Minnesota Pollution Control Agency

520 Lafayette Road North | St. Paul, Minnesota 55155-4194 | 651-296-6300

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August 10, 2017

Roger Walton
TCAAP Commander's Representative
U.S. Army Environmental Command
Midwest Environmental Services and Support Division
2450 Connell Road, Bldg. 2264 (Room 125-1)
JBSA Fort Sam Houston, TX 78234-7664

RE: Consistency Test for the Fiscal Year 2016 Annual Performance Report, New Brighton/Arden Hills Superfund Site, Arden Hills, Minnesota

Dear Mr. Walton:

Staff at the U.S. Environmental Protection Agency (U.S. EPA) and the Minnesota Pollution Control Agency (MPCA) have completed review of the Fiscal Year 2016 Annual Performance Report for the New Brighton/Arden Hills Superfund Site (FY16 APR). Our review of the FY16 APR included the following documents and communications:

- *Fiscal Year 2016 Annual Performance Report, New Brighton/Arden Hills Superfund Site, Draft Report*, prepared for the Commander, Twin Cities Army Ammunition Plant by PIKA Arcadis U.S., Inc (JV), Alliant Techsystems, Inc, and GHD (February 13, 2017);
- U.S EPA comments on the Draft FY16 APR (April 24, 2017)
- MPCA comments on the Draft FY16 APR (June 6, 2017)
- U.S. Army (Army) responses to U.S. EPA and MPCA comments (July 5, 2017)
- MPCA follow-up comments (July 12, 2107)
- Army response to MPCA follow-up comments (July 28, 2017)

Based upon our review, you are hereby advised that, in accordance with Chapter XIV of the Federal Facility Agreement, the *Fiscal Year 2016 Annual Performance Report* passes the Consistency Test.

If you have any questions, please contact Tom Barounis at (312) 353-5577 or Amy Hadiaris at (651) 757-2402.

Sincerely,

Amy Hadiaris

Amy Hadiaris, P.G.
Project Manager
Remediation Division
Minnesota Pollution Control Agency

Amy Hadiaris for Tom Barounis
Remedial Project Manager
U.S. Environmental Protection Agency
Region 5

PIKA

ARCADIS

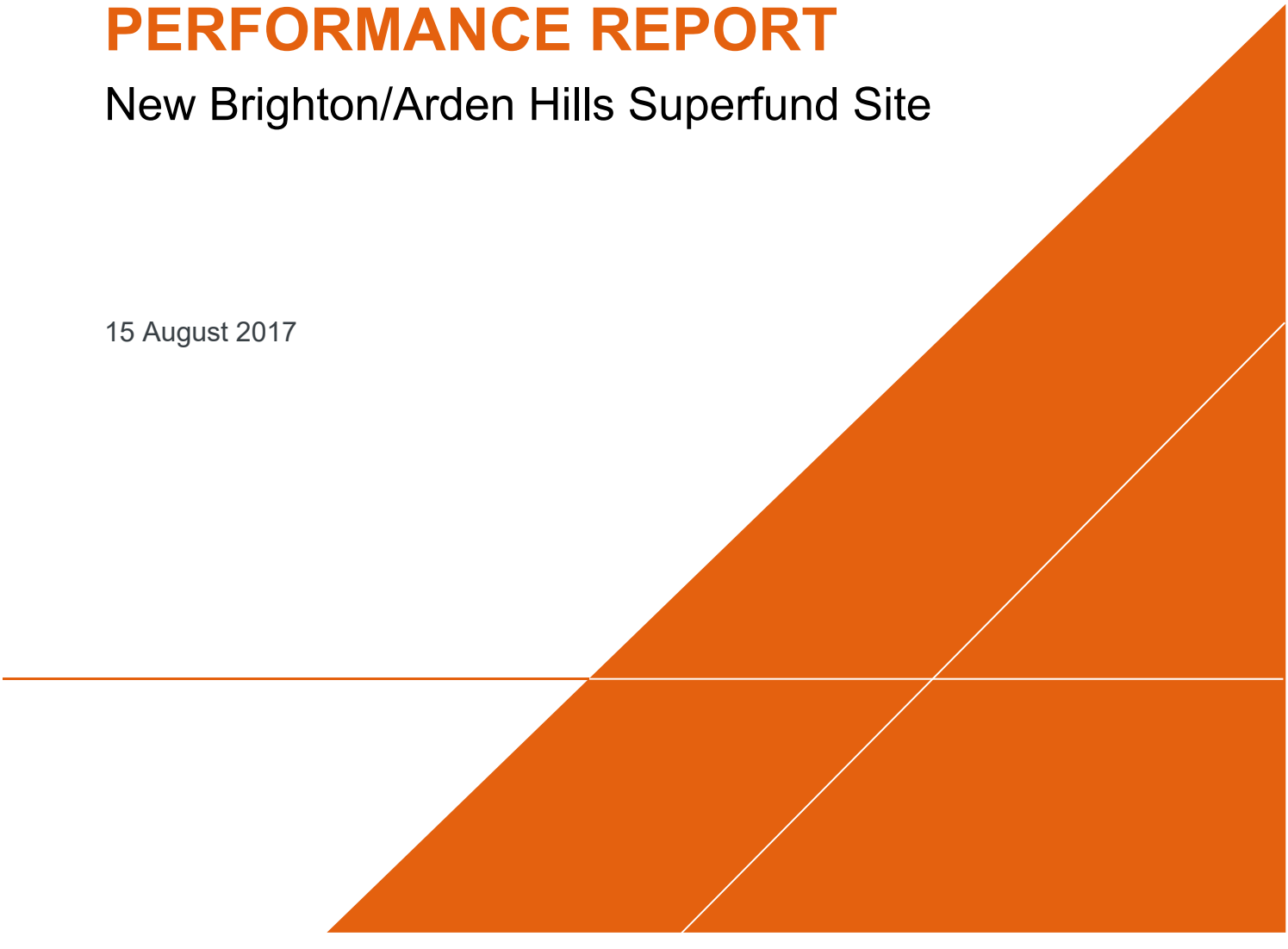
a joint venture

Twin Cities Army Ammunition Plant

FISCAL YEAR 2016 ANNUAL PERFORMANCE REPORT

New Brighton/Arden Hills Superfund Site

15 August 2017



FISCAL YEAR 2016 ANNUAL PERFORMANCE REPORT

New Brighton/Arden Hills Superfund Site

Prepared for:

Commander
Twin Cities Army Ammunition Plant
4761 Hamline Avenue
ATTN: DAIM-BD-TW
Arden Hills, Minnesota 55112

Prepared by:

PIKA Arcadis U.S., Inc. (JV)
430 First Avenue North
Suite 720
Minneapolis
Minnesota 55401
Tel 612 339 9434
Fax 612 336 4538

Our Ref.:

10153006.0001

Date:

15 August 2017

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ACRONYMS AND ABBREVIATIONS

APR	Annual Performance Report
Army	United States Army
AS	air sparging
AWC	area weighted concentration
Barr	Barr Engineering
BGRS	Boundary Groundwater Recovery System
BRAC	Base Realignment and Closure Division
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
COC	contaminant of concern
CRA	Conestoga-Rovers & Associates, Inc. (now GHD)
DNAPL	dense non-aqueous phase liquid
EBS	Environmental Baseline Survey
EE/CA	Engineering Evaluation/Cost Analysis
ESA	Environmental Site Assessment
ESD	Explanation of Significant Difference
EW	extraction well
FFA	Federal Facility Agreement
FS	feasibility study
FY	fiscal year
GAC	granular activated carbon
GOS	TGRS Global Operation Strategy
gpm	gallons per minute
HRL	Health Risk Limits
JV	PIKA Arcadis U.S., Inc. a Joint Venture
LUC	land use control
LUCRD	land use control remedial design
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal

MDH	Minnesota Department of Health
MNA	monitored natural attenuation
MOS	TGRS Micro Operation Strategy
MNARNG	Minnesota Army National Guard
MPCA	Minnesota Pollution Control Agency
MW	monitoring well
NB/AH	New Brighton/Arden Hills
NBCGRS	New Brighton Contaminated Groundwater Recovery System
NBM	New Brighton Municipal
NPL	National Priorities List
OM	Operating Minimum
OS	TGRS Operating Strategy
OU	Operable Unit
OU1	Operable Unit 1
OU2	Operable Unit 2
OU3	Operable Unit 3
OU1TG	OU1 Technical Group
PAR	Performance Assessment Report
PCE	tetrachloroethene
PGAC	permanent granular activated carbon
PGRS	Plume Groundwater Recovery System
PLC	programmable logic controller
PM	preventative maintenance
POTW	Publicly-Owned Treatment Works
PTA	Primer/Tracer area
QAPP	Quality Assurance Project Plan
QC	quality control
ROD	Record of Decision
scfm	standard cubic feet per minute
SDWA	Safe Drinking Water Act
Shaw	Shaw Environmental & Infrastructure, Inc. (formerly Stone & Webster)

SI Report	Summary Report for 135 Primer/Tracer Area Site Inspection Investigation
SRI/FS	Supplemental Remedial Investigation / Feasibility Study
SVE	soil vapor extraction
SWBCA	special well boring and construction area
SWCA	special well construction area
TCAAP	Twin Cities Army Ammunition Plant
TCE	trichloroethene
TGRS	TCAAP Groundwater Recovery System
TWISS	Tecumseh/Wenck Installation Support Services
USACHPPM	US Army Center for Health Promotion & Preventive Medicine
USEPA	United States Environmental Protection Agency
VIC	Voluntary Investigation and Cleanup
VOC	volatile organic compound
Wenck	Wenck Associates, Inc.
WWP	Wet Well Pump
µg/L	micrograms per liter

1 EXECUTIVE SUMMARY

This Fiscal Year (FY) 2016 Annual Performance Report (APR):

- Summarizes the status of remedy implementation, and
- Addresses how the remedies are performing,

for each of the three operable units related to the New Brighton/Arden Hills (NB/AH) Superfund Site. Figure 2-1 shows the approximate locations of the three operable units (OUs). FY 2016 is defined as the period from October 1, 2015 through September 30, 2016.

Records of Decision (RODs) have been signed for each of the three OUs:

- OU1 ROD signed 1993, Amended 2006
- OU2 ROD signed 1997, Amended 2007, 2009, 2012, and 2014
- OU3 ROD signed 1992, Amended 2006

The RODs, and subsequent Amendments and Explanations of Significant Differences (ESDs), present the major components of the final remedies for the media of concern. This report looks at each of the major components and addresses:

1. *Are the remedies being implemented? (Compliance check with the RODs and ROD Amendments)*
2. *Are the remedies doing what they are supposed to?*

Table 1-1 summarizes the status of remedial actions at the end of FY 2016. Following are highlights of the accomplishments for each OU, as well as other activities during FY 2016.

Operable Unit 1 (OU1)

OU1 consists of the “north” plume of volatile organic compound (VOC) groundwater contamination. The final remedy for OU1 consists of pumping from six municipal wells (New Brighton Municipal [NBM] wells NBM #3, #4, #5, #6, #14, and #15) and treating the extracted groundwater through the Permanent Granular Activated Carbon (PGAC) system. Treated water was formerly piped to the New Brighton water supply system for distribution as potable water. Since early summer 2016 New Brighton has made the switch to the City of Minneapolis water system (Mississippi River). Other remedy components include providing alternate water supply and/or well abandonment to affected private wells, and drilling advisories for new well construction. Highlights for FY 2016 are:

- Routine OU1 remedy pumping was ceased on April 15, 2015, with notice to the United States Environmental Protection Agency (USEPA)/Minnesota Pollution Control Agency (MPCA), due to detection of 1,4-dioxane in the Prairie du Chien and Jordan Aquifer municipal wells. Since the PGAC does not remove 1,4-dioxane, New Brighton had switched to preferentially pumping deep aquifer wells that have no detectable 1,4-dioxane while they evaluate the feasibility of 1,4-dioxane removal technologies. They have subsequently switched to using the City of Minneapolis water system. New Brighton will continue to use the City of Minneapolis water system until OU1 pumping is resumed. This has been referred to as a “remedy time-out,” and normal OU1 remedy pumping will not be

resumed until a technology is selected and modification of the New Brighton treatment system is designed and constructed, such that both VOCs and 1,4-dioxane are removed. The Fridley Interconnection was also closed on April 15, 2015. The remedy time-out continued throughout FY 2016.

- The Minnesota Department of Health (MDH) Special Well Construction Area (SWCA) remains in effect. The MDH has the regulatory responsibility to assure that wells constructed in the advisory area meet appropriate well construction and human health requirements. In FY 2016, there were no new recommendations for abandonment or alternate water supply.
- A major sampling event was conducted in FY 2016 due to the detections of 1,4-dioxane. The statistical trend analysis for VOCs, as developed by the OU1 Technical Group, indicates that aquifer restoration is occurring.

Operable Unit 2 (OU2)

OU2 is defined as the area occupied by Twin Cities Army Ammunition Plant (TCAAP) in 1983, when the NB/AH Superfund Site was placed on the National Priorities List (NPL). The remedial action requirements were set forth in the OU2 ROD (1997), ROD Amendment #1 related to Site C-2 (2007), ROD Amendment #2 related to Site I groundwater (2009), ROD Amendment #3 related to various soil sites (2009), ESD #1 related to groundwater (2009), ESD #2 related to various soil sites (2009), ROD Amendment #4 related to Building 102 shallow groundwater, aquatic sites, and various soil sites (2012), and ROD Amendment #5 related to various soil sites (2014). Highlights for activities within OU2 during FY 2016 are:

- Shallow Soil Sites
  - No activities other than ongoing United States Army (Army) implementation of land use controls (LUCs).
- Deep Soil Sites
  - No activities other than ongoing Army implementation of LUCs.
- Site A Shallow Groundwater
  - In accordance with the *Site A Shallow Groundwater: 10-Year Evaluation Report* (Wenck Associates [Wenck] 2008a), and with regulatory approval, the groundwater extraction system was shut down on September 24, 2008 to evaluate monitored natural attenuation (MNA) through abiotic degradation as a potential remedy component in lieu of groundwater extraction and discharge. The groundwater system has remained in stand-by mode in case MNA does not adequately control plume migration and one or more extraction wells need to be restarted. In late 2015, following review of FY 2015 groundwater monitoring results, MNA was deemed an acceptable remedy by the USEPA and MPCA. The Army, USEPA, and MPCA will prepare a ROD amendment in FY 2017 to document the change in this remedy component.
  - Monitoring results from the four contingency wells located along the north side of County Road I did not exceed the approved trigger levels.
  - The MDH SWCA remains in effect. In FY 2016, there were no locations identified in need of well abandonment or alternate water supply.

  - Monitoring wells were sampled to confirm the FY 2015 results which suggested 1,4-dioxane is not present in Site A shallow groundwater. The FY 2016 sampling results were consistent with the FY 2015 results for 1,4-dioxane.

- Site C Shallow Groundwater
  - In accordance with the *Site C Groundwater Extraction System Evaluation Report* (Wenck 2008c), and with regulatory approval, the groundwater extraction system was shut down on November 13, 2008. System operation was ceased because the area of lead concentrations that exceeded the groundwater cleanup level was no longer reaching the extraction wells.
  - Only the monitoring wells located near the source area still exceeded the groundwater cleanup level for lead in FY 2016.
  - None of the groundwater or surface water contingency locations exceeded the approved trigger levels in FY 2016.
  - Continued monitoring is recommended prior to any decision on whether to formally change the remedy to eliminate the groundwater extraction component.
- Site I Shallow Groundwater
  - All Site I Unit 1 monitoring wells were abandoned in FY 2014; therefore, no new groundwater quality data are available to evaluate.
  - Previous investigations indicate the Unit 1 groundwater is discontinuous and does not extend beyond Site I; rather, the Unit 1 contaminants leak downward into Unit 3, which is hydraulically contained by the TCAAP Groundwater Recovery System (TGRS).
  - Monitoring well 01U667 will be reinstalled following redevelopment related grading to occur in the area. soil remediation. The well is scheduled to be reinstalled in 2017, but could be delayed due to the significant extent of grading to be completed.
- Site K Shallow Groundwater
  - At Site K, the groundwater extraction trench and treatment system continued to operate as designed. The system captured and treated 5,861,506 gallons of water and maintained a continuous zone of capture downgradient of the former Building 103. A total of 9.25 pounds of VOCs were removed in FY 2016.
  - Groundwater samples were collected from all eight wells scheduled for sampling in FY 2016. With the exception of relatively stable trichloroethene (TCE) concentrations in 01U615, the overall trend throughout Site K Unit 1 monitoring wells continues to show a gradual decrease in TCE concentrations over the last 20 years of sampling.
  - The extracted water was treated and discharged to Rice Creek in compliance with all discharge criteria except for one sample for zinc and copper in March 2016. The effluent was resampled later in the month and both zinc and copper was below the effluent limit. The reason for the higher zinc and copper concentration was not determined.
  - Fifteen Unit 1 wells at Site K were abandoned as part of the site redevelopment activities in FY 2014; three of these wells are scheduled to be reinstalled in 2017.

  - Consistent with 2015, samples collected in 2016 for 1,4-dioxane contained low concentrations (less than the MDH Health Risk Limit (HRL) of 1.0 micrograms per liter [µg/L]) in Unit 1 wells sampled. A concentration of 9.3 µg/L was reported for Unit 3 well 03U621, but is not related to a release at Site K. Continued 1,4-dioxane monitoring is not recommended for Site K Unit 1 wells.

- Building 102 shallow groundwater
  - VOC concentrations were generally similar to those observed in the prior year.
  - The well adjacent to Rice Creek continued to show that shallow groundwater discharging to Rice Creek was below the cleanup levels for this site.
  - Monitoring wells were sampled to confirm the FY 2015 results which suggested 1,4-dioxane is not present in Building 102 shallow groundwater. The FY 2016 sampling results were consistent with the FY 2015 results for 1,4-dioxane, except at well 01U048, where 1,4-dioxane was detected at 0.15 µg/L, well below the MDH HRL.
- Aquatic Sites
  - No activities other than ongoing evaluation of Round Lake.
- Deep Groundwater
  - The TGRS operated in accordance with the OU2 ROD.
    - The TGRS operated at a rate sufficient to support the conclusion that the 5 µg/L TCE contour is hydraulically contained. In FY 2016, the total extraction well water pumped averaged 1,722 gallons per minute (gpm), which is approximately 1.3% less than the Global Operation Strategy (GOS) Operating Minimum (OM) (1,745 gpm). The GOS OM was based on a 4,000-foot wide 2001 TCE source area plume, which has since been reduced by 25% to a 3,000-foot wide source area plume width. There were five months in which the system didn't operate at the minimum gpm, due to significant required maintenance.
    - In FY 2016, the TGRS extracted and treated approximately 907,577,164 gallons of water. The mass of VOCs removed was 1,731 pounds and is 17 pounds less than that achieved in FY 2015. The total VOC mass removed by the TGRS through FY 2016 is 214,761 pounds.
  - Groundwater analytical data of the source area shows a general decrease in TCE concentration. This demonstrates that the TGRS is effectively removing VOC mass from the aquifer.
  - Effluent VOC concentrations were below contaminant-specific requirements for all sampling events.
  - A majority of the monitoring wells sampled (57 of 81) had 1,4-dioxane concentrations exceeding 1.0 µg/L with the highest concentrations found in the samples at 03U094 (320 µg/L) and 03U021 (112 µg/L).

Operable Unit 3 (OU3)

OU3 consists of the "south" plume of VOC groundwater contamination. Highlights for FY 2016 are:

- OU3 consists of the "south" plume of VOC groundwater contamination. Groundwater monitoring in FY 2016 was conducted during the annual event. Overall, the statistical evaluation indicated stable to declining trends in concentration at the center and edge of the South Plume. In addition, there is evidence of the North Plume mingling with the South Plume at the boundary between the two plumes and perhaps even toward the center of the South Plume.
- Consistent with 2015, the 2016 1,4-dioxane concentrations were low (less than 1.0 µg/L) near the center and eastern side of the OU3 area and higher (greater than 3.0 µg/L) along the western edge. Continued 1,4-dioxane monitoring is recommended for OU3.

Other Investigation and/or Remediation Activities Not Prescribed by a Current ROD

- Round Lake Supplemental Remedial Investigation and Feasibility Study
    - After a series of conference calls held in attempt to resolve the informal dispute between the Army, USEPA, and MPCA regarding the ecological risks and commensurate remedy associated with Round Lake, the EPA Region 5 Federal Facilities Chief and Headquarters Department of Army personnel reached an agreement on September 20, 2016. Per the agreement, a revised draft-final Supplemental Remedial Investigation and Feasibility Study (SRI/FS) for Round Lake will be prepared and submitted to the USEPA and MPCA in the third quarter of FY 2017.

2 INTRODUCTION

2.1 Purpose

This FY 2016 APR is intended to:

- Summarize the status of remedy implementation and
- Address how the remedies are performing

for remedial actions at the NB/AH Superfund Site. FY 2016 extended from October 1, 2015 through September 30, 2016.

The NB/AH Site is divided into three areas designated “OUs.” OU1 encompasses deep groundwater sometimes referred to as the “North Plume.” OU2 includes soil, sediment, surface water, and groundwater contamination in the area that comprised the TCAAP in 1983, when the NB/AH Site was placed on the NPL. OU2 also includes the Site A groundwater plume that extends off the north end of the federally-owned property. OU3 consists of the deep groundwater sometimes referred to as the “South Plume.” Figure 2-1 shows the approximate locations of the three OUs.

RODs have been signed for each of the three OUs:

- OU1 ROD signed 1993, Amended 2006
- OU2 ROD signed 1997, Amended 2007, 2009, 2012, and 2014
- OU3 ROD signed 1992, Amended 2006

The RODs, and subsequent Amendments and ESDs present the major components of the final remedies for the media of concern.

Monitoring activities and submittal of this APR are in fulfillment of the Federal Facility Agreement (FFA) signed in 1987 by the Army, USEPA, and MPCA.

Assessment of performance is answered with two questions:

1. *Are all of the remedies being implemented? (Compliance check with the RODs)*
2. *Are the remedies performing as required?*

To address these two questions, this APR is broken into the three OUs. Using each ROD (along with subsequent modifications), this APR addresses the major components of the selected remedy for each medium. Performance standards are then presented for each of the major remedy components and are used to evaluate when a remedy component has been successfully implemented and/or completed.

For some of the remedy components, the performance standards are clearly defined in the RODs (e.g., soil or groundwater cleanup levels). For other remedy components (e.g., alternate water supply) the performance standards are less clear in the RODs, but may have been agreed to through Work Plans or design documents.

With the performance standards identified, this APR then addresses the two questions described above, often through a series of sub-questions. The questions are written in the text to make this APR focused and user friendly. To the extent possible, answers are in the form of figures, graphs, etc.

In addition to reporting on FY 2016, this APR presents proposed monitoring for future years (Appendix A). Monitoring locations or frequencies that are new in this APR are highlighted in yellow in Appendix A. The monitoring plan covers a moving 5-year time span (i.e., currently FY 2016 through FY 2020 and next year FY 2016 will drop off and FY 2021 will be added).

This APR represents the collaboration of work performed by the Army and Orbital ATK (formerly Alliant Techsystems). On behalf of the Army, PIKA Arcadis U.S., Inc., a Joint Venture(JV) prepared Sections 2.0 through 7.0, 10.0, 11.0 and 14.0 of this APR. On behalf of Orbital ATK, GHD (formerly Conestoga-Rovers & Associates, Inc. [CRA]) prepared Sections 8.0, 9.0, 12.0 and 13.0. JV and GHD both contributed to Section 1.0.

2.2 Brief Overview of TCAAP

TCAAP was constructed between August 1941 and January 1943 in the northern portion of the Minneapolis – St. Paul metropolitan area, in Ramsey County, and is surrounded by the cities of New Brighton, Arden Hills, Mounds View, and Shoreview, Minnesota (Figure 2-1).

TCAAP primarily produced and proof-tested small-caliber ammunition and related materials for the Army. Other uses included manufacture of munitions-related components, handling/storage of strategic and critical materials for other government agencies, and various non-military tenant activities. Production began in 1942 and then alternated between periods of activity and standby related to wars. The last manufacturing operations ceased in 2005.

During periods of activity, solvents were utilized as part of some manufacturing operations. Disposal of solvents and other wastes at the TCAAP property resulted in soil and groundwater contamination, which has migrated beyond the original TCAAP boundary. Groundwater contamination was first discovered in July 1981, which led to investigation of the soil and groundwater on and off the TCAAP property. It was determined that TCAAP was the source of contamination, and the TCAAP property and area of affected groundwater contamination was placed on the NPL in 1983 as the NB/AH Superfund Site.

Several known and potential contaminant source areas were initially identified on the TCAAP property (OU2): Sites A, B, C, D, E, F, G, H, I, J, K, 129-3, 129-5, and 129-15 (see Figure 2-2 for locations). The 1997 OU2 ROD specified requirements for all of these sites except Site F (which was addressed under RCRA prior to 1997) and Site J (a sewer line that was determined not to have a release of contamination). Other areas have also undergone investigation and/or remediation, namely the Grenade Range, Outdoor Firing Range, Trap Range, 135 Primer/Tracer Area (PTA) (and adjacent stormwater ditch), 535 PTA, Water Tower Area, Environmental Baseline Survey (EBS) Areas, and Building 102. These areas are also shown on Figure 2-2.

Since 1983, when the NB/AH Site was placed on the NPL, the size of TCAAP has periodically shrunk due to property transfers. Some property has been transferred out of federal-ownership to Ramsey County and the City of Arden Hills. Other property is still owned by the federal government, but control has been reassigned to the Army Reserve or the National Guard Bureau. The National Guard Bureau has licensed the property it controls to the Minnesota Army National Guard (MNARNG). Figure 2-3 shows the property

presently under federal ownership, along with the organizations responsible for control. The majority of the remaining TCAAP property that was controlled by the Base Realignment And Closure (BRAC) Division of the U.S. Army was transferred to Ramsey County in 2013 for redevelopment. The minimal remaining TCAAP (BRAC-controlled) property is currently in the process of being transferred out of federal ownership. It is likely that within the next few years, there will no longer be an organization or property called TCAAP. These property transfers do not alter the responsibilities of the Army under the FFA.

2.3 Hydrogeologic Units and Well Nomenclature

For purposes of studies and work related to the NB/AH Superfund Site, four hydrogeologic units have been designated: Unit 1 through Unit 4. Descriptions of these four units are presented in Appendix B, along with a description of the nomenclature system used for well designations (e.g., 03U704). A well-designation cross-reference guide is included in Table B-1 in Appendix B. The well index includes all wells that are owned by or have been used by the Army in the past to gather groundwater elevation or water quality data, sorted by Minnesota unique number. Well information in this appendix includes the Army designation (IRDMIS number), Minnesota unique number, and any other name(s) the wells may have. Appendix B also includes information about each well. Locations of wells that are included in the monitoring plan are shown on Figure B-2 (OU1/OU3 wells) and Figure B-3 (OU2 wells) in Appendix B. With a known well name, the location of that well can be identified using the “Edit, Find” or “Edit, Search” function and typing in the well name, which will highlight the desired well name on the figure. Available information concerning a well, including well logs and other information, can be viewed in the Appendix B Attachment, which is sorted by Minnesota unique number.

