	5 / 6	Yes, unfavorable result isolated

Table 19-5. Natural Attenuation Indicator Parameters Summary - Site 73
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Analyte	Project Indicator Level		Surficial Aquifer			UCH Aquifer			UCH Aquifer - Bio-Barrier		
	Description	**Favorable Condition[a]**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**	**Range of Results**	**Frequency of Favorable Results**	**Conclusion**
Ethene (mg/L)	Ethene is a nonhazardous end product of reductive dechlorination. As the presence of ethene indicates the complete dechlorination of chlorinated VOCs, detectable concentrations of ethene are a favorable indicator for reductive dechlorination.	Detectable Concentrations	0.005 U to 0.005 U	0 / 6	No	0.005 U to 0.045	7 / 16	Favorable result in approximately half the wells	0.005 U to 0.016	1 / 6	Yes
Chloride (mg/L)	Chloride is a daughter product of reductive dechlorination. If elevated concentrations of chlorinated VOCs are present (e.g., greater than 1 mg/L), chloride concentrations may increase as biodegradation occurs. Appreciable changes in chloride concentrations are not expected for natural attenuation sites with lower concentrations of chlorinated VOCs.	Greater than Background	7.2 to 38	--	Neutral	12 to 170	--	Neutral	33 to 75	--	Neutral
pH (SU)	The pH of groundwater affects the presence and activity of microbial populations in groundwater. The optimal pH range for dechlorinating bacteria generally falls between pH 6 and 8 SU (Yang, 2017).	6 - 8	5.06 to 7.47	5 / 6	Yes, unfavorable result isolated	6.26 to 7.7	16 / 16	Yes	6.64 to 7.54	6 / 6	Yes
Alkalinity (mg/L)	Alkalinity measures the capacity of groundwater to resist changes in pH. As biodegradation processes increase aquifer acidity, higher concentrations of alkalinity indicate that pH values are more likely to remain stable.	> 50	22 to 270	5 / 6	Yes, unfavorable result isolated	160 to 560	16 / 16	Yes	220 to 330	6 / 6	Yes

[a]- If readings are near the Project Indicator Level, engineering judgment may be used to determine favorability.

[b] Nitrate not measured for IR73-MW16 or IR73-MW49IW

Notes:

-- = Count not performed; see Project Indicator Level description for rationale.

DO = dissolved oxygen

J = Analyte present, value may or may not be accurate or precise

MCH = Middle Castle Hayne

mg/L = milligram(s) per liter

mV = millivolt(s)

ORP = oxidation-reduction potential

SU = standard unit

TOC = total organic carbon

U = The material was analyzed for, but not detected

UCH = Upper Castle Hayne

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Legend

Monitoring Wells

- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Middle Castle Hayne Aquifer
- Surficial Aquifer - not in LTM
- Upper Castle Hayne Aquifer - not in LTM
- Middle Castle Hayne Aquifer - not in LTM
- Underground Storage Tank - not in LTM
- ERD Injection Well

- Location of Former Maintenance Building
- Horizontal Well and Screened Interval
- Surface Water Centerline

Land Use Control Boundary

- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil

N

0 175 350 Feet

1 inch = 350 feet

Figure 19-1
OU 21 (Site 73)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

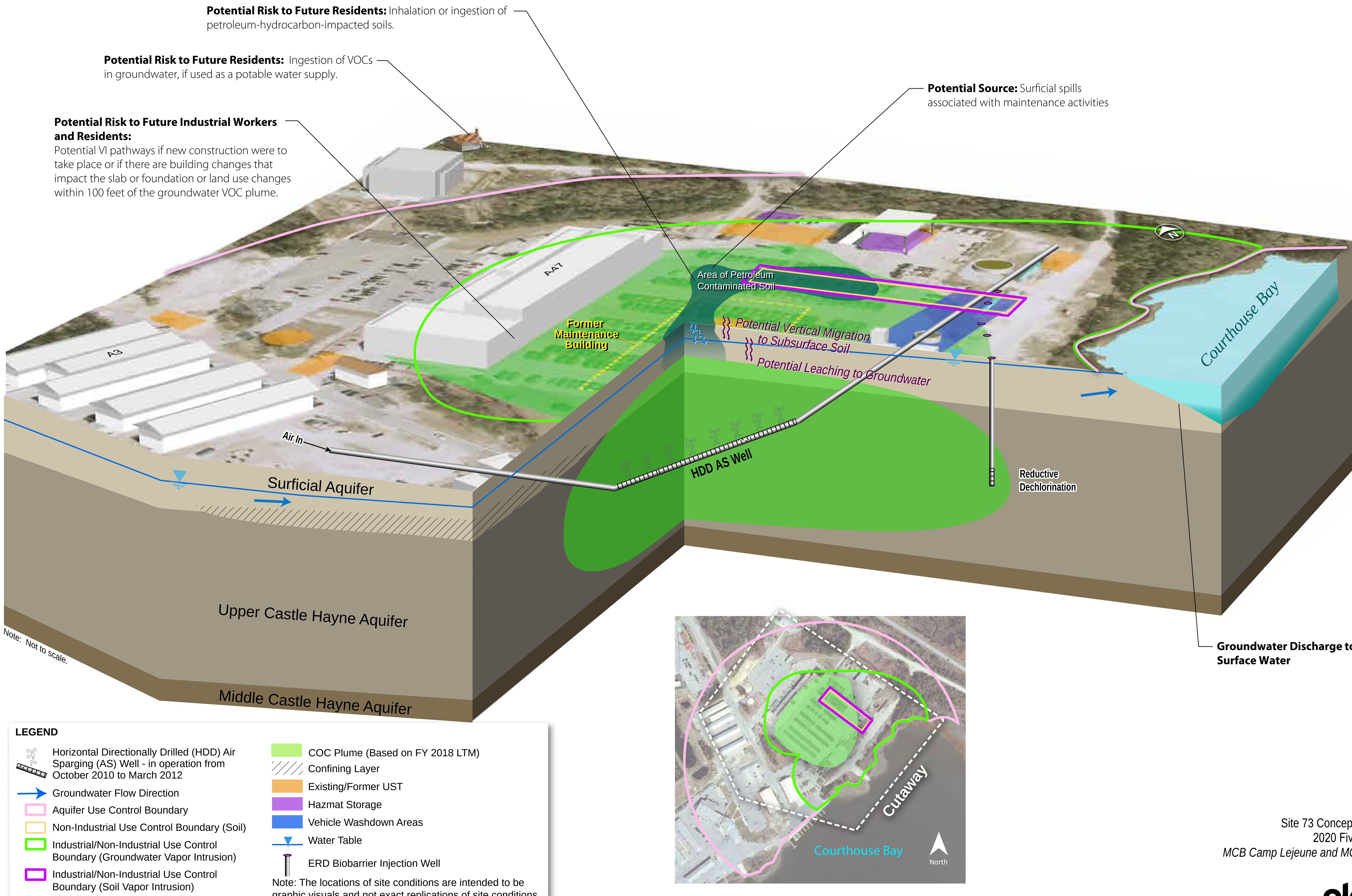

FIGURE 19-2
Site 73 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

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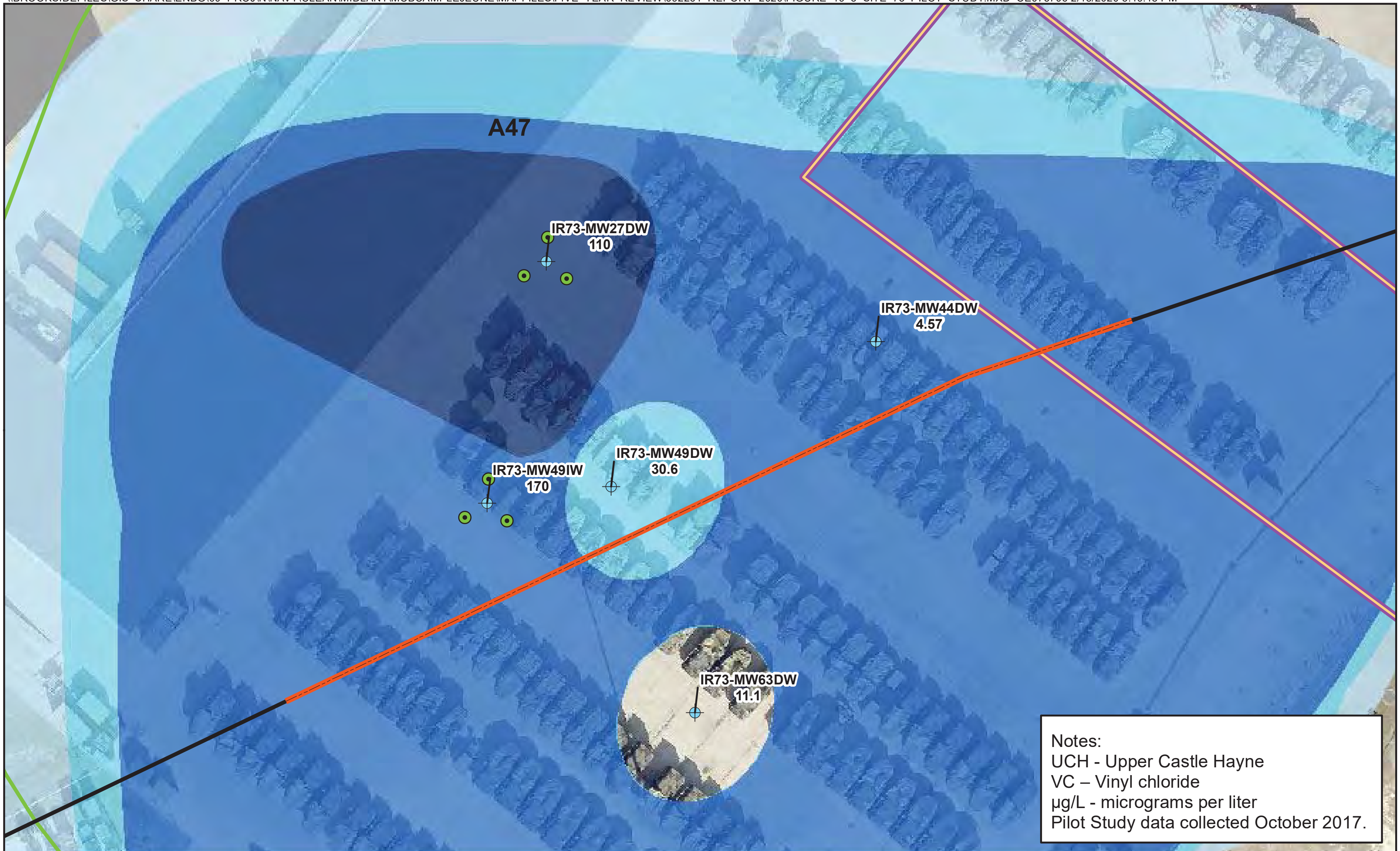

Notes:
UCH - Upper Castle Hayne
VC – Vinyl chloride
µg/L - micrograms per liter
Pilot Study data collected October 2017.

