Final

SWMU 54 Monitored Natural Attenuation Sampling Year Five Report

Radford Army Ammunition Plant, Virginia

May 2018

Submitted to:

United States Army Corps of Engineers, Baltimore District

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Acronyms and Abbreviations

ºC	degrees Celsius
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
2,4,6-TNT	2,4,6-trinitrotoluene
2ADNT	2-amino-4,6-dinitrotoluene
4ADNT	4-amino-2,6-dinitrotoluene
amsl	above mean sea level
bgs	below ground surface
BSEn	Bearing Sea Environmental, LLC
CAS	Chemical Abstracts Service
CCV	Continuing Calibration Verification
CMO	Corrective Measures Objective
CMS	Corrective Measures Study
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
COI	Chemical of Interest
COPC	Chemical of Potential ConcernDNT Dinitrotoluene
DNX	hexahydro-1,3,5-dinitroso-5-nitro-1,3,5-triazine
DO	Dissolved Oxygen
FD	Field Duplicate
ft	feet/foot
ft/day	feet per day
ft/year	feet per year
HHRA	Human Health Risk Assessment
HI	Hazard Index
HMX	High Melting Explosive
ICV	Initial Calibration Verification
IDW	Investigative Derived Waste
IM	Interim Measure
IMWP	Interim Measures Work Plan
IS	Internal Standard
LCS	Laboratory Control Sample

LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection
LOQ	Limit of Quantitation
LTM	Long-term Monitoring
MB	Method Blank
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
mg/L	milligrams per liter
mL/min	milliliters per minute
MNA	Monitored Natural Attenuation
MNX	hexahydro-1-nitroso-3,5- dinitro-1,2,5-triazine
MS	Matrix Spike
mS/cm	millisiemens per centimeter
MSD	Matrix Spike Duplicate
mV	millivolts
MWP	Master Work Plan
ND	Not Detected
NI	Not Identified
NG	Nitroglycerin
ng/L	nanograms per liter
NT	Not Tested
NTU	Nephelometric Turbidity Unit
ORP	Oxidation Reduction Potential
PETN	Pentaerythritol tetranitrate
PID	Photoionization Detector
PQL	Practical Quantitation Limit
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RDX	cyclotrimethylenetrinitramine
RFAAP	Radford Army Ammunition Plant
RFI	RCRA Facility Investigation
RG	Remedial Goal

RL	Reporting Limit
RPD	Relative Percent Difference
Shaw	Shaw Environmental, Inc.
SL	Screening Level
SU	Standard Unit
SVOC	Semi-volatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCDD	Tetrachlorodibenzodioxin
TCL	Target Compound List
TIC	Total Inorganic Carbon or Tentatively Identified Compound
TNT	Trinitrotoluene
TNX	hexhydro-1,3,5-trinitroso- 1,3,5-triazine
TOC	Top of the casing or Total Organic Carbon
URS	URS Corporation
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VA	Virginia
VI	Verification Investigation

1.0 Introduction

Bering Sea Environmental, LLC. (BSEn) has been contracted by the United States Army Corps of Engineers (USACE), Baltimore District, to perform Long-Term Monitoring (LTM) and Monitored Natural Attenuation (MNA) at Solid Waste Management Unit (SWMU) 54 (RAAP-014), Propellant Burning Ash Disposal Area, at Radford Army Ammunition Plant (RFAAP), Radford, Virginia (VA). This report provides a description of the groundwater sampling activities completed and analysis of results from the seventeenth through twentieth quarterly rounds conducted in 2016 through 2017. Further, this report provides a summary of the fifth year of sampling.

This work was performed under Contract No. W912QR-13-D-001, Delivery Order No. 0001 in accordance with the *Radford Army Ammunition Plant, Radford, Virginia, Final Master Work Plan (MWP)* (URS, 2003) and with Part II (D)(11-21) IM of the RFAAP Resource Conservation and Recovery Act (RCRA) Corrective Action Permit (USEPA, 2000). In order to maintain consistency with previous LTM and MNA sampling events (i.e., through year 3), the LTM and MNA activities followed the technical approach, Sampling and Analysis Plan, and quality assurance/quality control (QA/QC) procedures documented in the *Final SWMU 54 MNA Interim Measures Work Plan (IMWP)* (Shaw, 2011a).

1.1 Purpose and Scope

Soil interim measures (IMs) have been completed at SWMU 54 to mitigate the threat of a contaminant release, migration, and/or exposure to the public and the environment. The IMs included site preparation, soil excavation, waste characterization and off-site disposal, confirmation sampling, and site restoration. Detailed information concerning the IMs are presented in the *Final SWMU 54 RCRA Facility Investigation (RFI) / Corrective Measures Study (CMS) Report* (URS, 2008).

The Corrective Measures Objectives (CMOs) and Remedial Goals (RGs) were developed and presented in the *Final SWMU 54 RFI/CMS Report* (URS, 2008). The site-specific CMOs for SWMU 54 Area A are to mitigate further leaching of explosives constituents from soil-to-groundwater at levels that would potentially increase observed concentrations and adversely impact future beneficial use of groundwater; and to the extent practicable, a goal of restoring site groundwater to the most beneficial use. The site-specific CMOs for SWMU 54 Area B are to mitigate the potential hypothetical future risks that have been identified for exposure to soil under a future construction worker scenario; and to prevent leaching of contaminants of concern from soil-to-groundwater at levels that would potentially adversely impact future beneficial use of groundwater. The site-specific CMOs for Area A and B were met through the excavation and off-site disposal of contaminated soil, which was completed in 2010.

The objectives of the LTM and MNA program are to measure and track the reduction of the following compounds to levels below the RGs as defined in **Table 1-1**:

- 2,4,6-trinitrotoluene (2,4,6-TNT);
- dinitrotoluene (DNT)-mixture;
- cyclotrimethylenetrinitramine (RDX); and
- perchlorate.

Table 1-1 SWMU Groundwater Remedial Goals

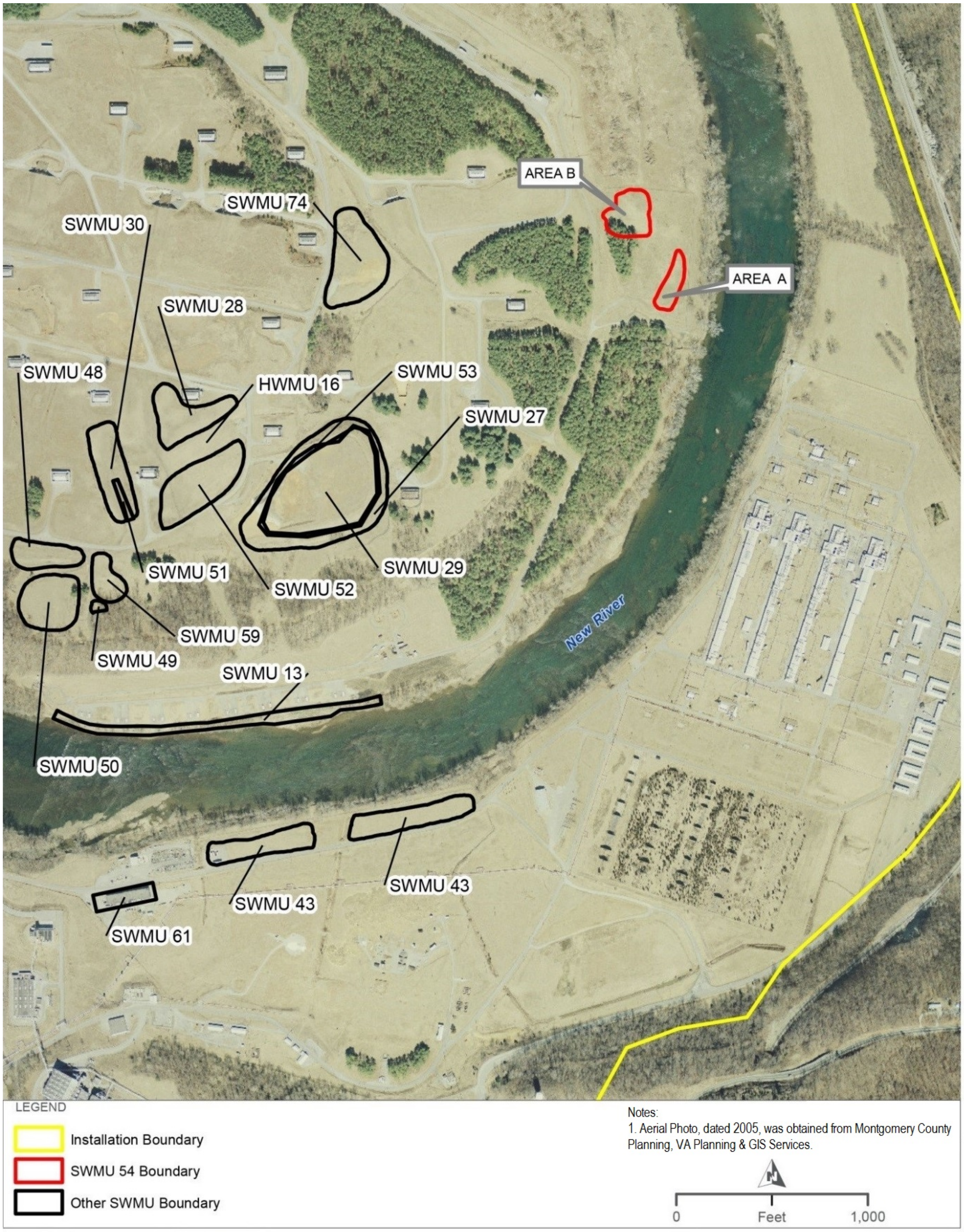
Chemical of Interest	Groundwater RG (mg/L)	Groundwater RG Source[(*)]
2,4,6-TNT	0.00782	RG
DNT Mixture	0.000932	RG
RDX	0.0061	RG
Perchlorate	0.0109	RG

**RGs were calculated using target risk 1E-5 for the lifetime resident and a target hazard of 1 for the adult and child resident (see URS, 2008).*

1.2 Site Description and Background

SWMU 54 is situated in the northeastern section of RFAAP within the easternmost portion of the Horseshoe Area. The SWMU consists of two contiguous disposal areas, Area A and B. Area A is a triangular shaped parcel located in the southeast section of SWMU 54 that covers approximately 0.58-acres. Area B is a somewhat round tract located in the northwestern section that covers approximately 1.09 acres. Both areas are open fields covered with grass and bordered to the east and north by the RFAAP installation security fence. The site is currently undeveloped. SWMU 54 was reportedly used as an ash disposal area in the late 1970s that received propellant ash from the Waste Propellant Burning Grounds. The location of SWMU 54 is provided in **Figure 1-1**. All figures are placed at the end of each report section.

Figure 1-1 SWMU 54 October 2016 (17th Quarter) SWMU 54 Site Location Map



LEGEND

🟨 Installation Boundary

🟥 SWMU 54 Boundary

⬛ Other SWMU Boundary

Notes:
1. Aerial Photo, dated 2005, was obtained from Montgomery County Planning, VA Planning & GIS Services.

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FIGURE 1- 1

SWMU 54 October 2016 (17th Quarter) Site Location Map

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2.0 Physical Characteristics

2.1 Topography

SWMU 54 is situated on a gently sloping terrace that leads to the New River to the east. Elevations range from a high of approximately 1,716 feet (ft) above mean sea level (amsl) in the western section of the SWMU to approximately 1,696 ft amsl in the eastern section. East and outside the SWMU boundary, the elevation steepens precipitously as it reaches the New River (at approximately 1,676 ft amsl). The site topography is shown in **Figure 2-1**.

2.2 Surface Water

The New River is situated approximately 150 ft east of SWMU 54, while a small stream is present on the southern boundary. Surface water runoff from the SWMU flows east and, possibly south, to the New River and the unnamed stream. SWMU 54 is located within the easternmost portion of the Horseshoe Area at RFAAP. As it currently stands, SWMU 54 is positioned within the New River 100-year floodplain.

2.3 Geology

2.3.1 Regional Geology

SWMU 54 is located in the New River Valley, which crosses the Valley and Ridge Province approximately perpendicular to the regional strike of bedrock, and cross cuts Cambrian and Ordovician limestone or dolostone. Deep clay-rich residuum is prevalent in areas underlain by carbonate rocks. The valley is covered by river floodplain and terrace deposits; karst topography is dominant throughout the area. A more detailed description of the regional geology is presented in the RFAAP Final MWP (URS, 2003).

2.3.2 Site-Specific Geology

Characterization of the SWMU 54 subsurface lithology was conducted during the advancement of soil and monitoring well borings at the site. Based on the borehole logs, two geologic cross-sections were developed and are presented in **Figure 2-1** (plan view of the cross-sectional lines), **Figure 2-2** (cross section A-A’), and **Figure 2-3** (cross section B-B’).

Soil and monitoring well borings ranged from 10 to 60 ft in depth. Depths to bedrock, which were reported to be measured directly at the monitoring well borings, ranged in elevation from approximately 1,716 ft amsl to 1,670 ft amsl. Based on the borehole logs, the determination was made that bedrock slopes to the east.

The site lithology consists of unconsolidated sediments comprised of alluvial deposits overlying a thin zone of saprolitic carbonate (i.e., weathered bedrock), which overlies the Cambrian-aged Elbrook Formation. The alluvial deposits consist primarily of silty sand overlying channel deposits of fine- to coarse-grained sand and gravel (river jack). These paleo-channel deposits rest directly on the saprolite, which reportedly reaches 2.5 ft in thickness. It was also reported that some areas of the SWMU contain fill material to depths of 9 to 10 ft below ground surface (bgs).

Depth to competent bedrock at the SWMU ranges from 17 to 24 ft bgs. This competent bedrock belongs to the Elbrook Formation, which is a thickly-bedded, blue-gray dolostone interspersed with blue-gray to white limestone. Locally, the formation is described as interbedded green and maroon shale, yellowish-brown dolostone, and greenish- to grayish-brown limestone and dolostone.

A more detailed discussion of the geology and soil at RFAAP is presented in Sections 3.4 through 3.7 of the RFAAP MWP (URS, 2003) and in the Facility-Wide Background Study Report (IT, 2001).

2.4 Hydrogeology

2.4.1 Regional Hydrogeology

Geologically, the Appalachian Plateaus and Valley and Ridge Province encompass two major tectonic domains: the southern Appalachian Basin and the southeastern part of the Eastern Interior Basin. The hydrogeologic framework is based on generalized stratigraphic succession, with indurated sedimentary rocks of the Paleozoic age forming predominant units.

Groundwater flow paths are typically short, commonly extending no more than several miles in their longest range. The largest groundwater supplies are produced from the carbonate rocks, especially where they are associated with thick regolith, an important storage reservoir throughout the entire area. The regolith stores recharge that otherwise would be rapidly diverted to overland flow. In addition, this unit slowly releases water to underlying carbonate aquifers. Because of the widespread distribution of carbonate rocks and associated regolith, abundant precipitation in a humid climate, and relatively steep hydraulic gradients, this region (and locally) is one of the major karstlands in the eastern United States.

Groundwater supplies in the Valley and Ridge Province are generally of good quality when compared to surface water supplies (Parsons, 1996). However, due to extended contact with minerals, many groundwater supplies contain higher levels of dissolved solids than the streams into which they discharge. Because of sinkholes and underground caverns in karst aquifers, there is a high potential for groundwater to be impacted by direct infiltration of contaminated surface water.

2.4.2 Site-Specific Hydrogeology

Monitoring wells installed at SWMU 54 were screened in both the shallow (surficial aquifer) and shallow bedrock aquifers. Water levels were measured in the wells to calculate the groundwater flow direction at the SWMU. Groundwater contour maps have been prepared using water level data collected prior to each round of groundwater sampling. The maps for the fifth year of monitoring are presented in **Figures 4-2, 4-3, 4-4,** and **4-5**. Contour lines shown on the figures represent lines of equal elevation of the water table; consequently, groundwater flow direction is always perpendicular to the contour lines. Groundwater at the site tends to flow east and appears to discharge to the New River along the eastern side of the site.

Figure 2-1 SWMU 54 Topography and Cross Section

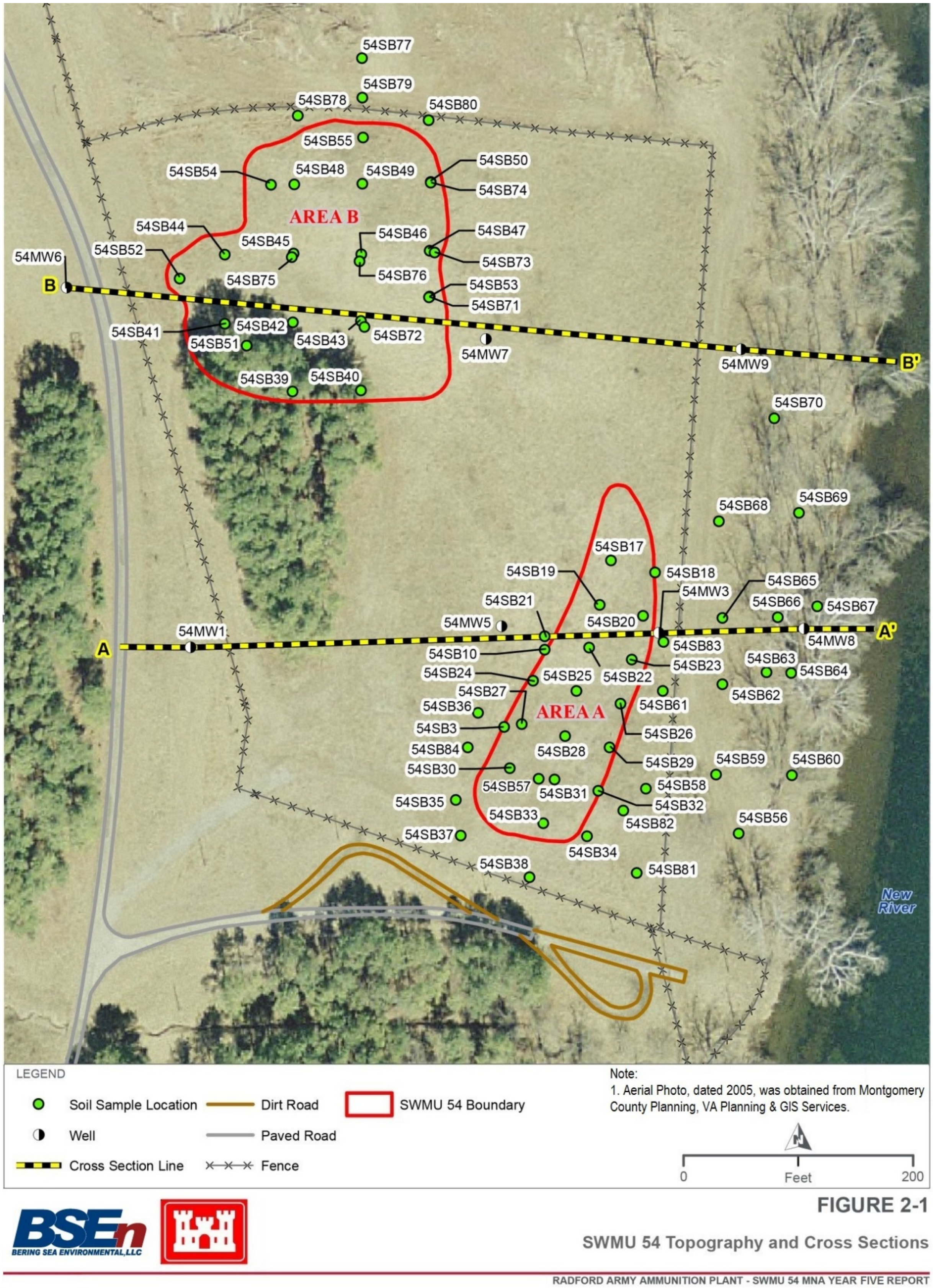
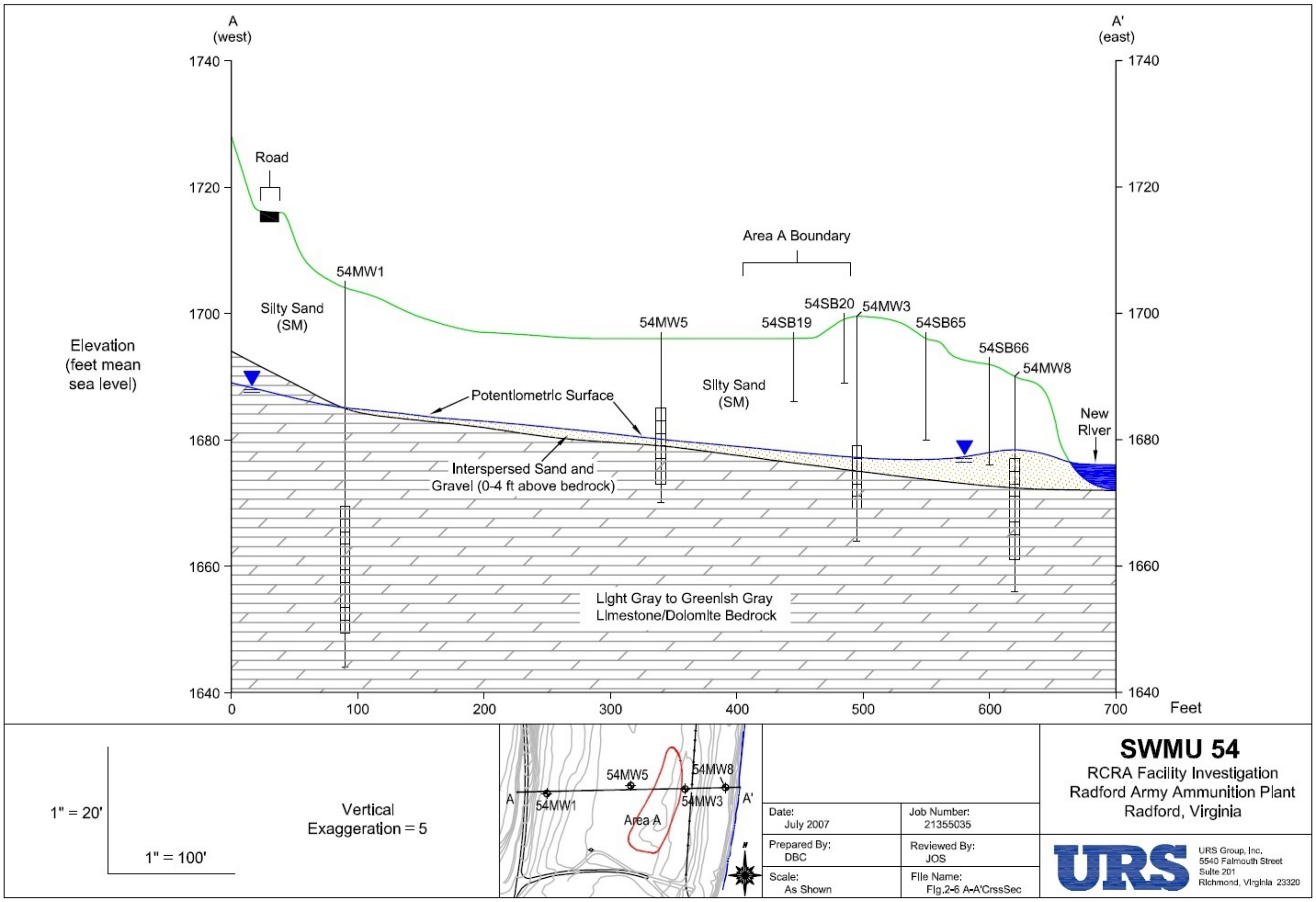