See the instructions in the Appendix B attachment for more information on using Appendix B.

2.4 Data Collection, Management, and Presentation

Performance monitoring data were collected in accordance with the:

- FY 2016 Monitoring Plan for Groundwater Monitoring Wells;
- FY 2016 Monitoring Plan for Remedial Treatment Systems;
- FY 2016 Monitoring Plan for Surface Water; and
- New Brighton Water System Sampling and Analysis Plan.

Data were collected principally by three parties: Wenck on behalf of the Army; GHD on behalf of Orbital ATK; and Barr Engineering (Barr) on behalf of the City of New Brighton. Appendix C presents information on data collection, management, and presentation. Data tables are presented following the text and are organized according to the sections in which they are mentioned. The comprehensive groundwater level and groundwater quality databases from 1987 through FY 2016 are contained in Appendix D.1.

Are the data complete and representative (are we making decisions based on complete and technically-sound information)?

Yes. The data were collected in accordance with the FY 2016 Monitoring Plan. Data were collected, verified, and validated in accordance with Quality Assurance Project Plan (QAPP) for Performance

Monitoring (Wenck 2015b) and QAPP Addendum #1 (Wenck 2016b), which clarifies the data validation requirements specified in the performance monitoring QAPP.

The data tables in the various report sections and the comprehensive water quality databases (Appendix D.1) show the data qualifiers assigned to the data as a result of data verification and/or data validation. The data qualifiers assigned to FY 2016 data are explained in the footnotes of the data tables in the various report sections. Data verification (performed on 100% of the data) and data validation (performed on 100% of 1,4-dioxane data and a minimum of 10% of the data, except at Site K) were provided to the USEPA and MPCA via submittal of quarterly Data Usability Reports covering the data collected in FY 2016. The final MPCA/USEPA approval letter for the FY 2016 Data Usability Reports is included in Appendix C.3.

Regarding completeness, Appendix C.2 summarizes any deviations from the FY 2016 Monitoring Plan. There were substantial changes in FY 2016, primarily due to emergence of the 1,4-dioxane issue in early 2015. The field and laboratory completeness goals for performance monitoring are both 95%, except for TGRS effluent, Site K effluent, and well inventory samples, for which the field and laboratory completeness goals are 100%. Apart from two missed 1,4-dioxane samples due to a broken bottle, and one missed sampling location due to a stuck sampling pump, actual field and laboratory completeness were both 100%, meeting the overall completeness goals (wells that were dry, frozen, or inoperative were not considered as missed samples, nor were well inventory locations where the well owner refused sample collection or was nonresponsive). Also, the actual field and laboratory completeness for the subset of samples with 100% completeness goals was 100%, meeting this goal.

Regarding quality control (QC) samples, the QAPP and Addendum #1 specify that field duplicates, equipment rinse blanks, and matrix spike/matrix spike duplicates are to be collected at overall frequencies of 10%, 10%, and 5%, respectively. Actual QC sample frequencies met these goals, with respective frequencies of 17%, 11% and 5% for VOCs and 15%, 12%, and 5% for 1,4-dioxane in the performance monitoring.

With regard to data validation, the performance monitoring QAPP Addendum #1 specifies that data validation be completed at an overall rate of 10%, with 100% validation of 1,4-dioxane data and well inventory samples. Prior to Addendum #1, which took effect for samples collected on or after June 1, 2016, the performance monitoring QAPP stated that 100% of all data would be validated, except no validation was required for Site K analytes that are not Site K contaminants of concern (COCs) per the QAPP. The actual validation rate for VOCs far exceeded 10%, and all data requiring 100% data validation were fully validated, meeting the specified validation rates for performance monitoring.

The data for FY 2016 are deemed to be representative and meet data quality objectives based on: 1) adherence to QAPP-specified sampling and laboratory analytical procedures; 2) completion of data verification and data validation; and 3) comparability to historical results (any substantial deviations from historical and/or anticipated results are discussed within the site-specific sections of this APR).

3 OPERABLE UNIT 1: DEEP GROUNDWATER

The reference for the OU1 ROD is:

RECORD OF DECISION
Groundwater Remediation
Operable Unit 1
At New Brighton/Arden Hills Superfund Site
1993, Amended 2006

The 2006 ROD amendment formalized the adoption of the statistical analysis of groundwater quality presented in the APRs since FY 2003.

Following are the six primary elements of the amended ROD, with the changed elements shown in italics:

1. Providing alternate water supplies to residents with private wells within the North Plume.
2. Implementing drilling advisories that would regulate the installation of new private wells within the North Plume as a SWCA.
3. *Extracting groundwater from the North Plume using the New Brighton Contaminated Groundwater Recovery System (NBCGRS), subject to the following:*
    a. the initial aggregate groundwater extraction rate shall be consistent with the long-term operating history of the NBCGRS;
    b. future decreases in the aggregate extraction rate shall be determined by the Army, USEPA, and MPCA using a transparent public process and rational engineering, scientific, and economic analyses at least as rigorous as those employed in the FS that was the basis for the original remedy selection;
    c. future changes to the aggregate or individual well extraction rates shall be made to assure that the rate of restoration of the aquifer will not be slowed or result in a duration of remedy longer than was contemplated by the original ROD;
    d. the facilities comprising the NBCGRS may be modified as necessary to assure the restoration of the full areal and vertical extent of the aquifer in a timeframe as contemplated in 3.c, above.
4. Pumping the extracted groundwater to the PGAC Water Treatment Facility in New Brighton for removal of VOCs by a pressurized granular activated carbon (GAC) system.
5. Discharging all treated water to the New Brighton municipal distribution system.
6. *Monitoring the groundwater to verify effectiveness of the remedy through measurement of overall plume shrinkage (geographically) and decreasing contaminant concentrations*.

The last requirement (No. 6) is met by evaluating the groundwater chemical data according to statistical methods contained in the *OU1 Technical Group Technical Memorandum Statistical Evaluation Method For Water Quality Data, Operable Unit 1*, dated December 2004 (and any subsequent addendums or revisions approved by the USEPA and MPCA). The statistical analysis is conducted annually and is reported in the Annual Performance Reports.

Groundwater extraction was provided by six municipal wells: NBM #3, #4, #5, #6, #14, and #15. The extracted water was treated in the PGAC treatment facility for removal of VOCs, and was then formerly used as part of the municipal water supply. NBM #3 through #6 were pre-existing wells. NBM #14 and NBM #15 began pumping in December 1996 and March 1998, respectively.

The remedy also relies on provision of an alternate water supply and/or well abandonment, as necessary, to manage risks for existing private water supply wells, and LUCs (drilling advisory) to prevent new water supply wells from being constructed into the affected portion of the aquifer. The City of New Brighton now relies on the City of Minneapolis water system as an alternate source, although this is a result of the combined pressures of impacts and increasing water demand as described below.

The OU1 remedy encountered a new and substantial issue in FY 2015 that has continued to affect remedy performance in FY 2016. In early 2015, the City of New Brighton was notified by the MDH that an emerging contaminant, 1,4-dioxane, had been detected in New Brighton's water supply. All NBCGRS wells extract groundwater from the Prairie du Chien and/or Jordan Aquifers (Upper and Lower Unit 4, respectively). 1,4-Dioxane can be present in some chlorinated solvents as a stabilizer, as well as other manufactured products. Confirmation sampling conducted by the city confirmed the presence of 1,4-dioxane in all NBCGRS wells, with detections ranging up to 6.8 µg/L. The city also sampled all their deeper aquifer municipal wells (Mt. Simon Aquifer) and found no detectable 1,4-dioxane. There is no federal drinking water standard for 1,4-dioxane; however, there is a state (MDH) HRL of 1 µg/L, and most of the NBCGRS wells were found to exceed this limit. Routine pumping of the NBCGRS was then ceased on April 15, 2015, with notice to the USEPA/MPCA. The Fridley Interconnection was also closed on April 15, 2015. Because GAC treatment does not remove 1,4-dioxane, the city switched to preferentially pumping their deep aquifer wells that have no detectable 1,4-dioxane while they evaluate the feasibility of 1,4-dioxane removal technologies. This has been referred to as a "remedy time-out," and normal pumping of the NBCGRS will not resume until a technology is selected and modification of the NBCGRS is designed and constructed, such that both VOCs and 1,4-dioxane are removed. The deep aquifer wells could not sustain enough production to meet water demand resulting in a switch to an alternate water supply in early summer 2016. The City of New Brighton is now using the City of Minneapolis water system and will continue its use until OU1 pumping can resume. Normal pumping of the NBCGRS was not resumed in FY 2016, as an acceptable remedial technology has not yet been implemented. However, a pilot study report for Advanced Oxidation Technology for treatment of 1,4-dioxane was completed in August 2016. Additionally, though not in FY 2016, it should be noted that a preliminary design review was held with the Army and Regulators in December 2016.

The six major components of the remedy prescribed by the amended ROD are evaluated in the following sections, including discussion of the effects of the remedy time-out noted above.

3.1 Remedy Component #1: Alternate Water Supply/Well Abandonment

Description: "Providing an alternative water supply to residents with private wells within the North Plume." (OU1 ROD, page 2)

- Clarified by the *OU1 Alternate Water Supply Plan* (Montgomery Watson 1995) to delete "residents with" because the remedy applies to other wells in addition to residential wells. The plan also lists the criteria for identifying the wells that are eligible for an alternate water supply.
- Clarified by the *OU1 Alternate Water Supply Plan* to also include well abandonment.
- Clarified by the *OU1 Alternate Water Supply Plan* (page i-2) to also encompass OU3 and the OU2 Site A shallow groundwater plume.

Performance Standard (how do you know when you're done):

For alternate water supply, when the owners of all wells that meet all the following criteria have been offered and provided with an alternate water supply (or when the well owners have rejected the offers):

i. The well is located within the area affected by groundwater plumes that originate at OU2, as shown on Figures E-2 and E-3 in Appendix E; and

ii. The well is completed in an affected aquifer; and

iii. The well contains detectable concentrations of the NB/AH Superfund Site-related COCs identified on page 18 of the OU1 ROD (or page 26 of the OU3 ROD, or Table 1 of the OU2 ROD, as appropriate for the well location); and

iv. The well is used in a manner to cause exposure (uses are defined in the *OU1 Alternate Water Supply Plan*); and

v. The well owner does not already have an alternate water supply.

If eligible well owners refuse the offer to have an alternate water supply provided, this also satisfies the performance standard.

For well abandonment, when the owners of all wells that meet all the following criteria have been offered and provided abandonment (or when the well owners have rejected the offers):

i. The well is located within the area affected by groundwater plumes that originate at OU2; and

ii. The well is completed in an affected aquifer; and

iii. The well contains detectable concentrations of the NB/AH Superfund Site-related COCs identified on page 18 of the OU1 ROD (or page 26 of the OU3 ROD, or Table 1 of the OU2 ROD, as appropriate for the well location); and

iv. The well was constructed prior to the MDH SWCA advisory; and

v. The well is being used by the well owner or use was discontinued due to contamination; and

vi. The well is used in a manner to cause exposure (uses are defined in the Alternate Water Supply Plan).

If eligible well owners refuse the offer for abandonment, this also satisfies the performance standard. An exception to abandonment would be if the well is needed for groundwater monitoring.

Also, note that per Appendix E, program requirements for both alternate water supply and well abandonment have been clarified such that a well should contain an exceedance of a cleanup level (or an additivity of 1.0, similar to the MDH Hazard Index calculation), rather than merely "detectable

concentrations" as noted above. On a case-by-case basis, review by the Army, USEPA, and MPCA could lead to an Army offer for alternate water supply and/or well abandonment for a given well with detectable concentrations that do not exceed a cleanup level (or additivity criteria), particularly if that well is used to supply drinking water.

Is this remedy component being implemented?

Yes. The Alternate Water Supply and Well Abandonment Program has been implemented and is an ongoing program maintained by the Army. The process of identifying wells eligible for alternate water supply and/or abandonment is accomplished by maintaining a "well inventory" (information on the well inventory is presented in Appendix E). The well inventory is a database that was initially developed in 1992 and has been periodically updated since then (now annually as part of the APR. For the purposes of the well inventory, a study area was established to encompass the groundwater plume (the study area boundary is the same as the MDH SWCA). The well inventory is intended to include all wells within the study area. Within the study area, areas of concern are defined by the edge of the groundwater plume, plus additional buffer area. The wells are grouped into categories based on factors such as location relative to the area of concern, type of use, active/non-active status, sealed, etc. Wells in categories with the potential to be impacted are periodically sampled to see if they qualify for alternate water supply and/or abandonment.

Thus, maintenance of the well inventory consists of the following tasks:

1. Check if the area of concern needs to be adjusted based on the extent of contamination,
2. Check if there are any previously unknown wells to be added to the database (in coordination with the MDH as described in Appendix E),
3. Sample wells on a prescribed schedule,
4. Take the appropriate course of action depending on the results,
5. Update the well inventory database with any new information (e.g., water quality results, owner information, construction information, well re-categorizing),
6. Report findings in the APR.

The following questions and answers summarize developments since the last APR with respect to OU1.

Did the area of concern within OU1 change during FY 2016, as defined by the 1 µg/L contour line?

No, the area of concern (the 1 µg/L contour line) did not change during FY 2016, except for a slight northward shift in the Upper Unit 4 contour line on the north side due to increases in TCE concentrations in wells 04U855, 04U879, and 04U839. The well inventory study area encompasses the FY 2016 area of concern.

Were any additional water supply wells discovered within the area of concern for OU1 that are completed within an aquifer of concern?

Yes. (see Appendix E for additional information).

Were any water supply wells within the area of concern for OU1 sampled during FY 2016 (outside of those included in the OU1 performance monitoring plan)? If yes, what were the findings?

Yes. Ten water supply wells within the area of concern for OU1 were sampled during FY 2016. Some water supply wells that were scheduled to be sampled in FY 2016 were not sampled because the well owner refused to provide access or did not respond to the request for access. Of the ten wells sampled, all were non-detect for VOCs, except 1,2-dichloroethane was detected below the MDH HRL at unique well number 200523, which is used for pond refilling at Windsor Green Association townhomes. Six wells had detections of 1,4-dioxane, four of which were below the MDH HRL of 1 µg/L, and two above the MDH HRL. The uses of the four wells with detections below MDH HRL are below:

107405 4355 Old Hwy 10 (Domestic)

200180 Town & Country Golf Course (Irrigation)

200523 Windsor Green South (Pond refilling)

249007 4453 Old Hwy 10 (Domestic)

Additionally, 1,4-dioxane was detected above the MDH HRL at unique well number 537801 in FY 2015. This well was targeted for resampling in FY 2016; however, despite initial approval to sample, no subsequent communication was received from the owner despite numerous follow up attempts. None of the wells at which 1,4-dioxane was detected above the MDH HRL are utilized for consumption purposes. Their uses are listed below:

206761 Brightwood Hills Golf Course (Irrigation)

234421 BioClean Industrial Use (Truck Washing)

537801 Midway Industrial Irrigation

Were any well owners offered an alternate water supply and/or well abandonment during FY 2016? No; however due to detections of 1,4-dioxane above the MDH HRL, it is recommended that the Army offer alternate water supply and well abandonment for wells 206761 and 234421.

For OU1, are there any well owners that meet the criteria, but have not yet been provided an alternate water supply? No.

For OU1, are there any wells that meet the criteria, but have not yet been abandoned? No.

Is any sampling of water supply wells (excluding those included in the OU1 performance monitoring plan) proposed prior to the next report?

No. FY 2017 is not a scheduled sampling event for well inventory wells, as shown in Appendix A.1. The next major sampling event for well inventory wells is scheduled for FY 2020.

Are there any changes or additional actions required for this remedy component? No.

3.2 Remedy Component #2: Drilling Advisories

Description: “Implementing drilling advisories that would regulate the installation of new private wells within the North Plume as a SWCA.” (OU1 ROD, page 2)

Performance Standard (how do you know when you’re done):

For initial implementation, when the MDH has issued a SWCA Advisory. Implementation will continue until such time that the groundwater concentrations are below the cleanup levels.

Has the MDH issued a SWCA Advisory?

Yes. It was issued in June 1996. In addition to covering OU1, the SWCA also encompasses OU3 and all of OU2 as of April 2016. In June 1999, the MPCA requested that the MDH extend the boundary of the SWCA further to the southwest to the Mississippi River and Marshall Avenue to ensure that the southern boundary fully encompassed the plume. The MDH revised the SWCA in December 1999. The current boundary is shown on Figure E-1 (Appendix E).

Are any changes or additional actions required for this remedy component? No.

3.3 Remedy Component #3: Extract Groundwater

Description: Extracting groundwater from the North Plume using the NBCGRS, subject to the following:

1. The initial aggregate groundwater extraction rate shall be consistent with the long-term operating history of the NBCGRS;
2. Future decreases in the aggregate extraction rate shall be determined by the Army, USEPA, and MPCA using a transparent public process and rational engineering, scientific, and economic analyses at least as rigorous as those employed in the FS that was the basis for the original remedy selection;
3. Future changes to the aggregate or individual well extraction rates shall be made so as to assure that the rate of restoration of the aquifer will not be slowed or result in a duration of remedy longer than was contemplated by the original ROD;
4. The facilities comprising the NBCGRS may be modified as necessary to assure the restoration of the full areal and vertical extent of the aquifer in a timeframe as contemplated in 3.c, above." (2006 OU1 ROD Amendment, page 5-2 & 5-3)"

Through January 2008, the remedy component consisted of recovering deep (Unit 4) groundwater using three primary City of NBM wells (NBM #4, #14, and #15) with three alternate wells (NBM #3, #5, and #6). NBM #3 and #4 were existing wells completed in both the Prairie du Chien and Jordan. NBM #5 and #6 were existing wells completed in the Jordan. NBM #14 and NBM #15 were constructed in the Prairie du Chien as part of the remedy and began pumping in December 1996 and March 1998, respectively. The locations of the recovery wells are shown on Figure 3-1.

The extracted groundwater is used as part of the New Brighton water supply system (except during the current remedy time-out), and as such, New Brighton took the lead on design and construction of the system, and is responsible for operation of the system. New Brighton contracted Barr to provide design and construction oversight services. The federal government is paying for the OU1 remedy.

In 2006, New Brighton proposed to the Army modifying the agreement between the two parties to allow more flexibility in how they operate the NBCGRS, and to increase removal of contaminant mass from the aquifer. In November 2007, the USEPA and MPCA provided consistency approval of the revised pumping rates. Appendix A.5 (Table D-1 and Table D-2 from the settlement agreement between the Army and New Brighton) presents the new pumping rates in effect as of January 2008.

The revised pumping approach does not affect the approved statistical analysis used to evaluate the effectiveness of the remedy as set forth by the OU1 ROD Amendment. The Army has made it clear to New Brighton that if the changes cause statistical evaluation results that are not in compliance with the OU1 ROD Amendment, the pumping allocations will revert to the previous scheme.

Performance Standard (how do you know when you're done):

When the NBCGRS is operating consistent with long-term NBCGRS operating rates.

During FY 2016, did the OU1 extraction system operate per the New Brighton operational plan and consistent with past operations?

No. Due to detections of 1,4-dioxane in the NBCGRS wells, the NBCGRS was shut down on April 15, 2015, including the Fridley Interconnection. Based on past operations, the target average daily pumping rate is 3.168 million gallons per day as shown in Appendix A.5. In FY 2016, the NBCGRS was in a remedy time-out and no water was pumped from the wells. Hence, the pumping in FY 2016 did not meet the pumping target during this remedy time-out period.

Are any changes or additional actions required for this remedy component?

Yes. The City of New Brighton will continue with their process of selecting a 1,4-dioxane removal technology, and then designing and constructing the modifications to the treatment system so the groundwater extraction remedy component can be resumed.

3.4 Remedy Component #4: Removal of VOCs by GAC

Description: "Pumping the extracted groundwater to the PGAC Water Treatment Facility in New Brighton for removal of VOCs by a pressurized GAC system." (OU1 ROD, page 2)

Treatment by the PGAC (along with iron and manganese removal and chlorination) makes the recovered groundwater suitable for municipal drinking water purposes. The PGAC is located approximately one-third mile south of Interstate 694 near Silver Lake Road. The City of New Brighton is responsible for operation and maintenance of the PGAC, with cost reimbursement from the Army for the operations related to the remedy.

Performance Standard (how do you know when you're done):

When the treated water meets the Maximum Contaminant Levels (MCLs) and non-zero Maximum Contaminant Level Goals (MCLGs) established by the Safe Drinking Water Act (SDWA) for the chemicals of concern, as identified on page 18 of the OU1 ROD.

Did the treated water meet the MCLs and non-zero MCLGs established by the SDWA for the OU1 chemicals of concern?

Not applicable. As the NBCGRS did not operate in FY 2016, no treated water samples could be collected and evaluated for compliance with the performance standard. The system was shut down on April 15, 2015 due to detections of 1,4-dioxane in the NBCGRS wells. There is no federal MCL or MCLG for 1,4-dioxane; however, there is a state (MDH) HRL of 1 µg/L that was exceeded in most of the NBCGRS wells (with detections up to 6.8 µg/L). Because GAC is not effective for removal of 1,4-dioxane, the PGAC does not provide an adequate level of treatment. Therefore, the NBCGRS wells were not utilized for water

supply during FY 2016. Some very limited pumping of the wells occurred for non-supply plant operations (e.g., filter backwashing).

Is any sampling of the treated water proposed prior to the next report?

When needed, given the limited pumping during the remedy time-out, sampling will continue to be performed by the City of New Brighton or their contractor.

Are any changes or additional actions required for this remedy component?

Yes. The City of New Brighton will continue with their process of selecting a 1,4-dioxane removal technology, and then designing and constructing the modifications to the treatment system so the water treatment remedy component can be resumed. Note that this remedy component will eventually need to be modified in a ROD amendment or ESD such that "removal of VOCs by GAC" will become "removal of VOCs and 1,4-dioxane by [the selected treatment technology]."

3.5 Remedy Component #5: Discharge of Treated Water

Description: "Discharging all of the treated water to the New Brighton municipal distribution system" (OU1 ROD, page 2).

Performance Standard (how do you know when you're done):

When the connection to the New Brighton municipal supply system has been completed and water is being discharged.

Is the treated water being discharged to the New Brighton municipal distribution system? No. Due to detections of 1,4-dioxane in the NBCGRS wells, the NBCGS was shut down in FY 2015. No water was treated or discharged through the PGAC system in FY 2016.

Are any changes or additional actions required for this remedy component?

Yes. The City of New Brighton will continue with their process of selecting a 1,4-dioxane removal technology, and then designing and constructing the modifications to the treatment system so the treated water discharge remedy component can be resumed.

3.6 Remedy Component #6: Groundwater Monitoring with Verification of Continuing Aquifer Restoration

Description: "Monitoring the groundwater to verify the effectiveness of the remedy through measurement of overall plume shrinkage (geographically) and decreasing contaminant concentrations" (2006 OU1 ROD Amendment, page 5-3).

Performance Standard (how do you know when you're done):

When performance groundwater monitoring verifies aquifer restoration.

Is this remedy component being implemented?

Yes. Performance monitoring programs have been established to collect the data required to verify the effectiveness of remedy components #1 through #6. Table 3-1 summarizes the performance monitoring requirements, implementing parties, and the specific documents that contain the monitoring plans.

Were the groundwater monitoring requirements for this remedy met?

Yes. FY 2016 was a "major" sampling year for the groundwater monitoring wells. Also, with the detection of 1,4-dioxane in the NBCGRS wells, the USEPA and MPCA requested that the Army analyze groundwater samples for 1,4-dioxane at all scheduled OU1 sampling locations during the summer FY 2016 sampling event. The USEPA and MPCA also requested that the list of wells to be sampled in a "major" well inventory sampling event be completed in June of FY 2016 (ten water supply wells within the area of concern for OU1 were sampled, as discussed previously) and select OU1 wells be sampled in January 2016 for VOCs and 1,4-dioxane. All the required and requested sampling was completed.

Is any groundwater monitoring proposed prior to the next report?

Yes, including the following:

When operating, monthly monitoring of the extraction wells and treatment system effluent is performed by the City of New Brighton in accordance with the "New Brighton Water System Sampling and Analysis Plan," June 1997. However, the OU1 extraction system is not anticipated to be restarted within FY 2017 and therefore no such monitoring is anticipated to occur.

Other groundwater monitoring will be in accordance with the Groundwater Monitoring Plan included as Appendix A.1. Because a "major" sampling event was conducted in FY 2016, a "minor" event is now scheduled for FY 2017, which was previously a "major" event year. Given the arrival of the 1,4-dioxane issue in FY 2015, the Army conducted a "major" sampling event in June and July of FY 2016 (in essence repeating the FY 2015 sampling event), to include both VOC and 1,4-dioxane analyses at all sampling locations. FY 2016 would otherwise have been a "minor" sampling event. The next "major" performance monitoring event will be in FY 2018. The next "major" well inventory sampling event is scheduled for FY 2020.

Does groundwater monitoring show aquifer restoration is occurring?

Yes. Trend graphs for TCE concentrations in NBM #3, #4, #5, #6, #14, and #15 are shown in Figure 3-2. The trend graphs only show data through April 2015, as the wells were shutdown at that time following detection of 1,4-dioxane, and samples have not been collected since. No groundwater samples were collected from the NBM wells in FY 2016. Historical water quality values for the wells can be found in Appendix D. At both NBM #3 and NBM #4, TCE concentrations significantly decreased between the start of pumping and 1998, increased slightly until approximately 2010, and have been relatively stable to slightly decreasing since then. At NBM #5, the TCE concentration appears to be relatively stable since 2013, after earlier decreases. At NBM #6, the TCE concentration also appears to be relatively stable since 2013, with a gradually declining trend overall. At NBM #14, the TCE concentration remained at or below the cleanup level for OU1 (5 µg/L), except for the April 2015 sampling event. At NBM #15, after earlier declines, the TCE concentration trend appeared to be relatively stable since 2009; however, it appears to be trending slightly upward in FY 2015. Overall, the water quality data from the extraction wells support the interpretation that the system is providing aquifer restoration.