Legend
- UCH Aquifer Monitoring Well
- Injection Well Location
- Horizontal Well and Screened Interval
- Building

VC Extent in UCH Aquifer
- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L

Land Use Control Boundary
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil

N

0 32.5 65 Feet
1 inch = 65 feet

Figure 19-3
Pilot Study Layout
2020 Five-Year Review
MCB Camp Lejeune
North Carolina

ch2m.

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Legend

- Surficial Aquifer Monitoring Well
- ERD Injection Well
- Horizontal Well and Screened Interval
- Surface Water Centerline
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil

VC Extent

- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L

N

0 225 450 Feet

1 inch = 450 feet

Figure 19-4
Approximate Extent of VC Exceedances in the Surficial Aquifer
2020 Five-Year Review
MCB Camp Lejeune
North Carolina

ch2m

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\N\NAVY\CLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\FIVE_YEAR_REVIEW\692261_REPORT_2020\FIGURE_19_5_TCE_UCH.MXD CE075706 2/18/2020 3:51:19 PM

Legend

- Upper Castle Hayne Aquifer Monitoring Well
- ERD Injection Well
- Horizontal Well and Screened Interval
- Surface Water Centerline
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil

TCE Extent

- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L
- >300 µg/L

N

0 225 450 Feet

1 inch = 450 feet

Figure 19-5
Approximate Extent of TCE Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune
North Carolina

ch2m

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\N\NAVY\CLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\FIVE_YEAR_REVIEW\692261_REPORT_2020\FIGURE_19_6_DCE_UCH.MXD CE075706 2/18/2020 3:52:18 PM

Notes:
DCE - Dichloroethene
µg/L - micrograms per liter
D - analyzed at a secondary dilution factor
J - concentration is estimated
U - analyte not detected above detection limit
NA - Not Available

Legend

- Upper Castle Hayne Aquifer Monitoring Well
- ERD Injection Well
- Horizontal Well and Screened Interval
- Surface Water Centerline
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil

cis-1,2-DCE Extent

- 70 µg/L - 700 µg/L
- >700 µg/L

N

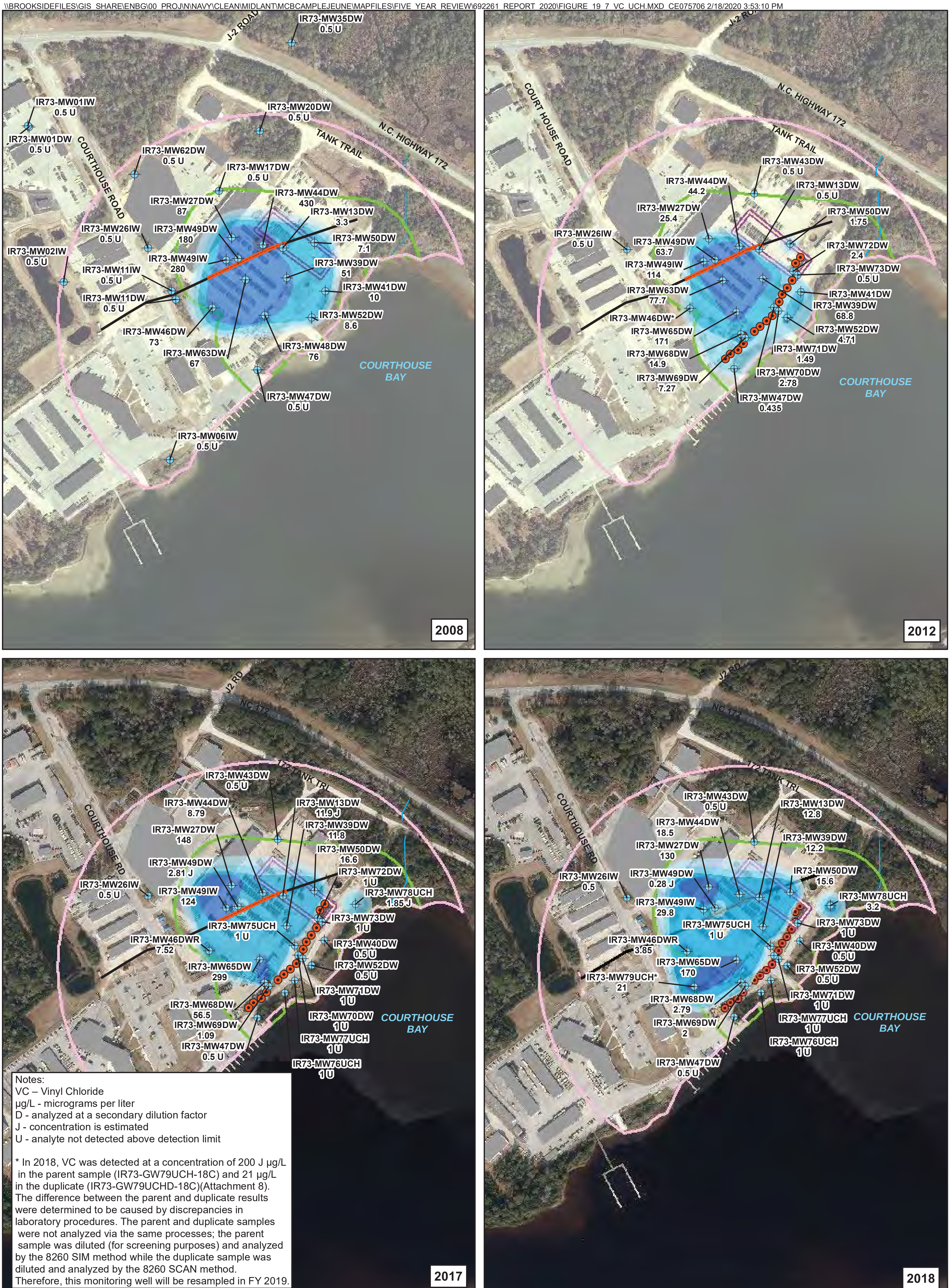
0 225 450 Feet

1 inch = 450 feet

Figure 19-6
Approximate Extent of cis-1,2-DCE Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune
North Carolina

ch2m.

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\N\NAVY\CLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\FIVE_YEAR_REVIEW\692261_REPORT_2020\FIGURE_19_7_VC_UCH.MXD CE075706 2/18/2020 3:53:10 PM



Notes:
VC – Vinyl Chloride
µg/L - micrograms per liter
D - analyzed at a secondary dilution factor
J - concentration is estimated
U - analyte not detected above detection limit

* In 2018, VC was detected at a concentration of 200 J µg/L in the parent sample (IR73-GW79UCH-18C) and 21 µg/L in the duplicate (IR73-GW79UCHD-18C)(Attachment 8). The difference between the parent and duplicate results were determined to be caused by discrepancies in laboratory procedures. The parent and duplicate samples were not analyzed via the same processes; the parent sample was diluted (for screening purposes) and analyzed by the 8260 SIM method while the duplicate sample was diluted and analyzed by the 8260 SCAN method. Therefore, this monitoring well will be resampled in FY 2019.

Legend
- Upper Castle Hayne Aquifer Monitoring Well
- ERD Injection Well
- Horizontal Well and Screened Interval
- Surface Water Centerline
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil

VC Extent
- 0.03 µg/L - 0.3 µg/L
- 0.3 µg/L - 3 µg/L
- 3 µg/L - 30 µg/L
- 30 µg/L - 300 µg/L
- >300 µg/L

N

0 225 450 Feet

1 inch = 450 feet

Figure 19-7
Approximate Extent of VC Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune
North Carolina

ch2m

\\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\N\NAVY\CLEAN\MIDLANT\MCBCAMPLEJEUNE\MAPFILES\FIVE_YEAR_REVIEW\692261_REPORT_2020\FIGURE_19_8_BENZENE_UCH.MXD CE075706 2/18/2020 11:28:09 AM

Legend

- Upper Castle Hayne Aquifer Monitoring Well
- ERD Injection Well
- Horizontal Well and Screened Interval
- Surface Water Centerline
- Aquifer Use Control Boundary
- Non-Industrial Use Control Boundary (Soil)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion) - Soil

Benzene Extent

- 1 μg/L - 10 μg/L

N

0 225 450 Feet

1 inch = 450 feet

Figure 19-8
Approximate Extent of Benzene Exceedances in the UCH Aquifer
2020 Five-Year Review
MCB Camp Lejeune
North Carolina

ch2m

Operable Unit 23 (Site 49)

20.1 Site History and Background

OU 23 is within MCAS New River (**Figure 1-2**) and consists of Site 49.

Site 49 – The **MCAS Suspected Minor Dump** covers approximately 1 acre and is located adjacent to the New River (**Figure 20-1**). The dates of operation are unknown, but Site 49 is suspected of having been used for the disposal of paint cans. A building is located approximately 50 feet from the northeast boundary of the site and is currently used for the storage of miscellaneous industrial materials and paint supplies. Various types of construction-related surface debris have been observed at the site.

OU 23 Timeline	
Year	**Event**
1983	IAS
2009-2011	PA/SI
2011-2012	RI/FS
2013	Proposed Plan
2014	ROD, RD, RIP (LUCs, MNA), and IRACR
2014-Present	MNA
2018-Present	AS Pilot Study
2019	Basewide PFAS PA

20.2 Site Characterization

The findings from various investigations at OU 23 pertinent to the FYR are summarized in this section.