Figure 2-2 SWMU 54 Cross Section A-A'



Date:
July 2007

Job Number:
21355035

Prepared By:
DBC

Reviewed By:
JOS

Scale:
As Shown

File Name:
Fig.2-6 A-A'CrssSec

FIGURE 2-2

SWMU 54 Cross Section A-A'

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Figure 2-3 SWMU 54 Cross Section B-B

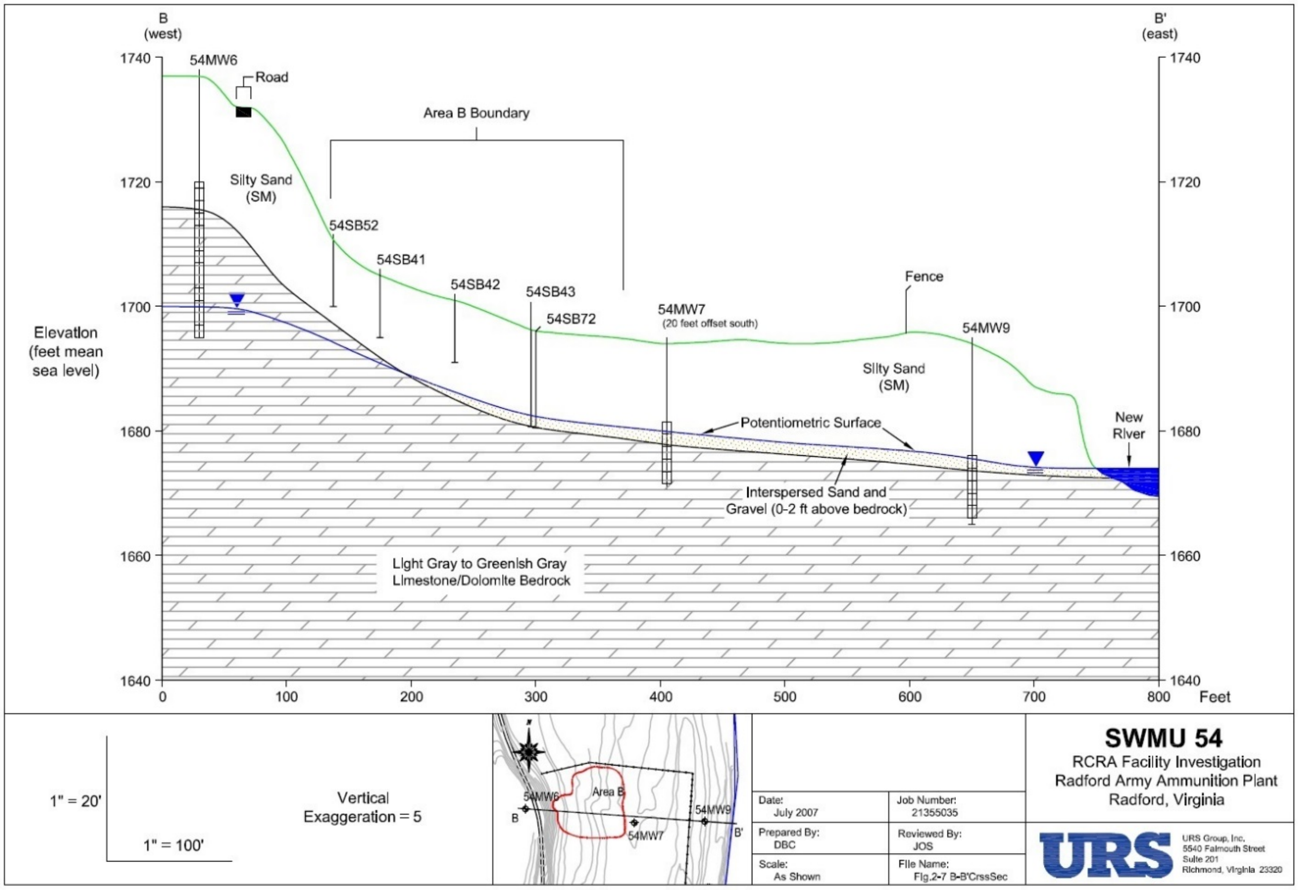

FIGURE 2-3

SWMU 54 Cross Section B-B'

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3.0 Previous Investigations

Four previous investigations have been conducted at this site prior to completion of an interim removal measure in 1999 by Parallax, Inc. Data obtained from previous site investigations prior to the IM were used to identify site boundaries and characteristics, and identify chemicals of potential concern (COPCs). In 1992, the Environmental Photographic Interpretation Center provided aerial photographic analysis of SWMU 54, under the direction of the Environmental Protection Agency (USEPA). Also in 1992, under authority of the 1984 Hazardous and Solid Waste Amendments, Dames & Moore conducted a RCRA Verification Investigation (VI) at the site to identify the ash disposal at Area A. As a follow-up to the 1992 VI, Parsons completed an RFI in 1996, as part of a multiple site investigation to "define the extent of ash and the limits of soil contamination." In 1998, a Supplemental RFI/CMS was conducted to investigate a flat grassy area ringed by mature pine trees northwest of Area A. This area was defined as Area B within SWMU 54. The purpose of the supplemental RFI was to "characterize the nature and extent of contamination within SWMU 54." In 1999, Parallax, Inc. completed IMs at Area A and Area B of SWMU 54 consisting of excavation of selected "hot spot" areas of lead and explosives in soil.

In 2008, URS Corporation (URS) conducted an RFI/CMS investigating both Area A and Area B to confirm the effectiveness of the IM as well as evaluate and assess current conditions at the sites and provide recommendations regarding potential corrective measure requirements at the sites. Direct push soil borings with chemical sampling were used to: characterize the nature and extent of constituents in soil at SWMU 54, identify the lateral and vertical extent of any waste material present, and characterize soil lithology and depth to groundwater and bedrock. Additionally, monitoring wells were installed at the site and groundwater samples were collected and analyzed. Details of these investigations are described in Section 3.0 (Field Investigation Program) of the Final SWMU 54 RFI/CMS Report (URS, 2008). A potentiometric map, portraying the groundwater levels measured in 2007 is provided as **Figure 3-1**. Historical data listing Chemicals of Interest (COI) concentrations in the on-site groundwater, New River surface water and New River sediment pore water can be found in **Tables 3-1** through **3-6**.

The nature and extent assessment indicated that the main concern at the site is the fill material and grossly-contaminated soil directly below the material. Areas A and B were evaluated separately for the soil and groundwater nature and extent assessments given the 200-ft separation between the areas, their topographic cross-gradient position, the lack of mobility of the chemicals in soil, and observed distributions of chemicals.

The main parameters of concern in Area A soil are lead, 2,4,6-TNT, DNT, RDX, amino DNTs, nitroglycerin (NG), heptachlor epoxide, and dioxins/furans. The main parameters of concern in groundwater at Area A are explosives and perchlorate. Concentrations of COIs 2,4,6-TNT, DNT, RDX, and perchlorate in groundwater have decreased since RFI monitoring began in 2003 and 2004. The lateral extent of explosives and perchlorate in groundwater extends from Area A eastward to the New River. Sampling of the groundwater/surface water interface (sediment pore water) and surface water of the New River did not indicate detectable impacts to sediment pore water or surface water from COPCs in groundwater.

Parameters of concern in Area B soils include lead, DNT, amino DNT, NG, RDX, dieldrin, Aroclor 1254, heptachlor epoxide, and dioxins/furans. No COIs were identified for Area B Groundwater.

The Human Health Risk Assessment (HHRA) identified eight COIs at Area A (2,4,6-TNT, DNT, RDX, perchlorate, amino DNTs, NG, heptachlor epoxide, and 2,3,7,8-tetrachlorodibenzodioxin [TCDD]) and ten COIs at Area B (2,4,6-TNT, DNT, RDX, amino DNTs, NG, lead, Aroclor 1254, heptachlor epoxide, dieldrin, and 2,3,7,8-TCDD) under both an industrial and residential future-use scenario for total soil at SWMU 54. The HHRA determined that unacceptable risks to potential future residential and industrial receptors were associated with the COIs. Based on the results from the HHRA, it was concluded that based on the levels detected in the soil hot spot areas, COIs could potentially leach from soil to groundwater at levels of concern, although groundwater impacts at levels of concern have not yet been identified at Area B. Because the RFI demonstrated that COI contamination is present at concentrations associated with unacceptable human health concerns, a CMS was performed to address the propellant ash material and grossly-contaminated soil under the ash material at SWMU 54. The alternatives evaluated were as follows:

- Alternative One: No Further Action.
- Alternative Two: Excavation of Soil at Area A and Area B, Off-site Disposal, and MNA of Groundwater.
- Alternative Three: Excavation of Soil at Area A and Area B, Off-site Disposal, and Enhanced In Situ Bioremediation of Groundwater.

These three alternatives were evaluated using the selection criteria: effectiveness, implementability, and cost. The site-specific CMO for SWMU 54 is to mitigate further leaching of explosives constituents from soil to groundwater at levels that would potentially increase observed concentrations and adversely impact future beneficial use of groundwater, and to eliminate the potential threats to human health and the environment that exist within materials found in SWMU 54. Observations from the SWMU 54 soil investigations indicate that the propellant ash consisted of a black, ashy material that was very evident when encountered. Therefore, identification and removal of the propellant ash and grossly-contaminated soil was partially based on visual observations during excavation, with analytical samples collected to confirm the observations.

Figure 3-1 SWMU 54 June 5, 2007 Groundwater Contour Map

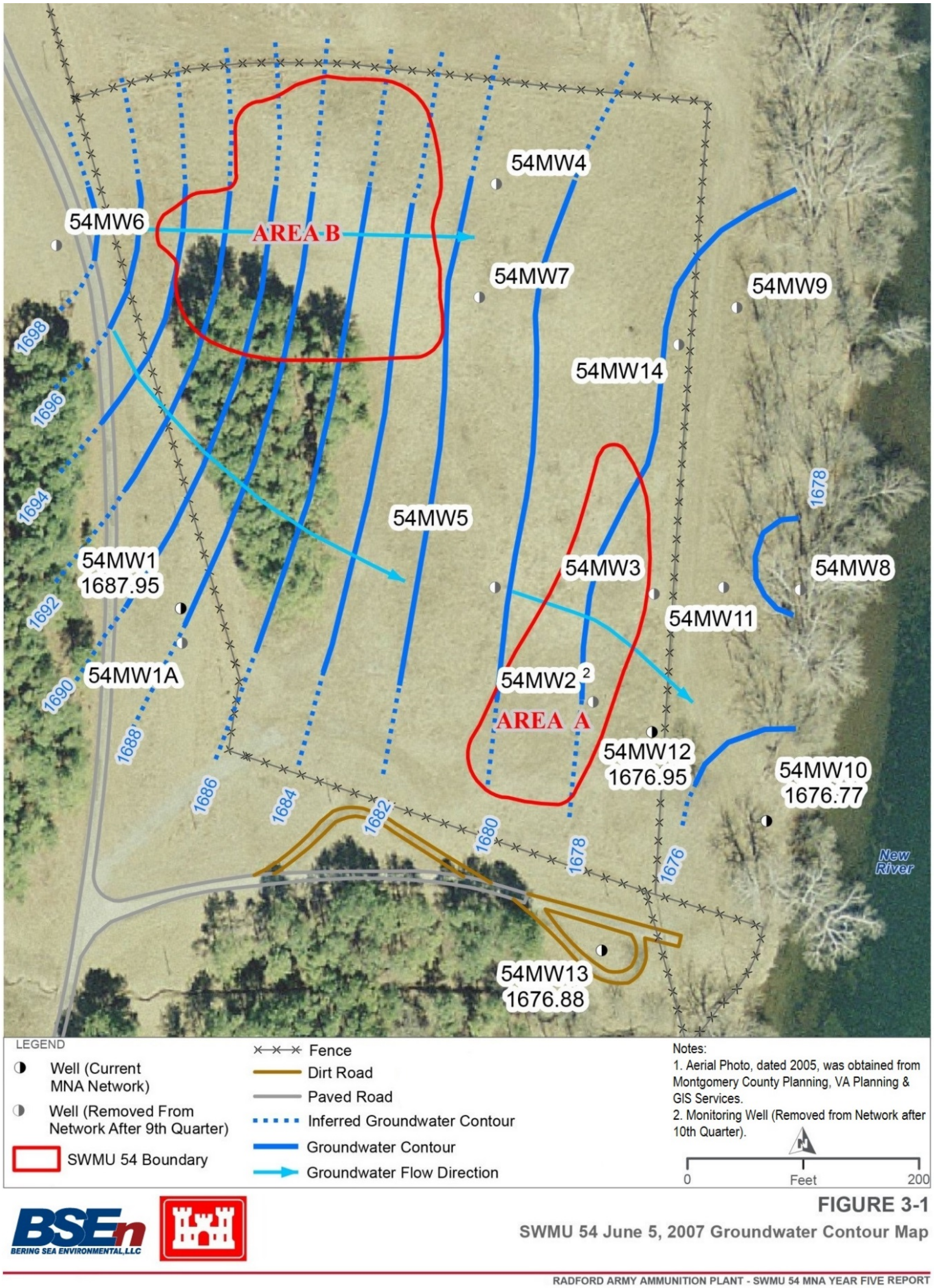

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Table 3-1 2002 Area A Direct Push Groundwater Analytical Results with Remedial Goals

Sample ID Sample Date	CAS	C/N	RG	Units	54DPW1 12/11/2002		DL	RL	54DPW2 12/11/2002		MDL	RL	54DPW3 12/11/2002		MDL	RL	54GP77 10/13/2004		MDL	RL	54GP78 10/11/2004		MDL	RL	54GP78-DUP(DUP-1) 10/11/2004		MDL	RL	54GP79 10/11/2004		MDL	RL
					Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	<7.2	U,R,l	0.73	7.2	1.5	JB,B,z	0.33	3.3	<2.1	U,R,l	0.21	2.1	NT				NT				NT				NT			
DNT mixture*			**0.932**		ND				ND				ND				ND				ND				ND				ND			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	<7.2	U,R,l	1	7.2	<3.3	U,R,l	0.48	3.3	<2.1	U,R,l	0.31	2.1	NT				NT				NT				NT			
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	5.5		0.54	1	27.7		0.54	1	2		0.54	1	3.5		0.1	1	<1	U	0.1	1	<1	U	0.1	1	<1	U	0.1	1

Sample ID Sample Date	CAS	C/N	RG	Units	54GP80 10/13/2004		MDL	RL	54GP81 10/11/2004		MDL	RL	54GP82 10/11/2004		MDL	RL	54GP83 10/11/2004		MDL	RL	54GP84 10/13/2004		MDL	RL	54GP85 10/14/2004		MDL	RL	54GP86 10/13/2004		MDL	RL
					Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	**NT**				**NT**				**NT**				**NT**				**NT**				**NT**				**NT**			
DNT mixture*			**0.932**		**ND**				**ND**				**ND**				**ND**				**ND**				**ND**				**ND**			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	**NT**				**NT**				**NT**				**NT**				**NT**				**NT**				**NT**			
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	**<1**	**U**	**0.1**	**1**	**1**		**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**	**<1**	**U**	**0.1**	**1**

Sample ID Sample Date	CAS	C/N	RG	Units	54GP87 10/14/2004		MDL	RL	54GW56 8/18/2004		MDL	RL	54GW57 8/17/2004		MDL	RL	54GW58 8/24/2004		MDL	RL	54GW59 8/18/2004		MDL	RL	54GW59-DUP(DUP-3) 8/18/2004		MDL	RL	54GW60 8/24/2004		MDL	RL
					Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	NT				160		0.15	1.3	1.7	,J,g	0.0749	0.65	15		0.0749	0.65	4.2	,L,f	0.0749	0.65	11	,J,g	0.0749	0.65	9.3		0.0749	0.65
DNT mixture*			**0.932**		ND				ND				ND	U			ND				ND				ND				ND			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	NT				35	,J,g	0.164	0.65	0.69		0.164	0.65	3.7		0.164	0.65	1		0.164	0.65	1.7		0.164	0.65	0.8		0.164	0.65
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	<1	U	0.1	1	13.5		0.1	1	2		0.1	1	25.8		0.1	1	4		0.1	1	3.6		0.1	1	1.7		0.1	1

Sample ID Sample Date	CAS	C/N	RG	Units	54GW61 8/24/2004		MDL	RL	54GW62 8/23/2004		MDL	RL	54GW63 8/23/2004		MDL	RL	54GW64 8/23/2004		MDL	RL	54GW64-DUP(DUP-9) 8/23/2004		MDL	RL	54GW65 8/20/2004		MDL	RL	54GW66 8/20/2004		MDL	RL
					Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	74		0.0749	0.65	9		0.0749	0.65	<0.65	U	0.0749	0.65	0.82	,J,g	0.0749	0.65	0.76	,J,g	0.0749	0.65	3		0.0749	0.65	NT			
DNT mixture*			**0.932**		ND				ND				ND				ND				ND				ND				ND			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	<0.65	U	0.164	0.65	1.6		0.164	0.65	<0.65	U	0.164	0.65	0.75	,J,g	0.164	0.65	0.73	,J,g	0.164	0.65	0.7		0.164	0.65	NT			
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	3		0.1	1	5.3		0.1	1	<1	U	0.1	1	1.1		0.1	1	0.97	B	0.1	1	1.7		0.1	1	0.94	B,J,m	0.1	1

Table 3-1 2002 Area A Direct Push Groundwater Analytical Results with Remedial Goals (Continued)

Sample ID Sample Date					54GW66 8/23/2004				54GW67 8/20/2004				54GW67 8/23/2004				54GW68 8/20/2004				54GW69 8/20/2004				54GW69 8/23/2004				54GW70 8/20/2004			
	CAS	C/N	RG	Units	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL
Explosives																																
2,4,6-Trinitrotoluene	**118-96-7**	**N**	**7.82**	**µg/L**	**<0.65**	**U**	**0.0749**	**0.65**	**NT**				**<0.65**	**U**	**0.0749**	**0.65**	**2.6**	**,J,g**	**0.0749**	**0.65**	**NT**				**1.4**		**0.0749**	**0.65**	**<0.65**	**U**	**0.0749**	**0.65**
DNT mixture*			**0.932**		**ND**				**ND**				**ND**				**ND**				**ND**				**ND**				**ND**			
RDX	**121-82-4**	**C**	**6.1**	**µg/L**	**<0.65**	**U**	**0.164**	**0.65**	**NT**				**<0.65**	**U**	**0.164**	**0.65**	**<0.65**	**U**	**0.164**	**0.65**	**NT**				**0.51**	**J**	**0.164**	**0.65**	**<0.65**	**U**	**0.164**	**0.65**
Perchlorate																																
Perchlorate	**14797-73-0**	**N**	**10.9**	**µg/L**	**NT**				**0.59**	**B,J,m**	**0.1**	**1**	**NT**				**<1**	**U**	**0.1**	**1**	**0.65**	**B,J,m**	**0.1**	**1**	**NT**				**0.76**	**B**	**0.1**	**1**

**The results of 2,4-DNT and 2,6-DNT were added together to get the DNT mixture result.*

Notes:
µg/L = micrograms per liter
MDL = Method Detection Limit
NI = Not Identified
NT = Not Tested
ND = Not Detected
RL = Reporting Limit
SVOC = Semi-volatile Organic Compound
TAL = Target Analyte List
TCL = Target Compound List
TIC = Tentatively Identified Compound
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

Data Qualifiers:
B = Not detected substantially above the level reported in laboratory or field blanks.
E = Concentration exceeded the upper level of the calibration range of the instrument for that specific analysis. For TICs, compound not present in calibration standard, calculated using total peak areas ion chromatographs and response factor of 1.
J = Analyte present. Reported value may not be accurate or precise.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
N = Sample spike recovery is outside of control limits.
P = Greater than 40% difference for detected concentrations between the two GC or HPLC columns.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
UL = Not detected, quantitation limit is probably higher.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.
o = Calibration blank contamination.
p = Preparation blank contamination.
s = Serial dilution failure.
w = Field and/or equipment blank contamination.

z = Method blank and/or storage blank contamination.