Figure 3-3, Figure 3-4, and Figure 3-5 show the TCE plumes in the Upper Unit 3, Lower Unit 3, and Upper Unit 4 portions of the aquifer for FY 2016, along with cross-section lines, based on the summer 2016 sampling event. Cross-sections showing the plumes are presented in Figure 3-6, Figure 3-7, and Figure 3-8. These figures show both the OU1 and OU3 plumes, which overlap to some extent and should be viewed together. Figure 3-1 shows the 1 µg/L TCE contour for Upper Unit 4 in 1990, 1999, 2009, and 2016 to help illustrate how the edge of the plume has changed over this time. Figure 3-9 shows how the 100 µg/L TCE contour in Upper Unit 4 has changed over the same period. In general, the plumes show "no trend" or stable concentrations (see the statistical analysis below); as Figure 3-1 and Figure 3-9 show, the plume foot print remains similar to 2009. A slight northward shift of the 1 µg/L TCE contour, north of the NBCGRS, can be seen on the northwest edge of the plume, likely a result of the NBCGRS remedy time-out since April 2015. This shift was first observed following the FY 2015 sampling event and was observed slightly farther north again in FY 2016. Additional sampling will be needed to see if the trend continues, and to see if the west edge of the plume in areas south of the NBCGRS also begin to show a shift. The water level data from June 2016 for Upper Unit 4 are presented as a potentiometric map on Figure 3-10.

The *OU1 Technical Group Technical Memorandum Statistical Evaluation Method for Water Quality Data, Operable Unit 1* (Army 2004) was prepared to develop statistical methods specifically selected to evaluate the long-term progress of remediation, plume evolution, and aquifer restoration in OU1. The OU1TG states the objective of the statistical evaluation as follows:

"Verify progress in cleanup of the plume through measurement of overall geographic plume shrinkage and decreasing contaminant concentrations."

The OU1TG identified five issues that need to be statistically addressed, now and over time, to achieve this objective:

1. Measure changing concentrations immediately downgradient of the TGRS, as this area is the first to be affected by any potential escape of contaminants from TCAAP.
2. Measure changes in the geographical size of the plume over time.
3. Measure changes in concentrations immediately downgradient of the NBCGRS, as this is the first area to be affected by any potential escape of contaminants from NBCGRS capture.
4. Measure any unforeseen changes in plume configuration. This addresses the possibility that changing flow patterns may cause a shift in the plume but not necessarily any change in size. A plume shift may require a redistribution of pumping.
5. Measure the long-term trends in overall VOC concentrations (as an indicator of contaminant mass). This provides an overall picture of remedial progress.

The OU1TG developed a series of five well groups designed to address each of the issues listed above. For each group, the appropriate statistical tools were specified and the statistical response threshold was identified that would trigger closer scrutiny by the Army and regulators (USEPA and MPCA). Appendix D.2.1.8 shows the factors to consider and potential additional actions that may be implemented if statistical threshold is triggered. As Appendix D.2.1.8 shows, a threshold trigger initiates a closer look at the data and the context of the data in terms of remedy performance or potential risk. A threshold trigger

does not automatically require any specific action. The five groups, corresponding to the five issues discussed above, are:

Group 1: Downgradient of the TGRS. This zone is the area downgradient of the TGRS capture zone. This zone should show overall reductions over time in response to TGRS mass removal and containment. However, it is also the stagnation zone of the TGRS so groundwater velocities are reduced and response may be slow. Furthermore, individual wells near the stagnation zone may show increases in contaminant concentrations during some points in time, as the plume shifts in response to changes in pumping.

Group 2: Plume Edge Wells. This zone includes wells that define the edges of the plume downgradient of the TGRS. These are wells with low concentrations of VOCs (<100 µg/L) that will indicate a reduction in overall plume size if VOC concentrations continue to decline.

Group 3: Downgradient Sentinel Wells. This is a zone downgradient of the NBCGRS stagnation zone. This group includes three wells but more accurately is defined as a geographic area immediately downgradient of the NBCGRS. This group should help demonstrate improvement due to the VOC mass removal by the NBCGRS over time, analogous to Group 1 and the TGRS.

Group 4: Lateral Sentinel Wells. These are “clean” wells downgradient of the TGRS that are beyond the current plume boundaries. These wells should help identify large, unexpected, lateral changes in plume configuration, such as a shifting or expansion of the plume boundary.

Group 5: Global Plume Mass Wells. This group includes all the monitoring wells necessary to construct a contour map of the VOC plume. Production wells are not used in Group 5 since the data may not be comparable to monitoring well data. Some wells located within OU2 are included in Group 5 to support the contouring near the OU2 boundary. This group reflects the overall VOC mass in the aquifer and should show an overall reduction in VOC mass over time.

In October 2005, the Army received a consistency determination on Modification #1 to**:** *OU1 Technical Group Technical Memorandum Statistical Evaluation Method for Water Quality Data, Operable Unit 1*, prepared by the Army, dated December 2004. This modification created well Group 6 to address the Jordan portion of the Unit 4 aquifer.

Group 6: Jordan Wells. The group includes all Jordan monitoring wells, the Prairie du Chien wells nested with them, and NBM Wells #3, #4, #5, and #6. The inclusion of the Prairie du Chien wells is to facilitate comparing the trends between it and the Jordan at these locations. This group will help identify any changes in the plume occurring in the Jordan portion of the aquifer.

Additional detail on the well groups and analysis is presented in the OU1 Technical Memorandum, Modification #1 and Appendix D.2.

FY 2016 was a major sampling year; therefore, new comprehensive plume mapping was completed based on the summer sampling event (Figures 3-3 through 3-8). Table 3-2 presents the FY 2016 groundwater quality data for OU1. These data were collected to support the statistical analysis developed by the OU1TG. Historical TCE concentrations at any well can be viewed in the Appendix D Groundwater Quality: Organic Data spreadsheet included on the FY 2016 APR CD-ROM.

The statistical analysis in Appendix D.2 follows the format described in the OU1 Technical Memorandum and Modification #1.

Table 3-3 summarizes the statistical results for all groups, from Appendix D.2, reflecting the data collected through FY 2016. Table 3-3 includes an assessment of the statistical thresholds that were triggered in the analysis and brief comments addressing these threshold triggers. Further discussion is presented below.

Group 1:

The Group 1 (downgradient of the TGRS) response threshold *was* triggered for the North Plume sub-group, with a no significant trend outcome. The Area Weighted Concentration (AWC) concentration for the Group 1 North Plume was 27 µg/L in FY 2016, down from 37 µg/L in FY 2015. This value represents a weighted estimate of the average total VOC concentration just downgradient of the TGRS.

The Group 1 (downgradient of the TGRS) response threshold was triggered for the South Plume sub-group, with a stable outcome. The AWC for the South Plume was 4 µg/L and has been 4 µg/L over the analysis period (since 2007).

Group 2:

Nine wells exhibited “increasing” or “no significant trend” trends in FY 2016, which triggered the thresholds identified for Group 2. Below is additional discussion of these nine wells, in the order they are presented in Table 3-3:

409549 (Increasing): The TCE concentration increased from 28 µg/L in FY 2005 to 77 µg/L in FY 2016. The trend statistics indicate high confidence the trend is upward. This well is in the more central part of the north plume and the trend most likely reflects slight plume shifts. The historical high TCE concentration at the well was 220 µg/L in FY 1988.

409557 (Increasing): The TCE concentration increased from 27 µg/L in FY 2005 to 79 µg/L in FY 2016. This well is in the Unit 3 between the North and South Plumes and the trend most likely reflects lateral dispersion between the plumes. This dispersion can be reasonably expected as the plume ages and pumping patterns change.

03U805 (Increasing): Concentrations of TCE fell slightly between FY 2013 and FY 2015, but increased significantly in FY 2016. The trend indicates a high confidence the trend is upward, and most likely reflects slight plume shifts. This well is part of the TGRS deep groundwater monitoring and is located on the southern edge of the north plume immediately down gradient of the TGRS.

04U673 (No Significant Trend): Historically a decreasing trend has been observed at this well; however, the FY 2016 TCE concentration was the highest observed at this well in the years included in the Mann-Kendall analysis (FY 2005 – FY 2016). The 2016 TCE concentration was 63 µg/L, compared to the FY 2005 and FY 2015 concentrations of 49 µg/L and 26 µg/L, respectively. This well is centrally located relative to the south plume and likely reflects slight plume shifts.

04U832 (No Significant Trend): Concentrations of TCE have ranged between 46 and 56 µg/L since 2007, and hence are relatively stable. This well is located on the southern edge of the south plume.

04U843 (Increasing): Concentrations of TCE at this well have been erratic but generally increasing since its installation in 1987. The concentration of TCE at this well in FY 2016 was the same as in FY 2015 and the overall trend appears to be stabilizing. As shown on the OU1 plume map (Figure 3-5), this well is in the more central part of the north plume not far downgradient of the TGRS. It is located just downgradient of the VOC “hot spot” at 04U847. Since the 04U847 area is outside of the TGRS capture zone, this well

can be expected to increase as migration of the hot spot continues. This well has not approached the magnitude of 04U847, which has exceeded 1,000 µg/L over most of its history. This suggests that the hot spot is attenuated as it migrates and/or is located just east of 04U843. The long-term trend for this well is unusual compared to overall decreases throughout the plume. Given that well 04U843 is near the core of the plume, the trend most likely indicates long-term redistribution of the plume in this area.

04U846 (Increasing): The TCE concentration has increased from 4.2 µg/L in 2005 to 26 µg/L in FY 2016. The trend statistics indicate high confidence the trend is upward. Historically, this well has been erratic with a maximum concentration of 120 µg/L in FY 1988. It is located towards the south side of the North Plume in an unusually tight bend in the plume as it enters the immediate hydraulic influence of the NBCGRS. The historically erratic trend seems to reflect the unusual plume shape in this area. The proximity to the NBCGRS has likely created varying flow patterns in this area suggesting the erratic trend history reflects redistribution of the plume over time.

04U877 (No Significant Trend): The trend at this well has previously been identified as stable. While results have varied less than 1.0 µg/L (between 0.34 µg/L and 1.2 µg/L) since 2005, the erratic increases and decreases in TCE concentrations over the years has resulted in a high “p-value” and thus a no significant trend outcome for this well.

206688 (No Significant Trend): The trend at this well has previously been identified as stable. While results have varied by less than 2.0 µg/L (between 9.4 µg/L and 11.0 µg/L) since 2005, the erratic increases and decreases in TCE concentrations over the years has resulted in a high “p-value” and thus a no significant trend outcome for this well.

The key factors that apply to Group 2 (from Appendix D.2.1.8) are contaminant concentrations, risk to human health and urgency of response needed. Except for 04U843, the data are generally well within historical ranges, and all locations are within the capture zones of the remedial systems. The trend at 04U843 is consistent with the migration of the hot spot upgradient of that well. These trends are not dramatic enough to suggest an expansion of the plume, so an immediate response is not needed. Human health is protected by the remedial systems and the SWCA. In the larger context, the overall trends continue to be downward suggesting that these anomalies, while worth monitoring, are not indicative of a larger issue with long-term plume control by the TGRS. The current sampling frequency is adequate to continue to monitor the trends in these wells.

Group 3 and Group 5:

The trend in the AWC for the Group 3 (downgradient sentinel wells) was probably decreasing. The Group 3 AWC was 17 µg/L in FY 2016, down slightly from 19 µg/L in FY 2015. The trend in the Group 5 (global plume mass wells) was probably increasing with an AWC of 44 µg/L, a slight increase from the FY 2015 result of 41 µg/L. The AWC represents a weighted average of the overall Unit 4 plume concentration. For further explanation of how the AWC is calculated see Appendix D.2.

Group 5 Unit 3 Wells:

The Unit 3 portion of Group 5 is presented in Table 3-3. Wells already in Group 2 were not included. Three wells in this group triggered a threshold: 409550, 03U822, and 03L809. Other wells included in this group had a conclusion of decreasing, except for the three abandoned wells included in the group (409597, 409596, and 03U831).

409550 (No Significant Trend): This well is located on the north edge of the north plume. Concentrations of TCE steadily decreased from 3,200 µg/L in 1991 and have been relatively stable since 2009 with a value of 37 µg/L in FY 2016. The raw trend for this well is decreasing.

03U822 (No Significant Trend): The TCE concentration was measured slightly over the 2005-2016 mean of 146 µg/L with a value of 150 µg/L in FY 2016. However, TCE concentration has been between 120 µg/L and 160 µg/L since FY 2005. The raw trend for this well is very slightly increasing; however, the well is in the center of the north plume, and therefore the increasing raw trend most likely reflects slight plume shifts consistent with the migration of the hotspot.

03L809 (No Significant Trend): The raw trend for this well is decreasing. Concentrations of TCE have been between 90 and 150 µg/L since FY 2009 and appear to be relatively stable over that time. The TCE concentration in July 2016 was 140 µg/L. The well is in the north plume just down gradient of the TGRS.

Group 4:

In Group 4, four wells exceeded the TCE cleanup level during FY 2016: 03L811 at 9.3 µg/L in June 2016; 04U839 at 43 µg/L in February 2016 and 50 µg/L in June 2016; 04U855 at 21 µg/L in June 2016; and 04U879 at 17 µg/L in February 2016 and 20 µg/L in June 2016. All four wells exceeded the cleanup level in FY 2015 as well; however, there appears to be an increasing trend at all four wells since 2011. The four wells are all located on the west/northwest edge of the plume between TCAAP and the NBCGRS. The higher detections in FY 2016 may have been influenced by shutting down the NBCGRS, which may allow a slight shifting and/or widening of the plume to the west. All four of these wells will be sampled again in June 2018.

All other Group 4 wells were below the TCE cleanup level during FY 2016.

Group 6:

The three wells installed and sampled since FY 2005 provide additional data points between OU2 and the NBCGRS to help complete the understanding of the extent and magnitude of VOC concentrations in the Jordan portion of the aquifer. In total, eight OU1 Jordan wells exhibited “Stable”, “No Significant Trend”, “Probably Increasing”, or “Increasing” trends in FY 2016, which triggered the thresholds identified for Group 6. Below is additional discussion of these eight wells:

04J822 (No Significant Trend): This well is located near the center of the plume, just downgradient from the TGRS. Since 2011, TCE concentrations have been between 40 µg/L and 47 µg/L with a concentration of 42 µg/L in FY 2016. The raw trend for this well is slightly decreasing.

Three Jordan wells near the NBCGRS (04J836, 04J837, 04J838) show increasing, no significant trend, and increasing results, respectively. These results are not of concern, given that they are likely due to the variability of pumping rates at the NBCGRS wells, which can cause substantial variability in the concentrations in the adjacent area. Also, the Jordan well in this area that had the historically highest concentrations (04J837) shows a historically downward trend from 147 µg/L in FY 1998 to 2.2 µg/L in FY 2013, before a slight rebound to 12 µg/L in FY 2015. Concentrations in 04J837 returned to 3.6 and 2.2 µg/L in February and June 2016, respectively. Based on the proximity of these three wells to the NBCGRS wells, which were shut off in April 2015, these wells have likely been influenced by the shutdown.

04J839 (Stable): Concentrations are below 5 µg/L, so the "stable" outcome is not significant. The February and June 2016 TCE concentrations were 2.8 and 3.0 µg/L, respectively.

04J847 (Increasing): This well is located just downgradient of the TGRS. The TCE concentration at this well increased from 790 in FY 2014 to 840 in FY 2015 to 910 in FY 2016. Continued annual monitoring is appropriate at this well given its central location in the plume.

04J849 (Probably Increasing): This well has historically been a non-detect well while the nested Unit 4 well has shown an increasing trend. The concentration of TCE jumped to 0.7 µg/L in FY 2016, but is still well below the TCE cleanup level.

04J708 (Increasing): Concentrations of TCE at this well have increased steadily since June 2009, to a concentration of 7.2 µg/L in FY 2016. This well is located on the southern edge of the north plume and may indicate a slight shift or expansion of the plume.

The Group 6 nested Unit 4 wells are also shown on Table 3-3 and generally correlate with their Jordan partners. This history suggests the NBCGRS is helping to reduce the Jordan concentrations in this area and thus is providing similar long-term improvement. In FY 2015, seven nested Unit 4 wells exhibited "Stable", "No Significant Trend", "Probably Increasing", or "Increasing" trends, which triggered the thresholds identified for Group 6. Below is additional discussion of these seven wells:

04U702 (No Significant Trend): Concentrations of TCE at this well have consistently been below 3 µg/L; therefore a "No Significant Trend" result is not of concern.

04U836 (No Significant Trend): This well is near the NBCGRS, so greater variability is expected. Concentrations of TCE at this well have varied between 23 µg/L and 79 µg/L. The TCE concentrations was 43 µg/L in both the February and June 2016 sampling events.

04U837 (No Significant Trend): This well is near the NBCGRS, so greater variability is expected. The raw trend is decreasing. The TCE concentrations was 2.6 µg/L in both the February and June 2016 sampling events.

04U838 (Stable): Concentrations of TCE at this well spiked at 48 µg/L in FY 2007, but have been less than 3 µg/L since 2009 (the five most recent sampling events). The raw trend is decreasing.

04U839 (Increasing): This well near the NBCGRS, so greater variability is expected. The well is located on the west/northwest edge of the plume and has historically had concentrations below 3 µg/L; however, the concentration increased substantially to 15 µg/L in FY 2015, and to 43 µg/L and 50 µg/L in February and June 2016. This increase may have been influenced by the NBCGRS being shut down in April 2015.

04U847 (No Significant Trend): This well is located at the VOC "hot spot" just downgradient of the TGRS, and hence greater variability is expected due to slight plume shifts. The raw trend is decreasing.

04U849 (Probably Increasing): Concentrations of TCE at this well have been erratic but generally increasing. This well is located near the center of the North Plume, downgradient from the VOC "hot spot" at 04U847, and hence greater variability is expected due to slight plume shifts. It appears to be relatively stabilized since FY 2011.

The New Brighton Municipal well trends were analyzed using a linear regression for data since 1998 (see Appendix D.2.5). Due to the large number of data points, regression was considered superior to the Mann-Kendall analysis for these wells. Data from FY 1998 were used to reflect the approximate time

window used throughout the statistical analysis and to avoid skewing the analysis from the earlier high concentrations. All the New Brighton wells showed downward concentration trends, except NBM #3 and #4, which show a slight upward trend (likely the result of gradual plume shifting due to changes in NBCGRS pumping). This suggests that, overall; concentrations are decreasing at the New Brighton municipal well field, which agrees with the decreasing mass removal observed over the life of the system.

Overall Statistical Assessment:

There were individual threshold triggers identified in FY 2016. These triggers highlight specific areas of the plume that are changing over time. This type of behavior is expected in a large complex flow system such as OU1. The thresholds triggered do not suggest any problems with the remedial systems, but suggest movement within the established plumes. The area weighted analysis for Group 1 shows continuing overall improvement or stability in the plume. Overall, therefore, the FY 2016 monitoring data indicate that aquifer restoration is occurring in the Prairie du Chien and Jordan.

Overall, the data meet the statistical criteria developed in this document for assessing the remedial progress in the OU1 aquifers. The data show continuing improvement in the OU1 plume through FY 2016. The statistical behavior of the OU3 plume is addressed in Section 13.0.

Lastly, there were potentially a few well trends that may have been influenced by the NBCGRS shutdown on April 15, 2015; however, future monitoring results will need to be reviewed to determine whether a shifting and/or widening of the OU1 plume to the west is occurring, and whether any other plume changes are occurring in response to the NBCGRS remedy time-out. OU1 wells 03L811, 04U839, 04U855, and 04U879 will be added to the annual groundwater sampling schedule to better assess potential plume influence due to the NBCGRS shutdown.

How much VOC mass has been removed (at each well and total)?

The NBCGRS did not operate in FY 2016; therefore, essentially no VOCs were removed by the NBCGRS in FY 2016. The total cumulative VOCs removed by the NBCGRS is 23,644 pounds.

Figure 3-11 shows the annual VOC mass removed (listed at the top of the graph), annual pumping volumes, and the trend in annual mass removal per unit volume pumped since FY 1997 (when NBM #14 was brought online). As stated above, the mass removal in FY 2016 was essentially zero, due to the shutdown of the NBCGRS system on April 15, 2015 when 1,4-dioxane was discovered in the NBCGRS wells. Generally, the mass removal has been on a decreasing trend since FY 1998, when the last extraction well was brought online (NBM #15). This overall decline in the mass removal trend agrees with the TCE trends in OU1 deep groundwater, which generally show a decreasing trend and suggests that aquifer restoration is progressing.

Are any changes or additional actions required for this remedy component?

Yes. Though the 1 µg/L TCE plume outline did not change significantly between FY 2015 and FY 2016; however, the 10 µg/L contour has shifted noticeably to the northwest during the remedy time-out. As stated previously, the City of New Brighton will continue with their process of selecting a 1,4-dioxane removal technology, and then designing and constructing the modifications to the treatment system so aquifer restoration can be resumed with better protection for the consumer.

4 OPERABLE UNIT 2: SHALLOW SOIL AND DUMP SITES

The reference for the OU2 ROD is:

Twin Cities Army Ammunition Plant
New Brighton/Arden Hills Superfund Site
Operable Unit 2
RECORD OF DECISION
1997
Amendment #1: 2007
Amendment #2 and #3: 2009
ESD #1 and #2: 2009
Amendment #4: 2012
Amendment #5: 2014

Sections 4.0 through 12.0 of this APR address the various media and requirements prescribed by the OU2 ROD and/or subsequent Amendments and ESDs. This section specifically addresses the shallow soil and dump sites.

Through the OU2 Remedial Investigation/Feasibility Study process, Sites A, C, E, H, 129-3, and 129-5 were found to have inorganic and/or organic contaminants above the cleanup goals specified in Table 1 of the OU2 ROD. Unpermitted landfills, or dumps, were identified within Sites A, B, E, H, and 129-15. The OU2 ROD (page 2) describes nine remedy components to address the shallow soil and dump sites.

The requirements for Site C-2 soil and sediment were later modified through ROD Amendment #1 (note that Site C groundwater and surface water is addressed separately in Section 7.0). Because the depth to groundwater is shallow at Site C-2, it was not feasible to remove all contaminated soil and sediment. The Amendment modified remedy component #2 related to excavation of soil, to allow the placement of a 4-foot thick soil cover over areas where contamination remains in-place above the cleanup levels. ROD Amendment #1 also specified LUCs as an additional remedy component for Site C-2.

OU2 ROD Amendment #2 addressed shallow groundwater at Site I, which is discussed in Section 8.0.

OU2 ROD Amendment #3 affected the shallow soil and dump sites in four principal ways:

1. The Amendment documented as final remedies the additional actions performed for shallow soil at Site D and the dump at Site G, after completion of the deep soil requirements set forth for these two sites in the OU2 ROD (see Section 5.0 of this report for discussion of the deep soil).
2. The Amendment documented the use of soil covers as part of the final remedy at Sites E, G, H, and 129-15.
3. The Amendment documented final remedies for five sites with soil contamination that were not originally included in the OU2 ROD: Grenade Range, Outdoor Firing Range, 135 PTA Stormwater Ditch, Trap Range, and Water Tower Area. At these sites, either previous removal actions had been completed that reduced soil contamination to below cleanup levels, or investigations had determined that no action or no further action was needed. The Amendment incorporated the remedies for these sites into the overall remedy for OU2.

4. The Amendment specified LUCs as an additional remedy component for shallow soil and dump Sites D, E, G, H, 129-15, Grenade Range, and Outdoor Firing Range. LUCs are not needed for the 135 PTA Stormwater Ditch or Trap Range because contamination levels are suitable for unlimited use/ unrestricted exposure. The water tower area is also suitable for unlimited use/ unrestricted exposure; however, it is located within the area having blanket land use restrictions as specified in the Land Use Control Remedial Design (LUCRD).

ESD #1 is discussed in Section 6.0 (Site A shallow groundwater), Section 9.0 (Site K shallow groundwater), and Section 12.0 (OU2 deep groundwater).

ESD #2 specified LUCs as an additional remedy component for Sites A, C-1, 129-3, and 129-5. ESD #2 also documented that no further action is required at Site B. Site B is located within the area having blanket land use restrictions.

ROD Amendment #4 was signed in January 2012 and documents previously-completed soil removal actions conducted at two sites: the 535 PTA and Site K. No further action is required for the soils located near the excavation areas at these two sites; though the excavation area for the 535 PTA is located within the area of the Arden Hills Army Training Site that has restricted commercial use. The ROD amendment also addressed Building 102 shallow groundwater, discussed in Section 10.0, and OU2 aquatic sites, discussed in Section 11.0.

ROD Amendment #5 was signed in March 2014 and documents previously-completed soil removal actions conducted at soil areas of concern at three sites: Site A, the eastern portion of the 135 PTA, and the MNARNG EBS Areas. It also documents that LUCs are required at these sites.

4.1 Remedy Components #1 through #9: Soil Remediation

The nine remedy components specified in the OU2 ROD (page 2) have been completed for the shallow soils and dumps at Sites A, C, D, E, G, H, K, 129-3, 129-5, 129-15, Grenade Range, Outdoor Firing Range, 135 PTA Stormwater Ditch, the eastern portion of the 135 PTA, 535 PTA, MNARNG EBS Areas, and Water Tower Area. Remedy Components #1 through #8 addressed the characterization, excavation, sorting, treatment, disposal, site restoration, site access restrictions (during remedial actions), and limited period of post-remediation groundwater monitoring. Remedy Component #9 addressed the characterization of dumps at Sites B and 129-15. The characterization work at both sites led to a determination that no further action was required at Site B and construction of a cover at Site 129-15, which were documented through ESD #2 and OU2 ROD Amendment #3, respectively.

4.2 Remedy Component #10: Land Use Controls

Description: “OU2 ROD Amendments and ESDs made LUCs a part of the remedy for shallow soil and dump sites where contamination remains in-place above levels that allow for unlimited use and unrestricted exposure. LUCs are also necessary to protect the integrity of the soil covers constructed at various sites.”

Performance Standard (how do you know when you’re done):

Initial implementation was done when the USEPA and MPCA have provided consistency approval for an OU2 LUCRD document. Implementation will continue indefinitely unless further action is taken that would allow for unlimited use and unrestricted exposure.

Has a LUCRD document been approved to address LUC issues for OU2, and is it being implemented?

Yes. The USEPA and MPCA provided consistency approval for the OU2 LUCRD in September 2010 and it is being implemented by the Army. Revision 4 of the OU2 LUCRD was approved by the USEPA and MPCA in August 2016. This revision eliminated soil LUCs from the “California-Shaped Area” (which is 380 acres of the 427 acres transferred/leased to Ramsey County in 2013), following soil cleanup to levels consistent with unlimited use / unrestricted exposure. LUCs for other shallow soil sites were not affected by this revision.

Was an annual site inspection for LUCs conducted in FY 2016?

Yes. On August 10, 2016, the Army, National Guard, and JV conducted the annual inspection of OU2 sites. The checklist that was completed during the inspection is included as Appendix F.