20.2.1 Physical Characteristics

- **Surface Features –** Site 49 is relatively flat and the ground surface slopes gently east-northeast toward the New River with a local drainage feature to the southeast. The northern portion of the site is a maintained grassy area while the southern portion consists of a forested wetland bisected by a terra cotta pipe associated with the former building foundation. A portion of the surface water runoff from MCAS New River flows through a series of drainage channels that converge in the drainage feature (**Figure 20-1**). Due to proximity to the New River, the site is tidally influenced.
- **Geology and Hydrogeology –** Subsurface conditions generally consist of Coastal Plain deposits that include sands, silts, clays, and cemented sands. From ground surface, a thin silty sand layer (0 to 3 feet thick) overlies a fine-grained sandy clay and clay deposit that extends to approximately 15 feet bgs. Isolated lenses of sand, woody debris, and brick were encountered within this unit near the New River. Beneath the clay, silty sand and weakly cemented sandy limestone with fossilized shells are present. Groundwater is a medium of concern and the only affected aquifer is the surficial aquifer which extends from 2 to approximately 35 feet bgs where the UCH aquifer is encountered. Groundwater is typically encountered at depths ranging from 2 to 4 feet bgs and flows toward the New River in both the surficial and UCH aquifer zones (**Figure 20-1**). In the surficial aquifer, the average hydraulic conductivity is 1.18 ft/day and the average groundwater velocity is 0.0373 ft/day.

20.2.2 Land Use

- **Current Land Use –** A portion of the site (Building AS810) is currently used for storage, but the site is generally uninhabited.
- **Future Land Use –** There are no anticipated changes in land use.

20.2.3 Basis for Taking Action

This section describes the site investigations and risk assessments that provide the basis for taking action at OU 23. Details are in the RI/FS report (CH2M, 2012) and the ROD (CH2M, 2013b).

Soil, groundwater, surface water, sediment, and pore water were investigated. The HHRA evaluated current site workers, trespassers, and visitors and potential future construction, industrial, and site workers, trespassers and visitors, and residents. Potential unacceptable risks were identified to future residents from exposure to CVOCs in surficial aquifer groundwater if used as a potable source. Indoor air concentrations could exceed the VISLs should VI occur in the future if any buildings are constructed within 100 feet of the VOC-impacted groundwater. The ERA evaluated terrestrial and aquatic receptors and no unacceptable risks were identified.

20.3 Remedial Action Objectives

The ROD for OU 23 was signed in March 2014 with the following RAOs (CH2M, 2013b):

- Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201.
- Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or VI mitigation measures allow for UU/UE.
- Minimize potential degradation of the New River by COC-affected groundwater.

The COCs and cleanup levels for OU 23 are presented in **Table 20-1**.

20.4 Remedial Actions

The RA for OU 23 includes the following major components:

- MNA of VOCs in groundwater.
- LUCs to prevent exposure to contaminants in groundwater and mitigate VI.

20.4.1 Remedy Implementation

LTM was initiated in 2014 and is ongoing as described in the following section. LUCs were implemented in 2014 (CH2M, 2014a). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Aquifer Use Control** – Prohibit the withdrawal and use of groundwater, except for environmental monitoring, where groundwater contamination remains in place above concentrations that allow for UU/UE. This LUC boundary encompasses the land area within 1,000 feet of groundwater within the surficial aquifer with COC concentrations exceeding cleanup levels.
- **Industrial and Non-Industrial Use Control (VI)** – Evaluate future buildings and land use for potential VI pathways, prior to construction, within the extent of groundwater contamination remaining in-place above concentrations that allow for UU/UE. This LUC boundary encompasses the area within 100 feet of groundwater within the surficial aquifer with COC concentrations exceeding cleanup levels.

20.4.2 Remedy Operation and Maintenance

Ongoing operations at Site 49 include MNA sampling and LUCs. The total annual cost is approximately $13,000.

Long-term Monitoring

In 2014, MNA sampling was initiated and consisted of biennial sampling of four surficial aquifer monitoring wells, one UCH aquifer monitoring well, and two pore water sampling locations for analysis of all COCs listed in **Table 20-1**.

In FY 2016, the concentrations of COCs in pore water increased above concentrations observed in groundwater and the sampling frequency was increased to quarterly for two quarters in FY 2017 to evaluate trends and variability. Concentrations returned to 2014 levels and sampling frequency returned to biennially (CH2M, 2019a).

Based on the results over time, COCs and monitoring wells have been removed from the LTM program because concentrations were not detected above cleanup levels for four consecutive monitoring events. The LTM protocol currently consists of biennial sampling of one surficial aquifer monitoring well and one pore water sampling location for TCE, cis-1,2-DCE, and VC (CH2M, 2019a). In addition to comparing to cleanup levels (**Table 20-1**), data in the surficial aquifer are compared to the non-residential NC VISLs, consistent with the overall site use, to evaluate whether concentrations indicate the potential for a complete VI pathway. Pore water data is compared to the NCSWQS for water supply to evaluate water quality at the groundwater-surface water interface and to 10 times the NCSWQS for human health to evaluate potential impacts to the New River. Starting in FY 2019, MK statistical analysis is performed to evaluate the significance of historical COC concentration trends at the site and the performance of MNA.

Land Use Controls

LUCs are shown on **Figure 20-1** and are summarized in **Table 20-2**. Monitoring of the LUCs is performed quarterly by the Base; annual reports to the USEPA and NCDEQ from 2015 to 2019 are provided in **Appendix A**. There were no violations observed during this review cycle.

In October 2018, a post-hurricane inspection was completed and a fallen tree blocking access to site monitoring wells was observed. The portion of the tree blocking the monitoring well currently sampled in the LTM program was removed in December 2018. During the FYR site inspections conducted in March 2019, it was observed that the remaining portions of the fallen tree were still in-place (**Appendix B**).

Table 20-2. OU 23 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most current LUCIP Date	Onslow County Registration Date
Aquifer Use Control Boundary (1,000 feet)	37.58	January 2014	September 8, 2014
Industrial/Non-Industrial Use Control Boundary (VI)	0.46		

20.4.3 Post-ROD Removal Actions and Pilot Studies

Air Sparging Pilot Study

A pilot study was recommended based on the findings that TCE and VC were not attenuating as rapidly as expected in the ROD: within 5 years of initiation of MNA, or by 2019. Based on FY 2016 data, the estimated time to reach cleanup levels was 2025 for TCE and 2046 for VC (CH2M, 2017). A pilot study to evaluate the effectiveness of injecting air into the UCH aquifer monitoring well IR49-MW01IW to reduce contamination in surficial aquifer monitoring well IR49-MW01 was initiated in April 2018. Air was injected into IR49-MW01IW for 5 days and data and field observations indicated that the air was widely delivered to the surficial aquifer. Initial performance monitoring showed TCE in groundwater decreased from 27.5 to 3.16 µg/L and VC in groundwater decreased from 1 µg/L to below laboratory detection limits (CH2M, 2019a). Based on the results, the AS system was restarted and performance monitoring will continue in 2019.

20.4.4 Progress Since the 2015 Five-Year Review

No issues were identified for OU 23 during the 2015 FYR. LTM has continued and the AS pilot study was initiated and is currently being monitored. LUCs continue to be monitored to ensure they remain properly implemented, and no deficiencies or inconsistent uses were observed.

The current understanding of the CSM, including potential risk pathways, approximate extent of COCs, and potential sources, is shown on **Figure 20-2**. The OU 23 RA components and expected outcomes are summarized in **Table 20-3**.

Basewide Preliminary Assessment for Per- and Polyfluoroalkyl Substances

Sites 49 was evaluated in the Basewide PFAS PA as a potential PFAS release area based on its designation as a dump site/waste disposal area. No documentation or institutional knowledge of AFFF, or other PFAS-containing materials being used, released, or transferred was identified. Therefore, no further evaluation was recommended (CH2M, 2019b).

20.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

No. Based on MNA data, the estimated timeframe to remediation would not be met by the expected timeframe from the ROD. However, current and future protectiveness would not be affected because LUCs are in place to prevent exposure to contaminated groundwater.

Monitored Natural Attenuation

The timeframe to remediation estimated in the ROD was estimated to be 2019; however, the estimate increased to 2025 for TCE and 2046 for VC after FY 2016 data was evaluated. As a result, a pilot study was implemented to evaluate reducing the timeframe to remediation. Initial results of the AS pilot study indicate that AS has been effective at reducing VOC concentrations in groundwater. The pre- and most recent post-AS data are shown on **Figure 20-3** and **20-4**. The system was restarted as TCE concentrations in groundwater continue to be slightly above cleanup levels and performance monitoring is ongoing. Concentrations of COCs in pore water continue to be below the maximum concentrations reported in FY 2016 and 10 times the NCSWQS for human health, indicating that groundwater is not likely affecting the New River (**Figure 20-5**). Concentrations of VOCs are expected to continue to decrease as treated groundwater migrates to the New River (CH2M, 2019a).

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. Exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection are still valid.

The ROD was signed in 2014 and there have been no changes in toxicity values since the ROD that would impact the protectiveness of the remedy. Additionally, there have been no changes in toxicity values for the COCs identified in the HHRA since the last five-year review which concluded that the remedy at OU 23 is protective of human health and the environment (**Table 2-1**). There have been no changes in regulatory standards, and risk characteristics of COCs at OU 23 identified in the ROD. Additionally, any changes would not affect the protectiveness of the remedy, as LUCs prevent exposure to site media and limit site use.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the OU 23 remedy with respect to extreme weather events, primarily hurricanes, was completed. The effects of extreme weather events are most likely limited to flooding close to the New River and fallen trees resulting in damage to monitoring wells in the wooded areas. However, flooding and damage to monitoring wells would not significantly affect protectiveness of the remedy because the potential risk at OU 23 is from potable use of groundwater which is restricted through LUCs. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

20.6 Issues, Recommendations, and Follow-up Actions

No issues affecting protectiveness were identified for OU 23.

20.7 Statement of Protectiveness

The remedy at OU 23 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks are being controlled. LUCs are in place to prohibit aquifer use and evaluate and/or mitigate potential VI pathways. MNA is ongoing until cleanup levels are achieved.