Table 3-2 2003-2004 Area A Groundwater Analytical Results with Remedial Goals

Sample ID Sample Date	CAS	C/N	RG	Units	54MW2 3/4/2003				54MW3 3/4/2003				54MW5 3/4/2003				54MW-8 12/21/2004				54MW-9 12/21/2004				54MW-10 12/21/2004				54MW10-DUP(DUP-1) 12/21/2004			
					Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL
Explosives																																
2,4,6-Trinitrotoluene	118-96-7	N	7.82	µg/L	<3.6	U	0.365	3.6	38		0.365	3.6	<4.2	U	0.43	4.2	<0.65	U	0.0749	0.65	<0.65	U	0.0749	0.65	62		0.15	1.3	65		0.15	1.3
DNT mix*			0.932	µg/L	ND				ND				ND				ND				ND				ND				ND			
RDX (Hexahydro-1,3,5-trinitro-1,3,5-tria	121-82-4	C	6.1	µg/L	<3.6	U	0.526	3.6	32		0.526	3.6	<4.2	U	0.61	4.2	0.2	J,J,g	0.164	0.65	1.1	,J,g	0.164	0.65	28		0.164	0.65	29		0.164	0.65
Perchlorate																																
Perchlorate	14797-73-0	N	10.90	µg/L	12		0.54	1	59.2		0.54	1	1.6		0.54	1	0.22	B	0.1	1	0.21	B	0.1	1	9.8		0.1	1	9.1		0.1	1
Field Parameters																																
Dissolved Oxygen	--	--	--	mg/L	6.97				5.18				2.88				0.25				2.56				1.25				1.25			
Oxidation Reduction Potential	--	--	--	mV	159.5				119.0				95.1				215				234				208				208			
pH	--	--	--	SU	6.37				6.65				7.00				7.20				7.53				7.06				7.06			
Conductivity	--	--	--	mS	0.191				0.341				0.310				0.627				0.706				0.760				0.760			
Temperature	--	--	--	°C	16.24				15.97				12.91				13.6				13.2				13.8				13.8			
Turbidity	--	--	--	NTU	0.80				1.93				12.0				4.17				4.13				3.52				3.52			

**DNT mixture result is the result of the adding together of 2,4-DNT and 2,6-DNT.*

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MCL = Maximum Contaminant level
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
NT = Not Tested
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
SVOC = Semi-volatile Organic Compound
TAL = Target Analyte List
TCL = Target Compound List
TIC = Tentatively Identified Compound
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

RBC = USEPA Region III Risk-Based Concentration (RBC) values from the October 11, 2007, RBC Table and October 11, 2007, Alternate RBC Table

Data Qualifiers:
B = Not detected substantially above the level reported in laboratory or field blanks.
E = Concentration exceeded the upper level of the calibration range of the instrument for that specific analysis. For TICs, compound not present in calibration standard, calculated using total peak areas ion chromatographs and response factor of 1.
J = Analyte present. Reported value may not be accurate or precise.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
N = Sample spike recovery is outside of control limits.
P = Greater than 40% difference for detected concentrations between the two GC or HPLC columns.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
UL = Not detected, quantitation limit is probably higher.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.
o = Calibration blank contamination.
p = Preparation blank contamination.
s = Serial dilution failure.
w = Field and/or equipment blank contamination.
.
z = Method blank and/or storage blank contamination.

Table 3-3 2006-2007 Area A Quarterly Groundwater Monitoring Results with Remedial Goals

First Quarter – November/December 2006																															
Sample ID Sample Date				**54MW1 11/29/2006**				**54MW2 11/29/2006**				**54MW3 12/5/2006**				**54MW5 11/29/2006**				**54MW8 12/1/2006**				**54MW9 12/1/2006**				**54MW10 12/1/2006**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (μg/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	**<5**	**U**	**0.075**	**5**	**5.6**		**0.075**	**5**	**0.85**	**J**	**0.075**	**5**	**0.29**	**J**	**0.075**	**5**	**<5**	**U**	**0.075**	**5**	**<5**	**U**	**0.075**	**5**	**2.1**	**J**	**0.075**	**5**
Dinitrotoluene Mixture	--	C	**0.932**	<5				<5				<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**<5**	**U**	**0.16**	**5**	**3.3**	**J**	**0.16**	**5**
Perchlorate (μg/L)																															
Perchlorate	14797-73-0	N	**10.90**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	11.95				10.29				11.94				10.1				8.94				8.51				8.13			
Oxidation Reduction Potential (mV)	--	--	--	153				159				171				231				32				53				36			
pH (SU)	--	--	--	7.86				7.15				7.26				7.2				7.53				7.65				7.39			
Conductivity (mS)	--	--	--	0.44				0.533				0.580				0.557				0.605				0.790				0.733			
Temperature (°C)	--	--	--	18.6				17.7				18.3				18.5				17.1				19.1				16.3			
Turbidity (NTU)	--	--	--	4.47				1.16				0.07				16.6				11.83				23.5				10.31			

Second Quarter – March 2007																															
Sample ID Sample Date				**54MW-1 3/28/2007**				**54MW-2 3/28/2007**				**54MW-3 3/28/2007**				**54MW-5 3/28/2007**				**54MW-8 3/27/2007**				**54MW-9 3/27/2007**				**54MW10 DUP AVG 3/27/2007**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (ug/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	0.25	J,J,d	0.1	5	<5	U	0.1	5	0.84	J,J,g	0.1	5	14		0.1	5	<5	U	0.1	5	6.018		0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				1.146				<5				<5				<5				<5				0.898			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	8.1		0.092	5	<5	U	0.092	5	3.87		0.092	5
Perchlorate (ug/L)																															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.036	0.2	3.6		0.036	0.2	<0.2	U	0.036	0.2	0.52		0.036	0.2	0.26		0.036	0.2	0.24		0.036	0.2	2.9		0.036	0.2
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	8.06				7.75				6.12				8.38				6.68				6.51				8			
Oxidation Reduction Potential (mV)	--	--	--	-5				44				-11				53				-17				-10				11			
pH (SU)	--	--	--	7.63				6.45				6.94				6.51				7.05				7.18				6.88			
Conductivity (mS)	--	--	--	0.199				0.183				0.311				0.167				0.267				0.960				0.334			
Temperature (°C)	--	--	--	13.44				15.8				15.22				12.73				13.92				14.43				15.95			
Turbidity (NTU)	--	--	--	1.82				0.37				2.13				1.22				13.96				7.71				3.64			

Table 3-3 2006-2007 Area A Quarterly Groundwater Monitoring Results with Remedial Goals (Continued)

Fourth Quarter – September 2007

Sample ID Sample Date				54MW-1 6/5/2007				54MW-2 6/5/2007				54MW-3 6/5/2007				54MW-5 6/5/2007				54MW-8 6/5/2007				54MW-9 6/5/2007				54MW-10 6/5/2007			
	CAS	C/N	RG	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL
Explosives (ug/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	3.9	J	0.1	5	1	J	0.1	5	0.49	J	0.1	5	<5	U	0.1	5	<5	U	0.1	5	2.4	J	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	ND				ND				ND				ND				ND				0.466				ND			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	6.3		0.092	5	<5	U	0.092	5	1.6	J	0.092	5
Perchlorate (ug/L)																															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	2		0.08	0.2	0.88		0.08	0.2	0.58		0.08	0.2	0.7		0.08	0.2	0.23		0.08	0.2	0.37		0.08	0.2
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	7.57				8.46				5.06				8.44				8.82				5.21				7.35			
Oxidation Reduction Potential (mV)	--	--	--	297				268				109				236				285				94				187			
pH (SU)	--	--	--	7.33				6.78				6.2				6.24				6.9				6.25				6.87			
Conductivity (mS)	--	--	--	0.192				0.225				0.003				0.163				0.245				0.003				0.353			
Temperature (°C)	--	--	--	13.58				13.48				15.66				21.68				13.4				15.44				14.51			
Turbidity (NTU)	--	--	--	0.48				0.29				0.36				0.67				0.06				1.67				**9.37**			

Fourth Quarter – September 2007

Sample ID Sample Date				54MW-1 9/19/2007				54MW-2 9/19/2007				54MW-3 9/19/2007				54MW-5 9/19/2007				54MW-8 9/18/2007				54MW-9 9/18/2007				54MW-10 9/18/2007			
	CAS	C/N	RG	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL
Explosives (ug/L)																															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	0.78	J	0.1	5	1.2	J	0.1	5	0.38	J,J,g	0.1	5	<5	U	0.1	5	<5	U	0.1	5	17		0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	ND				ND				ND				ND				ND				ND				0.696			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5	8		0.092	5
Perchlorate (ug/L)																															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	0.57		0.08	0.2	0.31		0.08	0.2	0.34		0.08	0.2	0.37		0.08	0.2	<0.2	U	0.08	0.2	2.9		0.08	0.2
Field Parameters																															
Dissolved Oxygen (mg/L)	--	--	--	4.03				2.37				6.34				5.53				4.06				3.78				3.89			
Oxidation Reduction Potential (mV)	--	--	--	233				172				205				228				288				237				239			
pH (SU)	--	--	--	8.2				7.01				5.67				6.89				6.82				7.11				6.76			
Conductivity (mS)	--	--	--	0.487				0.637				0.57				0.647				0.711				0.833				0.844			
Temperature (°C)	--	--	--	19.79				15.91				15.6				17.36				14.41				18.05				17.27			
Turbidity (NTU)	--	--	--	0.79				2.19				2.02				1.62				0.43				2.19				7.19			

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MCL = Maximum Contaminant level
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
ng/L= nanograms per liter
NT = Not Tested
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

RBC = USEPA Region III Risk-Based Concentration (RBC) values from the October 11, 2007, RBC Table and October 11, 2007, Alternate RBC Table

Data Qualifiers:
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
c = calibration failure.
d = MS/MSD or LCS/LCSD RPD imprecision.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.

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Table 3-4 2003 Area B Groundwater Analytical Results with Remedial Goals

Sample ID **Sample Date**	**RG**	**Units**	**54MW4** **3/4/2003**		**MDL**	**RL**	**54MW6** **3/3/2003**		**MDL**	**RL**	**54MW7** **3/4/2003**		**MDL**	**RL**	**54MW7-DUP (GW-DUP-1)** **3/4/2003**		**MDL**	**RL**
			Result	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**		
Explosives																		
2,4,6-Trinitrotoluene	**7.82**	µg/L	<5.4	U	0.55	5.4	<4.2	U	0.43	4.2	<3.6	U	0.365	3.6	<4.8	U	0.487	4.8
DNT Mixture	**0.932**	µg/L	ND				ND				ND				ND			
RDX (Hexahydro-1,3,5-trinitro-1,3,5-tria	**6.1**	µg/L	<5.4	U	0.79	5.4	<4.2	U	0.61	4.2	<3.6	U	0.526	3.6	<4.8	U	0.701	4.8
Perchlorate																		
Perchlorate[1]	**10.9**	µg/L	<1	U	0.54	1	<1	U	0.54	1	<1	U	0.54	1	<1	U	0.54	1

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit

SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

Data Qualifiers:
B = Not detected substantially above the level reported in laboratory or field blanks.
E = Concentration exceeded the upper level of the calibration range of the instrument for that specific analysis. For TICs, compound not present in calibration standard, calculated using total peak areas ion chromatographs and response factor of 1.
K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
J = Analyte present. Reported value may not be accurate or precise.
L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
N = Sample spike recovery is outside of control limits.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.
UJ = Not detected, quantitation limit may be inaccurate or imprecise.
UL = Not detected, quantitation limit is probably higher.
g = Dual column confirmation imprecision.
l = LCS recovery failure.
m = MS/MSD recovery failure.
o = Calibration blank contamination.
p = Preparation blank contamination.
s = Serial dilution failure.
w = Field and/or equipment blank contamination.

z = Method blank and/or storage blank contamination.

Table 3-5 2006-2007 Area B Quarterly Groundwater Monitoring Results with Remedial Goals

First Quarter – November/December 2006

Sample ID Sample Date	CAS	C/N	Adjusted Tap Water RBC	54MW4 11/30/2006		MDL	RL	54MW6 11/29/2006		MDL	RL	54MW7 12/5/2006		MDL	RL
				Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	9.9				11.63				10.46			
Oxidation Reduction Potential (mV)	--	--	--	-92				181				170			
pH (SU)	--	--	--	7.77				8				7.56			
Conductivity (mS)	--	--	--	1.13				0.297				0.729			
Temperature (°C)	--	--	--	15				16.6				15.9			
Turbidity (NTU)	--	--	--	2.66				4.87				5.91			

Second Quarter – March 2007

Sample ID Sample Date	CAS	C/N	RG	54MW-4 3/27/2007		MDL	RL	54MW-6 3/27/2007		MDL	RL	54MW-7 3/27/2007		MDL	RL
				Result	LQ, VQ, r			Result	LQ, VQ, r			Result	LQ, VQ, r		
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	<5	U	0.1	5	<5	U	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.036	0.2	<0.2	U	0.036	0.2	<0.2	U	0.036	0.2
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	5.97				8.8				6			
Oxidation Reduction Potential (mV)	--	--	--	-95				135				-44			
pH (SU)	--	--	--	7.16				8.21				7			
Conductivity (mS)	--	--	--	1.11				0.314				0.323			
Temperature (°C)	--	--	--	15.68				17.77				14.25			
Turbidity (NTU)	--	--	--	1.54				31.1				6.59			

Table 3-5 2006-2007 Area B Quarterly Groundwater Monitoring Results with Remedial Goals (Continued)

Third Quarter – June 2007															
Sample ID Sample Date				54MW4 DUP AVG 6/5/2007				54MW-6 6/5/2007				54MW-7 6/5/2007			
	CAS	C/N	RG	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	<5	U	0.1	5	<5	U	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	<0.2	U	0.08	0.2	<0.2	U	0.08	0.2
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	5.15				4.5				7.72			
Oxidation Reduction Potential (mV)	--	--	--	91				76				225			
pH (SU)	--	--	--	6.39				6.03				6.97			
Conductivity (mS)	--	--	--	0.003				0.003				0.302			
Temperature (°C)	--	--	--	14.54				19.28				3.03			
Turbidity (NTU)	--	--	--	0.67				9.96				0.71			

Fourth Quarter – September 2007															
				54MW4 9/19/2007				54MW6 9/19/2007				54MW7 DUP AVG 9/19/2007			
Sample ID Sample Date	CAS	C/N	RG	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL	Result	LQ, VQ, r	MDL	RL
Explosives (µg/L)															
2,4,6-Trinitrotoluene	118-96-7	N	**7.82**	<5	U	0.1	5	<5	U	0.1	5	<5	U	0.1	5
Dinitrotoluene Mixture	--	C	**0.932**	ND				ND				ND			
RDX	121-82-4	C	**6.100**	<5	U	0.092	5	<5	U	0.092	5	<5	U	0.092	5
Perchlorate (µg/L)															
Perchlorate	14797-73-0	N	**10.90**	<0.2	U	0.08	0.2	0.1	J	0.08	0.2	<0.2	U	0.08	0.2
Field Parameters															
Dissolved Oxygen (mg/L)	--	--	--	4.03				7.47				4.56			
Oxidation Reduction Potential (mV)	--	--	--	-1				236				266			
pH (SU)	--	--	--	7.91				8.13				6.97			
Conductivity (mS)	--	--	--	1.1				0.267				0.766			
Temperature (°C)	--	--	--	16.08				16.69				16.83			
Turbidity (NTU)	--	--	--	0.43				4.37				0.39			

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MDL = Method Detection Limit
mV = millivolt
mS = milliSiemen
ND = Not Detected
ng/L = nanogram per liter
See Table 6-3D (December 2006) and Table 6-3E (June 2007) for Total 2,3,7,8-TCDD TEQ Calculations

NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

Data Qualifiers:
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

Table 3-6 2006 New River Surface and Sediment Pore Water Sample Results with Remedial Goals

Surface Water																											
Sample ID Sample Date				**NR-SW-1 11/30/2006**				**NR-SW-2 11/30/2006**				**NR-SW-3 11/30/2006**				**NR-SW-4 11/30/2006**				**NR-SW-5 11/30/2006**				**NR-SW-6 11/30/2006**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (µg/L)																											
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)																											
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																											
Dissolved Oxygen (mg/L)	--	--	--	17.05				15.83				14.64				12.93				14.83				15.11			
Oxidation Reduction Potential (mV)	--	--	--	219				118				47				53				32				35			
pH (SU)	--	--	--	8.9				8.1				7.96				7.81				7.67				8.3			
Conductivity (mS)	--	--	--	0.116				0.113				0.118				0.174				0.117				0.155			
Temperature (°C)	--	--	--	10.1				9.9				10.1				10.3				10.2				10.4			
Turbidity (NTU)	--	--	--	71.3				13.7				17.48				9.94				7.66				6.21			

Pore Water																											
Sample ID Sample Date				**NR-PW-1 11/30/2006**				**NR-PW-2 11/30/2006**				**NR-PW-3 11/30/2006**				**NR-PW-4 11/30/2006**				**NR-PW-5 11/30/2006**				**NR-PW-6 11/30/2006**			
	CAS	**C/N**	**RG**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**	**Result**	**LQ, VQ, r**	**MDL**	**RL**
Explosives (µg/L)																											
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)																											
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																											
Dissolved Oxygen (mg/L)	--	--	--	10.38				10.46				12.2				9.35				10.82				11.34			
Oxidation Reduction Potential (mV)	--	--	--	-109				-174				20				-182				-44				-58			
pH (SU)	--	--	--	7.33				7.21				7.47				7.57				7.44				7.2			
Conductivity (mS)	--	--	--	0.307				0.344				0.248				0.38				0.553				0.353			
Temperature (°C)	--	--	--	12.8				10.7				10.8				10.6				13.2				11.9			
Turbidity (NTU)	--	--	--	16.35				37.9				22.7				4.86				3.63				11.85			