Did the inspection identify any follow-up actions needed to maintain the protectiveness of the LUCs? No.

5 OPERABLE UNIT 2: DEEP SOIL SITES

For purposes of the OU2 ROD, Sites D and G were considered deep soil sites because VOC contamination extended to depths between 50 and 170 feet. Some additional shallow soil contaminants were also present at Site D, and Site G also contains a dump. The OU2 ROD (pages 2-3) describes seven remedy components to be implemented for these two sites:

- Remedy Component #1: Groundwater Monitoring
- Remedy Component #2: Restrict Site Access (During Remedial Actions)
- Remedy Component #3: Soil Vapor Extraction (SVE) Systems
- Remedy Component #4: Enhancements to the SVE Systems
- Remedy Component #5: Maintain Existing Site Caps
- Remedy Component #6: Maintain Surface Drainage Controls
- Remedy Component #7: Characterize Shallow Soils and Dump

For Remedy Component #1, ongoing groundwater monitoring near these two sites is completed as part of OU2 deep groundwater monitoring (Section 12.0) and is not discussed separately in this section.

Remedy Components #2 to #6 were related to continued operation of the SVE systems that had been installed in 1986, along with modifications to those systems to enhance performance. The caps were in-place primarily to minimize short-circuiting of air flow, and to minimize infiltration. Studies conducted after the 1997 ROD showed that enhancements to the SVE systems were not necessary, and in fact, the soil VOC concentrations had achieved the soil VOC cleanup levels. The systems were turned off in 1998 and were subsequently removed, hence completing Remedy Components #2 to #6 related to deep soil.

Regarding Remedy Component #7, additional shallow soil investigation work (for non-VOC contaminants) was completed at Site D, and characterization work of the dump was completed at Site G, which completed this remedy component. The investigation/characterization work led to removal of shallow soils at Site D and construction of a cover at Site G, which were documented through OU2 ROD Amendment #3.

In summary, the deep soil requirements of the OU2 ROD have been completed. There are ongoing LUC requirements for the shallow soil at Site D and the dump at Site G, as discussed in Section 4.0.

6 OPERABLE UNIT 2: SITE A SHALLOW GROUNDWATER

Shallow groundwater at Site A has been impacted by VOCs and antimony. The selected remedy in the OU2 ROD incorporates the use of a groundwater extraction system, which began operation May 31, 1994. When operating, this system discharged the extracted groundwater to the sanitary sewer for treatment at a Publicly-Owned Treatment Works (POTW). However, as further discussed below, the groundwater system was shut off (with regulatory approval) on September 24, 2008, while implementation of MNA was being evaluated as a potential remedy component in lieu of groundwater extraction and discharge. In late 2015, the Army received approval from the USEPA and MPCA to formally change the remedy to MNA. The ROD prescribes five major components of the remedy, and until a ROD amendment can be approved, the original components of the ROD will be retained in this section (with discussion that is appropriate to the MNA remedy).

The original 8-well groundwater extraction system that was selected in the OU2 ROD began operation May 31, 1994. On July 11, 2000, with regulatory approval, EW-5 through 8 (the “second line” of extraction wells) were shut down due to their VOC concentrations having declined below cleanup levels. In July 2008, the USEPA and MPCA approved the *Site A Shallow Groundwater: 10-Year Evaluation Report (*Wenck 2008a). The 10-Year Report was prepared to fulfill a requirement of the ROD, which states that for shallow groundwater contamination at Site A, “should aquifer restoration not be attained within the ten-year lifespan of the remedy, additional remedial measures will be addressed”. Because the 10-year mark had been reached and contamination was still present above the cleanup levels, the 10-Year Report was prepared to discuss the status of the site and to evaluate any potential changes to the remedy that would be beneficial. MNA (through abiotic degradation) was the recommended alternative for Site A that was approved by the USEPA and MPCA.

In September 2008, the USEPA and MPCA approved the *Site A Shallow Groundwater: Monitoring and Contingency Plan* (Wenck 2008b), and EW-1 through 4 (the “first line” of extraction wells) were then shut off on September 24, 2008. The Monitoring and Contingency Plan presented the monitoring plan to be implemented at the point that the extraction wells were shut off, and presented the contingency actions that will be taken by the Army if groundwater monitoring indicates that any of the identified trigger points are exceeded. These monitoring and contingency actions were incorporated into the APR, and thus any changes to monitoring and contingency actions must be approved by the USEPA and MPCA through revisions to the APR.

The decision to proceed with MNA was based in part on the MPCA and USEPA natural attenuation study at the site (2000), and on follow-up MPCA/USEPA microcosm studies that have verified that abiotic degradation of VOCs in Site A groundwater is occurring at substantial rates. Such degradation acts to reduce contaminant mass and mobility by breaking down the contaminants as they move downgradient. The decision to proceed with MNA was also based on the absence of any likely receptors. The closest potential groundwater receptor is located approximately 1,000 feet downgradient from 01U352 (EW-2) and 01U353 (EW-3), and this domestic well has not been operable for many years (and even when it was, the water was only used for irrigation purposes). Beyond this unlikely receptor, there are no other existing downgradient receptors between the plume and Rice Creek, which is approximately 1,800 feet away.

Based on a November 11, 2015 Technical Memorandum submitted by the Army that documented the FY 2015 monitoring results and recommended changing the remedy to MNA, the USEPA and MPCA have approved changing the remedy to MNA in lieu of groundwater extraction and discharge. In FY 2017, a proposed plan and ROD amendment will be prepared by the Army, USEPA, and MPCA to formally document this change. Since the extraction wells are still included in the monitoring plan for Site A, they will not be sealed.

6.1 Remedy Component #1: Groundwater Monitoring

Description: "Groundwater monitoring to track plume migration and remedy performance." (OU2 ROD, page 3)

Performance Standard (how do you know when you're done):

When a performance groundwater monitoring program has been established and ongoing monitoring is compliant the program.

Is this remedy component being implemented?

Yes. Table 6-1 summarizes the performance monitoring requirements, the implementing parties, and the documents that contain the monitoring plans. The FY 2016 Monitoring Plan is included in Appendix A, and the FY 2016 water quality monitoring locations and frequencies are also summarized on Figure 6-1. Any deviations are explained in Appendix C.2. Figure 6-2 presents groundwater elevation contours based on measurements in June and July 2016.

Were the groundwater monitoring requirements for this remedy met? Yes.

Is any groundwater sampling proposed prior to the next report?

Yes, including the following:

Groundwater sampling of water supply wells related to alternate water supply and well abandonment will be in accordance with recommendations in Appendix E. The next "major" event was previously scheduled for FY 2017; however, due to the discovery of 1,4-dioxane in deep groundwater, an unscheduled "major" event was conducted in FY 2015 and repeated by the Army in FY 2016. The next "major" event is now scheduled for FY 2020 to maintain the normal frequency of once every four years.

Other groundwater monitoring at Site A will be in accordance with the monitoring plan shown in Appendix A.1.

Are any changes or additional actions required for this remedy component?

Yes. Given that wells 01U350, 01U351, and 01U354 are essentially redundant monitoring points to nearby wells 01U108, 01U116, and 01U138, respectively, monitoring of 01U350, 01U351, and 01U354 will be ceased beginning in FY 2017 until Site A nears the point of closure.

6.2 Remedy Component #2: Groundwater Containment and Mass Removal

Description: "Use of existing gradient control wells to contain the contaminant plume and remove mass" (OU2 ROD, page 3).

Is this remedy component being implemented?

No. As discussed previously, since the groundwater extraction system has been shut off to allow evaluation of MNA, this remedy component is not currently being implemented. After a ROD amendment is completed by the Army, USEPA, and MPCA in FY 2017, this remedy component will be eliminated.

6.3 Remedy Component #3A: Land Use Controls

Description: The OU2 ROD (page 3) listed the following: "Institutional controls to restrict new well installations and provide alternate water supplies and well abandonment as necessary." For ease of discussion, the requirement has been broken into two pieces, with this section focusing on the LUCs. OU2 ESD #1 clarified the LUC component to include protection of the groundwater monitoring and extraction system infrastructure.

Performance Standard (how do you know when you're done):

For initial implementation, when the MDH has issued a SWCA Advisory, and when the USEPA and MPCA have provided consistency approval for an OU2 LUCRD document. Implementation will continue until such time that the groundwater concentrations are below the cleanup levels.

Has the MDH issued a SWCA Advisory for the area impacted by Site A?

Yes, it was issued in June 1996 and revised in December 1999 and April 2016; however, this revision did not affect the boundary for the Site A vicinity.

Has a LUCRD document been approved to address LUC issues for OU2, including Site A groundwater, and is it being implemented?

Yes. The USEPA and MPCA provided consistency approval for the OU2 LUCRD in September 2010 and it is being implemented by the Army. Revision 4 of the OU2 LUCRD was approved by the USEPA and MPCA in August 2016; however, this revision did not affect LUCs for Site A.

Was an annual site inspection for LUCs conducted in FY 2016?

Yes. On August 10, 2016, the Army, National Guard, and JV conducted the annual inspection of OU2 sites. The checklist that was completed during the inspection is included as Appendix F.

Did the inspection identify any follow-up actions needed to maintain the protectiveness of the LUCs? No.

6.4 Remedy Component #3B: Alternate Water Supply/Well Abandonment

Description: The OU2 ROD (page 3) listed the following: “Institutional controls to restrict new well installations and provide alternate water supplies and well abandonment as necessary.” For ease of discussion, the requirement has been broken into two pieces, with this section focusing on the alternate water supplies and well abandonment.

Performance Standard (how do you know when you’re done):

When well owners who qualify have been offered and provided with alternate water supply and/or have had their wells abandoned (or the offers have been rejected).

Is the remedy component being implemented?

Yes. The OU1 Alternate Water Supply and Well Abandonment Program is underway and was expanded to cover the area affected by the OU2 Site A shallow groundwater plume. See Section 3.1 of this APR for more information on this program.

Did the boundary of the Site A plume get any bigger during FY 2016, as defined by the 1 µg/L contour?

No. Table 6-2 presents the FY 2016 groundwater quality data for Site A. Using these data, Figure 6-3 shows the tetrachloroethene (PCE) concentrations and Figure 6-4 shows the cis-1,2-dichloroethene (cis-1,2-DCE) concentrations. The latter is a degradation product of the former, and represents the larger areal footprint. The footprints did not increase in size from the previous year.

Were any additional water supply wells discovered within the area of concern for the Site A plume that are completed within the aquifer of concern? No.

Were any water supply wells within the Site A plume sampled during FY 2016? If yes, what were the findings? No wells were sampled.

Were any well owners offered an alternate supply and/or well abandonment in FY 2016? No.

Within the Site A plume, are there any well owners that meet the criteria, but have not yet been provided an alternate water supply? No.

Within the Site A plume, are there any wells that meet the criteria, but have not yet been abandoned? No.

Is any sampling of water supply wells proposed prior to the next report?

No. There are no water supply wells in the Site A vicinity that require sampling.

Are any changes or additional actions required for this remedy component? No.

6.5 Remedy Component #4: Discharge of Extracted Water

Description: “Discharge of extracted groundwater to a POTW” (OU2 ROD, page 3).

Is this remedy component being implemented?

No. As discussed previously, because the groundwater extraction system has been shut off to allow evaluation of MNA, this remedy component is not currently being implemented. After a ROD amendment is completed by the Army, USEPA, and MPCA in FY 2017, this remedy component will be eliminated.

6.6 Remedy Component #5: Source Characterization/ Remediation

Description: "Source characterization/remediation" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

For characterization, when the investigation has answered the questions needed to prepare remedial design documents. For remediation, when the contaminant concentrations in soil are below the cleanup levels specified in Table 1 of the OU2 ROD.

Is this remedy component being implemented?

Yes. Characterization work has been completed. Stone & Webster performed investigation work in 1997 and the *Final Site A Investigation Report* (Stone & Webster Environmental Technology & Services 1997) was issued December 12, 1997. The report delineated the extent of both VOC-contaminated and metal-contaminated soils requiring remediation. The source of VOC-contaminated soils was found to be the "1945 Trench".

Remediation has been completed. Shaw Environmental and Infrastructure, Inc. (Shaw, formerly Stone & Webster) completed removal of metal-contaminated soils in FY 1999. Construction of an air sparging/soil vapor extraction (AS/SVE) system to remediate VOC-contaminated soils was completed by Stone & Webster in FY 2000, which began operation in early FY 2001. The AS system was shut off permanently in June 2001 due to a lack of increase in SVE VOC levels and due to concern regarding potential plume spreading. The AS system was being implemented voluntarily by the Army and was not a requirement of the OU2 ROD. Soil samples were collected within the source area in July 2002 (and previously in August 2001). In both events, the results showed minimal reduction in soil VOC concentrations. Since it appeared that many years of SVE system operation would be required before soil cleanup levels would be reached (if ever), the Army ceased SVE system operation on August 21, 2002, and submitted a work plan clarification to the USEPA and MPCA for excavation of the VOC-contaminated soils in the source area. The work plan clarification received regulatory approval in early FY 2003, and 688 cubic yards of contaminated soil were excavated by Shaw and transported off-site to a permitted disposal facility (see Figures 6-3 and 6-4 for the location of the soil excavation area at the former 1945 Trench). The Site A Former 1945 Trench Closeout Report (prepared by Shaw) received regulatory consistency in FY 2004.

Are any changes or additional actions required for this remedy component? No.

6.7 Overall Remedy for Site A Shallow Groundwater

Performance Standard (how do you know when you're done):

When the cleanup levels in Table 1 of the OU2 ROD have been attained throughout the areal and vertical extent of the Site A plume (OU2 ROD, page 54).

Has the Site A shallow groundwater remedy been completed (i.e., have the cleanup levels in Table 1 of the OU2 ROD been attained throughout the areal and vertical extent of the Site A plume)?

No. Table 6-2 presents the FY 2016 groundwater quality data and highlights the values that exceed a cleanup level. The respective cleanup levels were exceeded by concentrations of cis-1,2-DCE at 01U139

(260 µg/L), 01U158 (80 µg/L), and 01U356/EW-6 (340 µg/L), and of antimony at 01U103 (8.0 µg/L). None of the other COCs exceeded their respective cleanup levels in FY 2016.

What impact is MNA having on contaminant concentrations?

As evident in Table 6-2, and on Figures 6-3 and 6-4, PCE and TCE continue to be degraded to cis-1,2-DCE via natural attenuation. This degradation generally occurs within the distance between the source area and the first line of extraction wells (EW-1 through EW-4), with primarily only cis-1,2-DCE being detected downgradient of the first line of extraction wells. Figure 6-5 shows the cis-1,2-DCE concentrations plotted on geologic cross sections to illustrate the vertical extent of contamination (the cross section locations are illustrated on Figure 6-4). Cis-1,2-DCE continues to be degraded as the plume migrates via an abiotic process. The MPCA and USEPA initially evaluated attenuation at the site using computer modeling of contaminant degradation, as documented in *Evaluation of Natural Attenuation of Chlorinated Solvents in Ground Water at the Twin Cities Army Ammunition Plant* (MPCA and USEPA 2000). The MPCA conducted a follow-on microcosm study (unpublished) using samples collected from Site A, the results of which were presented to the Army, MPCA, and USEPA on April 10, 2007. The work conducted in this study showed that the degradation being observed at Site A was an abiotic process (not biological), which likely involves the presence of the mineral magnetite in soils at Site A. Note that the predominant degradation process does not “degrade through” vinyl chloride, which is no longer monitored at this site given the historical lack of detections that led to the OU2 ROD *not* selecting this compound as a COC.

Since September 2008 when the “first line” of extraction wells was shut off, some wells have shown decreased concentrations while others have, in some periods, shown increased concentrations (see Figures 6-6, 6-7, 6-8, and 6-9). Collectively, the cis-1,2-DCE water quality trends evident on Figures 6-6 through 6-9 indicate the plume has essentially stabilized. Most importantly, the contingency locations (the four 900-series wells located along the north side of County Road I) have peaked and now show stable or decreasing trends at concentrations below the cis-1,2-DCE cleanup level of 70 µg/L (Figure 6-9). Specifically, concentrations of cis-1,2-DCE in 01U901 and 01U903 have been at or near non-detect since 2008 and basically throughout their history. The concentrations of cis-1,2-DCE in 01U902 had stabilized between 15 and 20 µg/L since June 2013. The cis-1,2-DCE concentration jumped to 29 µg/L in FY 2016, but remains well below the cleanup level. Additional monitoring will be necessary to evaluate if the cis-1,2-DCE concentration at 01U902 is trending upwards, or if it remains stable. The concentration of cis-1,2,-DCE in 01U904, which increased to a peak of 57 µg/L in June 2013, decreased steadily through FY 2014 and now appears to have stabilized between approximately 20 and 30 µg/L. The cis-1,2-dichloroethene concentration at 01U904 was 28 µg/L in July 2016. 01U904 is located directly downgradient of the two highest-concentration wells in June 2016: EW-6 and 01U139.

In EW-5 through 8 (Figure 6-8), concentrations of cis-1,2,-DCE EW-8 have been stable near non-detect since December 2012. After peaking just above the cleanup level in December 2012, concentrations of cis-1,2-DCE at EW-7 have steadily declined to the July 2016 concentration 13 µg/L, respectively. A similar pattern was observed at EW-5, but cis-1,2-DCE concentrations at this well appear now to have stabilized. A cis-1,2,-DCE concentration of 28 µg/L was observed at EW-5 in July 2016. A generally increasing trend has been observed at EW-6 since 2012. The reason for this is not clear, but continued monitoring of EW-6 will be performed and alternate strategies may be implemented if the trend continues.

In the monitoring wells located between the two rows of extraction wells (Figure 6-7), concentrations of cis-1,2,-DCE appear to have stabilized or to be on a declining trend. 01U139, currently the well with the highest concentration of cis-1,2,-DCE at Site A, had a peak concentration of 510 µg/L in June 2013, but has since stabilized between 240 and 350 µg/L. 01U140, after showing three slight exceedances of the cleanup level in 2011 and 2012, has shown a steadily declining cis-1,2,-DCE concentration to 6.8 µg/L in June 2016. 01U157 had two slight exceedances of the cis-1,2,-DCE cleanup level in 2011 and 2012, but has since stabilized between 18 and 25 µg/L. 01U158 had a peak cis-1,2,-DCE concentration of 410 µg/L in April 2011, but had since stabilized between 28 and 67 µg/L. The observed cis-1,2,-DCE concentration of 80 µg/L in June 2016 was the first exceedance of the cleanup level at 01U158 since December 2011, though the overall trend at this location still appears to be stable. Future monitoring will be evaluated to verify the trend has not shifted to increasing.

In EW-1 through 4 (Figure 6-6), concentrations of cis-1,2,-DCE in the outermost wells EW-1 and EW-4 have been at or near non-detect since 2010 or earlier. Concentrations of cis-1,2,-DCE EW-2 has generally been below 20 µg/L since the extraction wells were shut off in 2008, and has been below 10 µg/L in the seven most-recent sampling events. EW3 had a peak cis-1,2,-DCE concentration of 950 µg/L in December 2009, but declined to 170 µg/L in April 2011 and has displayed variable concentrations since that time (but not exceeding 170 µg/L).

In summary, the cis-1,2-DCE plume has essentially stabilized following shutdown of EW-1 through 4 in 2008. Although one well, EW-6, has not definitively stabilized, it is in the middle of the plume and is surrounded by wells with stable or decreasing trends. Most importantly, the contingency locations along the north side of County Road I show stable or decreasing trends at concentrations below the cis-1,2-DCE cleanup level of 70 µg/L (despite 01U904 being located directly downgradient of EW-6). Hence the collective trend suggests that the slight uptrend at EW-6 merely reflects a slight shifting of the axis of the plume in the “cross-plume” direction, which also likely explains the greater variability that is evident in two other wells near the axis of the plume (EW-3 and 01U139).

Were any trigger levels exceeded at any of the contingency locations?

No. The four contingency locations are 01U901, 902, 903 and 904, which are the four monitoring wells located along the north side of County Road I. The trigger level is equal to groundwater cleanup levels and no COCs at Site A exceeded their respective cleanup levels in these four wells in FY 2016 (Table 6-2). As noted previously, 01U901 and 01U903 have been at or near non-detect for cis-1,2-DCE since 2008 and basically throughout their history, and concentrations of cis-1,2-DCE in 01U902 and 01U904 have peaked and now show stable or slightly increasing trends with cis-1,2-DCE concentrations below the cleanup level of 70 µg/L.

The *Site A Shallow Groundwater: Monitoring and Contingency Plan* (Wenck 2008b) noted that if the groundwater trigger is exceeded, three key contingency actions are required:

1. Army will contact the well owner at 1783 Pinewood Drive to verify the well remains out of service (and will do this annually for as long as the trigger is being exceeded);
2. Army will prepare and submit a plan to address the exceedance to the USEPA and MPCA for approval; and
3. Army will prepare and submit a plan to evaluate the indoor air pathway.

The third action was perhaps the most critical item, as no soil vapor sampling had ever been conducted at Site A, and increasing VOC groundwater concentrations in any of the wells north of County Road I would raise the question of whether these increases could cause an increase in soil gas VOC concentrations leading to a vapor intrusion risk. A vapor intrusion report had been prepared previously: *Off-TCAAP Vapor Intrusion Pathway Analysis, Operable Unit 1, Operable Unit 3, and Operable Unit 2 (Site A)* prepared by Tecumseh/Wenck Installation Support Services (TWISS), May 2005. This report concluded that the vapor intrusion pathway for the offsite Site A plume was incomplete, since the concentrations in groundwater were below the USEPA generic screening criteria. However, no actual soil vapor sampling was conducted for that report. In December 2012, the MPCA requested that soil vapor sampling be conducted since their 2008/2010 vapor intrusion guidance is newer than the 2005 report, and since that guidance states that groundwater screening levels should not be used as a single line of evidence for decisions regarding vapor intrusion risk. Based on this MPCA request, the Army prepared an investigation QAPP, which was approved by the USEPA and MPCA in June 2013, and then conducted the vapor intrusion investigation work in July 2013. This work was documented in *Site A Vapor Intrusion Investigation Report* (Wenck 2014), which received regulatory consistency approval in FY 2014. The report concluded that no significant VOC concentrations are present in soil gas near the 14 samples collected (10 of which were located along the north side of County Road I), and that there is no significant soil vapor risk. Hence, the third contingency action has already been completed and was ultimately found not to be of concern.

With regard to the first contingency action, the Army attempted to contact the well owner at 1783 Pinewood Drive in FY 2014, even though the trigger had not been exceeded. While there is no reason to believe the owner will ever put this well back into service (and it would be physically difficult based on prior conversation), if this intention could be reconfirmed with the well owner, the well should be properly sealed. The Army was willing to voluntary conduct the sealing work. While it remains a very unlikely receptor, sealing of this well would eliminate the only known groundwater receptor between Site A and Rice Creek. Unfortunately, the resident did not respond to the two letters mailed to this address and it appears the Army will be unable to obtain approval to conduct this work.

If a trigger level should be exceeded, the only remaining contingency action would be the second one. However, the need to “address the exceedance” would have been driven primarily by either a groundwater receptor or a vapor receptor, and since these pathways have been eliminated as discussed above (or deemed not to be of concern, in the case of a nonresponsive and unlikely groundwater receptor), a slight exceedance of the trigger may not require any specific remedial action, *especially given* the strong degradation evident at the site (i.e., the distance any slight exceedance would carry downgradient from the “900” wells would be expected to be minimal).

Can it be determined whether MNA is an adequate long-term remedy for Site A in lieu of groundwater extraction and discharge? (If MNA is determined to be adequate, a recommendation to formally change the remedy should be made.)

Yes. In the November 11, 2015 Technical Memorandum, the Army recommended that MNA be implemented as the long-term remedy for Site A in lieu of groundwater extraction and discharge. This recommendation was made in consideration of three key facts: 1) the vapor intrusion investigation concluded that there is no significant soil vapor risk north of County Road I; 2) the only known groundwater receptor between Site A and Rice Creek (1783 Pinewood Drive) is not believed to be

operable, was only used for irrigation purposes when it was operable, and now has an unresponsive resident to a voluntary Army offer to seal this well; and 3) 1,4-dioxane was not found to be present in Site A shallow groundwater. Because the USEPA and MPCA have approved this recommendation, a ROD amendment will be completed by the Army, USEPA, and MPCA in FY 2017 to formally change the remedy to MNA.

Regarding the third key fact noted above, due to the discovery of 1,4-dioxane within the OU1 plume, the USEPA and MPCA requested sampling for the presence of 1,4-dioxane at all sites where VOCs are present (including Site A shallow groundwater) during the FY 2016 sampling event. As shown in Table 6-2, there was only one detection of 1,4-dioxane, below the MDH HRL, in Site A shallow groundwater in the summer 2016 sampling event. These results are consistent with those observed during the June 2015 sampling event, and results of both events support the conclusion that 1,4-dioxane is not present in shallow groundwater at Site A. Therefore, no further 1,4-dioxane monitoring is necessary at Site A.

Annual monitoring of Site A wells will continue in FY 2017, per the November 11, 2015 Technical Memorandum.

Do additional remedial measures need to be addressed?

As noted above, a ROD amendment will be completed by the Army, USEPA, and MPCA in FY 2017 to formally change the remedy to MNA in lieu of groundwater extraction and discharge.

7 OPERABLE UNIT 2: SITE C SHALLOW GROUNDWATER

Impacts to Site C shallow groundwater had not occurred at the time of the OU2 ROD (1997). In FY 1997, the U.S. Army Environmental Command sponsored a technology demonstration project to phytoremediate lead-contaminated soil at Site C. During the growing seasons, ethylenediaminetetraacetic acid and acetic acid were applied to the soils to improve the metals uptake by the crops and had the unintended consequence of causing migration of lead from the soils into the shallow groundwater at Site C, which is present within a few feet from the ground surface. In FY 2000, the MPCA took enforcement action, requiring that the Army implement corrective actions. Initially, the Army installed a groundwater recovery trench to contain the lead plume (operated between November 2000 and July 2001). On July 6, 2001, the Army began operating three extraction wells to contain the plume (replacing recovery trench operation), with discharge of extracted groundwater (treated as necessary) to a POTW. In FY 2004, a Stipulation Agreement was signed that resolved the enforcement action and directed that response actions be conducted under the authority of the FFA. The 2007 OU2 ROD Amendment #1 incorporated the existing groundwater extraction system as the final remedy.