20.8 References

CH2M HILL, Inc. (CH2M). 2011. *Preliminary Assessment/Site Inspection Report, Site 49, Marine Corps Air Station, Suspected Minor Dump. Marine Corps Base Camp Lejeune, Jacksonville, North Carolina*. March.

CH2M. 2012. *Remedial Investigation/Feasibility Study, Operable Unit No. 23, Site 49-Suspected Minor Dump Site, Marine Corps Installations East - Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* August.

CH2M. 2013a. *Proposed Remedial Action Plan Site 49: Operable Unit No. 23, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina.* February.

CH2M. 2013b. *Record of Decision Site 49: Operable Unit No. 23, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina*. December. (Signed March 2014)

CH2M. 2014a. *Remedial Design Site 49, Operable Unit No. 23, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina.* January.

CH2M. 2014b. *Interim Remedial Action Completion Report, Operable Unit 23, Site 49, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina*. November.

CH2M. 2017. *Long-term Monitoring Report Site 49 Fiscal Years 2015 – 2016, Marine Corps Base Camp Lejeune North Carolina*. May.

CH2M. 2018. *Site 49 Air Sparging Pilot Study Work Plan, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* February.

CH2M. 2019a. *Long-Term Monitoring Report Site 49 Fiscal Years 2017 and 2018, Marine Corps Base Camp Lejeune. North Carolina.* August.

CH2M. 2019b. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* December.

Water and Air Research, Inc. (WAR). 1983. *Initial Assessment Study for MCB Camp Lejeune, North Carolina.*

Table 20-1. Cleanup Levels for OU 23 (Site 49)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Media	COCs	Cleanup Levels[a] (CH2M, 2014)	Current Standard	
			Concentration	Reference
Groundwater (µg/L)	**VOCs**			
	1,1,2,2-Tetrachloroethane	0.2	0.2	NCGWQS
	1,1,2-Trichloroethane	5	5	MCL
	1,2-Dichloroethane	0.4	0.4	NCGWQS
	Benzene	1	1	NCGWQS
	cis-1,2-Dichloroethene	70	70	NCGWQS/MCL
	Tetrachloroethene	0.7	0.7	NCGWQS
	trans-1,2-Dichloroethene	100	100	NCGWQS/MCL
	Trichloroethene	3	3	NCGWQS
	Vinyl chloride	0.03	0.03	NCGWQS

Notes:
[a]Cleanup Level is the more conservative between the NCGWQS and MCL, NCGWQS/MCL denotes NCGWQS and MCL are the same value.
Shading indicates cleanup level achieved per LTM report (CH2M, 2019a)
µg/L = micrograms per liter
COC = constituent of concern
LTM = long-term monitoring
MCL = maximum contaminant level
NCGWQS = North Carolina Groundwater Quality Standard
ROD = Record of Decision
Current Standard Reference Dates:
MCL (March 2018)
NCGWQS (February 2016)

Table 20-3. OU 23 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
49	Groundwater	Potential unacceptable risks to future child and adult residents from exposure to VOCs in groundwater and indoor air via the VI pathway.	Industrial/Storage	Restore groundwater quality to meet NCDEQ and federal primary drinking water standards, based on the classification of the aquifer as a potential source of drinking water (Class GA or Class GSA) under 15A NCAC 02L.0201. Minimize potential degradation of the New River by COC-affected groundwater.	MNA	Groundwater and pore water MNA to monitor VOC concentrations and migration to the New River until each groundwater VOC is at or below its respective cleanup level for 4 consecutive sampling events.	UU/UE
				Prevent exposure to COCs in groundwater and VI from COCs in groundwater until such time as groundwater concentrations or vapor intrusion mitigation measures allow for UU/UE.	LUCs	Maintain industrial/non-industrial use and aquifer use controls and monitor quarterly until groundwater cleanup levels are achieved.	

Notes:
COC = constituent of concern
LUC = land use control
MNA = monitored natural attenuation
NCDEQ = North Carolina Department of Environmental Quality
RAO = remedial action objectives
UU/UE = unlimited use/unrestricted exposure
VI = vapor intrusion
VOC = volatile organic compound

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Legend
Monitoring Wells
- Surficial Aquifer
- Upper Castle Hayne Aquifer
- Surficial Aquifer - not in LTM
- Pore Water Sample Location
- Approximate Location of Terra Cotta Pipe
- Groundwater Flow Direction
- Buildings

Land Use Control Boundaries
- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

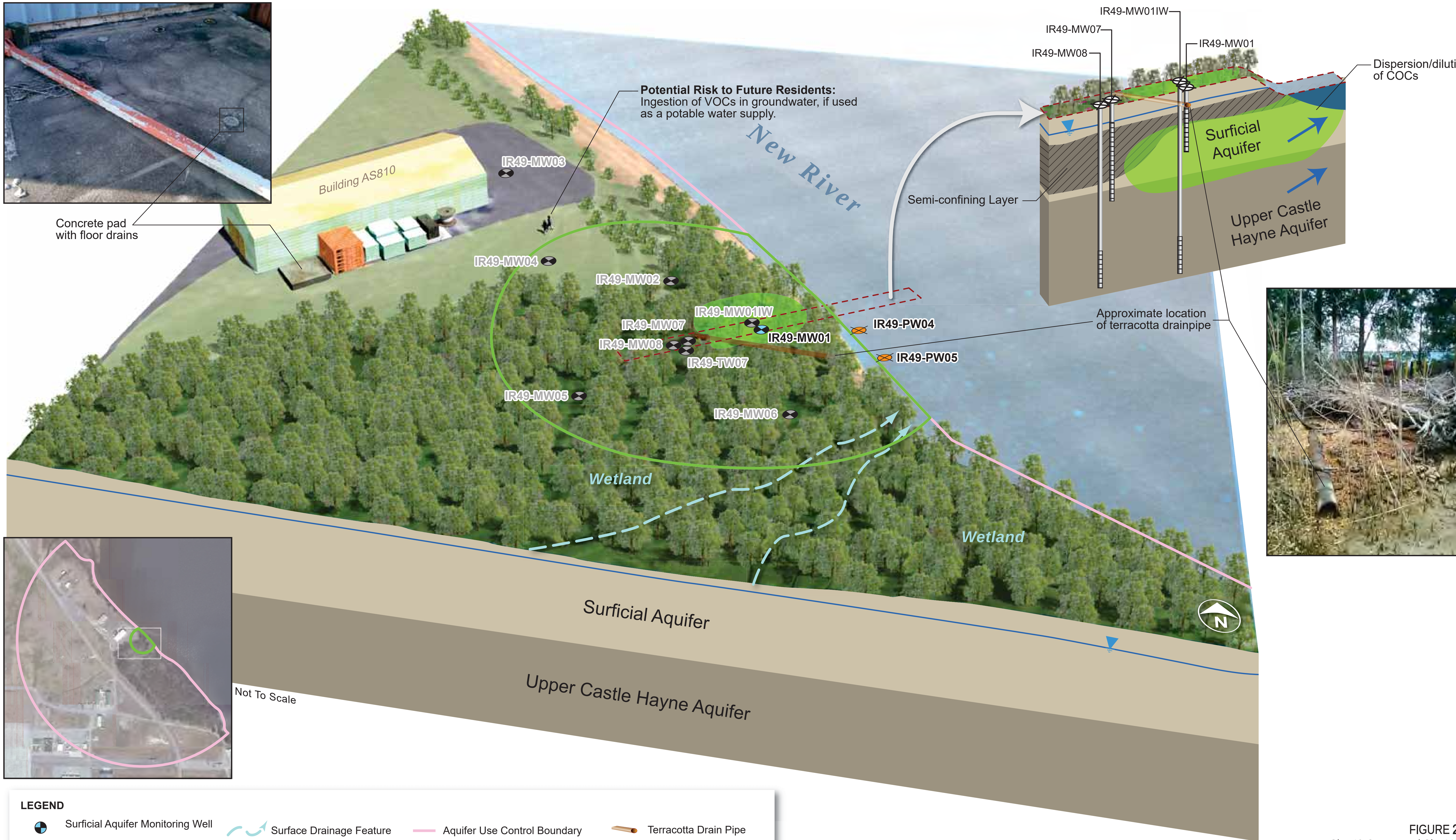
Notes:
IR49-PW05 and IR49-MW01IW were removed from the LTM program beginning in FY 2020

N

0 30 60
Feet
1 inch = 30 feet

Figure 20-1
OU 23 (Site 49)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m:



LEGEND

Surficial Aquifer Monitoring Well	Surface Drainage Feature	Aquifer Use Control Boundary	Terracotta Drain Pipe
Upper Castle Hayne Aquifer Monitoring Well	Water Table	Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)	VOC Plume (Based on FY 2018 LTM)
Surficial Aquifer Monitoring Well - not in LTM	Estimated Direction of Groundwater Flow		
Pore Water Sample Location			

Note:
The locations of site conditions are intended to be graphic visuals and not exact replications of site conditions.

FIGURE 20-2
Site 49 Conceptual Site Model
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m.