Table 3-6 2006 New River Surface and Sediment Pore Water Sample Results with Remedial Goals (Continued)

Surface Water																							
Sample ID Sample Date	**CAS**	**C/N**	**RG**	**NR-SW-7 12/1/2006**		**MDL**	**RL**	**NR-SW-8 12/1/2006**		**MDL**	**RL**	**NR-SW-8-DUP(DUP-4) 12/1/2006**		**MDL**	**RL**	**NR-SW-9 12/1/2006**		**MDL**	**RL**	**NR-SW-10 12/1/2006**		**MDL**	**RL**
				Result	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**		
Explosives (µg/L)																							
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)																							
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																							
Dissolved Oxygen (mg/L)	--	--	--	13.13				13.27				13.27				13.76				14.69			
Oxidation Reduction Potential (mV)	--	--	--	10				41				41				51				52			
pH (SU)	--	--	--	8.11				7.8				7.8				7.62				7.83			
Conductivity (mS)	--	--	--	0.140				0.124				0.124				0.131				0.114			
Temperature (°C)	--	--	--	11.7				12.5				12.5				11.8				11			
Turbidity (NTU)	--	--	--	148				13.8				13.8				20.5				11.46			

Pore Water																							
Sample ID Sample Date	**CAS**	**C/N**	**RG**	**NR-PW-6-DUP(DUP-3) 11/30/2006**		**MDL**	**RL**	**NR-PW-7 12/1/2006**		**MDL**	**RL**	**NR-PW-8 12/1/2006**		**MDL**	**RL**	**NR-PW-9 12/1/2006**		**MDL**	**RL**	**NR-PW-10 12/1/2006**		**MDL**	**RL**
				Result	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**			**Result**	**LQ, VQ, r**		
Explosives (µg/L)																							
2,4,6-Trinitrotoluene	118-96-7	C	**7.82**	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5	<5	U	0.075	5
2,4-Dinitrotoluene	121-14-2	N		<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5	<5	U	0.12	5
2,6-Dinitrotoluene	606-20-2	N		<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5	<5	U	0.27	5
DNT mixture*			**0.932**	<5				<5				<5				<5				<5			
RDX	121-82-4	C	**6.100**	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5	<5	U	0.16	5
Perchlorate (µg/L)																							
Perchlorate	14797-73-0	--	**10.900**	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10	<10	U	1.84	10
Field Parameters																							
Dissolved Oxygen (mg/L)	--	--	--	11.34				9.25				9.74				10.55				10.18			
Oxidation Reduction Potential (mV)	--	--	--	-58				-194				-173				-173				-157			
pH (SU)	--	--	--	7.2				7.54				7.36				7.23				7.47			
Conductivity (mS)	--	--	--	0.353				0.517				0.660				0.533				0.479			
Temperature (°C)	--	--	--	11.9				13				12.9				13.2				13.1			
Turbidity (NTU)	--	--	--	11.85				3.72				5.6				15.87				1.66			

**DNT mixture results are obtained by adding together the results of 2,4-DNT and 2,6-DNT*

Notes:
µg/L = micrograms per liter
ºC = degrees Celsius
CAS = Chemical Abstracts Service
MDL = Method Detection Limit
mg/L = milligram per liter
mV = millivolt
mS = milliSiemen
NTU = Nephelometric Turbidity Unit
RL = Reporting Limit
SU = Standard Units
LQ = Laboratory Qualifier
VQ = Validation Qualifier
r = Reason Code

C = Carcinogenic per EPA RBC Table (October 2007)
N = Noncarcinogenic per EPA RBC Table (October 2007)
☐ *=Exceeds RG*

RBC = USEPA Region III Risk-Based Concentration (RBC) values from the October 11, 2007, RBC Table and October 11, 2007, Alternate RBC Table

BTAG = Biological Technical Assistance Group Water - BTAG Freshwater Screening Values, 2006a

Data Qualifiers:
J = Analyte present. Reported value may not be accurate or precise.
U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.

Alternative Two, which entails excavation and off-site disposal as the primary remediation process, was found to achieve the CMO. Therefore, Alternative Two was selected as the final alternative for SWMU 54 because it is implementable and provides a greater level of protection to human health and the environment not provided by other alternatives. In addition, Alternative Two is the sole alternative that facilitates RGs without potential adverse effects to groundwater (i.e., degradation of secondary water quality parameters) from remedial implementation activities, which would occur with implementation of Alternative Three.

The CMOs and RGs were developed in the Final SWMU 54 RFI/CMS Report (URS, 2008). The following is a summary of the findings from that process.

The site-specific CMO for SWMU 54 Area A is to mitigate further leaching of explosives constituents from soil-to-groundwater at levels that would potentially increase observed concentrations and adversely impact future beneficial use of groundwater; and to the extent practicable, a goal of restoring site groundwater to the most beneficial use. The soil CMOs for Area A have been met, and the purpose of this report is to implement the groundwater IMs to meet the CMOs for groundwater.

The site-specific CMO for SWMU 54 Area B is to mitigate the potential hypothetical future risks that have been identified for exposure to soil under a future construction worker scenario; and to prevent leaching of contaminants of concern from soil-to-groundwater at levels that would potentially adversely impact future beneficial use of groundwater. The site-specific CMOs have been met through the soil excavation and off-site disposal completed in 2010.

RGs for SWMU 54 groundwater, shown in **Table 1-1** of this report, were used at SWMU 54 to confirm that all COIs were removed from soil to levels that are safe for human health and the environment. Results from the soil remedial action at SWMU 54 can be found in the approved Final Interim Measures Completion Report for SWMU 54 (Shaw, 2011b). The groundwater RGs will be used to compare results from groundwater monitoring wells to assess the progress of the MNA process.

4.0 Field Activities

The following sections provide a discussion of field activities conducted by BSEn in the fifth year of monitoring at SWMU 54.

The fifth year of groundwater monitoring consisted of four sampling events conducted in October 2016 (seventeeth quarter), January 2017 (eighteenth quarter), April 2017 (nineteenth quarter), and July 2017 (twentieth quarter). Multiple wells were removed from the monitoring network after the ninth and tenth quarters and were not sampled during this fifth year. As such, monitoring wells that were included in the fifth year monitoring events included 54MW1, 54MW10, 54MW12, and 54MW13, which monitor Area A at SWMU 54. Field activities were conducted in accordance with the *Final SWMU 54 MNA IMWP* (Shaw, 2011a). Copies of the groundwater sample forms are presented in **Appendix A**.

4.1 Seventeenth Quarter Groundwater Sampling (October 2016)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 during the seventeenth quarter event. The seventeenth quarter of groundwater sampling was conducted 10 – 14 October 2016. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.1.1 Groundwater Elevation Measurements

Water level elevations were collected during each fifth year quarterly event from the four monitoring wells at SWMU 54 prior to the collection of groundwater samples. **Table 4-1** provides the measured depth to water levels (from the top of the casing [TOC]) and groundwater elevations amsl collected on 10 October 2016. **Figure 4-2** presents a groundwater elevation contour map developed from the elevation data collected during this quarterly monitoring event. Groundwater contours were derived using Esri ArcGIS Desktop Spatial Analyst 10.5.1 software and creating a spline interpolated continuous surface based on limited groundwater data. The surface model was executed using default values in most cases and forces to cover an area inclusive of all wells using the extent polygon to define the area of interest. Contour lines were then constructed from the output splined surface at 10-foot and 2-foot intervals, depending on the site, with zero base contour. The results of the automated processing were then reviewed by subject knowledge experts and manually adjusted to accurately represent ground conditions.

Table 4-1 Seventeenth Quarter Groundwater Elevations at SWMU 54

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Reading (ppm)
54MW1	34.8 - 54.8	20	62	19.00	1707.78	1688.78	0.0
54MW10	12 - 27	15	35	15.52	1691.10	1675.58	0.0
54MW12	20 – 30	10	30	25.64	1702.42	1676.78	0.0
54MW13	12 – 25	10	25.33	22.10	1698.90	1676.80	0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm = parts per million
TOC = top of casing
PID=Photoionization detector

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 13.2 ft, resulting in a calculated hydraulic gradient of 0.025 ft/ft. Using an average K value for Area A of 4.86 feet per day (ft/day) and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.60 ft/day [217.45 feet per year (ft/year)].

Area B, although not monitored during the fifth year, is expected to have a similar groundwater flow velocity as Area A, as reported in the Third Year MNA Report (CB&I, 2014).

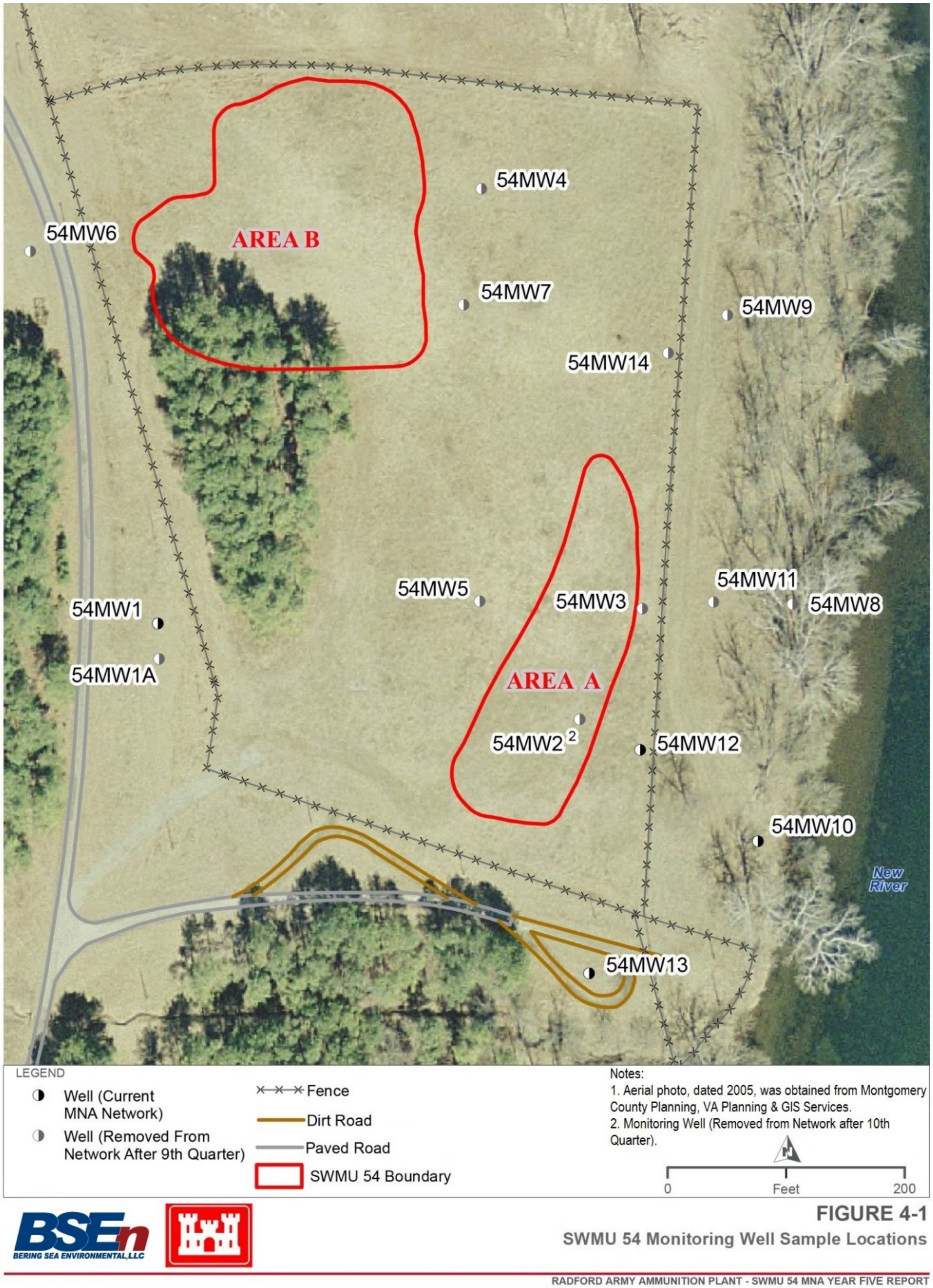
4.1.2 Groundwater Sampling

Groundwater samples were collected from the four monitoring wells between 11-12 October 2016 and analyzed for the analytical suites covering explosives, perchlorate, and RDX and it’s breakdown by-products hexahydro-1,3,5-dinitroso-5-nitro-1,3,5-triazine (DNX), hexahydro-1-nitroso-3,5-dinitro-1,2,5-triazine (MNX), and hexhydro-1,3,5-trinitroso-1,3,5-triazine (TNX). The breakdown by-products of RDX are considered MNA indicators. In addition, the following indicator parameters were collected: Total Organic Carbon (TOC), Total Inorganic Carbon (TIC), dissolved ferrous iron, dissolved manganese, chlorate, chloride, chlorite, nitrate, and sulfate. Water quality parameters collected during low flow sampling included pH, temperature, specific conductance, dissolved oxygen (DO), oxidation-reduction potential (ORP), and turbidity. **Table 4-2** presents the suite of analytes collected for analysis during the seventeenth quarterly monitoring event.

Table 4-2 Year 5 Quarterly Monitoring Analytical Suite

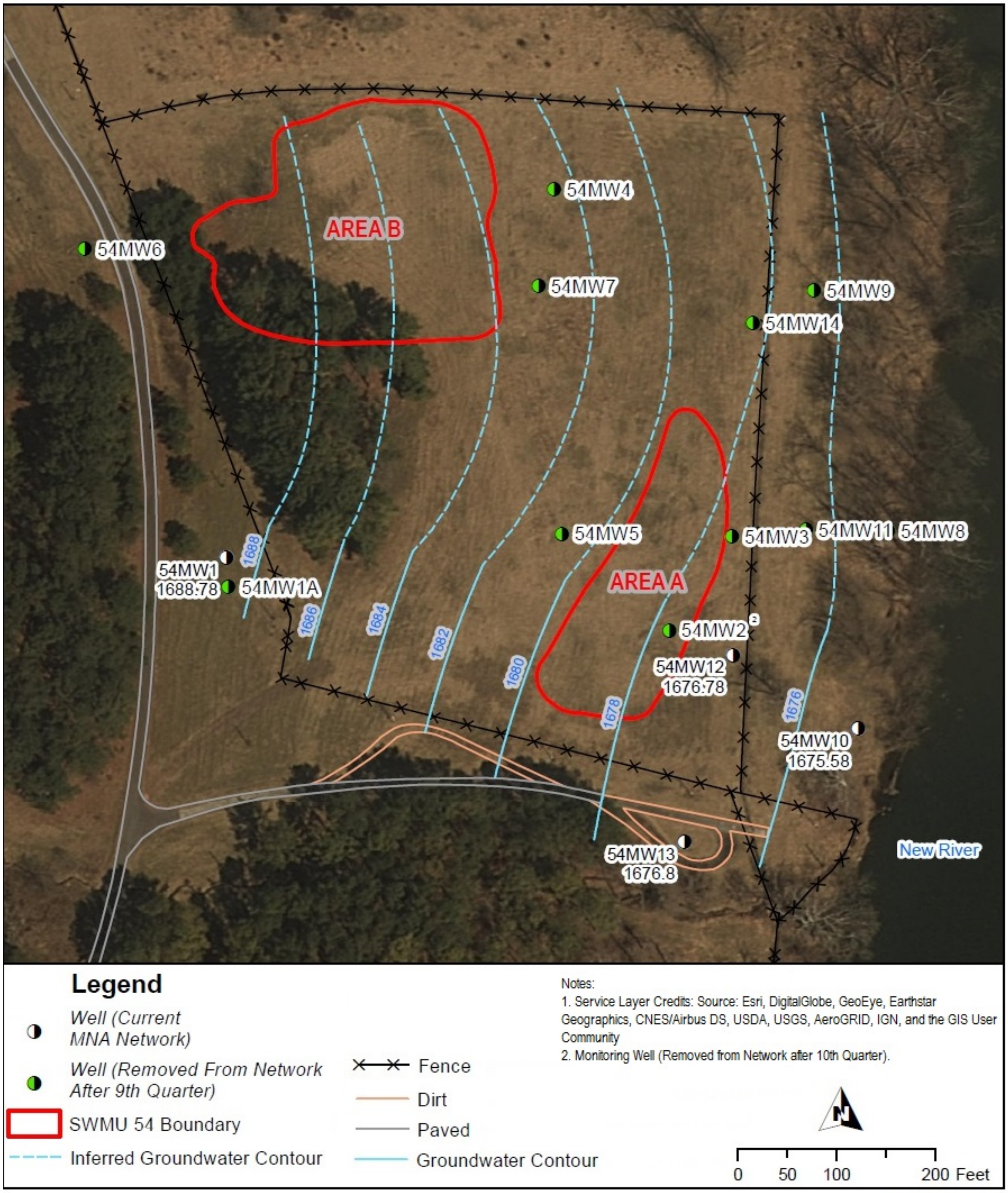
Well/Sample ID	Frequency	Explosives	Perchlorate	RDX MNA Parameters	MNA Indicator Parameters	Water Quality Parameters
54MW1	**Quarterly**	**X**	**X**	**X**	**X**	**X**
54MW10	**Quarterly**	**X**	**X**	**X**	**X**	**X**
54MW12	**Quarterly**	**X**	**X**	**X**	**X**	**X**
54MW13	**Quarterly**	**X**	**X**	**X**	**X**	**X**

Figure 4-1 SWMU 54 Monitoring Well Sample Locations



Notes:
1. Aerial photo, dated 2005, was obtained from Montgomery County Planning, VA Planning & GIS Services.
2. Monitoring Well (Removed from Network after 10th Quarter).

Figure 4-2 SWMU 54 October 2016 (17th Quarter) Groundwater Contour Map



Notes:
1. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
2. Monitoring Well (Removed from Network after 10th Quarter).

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FIGURE 4-2
SWMU 54 October 2016 (17th Quarter) Groundwater Contour Map

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Groundwater samples were collected via low-flow bladder pumps to obtain representative groundwater samples and to minimize investigative derived waste (IDW) purge water. The following procedures were followed during all quarterly groundwater monitoring events:

1. A photoionization detector (PID) reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sandpack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to ensure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI 556 water quality flow cell.
4. Monitoring wells were pumped at a rate of approximately 200 milliliters per minute (mL/min). Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO, ORP, turbidity, and conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were measured in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.
5. **Table 4-3** presents a summary of the final (stabilized) water quality readings for each well from the seventeenth quarter.

With the exception of monitoring well 54MW10 (i.e., DO < 1 ppm), the DO data collected during the seventeenth quarterly monitoring event indicate aerobic groundwater conditions. The DO levels ranged from a low of 0.54 milligrams per liter (mg/L) at monitoring well 54MW10 to a high of 5.05 mg/L at monitoring well 54MW12. ORP measurements ranged from a low of 30.4 millivolts (mV) in monitoring well 54MW12 to a high of 138.2 mV at monitoring well 54MW1. Measurements of pH ranged from a low of 5.91 standard units at monitoring well 54MW10 to a high of 7.28 at monitoring well 54MW1. The pH levels were generally in agreement with measurements observed during the sixteenth quarterly monitoring event. Measurements of specific conductance ranged from a low of 474 microsiemens per centimeter (µS/cm) at monitoring well 54MW1 to a high of 839 µS/cm at monitoring well 54MW10.

Table 4-3 Seventeenth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)
54MW1	7.28	474	0.14	2.60	138.2	14.48
54MW10[1]	5.91	839	3.22	0.54	69.1	14.63
54MW12	6.34	579	3.02	5.05	30.4	15.55
54MW13	6.92	673	9.98	3.40	44.8	13.10

Notes:

[1] Well 54MW10 is located adjacent to the New River	*mV - millivolts*
µS/cm - microsiemens per centimeter	*°C - degrees Celsius*
NTU - nephelometric turbidity unit	*ORP – Oxygen reduction potential*
mg/L - milligrams per liter	

Prior to sampling, the flow cell was disconnected and the groundwater flow rate was maintained at 200 mL/min during sample collection. Samples were collected, labeled, and packed in ice until shipment to the laboratory. Chain-of-custody (COC) forms were filled out and shipped with the samples. Copies of the COC forms are provided in **Appendix B** along with the raw analytical data packages. Copies of the Low Flow Stabilization Data Sheets are provided in **Appendix A**.