On November 13, 2008, the groundwater system was shut off (with regulatory approval), since the lead concentrations in the three extraction wells had been below the groundwater cleanup level since March 2008 (i.e., the area of lead concentrations that exceeded the groundwater cleanup level was not even reaching the extraction wells, so operation of the extraction system was no longer required to contain the plume). The recommendation to shut the extraction system off was presented in the *Site C Groundwater Extraction System Evaluation Report* (Evaluation Report; Wenck 2008c), which was approved by the USEPA and MPCA in November 2008. The 2007 ROD Amendment #1 prescribes four major components of the remedy, and until a decision is made to formally change the remedy, the original components of ROD Amendment #1 will be retained in this section (with discussion that is appropriate to the current remedy implementation status).

The Evaluation Report also presented the monitoring plan to be implemented at the point that the extraction wells were shut off, and presented the contingency actions that will be taken by the Army if groundwater and/or surface water monitoring indicates that any of the stated trigger points are exceeded. These monitoring and contingency actions have been incorporated into the APR, and thus any changes to monitoring and contingency actions must be approved by the USEPA and MPCA through revisions to the APR.

At some point, the remedy could be formally changed. This change would presumably require an ESD, at a minimum, or possibly a ROD amendment. However, given that groundwater cleanup levels may be reached throughout Site C within a few years, it may not be necessary to go through the process of formally changing the remedy. Evaluation in future APRs will ultimately determine whether the USEPA, MPCA, and Army should formally change the remedy or, possibly, whether the site should just be closed.

7.1 Remedy Component #1: Groundwater and Surface Water Monitoring

Description: "The existing Site C groundwater monitoring program will be revised as needed." "A new surface water monitoring plan will be prepared" (OU2 ROD Amendment #1, page 39-40).

Performance Standard (how do you know when you're done):

When a performance groundwater and surface water monitoring program has been established and ongoing monitoring is in compliance with the program.

Is this remedy component being implemented?

Yes. Table 7-1 summarizes the performance monitoring requirements, the implementing parties, and the documents that contain the monitoring plans. FY 2016 monitoring was conducted in accordance with the Monitoring Plans included in Appendix A. The water quality monitoring locations and frequencies are also summarized on Figure 7-1, and any deviations are explained in Appendix C.2.

Were the monitoring requirements for this remedy met? Yes.

Is any sampling proposed prior to the next report?

Yes. Groundwater and surface water monitoring at Site C will be in accordance with the monitoring plans shown in Appendix A.1 and A.3, respectively.

Are any changes or additional actions required for this remedy component? No.

7.2 Remedy Component #2: Groundwater Containment

Description: "Three extraction wells, EW-1 through EW-3, will continue collecting contaminated groundwater" (OU2 ROD Amendment #1, page 38).

Is this remedy component being implemented?

No. As discussed previously, because the area of lead concentrations that exceed the groundwater cleanup level no longer extends to the extraction wells, the extraction system is no longer operating and this remedy component is not currently being implemented.

7.3 Remedy Component #3: Discharge of Extracted Water

Description: "Extracted groundwater will be pretreated onsite (as necessary) to meet the sanitary sewer discharge limit" (OU2 ROD Amendment #1, page 38).

Is this remedy component being implemented?

No. As discussed previously, because the area of lead concentrations that exceed the groundwater cleanup level no longer extends to the extraction wells, the extraction system is no longer operating and this remedy component is not currently being implemented.

7.4 Remedy Component #4: Land Use Controls

Description: "LUCs will be established to protect the groundwater extraction, treatment, and monitoring system and to prohibit the drilling of water supply wells within the contaminated portion of the Unit 1 aquifer" (OU2 ROD Amendment #1, page 39).

Performance Standard (how do you know when you're done):

For initial implementation, when the USEPA and MPCA have provided consistency approval for an OU2 LUCRD document. Implementation will continue until such time that the groundwater concentrations are below the cleanup levels.

Has a LUCRD document been approved to address LUC issues for OU2, including Site C groundwater, and is it being implemented?

Yes. The USEPA and MPCA provided consistency approval for the OU2 LUCRD in September 2010 and it is being implemented by the Army. Revision 4 of the OU2 LUCRD was approved by the USEPA and MPCA in August 2016; however, this revision did not affect LUCs at Site C.

Was an annual site inspection for LUCs conducted in FY 2016?

Yes. On August 10, 2016, the Army, National Guard, and JV conducted the annual inspection of OU2 sites. The checklist that was completed during the inspection is included as Appendix F.

Did the inspection identify any follow-up actions needed to maintain the protectiveness of the LUCs? No.

7.5 Overall Remedy for Site C Shallow Groundwater

Performance Standard (how do you know when you're done):

When the cleanup levels in Table 1 of OU2 ROD Amendment #1 have been attained throughout the areal and vertical extent of the Site C plume.

Has the Site C shallow groundwater remedy been completed (i.e., have the cleanup levels in Table 1 of the OU2 ROD Amendment #1 been attained throughout the areal and vertical extent of the Site C plume)?

No. Table 7-2 and 7-3 present the FY 2016 groundwater and surface water quality data, respectively, and highlight the values that exceed the lead cleanup level. Figure 7-2 presents groundwater elevation contours based on measurements in June 2016. Figure 7-3 shows the lead results for groundwater and surface water. Figures 7-4 and 7-5 show the lead concentrations plotted on geologic cross sections for

Site C to illustrate the vertical extent of contamination (the cross section locations are illustrated on Figure 7-3).

In FY 2016, lead exceeded the groundwater cleanup level of 15 µg/L in two monitoring wells located near the source area. The lead concentration at MW-14 was detected at 140 µg/L in February 2016, and dropped to 4.9 µg/L in July 2016. At MW-3, a concentration of 6.6 µg/L was observed in February 2016 and spiked to 27 µg/L in July 2016. The water quality trends (dissolved lead) for wells nearest the source are (MW-3, MW-13, MW-14, and MW-15) are shown on Figure 7-6. As Figure 7-6 shows, the variable concentrations observed at individual wells in FY 2016 is the norm in recent years for the four source are wells. Overall, lead concentrations at source area wells have decreased significantly in the last 10 years indicating substantial progress towards reaching the groundwater cleanup levels.

Surface water monitoring results were all below the surface water cleanup level in FY 2016 (lead was not detected in any surface water sample).

Were any trigger levels exceeded at any of the contingency locations?

No. The Site C contingency locations and trigger levels are shown in Table 7-4. Depending on the location, the trigger level is either equal to the groundwater cleanup level or a surface water cleanup level. The groundwater results (Table 7-2) and surface water results (Table 7-3) show that none of the trigger levels were exceeded in FY 2016. If a trigger level were to be exceeded, the Army would implement the contingency action(s) specified in the footnotes to Table 7-4.

Can it be determined whether a formal change to the remedy should be made (to eliminate the groundwater extraction and discharge components) or, possibly, whether the Site should just be closed?

No, two wells still exceeded the cleanup level. Additional monitoring should be conducted before this determination is made.

Do additional remedial measures need to be addressed?

No. Continued monitoring will provide the additional data needed to determine whether a formal change to the remedy should be made or, possibly, whether the site should just be closed.

8 OPERABLE UNIT 2: SITE I SHALLOW GROUNDWATER

VOCs have been identified in the Unit 1 (perched aquifer) at Site I. The selected remedy in the OU2 ROD (1997) consisted of four components:

- Groundwater monitoring
- Groundwater extraction
- POTW discharge
- Additional characterization

The additional investigation and *Predesign Investigation Work Plan* (CRA 1999) were completed in FY 2000. Based on these, the remedy was proposed to consist of a dual-phase vacuum extraction system, which combined groundwater extraction with soil vapor extraction, to be installed beneath Building 502. A pilot test of dual-phase extraction subsequently determined that the technology was not feasible due to the low permeability of the Unit 1 aquifer beneath the building.

OU2 ROD Amendment #2 (2009) revised the requirements for shallow groundwater to the following:

- Groundwater monitoring
- Additional characterization
- LUCs

These three major remedy components are evaluated in the following sections.

8.1 Remedy Component #1: Groundwater Monitoring

Description: “Groundwater monitoring to track remedy performance” (OU2 ROD, page 3).

Performance Standard (how do you know when you’re done):

When a monitoring plan has been established and ongoing monitoring is in compliance with the plan.

Is the remedy component being implemented?

Yes. Table 8-1 summarizes the performance monitoring requirements, the implementing parties, and the documents that contain the monitoring plans. Appendix A summarizes the FY 2016 monitoring plan and any deviations are explained in Appendix C.2.

As previously approved by the USEPA and MPCA, all Site I (Building 502) Unit 1 monitoring wells were abandoned in FY 2014 prior to the demolition of Building 502. Only well 01U667 is scheduled to be replaced following the completion of regrading in the Building 502 area, which could be delayed beyond FY2017 due to the extent of regarding to be completed. Well 01U667 was not replaced in FY 2016, so no groundwater sampling was conducted during FY 2016. Once reinstalled, monitoring well 01U667 will be sampled annually in accordance with the FY 2017 – FY 2021 Monitoring Plan (see Appendix A.1). Figure 8-1 presents a site plan for Site I, including the former locations of the now-abandoned monitoring wells, and the location of the geologic cross-section presented on Figure 8-2.

Is any groundwater sampling proposed prior to the next report? Yes. Monitoring well 01U667 is expected to be reinstalled and monitored after completion of site redevelopment activities. Groundwater monitoring at Site I will be in accordance with the monitoring plan shown in Appendix A.1.

Are any changes or additional actions required for this remedy component? Yes. Remedy Component #1 will require modification due to the abandonment of the Unit 1 monitoring wells.

8.2 Remedy Component #2: Additional Investigation

Description: "Additional characterization of the Unit 1 and Unit 2 soil and groundwater" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When the work has been completed according to an Agency-approved work plan.

Has the remedy component been implemented?

Yes. The results of the additional investigation were included in the work plan. The additional investigation resulted in a pilot study to evaluate the applicability of dual-phase vacuum extraction technology to the site. The pilot study concluded that neither dual-phase extraction nor groundwater extraction is feasible at Site I. The May 2009 OU2 ROD Amendment removed the groundwater extraction and POTW discharge component of the remedy.

Are any changes or additional actions required for this remedy component? No.

8.3 Remedy Component #3: Land Use Controls

Description: "LUCs will be established to protect the groundwater extraction, treatment, and monitoring system and to prohibit the drilling of water supply wells within the contaminated portion of the Unit 1 aquifer." (OU2 ROD Amendment #1, page 39)

Performance Standard (how do you know when you're done):

Implementation of the LUCs will continue until such time that the groundwater concentrations are below the cleanup levels.

Has a LUCRD document been approved to address LUC issues for OU2, including Site I groundwater, and is it being implemented?

Yes. The USEPA and MPCA provided consistency approval for the Revision 2, OU2 LUCRD in June 2011 and it is being implemented by the Army.

Was an annual site inspection for LUCs conducted in FY 2016?

On August 10, 2016, the Army, National Guard, and JV conducted the annual inspection of OU2 sites. The checklist that was completed during the inspection is included as Appendix F.

Did the inspection identify any follow-up actions needed to maintain the protectiveness of the LUCs? No.

8.4 Overall Remedy for Site I Shallow Groundwater

Performance Standard (how do you know when you're done):

When the cleanup levels in Table 1 of the OU2 ROD have been attained throughout the areal and vertical extent of the Site I plume (OU2 ROD, page 55).

Has the Site I shallow groundwater remedy been completed (i.e., have the cleanup levels in Table 1 of the OU2 ROD been attained throughout the areal and vertical extent of the Site I plume)?

No. Groundwater monitoring was not conducted in FY 2016 due to the approved abandonment of all Unit 1 wells and Site I demolition activities; however, the most recent groundwater quality data (from FY 2013) suggest that cleanup levels have not been attained. Table 8-2 presents the most recent groundwater quality data (from FY 2013) and highlights the values that exceeded a cleanup level. The concentration of TCE in former well 01U632 had decreased over time, but was still above the cleanup level in FY 2013. Results from the sampling of well 01U667 indicated concentrations of 1,2-dichloroethene and vinyl chloride remained above the cleanup levels. Figure 8-3 presents the FY 2013 Site I shallow groundwater TCE and vinyl chloride sample results.

Do additional remedial measures need to be addressed?

Yes. As requested by Orbital ATK in their letter dated August 12, 2013 and approved by the USEPA and MPCA by letter dated August 14, 2013, all Unit 1 monitoring wells were abandoned in 2014, resulting in the need for modifications to the Groundwater Monitoring Remedy Component. In accordance with the Orbital ATK request and agency approval, monitoring well 01U667 will be reinstalled at the same location and depth following completion of redevelopment related grading to occur in the former Building 502 area, with expected installation to be in 2017. However, due to the significant extent of grading to occur, reinstallation of 01U667 could be delayed. Monitoring well 01U667 will be sampled annually in accordance with the FY 2017 – FY 2021 Monitoring Plan (see Appendix A.1).

9 OPERABLE UNIT 2: SITE K SHALLOW GROUNDWATER

VOC contamination has been identified in the Unit 1 (perched aquifer) at former Building 103. The limits of the VOC plume in the perched groundwater have been defined to be beneath and immediately northwest of former Building 103.

The remedy selected in the OU2 ROD consisted of seven components that incorporated the existing groundwater extraction trench and air stripper, which began operation in August 1986. The remedy also included additional investigation of the unsaturated soils beneath the building slab. OU2 ESD #1 added LUCs as a remedy component in 2009.

9.1 Remedy Component #1: Groundwater Monitoring

Description: "Groundwater monitoring to track remedy performance" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When a monitoring plan is established and monitoring is in compliance with the plan.

Is the remedy component being implemented?

Yes. Table 9-1 summarizes the performance monitoring requirements, the implementing parties, and the documents that contain the monitoring plans. Appendix A summarizes the FY 2016 monitoring plan and any deviations are explained in Appendix C.2.

Water levels are collected annually from the monitoring wells and bundle piezometers in the vicinity of the groundwater collection and treatment system. In FY 2014, 15 Unit 1 monitoring wells were permanently abandoned, as approved by the USEPA and MPCA on August 14, 2013 and May 7, 2014. The monitoring wells currently included in the Site K Monitoring Plan were sampled in June 2016. Figure 9-1 presents the sampling and water level monitoring locations, as well as the location of the monitoring wells abandoned in FY 2014. Figure 9-1 also shows the cross section alignment. Three of the wells abandoned in 2014 (01U608, 01U609, and 01U611) were scheduled to be reinstalled in spring 2016; however, the scheduling was pushed to 2017 due to onsite construction. Once reinstalled, the wells will have the same monitoring requirements they had prior to abandonment. Wells 01U608 and 01U609, once reinstalled, will be added to the water level monitoring list and well 01U611 will be added to the annual water quality sampling list.

Is any groundwater sampling proposed prior to the next report? Yes. Groundwater monitoring at Site K will be in accordance with the monitoring plan shown in Appendix A.1.

Are any changes or additional actions required for this remedy component? Yes. Wells 01U608, 01U609, and 01U611, which were abandoned in 2014, are scheduled to be reinstalled in 2017. However, due to construction of pending storm water infrastructure related to redevelopment, replacement of these wells may be delayed. Once installed, the replacement wells will be added to the monitoring plan and monitored for water level (01U608, 01U609, and 01U611) and water quality (01U611).

9.2 Remedy Component #2: Sentinel Wells

Description: "Installation of sentinel wells at the bottom of Unit 1 and top of Unit 3" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When the wells have been installed according to a regulator approved work plan.

Is the remedy component being implemented?

Yes. The upper Unit 3 sentinel well was installed in February 2000. The sentinel well was installed to monitor the potential for VOCs to migrate through the Unit 2 till aquitard and into the Unit 3 aquifer.

Existing piezometers were used to accomplish the deep Unit 1 sentry monitoring. Piezometers 01U625D, 01U626D, 01U627D, and 01U628D were used because they monitor the base of the Unit 1 aquifer near the trench. The issue is the potential for dense non-aqueous phase liquids (DNAPLs) to migrate beneath the trench along the Unit 1/Unit 2 interface. These four piezometers are screened at that interface.

Figure 9-1 shows the location of the upper Unit 3 sentinel well (03U621) and the piezometers.

What are the results of the Unit 1 piezometer and Unit 3 sentinel well sampling?

The piezometers (Unit 1 sentinel wells) were sampled in March 2000 and the results were discussed in the FY 2000 APR. The results did not indicate the presence of DNAPLs at the Unit 1/Unit 2 interface. This was a one-time sampling event, as required by the MPCA/USEPA approved *Predesign Investigation Work Plan, Site K, TCAAP* (CRA 1999), and as documented in the *Predesign Investigation Report, Site K, TCAAP* (CRA 2001), for which concurrence was received.

The Unit 3 sentinel well (03U621) was sampled in March, July, and September 2000 of FY 2000, and in January 2001 for the quarterly sampling required by the work plan. After that, the well was incorporated into the regular TCAAP monitoring plan. The well was sampled in June 2016 for FY 2016. The results of the sample collected during FY 2016 are presented in Table 9-2. There were no COCs detected in the Unit 3 sentinel well at concentrations above the method detection limit. Although not a COC for Site K, a 1,4-dioxane concentration of 9.3 µg/L was reported for the well 03U621 sample. The MDH, established a HRL value of 1.0 µg/L for 1,4-dioxane.

Are any changes or additional actions required for this remedy component? No.

9.3 Remedy Component #3: Hydraulic Containment

Description: "Use of existing interceptor/recovery trench to contain the plume and remove impacted groundwater." (OU2 ROD, page 3)

Performance Standard (how do you know when you're done):

When the trench is operating as designed and capturing all groundwater exceeding the cleanup levels presented in Table 1 of the OU2 ROD, as described below.

Is the remedy component being implemented?

Yes. The groundwater collection system continues to provide capture (as described later) of the Unit 1 groundwater, upgradient of the trench and beneath the former Building 103 footprint, as designed. In FY 2014, the Building 103 slab was removed as part of the site redevelopment activities.

Is the system providing hydraulic capture of the plume?

Yes. Water level data are presented in Table 9-3. Figure 9-2 presents a plan view of the groundwater contours from the June 2016 round of groundwater level measurements. At nested wells, the numerically lowest water elevation was used to create the plan view contours. Monitoring wells downgradient (e.g., 01U627) of the extraction trench show consistently higher water levels than those near of the trench (e.g., 01U626). This demonstrates that the horizontal hydraulic gradient has been reversed toward the extraction trench due to system operation.

Vertical capture was also effective as illustrated on Figure 9-3. As shown on the figure, groundwater both upgradient and downgradient of the trench is captured and collected. The upward gradient exhibited on the downward gradient side of the trench (01U626) indicates that groundwater does not migrate below the trench. The monitoring coverage provided by the bundle piezometers, demonstrates complete vertical and horizontal hydraulic capture.

It is noted that an upgradient well (01U625C) is obstructed. The cause of the obstruction is unknown. An attempt to remove the obstruction will occur in spring 2017. Well 01U625C is not considered critical in the collection trench flow evaluation. Historically, this well has maintained a similar groundwater elevation as 01U625B and 01U625D (see Appendix D). Based on 2015 and 2016 groundwater elevation data showing the return to typical levels, replacement of 01U625C is not recommended.

Figure 9-4 presents the TCE concentrations from the June 2016 annual sampling event. The plume was originally defined based on data from all the monitoring wells. The plume was then refined based on the results of the 2014 geoprobe investigation. The current monitoring well network is used to confirm the plume contours and measure the progress of remediation. Thus, the contours on Figure 9-4 were drawn with consideration of the extensive historical data, specifically the 2014 data from the geoprobe investigation.

Are any changes or additional actions required for this remedy component? Not at this time. Two monitoring wells (01U604 and 01U628) historically used to monitor hydraulic capture were abandoned in 2014 as a result of site redevelopment activities. However, existing wells (e.g., 01U603, 01U612, 01U615, 01U617, 01U621, 01U625, 01U626, and 01U67) located upgradient and downgradient of the collection trench provide adequate coverage to continue hydraulic and water quality monitoring of the shallow groundwater, and verify hydraulic containment at Site K. Additional monitoring (including the need for additional monitoring wells) will be evaluated upon completion of redevelopment plans for the area.

9.4 Remedy Component #4: Groundwater Treatment

Description: “Treatment of contaminated groundwater using air stripping” (OU2 ROD, page 3).

Performance Standard (how do you know when you’re done):

When the air stripping facility is treating water to the cleanup standards.

Is the remedy component being implemented?

Yes. During FY 2016, the treatment system functioned and was operational 96% of the time. During FY 2016, a regular maintenance schedule was maintained. Appendix G.1 summarizes operational data and events at the groundwater extraction and treatment system.

Are any changes or additional actions required for this remedy component? No.

9.5 Remedy Component #5: Treated Water Discharge

Description: "Discharge of treated groundwater to Rice Creek" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When the system is operating as designed with treated water discharge to the storm sewer that, in turn, discharges to Rice Creek. The water is required to meet the substantive requirements of Document No. MNU000579 (MPCA), which contains the state-accepted discharge limits for surface water. Sampling and analysis are performed to monitor performance (see below).

Is the remedy component being implemented?

Yes. See discussion in Section 9.6.

Are any changes or additional actions required for this remedy component? No.

9.6 Remedy Component #6: Discharge Monitoring

Description: "Monitoring to track compliance with discharge requirements" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When a monitoring plan is established and is being implemented in accordance with the plan.

Is the remedy component being implemented?

Yes. Treatment system monitoring consisted of quarterly influent and effluent sampling. Influent and effluent analytical results are presented in Table 9-4 (organics) and Table 9-5 (inorganics). The discharge met all the treatment requirements during FY 2016, with the exception of copper and zinc in the effluent sample collected on March 1, 2016. The discharge concentration of copper and zinc exceeded the substantive requirements document effluent concentration limit; and therefore, the discharge was resampled on March 21, 2016 per the requirements of the project Data Quality Objectives (Performance Monitoring QAPP, Rev. 12; Table 2e). The concentrations of copper and zinc collected from the treatment system discharge on March 21, 2016 were below the defined effluent concentration limits as shown on Table 9-5. Review of the treatment system operations and sampling procedures did not identify the cause for the elevated copper and zinc results.

Are any changes or additional actions required for this remedy component? No.

9.7 Remedy Component #7: Additional Investigation

Description: "Additional characterization of the unsaturated Unit 1 soil" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When the additional investigation has been completed according to a regulator approved work plan.

Is the remedy component being implemented?

Yes. The work plan was approved in FY 1999. A report of the investigation results received a consistency determination from the Agencies on December 6, 2001. The report defined the extent of VOC contaminated soils beneath Building 103 and refined the location of the source area. The report and subsequent follow up sampling resolved anomalous dissolved zinc, lead, and nickel data at two monitoring wells. Zinc, lead, and nickel are no longer groundwater concerns.

Are any changes or additional actions required for this remedy component? No.

9.8 Remedy Component #8: Land Use Controls

Description: "LUCs will be established to protect the groundwater extraction, treatment, and monitoring system and to prohibit the drilling of water supply wells within the contaminated portion of the Unit 1 aquifer" (OU2 ROD Amendment #1, page 39).

Performance Standard (how do you know when you're done):

Implementation of the LUCs will continue until such time that the groundwater concentrations are below the cleanup levels.

Has a LUCRD document been approved to address LUC issues for OU2, including Site K groundwater, and is it being implemented?

Yes. The USEPA and MPCA provided consistency approval for the Revision 2, OU2 LUCRD in June 2011 and it is being implemented by the Army.

Was an annual site inspection for LUCs conducted in FY 2016?

On August 10, 2016, the Army, National Guard, and Wenck conducted the annual inspection of OU2 sites. The checklist that was completed during the inspection is included as Appendix F.

Did the inspection identify any follow-up actions needed to maintain the protectiveness of the LUCs? No.

9.9 Overall Remedy for Site K

Performance Standard (how do you know when you're done):

Once the cleanup levels in Table 1 of the OU2 ROD have been attained throughout the areal and vertical extent of the Site K plume (OU2 ROD, page 55).

Has the Site K shallow groundwater remedy been completed (i.e., have the cleanup levels in Table 1 of the OU2 ROD been attained throughout the areal and vertical extent of the Site K plume)?

No. Overall, the remedy for Site K continued to operate consistent with past years and is in compliance with the required performance criteria.

Table 9-6 presents the VOC mass removal and monthly flow rates. The treatment system captured and treated 5,861,506 gallons of water resulting in the removal of 9.25 pounds of VOCs from the aquifer in FY 2016. The cumulative mass removal is 372.7 pounds of VOCs.

As shown on Figure 9-4, TCE concentrations range from non-detect to 1,700 µg/L. In general, site wide TCE concentrations were lower than those reported in 2015. Monitoring wells 01U611 and 01U615 monitor the core of the plume. Well 01U611 was abandoned in 2014 for site redevelopment activities and is scheduled to be reinstalled in spring 2017, so no data are available for FY 2016. Prior to abandonment, TCE concentrations at monitoring well 01U611 had been relatively stable over the previous seven years, ranging from 4,900 µg/L to 11,000 µg/L. The FY 2016 concentration at well 01U615 showed a decrease from 2,400 µg/L to 1,700 µg/L compared to the concentration measured in FY 2015. The FY 2016 concentration of TCE at 01U615 is a ten year low, but is comparable with historical concentrations from the last ten years of sampling, which have ranged from 1,700 µg/L to 6,500 µg/L. Figure 9-5 shows TCE and total 1,2-dichloroethene versus time for 01U615. Water levels measured during the FY 2016 monitoring were 2.1 feet lower at 01U615 compared to FY 2015 elevations. This well has historically exhibited fluctuating groundwater elevations.

Concentrations of TCE in monitoring well 01U603 had always been non-detect (less than 1.0 µg/L). However, in May 2014, TCE was detected at a 2,000 µg/L in 01U603. Well 01U603 was resampled in July 2014 (5,600 µg/L) and September 2014 (4,600 µg/L). The July and September results confirmed that elevated concentrations of TCE and other VOCs are present in the well. However, groundwater samples collected downgradient of 01U603 as part of a Site K geoprobe investigation in September 2014 were non-detect for TCE and confirmed capture by the collection trench. The geoprobe investigation in 2014 determined that historically high groundwater levels in April and May 2014 likely mobilized trichloroethene in the former storm sewer bedding that was present underneath the former building footprint. The geoprobe results were submitted to the USEPA and MPCA in a letter dated February 3, 2015. The FY 2016 TCE concentration at well 01U603 decreased considerably to 30 µg/L from 1,200 µg/L in FY 2015.

Well 01U617 continues to exhibit low and relatively consistent concentrations of 1,2-dichloroethene downgradient of the groundwater collection system's capture zone. The concentration at this well was consistent with those measured in FY 2014 and previous years. The detected 1,2-dichloroethene concentration is below the cleanup level for Site K.

Do additional remedial measures need to be addressed? No.