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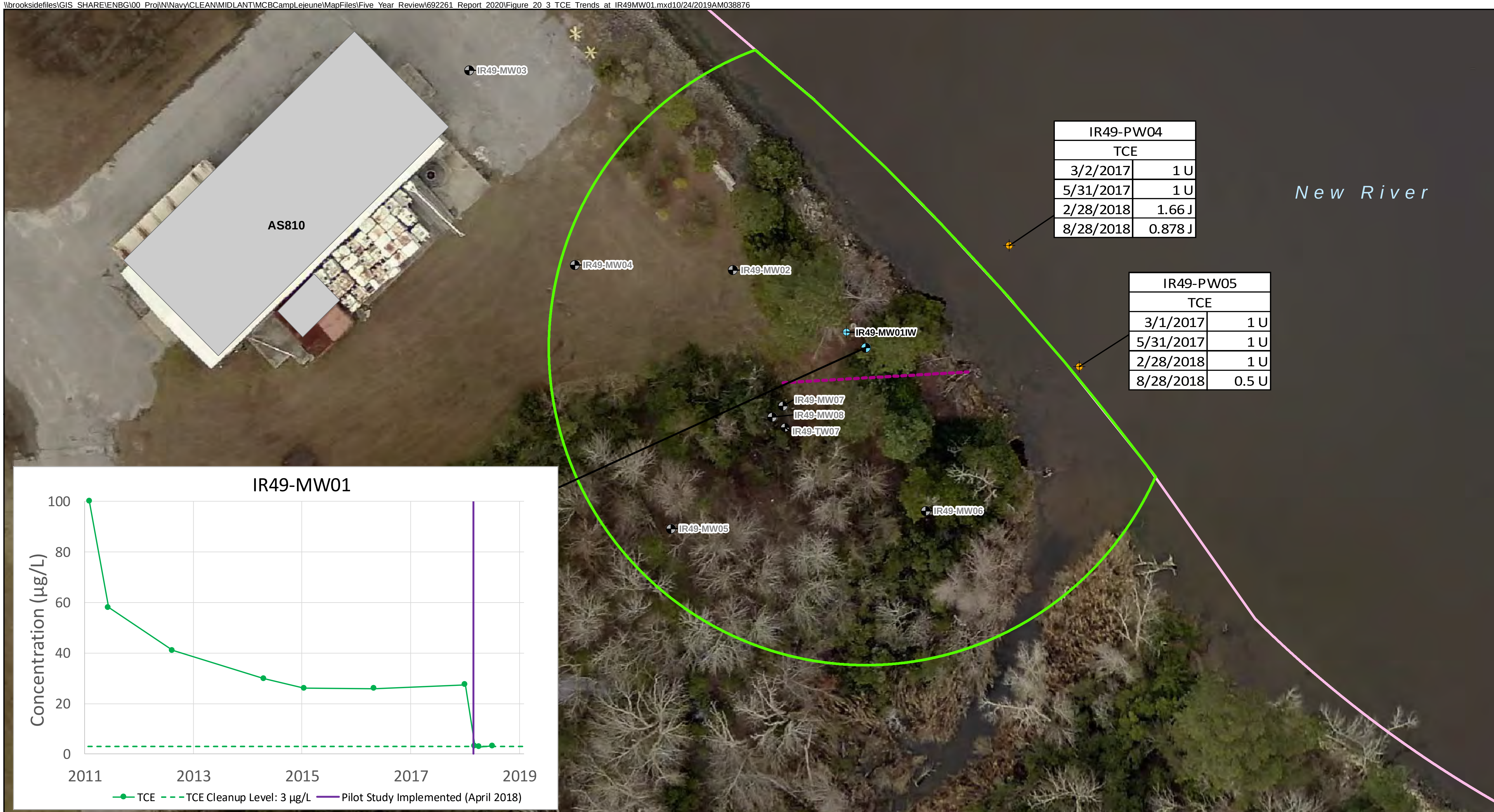

IR49-PW04	
TCE	
3/2/2017	1 U
5/31/2017	1 U
2/28/2018	1.66 J
8/28/2018	0.878 J

IR49-PW05	
TCE	
3/1/2017	1 U
5/31/2017	1 U
2/28/2018	1 U
8/28/2018	0.5 U

Legend

- Surficial Aquifer Monitoring Well
- Upper Castle Hayne Aquifer Monitoring Well
- Surficial Aquifer Monitoring Well - not in LTM
- Pore Water Sample Location
- Approximate Location of Terra Cotta Pipe
- Buildings

Land Use Control Boundaries

- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

Notes:
TCE - Trichloroethene
IR49-PW05 and IR49-MW01IW were removed from the LTM program beginning in FY 2020

N

0 30 60 Feet

1 inch = 30 feet

Figure 20-3
TCE Trends at IR49-MW01
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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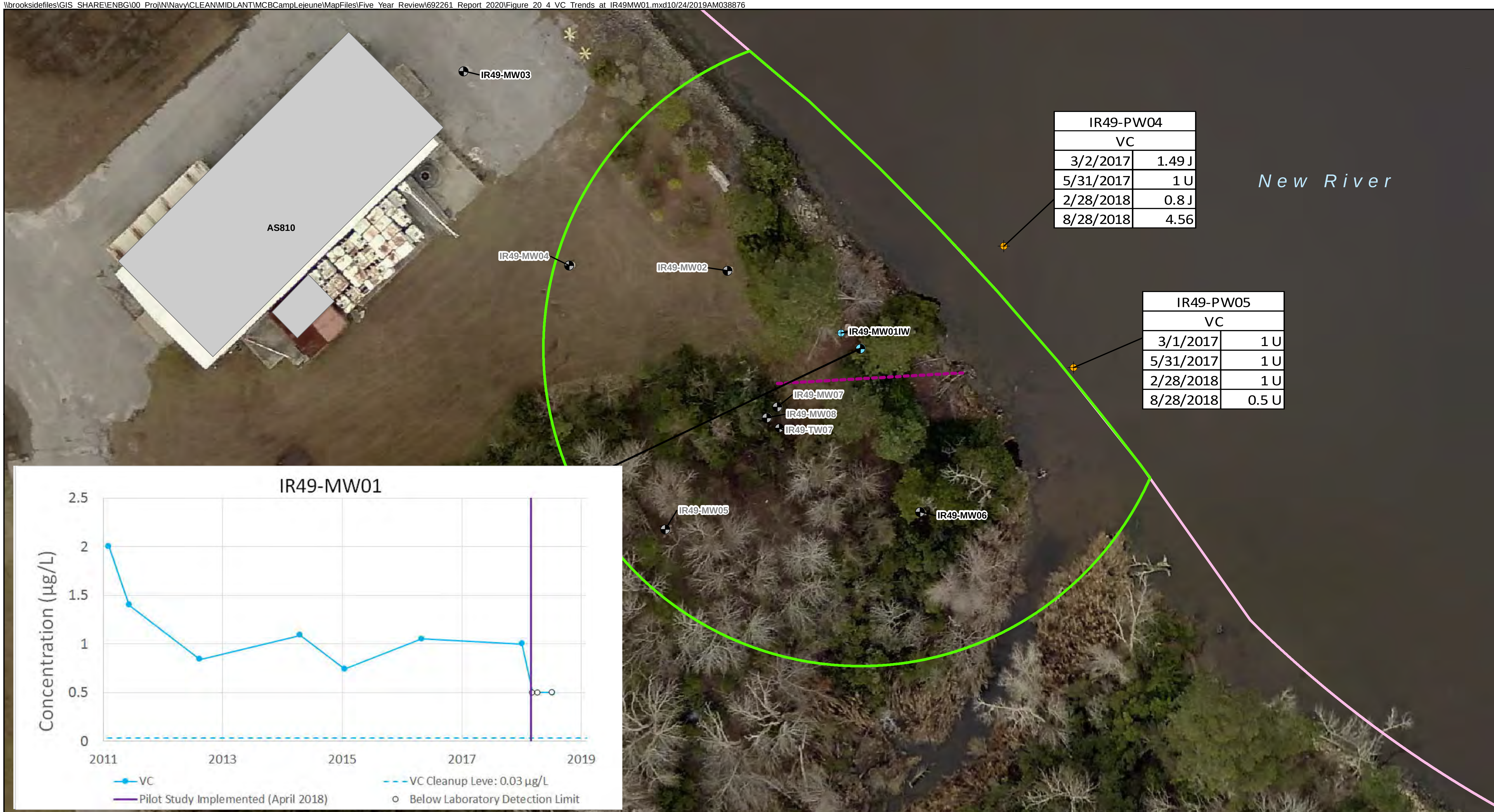

IR49-PW04	
VC	
3/2/2017	1.49 J
5/31/2017	1 U
2/28/2018	0.8 J
8/28/2018	4.56

IR49-PW05	
VC	
3/1/2017	1 U
5/31/2017	1 U
2/28/2018	1 U
8/28/2018	0.5 U

Legend
- Surficial Aquifer Monitoring Well
- Upper Castle Hayne Aquifer Monitoring Well
- Surficial Aquifer Monitoring Well - not in LTM
- Pore Water Sample Location
- Approximate Location of Terra Cotta Pipe
- Buildings

Land Use Control Boundaries
- Aquifer Use Control Boundary
- Industrial/Non-Industrial Use Control Boundary (Vapor Intrusion)

Notes:
VC - Vinyl Chloride
IR49-PW05 and IR49-MW01IW were removed from the LTM program beginning in FY 2020

N

0 30 60 Feet

1 inch = 30 feet

Figure 20-4
VC Trends at IR49-MW01
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