4.1.3 Quality Control Samples

QC samples including rinse, duplicate and temperature blanks were collected during the seventeenth monitoring event.

One duplicate sample was collected during the seventeenth monitoring event (rate of 10 percent) at 54MW13 (duplicate as 54TM13) and analyzed for the same suite of compounds as the parent sample. Further, one matrix spike/matrix spike duplicate (MS/MSD) [at a rate of 5 percent]) was collected at monitoring well 54MW12 (54MW12 MS/MSD) and analyzed for the same suite of compounds as the parent sample.

One equipment rinse blank (101216R1) was collected during the seventeenth quarterly monitoring event by pouring de-ionized water over a decontaminated bladder pump and into clean laboratory supplied bottles. The rinse blank was collected and analyzed for the same suite of compounds as the monitoring well samples. Finally, one IDW purge water sample (54ADW01) was collected and analyzed for pH, chemical oxygen demand (COD), and total metals for disposal of IDW purge water per the RFAAP SWMU 54 MNA IMWP. Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B**.

4.2 Eighteenth Quarter Groundwater Sampling (January 2017)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 between 9 - 10 January 2017. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.2.1 Groundwater Elevation Measurements

Table 4-4 provides the measured depth to water levels (from TOC) and groundwater elevations collected on 9 January 2016 during the eighteenth quarter monitoring event. **Figure 4-3** presents a groundwater elevation contour map developed from the elevation data collected during the quarter.

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 14.83 ft, resulting in a calculated hydraulic gradient of 0.028 ft/ft. Using an average K value for Area A of 4.86 ft/day and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.70 ft/day (244.3 ft/year).

Table 4-4 Eighteenth Quarter Groundwater Elevations at SWMU 54

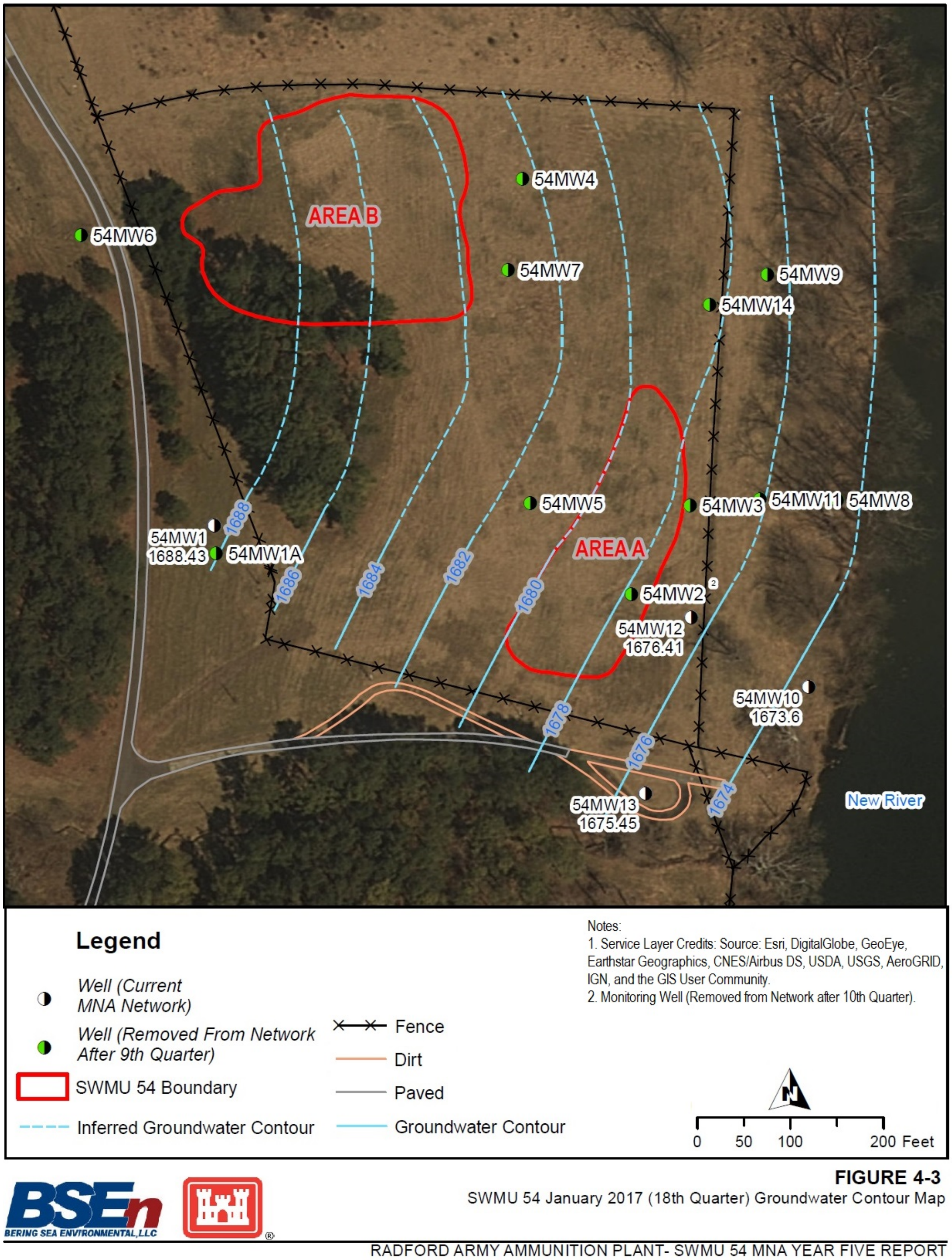
Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Readings (ppm)
54MW1	34.8 - 54.8	20	62	19.35	1707.78	1688.43	PID = 0.0
54MW10	12 - 27	15	35	17.50	1691.10	1673.60	PID = 0.0
54MW12	20 - 30	10	30	26.01	1702.42	1676.41	PID = 0.0
54MW13	12 - 25	10	25.33	23.45	1698.90	1675.45	PID = 0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm = parts per million
TOC = top of casing
PID = Photoionization detector

4.2.2 Groundwater Sampling

Groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 between 9 – 10 January 2017. The eighteenth quarter monitoring samples were tested for the same analytes as the seventeenth quarter, which are presented in **Table 4-2**.

Figure 4-3 SWMU 54 January 2017 (18th Quarter) Groundwater Contour Map



Notes:
1. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
2. Monitoring Well (Removed from Network after 10th Quarter).

Groundwater samples were collected applying the same method and approach used during the seventeenth quarterly monitoring event: specifically, via low-flow bladder pumps. The sample procedures are provided below.

1. A PID reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sandpack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to insure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI 556 water quality flow cell.
4. Monitoring wells were pumped at a rate of approximately 200 mL/min. Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO, ORP, turbidity, and conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were tested in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.
5. **Table 4-5** presents a summary of the final (stabilized) water quality readings for each well from the eighteenth quarter.

Based on the DO data collected during the eighteenth quarterly monitoring event, groundwater within Area A exhibit aerobic conditions. The DO levels ranged from a low of 1.4 mg/L at monitoring well 54MW10 to a high of 5.40 mg/L at monitoring well 54MW12. ORP measurements ranged from a low of 49 mV at monitoring well 54MW10 to a high of 75 mV at monitoring well 54MW12. Measurements of pH ranged from a low of 6.70 standard units at monitoring well 54MW12 to a high of 7.43 at monitoring well 54MW1. The pH levels were generally more neutral than observed during the seventeenth quarterly monitoring event, but is likely due to the colder weather duing the eighteenth quarterly monitoring event. Measurements of specific conductance ranged from a low of 486.2 µS/cm in monitoring well 54MW1 to a high of 854 µS/cm observed at monitoring well 54MW10

Table 4-5 Eighteenth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)
54MW1	7.43	486.2	0.28	2.21	74.8	12.8
54MW10	7.19	854	1.39	1.40	49	12.5
54MW12	6.70	647.5	1.04	5.40	75	11.8
54MW13	7.04	740.0	8.20	3.29	71.0	11.7

Notes:
mg/L - milligrams per liter
µS/cm - microsiemens per centimeter
NTU - nephelometric turbidity unit
mV - millivolts
°C - degrees Celsius
ORP – Oxygen reduction potential

Copies of the COC forms are provided in **Appendix B** along with the raw analytical data packages.

4.2.3 Quality Control Samples

QC samples including rinse, duplicate and temperature blanks were collected during the eighteenth monitoring event.

One duplicate sample was collected at 54MW12 (duplicate as 54TM12) and analyzed for the same suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 54MW10 (54MW10 MS/MSD) and analyzed for the same suite of compounds as the parent sample.

One equipment rinse blank (010917R1) was collected during the eighteenth quarterly monitoring event by pouring de-ionized water over a decontaminated bladder pump and into clean laboratory supplied bottles. The rinse blank was collected and analyzed for the same suite of compounds as the monitoring well samples. Finally, one IDW purge water sample (54ADW01) was collected and analyzed for pH, COD, and total metals. Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B**.

4.3 Nineteenth Quarter Groundwater Sampling (April 2017)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 on 10 – 11 April 2017. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.3.1 Groundwater Elevation Measurements

Table 4-6 provides the measured depth to water levels (from TOC) and groundwater elevations collected on 10 April 2017 during the quarterly monitoring event. **Figure 4-4** presents a groundwater elevation contour map developed from the elevation data collected during the quarter.

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 13.68 ft, resulting in a calculated hydraulic gradient of 0.025 ft/ft. Using an average K value for Area A of 4.86 ft/day and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.62 ft/day (225.4 ft/year).

Table 4-6 Nineteenth Quarter Groundwater Elevations at SWMU 54

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Readings (ppm)
54MW1	34.8 - 54.8	20	62	18.57	1707.78	1689.21	PID = 0.0
54MW10	12 - 27	15	35	15.57	1691.10	1675.53	PID = 0.0
54MW12	20 - 30	10	30	24.21	1702.42	1678.21	PID = 0.0
54MW13	12 - 25	10	25.33	20.64	1698.90	1678.26	PID = 0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm= parts per million
TOC = top of casing
PID = Photoionization detector

4.3.2 Groundwater Sampling

Groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 between 10-11 April 2017. The nineteenth quarter monitoring samples were tested for the same analytes as the previous two quarters, which are presented in **Table 4-2**.

Groundwater samples were collected applying the same method and approach used during the previous two quarterly monitoring events: specifically, via low-flow bladder pumps. The sample procedures are provided below.

1. A PID reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sandpack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to

4. insure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI 556 water quality flow cell.
5. Monitoring wells were pumped at a rate of approximately 200 mL/min. Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO, ORP, turbidity, and conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were tested in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.
6. **Table 4-7** presents a summary of the final (stabilized) water quality readings for each well from the nineteenth quarter.

Based on the DO data collected during the nineteenth quarterly monitoring event, groundwater within Area A exhibited aerobic groundwater conditions. The DO levels ranged from a low of 3.2 mg/L at monitoring well 54MW10 to a high of 8.38 mg/L at monitoring well 54MW1. ORP measurements ranged from a low of 57.3 mV at monitoring well 54MW10 to a high of 93.4 mV at monitoring well 54MW12. Measurements of pH ranged from a low of 6.7 standard units at monitoring well 54MW12 to a high of 7.65 at monitoring well 54MW1. The pH levels were generally in agreement with measurements observed during the eighteenth quarterly monitoring event. Measurements of specific conductance ranged from a low of 443 µS/cm in monitoring well 54MW1 to a high of 627 µS/cm observed at monitoring well 54MW12. These values were significantly lower than those observed in previous fifth year quarterly monitoring events.

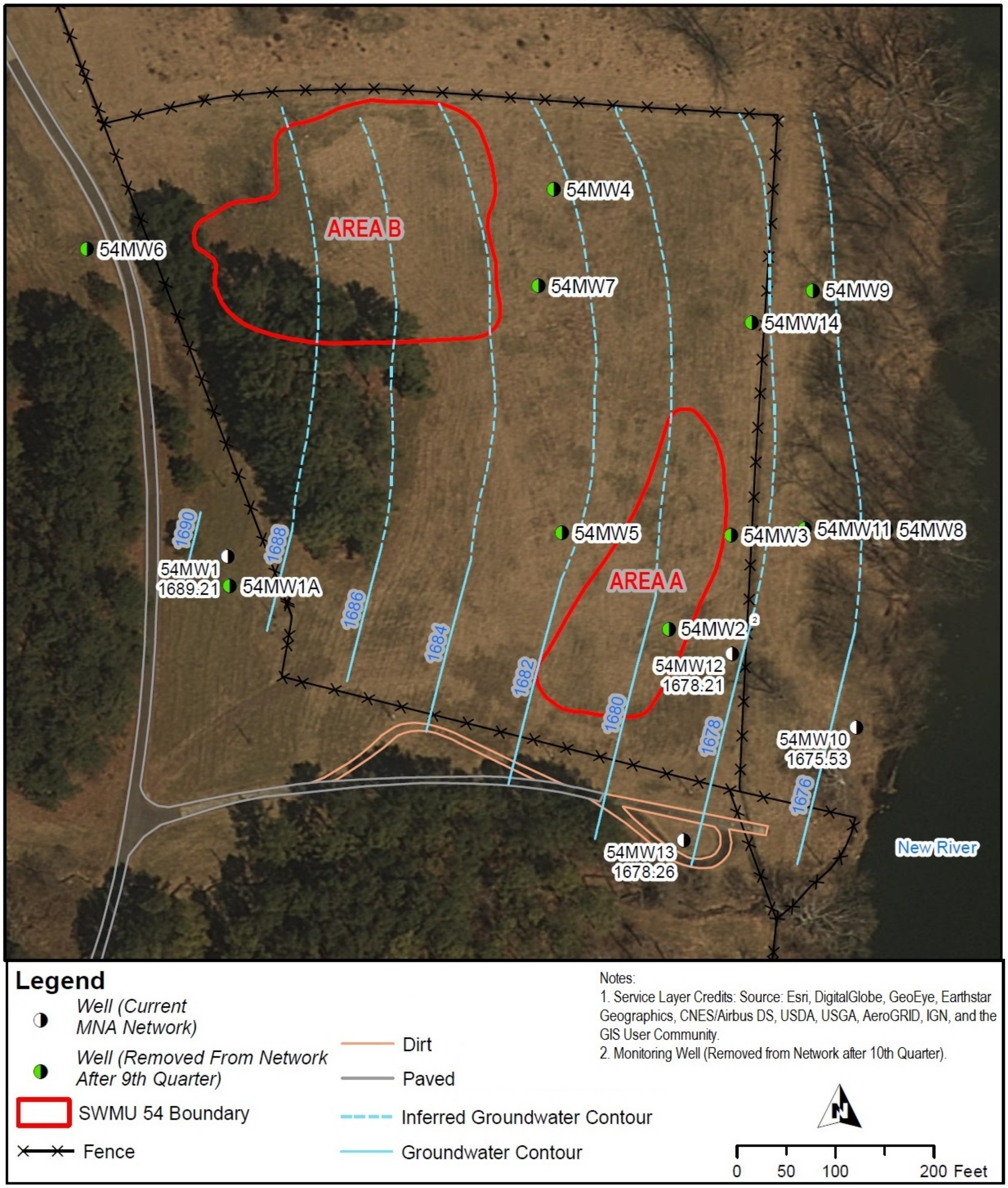
Table 4-7 Nineteenth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (°C)
54MW1	7.65	443	0.25	8.38	91.0	13.1
54MW10	6.88	614	0.71	3.2	57.3	13.80
54MW12	6.7	627	1.92	5.39	93.4	13.1
54MW13	6.97	474	14.2	4.74	77.5	14

Notes:
mg/L - milligrams per liter
µS/cm - microsiemens per centimeter
NTU - nephelometric turbidity unit
mV - millivolts
°C - degrees Celsius
ORP – Oxygen reduction potential

Copies of the COC forms are provided in **Appendix B** along with the raw analytical data packages.

Figure 4-4 SWMU 54 April 2017 (19th Quarter) Groundwater Contour Map



Notes:
1. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGA, AeroGRID, IGN, and the GIS User Community.
2. Monitoring Well (Removed from Network after 10th Quarter).

FIGURE 4-4

SWMU 54 April 2017 (19th Quarter) Groundwater Contour Map

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4.3.3 Quality Control Samples

QC samples, including rinse, duplicate and temperature blanks were collected during the nineteenth monitoring event.

One duplicate sample was collected at 54MW10 (duplicate as 54TM10) and analyzed for the same suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 54MW12 (54MW12 MS/MSD) and analyzed for the same suite of compounds as the parent sample.

One equipment rinse blank (0411171R1) was collected during the nineteenth quarterly monitoring event by pouring de-ionized water over a decontaminated bladder pump and into clean laboratory supplied bottles. The rinse blank was collected and analyzed for the same suite of compounds as the monitoring well samples. Finally, one IDW purge water sample (54ADW01) was collected and analyzed for pH, COD, and total metals. Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B**.

4.4 Twentieth Quarter Groundwater Sampling (July 2017)

Groundwater elevation measurements and groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 between 10 - 11 July 2017. Groundwater elevation measurements were collected prior to sampling activities. The locations of monitoring wells sampled during this quarterly event are provided in **Figure 4-1**.

4.4.1 Groundwater Elevation Measurements

Table 4-8 provides the measured depth to water levels (from TOC) and groundwater elevations collected on 10 July 2017 during the quarterly monitoring event. **Figure 4-5** presents a groundwater elevation contour map developed from the elevation data collected during the quarter.

Estimated groundwater flow velocity for Area A was calculated based on parameters used in the SWMU 54 RFI/CMS Report (URS, 2008). The Area A flow path of approximately 538.4 ft had a groundwater elevation difference of 14.57 ft, resulting in a calculated hydraulic gradient of 0.027 ft/ft. Using an average K value for Area A of 4.86 ft/day and an estimated effective porosity of 0.20, the groundwater flow velocity for Area A is approximately 0.66 ft/day (240.0 ft/year).

Table 4-8 Twentieth Quarter Groundwater Elevations at SWMU 54

Well	Screen Interval (ft bgs)	Screen Length (ft)	Total Depth (ft)	Water Level (TOC)	Elevation TOC	Water Level (ft amsl)	PID Readings (ppm)
54MW1	34.8 - 54.8	20	62	18.61	1707.78	1689.17	PID = 0.0
54MW10	12 - 27	15	35	16.50	1691.10	1674.60	PID = 0.0
54MW12	20 - 30	10	30	24.88	1702.42	1677.54	PID = 0.0
54MW13	12 - 25	10	25.33	21.47	1698.90	1677.43	PID = 0.0

Notes:
amsl = above mean sea level
bgs = below ground surface
ft = feet
ppm= parts per million
TOC = top of casing
PID = Photoionzation detector

4.4.2 Groundwater Sampling

Groundwater samples were collected from monitoring wells 54MW1, 54MW10, 54MW12, and 54MW13 between 10 - 11 July 2017. The twentieth quarter monitoring samples were tested for the same analytes as the previous three quarters, which are presented in **Table 4-2**.

Groundwater samples were collected applying the same method and approach used during the previous quarterly monitoring events: specifically, via low-flow bladder pumps. The sample procedures are provided below.

1. A PID reading was taken upon removing the well cap to determine the presence of potentially hazardous levels of volatile gases. The PID readings were collected during the water elevation sweeps and again during sample collection. All PID readings were within acceptable levels.
2. During the water level sweep, depth to water and total depth measurements were recorded to determine the amount of water in the well casing and sandpack.
3. Groundwater samples were collected after all water level elevations had been recorded. The general practice was to lower the bladder pump to a depth where the pump inlet was within the screened interval. Ample hydraulic head was maintained above the pump to insure a sufficient water supply. The pump was connected to a Geocontrol PRO control unit, while the discharge tubing was connected to a YSI 556 water quality flow cell.
4. Monitoring wells were pumped at a rate of approximately 200 mL/min. Flow rate was determined by gauging the time it took to fill a 200 mL vial. Water quality parameters were recorded continuously including temperature, pH, DO, ORP, turbidity, and conductivity. Turbidity was measured using a HACH 2100Q turbidity meter, while concentrations of dissolved ferrous iron and manganese were tested in the field using a Hach DR900 test kit via Method 8146 and 8149, respectively.

5. **Table 4-9** presents a summary of the final (stabilized) water quality readings for each well from the twentieth quarter.