9.10 Other Related Activity in FY 2016

In March 2015, the USEPA and MPCA requested sampling and analysis for 1,4-dioxane to be included in the annual sampling event for Site K. The analysis was added to all regularly scheduled monitoring wells in 2015 and 2016. Table 9-7 presents the results of the 1,4-dioxane sampling for the 2016 event. No Federal MCL has been established for 1,4-dioxane; however, the MDH established a HRL value of 1.0 µg/L as shown on Table 9-7. Unit 3 monitoring well 03U621 had a 1,4-dioxane concentration exceeding the HRL of 9.3 µg/L. The low levels of 1,4-dioxane in the Unit 1 wells indicate that the higher

concentration in the Unit 3 well is unrelated to Site K activities. Future sampling for 1,4-dioxane in Unit 1 wells at Site K is not recommended.

10 OPERABLE UNIT 2: BUILDING 102 SHALLOW GROUNDWATER

The former Building 102, located as shown on Figure 10-1, was constructed in 1942 and used periodically until the 1980s for production of small caliber ammunition and various other munitions components. Between March 2002 and February 2004, shallow (Unit 1) groundwater contamination was discovered emanating from beneath Building 102 (discovered during the Phase I and Phase II Environmental Site Assessment (ESA) in support of the future transfer of the remaining TCAAP property).

Additional groundwater investigation was conducted and is documented in the *Groundwater Investigation Report for Building 102* (Wenck and Keres Consulting Inc 2006), approved by the USEPA and MPCA in FY 2006. The Army then proceeded to address the remedy for Building 102 shallow groundwater as a non-time critical removal action under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). To support the Engineering Evaluation/Cost Analysis (EE/CA), additional groundwater investigation was conducted in FY 2007 and FY 2008 to further define the extent and magnitude of groundwater contamination. Delineation was completed and COCs were identified, including TCE and related chlorinated VOCs (TCE was found to be degrading to cis-1,2-DCE and vinyl chloride through abiotic degradation). The EE/CA documenting the additional investigation work and recommending a remedy for the Building 102 shallow groundwater was approved by the USEPA and MPCA in FY 2008.

The Army Action Memorandum documenting the final remedy selection for Building 102 groundwater (MNA) was signed early in FY 2009. The remedy also includes LUCs to prohibit installation of water supply wells into the contaminated portion of the Unit 1 aquifer and to protect the groundwater monitoring system infrastructure (i.e., monitoring wells). OU2 ROD Amendment #4 formally documented selection of MNA and LUCs for the Building 102 groundwater remedy and thereby added this site to the OU2 remedy.

The decision to proceed with MNA was based on the strong evidence from water quality monitoring (i.e., degradation products) and on MPCA microcosm studies that have verified that abiotic degradation of VOCs in Building 102 groundwater is occurring at substantial rates. Such degradation acts to reduce contaminant mass and mobility by breaking down the contaminants as they move downgradient. The decision to proceed with MNA was also based on the absence of any groundwater receptors.

10.1 Remedy Component #1: Monitored Natural Attenuation

Description: “Use of naturally-occurring abiotic degradation to limit plume mobility and to ultimately restore the aquifer” (OU2 ROD Amendment #4, page 4-1).

Performance Standard (how do you know when you’re done):

When a monitoring program is established and monitoring is in compliance with the regulator approved Annual Monitoring Plan.

Is the remedy component being implemented?

Yes. Appendix A summarizes the FY 2016 monitoring plan and any deviations are explained in Appendix C.2. Details of the groundwater monitoring program are discussed in the next section.

10.2 Remedy Component #2: Groundwater Monitoring

Description: "Groundwater monitoring to track remedy performance and to verify that groundwater reaching Rice Creek does not exceed state surface water standards" (OU2 ROD Amendment #4, page 4-1).

Performance Standard (how do you know when you're done):

When a performance groundwater monitoring program has been established and ongoing monitoring is in compliance with the program.

Is this remedy component being implemented?

Yes. Table 10-1 summarizes the performance monitoring requirements, the implementing parties, and the documents that contain the monitoring plans. The FY 2016 Monitoring Plan is included in Appendix A, documenting the water quality monitoring locations and frequencies. Building 102 groundwater level data collected in June 2016 are shown as groundwater elevation contours on Figure 10-2. Site K water levels are also contoured on the figure to provide a more complete water level map in the site vicinity. Groundwater quality data collected in FY 2016 are shown in Table 10-2. Groundwater quality data for FY 2016 are also shown on plume maps for two of the COCs: TCE (Figure 10-3), cis-1,2-DCE (Figure 10-4), and vinyl chloride (Figure 10-5).

Also, due to the discovery of 1,4-dioxane within the OU1 plume, the FY 2015 1,4-dioxane monitoring was repeated during the FY 2016 summer sampling event to verify that 1,4-dioxane is not a COC in Building 102 shallow groundwater. As shown in Table 10-2, there was only one low detection of 1,4-dioxane in Building 102 shallow groundwater in the July 2016 sampling event. These results are consistent with the FY 2015 sampling results and support the conclusion that 1,4-dioxane is not a contaminant of concern in Building 102 shallow groundwater.

Were the groundwater monitoring requirements for this remedy met? Yes.

Is any groundwater sampling proposed prior to the next report?

Yes. Groundwater monitoring at Building 102 will be in accordance with the monitoring plan shown in Appendix A.1.

Are any changes or additional actions required for this remedy component? No.

10.3 Remedy Component #3: Land Use Controls

Description: "LUCs to restrict installation of water supply wells into the contaminated portion of the Unit 1 aquifer and to protect the infrastructure related to this alternative (monitoring wells)" (OU2 ROD Amendment #4, page 4-2).

Performance Standard (how do you know when you're done):

Implementation of the LUCs will continue until such time that the groundwater concentrations are below the cleanup levels.

Has a LUCRD document been approved to address LUC issues for OU2, including Building 102 groundwater, and is it being implemented?

Yes. The USEPA and MPCA provided consistency approval for the OU2 LUCRD in September 2010 and it is being implemented by the Army. Revision 4 of the OU2 LUCRD was approved by the USEPA and MPCA in August 2016; however, this revision did not affect LUCs for Building 102.

Was an annual site inspection for LUCs conducted in FY 2016?

Yes. On August 10, 2016, the Army, National Guard, and JV conducted the annual inspection of OU2 sites. The checklist that was completed during the inspection is included as Appendix F.

Did the inspection identify any follow-up actions needed to maintain the protectiveness of the LUCs? No.

10.4 Overall Remedy for Building 102 Shallow Groundwater

Performance Standard (how do you know when you're done):

When the cleanup levels in OU2 ROD Amendment #4 have been attained throughout the areal and vertical extent of the Building 102 plume (OU2 ROD Amendment #4, page 2-13).

Has the Building 102 shallow groundwater remedy been completed (i.e., have the cleanup levels in the table on Page 2-13 of OU2 ROD Amendment #4 been attained throughout the areal and vertical extent of the Building 102 plume)?

No. As shown in Table 10-2, cleanup levels have not been reached throughout the areal extent of the plume and the site cannot be closed. TCE concentrations exceed the cleanup level in four monitoring wells.

What impact is MNA having on contaminant concentrations?

Natural attenuation continues to occur at this site, with TCE being the primary VOC present in the source area vicinity, and primarily degradation products being present in downgradient wells (e.g., primarily cis-1,2-DCE and vinyl chloride in 01L582 and 01U582). Significant changes that were noted in the FY 2016 groundwater quality results include:

01U579 and 01U580 (source area): The TCE concentration decreased in 01U579 and 01U580. Historically, the concentrations in these two wells have shown relatively large increases and decreases.

01L582 (further downgradient of the source area): The concentration of cis-1,2-DCE decreased significantly (38 to 14 µg/L) and vinyl chloride also decreased (0.41 to 0.21 J µg/L), continuing the trend that was observed from FY 2013 to FY 2014 and FY 2014 to FY 2015.

01U048 (adjacent to Rice Creek): 1,4 dioxane was the only contaminant detected in this well. 1,4-Dioxane was detected at 0.15 µg/L, below the MDH HRL of 1.0 µg/L.

Were any trigger levels exceeded at the contingency location?

No. The contingency location is 01U048, located next to Rice Creek. The trigger level is equal to groundwater cleanup levels and no COCs for Building 102 groundwater exceeded their respective cleanup levels in FY 2016 (Table 10-2).

Do additional remedial measures need to be addressed?

No. However, it should be noted that as part of Ramsey County's site redevelopment work, Ramsey County has relocated a section of Rice Creek to create more space for construction of a new I-35W / County Road H interchange. The relocation work placed Rice Creek much closer to the west side of the Building 102 plume. While the long-term impacts to groundwater flow are not yet known, given that Unit 1 groundwater discharges to Rice Creek, it is a possible that the new location could cause contaminated groundwater to begin flowing in a more westerly direction, and could potentially discharge into the creek in its revised location rather than continuing to discharge into the creek near 01U048. With this potential adverse outcome in mind, in FY 2016, Ramsey County installed two sets of nested monitoring wells adjacent to the revised creek location, on the east side of the creek near the point of potential groundwater discharge. Ramsey County intends to perform ongoing sampling at the new wells. The MPCA has indicated to Ramsey County that if Ramsey County's actions cause a shift in the Building 102 plume and resultant exceedance of an action level in a Ramsey County Rice Creek monitoring well, it will be Ramsey County's responsibility to address that situation.

Bay West, working on behalf of Ramsey County, provided the "Groundwater Monitoring Report – March 2017 Sampling Event for the Rice Creek Remeander, TCAAP Redevelopment" to Arcadis in April 2017. According to groundwater monitoring performed at Building 102 in March 2017 after the Rice Creek Remeander was completed, there appears to be no impacts to groundwater quality. Vinyl Chloride was detected in 01URC1D during the March 2017 event at a concentration of 0.058 µg/L, which is well below the MDH HRL of 0.2 µg/L. As of the March 2017 groundwater monitoring event, there was no apparent change in the Building 102 plume configuration or groundwater flow. Bay West will continue to monitor the groundwater quality during four semi-annual events and will provide a monitoring report with cumulative monitoring data following each event. For a more detailed summary of the Rice Creek Remeander groundwater monitoring, refer to Bay West, 2017.

It should also be noted that Ramsey County plans further development in this area that may result in loss of monitoring wells due to installation of a storm water control basin. Ongoing efforts will be made to address any issues resulting from Ramsey County's development plans.

11 OPERABLE UNIT 2: AQUATIC SITES

The *Tier II Ecological Risk Assessment Report* (U.S. Army Center for Health Promotion and Preventative Medicine [USACHPPM] 2004) for aquatic sites, was approved by the MPCA and USEPA in December 2004. In June 2005, the Army submitted a draft feasibility study (FS) for aquatic sites to support the risk management decisions with respect to "No Further Action" or "Implement a Remedy" for each aquatic site. Following comments to the draft FS, it was agreed that additional sampling of Marsden Lake and Pond G would be conducted. This sampling was completed in 2008. Revised draft FS versions were submitted in January 2009 and April 2010. After review of the 2010 draft FS, the USEPA and MPCA requested that the Army prepare a work plan for collection of additional Round Lake sediment data (Round Lake is located off the southwest corner of OU2). Given the time required to collect the additional data, the Army, USEPA, and MPCA agreed to separate the FS into two documents: one for Round Lake and one for the OU2 aquatic sites, i.e., Rice Creek, Sunfish Lake, Marsden Lake North, Marsden Lake South, and Pond G. These sites are located as shown on Figure 11-1.

The USEPA and MPCA provided consistency for the Rice Creek, Sunfish Lake, Marsden Lake, and Pond G FS in January 2011. No Action was recommended for Rice Creek, Sunfish Lake, Marsden Lake North, and Marsden Lake South. A remedy was recommended for Pond G (surface water hardness adjustment) to attain compliance with the Minnesota surface water standard for lead (Class 2Bd chronic standard). OU2 ROD Amendment #4, which documents selection of the recommended alternative, was signed in January 2012.

The USEPA and MPCA provided consistency for the Pond G RD/RA Work Plan in March 2012, and the pond was treated in June 2012. The pond surface water was then monitored in 2012 and 2013, and results verified compliance with the surface water standard for lead. The completed Pond G remedial action work and surface water monitoring results were documented in the *Remedial Action Completion and Close Out Report, Pond G* (Wenck 2013b), which received regulatory consistency approval in FY 2014. The report recommended that the Pond G site be closed with no long-term maintenance, monitoring, or LUC requirements. The 2014 CERCLA five-year review also indicated final concurrence regarding the adequacy of the Pond G remedy, and the Pond G site has been closed. Since the completed remedy does not result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, future CERCLA 5-year reviews are not required for Pond G and, as noted above, there are no monitoring or LUC requirements.

12 OPERABLE UNIT 2: DEEP GROUNDWATER

The selected remedy for the Deep Groundwater in the OU2 ROD consists of five remedial components that include continued use of the TGRS, with modifications to improve VOC contaminant removal from the source area. It also includes an annual review of new and emerging technologies potentially applicable to the Deep Groundwater. This APR documents all performance and monitoring data collected from October 2015 through September 2016.

Historical Design and Evaluation of TGRS Remedial Action

In September 1987, a Record of Decision (1987 ROD) was prepared by the USEPA to implement the *Interim Response Action Plan for TCAAP* (USEPA 1987a). The 1987 ROD provided specific criteria for the Boundary Groundwater Recovery System (BGRS). Following extensive interagency negotiations on the FFA and the ROD, the BGRS started on October 19, 1987.

The BGRS consisted of six Unit 3 extraction wells (B1 through B6) connected by forcemain to an air stripping treatment facility. The initial six BGRS extraction wells (B1 through B6) were installed and pumping tests were conducted prior to startup of the BGRS. The pumping tests were documented in the *BGRS Extraction Well Pumping Test Report* (CRA 1987).

Following the initial 90-day operation of the BGRS, the *IRA–BGRS Performance Assessment Report* (PAR; CRA 1988) was prepared. The PAR assessed the hydraulic and treatment performance of the BGRS. The PAR presented an extensive database collected during the initial 90-day period of BGRS operation and prior pertinent data. The PAR also included a summary of the geology, hydrogeology, and remediation history for TCAAP. The PAR was subsequently approved by the MPCA and USEPA.

A pumping test was conducted on Unit 4 extraction well B9 in August 1988 and formed the basis of the final design of the TGRS. This test, and the previous pumping tests, was utilized to determine the pumping rate required to achieve the necessary zone of capture for the TGRS, based on the plume size at that time. The PAR stated that the overall pumping rate needed for hydraulic capture from the 17 extraction wells was 2,450 gpm. During the detailed design of the TGRS, the system was designed with the capacity to operate at a maximum theoretical rate of 2,900 gpm. The additional pumpage was included to provide a safety margin for the calculations and to allow for fluctuations in system operation.

The PAR made recommendations for expansion of the BGRS into the TGRS to meet the Phase II remediation criteria established in the 1987 ROD. These modifications were completed and the expanded TGRS system began operation on January 31, 1989.

The *IRA-TGRS: 1989 Annual Monitoring Report and Monitoring Plan* (CRA 1991) was the first report covering the fully configured TGRS. The 1989 report concluded that the TGRS developed a continuous zone of capture that was approximately 4,500 feet wide at the TCAAP property boundary. The zone of capture widened to approximately 8,300 feet upgradient of the boundary. This zone of capture was developed at average system pumping rates of 2,400 to 2,700 gpm.

The *IRA-TGRS: 1989 Annual Monitoring Report and Monitoring Plan* (CRA 1991) was wider in scope than subsequent annual monitoring reports for the TGRS; because the 1989 report was both a PAR and a monitoring report. The 1989 report represented the first year of the expanded TGRS operation. Thus, a

more detailed and exhaustive performance assessment was appropriate and possible because there were data available from non-pumping conditions for detailed comparison with pumping conditions. Between 1990 and 2002, the system continued to operate at an essentially steady state condition, so the TGRS was evaluated by comparing the pumping rates to those achieved for the 1989 evaluation.

In FY 2003, the Army received agency approval on the TGRS Operating Strategy (OS) document. The OS was based, in part, on findings from the 1989 Annual Monitoring Report. The OS presented a GOS for the entire TGRS extraction system and a Micro Operation Strategy (MOS) for selected well groups. Evaluations now consider and compare actual pumping rates to the GOS and MOS rates presented in the Final TGRS OS.

TGRS Modifications

Since 1990, the TGRS has experienced a number of modifications in response to changes in plume configuration or operational issues. A brief summary of the major changes is presented below:

1. Source control well SC4 was shut down in November 1996 in response to insignificant VOC mass removal by this well. SC4 operated at an average extraction rate of 29 gpm in 1989 and 45 gpm prior to shut down.
2. Boundary extraction well B12 was shut down in November 1996. The plume in the B12 area had dropped below cleanup standards for several years prior to shutdown. Well B12 operated at an average extraction rate of 139 gpm in 1989 and 190 gpm prior to shut down.
3. As per the OS, boundary extraction well B2 was shut down and replaced with well B13, which began production in December 2002. B2 was shutdown because the well screen became fouled and flow rates decreased from an average of nearly 200 gpm in the early 1990s to 52 gpm in 2002. During FY 2003, well B13 operated at maximum pumping capacity of nearly 100 gpm. The original design capacity for B13 was 200 gpm, but the aquifer is not able to produce at this rate. The replacement Well B13 pumped at an average rate of 100 gpm.
4. As per the OS, boundary extraction wells B7 and B10, and source control well SC3 were officially shut down in December 2002 due to the low TCE concentrations.
5. As per the OS, a larger capacity pump was installed at well B9 in December 2002 to raise the pumping rate from 150 gpm to approximately 300 gpm.
6. In July 2004, the TGRS was modified (Modification #3) as approved by the Agencies in May 2004. Pumps in Wells B1 and B13 were replaced and the pump in Well B13 was lowered to allow pumping below the well screen.
7. In March 2011, the TGRS was modified to allow for two air stripping tower treatment instead of the original design of four air stripping tower treatment. Wet Well Pumps 1 and 2 (WWP#1 and WWP#2 located in Wet Wells 1 and 2) and blowers 1 and 2 were shut down and the valves to Towers 1 and 2 were closed. Groundwater is effectively treated by air stripping Towers 3 and 4 while Towers 1 and 2 remain in standby.
8. Boundary extraction well B11 was shut down on February 7, 2013 as approved by the Agencies in their letter dated February 5, 2013. The plume concentration in the B11 area was below cleanup

standards for several years prior to B11 shutdown. Well B11 operated at an average extraction rate of 178 gpm in 1989 and at approximately 100 gpm prior to shutdown.

Flow rates at individual wells have been modified from time to time due to plume configuration changes, operational issues, and to maintain the OS.

12.1 Remedy Component #1: Hydraulic Containment and Contaminant Removal From the Source Area

Description: "Groundwater extraction to hydraulically contain the contaminated source area to the 5 µg/L TCE concentration contour and optimize the removal of contaminants from the source area through pumping of select wells" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When the TGRS is containing the contaminated source area to the 5 µg/L TCE contour and the system is operated to maximize the contaminant removal from the source area.

Is the remedy component being implemented?

Yes. The TGRS was operated in FY 2016 consistent with the requirements of the OU2 ROD. Table 12-1 presents the cleanup requirements for the TGRS from the OU2 ROD.

During FY 2016, the TGRS average extraction rate was approximately 1,722 gpm. This rate is approximately 1.3 percent less than the GOS Total System Operational Minimum (1,745 gpm) where the Army and the Agencies agree that OU2 ROD requirements are met with an adequate safety factor. The GOS OM pumping rate was based on a wider TCE source area plume of 4,000 feet in 2001 compared to a plume area source width of 3,000 feet in 2016 and represents a 25 percent reduction in the source area plume width, because the plume width reduction (25%) far exceeds the pumping rate reduction (1.3%), hydraulic capture of 5 µg/L TCE concentration contour is very likely, but the factor of safety could be less.

Two of the three individual well groupings were above their respective MOS minimums for FY 2016. The B1, B11, B13 well grouping was below the MOS minimum of 415 gpm due to the approved B11 shut down in February 2013 and TGRS wide maintenance events. B11 will continue to be monitored to verify containment.

How is the system operated and what preventative maintenance (PM) measures were conducted during the year?

Summary of Operations

Beginning in FY 2003, the system operation changed to conform to the OS. Under the OS, groundwater was extracted from nine wells along the southwest boundary of TCAAP (B1, B3, B4, B5, B6, B8, B9, B11, and B13) and three wells downgradient of interior source areas on TCAAP (SC1, SC2, and SC5). In February 2013, the Agencies approved the shutdown of B11 leaving 11 wells currently operating. Prior to the current configuration, wells B2, B7, B10, B12, SC3, and SC4 were also operating components of the system. Submersible pumps in the extraction wells discharge into a common pressurized forcemain that carries the water to the treatment system. The treatment system is located adjacent to Building 116. The TGRS layout is presented on Figure 12-1.

The TGRS was designed and constructed with three options for treated water discharge: recharge at the Arsenal Sand and Gravel Pit, discharge to Rice Creek, and discharge to the elevated water tank. Water stored in the elevated tank was “softened” and then “polished” with GAC prior to distribution at the facility. Due to the Army discontinuing all non-environmental services at the facility in September 2007, the elevated water tank and the water softening and polishing equipment are no longer used. As such, the Arsenal Sand and Gravel Pit receives all of the extracted and treated water from the TGRS.

System Operation Specifications

In general, the influent and effluent water flow rates at the treatment plant are designed to be equal, thereby providing continuous operation of all processes and equipment. The following is a summary of the original system design parameters:

- The groundwater extraction system, including the treatment center and 17 TGRS extraction wells, was originally designed to provide a theoretical hydraulic capacity of 2,900 gpm and a sustained daily average capacity of 2,730 gpm
- The influent to the treatment plant is divided between Towers 1 and 2, each receiving up to a maximum of 1,450 gpm.
- Wet Well Pumps 1 and 2 (WWP#1 and WWP#2 located in Wet Wells 1 and 2) transfer water to Towers 4 and 3, respectively. Each pump and tower handles up to a maximum of 1,450 gpm.
- Wet Well Pumps 3 and 4 (WWP#3 and WWP#4 located in Wet Well 3) discharge treated water to an end use at a combined rate of up to a maximum of 2,900 gpm.
- Air blowers provide air to the towers. The blowers for Towers 1 and 2 are designed to provide 6,000 – 7,000 standard cubic feet per minute (scfm) each. The blowers for Towers 3 and 4 are designed to provide 9,000 – 14,000 scfm each.

As stated earlier, the TGRS was modified to allow for two air stripping tower treatment instead of the original design of four air stripping tower treatment. This modification resulted in a reduction of energy use while still meeting the effluent discharge limit of 5 µg/L TCE. Wet Well Pumps 1 and 2 (40 horsepower each) and blowers 1 and 2 (5 horsepower each) were shut down and the valves to Towers 1 and 2 were closed. Since March 2010, groundwater has been effectively treated by air stripping Towers 3 and 4 while Towers 1 and 2 remain in standby.

Water level sensors within the wet wells communicate with the programmable logic controller (PLC) according to changing water levels. A complete and balanced operation should provide continuing water levels above the low-level sensors and below the high-level sensors. However, given the probability of unbalanced flows for any number of reasons (e.g., changing hydraulic heads, maintenance, repairs, temporary malfunctions), the PLC has provisions within its program to cycle-off the extraction well(s) or wet well pumps according to high water levels occurring in the wet wells; and in turn, cycle-off the wet well pumps according to low levels occurring within these wet wells.

The system operates such that the wet well pumps cycle rather than the extraction well pumps. The rationale behind this is that there are a relatively small number of motors, starters and electrically controlled valves associated with the wet wells when compared with the extraction well field. This also

provides for more continuous and complete hydraulic capture within the aquifer units. However, the extraction well field will cycle if necessary, starting with the least contaminated extraction well, B7 (if operating), and followed by the other extraction wells in a predetermined sequence.

In summary, the priority of operation is as follows:

- Maintain constant operation of all extraction wells and air stripping towers above the OM;
- Maintain the desired flow rates at individual wells;
- If operating in four tower mode, maintain the WWP#1 and WWP#2 pumping rate equal to or slightly above the combined pumping rate of the extraction well field; and
- Maintain treatment center WWP#3 and WWP#4 pumping rate equal to or slightly above the WWP#1 and #2 pumping rate (if operating in four tower mode) or slightly above the combined pumping rate of the extraction well field (if operating in two tower mode).

FY 2016 Maintenance and Inspection Activity

During FY 2016, the following inspection and maintenance activities occurred:

Preventative Maintenance (PM): The extensive PM program allowed the operations staff to identify and repair or replace equipment to avoid a downtime failure. The program consists of monthly, quarterly, and annual maintenance tasks. When required, further repair work was scheduled rather than waiting for the failure to occur. A broad range of system-specific information was collected during this year's PM. This information is used to direct future repair work.

Electrical Inspection and Temperature Survey: A system-wide electrical inspection and infrared temperature survey was performed to identify loose connections and overheating components. Component overheating often precedes equipment failure. Electrical components that were identified as failing were replaced.

Verification of Flow Meters: As part of the routine PM, flow meters in the pumphouses were compared to a factory-calibrated flow meter. Flow volume measurements before and after conducting maintenance on the meters were compared to verify the consistency of measurements. Meters found to be out of calibration were replaced or recalibrated.

Daily Tracking of Flow Rates: Pumphouse and treatment center meter readings were recorded in the course of the daily inspections. Daily meter readings were tabulated and the flow rates were calculated and reviewed by the operations staff. Early detection of changes in flow rate was critical in early identification of failing equipment. By early detection of flow rate changes, equipment repair was typically scheduled before a failure occurred.

Did the system operate at a rate sufficient for complete capture?

Yes. The TGRS average extraction rate was approximately 1,722 gpm. This rate is approximately 1.3% less than the GOS Total System Operational Minimum (1,745 gpm) where the Army and the agencies agree that OU2 ROD requirements are met with an adequate safety factor. The GOS OM was based on 4,000 foot wide 2001 TCE source area plume, which has been reduced by 25% to a 3,000 foot wide source area plume width (4,000 feet). Given the substantial plume width reduction, hydraulic capture of the 5 µg/L TCE concentration contour is very likely, but the factor of safety could be smaller. Figure 12-2

plots the daily average flow rate from October 1, 2015 through September 30, 2016, and shows that the TGRS operated above the OM for the majority of the time in FY 2016. On a monthly basis, total TGRS extraction rates were below 1,745 gpm during the following months:

- March 2016 (1,736 gpm, SC2 down for an extended period for a blown motor);
- April 2016 (1,682 gpm, lower flow rate due to downtime issues with SC2, SC1 and B8);
- May 2016 (1,738 gpm, lower flow rate due to SC2 pump and motor failure and repair of valve leak near B9 requiring the shutdown of wells B1, B3, B4, B5, B8, B13, B8 and B9);
- June 2016 (1,727 gpm, lower flow rate due to power failure at wells SC1, SC2 and SC5 an control issues at B9;
- July 2016 (1,497 gpm, lower flow rate due to a motor failure at B5 and significant forcemain and treatment system maintenance that required the shutdown of a number of extraction wells for an extended period; and
- August 2016 (1,657 gpm, lower flow rate due to the forcemain and treatment system maintenance, a blown motor at well B5 and communication system failure at well B9.