ch2m

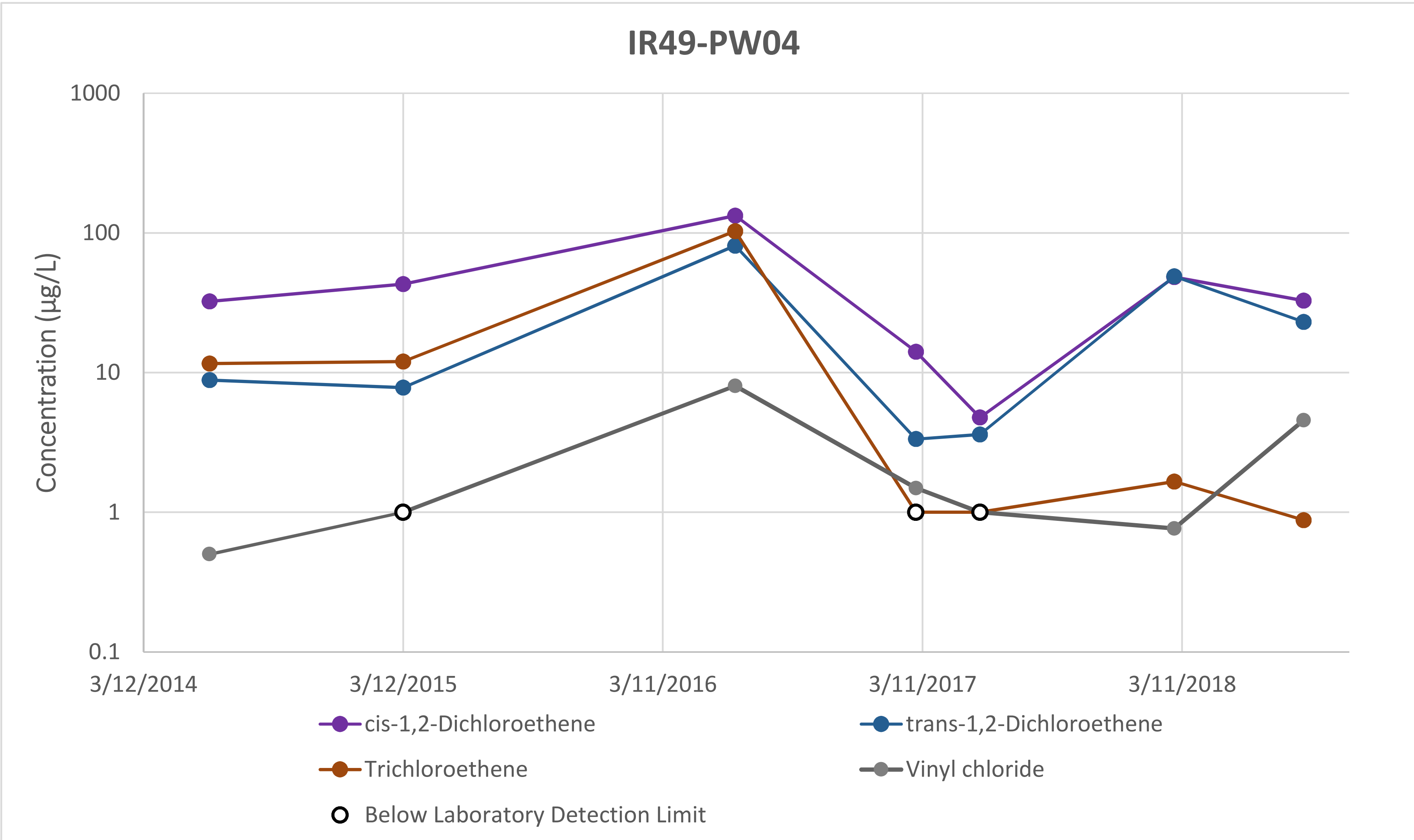

Figure 20-5
Trends at IR49-PW04
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

Operable Unit 24 (Site UXO-06)

21.1 Site History and Background

OU 24 is within the Mainside area of MCB Camp Lejeune (**Figure 1-2**) and consists of Site UXO-06.

Site UXO-06 – The **Fortified Beach Assault Area (Archive Search Report [ASR] #2.65)** covers approximately 366 acres (**Figure 21-1**). This range was reportedly in use from 1953 until approximately 1977. The types of munitions used onsite include blank small arms, demolitions, flame throwers, 3.5-inch practice rockets, practice rifle grenades, and smoke and white phosphorus hand grenades. In addition, solvents and solutions were used at the site to clean equipment. The east central portion of Site UXO-06 has been investigated and cleared and was most recently being used as a borrow pit to support construction projects across the Base.

OU 24 Timeline	
Year	**Event**
2006-2007	Focused SI
2007	Focused PA/SI
2008-2012	PA/SI
2010-2012	Focused SIs
2012-2015	RI
2016	FS
2017	Proposed Plan
2018	ROD, RD
2019	RIP (Surface MEC Clearing, LUCs)
2019	Basewide PFAS PA

21.2 Site Characterization

The findings from various investigations at OU 24 pertinent to the FYR are summarized in this section.

21.2.1 Physical Characteristics

- **Surface Features –** Site UXO-06 consists of undeveloped, wooded land surrounding a 51-acre borrow pit. Except for the borrow pit, the area is relatively flat near the developed areas surrounding Gonzales Boulevard, with local depressions and wetlands near Cowhead Creek and an unnamed tributary. Surface runoff generally flows south and southwest toward Cowhead Creek, tributaries of French Creek, or directly into French Creek located on the southern boundary of the investigation area. Cowhead Creek and its tributary also discharge into French Creek, a tributary of the New River. Surface water runoff patterns are variable because of borrow pit excavations changing the topography of the site. Water that accumulates in the borrow pit is pumped into the nearby pond in the eastern portion of the site.

- **Geology and Hydrogeology –** The geology underlying Site UXO-06 consists of layered laterally discontinuous fine-grained soil, consistent with the Tidewater region of the Atlantic Coastal Plain Physiographic Province. Soil consists of layered interfingered beds and lenses of sands, silts, clays, calcareous clays, shell beds, sandstone, and limestone that were deposited over pre-Cretaceous crystalline bedrock. Groundwater in the surficial aquifer is encountered at approximately 10 to 20 feet bgs. Groundwater is not a medium of concern at the site.

21.2.2 Land Use

- **Current Land Use –** The site is primarily undeveloped and consists of the former Base borrow pit, wooded areas, wetlands, and limited recreational areas. There are buildings, including the French Creek Fire Station, located within the site boundary along Gonzales Boulevard and McHugh Boulevard.

- **Future Land Use –** There are no anticipated changes in land use.

21.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 24. Details in the PA/SI (CH2M, 2012), RI (CH2M, 2015), and the ROD (CH2M, 2018).

Groundwater, surface and subsurface soil, surface water, and sediment were investigated. The human health risk screening conducted as part of the PA/SI evaluated current military personnel, maintenance workers, trespassers, and future construction workers and residents. No unacceptable risks from chemical constituents in site media were identified. The ecological risk screening evaluated terrestrial and aquatic receptors and found no unacceptable risks to ecological receptors.

MMRP intrusive investigations were conducted over portions of the site during the PA/SI, focused SIs, and the RI. Fewer than one percent (18 items) of the anomalies investigated were MEC and slightly more than 15 percent (2,729 items) were MPPEH. An explosive hazard assessment evaluated conditions post-MMRP intrusive investigation and concluded that there is a potential for explosive hazards from the potential presence of surface and subsurface MEC/MPPEH remaining onsite in areas not cleared during previous investigations.

21.3 Remedial Action Objectives

The ROD addressing for OU 24 was signed in April 2018 (CH2M, 2018) with the following RAO:

- Reduce or prevent the potential for direct physical contact with MEC/MPPEH, which can present unacceptable risk to human health and safety due to the explosive nature of the items/materials

21.4 Remedial Actions

The RA for OU 24 includes the following:

- Removal of MEC/MPPEH on the ground surface in accessible areas of the site.
- LUCs to prevent exposure to MEC/MPPEH.

21.4.1 Remedy Implementation

Surface MEC Clearance

Surface MEC clearance activities were completed from March to June 2019 and consisted of a visual sweep of the ground surface (using 5-foot lanes) with a handheld magnetometer to detect MEC/MPPEH and other metallic debris that may have been concealed by vegetation. Exposed and partially exposed MPPEH and metallic items 2-inches or larger were collected, managed, and staged in an appropriate collection area. MEC items were not identified and a total of 54 MPPEH items were identified. MPPEH items that were not able to be fully inspected were detonated in place. Following detonation, soil samples were collected to confirm that the controlled detonation activities did not introduce explosives residues to the environment. All samples were below screening levels. All other MPPEH items were classified as material documented as safe upon proper inspection and were disposed offsite to a recycling facility in Chesapeake, Virginia (CH2M, 2019a).

Land Use Controls

LUCs were implemented in 2019 (CH2M, 2019a). Fifteen warning signs, three of which had informational flyers attached, were installed at access points around the perimeter of Site UXO-06 to notify non-UXO-qualified Base personnel/contractors and/or the public of site hazards. The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Intrusive Activities Control (MEC/MPPEH)** – Require UXO construction support (on-call only for Borrow Pit Area A) for any intrusive activities. Require 3Rs Explosives Safety Education for non-explosive ordnance disposal (EOD) and non-UXO-qualified Base personnel and contractors. Provide educational support to inform onsite personnel and contractors about the implemented LUCs at the site.

- **Industrial/Non-Industrial Use Control (MEC/MPPEH)** – Require site approval if new buildings are to be constructed or if land use changes; this includes evaluating the need for MEC clearance and/or UXO construction support. Prohibit non-industrial land use; this includes prohibiting the construction of residential housing, hospitals, hotels, nursing homes, elementary and secondary schools, and day care facilities.
- **Explosives Safety Education Program** – Require 3Rs Explosives Safety Education for non-EOD and non-UXO-qualified Base personnel and contractors.

21.4.2 Remedy Operation and Maintenance

LUCs are shown on **Figure 21-1** and are summarized in **Table 21-1**. Monitoring of the LUCs is performed quarterly by the Base and was initiated at Site UXO-06 in October 2019. There were no violations observed during this review cycle.

In September 2018, a post hurricane inspection was completed, and no damage was observed. During the FYR inspections, conducted in March 2019, vegetation reduction activities were in progress (**Appendix B**). No issues affecting protectiveness were observed.

Table 21-1. OU 24 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most current LUCIP Date	Onslow County Registration Date
Intrusive Activities Control (MEC/MPPEH)	323.69	September 2018 (RD)	September 26, 2019
Industrial/Non-Industrial Use Control (MEC/MPPEH)	199.32		
Explosives Safety Education Program	5.38		

21.4.3 Progress Since the 2015 Five-Year Review

This is the first FYR for OU 24. The OU 24 RA components and expected outcomes are summarized in **Table 21-2**.

21.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. The surface removal was completed in all accessible areas as planned, reducing the potential for exposure to surface MEC/MPPEH. LUCs are in place and inspections are conducted quarterly.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. Exposure assumptions and RAOs used at the time of selection are still valid. There were no COCs identified during risk assessments and no new data has been collected since the ROD; therefore, changes in toxicity data or cleanup levels are not applicable.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the Site UXO-06 remedy with respect to extreme weather events, primarily hurricanes, was completed. Damage from hurricanes could lead to migration of MEC/MPPEH items through erosion of surface soils, particularly near waterways, and exposure in roots of downed trees resulting in MEC present at shallower depths than previously understood. However, protectiveness would not be affected because 3Rs Explosives Safety Education is a component of the remedy so if an item were to be exposed, personnel are trained to respond. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

21.6 Issues, Recommendations, and Follow-up Actions

No issues affecting protectiveness have been identified for OU 24 during this review.