Based on the DO data collected during the twentieth quarterly monitoring event, groundwater within Area A indicated anaerobic groundwater conditions. The DO levels ranged from a low of 0.01 mg/L at monitoring well 54MW13 to a high of 0.83 mg/L at monitoring well 54MW10. These values were significantly lower than those observed during the two previous quarterly monitoring events. ORP measurements ranged from a low of 15.5 mV at monitoring well 54MW13 to a high of 116.5 mV at monitoring well 54MW1. Measurements of pH ranged from a low of 6.63 standard units at monitoring well 54MW12 to a high of 7.43 at monitoring well 54MW1. The pH levels were generally in agreement with measurements observed during the previous three quarterly monitoring events. Measurements of specific conductance ranged from a low of 468 µS/cm in monitoring well 54MW1 to a high of 740 µS/cm observed at monitoring well 54MW10. These values were generally in agreement with values observed during the seventeenth and eighteenth quarterly monitoring events, but were significantly higher than those observed during the nineteenth quarterly monitoring event.

Table 4-9 Twentieth Quarter Water Quality Parameters at SWMU 54

Well ID	pH	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Temperature (ºC)
54MW1	7.43	468	0.52	0.69	116.5	14.8
54MW10	7.00	740	0.52	0.83	24.1	14.9
54MW12	6.63	505	0.71	0.11	85.5	13.7
54MW13	7.00	600	1.36	0.01	15.5	14.8

Notes:

mg/L - milligrams per liter	*mV - millivolts*
µS/cm - microsiemens per centimeter	*°C - degrees Celsius*
NTU - nephelometric turbidity unit	*ORP – Oxygen reduction potential*

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Copies of the COC forms are provided in **Appendix B** along with the raw analytical data packages.

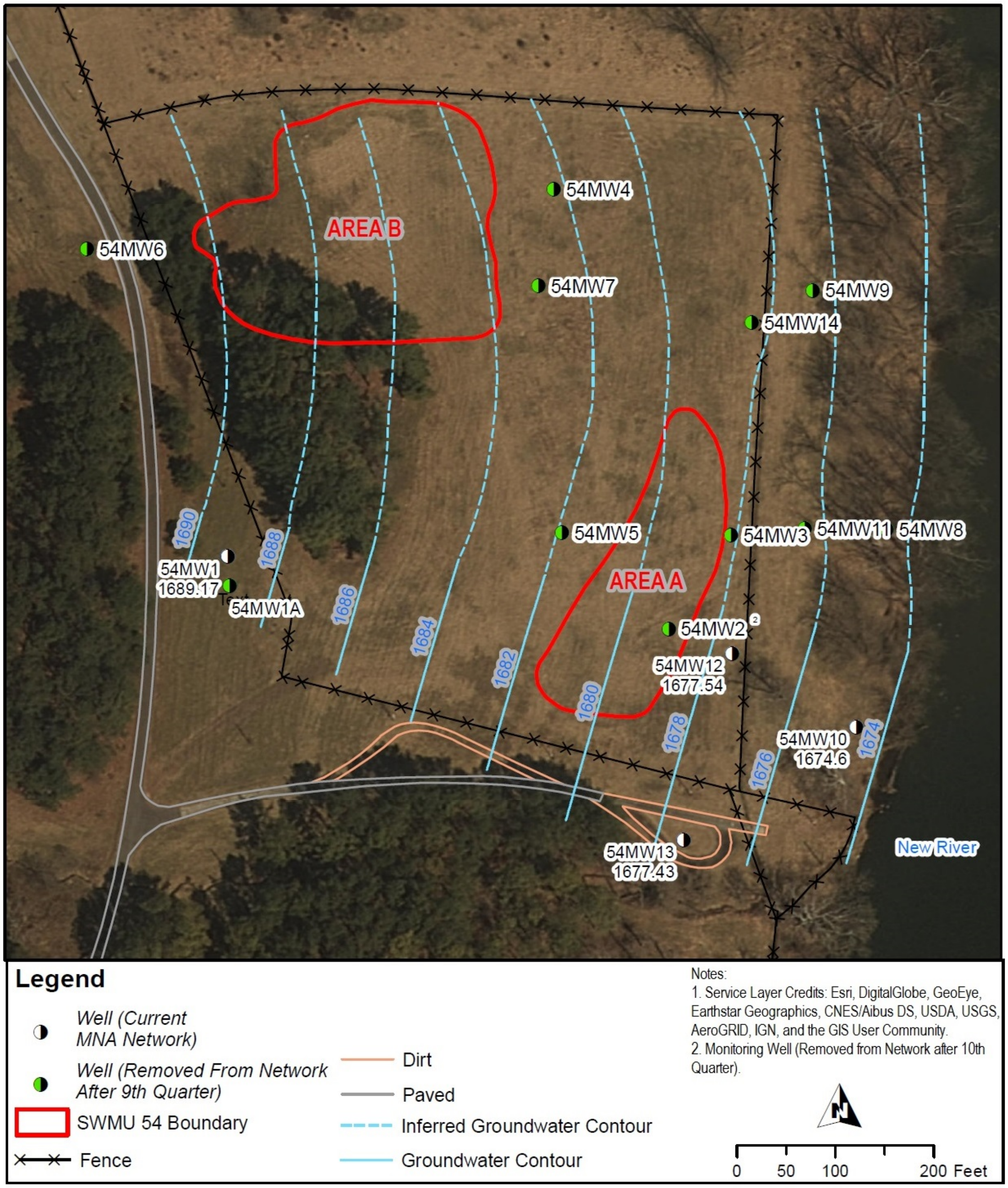
4.4.3 Quality Control Samples

QC samples, including rinse, duplicate and temperature blanks were collected during the twentieth quarterly monitoring event.

One duplicate sample was collected at 54MW10 (duplicate as 54TM10) and analyzed for the same suite of compounds as the parent sample. Further, one MS/MSD was collected at monitoring well 54MW12 (54MW12 MS/MSD) and analyzed for the same suite of compounds as the parent sample.

One equipment rinse blank (071017R1) was collected during the twentieth quarterly monitoring event by pouring de-ionized water over a decontaminated bladder pump and into clean laboratory supplied bottles. The rinse blank was collected and analyzed for the same suite of compounds as the parent samples. Finally, one IDW purge water sample (54ADW01) was collected and analyzed for pH, COD, and total metals. Results of the QA/QC samples are presented in the raw analytical data package provided in **Appendix B**.

Figure 4-5 SWMU 54 July 2017 (20th Quarter) Groundwater Contour Map



Notes:
1. Service Layer Credits: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Aibus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
2. Monitoring Well (Removed from Network after 10th Quarter).

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FIGURE 4-5

SWMU 54 July 2017 (20th Quarter) Groundwater Contour Map

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5.0 Chemical Analytical Results

5.1 Selection of Comparison Criteria

The analytical data collected during this investigation were compared to RGs selected in the Final SWMU 54 RFI/CMS Report (URS, 2008). Screening levels (SLs) are calculated values that are derived from theoretical risk scenarios. Compounds are grouped as carcinogens or noncarcinogens, and carcinogen SL values are calculated to represent an increase of 10^{-6} in cancer risk. Noncarcinogen SLs are calculated to a Hazard Index (HI) of 1. In order to account for potential cumulative effects of exposure to noncarcinogenic compounds, values for noncarcinogens have been recalculated to an HI of 0.1. **Tables 5-1** through **5-10** present the analytical results and summaries of the seventeenth through twentieth quarterly monitoring data, including number of results that exceed the RGs, frequency of detection, the minimum and maximum detected concentrations, and the location of the maximum concentration.

5.2 Seventeenth Quarter Groundwater Results (October 2016)

Four (4) groundwater monitoring wells were sampled during this quarterly monitoring event including wells 54MW1, 54MW10, 54MW12, and 54MW13, with a duplicate sample collected from monitoring well 54MW13. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-1**, while the complete results are presented in **Table 5-2**. Sample locations are provided in **Figure 4-1**.

Explosives

Four explosives were detected in groundwater samples including 2,4,6-TNT, 2-amino-4,6-dinitrotoluene (2ADNT), 4-amino-2,6-dinitrotoluene (4ADNT), and RDX. All four explosives were detected in monitoring wells 54MW10, 54MW12, and 54MW13. No explosives were detected in monitoring well 54MW1.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at a concentration of 1.6 micrograms per liter (µg/L); at monitoring well 54MW12 at a concentration of 10.6 µg/L; and at monitoring well 54MW13 at concentrations of 8 µg/L and 8.5 µg/L (field duplicate, 54TM13). The concentrations of 2,4,6-TNT at monitoring wells 54MW12 and 54MW13 exceed the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW10 at a concentration of 0.35 µg/L; at monitoring well 54MW12 at a concentration of 4.1 µg/L; and at monitoring well 54MW13 at a concentration of 1.5 µg/L (in the parent and duplicate samples). An RG has not been established for 2ADNT.

The explosive 4ADNT was detected at monitoring well 54MW10 at a concentration of 0.31 µg/L; at monitoring well 54MW12 at a concentration of 2 µg/L; and at monitoring well 54MW13 at concentrations of 0.92 µg/L and 1 µg/L (field duplicate 54TM13). An RG has not been established for 4ADNT.

RDX was detected at monitoring well 54MW10 at a concentration of 0.4 µg/L; at monitoring well 54MW12 at a concentration of 6 µg/L; and at monitoring well 54MW13 at a concentration of 0.7 µg/L and 0.69 (field duplicate 54TM13). All three detections are below the RG of 6.1 µg/L. No RDX breakdown by-products (DNX, MNX, and TNX) were detected at any of the monitoring wells during this quarterly monitoring event.

The monitoring wells with detected concentrations of explosives are typically the same wells with observed hits recorded during previous sampling rounds. The monitoring well locations (54MW12 and 54MW13) where 2,4,6-TNT exceed the RG is provided in **Figure 5-1**.

Perchlorate

Perchlorate was detected in three groundwater samples collected from monitoring wells 54MW10, 54MW12, and 54MW13 during this quarterly monitoring event. Perchlorate was detected at monitoring well 54MW10 at an estimated concentration of 0.12 µg/L; at monitoring well 54MW12, concentrations equaled 1.6 µg/L; and monitoring well 54MW13 had observed concentrations of 0.21 µg/L and 0.22 µg/L (field duplicate, 54TM13). All four detections were well below the RG of 10.9 µg/L.

Miscellaneous Analytes

Groundwater samples were also analyzed for MNA indicators (TOC, TIC, dissolved ferrous iron, dissolved manganese, chlorate, chlorite, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed concentrations of TOC in the four monitoring wells ranged from an estimated low of 0.55 mg/L (54MW10) to an estimated high of 0.99 mg/L (54MW12), while the concentrations of TIC ranged from a low of 59 mg/L (54MW1) to a high of 79 mg/L (54MW13). Dissolved ferrous iron concentrations ranged from a low of 0.0 mg/L (non detect) (54MW 12) to a high of 0.52 mg/L (54MW10). Dissolved manganese concentrations ranged from a low of 0.003 mg/L (54MW10) to a high of 0.061 mg/L (54MW13). Chloride concentrations ranged from an estimated low of 2.8 mg/L (54MW1) to a high of 6.4 mg/L (54MW13). Detected concentrations of nitrate ranged from an estimated low of 0.26 mg/L (54MW10) to a high of 1.2 mg/L (54MW12). Sulfate concentrations ranged from a low of 30.0 mg/L (54MW1) to a high of 150.0 mg/L (54MW10). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-2** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-1 SWMU 54 Summary of Seventeenth Quarter Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples(1)	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives								
1,3-Dinitrobenzene	**µg/L**	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	3	4	5	1.6	10.6	54MW12
DNT Mixture*	**µg/L**	**0.932**	0	0	5	ND	ND	na
2,4-Dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	na	4	5	0.35	4.1	54MW12
2-Nitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	na	4	5	0.31	2	54MW12
RDX	**µg/L**	**6.1**	0	4	5	0.4	6	54MW12
DNX	**µg/L**	**na**	na	0	5	ND	ND	na
MNX	**µg/L**	**na**	na	0	5	ND	ND	na
TNX	**µg/L**	**na**	na	0	5	ND	ND	na
Misc.								
Perchlorate	**µg/L**	**10.9**	0	4	5	0.12	1.6	54MW12
Chlorate	**µg/L**	**na**	na	0	5	ND	ND	na
Chlorite	**µg/L**	**na**	na	0	5	ND	ND	na
Chloride	**mg/L**	**na**	na	5	5	2.8	6.6	54MW13
Nitrate (as N)	**mg/L**	**na**	na	4	5	0.26	1.2	54MW12
Sulfate	**mg/L**	**na**	na	5	5	30	150	54MW10
Total Inorganic Carbon	**mg/L**	**na**	na	5	5	59	79	54MW13
Total Organic Carbon	**mg/L**	**na**	na	2	5	0.55	0.99	54MW12

Notes:
[1] One sample was a duplicate
na = not applicable
ND = non detect

Table 5-2 SWMU 54 Detected Analytes in Seventeenth Quarter Groundwater Samples

Sample ID			**54MW1**					**54MW10**					**54MW12**				
Date Collected			**10/11/2016**					**10/12/2016**					**10/11/2016**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives																	
1,3-Dinitrobenzene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	0.1	U	U	0.2	0.08	1.6			0.2	0.08	10.6			0.2	0.08
DNT Mixture*	**µg/L**	**0.932**	0.2	U	U	0.2	0.08	0.2	U	U	0.2	0.08	0.2	U	U	0.2	0.08
2,4-Dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,6-Dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.35			0.2	0.08	4.1			0.2	0.08
2-Nitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.31			0.2	0.08	2			0.2	0.08
RDX	**µg/L**	**6.1**	0.1	U	U	0.2	0.08	0.4			0.2	0.08	6			0.2	0.08
DNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
MNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
TNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
Misc.																	
Perchlorate	**µg/L**	**10.9**	0.1	U	U	0.2	0.05	0.12	J	J	0.2	0.05	1.6			0.2	0.05
Chlorate	**µg/L**	**na**	10	U	U	10	1.9	10	U	U	10	1.9	10	U	U	10	1.9
Chlorite	**µg/L**	**na**	10	U	U	10	5.7	10	U	U	10	5.7	10	U	U	10	5.7
Chloride	**mg/L**	**na**	2.8	J	J	4	1.1	4.9			4	1.1	6.2	M	J	4	1.1
Nitrate (as N)	**mg/L**	**na**	0.15	U	U	0.4	0.08	0.26	J	J	0.4	0.08	1.2			0.4	0.08
Sulfate	**mg/L**	**na**	30			5	1.3	150			25	6.5	41			5	1.3
Total Inorganic Carbon	**mg/L**	**na**	59			3	0.5	72			3	0.5	68			3	0.5
Total Organic Carbon	**mg/L**	**na**	1.5	U	U	3	0.5	0.55	J	J	3	0.5	0.99	J	J	3	0.5
MNA																	
Dissolved Fe^{2+}	**mg/L**	**na**	0.05					0.52					0.00				
Dissolved Mn	**mg/L**	**na**	0.049					0.003					0.038				

Table 5-2 SWMU 54 Detected Analytes in Seventeenth Quarter Groundwater Samples (Continued)

Sample ID			54MW13					54TM13 (Field Duplicate 54MW13)				
Date Collected			10/12/2016					10/12/2016				
Analyte	Units	Remedial Goals (1)	Result	Lab Q	Val Q	RL	MDL	Result	Lab Q	Val Q	RL	MDL
Explosives												
1,3-Dinitrobenzene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,4,6-Trinitrotoluene	µg/L	**7.82**	8			0.2	0.08	8.5			0.2	0.08
DNT Mixture*	µg/L	**0.932**	0.2	U	U	0.2	0.08	0.2	U	U	0.2	0.08
2,4-Dinitrotoluene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,6-Dinitrotoluene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2-Amino-4,6-dinitrotoluene	µg/L	na	1.5			0.2	0.08	1.5			0.2	0.08
2-Nitrotoluene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
4-Amino-2,6-dinitrotoluene	µg/L	na	0.92			0.2	0.08	1			0.2	0.08
RDX	µg/L	**6.1**	0.7			0.2	0.08	0.69			0.2	0.08
DNX	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
MNX	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
TNX	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
Misc.												
Perchlorate	µg/L	**10.9**	0.21			0.2	0.5	0.22			0.2	0.05
Chlorate	µg/L	na	10	U	U	10	1.9	10	U	U	10	1.9
Chlorite	µg/L	na	10	U	U	10	5.7	10	U	U	10	5.7
Chloride	mg/L	na	6.4			4	1.1	6.6			4	1.1
Nitrate (as N)	mg/L	na	0.49			0.4	0.08	0.53			0.4	0.08
Sulfate	mg/L	na	38			5	1.3	36			5	1.3
Total Inorganic Carbon	mg/L	na	79			3	0.5	78			3	0.5
Total Organic Carbon	mg/L	na	1.5	U	U	3	0.5	1.5	U	U	3	0.5
MNA												
Dissolved Fe^{2+}	mg/L	na	0.08					0.08				
Dissolved Mn	mg/L	na	0.061					0.061				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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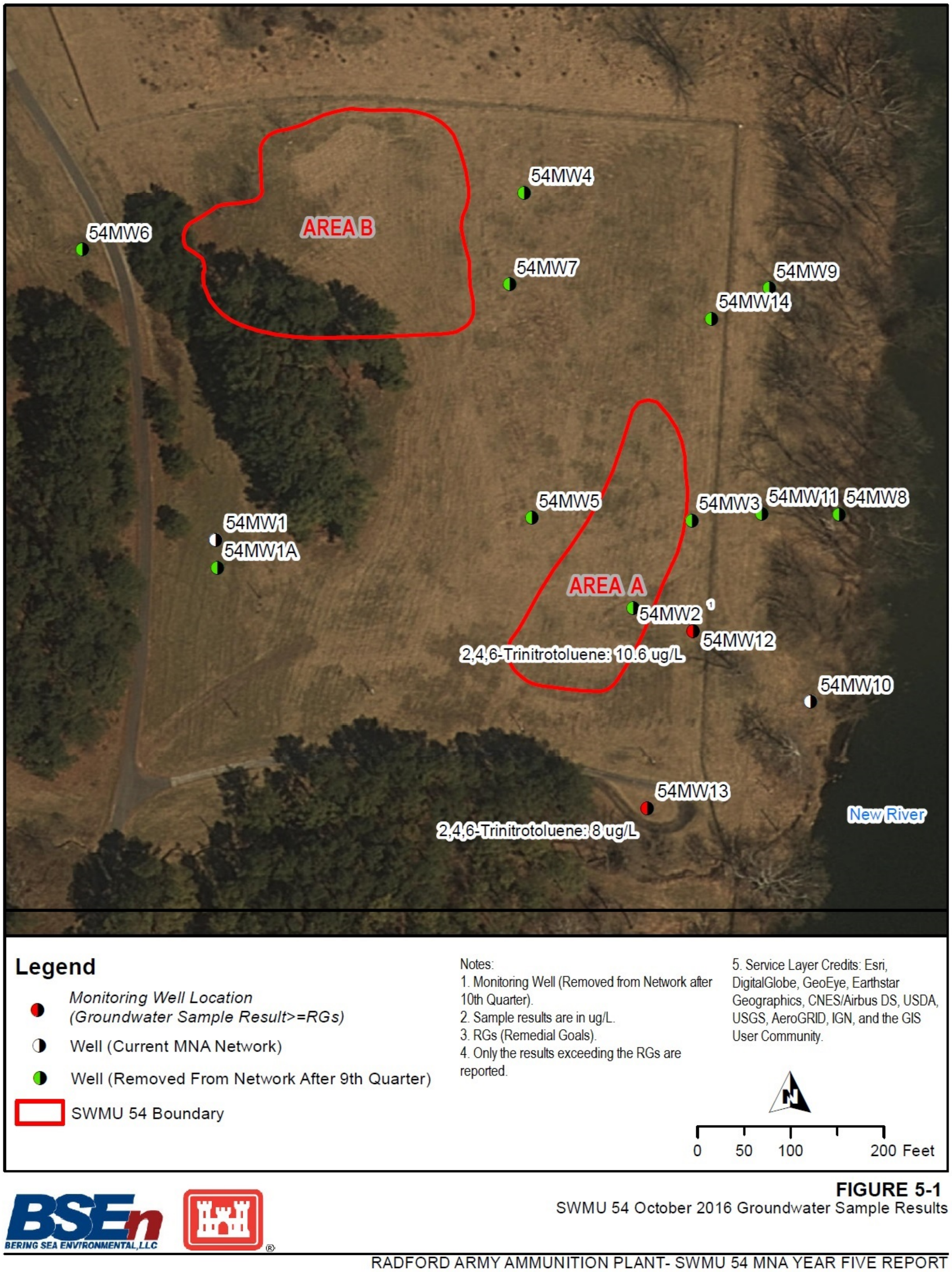
Figure 5-1 SWMU 54 October 2016 Groundwater Sample Results



Notes:
1. Monitoring Well (Removed from Network after 10th Quarter).
2. Sample results are in ug/L.
3. RGs (Remedial Goals).
4. Only the results exceeding the RGs are reported.
5. Service Layer Credits: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

FIGURE 5-1
SWMU 54 October 2016 Groundwater Sample Results

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5.3 Eighteenth Quarter Groundwater Results (January 2017)

Four (4) groundwater monitoring wells were sampled during the eighteenth quarterly monitoring event, including wells 54MW1, 54MW10, 54MW12, and 54MW13. A duplicate sample (54TM12) was collected from monitoring well 54MW12. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-3**, while the analytical results are presented in **Table 5-4**. Sample locations are provided in **Figure 4-1**.