Appendix G.2 provides additional information on the various downtimes throughout FY 2016.

The monthly and annual volume of water pumped is presented in Tables 12-2 and 12-3. Table 12-2 presents the pumphouse metered monthly flow volumes of each extraction well. The individual pumphouse flow meters are used to determine the amount of groundwater extracted from the various MOS well groups, individual extraction wells, and the total amount of groundwater extracted during the fiscal year. Table 12-3 presents the combined pumphouse-metered flow volume (extraction wells) and the flow volumes metered at various stages in the treatment center along with historical data. These flow meters are used to evaluate the flow of water through the treatment process to ensure proper system operation.

As shown on Table 12-3, the TGRS successfully captured and treated approximately 907,577,164 gallons of contaminated water from October 2015 through September 2016 based on the sum of the individual pumphouse flow meters. This volume converts to an average flow rate of 1,722 gpm.

The TGRS as a whole was operational 95.6% of the time (i.e., 350 days out of 366 days in FY 2016).

Monthly Flow Reports

Each month a Monthly Flow Report is prepared. The report includes the month's meter totalizer readings, calculated flow volumes and operational notes. Flow volumes are presented on a daily basis and are totaled to provide a monthly flow volume. A compilation of FY 2016 operational notes is presented in Appendix G-2. During FY 2016, the sum of the individual pumphouse flow meters was used to measure total flow volumes in monthly reports for comparison with OS limits. Daily variation in readings at individual wells is primarily due to differences in the time of day when meter readings were taken.

How much down time occurred during the year?

The down time for each extraction well, over the last five years, is presented in Table 12-4. A summary of average down time for the pumphouses and the treatment center by the category of failure is presented in Table 12-5. A description of each down time event, organized chronologically, is presented in

Appendix G-2. The same descriptions organized by affected pumphouse, treatment center, and forcemain is presented in Appendix G-3.

Treatment center and extraction well down times resulted primarily from failure and subsequent repair of components in the pumphouses, treatment center, and electrical service. The downtime in FY 2016 increased from FY 2015 (from 6.0 days in FY 2015 to 15.9 days in FY 2016). The increase in downtime is primarily due to the maintenance effort in July and August 2016 which included jetting over 700 feet of forcemain near B9 to remove scale that had accumulated since the beginning of operation and removal, cleaning, and reinstallation of air stripping tower distribution heads.

Description of Down Time Categories

Pumphouse component failures accounted for an average of 9.1 days down time per pumphouse. The major pumphouse repairs causing down time were:

- Redeveloped Pumphouse SC2,
- Electrical issues and pump and motor replacement at Pumphouse SC2,
- Replaced motor at Pumphouse B5, and
- Troubleshoot and replace check valve at Pumphouse B9.

Treatment center component failures and repairs that caused pumphouse down time consisted of electric check valve maintenance, malfunctions and repairs, and electrical control equipment failures and subsequent repairs. Treatment center component failures, repairs, and adjustments accounted for an average of 0.7 days down time per pumphouse. The major treatment center repair causing substantial down time was the failure and replacement of the WWP#4 motor.

Electrical service system failures accounted for an average of 2.4 days down time per pumphouse. Electrical storm damage and power grid failures were the primary causes of down time.

PM procedures accounted for less than 3.5 days of down time in FY 2016. For the most part, PM was performed without interruptions to the treatment system. PM procedures are described in the project Operation and Maintenance Manual.

System modifications did not account for any days of down time in FY 2016.

Forcemain issues accounted for 0.2 days down time per pumphouse. A leaking gate valve in the forcemain near Pumphouse B9 was repaired May 2016.

Were there any major operational changes during the year?

No.

Did the system achieve hydraulic capture?

Yes. The TGRS average extraction rate for FY 2016 was approximately 1,722 gpm. This rate is approximately 1.3% less than the GOS Total System Operational Minimum (1,745 gpm) where the Army and the Agencies agree that OU2 ROD requirements are met with an adequate safety factor. The GOS OM was based on 4,000-foot wide 2001 TCE source area plume, which has been reduced by 25% to a 3,000-foot wide source area plume width (4,000 feet). Given the substantial plume width reduction, hydraulic capture of the 5 µg/L TCE concentration contour is very likely, but the factor of safety could be

smaller. A positive sign with respect to capture is the generally stable or decreasing TCE concentrations evident at many wells across the TGRS boundary since FY 2001. The FY2016 maintenance work that resulted in the average extraction rate below the GOS OM rate represents a very infrequent occurrence. This amount of downtime is not expected to occur in the foreseeable future and should not affect the TGRS ability to maintain extraction rates above the GOS OM rate.

Groundwater elevation measurements were collected in June 2016. Appendix D contains the water level database for the monitoring wells. Figures 12-3 through 12-5 present the groundwater elevations for Upper Unit 3, Lower Unit 3, and Unit 4 during this time period. These figures present the potentiometric contours from three vertical portions of the aquifer. The groundwater elevation contours and limits of capture in the three portions of the aquifer are similar to those observed in FY 2003 after the modification to the OS was implemented. The zone of capture created by the TGRS extends beyond the 5 µg/L TCE contour, in both the Unit 3 and the Unit 4 aquifers.

How much VOC mass was removed by the system and how is it changing with time?

As discussed above, the TGRS extracted and treated approximately 907,577,164 gallons of water from October 2015 through September 2016. Based on the monthly influent and effluent VOC concentrations and the monthly flow totals as measured by the extraction well flow meters, the TGRS removed a total of 1,731 pounds of VOCs from October 2015 through September 2016. The VOC mass removal in FY 2015 was 1,748 pounds. The decrease in FY 2016 reflects an overall decrease in plume mass.

Average VOC influent concentrations increased slightly from 229 µg/L in FY 2015 to 230 µg/L in FY 2016 (0.4 percent higher). Table 12-6 summarizes the individual VOC mass contribution of each extraction well and the entire system. Overall, the TGRS has removed over 107 tons (214,761 pounds) of VOCs from the aquifers since 1987 and 19 tons of VOCs since the end of FY 2001 (the TGRS OS was based on data through 2001). If the annual VOC mass removal from the TGRS is less than 1,709 pounds (50% of the FY 2001 mass removal) then the Army and Agencies have agreed that review of the OS OM rates should be conducted and potentially reduced. At 1,731 pounds in FY 2016, the VOC mass removal from the TGRS is at 50.6% of the FY 2001 mass removal.

The total mass removed is based on the monthly TGRS influent and effluent sampling and flow through the treatment system. The monthly sampling of the treatment system provides the best estimate of overall mass removal, compared to the individual extraction well sampling, due to the larger number of samples and consistency in the month-to-month analytical results. The percent contributions for each well are based on the average flows from each well and the semi-annual VOC results from each well.

VOC samples were collected semi-annually from the operating extraction wells that comprise the TGRS. Wells B2, B7, B10, B11, B12, SC3, and SC4 are shut down, but were temporarily operated for June 2016 sampling. Table 12-7 presents a summary of the sampling results for the extraction wells. Variations in detection limits from round to round are the result of varying sample dilution performed by the laboratory. Dilutions are required due to the high concentrations of some analytes. The locations of the extraction wells are presented on Figure 12-1.

Appendix H-1 presents TCE versus time graphs for each extraction well. As shown, TCE concentrations have declined in each well and now at many wells, the TCE concentrations appear to be stable or still declining. Since FY 2001, the following extraction wells have shown the most improvement (greater than 50% reduction) in TCE concentrations:

- B11 (4.8 µg/L in FY 2001 to non-detect in FY 2016 – 100% reduction);
- SC3 (5.5 µg/L in FY 2001 to 0.33 µg/L in FY 2016 – 94% reduction);
- B10 (5.1 µg/L in FY 2001 to non-detect µg/L in FY 2016 – 100% reduction);
- B6 (230 µg/L in FY 2001 to 27 µg/L in FY 2016 – 88% reduction);
- B4 (500 µg/L in FY 2001 to 85 µg/L in FY 2016 – 83% reduction);
- B5 (410 µg/L in FY 2001 to 85 µg/L in FY 2016 – 79% reduction);
- B1 (180 µg/L in FY 2001 to 51 µg/L in FY 2016 – 72% reduction);
- SC2 (100 µg/L in FY 2001 to 40 µg/L in FY 2016 – 60% reduction);
- B3 (8.7 µg/L in FY 2001 to 2.6 µg/L in FY 2016 – 70% reduction);
- B9 (110 µg/L in FY 2001 to 37 µg/L in FY 2016 – 66% reduction);
- SC4 (6.9 µg/L in FY 2001 to 2.7 µg/L in FY 2016 – 61% reduction); and
- B8 (21 µg/L in FY 2001 to 8.8 µg/L in FY 2016 – 58% reduction).

In fact, only three wells (B2, SC5, and SC1) have shown less than a 50% reduction in TCE concentrations since FY 2001. These trends reflect the overall decline in OU2 deep groundwater contaminant concentrations. In addition, as discussed below, there has been a reduction in overall TGRS influent concentrations over the previous several years.

As Table 12-6 illustrates, eight wells, B1, B4, B5, B6, B9, B13, SC1, and SC5, that are located in the centers of the plume, achieve the largest rates of VOC removal. These eight wells together accounted for over 99% of the VOC mass removed.

The source control wells, SC1 through SC5, together accounted for over 81% of the VOC mass removed while accounting for only 10.1% of the water pumped by the system. SC5, in particular, removed over 73.1% of the total VOC mass at a rate of only approximately 104 gpm (6.4% of the total water pumped by the system). This illustrates the efficiency of extracting groundwater from near the source areas.

What do the long-term trends in the monitoring wells show?

A majority of wells on and off TCAAP exhibit decreasing trends in TCE concentration, indicating an overall improvement in water quality both upgradient and downgradient of the TGRS. Due to the complexity of the flow system, changes in flow direction over time, and the variation in chemical transport properties across the study area, the trends may not reflect a uniform or easily predictable pattern.

Several wells were identified in previous APRs, or when reviewing the FY 2016 database, that have inconsistent or upward trends in TCE concentrations that warrant further observation and discussion:

Well	***Trend Observation***
03L806	Trend identified in FY 2001 APR. Dropped from 1,000's of µg/L in early 1990s. TCE decreased steadily from 410 µg/L in 2001 to 140 µg/L in 2005. From 2006 to 2011, TCE concentrations varied between 120 µg/L and 240 µg/L with no apparent trend. TCE increased to 490 µg/L in 2012 and 620 µg/L in 2013. Decreased to 440 µg/L in 2014, 330 µg/L in 2015, and 120 µg/L in 2016. The

Well	***Trend Observation***
	overall increase in 2012 through 2014 coincided with a decrease in TCE concentration at well 03M806. However, in 2016 the TCE levels dropped to pre-2012 concentrations. Maintain annual sampling frequency to determine if this downward trend continues.
04U806	Trend identified in FY 2001 APR. Dropped from 1,000's of µg/L in early to mid-1990s. TCE decreased steadily from 470 µg/L in 2001 to 96 µg/L in 2007. In 2008, TCE spiked at 380 µg/L, but concentrations decreased the next year and have varied between 130 µg/L and 220 µg/L since 2009 with no apparent trend (130 µg/L in 2016). Maintain annual sampling frequency.
03U094	Trend identified during FY 2004 data review. TCE increased from 170 µg/L in 2003 to 470 µg/L in 2005. From 2005 to 2013, TCE concentrations overall had been decreasing and had decreased to 80 µg/L in 2013, a historical low concentration. Increased to 610 µg/L in 2015, the highest concentration since 1996, then decreased to 360 µg/L in 2016. Maintain biennial sampling frequency (next event 2018).
03M806	Trend identified during FY 2003 data review. TCE concentrations dropped from near 900 µg/L in 1987, to below 100 µg/L from 1993 through 1996. Increased to 1,300 µg/L, a historical high concentration, in 2003. TCE concentrations have decreased from 680 µg/L in 2008 to 250 µg/L in 2015 with an increase to 380 µg/L in 2016. Maintain annual sampling frequency.
03U711	Trend identified in FY 2001 APR. TCE concentrations decreased from near 1,000 µg/L in 1994 to 75 µg/L in 1999, but rebounded to 250 µg/L by 2004. Since 2004, concentrations have steadily decreased and were down to 27 µg/L in 2016. Maintain biennial sampling frequency (next event 2018).
03L809	Trend identified in FY 2001 APR. TCE concentrations decreased from over 3,000 µg/L to 67 µg/L through 1998, but rebounded to 520 µg/L by 2001. Since 2001, concentrations have decreased overall to 140 µg/L in 2016. Maintain biennial sampling frequency (next event 2018).
04U843	Trend identified in FY 2001 APR. TCE concentrations were below 15 µg/L from late 1980s through 1997, and then increased to between 22 µg/L and 38 µg/L from 1998 through 2001. In 2003, TCE dropped to below 1 µg/L, but has been steadily increasing since and is at 180 µg/L in 2016. Well is nearly 1 mile from TGRS and is part of the OU1 sampling program; therefore, see also Section 3. Maintain biennial sampling frequency (next event 2018).
04U841	Trend identified in FY 2001 APR. TCE concentrations were below 10 µg/L through 1995, and then increased to 25 µg/L in 2001. In 2003, TCE decreased to 5 µg/L, but rebounded to 19 µg/L in 2005. TCE appears to be stabilizing around 20 µg/L, with concentrations ranging between 14 and 24 µg/L since 2005 (14 µg/L in 2016). Well is nearly 0.5 mile from TGRS and is part of the OU1 sampling program; therefore, see also Section 3. Maintain biennial sampling frequency (next event 2018).
03U822	Trend identified during FY 2003 data review. TCE concentrations were below 25 µg/L through 1998, and then peaked at 375 µg/L in 1999. Concentrations have ranged between 120 and 160 µg/L from 2005 to 2015 (150 µg/L in 2016). Well is approximately 1 mile from TGRS and is part of the OU1 sampling

Well	*Trend Observation*
	program; therefore, see also Section 3. Maintain biennial sampling frequency (next event 2018).
03L822	Trend identified in FY 2001 APR. TCE concentration increased from below 5 µg/L during early 1990s to over 600 µg/L from 1999 through 2003. Concentrations steadily decreased from 620 µg/L in 2003 to 180 µg/L in 2011, but rebounded slightly in 2013 to 220 µg/L. Concentration decreased slightly in 2016 to 190 µg/L. Well is approximately 1 mile from TGRS and is part of the OU1 sampling program; therefore, see also Section 3. Well historically showed 1,1,1-trichloroethane as major contaminant. Maintain biennial sampling frequency (next event 2018).

12.2 Remedy Component #2: Groundwater Treatment

Description: "Groundwater treatment using air stripping" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When the air stripping treatment facility is treating water, and meeting the cleanup requirements in Table 1 of the OU2 ROD.

Is the remedy component being implemented?

Yes. The air stripping treatment facility has been operating since 1986.

Did the treatment system meet the treatment requirements in the OU2 ROD?

Yes. Influent and effluent water were sampled on a monthly basis during FY 2016. The influent/effluent database for FY 2016 is contained in Appendix H-2. Figure 12-6 presents a graph of influent TCE versus time. This graph is cumulative and includes data from before 1989, when the system consisted of only six extraction wells. The average FY 2016 influent TCE concentration was 187 µg/L, slightly up from 184 µg/L in FY 2015. FY 2016 represents the fourteenth year since the TGRS was reconfigured to achieve greater pumping in the centers of the VOC plumes and less pumping on the edges of the plumes where VOC concentrations are much lower. The influent TCE concentrations had been steadily decreasing for several years, likely due to the overall decrease in plume concentration, but increased in FY 2013 and remained above the FY 2012 concentration in FY 2014. However, as stated earlier, the increased influent TCE concentrations observed in FYs 2013 and 2014 are due, in part, to the higher extraction rate at well SC5 that resulted from the cleaning of the forcemain in April 2013, and from the shutdown of well B11 in February 2013, which was pumping clean water into the treatment system. The FY 2016 influent concentration nearly decreased to the FY 2012 concentration of 180 µg/L, while the SC5 extraction rate remained higher and B11 remained off, likely indicating a continuing overall decrease in plume concentration.

Figure 12-6 also presents a graph of the effluent TCE concentration versus time. As indicated, the effluent was below 5 µg/L TCE for all sampling events in FY 2016. A review of the FY 2016 database indicates that the effluent has also remained below the treatment requirements for all other VOC

compounds specified in the OU2 ROD. Comparison of influent and effluent concentrations for all specified VOC compounds indicates an average removal efficiency of 99.2%. As expected, effluent concentrations of TCE increased slightly after the treatment was changed to two tower operation (two tower operation was tested in February 2011 and went into full operation in March 2011). The maximum effluent TCE concentration in FY 2016 was 2.5 µg/L and the average was 1.6 µg/L, which are both well below the discharge limit.

What was the mass of VOCs emitted into the air?

The air stripping towers remove VOCs with an efficiency of approximately 99.3%. The air emissions are equal to the VOC mass removal rates presented in Table 12-6. Air emissions averaged 4.7 pounds per day based on the VOC mass removal rates. The total VOC emissions from October 2015 through September 2016 were 1,731 pounds.

12.3 Remedy Component #3: Treated Water Discharge

Description: "Discharge of treated water to the on-site gravel pit" (OU2 ROD, page 3).

Performance Standard (how do you know when you're done):

When the gravel pit is accommodating the discharge from the treatment system and allowing it to recharge to the aquifer.

Is the remedy component being implemented?

Yes. Based on visual observation during FY 2016, there were no noticeable changes in Gravel Pit performance. The Gravel Pit is accommodating the TGRS discharge as designed.

12.4 Remedy Component #4: Institutional Controls

Description: "Institutional controls to restrict access to contaminated aquifers and prevent exposure to contaminated groundwater" (OU2 ROD, page 4).

Performance Standard (how do you know when you're done):

When a SWCA and alternate water supply have been established and private wells in impacted areas have been sealed.

Is the remedy component being implemented?

Yes. There are no private users of groundwater on the property and the potable water supply is no longer used. The property is a government reservation, is fenced, and access is restricted to authorized personnel.

Are any changes or additional actions required for this remedy component?

Yes. On April 20, 2016, the MDH issued a memorandum updating the Special Well and Boring Construction Area (SWBCA) that noted the rezoning of the TCAAP facility for future development and updated the SWBCA boundary to include the portion of the TCAAP property that was transferred to Ramsey County. As such, all wells and borings constructed or modified within the SWBCA must first be approved by the MDH.

12.5 Remedy Component #5: Review of New Technologies

Description: "Reviews of new and emerging technologies that have the potential to cost-effectively accelerate the timeframe for aquifer restoration. Reviews shall be performed by the Army and reported annually in accordance with the consistency provisions of the TCAAP FFA" (OU2 ROD, page 4).

The intent is to consider new technologies of merit, which is not on any set schedule. To have merit, a new technology must have promise in reducing cost and time for cleanup. There may be years where no technologies are considered. It is envisioned that at any time, any interested party (Army, USEPA, and MPCA) can suggest new technologies for consideration. If a technology is agreed to have merit by the Army, USEPA, and MPCA, then the Army will evaluate the technology. The level of effort for evaluations can range from simple literature searches to extensive treatability studies. On an annual basis, the Army will report on:

- Whether or not any new technologies were identified and considered to have merit that year;
- The progress or results of any evaluations during that year; and
- Any planned evaluations for the following year.

Performance Standard (how do you know when you're done):

When the Army reports on the status of any reviews of emerging technologies in the annual monitoring report.

Is the remedy component being implemented?

Yes. Since the FY 1997 APR, the Army reports annually on the status of any reviews of emerging technologies.

In September 2002, the MPCA and USEPA announced they would be conducting a natural attenuation microcosm study using carbon dating. In October 2002, Army drilled a boring at Site G to collect soil for the study. The study results were published in 2004.

The MPCA identified a study involving the addition of vegetable oil to groundwater that is being monitored at the Navy site in Fridley, Minnesota, as a potential technology of interest.

Were any new technologies identified and considered to have merit during FY 2016?

Yes. The Army is currently evaluating optimization strategies for the TGRS. The report on this optimization evaluation is expected in 2017.

What is the status and/or findings of any previously initiated reviews of emerging technologies?

MPCA continued its research into natural attenuation processes at TCAAP. The MPCA and USEPA published the results of the microcosm study for deep groundwater sediments in 2004 showing that abiotic degradation of cis-1,2-DCE is an important factor contributing to the natural attenuation of this compound at the site (*Non-biological Removal of cis-dichloroethylene and 1,1-dichloroethylene in aquifer sediment containing magnetite.* Environmental Science and Technology, 38: 1746-1752).

Are any new reviews planned at this time for the coming year?

Yes. As stated earlier, the Army is currently evaluating optimization strategies for the TGRS. The report on this optimization evaluation is expected in 2017.

12.6 Remedy Component #6: Groundwater Monitoring

Description: "Groundwater monitoring to track remedy performance" (OU2 ROD, page 4).

Performance Standard (how do you know when you're done):

When a regulator approved monitoring plan is in place and monitoring is conducted according to the plan.

Is the remedy component being implemented?

Yes. Monitoring in FY 2016 was consistent with the OU2 ROD. Water level measurements and water quality samples were collected as stated in Appendix A.1. Appendix A summarizes the FY 2016 monitoring plan and any deviations are explained in Appendix C-2. Monitoring was as follows:

Groundwater

TGRS groundwater level measurements were collected during December 2016 and June 2016 per the monitoring plan. Appendix D contains the comprehensive groundwater quality and water level database for the TGRS monitoring wells. Water quality samples were collected from TGRS wells per the monitoring plan that also included sampling of some select wells in January and February 2016. Groundwater samples were collected at wells stated in Appendix A.1. All wells were sampled for VOC (8260B) analysis and 1,4-dioxane (Method 522). FY 2016 was a "large round" year in the biennial sample program, and samples were collected from a select list of wells. Table 12-8 presents the groundwater quality data for FY 2016. Figures 12-7 through 12-9 present plan views of the TCE plumes and Figure 12-10 and Figure 12-11 present a cross sectional view of the plume along the property boundary.

Results from the 2016 groundwater sampling showed that most of the wells sampled continued to have declining or stable TCE concentrations. Notable steadily decreasing trends are observed at 03U030 (steady decrease from 43 µg/L in 2007 to 4.6 µg/L in 2016), 03U709 (steady decrease from 61 µg/L in 2005 to 18 µg/L in 2016), 03U711 (steady decrease from 250 µg/L in 2004 to 27 µg/L in 2016), and 04U077 (steady decrease from 98 µg/L in 2005 to 32 µg/L in 2016). There was also a notable decrease at 03L806 (620 µg/L in 2013, 440 µg/L in 2014, 330 µg/L in 2015, 120 µg/L in 2016), ending a steady upward trend observed since 2010 when this well had decreased to 120 µg/L. Both 03M806 and 03L806 are likely located in a hydraulic stagnation zone, which may explain their shifting upward and downward trends, as discussed in more detail earlier in Section 12.1.

Although the general trend at most wells since 1999 appears to be declining or stable, the monitoring wells listed below had notable increases in TCE concentration since 2013:

- 03U003 (41 µg/L in 2011, 56 µg/L in 2013, 140 µg/L in 2015 and 120 in 2016);
- 03U094 (80 µg/L in 2013, 610 µg/L in 2015 and 360 in 2016); and
- 03U659 (41 µg/L in 2011, 87 µg/L in 2013, 130 µg/L in 2015, and 880 µg/L in 2016).

With the exception of 03U659, the increases in the remaining wells listed are generally within historical ranges within the last 10 years. All of these wells will continue to be monitored and no further sampling beyond the scheduled events is necessary at this time.

Estimated TCE Plume Width

The 2003 TGRS OS stated that the actual measured width of the 5 µg/L TCE plume at the source area based on FY 2001 analytical data was 3,600 feet (this value was then rounded up to 4,000 feet to determine an operating minimum flow rate noted in Section 12-1). Since that time, 19 tons of VOCs have been removed from the groundwater. TCE concentrations are decreasing across the site, especially at the following wells that have been below 5 µg/L since 2001: B10, SC4, 03L021, 03L833, 03U701, 04J702, 04U701, 04U702, and 04U833. Monitoring well 03U672, which was located outside the southern end of the 5 µg/L TCE plume, decreased from 3.1 µg/L in 2001 to not detectable (less than 1 µg/L) from 2003 until it was abandoned in 2014. Well 03U677 replaced 03U672 in September 2014 and has never contained detectable concentrations of VOCs (including TCE). In addition, B11, which is no longer operating, reported a June 2015 TCE concentration of non detect.

As a result, the width of TCE plume is narrowing. Figure 12-12 shows FY 2015 TCE data with the 5 µg/L TCE contours for FY 2001 and FY 2016. Based on these contours, the estimated width of the source area TCE plume has decreased approximately 17% from 3,600 feet to 3,000 feet or approximately 83% of the FY 2001 width. According to the TGRS OS, overall TGRS operating goals will be reviewed if the source area plume width shrinks to 75% of the FY 2001 width, or 2,700 feet. At the boundary, the TCE plume narrowing is more pronounced, having decreased approximately 24% from 4,600 feet to 3,500 feet, which represents approximately 76% decrease from the FY 2001 width. Based on discussions and correspondence with MPCA and USEPA staff, the Agencies may be receptive to changes in the OS earlier than that stated in the current TGRS OS. As stated previously, Army is evaluating optimization alternatives to the TGRS extraction system. The report on this evaluation is scheduled for submittal in 2017.

Treatment System

The TGRS treatment system influent and effluent was sampled monthly during FY 2016 in accordance with the FY 2016 monitoring plan. Groundwater samples from the extraction wells were collected in December 2015 and June 2016 in accordance with the FY 2016 monitoring plan.

Is additional monitoring proposed prior to the next report?

No. FY 2016 would otherwise have been a “small” sampling event. Table 12-9 and Appendix A of this APR provide FY 2017 monitoring requirements.

12.7 Overall Remedy for Deep Groundwater

Did the TGRS meet the requirements of the OU2 ROD? Yes.

- Hydraulic capture in Unit 3 extends beyond the 5 µg/L TCE contour. This meets the VOC capture criterion in the OU2 ROD. Hydraulic capture in Unit 4 extends beyond the 5 µg/L TCE contour. This meets the VOC capture criterion in the OU2 ROD.
- The total average extraction well water pumped (1722 gpm) was approximately 1.3% below the Total System Operational Minimum (1,745 gpm). However, hydraulic capture of the 5 µg/L TCE contour was achieved since the width of the TCE contour has significantly decreased since the establishment of the OM.