Other Findings

In addition, the following information was identified during the FYR that does not affect current and/or future protectiveness but is relevant to long-term site management:

- Although Site UXO-06 was not identified as a potential PFAS release area based on site use, the French Creek Fire Station is located within the intrusive activities LUC boundary and was identified as a potential PFAS release area based on use as a fire station. The station was built in 2000 and due to the presence of AFFF-containing fire engines, there is a potential for AFFF to have been released. Therefore, further evaluation is recommended (CH2M, 2019b).

There are no active public or private drinking water supply wells within 1 mile downgradient of the potential PFAS release area identified; therefore, there is no current exposure pathway (CH2M, 2019b). This area will be included in a Basewide Site Inspection to determine if PFAS are present in site media, and if present, potential unacceptable risks to human health and/or a potential exposure pathway to drinking water receptors will be evaluated.

21.7 Statement of Protectiveness

The remedy at OU 24 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks (explosive hazards) are being controlled. LUCs are in place to prohibit intrusive activities, educate site users, and prohibit non-industrial use.

21.8 References

Arcadis. 2007. *Focused Preliminary Assessment/Site Inspection, AOC#3, Proposed Force Main Easement near MMRP Site UXO-06 (Fortified Beach Assault Area), Marine Corps Base Camp Lejeune.* August.

CH2M HILL, Inc. (CH2M). 2007. *Focused Site Inspection Report, Site UXO-06 MILCON Area, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* March.

CH2M. 2010. *Focused Site Inspection – Site UXO-06 Borrow Pit Expansion Area Phase 1, Marine Corps Base Camp Lejeune, North Carolina.* March.

CH2M. 2011a. *Focused Site Inspection – Site UXO-06 Borrow Pit Expansion Area Phase 1A Subarea 1, Marine Corps Base Camp Lejeune, North Carolina.* April.

CH2M. 2011b. *Focused Site Inspection – Site UXO-06 Borrow Pit Expansion Area Phase 2 Subarea 1 , Marine Corps Base Camp Lejeune, North Carolina.* July.

CH2M. 2012a. *Focused Site Inspection – Site UXO-06 Borrow Pit Expansion Area Phase 1A/2 Subarea* 2*, Marine Corps Base Camp Lejeune, North Carolina.* January.

CH2M. 2012b. *Preliminary Site Assessment/Site Inspection Report MMRP Site UXO-06, Former Fortified Beach Assault Area, Marine Corps Base, Camp Lejeune, North Carolina.* February.

CH2M. 2015. *Remedial Investigation Report Operable Unit 24/Site UXO-06, Former Fortified Beach Assault Area (ASR #2.65). Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina.* March.

CH2M. 2016. *Feasibility Study, Operable Unit 24/Site UXO-06, Former Fortified Beach Assault Area (ASR #2.65), Marine Corps Base Camp Lejeune, North Carolina.* October.

CH2M. 2017. *Proposed Plan Site UXO-06: Operable Unit 24, Marine Corps Base Camp Lejeune, North Carolina.* June.

CH2M. 2018a. *Record of Decision, Site UXO-06, Operable Unit 24, Marine Corps Base Camp Lejeune, North Carolina.* April.

CH2M. 2018c. *Remedial Design, Site UXO-06, Operable Unit 24, Marine Corps Base Camp Lejeune, North Carolina.* September.

CH2M. 2019a. *Remedial Action Completion Report, Operable Unit 24, Site UXO-06, Marine Corps Base Camp Lejeune, North Carolina.* September.

CH2M. 2019b. *Preliminary Assessment for Per- and Polyfluoroalkyl Substances, Marine Corps Base Camp Lejeune and Marine Corps Air Station New River, North Carolina.* December.

Table 21-2. OU 24 Remedial Action Summary and Expected Outcomes

2020 Five-Year Review

MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
UXO 6	MEC/MPPEH	Potential explosive hazard from contact with MEC/MPPEH on the ground surface within the Borrow Pit Area B, Cantonment Area B, Wooded Area, and Limited Use area; and MEC/MPPEH that may be present in the subsurface within the site boundary.	Recreational/ General Operational/ Cantonment	Reduce or prevent the potential for direct physical contact with MEC/MPPEH, which can present unacceptable risk to human health and safety due to the explosive nature of the items/materials.	Surface MEC Clearance	A visual sweep of the ground surface was conducted with a handheld magnetometer to detect potential MEC/MPPEH that may have been concealed by vegetation or fallen leaves and pine needles within the accessible portions of Site UXO-06. Recovered MPPEH was processed, inspected, certified as MDAS and disposed of in accordance with the ESS.	Recreational/ General Operational/ Cantonment
					LUCs	Maintain intrusive activities and non-industrial LUCs for MEC/MPPEH and conduct quarterly monitoring.	

Notes:

LUC = land use control

MDAS = material documented as safe

MEC = munitions and explosives of concern

MPPEH = material potentially presenting an explosive hazard

RAO = remedial action objective

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Legend

- UXO Warning Sign Location
- UXO Warning Sign Location with Informational Flyer
- Surface MEC Clearance Areas
- Intrusive Activities Control (Munitions and Explosives of Concern/ MaterialPotentially Presenting an Explosive Hazard [MEC/MPPEH])
  - -Require UXO construction support for any intrusive activities. (on-call only for Borrow Pit Area A)
  - -Require 3Rs Explosives Safety Education Program for non-UXO-qualified Base personnel and contractors.
  - -Provide educational support to inform personnel and contractors on the implemented LUCs at the site.
- Industrial/Non-Industrial Use Control (Munitions and Explosives of Concern/Material Potentially Presenting an Explosive Hazard [MEC/MPPEH])
  - -Require site approval if new buildings are to be constructed or if land use changes; this includes evaluating the need for MEC clearance and/or UXO construction support.
  - -Prohibit non-industrial land use; this includes prohibiting the construction of residential housing, hospitals, hotels, nursing homes, elementary and secondary schools, and day care facilities.
- Explosives Safety Education Program
  - -Require 3Rs Explosives Safety Education Program for non-UXO-qualified Base personnel and contractors.

N

0 450 900 Feet

1 inch = 900 feet

Figure 21-1
OU 24 (Site UXO-06)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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Operable Unit 25 (Site UXO-19)

22.1 Site History and Background

OU 25 is within the Camp Devil Dog Training Area south of MCAS New River (**Figure 1-2**) and consists of Site UXO-19.

OU 25 Timeline	
Year	**Event**
2010	PA/SI
2013	MMRP Intrusive Investigation
2013-2015	RI/FS
2015	Proposed Plan and ROD
2016	RD, RIP (LUCs)
2017	Warning Signs Installed
2018	RACR

Site UXO-19 – The **Camp Devil Dog Historical Ranges** covers approximately 64 acres (**Figure 22-1**). The site initially covered approximately 80 acres; however, a 22-acre area in the eastern portion of the initial site boundary is currently active and used as a Military Operations in Urban Terrain training facility. There are eight overlapping ranges within the UXO-19 boundary, three of which were identified for closure under the MMRP:

- The M-4 Rifle Grenade Range (ASR #2.104) was used between 1950 and 1960. Reported munitions used were M28 and M29 rifle grenades, white phosphorus hand and rifle grenades, pyrotechnics, and demolitions.
- The K-22 Practice Hand Grenade Course (ASR #2.111) was used between 1950 and 1960 to practice grenade throwing techniques. Facilities included a bunker and foxhole.
- The M-115 Hand Grenade Range (ASR #2.168) was used from 1970 to 1977 for high explosive hand grenades. The range consisted of six throwing pits, six control pits, and a barricade with two observation ports.

22.2 Site Characterization

The findings from various investigations at OU 25 pertinent to the FYR are summarized in this section.

22.2.1 Physical Characteristics

- **Surface Features –** The ground surface at Site UXO-19 is relatively flat, with surface elevations ranging from 14 feet to 26 feet above mean sea level across the site. No surface water bodies lie within the site boundary, although stormwater runoff is presumed to flow toward the east and southeast, eventually discharging to unnamed tributaries of the New River. Buildings within the site consist of small concrete block classrooms, military housing, a small medical facility, a bath house, and a headquarters building. An obstacle training course is also located at the site. The eastern portion of the site is generally undeveloped. Before investigation activities began, a portion of the site was heavily vegetated. Much of the vegetation, including trees smaller than 6 inches in diameter, was cleared during the MMRP intrusive investigations.
- **Geology and Hydrogeology –** The shallow soils, from ground surface to approximately 25 feet bgs, encountered within the site consist of poorly graded sands, sands with variable amounts of silt and clay, and occasional clay lenses ranging from 3 inches to more than 9 feet thick. The water table is encountered at depths ranging from 9.54 to 17.2 feet bgs. Groundwater is not a medium of concern at this site.

22.2.2 Land Use

- **Current Land Use –** The site is an active training area that primarily consists of billeting, training classrooms, and messing.
- **Future Land Use –** There are no anticipated changes in land use.

22.2.3 Basis for Taking Action

This section describes the results of site investigations and risk assessments that provide the basis for taking action at OU 25. Details are located in the RI/FS report (CH2M, 2015a) and the ROD (CH2M, 2015b).

Groundwater and surface and subsurface soil were investigated for munitions constituents (select metals and explosives residues). The human health risk screening, conducted as part of the PA/SI, evaluated current military personnel, maintenance workers, trespassers and future construction workers and residents. No unacceptable risks from exposure to munitions constituents in site media were identified for any exposure scenarios. The ecological risk screening evaluated terrestrial and aquatic receptors. No unacceptable risks to ecological receptors were identified.

An MMRP intrusive investigation was completed over 100 percent of accessible areas of the site. A total of 447 MEC and 50,771 MPPEH items were identified at depths up to 3 feet bgs. An explosive hazard assessment evaluated conditions post-MMRP intrusive investigation and concluded that there is a potential for explosive hazards from the potential presence of subsurface MEC/MPPEH at depths greater than the investigation limits (18 inches bgs) in the undeveloped area, and at any depth in developed or areas that were inaccessible during the MMRP intrusive investigation.

22.3 Remedial Action Objectives

The ROD for OU 25 was signed in December 2015 (CH2M, 2015c) with the following RAO:

- Reduce or prevent the potential for direct physical contact with MEC/MPPEH to allow current and reasonably anticipated land use (infantry training) at the site to continue.