Explosives

Four explosives were detected in groundwater samples including 2,4,6-TNT, 2ADNT, 4ADNT, and RDX. The explosive RDX was only detected at monitoring wells 54MW10 and 54MW12 while 2,4,6-TNT, 2ADNT, and 4ADNT were detected at monitoring wells 54MW10, 54MW12, and 54MW13. Only 2,4,6-TNT was qualified as an estimated value at monitoring well 54MW10. No explosives were detected in monitoring well 54MW1.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at an estimated concentration of 4.2 µg/L. At monitoring well 54MW12 2,4,6-TNT was detected at concentrations of 28.1 µg/L and 29.1 µg/L (field duplicate, 54TM12); and at monitoring well 54MW13 at a concentration of 5.9 µg/L. The concentration of 2,4,6-TNT at monitoring well 54MW12 exceeds the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW10 at a concentration of 1.6 µg/L; at monitoring well 54MW12 at concentrations of 5.2 µg/L and 5.3 µg/L (field duplicate, 54TM12); and at monitoring well 54MW13 at a concentration of 1.5 µg/L. An RG has not been established for 2ADNT.

The explosive 4ADNT was detected at monitoring well 54MW10 at a concentration of 1.3 µg/L; at monitoring well 54MW12 at concentrations of 2.7 µg/L and 2.8 µg/L (field duplicate, 54TM12); and at monitoring well 54MW13 at a concentration of 1 µg/L. An RG has not been established for 4ADNT.

RDX was detected at monitoring well 54MW10 at a concentration of 1.1 µg/L; and at monitoring well 54MW12 at concentrations of 4.8 µg/L and 5 µg/L (field duplicate, 54TM12). No concentration of RDX detected at monitoring wells 54MW10 or 54MW12 exceeds the RG of 6.1 µg/L.

The monitoring wells with detected concentrations of explosives are typically the same wells with hits recorded during previous sampling rounds. The monitoring well location (54MW12) where 2,4,6-TNT exceeds the RG is provided in **Figure 5-2**.

Perchlorate

Perchlorate was detected in three groundwater samples collected from monitoring wells 54MW10, 54MW12, and 54MW13. Perchlorate was detected at monitoring well 54MW10 at an estimated concentration of 0.1 µg/L; at monitoring well 54MW12 at a concentration of 2.9 µg/L; and at monitoring well 54MW13 at a concentration of 0.29 µg/L. All three detections are below the RG of 10.9 µg/L.

Miscellaneous Analytes

Groundwater samples were also analyzed for MNA indicators (TOC, TIC, dissolved ferrous iron, dissolved manganese, chlorate, chlorite, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed concentrations of TOC in the four monitoring wells ranged from an estimated low of 0.56 mg/L (54MW1) to an estimated high of 1.4 mg/L (54MW12), while the concentrations of TIC ranged from a low of 64.0 mg/L (54MW1) to a high of 110.0 mg/L (54MW13). Dissolved ferrous iron concentrations ranged from a low of 0.0 mg/L (non detect) (54MW1 and 54MW12) to a high of 0.04 mg/L (54MW10). Dissolved manganese concentrations ranged from a low of 0.036 mg/L (54MW1) to a high of 0.069 mg/L (54MW10). Chloride concentrations ranged from an estimated low of 3.1 mg/L (54MW1) to a high of 6.8 mg/L (54MW12). Detected concentrations of nitrate ranged from an estimated low of 0.38 mg/L (54MW10) to a high of 0.94 mg/L (54MW12). Sulfate concentrations ranged from a low of 31.0 mg/L (54MW1) to a high of 110.0 mg/L (54MW10). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-4** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-3 SWMU 54 Summary of Eighteenth Quarter Groundwater Samples

	RG	# of RG Exceedances	# of Detections	# of Samples[(1)]	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (µg/L)							
1,3-Dinitrobenzene	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**7.82**	2	4	5	4.2	29.1	54MW12
DNT Mixture	**0.932**	0	0	5	ND	ND	na
2,4-Dinitrotoluene	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**na**	na	0	5	ND	ND	na
2-Amino-4,6-dinitrotoluene	**na**	na	4	5	1.5	5.3	54MW12
2-Nitrotoluene	**na**	na	0	5	ND	ND	na
4-Amino-2,6-dinitrotoluene	**na**	na	4	5	1	2.8	54MW12
RDX	**6.1**	0	3	5	1.1	5	54MW12
DNX	**na**	na	0	5	ND	ND	na
MNX	**na**	na	0	5	ND	ND	na
TNX	**na**	na	0	5	ND	ND	na
Misc. (µg/L)							
Perchlorate	**10.9**	0	4	5	0.1	2.9	54MW12
Chlorate	**na**	na	0	5	ND	ND	na
Chlorite	**na**	na	0	5	ND	ND	na
Chloride	**na**	na	5	5	3.1	6.8	54MW12
Nitrate (as N)	**na**	na	4	5	0.38	0.94	54MW12
Sulfate	**na**	na	4	5	31	110.0	54MW10
Total Inorganic Carbon	**na**	na	4	5	88.0	110.0	54MW13
Total Organic Carbon	**na**	na	3	5	0.56	1.4	54MW12

Notes:
[1] One sample was a duplicate
na = not applicable
ND = non detect

Table 5-4 SWMU 54 Detected Analytes in Eighteenth Quarter Groundwater Samples

Sample ID			54MW1					54MW10					54MW12				
Date Collected			1/10/2017					1/09/2017					1/10/2017				
Analyte	Units	Remedial Goals $^{(1)}$	Result	Lab Q	Val Q	RL	MDL	Result	Lab Q	Val Q	RL	MDL	Result	Lab Q	Val Q	RL	MDL
Explosives																	
1,3-Dinitrobenzene	µg/L	na	0.10	U	U	0.2	0.8	0.099	U	U	0.2	0.079	0.1	U	U	0.2	0.081
2,4,6-Trinitrotoluene	µg/L	7.82	0.10	U	U	0.2	0.8	4.2		J	0.2	0.079	28.1			0.4	0.16
DNT Mixture	µg/L	0.932	0.20	U	U	0.2	0.8	0.198	U	U	0.2	0.8	0.2	U	U	0.2	0.081
2,4-Dinitrotoluene	µg/L	na	0.10	U	U	0.2	0.8	0.099	U	U	0.2	0.079	0.1	U	U	0.2	0.081
2,6-Dinitrotoluene	µg/L	na	0.10	U	U	0.2	0.8	0.099	U	U	0.2	0.079	0.1	U	U	0.2	0.081
2-Amino-4,6-dinitrotoluene	µg/L	na	0.10	U	U	0.2	0.8	1.6			0.2	0.079	5.2			0.2	0.081
2-Nitrotoluene	µg/L	na	0.10	U	U	0.2	0.8	0.099	U	U	0.2	0.079	0.1	U	U	0.2	0.081
4-Amino-2,6-dinitrotoluene	µg/L	na	0.10	U	U	0.2	0.8	1.3			0.2	0.079	2.7			0.2	0.081
RDX	µg/L	6.1	0.10	U	U	0.2	0.8	1.1			0.2	0.079	4.8			0.2	0.081
DNX	µg/L	na	0.10	U	U	0.2	0.8	0.099	U	U	0.2	0.079	0.1	U	U	0.2	0.081
MNX	µg/L	na	0.10	U	U	0.2	0.8	0.099	U	U	0.2	0.079	0.1	U	U	0.2	0.081
TNX	µg/L	na	0.10	U	U	0.2	0.8	0.099	U	U	0.2	0.079	0.1	U	U	0.2	0.081
Misc.																	
Perchlorate	µg/L	10.9	0.10	U	U	0.2	0.05	0.1	J	J	0.2	0.05	2.9			0.2	0.05
Chlorate	µg/L	na	10.0	U	U	10.0	1.3	10	U	U	10.0	1.3	10.0	U	U	10.0	1.3
Chlorite	µg/L	na	10.0	U	U	10.0	2.4	10	U	U	10.0	2.4	10.0	U	U	10.0	2.4
Chloride	mg/L	na	3.1	J	J	4.0	1.1	5.3	M	J	4.0	1.1	6.8			4.0	1.1
Nitrate (as N)	mg/L	na	0.15	U	U	0.40	0.08	0.38	JM	J	0.40	0.08	0.94			0.40	0.08
Sulfate	mg/L	na	31			5.0	1.3	110	MY		10.0	2.6	38			5.0	1.3
Total Inorganic Carbon	mg/L	na	64			3.0	0.50	88			3.0	0.50	96			3.0	0.50
Total Organic Carbon	mg/L	na	0.56	J	J	3.0	0.50	1.5	U	U	3.0	0.50	1.4	J	J	3.0	0.50
MNA																	
Dissolved Fe^{2}+	mg/L	na	0.0					0.4					0.0				
Dissolved Mn	mg/L	na	0.036					0.069					0.040				

Table 5-4 SWMU 54 Detected Analytes in Eighteenth Quarter Groundwater Samples (Continued)

Sample ID			54TM12 (Field Duplicate 54MW12)					54MW13				
Date Collected			**1/10/2017**					**1/09/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives												
1,3-Dinitrobenzene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	29.1			0.4	0.16	5.9			0.2	0.08
DNT Mixture	**µg/L**	**0.932**	0.2	U	U	0.2	0.08	0.2	U	U	0.2	0.08
2,4-Dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,6-Dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	5.3			0.2	0.08	1.5			0.2	0.08
2-Nitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	2.8			0.2	0.08	1			0.2	0.08
RDX	**µg/L**	**6.1**	5			0.2	0.08	0.1	U	U	0.2	0.08
DNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
MNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
TNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
Misc.												
Perchlorate	**µg/L**	**10.9**	2.9			0.2	0.05	0.29			0.2	0.05
Chlorate	**µg/L**	**na**	10.0	U	U	10.0	1.3	10.0	U	U	10.0	1.3
Chlorite	**µg/L**	**na**	10.0	U	U	10.0	2.4	10.0	U	U	10.0	2.4
Chloride	**mg/L**	**na**	6.8			4.0	1.1	5.6			4.0	1.1
Nitrate (as N)	**mg/L**	**na**	0.93			0.40	0.08	0.48			0.40	0.08
Sulfate	**mg/L**	**na**	39			5.0	1.3	42			5.0	1.3
Total Inorganic Carbon	**mg/L**	**na**	98			3.0	0.50	110			3.0	0.50
Total Organic Carbon	**mg/L**	**na**	1.4	J	J	3.0	0.50	1.5	U	U	3.0	0.50
MNA												
Dissolved Fe^{2+}	**mg/L**	**na**	0.0					0.03				
Dissolved Mn	**mg/L**	**na**	0.040					0.060				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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Figure 5-2 SWMU 54 January 2017 Groundwater Sample Results

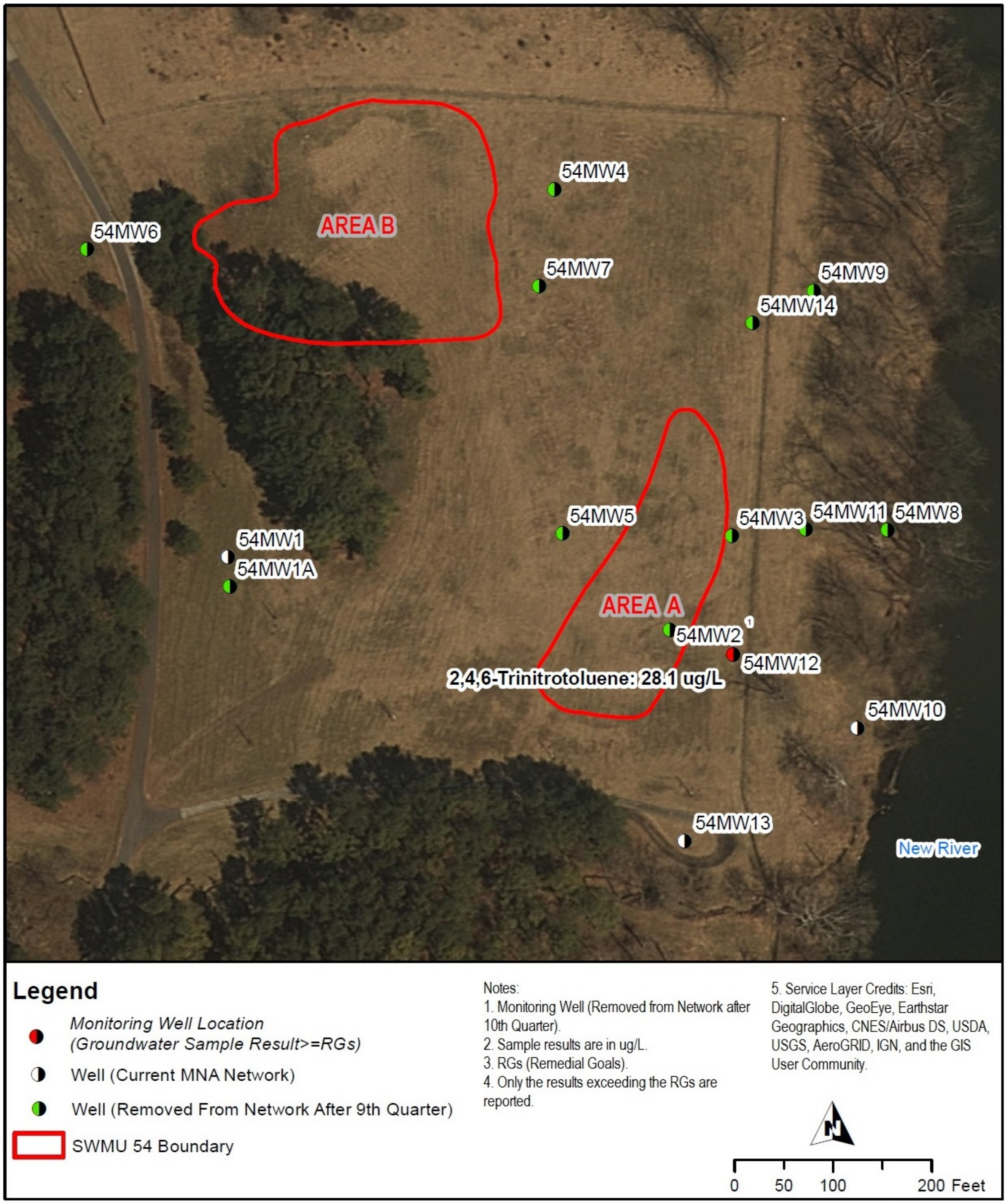

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FIGURE 5-2
SWMU 54 January 2017 Groundwater Sample Results

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5.4 Nineteenth Quarter Groundwater Results (April 2017)

Four (4) groundwater monitoring wells were sampled during the nineteenth quarterly monitoring event, including wells 54MW1, 54MW10, 54MW12, and 54MW13. A duplicate sample (54TM10) was collected from monitoring well 54MW10. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-5**, while the complete analytical results are presented in **Table 5-6**. Sample locations are provided in **Figure 4-1**.

Explosives

Four explosives were detected in groundwater samples including 2,4,6-TNT, 2ADNT, 4ADNT, and RDX. All four explosives were detected in monitoring wells 54MW12 and 54MW13. No explosives were detected in monitoring well 54MW1.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at concentrations of 1.0 µg/L and 1.1 µg/L (field duplicate, 54TM10); at monitoring well 54MW12 at a concentration of 78.6 µg/L; and at monitoring well 54MW13 at a concentration of 1.8 µg/L. Only the concentration of 2,4,6-TNT detected at monitoring well 54MW12 exceeds the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW10 at a concentration of 1.4 µg/L; at monitoring well 54MW12 at a concentration of 9.4 µg/L; and at monitoring well 54MW13 at a concentration of 0.65 µg/L. An RG has not been established for 2ADNT.

The explosive 4ADNT was detected at monitoring well 54MW10 at a concentration of 1.2 µg/L; at monitoring well 54MW12 at a concentration of 4.6 µg/L; and at monitoring well 54MW13 at a concentration of 0.48 µg/L. An RG has not been established for 4ADNT

RDX was detected at monitoring well 54MW12 at a concentration of 51.4 µg/L; and at monitoring well 54MW13 at a concentration of 1.0 µg/L. The concentration of RDX detected at monitoring well 54MW12 exceeds the RG of 6.1 µg/L.

The monitoring wells with detected concentrations of explosives are typically the same wells with hits recorded during previous sampling rounds. The monitoring well location (54MW12) where 2,4,6-TNT and RDX exceeds the RG is provided in **Figure 5-3**.

Perchlorate

Perchlorate was detected in three groundwater samples collected from monitoring wells 54MW10, 54MW12, and 54MW13. Perchlorate was detected at monitoring well 54MW10 at a concentration of 0.24 µg/L; at monitoring well 54MW12 at a concentration of 4.3 µg/L; and at monitoring well 54MW13 at a concentration of 0.23 µg/L. All three detections are below the RG of 10.9 µg/L.