- The TGRS extracted and treated 907,577,164 gallons of water and removed 1,731 pounds of VOCs from October 2015 to September 2016. Average VOC influent concentrations increased by 0.4% from FY 2015.
- Groundwater analytical data of the source area show a general decrease in TCE concentration. This demonstrates that the TGRS is effectively removing VOC mass from the aquifer.
- Effluent VOC concentrations were below contaminant-specific requirements for all sampling events.

Do any additional measures need to be addressed?

Not at this time.

12.8 Other Related Activity in FY 2016

In 2016, a second full round of samples were collected for 1,4-dioxane. Additional samples were also collected at select wells in January and February 2016. Table 12-10 presents the results of the 1,4-dioxane sampling for the TGRS influent, effluent, and extraction wells. No Federal MCL has been established for 1,4-dioxane; however, the MDH has established a HRL value of 1.0 µg/L. All locations sampled except two of the extraction wells (B5, B11, and SC5) had 1,4-dioxane concentrations exceeding the HRL. The TGRS influent and effluent were sampled in June 2016. The 1,4-dioxane concentrations were virtually identical in the influent and effluent samples, indicating no reduction from the treatment system. The results of the monitoring well sampling are presented on Table 12-11. A majority of the monitoring wells sampled (57 of 81) had 1,4-dioxane concentrations exceeding the HRL, with the highest concentrations found in the samples at 03U094 (320 µg/L) and 03U021 (112 µg/L). Figure 12-13 shows the 1,4-dioxane concentrations in plan view for the west portion of OU2. Figures 12-7 through 12-9 present plan views of the 1,4-dioxane plumes and Figures 12-14 and 12-15 present cross sectional views of the plume along the property boundary. Generally, the 2016 results are similar to those results reported for wells sampled in FY 2015.

13 OPERABLE UNIT 3: DEEP GROUNDWATER

RECORD OF DECISION
Groundwater Remediation
Operable Unit 3
at New Brighton/Arden Hills Superfund Site
September 1992

RECORD OF DECISION AMENDMENT
For Operable Unit 3
New Brighton/Arden Hills Superfund Site
August 2006

A ROD Amendment was finalized in August 2006 that significantly changed the remedy for OU3. The basis for the OU3 ROD Amendment was the "Groundwater Statistical Evaluation, OU3" technical memorandum, which received consistency on May 2, 2005. This document presented a statistical evaluation showing that the South Plume has been receding since at least 1996, including the period after the Plume Groundwater Recovery System (PGRS) was shut off in 2001. The South Plume had receded well upstream of the PGRS and the PGRS was basically pumping clean water. The ROD Amendment removed the need for a pump and treat remedy, eliminating the PGRS extraction well and treatment train.

The PGRS was an off-post groundwater extraction and treatment system and municipal potable water supply. The PGRS consisted of NBM #13 and a GAC treatment plant. New Brighton used the water for municipal supply. The PGRS was designed to contain the South Plume of VOC contamination emanating from the former TCAAP property and to prevent further downgradient migration. Recovered groundwater was treated and used by the City of New Brighton to fulfill its municipal water supply demand. Figure 13-1 presents an OU3 site plan.

The PGRS began operating on May 3, 1994. In 1997, the PGRS influent dropped below the ROD required limits for all VOCs. In December 1999, under an agreement with the Agencies, the PGRS pumping rate was reduced from a nominal rate of 1,000 gpm to 400 gpm to help determine if the VOC reductions in concentration were the result of actual plume decreases or the result of dilution from over pumping. In conjunction with the flow rate decrease, a quarterly monitoring program was undertaken to monitor for potential "rebound" in VOC concentrations. By the end of FY 2000, no rebound was observed and a review of the historical database for all of OU3 and the associated source area in OU2 revealed that the entire South Plume had dramatically decreased in size and concentration since the early 1990s. The VOC concentration decreases were such that the leading edge of the South Plume, at the PGRS, dropped below the ROD requirements.

The results of this evaluation were presented to the Agencies on September 6, 2000, and a report titled *Plume History Evaluation, Operable Unit 3* (CRA 2000), was submitted to the Agencies on October 10, 2000. The report documents the history of plume size and concentration reductions throughout OU3. Based on the dramatic reductions in plume size and concentration, the report recommended shutting down the PGRS. The Agencies subsequently accepted the recommendation. The City of New Brighton stopped significant pumping in August 2001 and the PGRS was maintained in standby status. During the

period from May 2003 through September 2003, the PGRS was operated solely to satisfy peak water supply demands and then was placed back into standby status. The PGRS remained in standby status throughout FY 2004, FY 2005, and FY 2006. The city conducted an evaluation of its municipal system to, in part, determine the future use of the PGRS extraction well and treatment system. The city decided the PGRS treatment system and well NBM #13 were not part of the city's long-term water supply plan. During FY 2007, the PGRS treatment system was dismantled and NBM #13 was abandoned.

13.1 Remedy Component #1: Monitored Natural Attenuation

Description: "MNA" (OU3 ROD Amendment, page 17).

Performance Standard (how do you know when you're done):

When a monitoring program is established and monitoring is in compliance with the regulator approved Annual Monitoring Plan.

Is the remedy component being implemented?

Yes. Appendix A summarizes the FY 2016 monitoring plan and any deviations are explained in Appendix C.2. Details of the groundwater monitoring program are discussed in Section 13.2.

13.2 Remedy Component #2: Groundwater Monitoring

Description: "Monitoring of the groundwater for VOCs to verify the effectiveness of the selected remedy and the natural attenuation of the South Plume" (OU3 ROD Amendment, page 17).

Performance Standard (how do you know when you're done):

When a monitoring program is established and monitoring is in compliance with the regulator approved Annual Monitoring Plan.

Is the remedy component being implemented?

Yes. Appendix A summarizes the FY 2016 monitoring plan and any deviations are explained in Appendix C.2.

Groundwater samples were collected from 16 OU3 wells in FY 2016 as part of the OU1, OU2, and OU3 comprehensive biennial sampling round. Samples were collected as specified in the monitoring plan and analyzed for VOCs and 1,4-dioxane. Well locations are shown on Figure 13-1. The specific purpose of monitoring each well is provided in Appendix A. Water elevations were also measured during the monitoring event and are presented in Appendix D.1.

Table 13-1 presents a summary of the analytical results. All of the wells sampled contained TCE concentrations similar to those reported for the previous sampling event (either 2013 or 2014). The TCE concentration in the downgradient sentry well, 04U863, remained not detectable (less than 1.0 µg/L) for the fourth consecutive year, after rising above 1.0 µg/L for the first time since December 1999 in 2012 (1.2 µg/L). TCE concentrations were also less than 1.0 µg/L in wells 03L854, 03U673, 04J866, 04U860, and 04U866. Two wells, 03L848 and 04U848, had TCE concentrations greater than 1.0 µg/L, but below

the cleanup standard of 5 µg/L. The other eight wells had TCE concentrations above the cleanup standard of 5 µg/L, ranging from 6.0 µg/L to 110 µg/L.

1,1,1-trichloroethane or its degradation products, 1,1-dichloroethane and 1,1-dichloroethene, were present in three wells at the boundary between OU1 and OU3 (03L859, 04U859, and 04U832), indicating a mingling of the North Plume and the South Plume in this area. These parameters have also been detected at low concentrations at 03M848 and 03L673, center-of-plume wells, for several years, including FY 2016.

What were the results of the Statistical Analyses?

The Mann-Kendall statistical analysis was updated for ten edge-of-plume and center-of-plume wells sampled in FY 2016. A summary of the statistical analyses is presented in Table 13-2. A spreadsheet and graph presenting the Mann-Kendall test results for the wells are provided in Appendix I.

The trend for 03M848, which has historically been the center of the South Plume, changed from no trend or stable to definitely decreasing as concentrations have decreased over the last four sampling events. The TCE concentrations at 03M848 have steadily decreased from 1,400 µg/L (FY 1996) to 700 µg/L (FY 1999) to 450 µg/L (FY 2003) to the current concentration of 110 µg/L in FY 2016. TCE concentrations at 03M848 have steadily decreased over the last four years from 190 µg/L (FY2012) to 110 µg/L (FY2016). However, recent low-level detections of 1,1,1-trichloroethane and its degradation products at 03M848 may indicate that the North Plume is not only beginning to mingle with the South Plume at the OU1-OU3 boundary, but may be present even toward the center of the South Plume. The possible mingling of these two plumes at this well may be a factor in future statistical trends.

The statistical analysis for well 04U859, which is classified as a center-of-plume well and is at the boundary with OU1, shows a definitely decreasing trend. It had previously showed a stable trend. The presence of 1,1,1-trichloroethane, and its degradation products, which have historically been present in 04U859, indicates that the North Plume is present at this location and may be a factor in the statistical analysis.

The trends for wells 03L848, 04U832, and 04U848 located at the edge-of-plume remain unchanged from the last statistical analysis. Well 03L848 has a definitely decreasing trend and well 04U832 is unchanged at no trend. The trend at well 04U848 remains unchanged with a probable decreasing. The trends for wells 03L673, 03L859, 04U673, and 04U854 remained unchanged from the last statistical analysis with a definitely decreasing trend. A stable trend was again noted at well 04U845.

In summary, based on the data collected in FY 2016, the center of the South Plume, represented by 03M848, indicates decreasing concentration trends; which is consistent with wells 03L859 and 04U859, also classified as center-of-plume wells. The edge of the South Plume appears to be decreasing or stable. A stable or decreasing trend at the edge of the plume indicates that the South Plume is not expanding. In addition, the presence of 1,1,1-trichloroethane and its degradation products near the OU1-OU3 boundary indicates that the North Plume may be mingling with the South Plume and may be a factor in the trends noted at the wells near the boundary. Recent data show that the North Plume may be present even toward the center of the South Plume and may also be a factor in the trends noted there.

Are contingency actions warranted?

No. The OU3 ROD Amendment requires contingency actions to be considered when the Mann-Kendall statistical analysis shows that a well at the edge of the South Plume has an increasing trend. No edge-of-plume wells analyzed in FY 2016 showed an increasing trend.

What groundwater monitoring is proposed before the next report?

Given the arrival of the 1,4-dioxane issue in FY 2015, a "major" sampling event in June of FY 2016 (in essence repeating the FY 2015 sampling event) was conducted for 1,4-dioxane. FY 2017 will continue monitoring for 1,4-dioxane. The proposed OU3 monitoring requirements are presented in Table 13-3 and Appendix A.

13.3 Remedy Component #3: Drilling Advisories

Description: "Continued implementation of the drilling advisories that regulates the installation of new private wells within OU3 as a SWCA" (OU3 ROD Amendment, page 17).

Performance Standard (how do you know when you're done):

When the MDH has issued a SWCA Advisory.

Has the MDH issued a SWCA Advisory?

Yes. It was issued in June 1996. The SWCA encompasses OU1, OU3, and the OU2 Site A shallow groundwater plume. In June 1999, the MPCA requested that the MDH extend the boundary of the SWCA further to the southwest to the Mississippi River and Marshall Avenue to ensure that the southern boundary fully encompassed the plume. The MDH revised the SWCA in December 1999. The current boundary is shown on Figure E-1 (Appendix E).

Are any changes or additional actions required for this remedy component? No.

13.4 Overall Remedy for OU3

Is the Remedy for OU3 Operating in Compliance with the OU3 ROD and OU3 ROD Amendment?

Yes. In FY 2016, groundwater monitoring took place as prescribed in the Annual Monitoring Plan. The comprehensive biennial sampling round of FY 2016 indicates that the South Plume footprint appears to be decreasing or at least stable, with a stable to decreasing trend at the center of the plume.

Are any changes or additional actions required for OU3?

No. No additional actions are necessary because no increasing trends at the edge of the plume were identified by the statistical analysis.

13.5 Other Related Activity in FY 2016

In 2016, a second full round of samples were collected for 1,4-dioxane for the annual sampling event for OU3. Table 13-4 presents the results of the 1,4-dioxane sampling. No Federal MCL has been established for 1,4-dioxane; however, the MDH has established a HRL value of 1.0 µg/L. Three of the 18 locations sampled (03L673, 04U832, and 04U859) had 1,4-dioxane concentrations exceeding the HRL. The highest concentration was detected at 04U859 at 5.4 µg/L. Nine of the monitoring wells sampled had 1,4-

dioxane detections below the HRL and 1,4-dioxane was not detected at six wells. Figures 3-3 through 3-5 present plan views of the 1,4-dioxane plumes in the OU3 area. The 2016 1,4-dioxane concentrations were lower (less than 1.0 µg/L) near the center and eastern side of the OU3 area and higher (greater than 3.0 µg/L) along the western edge.

14 OTHER INSTALLATION RESTORATION ACTIVITIES DURING FY 2016

This section summarizes the status of other activities that are related to the Installation Restoration Program, but are not required in the RODs for OU1 through OU3.

14.1 Deep Groundwater Background Monitoring

The Army voluntarily conducts monitoring at locations near the upgradient side of OU2 (the northeast corner and east side) to assess the quality of deep groundwater entering the OU. The five wells sampled for this purpose include 03U007, 03U009, 03L007, 04U007, and 04U510. Locations of these wells are shown on Figure B-3 in Appendix B. The FY 2016 results were:

Well	Trichloroethene	1,4-Dioxane
03U007	< 1.0 JT (10)	0.31 JT (10)
03U009	< 1.0	0.10 UFB (0.052)
03L007	< 1.0 JT (10)	0.12 JT (10)
04U007	< 1.0 JT (10)	0.11 JT (10)
04U510	< 1.0	< 0.070

The low-level detections of 1,4-dioxane are below the method reporting limit and are therefore only estimates. These levels are well below the MDH HRLs.

14.2 Round Lake

The *Tier II Ecological Risk Assessment Report* (USACHPP 2004) for aquatic sites (including Round Lake), was approved by the MPCA and USEPA in December 2004. In June 2005, the Army submitted a draft FS for aquatic sites to support the risk management decisions with respect to “No Further Action” or “Implement a Remedy” for each aquatic site. Based on comments to the draft FS, it was agreed to conduct additional sampling of Marsden Lake and Pond G, which was completed in 2008. A revised FS was submitted in January 2009. Based on comments received and resolution thereof, the Army then submitted a revised (redlined) FS in April 2010. After review of this report, USEPA and MPCA requested that the Army prepare a work plan for collection of additional Round Lake sediment data. Given the time required to collect the additional data, the Army, USEPA, and MPCA agreed to separate the FS for aquatic sites into two documents: one for Round Lake and one for Rice Creek, Sunfish Lake, Marsden Lake, and Pond G.

The USEPA and MPCA provided consistency for the QAPP for Round Lake Sediment Investigation in January 2011. The sediment sampling work was completed in January – February 2011. A *Draft Summary of Investigation Findings* was submitted in May 2011, and a meeting between Army, USEPA,

MPCA, Minnesota Department of Natural Resources, U.S. Fish and Wildlife Service, and the TCAAP Restoration Advisory Board was held in June 2011 for preliminary discussion of the findings. Final core dating results were distributed in February 2012. In March 2012, the Army provided responses to the stakeholder comments on the Round Lake portion of the April 2010 FS, which had been placed on hold pending collection and evaluation of the 2011 sediment data. A comment resolution meeting was then held in April 2012, and a TCAAP Restoration Advisory Board meeting was held in May 2012, primarily to discuss the status of the Round Lake FS.

With USEPA and MPCA agreement, the Army initiated a strategy to revise the FS in segments, with the intent to gain agreement/approval at key steps along the way. In accordance with this strategy, the Army submitted revised Sections 1 through 5 of the Round Lake FS in August 2012, and the USEPA and MPCA provided comments in September 2012. The Army sought clarifications on these comments, and ultimately submitted responses to those comments and the proposed redlines to Sections 1 through 5 in January 2013. The USEPA and MPCA provided comments to that submittal in March 2013. Through this process (and the multiple earlier drafts of the FS), it became clear that the Army, USEPA, and MPCA did not agree on the ecological risks and commensurate remedy associated with Round Lake. Given the difficulty reaching a consensus, the Army Environmental Command desired a fresh look at the ecological risk by someone who has national experience with such matters and obtained the assistance of the Risk and Regulatory Analysis Team of the Environmental Sciences Division at the Oak Ridge National Laboratory. In early FY 2014, the Army submitted a *Supplemental Remedial Investigation and Feasibility Study for Round Lake* (Wenck 2013a) which incorporated the *Supplemental Ecological Risk Assessment* (Oak Ridge National Laboratory 2013). Comments received from the USEPA and MPCA in March 2014 indicated that significant disagreement remained. In April 2014, the Army notified the USEPA and MPCA that their findings were being disputed by the Army. Efforts to resolve this dispute continued in FY 2015 and FY 2016. In a teleconference between the USEPA Region 5 Federal Facilities Chief and Headquarters Department of Army personnel on September 20, 2016, an agreement was reached, which requires submission of a revised SRI/FS in the third quarter of FY 2017.

14.3 135 Primer/Tracer Area

The *Preliminary Assessment* (Alliant Techsystems Inc. 2001) report received regulatory approval in FY 2002. It was recommended that a site inspection SI be conducted. The *Summary Report for the 135 Primer/Tracer Area Site Inspection Investigation* (SI Report; EnecoTech Midwest, Inc. 2005) received MPCA and USEPA approval in FY 2005. The SI Report recommended that an EE/CA be conducted to determine what, if any, remediation is required to address contamination observed in the soil. The 135 PTA is on property that is proposed to be transferred out of federal ownership. The Army is anticipating transfer of the 135 PTA to Ramsey County. Currently, it is anticipated that the western portion of the 135 PTA would be utilized for purposes of a public trail corridor, and the eastern portion would be utilized for other development purposes.

For the western portion, in anticipation of the property transfer, Ramsey County conducted soil investigation work on this portion of the 135 PTA in early FY 2012. A Draft Phase II ESA report documenting this work was submitted to the MPCA Voluntary Investigation and Cleanup (VIC) Program in December 2011.

For the eastern portion, additional soil investigation to support preparation of an EE/CA was conducted in March-June 2012. The EE/CA received consistency approval from the USEPA and MPCA in November 2012, and the EE/CA recommended soil excavation and off-site disposal. The Army published legal notices in newspapers regarding the availability of the EE/CA for public comment and established a 30-day public comment period beginning on November 7, 2012. No comments were received. The Army selected the EE/CA-recommended remedy in an Action Memorandum signed on December 18, 2012. The Army then prepared a Removal Action Work Plan to describe the implementation procedures for the soil excavation and offsite disposal. The Removal Action Work Plan received consistency approval from the USEPA and MPCA in March 2013. The soil excavation and off-site disposal work was implemented in May-June 2013, with a total of 1,846 tons of contaminated soil removed from the various soil areas of concern, collectively (i.e., Site A, the eastern portion of the 135 PTA, and the MNARNG EBS areas). The *Removal Action Completion Report* (Wenck 2013c), documenting implementation of this work, received consistency approval from the USEPA and MPCA in November 2013. OU2 ROD Amendment #5, signed in March 2014, documented that the soil removal actions were the final remedies for these sites and incorporated these remedies into OU2. Discussion of the eastern portion of the 135 PTA is now being included in Section 4.0.

14.4 Property Transfer-Related Environmental Activities

In 2002, the remaining 774 acres still under the control of TCAAP were declared excess to the needs of the Department of Defense. The Army BRAC Office funded ESA work to collect information regarding the environmental condition of the property to facilitate property transfer. The work included document reviews and field sampling of various media. The findings were published in *Environmental Site Assessment for 774-Acre Excess Parcel, Phase I and Phase II Report, Twin Cities Army Ammunition Plant* (Plexus Scientific Corporation 2004). Based on comments from the MPCA and USEPA, additional samples were collected and analyzed in FY 2005. The Army prepared an *ESA Addendum Report* (TWISS 2006) that was approved in FY 2006. Originally, it was proposed to transfer approximately 585 acres through a negotiated sale with the City of Arden Hills, who in turn had an agreement with a developer. In FY 2007, the developer collected additional samples of various media on the property proposed for transfer to Arden Hills. In FY 2009, the developer withdrew from its agreement with Arden Hills, who in turn withdrew its offer to purchase with the federal government. The federal government was then working towards a public auction of the remaining TCAAP property; however, in FY 2011, Ramsey County initiated discussions with the federal government regarding purchase of the property for the potential purpose of locating a new Minnesota Vikings stadium (and other development). Although the final decision placed the Vikings stadium in Minneapolis, Ramsey County then sought to purchase 427 acres of the TCAAP property even without locating the stadium on it. Ultimately, this deal was closed in April 2013, which initially transferred ownership of approximately 397 acres to Ramsey County and provided a lease to Ramsey County for the balance of the property (approximately 30 acres) to allow Ramsey County to clean up these portions of the property that had known exceedances of the MPCA industrial cleanup standards (cleanup of such exceedances must be completed before the federal government can transfer these areas to Ramsey County).

Ramsey County contracted Carl Bolander & Sons, Co. (who teamed with Wenck) to conduct contaminated soil cleanup on the 427-acre property, as well as other site work in preparation for future development (i.e., building abatement/removal, road/parking lot removal, utility removal, etc.). Ramsey

County has enrolled in the MPCA VIC Program to conduct this work. The VIC Program has primary oversight responsibility, in conjunction with USEPA review of certain key elements of the work. Ramsey County intends to conduct soil cleanup work to meet MPCA residential cleanup standards (unrestricted use), though development is anticipated to be mixed use (residential, recreational, and commercial/industrial). The contaminated soil cleanup work is also intended to fulfill the Army's obligation under the FFA to remediate soils to industrial cleanup standards.

In early FY 2014, a QAPP for conducting soil sampling was approved by the MPCA and USEPA, and various Response Action Plans were also approved during FY 2014. As of the end of FY 2015, the demolition-type site work in preparation for future development had been completed (i.e., building abatement/removal, road/parking lot removal, utility removal, etc.), and nearly all the investigative soil sampling and contaminated soil excavation had also been completed. Most of the documentation reports for site work were also submitted by the end of FY 2015. Finalizing of the remaining documentation reports, including the *Final Documentation Report Compendium* (Wenck 2016c), which summarizes the work, was completed in FY 2016. The 30 acres of leased property will be fully transferred to Ramsey County, and an OU2 LUCRD revision to document the property's suitability for unlimited use and unrestricted exposure (with respect to soils) is anticipated to be completed in FY 2017.

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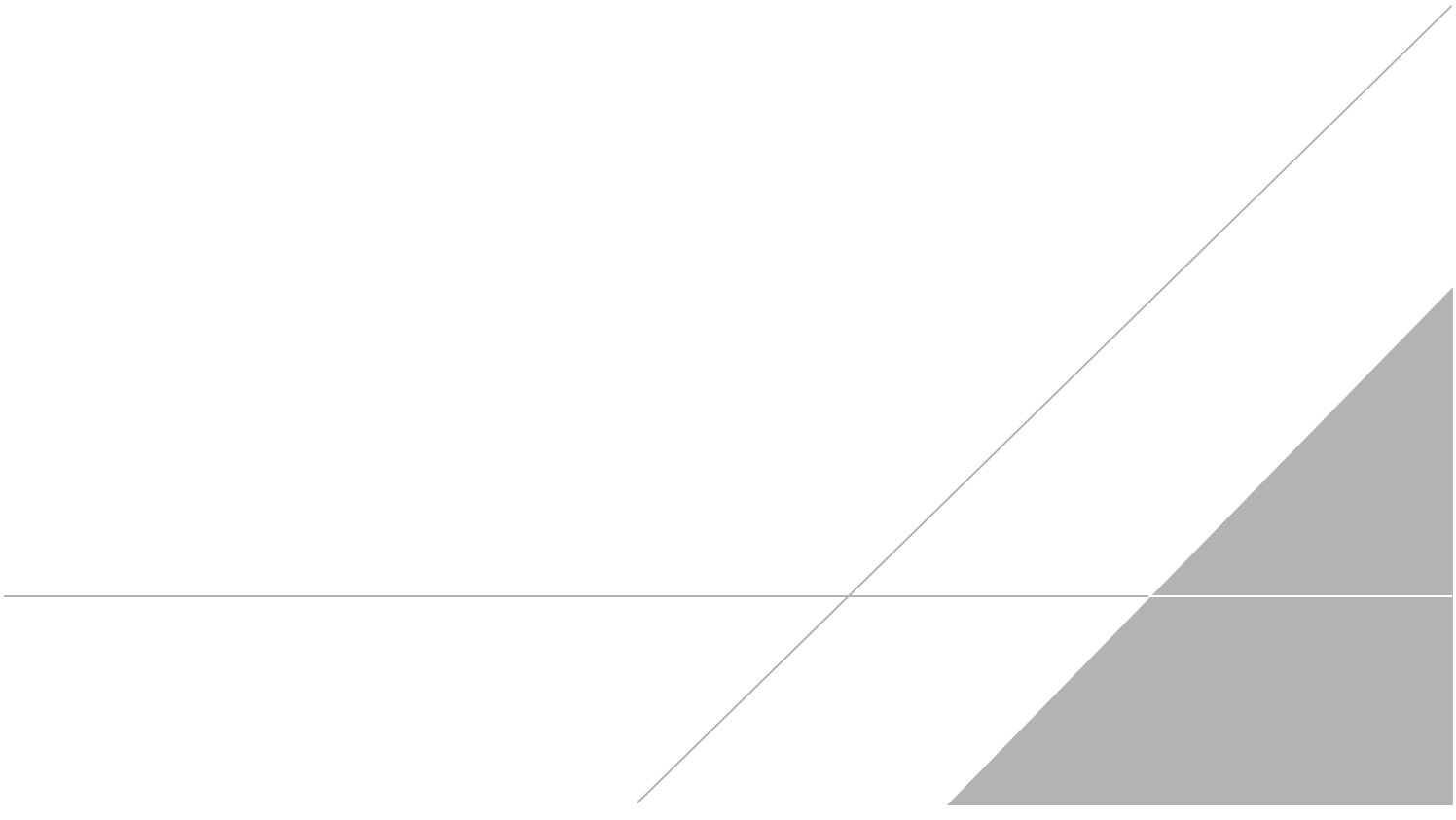
TABLES

FIGURES

APPENDIX A

FY 2016 – FY 2020 Monitoring Plan



APPENDIX B

Monitoring Well Index

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Data Collection, Management, and Presentation

APPENDIX D

Groundwater Data

APPENDIX E

Well Inventory

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Inspection Checklist

APPENDIX G

Inspection and Maintenance Activities

APPENDIX H

TRGS Extraction Data

APPENDIX I

Mann-Kendall Test Results

PIKA Arcadis U.S., Inc. (JV)

430 First Avenue North

Suite 720

Minneapolis, Minnesota 55401

Tel 612 339 9434

Fax 612 336 4538