22.4 Remedial Actions

The RA for OU 25 includes the following:

- LUCs to prevent exposure to MEC/MPPEH.

22.4.1 Remedy Implementation

LUCs were implemented in 2016 and 18 warning signs were installed in October 2017 (CH2M, 2018). The following LUCs were recorded with Onslow County as a Notice of Contaminated Site and are included in the Base GIS and Master Plan:

- **Intrusive Activities Control (MEC) in Developed/Inaccessible Areas –** Require UXO construction support for any intrusive activities within the areas identified as developed or inaccessible within Site UXO-19. Require 3R munitions safety awareness training for Base personnel and subcontractors working within the Site UXO-19 boundary.

- **Intrusive Activities Control (MEC) in Undeveloped Areas –** Restrict intrusive activities within the undeveloped area with potential explosive safety hazards to less than 18 inches bgs. Require UXO construction support for all intrusive activities greater than 18 inches bgs and 3R munitions safety awareness training for all personnel working within the Site UXO-19 boundary.

3Rs Explosives Safety Education (formerly referred to as 3R munitions safety awareness training) is a Base requirement for all non-EOD and non-UXO-qualified personnel accessing the site.

22.4.2 Remedy Operation and Maintenance

LUCs are shown on **Figure 22-1** and are summarized in **Table 22-1**. Monitoring of the LUCs is performed quarterly by the Base, initiated in October 2017; annual reports to the USEPA and NCDEQ from 2017 to 2019 are provided in **Appendix A**. One unauthorized intrusion into soil was observed in April 2018. A letter was sent to USEPA and

NCDEQ in June 2018 summarizing the intrusive action and response. The response included coordination with the Base unit to increase awareness of LUCs and provide training to ensure LUCs are followed. There were no incidents as a result of this violation.

In October 2018, a post-hurricane inspection was completed and no issues were observed. No issues were observed during the FYR site inspections conducted in March 2019 (**Appendix B**).

Table 22-1. OU 25 Land Use Control Summary

LUC Boundary	Estimated Area (Acres)	Most current LUCIP Date	Onslow County Registration Date
Intrusive Activities Control (MEC) in Developed/Inaccessible Areas	22	March 2016 (RD)	September 30, 2016
Intrusive Activities Control (MEC) in Undeveloped Areas	43		

22.4.3 Progress Since the 2015 Five-Year Review

This is the first FYR for OU 25. The OU 25 RA components and expected outcomes are summarized in **Table 22-2**.

22.5 Technical Assessment

Question A: Is the remedy functioning as intended by the decision document?

Yes. Ongoing quarterly inspections have documented that the warning signs are in place and functioning as designed. The intrusive LUC violation identified in April 2018 was addressed and no violations have been observed since.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of selection still valid?

Yes. Exposure assumptions and RAOs used at the time of selection are still valid. There were no COCs identified during risk assessments and no new data has been collected since the ROD; therefore, changes in toxicity data or cleanup levels are not applicable.

Question C: Has any other information come to light that could question the protectiveness of the remedy?

No additional information has come to light that could question the protectiveness of the remedy. As discussed in **Section 2.2.2**, a qualitative review of the Site UXO-19 remedy with respect to extreme weather events, primarily hurricanes, was completed. Damage from hurricanes could lead to migration of MEC/MPPEH items through erosion of surface soils from overland flows and exposure in roots of fallen trees and MEC may be present at shallower depths than previously understood. However, protectiveness would not be affected because 3Rs Explosives Safety Education is a component of the remedy so if an item were to be exposed, personnel are trained to respond. LUCs are inspected quarterly and following major storm events and repairs are conducted as needed to maintain protectiveness.

22.6 Issues, Recommendations, and Follow-up Actions

No issues have been identified for OU 25 during this review.

22.7 Statement of Protectiveness

The remedy at OU 25 is protective of human health and the environment.

Exposure pathways that could result in unacceptable risks (explosive hazards) are being controlled. LUCs are in place to prohibit intrusive activities in developed/inaccessible and undeveloped areas of the site.

22.8 References

CH2M HILL, Inc. (CH2M). 2010. *Focused Preliminary Assessment/Site Inspection Report, Camp Devil Dog Construction Area and Military Munitions Response Program UXO-19. Marine Corps Base Camp Lejeune, Jacksonville, North Carolina*. October.

CH2M. 2015a. *Revised Final Remedial Investigation/ Feasibility Study Report, Operable Unit 25/Site UXO-19, Camp Devil Dog, Marine Corps Installations East – Marine Corps Base Camp Lejeune, North Carolina.* January.

CH2M. 2015b. *Proposed Plan, Site UXO-19: Operable Unit 25, Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina.* February.

CH2M. 2015c. *Record of Decision, Operable Unit 25, Site UXO-19, Marine Corps Installations East-Marine Corps Base Camp Lejeune, North Carolina.* October.

CH2M. 2016. *Remedial Design, Operable Unit 25, Site UXO-19, Marine Corps Base Camp Lejeune, North Carolina*. March.

CH2M. 2018. *Remedial Action Completion Report Operable Unit 25, UXO-19, Marine Corps Base Camp Lejeune, North Carolina.* July.

Table 22-2. OU 25 Remedial Action Summary and Expected Outcomes
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River, North Carolina

Site	Media	Risk/Basis for Action	Reasonably Anticipated Land Use	RAO	Remedy Component	Performance Metric	Expected Outcome
UXO 19	MEC/MPPEH	Potential explosive hazard from contact with MEC/MPPEH within the undeveloped area at depths greater than 18 inches below ground surface or at any depth in the developed or inaccessible areas at the site.	Infantry Training	Reduce or prevent the potential for direct physical contact with MEC/MPPEH to allow current and reasonably anticipated land use (infantry training) at the site to continue.	LUCs	Maintain intrusive activities and non-industrial LUCs for MEC/MPPEH and conduct quarterly monitoring.	Restricted Use

Notes:

LUC = land use control

MEC = munitions and explosives of concern

MPPEH = material potentially presenting an explosive hazard

RAO = remedial action objective

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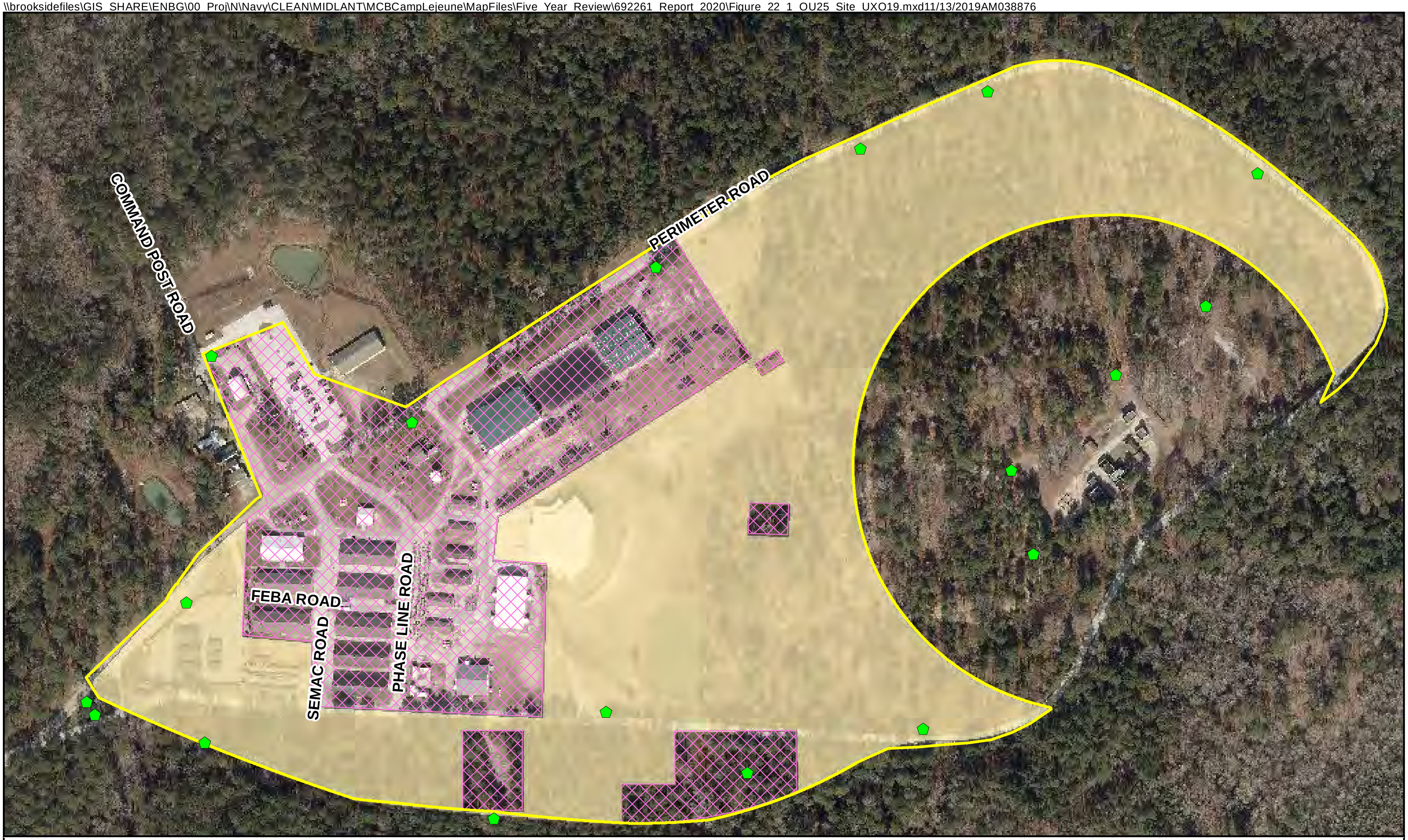

Legend

- UXO Warning Sign Locations
- Intrusive Activities Control for Munitions and Explosives of Concern in Developed/Inaccessible Areas
- Intrusive Activities Control for Munitions and Explosives of Concern in Undeveloped Areas
- Current Site UXO-19 Boundary

N

0 175 350 Feet

1 inch = 350 feet

Figure 22-1
OU 25 (Site UXO-19)
2020 Five-Year Review
MCB Camp Lejeune and MCAS New River
North Carolina

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