Miscellaneous Analytes

Groundwater samples were also analyzed for MNA indicators (TOC, TIC, dissolved ferrous iron, dissolved manganese, chlorate, chlorite, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed TOC concentrations in the four monitoring wells ranged from a low of 3.3 mg/L (54MW1) to a high of 6.9 mg/L (54MW10), while the concentrations of TIC ranged from a low of 54.0 mg/L (54MW1) to a high of 77.0 mg/L (54MW12). Dissolved ferrous iron concentrations ranged from a low of 0.00 mg/L (54MW1) to a high of 0.14 mg/L (54MW13). Dissolved manganese concentrations ranged from a low of 0.036 mg/L (54MW12) to a high of 0.067 mg/L (54MW13). Chloride concentrations ranged from an estimated low of 2.7 mg/L (54MW1) to a high of 6.6 mg/L (54MW12). Detected concentrations of nitrate ranged from an estimated low of 0.29 mg/L (54TM10) to a high of 1 mg/L (54MW12). Sulfate concentrations ranged from a low of 30.0 mg/L (54MW13) to a high of 65.0 mg/L (54MW10). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-6** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-5 SWMU 54 Summary of Nineteenth Quarter Groundwater Samples

Analyte	Units	RG	# of RG Exceedances	# of Detections	# of Samples [(1)]	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives								
1,3-Dinitrobenzene	**µg/L**	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	1	4	5	1	78.6	54MW12
DNT Mixture*	**µg/L**	**0.932**	0	0	5	ND	ND	na
2,4-Dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	na	4	5	.65	9.4	54MW12
2-Nitrotoluene	**µg/L**	**na**	na	0	5	ND	ND	na
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	na	4	5	.48	4.6	54MW12
RDX	**µg/L**	**6.1**	1	2	5	1	51.4	54MW12
DNX	**µg/L**	**na**	na	0	5	ND	ND	na
MNX	**µg/L**	**na**	na	0	5	ND	ND	na
TNX	**µg/L**	**na**	na	0	5	ND	ND	na
Misc.								
Perchlorate	**µg/L**	**10.9**	0	4	5	.23	4.3	54MW12
Chlorate	**µg/L**	**na**	na	0	5	ND	ND	na
Chlorite	**µg/L**	**na**	na	0	5	ND	ND	na
Chloride	**mg/L**	**na**	na	5	5	2.7	6.6	54MW12
Nitrate (as N)	**mg/L**	**na**	na	4	5	0.29	1	54MW12
Sulfate	**mg/L**	**na**	na	5	5	30	65	54MW10
Total Inorganic Carbon	**mg/L**	**na**	na	5	5	54	77	54MW12
Total Organic Carbon	**mg/L**	**na**	na	5	5	3.3	6.9	54MW10

Notes:
[1] One sample was a duplicate
na = not applicable
ND = non detect

Table 5-6 SWMU 54 Detected Analytes in Nineteenth Quarter Groundwater Samples

Sample ID			**54MW1**					**54MW10**					**54TM10 (Field Duplicate 54MW10)**				
Date Collected			**4/11/2017**					**4/10/2017**					**4/10/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives																	
1,3-Dinitrobenzene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	0.1	U	U	0.2	0.08	1			0.2	0.08	1.1			0.2	0.08
DNT Mixture	**µg/L**	**0.932**	0.2	U	U	0.2	0.08	0.2	U	U	0.2	0.08	0.2	U	U	0.2	0.08
2,4-Dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,6-Dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	1.4			0.2	0.08	1.4			0.2	0.08
2-Nitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	0.1	U	U	0.2	0.08	1.2			0.2	0.08	1.2			0.2	0.08
RDX	**µg/L**	**6.1**	0.1	U	U	0.2	0.08	2	U	U	2	2	2	U	U	2	2
DNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
MNX	**µg/L**	**na**	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
TNX	**µg/L**	**na**	0.1	U	UJ	0.2	0.08	0.1	U	UJ	0.2	0.08	0.1	U	UJ	0.2	0.08
Misc.																	
Perchlorate	**µg/L**	**10.9**	0.1	U	U	0.2	0.050	0.24			0.2	0.050	0.24			0.2	0.050
Chlorate	**µg/L**	**na**	10	U	U	10	1.3	10	U	U	10	1.3	10	U	U	10	1.3
Chlorite	**µg/L**	**na**	10	U	U	10	2.4	10	U	U	10	2.4	10	U	U	10	2.4
Chloride	**mg/L**	**na**	2.7	J	J	4.0	1.1	6.4	M	J	4.0	1.1	6.3		J	4.0	1.1
Nitrate (as N)	**mg/L**	**na**	0.15	U	U	0.4	0.08	0.3	J	J	0.4	0.08	0.29	J	J	0.4	0.08
Sulfate	**mg/L**	**na**	33			5.0	1.3	65			5.0	1.3	65			5.0	1.3
Total Inorganic Carbon	**mg/L**	**na**	54			3.0	0.50	68			3.0	0.50	68			3.0	0.50
Total Organic Carbon	**mg/L**	**na**	3.3			3.0	0.50	6.9			3.0	0.50	5.5			3.0	0.50
MNA																	
Dissolved Fe^{2+}	**mg/L**	**na**	0.0					0.04					0.04				
Dissolved Mn	**mg/L**	**na**	0.049					0.039					0.039				

Table 5-6 SWMU 54 Detected Analytes in Nineteenth Quarter Groundwater Samples (Continued)

Sample ID			54MW12					54MW13				
Date Collected			4/11/2017					4/10/2017				
Analyte	Units	Remedial Goals (1)	Result	Lab Q	Val Q	RL	MDL	Result	Lab Q	Val Q	RL	MDL
Explosives												
1,3-Dinitrobenzene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,4,6-Trinitrotoluene	µg/L	**7.82**	78.6			2	0.8	1.8			0.2	0.08
DNT Mixture	µg/L	**0.932**	0.2	U	U	0.2	0.08	0.2	U	U	0.2	0.08
2,4-Dinitrotoluene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2,6-Dinitrotoluene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
2-Amino-4,6-dinitrotoluene	µg/L	na	9.4			0.2	0.08	0.65			0.2	0.08
2-Nitrotoluene	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
4-Amino-2,6-dinitrotoluene	µg/L	na	4.6			0.2	0.08	0.48			0.2	0.08
RDX	µg/L	**6.1**	51.4			2	0.8	1			0.2	0.08
DNX	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
MNX	µg/L	na	0.1	U	U	0.2	0.08	0.1	U	U	0.2	0.08
TNX	µg/L	na	0.1	U	UJ	0.2	0.08	0.1	U	UJ	0.2	0.08
Misc.												
Perchlorate	µg/L	**10.9**	4.3			0.2	0.050	0.23			0.2	0.050
Chlorate	µg/L	na	10	U	U	10	1.3	10	U	U	10	1.3
Chlorite	µg/L	na	10	U	U	10	2.4	10	U	U	10	2.4
Chloride	mg/L	na	6.6	M	M	4.0	1.1	4.3		J	4.0	1.1
Nitrate (as N)	mg/L	na	1	M	M	0.4	0.08	0.44			0.4	0.08
Sulfate	mg/L	na	47	M	M	5.0	1.3	30			5.0	1.3
Total Inorganic Carbon	mg/L	na	77			3.0	0.50	58			3.0	0.50
Total Organic Carbon	mg/L	na	6.7			3.0	0.50	4.4			3.0	0.50
MNA												
Dissolved Fe^{2+}	mg/L	na	0.02					0.14				
Dissolved Mn	mg/L	na	0.036					0.067				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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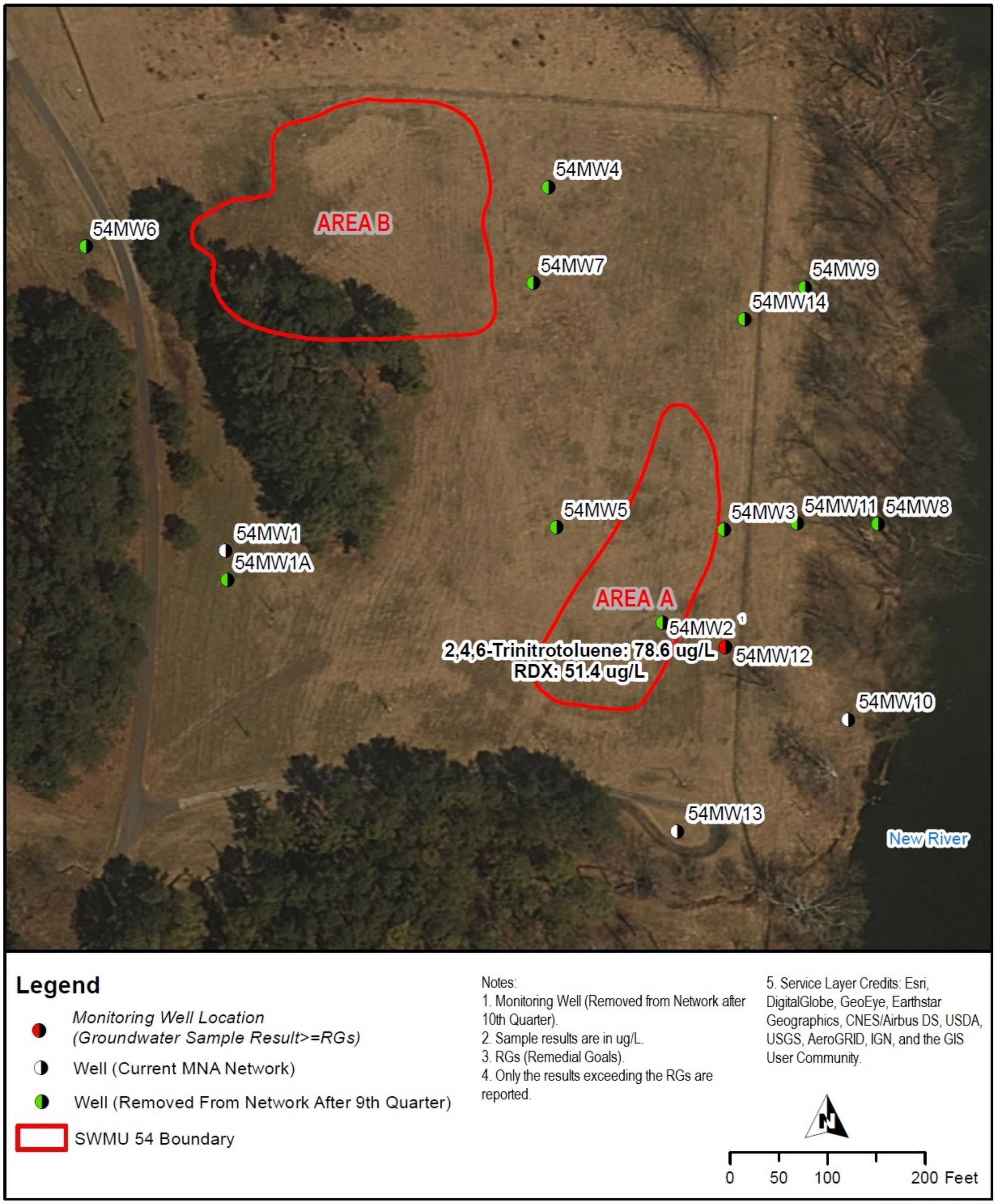
Figure 5-3 SWMU 54 April 2017 Groundwater Sample Results



Notes:
1. Monitoring Well (Removed from Network after 10th Quarter).
2. Sample results are in ug/L.
3. RGs (Remedial Goals).
4. Only the results exceeding the RGs are reported.
5. Service Layer Credits: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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FIGURE 5-3
SWMU 54 April 2017 Groundwater Sample Results

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5.5 Twentieth Quarter Groundwater Results (July 2017)

Four (4) groundwater monitoring wells were sampled during the twentieth quarterly monitoring event, including wells 54MW1, 54MW10, 54MW12, and 54MW13. A duplicate sample (54TM10) was collected from monitoring well 54MW10. Samples were submitted for explosives, perchlorate, RDX breakdown by-products (DNX, MNX and TNX), and MNA indicator parameter analyses. Detected constituents are summarized in **Table 5-7**, while the complete analytical results are presented in **Table 5-8**. Sample locations are provided in **Figure 4-1**.

Explosives

Four explosives were detected in groundwater samples including 2,4,6-TNT, 2ADNT, 4ADNT, and RDX. 2,4,6-TNT was detected in monitoring wells 54MW10, 54MW12, and 54MW13; 2ADNT was detected in monitoring wells 54MW12 and 54MW13; 4ADNT was detected in monitoring wells 54MW10 (field duplicate 54TM10) and 54MW13; and RDX was detected in monitoring well 54MW10. No explosives were detected in monitoring well 54MW1.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 at estimated concentrations of 0.44 µg/L and 4.5 µg/L (field duplicate, 54TM10); at monitoring well 54MW12 at a concentration of 8.7 µg/L; and at monitoring well 54MW13 at a concentration of 8.2 µg/L. The concentration of 2,4,6-TNT detected at monitoring wells 54MW12 and 54MW13 exceeds the RG of 7.82 µg/L.

The explosive 2ADNT was detected at monitoring well 54MW12 at a concentration of 4.4 µg/L; and at monitoring well 54MW13 at a concentration of 1.4 µg/L. An RG has not been established for 2ADNT.

The explosive 4ADNT was detected at monitoring well 54MW10 at a estimated concentration of 0.51 µg/L (field duplicate, 54TM10); and at monitoring well 54MW13 at a concentration of 1.1 µg/L. An RG has not been established for 4ADNT

RDX was detected at monitoring well 54MW10 at estimated concentrations of 0.76 µg/L and 5.5 µg/L (field duplicate, 54TM10). The concentrations of RDX detected at monitoring well 54MW10 did not exceed the RG of 6.1 µg/L.

The monitoring wells with detected concentrations of explosives are typically the same wells with hits recorded during previous sampling rounds. The monitoring well locations where 2,4,6-TNT (54MW12 and 54MW13) exceeds the RGs are provided in **Figure 5-4**.

Perchlorate

Perchlorate was detected in three groundwater samples collected from monitoring wells 54MW10, 54MW12, and 54MW13. Perchlorate was detected at monitoring well 54MW10 at estimated concentrations of 0.20 µg/L and 0.40 µg/L (field duplicate, 54TM10); at monitoring well 54MW12 at a concentration of 1.1 µg/L; and at monitoring well 54MW13 a concentration of 0.45 µg/L. All three detections are below the RG of 10.9 µg/L.

Miscellaneous Analytes

Groundwater samples were also analyzed for MNA indicators (TOC, TIC, dissolved ferrous iron, dissolved manganese, chlorate, chlorite, chloride, nitrate, and sulfate) for the purposes of evaluating the effectiveness of the MNA process.

Observed TOC concentrations in the four monitoring wells ranged from an estimated low of 0.71 mg/L (54MW1) to a high of 2.6 mg/L (54MW10), while the concentrations of TIC ranged from a low of 59.0 mg/L (54MW1) to a high of 75.0 mg/L (54MW13). Dissolved ferrous iron concentrations ranged from a low of 0.0 mg/L (non-detect) (54MW1) to a high of 0.08 mg/L (54MW13). Dissolved manganese concentrations ranged from a low of 0.031 mg/L (54MW1) to a high of 0.084 mg/L (54MW13). Chloride concentrations ranged from a low of 5 mg/L (54MW13) to an estimated high of 5.9 mg/L (54MW12). Detected concentrations of nitrate ranged from an estimated low of 0.1 mg/L (54MW10) to a high of 0.75 mg/L (54MW12). Sulfate concentrations ranged from a low of 28.0 mg/L (54MW1) to a high of 110.0 mg/L (54MW10). The MNA indicator parameters chlorate and chlorite went undetected during this quarterly monitoring event. **Table 5-8** presents the MNA indicator parameters sample results. A more detailed discussion of the MNA results is provided in **Section 6.0**.

Table 5-7 SWMU 54 Summary of Twentieth Quarter Groundwater Samples

	RG	# of RG Exceedances	# of Detections	# of Samples	Minimum Concentration	Maximum Concentration	Location of Maximum
Explosives (µg/L)							
1,3-Dinitrobenzene	**na**	na	0	5	ND	ND	na
2,4,6-Trinitrotoluene	**7.82**	2	4	5	0.44	8.7	54MW12
DNT Mixture*	**0.932**	na	0	5	ND	ND	na
2,4-Dinitrotoluene	**na**	na	0	5	ND	ND	na
2,6-Dinitrotoluene	**na**	na	0	5	ND	ND	na
2-Amino-4,6-dinitrotoluene	**na**	na	2	5	1.4	4.4	54MW12
2-Nitrotoluene	**na**	na	0	5	ND	ND	na
4-Amino-2,6-dinitrotoluene	**na**	na	2	5	0.51	1.1	54MW13
RDX	**6.1**	0	2	5	0.76	5.5	54MW10
DNX	**na**	na	0	5	ND	ND	na
MNX	**na**	na	0	5	ND	ND	na
TNX	**na**	na	0	5	ND	ND	na
Misc.							
Perchlorate	**10.9**	0	4	5	.20	1.1	54MW12
Chlorate	**na**	na	0	5	ND	ND	na
Chlorite	**na**	na	0	5	ND	ND	na
Chloride	**na**	na	2	5	5	5.9	54MW12
Nitrate (as N)	**na**	na	4	5	0.10	0.75	54MW12
Sulfate	**na**	na	5	5	28	110	54MW10
Total Inorganic Carbon	**na**	na	5	5	59	75	54MW13
Total Organic Carbon	**na**	na	5	5	0.71	2.6	54MW10

Notes:
na = not applicable
ND = no

Table 5-8 SWMU 54 Detected Analytes in Twentieth Quarter Groundwater Samples

Sample ID			**54MW1**					**54MW10**					**54TM10 (Field Duplicate 54MW10)**				
Date Collected			**7/10/2017**					**7/10/2017**					**7/10/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives																	
1,3-Dinitrobenzene	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.1	U	U	0.20	0.08	0.10	U	U	0.20	0.08
2,4,6-Trinitrotoluene	**µg/L**	**7.82**	0.10	U	U	0.20	0.08	0.44		J	0.20	0.08	4.5		J	0.20	0.08
DNT Mixture	**µg/L**	**0.932**	0.20	U	U	0.20	0.08	0.20	U	U	0.20	0.08	0.20	U	U	0.20	0.08
2,4-Dinitrotoluene	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
2,6-Dinitrotoluene	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
2-Amino-4,6-dinitrotoluene	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
2-Nitrotoluene	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
4-Amino-2,6-dinitrotoluene	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	UJ	0.20	0.08	0.51		J	0.20	0.08
RDX	**µg/L**	**6.1**	0.10	U	U	0.20	0.08	0.76		J	0.20	0.08	5.5		J	0.20	0.08
DNX	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
MNX	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
TNX	**µg/L**	**na**	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
Misc.																	
Perchlorate	**µg/L**	**10.9**	0.10	U	U	0.20	0.05	0.20		J	0.20	0.05	0.40		J	0.20	0.05
Chlorate	**µg/L**	**na**	10	U	U	10	5.9	10	U	U	10	5.9	10	U	U	10	5.9
Chlorite	**µg/L**	**na**	10	U	U	10	4.0	10	U	U	10	4.0	10	U	U	10	4.0
Chloride	**mg/L**	**na**	4.6		U	4.0	1.1	8.9		UJ	4.0	1.1	5.6		UJ	4.0	1.1
Nitrate (as N)	**mg/L**	**na**	0.15	U	U	0.40	0.08	0.10	J	J	0.40	0.08	0.21	J	J	0.40	0.08
Sulfate	**mg/L**	**na**	28			5.0	1.3	110		J	25	6.5	62		J	25	6.5
Total Inorganic Carbon	**mg/L**	**na**	59			3.0	0.5	73			3.0	0.5	70			3.0	0.5
Total Organic Carbon	**mg/L**	**na**	0.71	J	J	3.0	0.5	2.6	J	J	3.0	0.5	2.2	J	J	3.0	0.5
MNA																	
Dissolved Fe^{2+}	**mg/L**	**na**	0.0					0.05					0.05				
Dissolved Mn	**mg/L**	**na**	0.031					0.060					0.060				

Table 5-8 SWMU 54 Detected Analytes in Twentieth Quarter Groundwater Samples (Continued)

Sample ID			**54MW12**					**54MW13**				
Date Collected			**7/11/2017**					**7/11/2017**				
Analyte	**Units**	**Remedial Goals (1)**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**	**Result**	**Lab Q**	**Val Q**	**RL**	**MDL**
Explosives												
1,3-Dinitrobenzene	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
2,4,6-Trinitrotoluene	**µg/L**	7.82	8.7			0.20	0.08	8.2			0.20	0.08
DNT Mixture	**µg/L**	0.932	0.20	U	U	0.20	0.08	0.20	U	U	0.20	0.08
2,4-Dinitrotoluene	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
2,6-Dinitrotoluene	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
2-Amino-4,6-dinitrotoluene	**µg/L**	na	4.4			0.20	0.08	1.4			0.20	0.08
2-Nitrotoluene	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
4-Amino-2,6-dinitrotoluene	**µg/L**	na	0.10	U	U	1.8	1.8	1.1			0.20	0.08
RDX	**µg/L**	6.1	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
DNX	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
MNX	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
TNX	**µg/L**	na	0.10	U	U	0.20	0.08	0.10	U	U	0.20	0.08
Misc.												
Perchlorate	**µg/L**	10.9	1.1			0.20	0.05	0.45			0.20	0.05
Chlorate	**µg/L**	na	10	U	U	10	4.2	10	U	U	10	4.2
Chlorite	**µg/L**	na	10	U	U	10	4.9	10	U	U	10	4.9
Chloride	**mg/L**	na	5.9	M	J	4.0	1.1	5			4.0	1.1
Nitrate (as N)	**mg/L**	na	0.75			0.40	0.08	0.56			0.40	0.08
Sulfate	**mg/L**	na	32	M	M	5.0	1.3	32			5.0	1.3
Total Inorganic Carbon	**mg/L**	na	68			3.0	0.50	75			3.0	0.50
Total Organic Carbon	**mg/L**	na	1.5	J	J	3.0	0.50	1.9	J	J	3.0	0.50
MNA												
Dissolved Fe^{2+}	**mg/L**	na	0.07					0.08				
Dissolved Mn	**mg/L**	na	0.073					0.084				

Notes:
(1) Remedial Goals developed in SWMU 54 RFI/CMS Report, Final Document (URS, 2008). Exceedances denoted by bold font.
µg/L = micrograms per liter (parts per billion)
mg/L = milligrams per liter (parts per million)
MDL = Method Detection Limit
na = not applicable; remedial goal not established for analyte at SWMU 54
ND = non detect
RL = Reporting Limit
Lab Q = Lab Data Qualifiers
Val Q = Validation Data Qualifiers

Date Qualifiers:
B = Analyte detected in associated Method Blank.
J = Estimated value.
M = Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits.
P = Concentration of analyte differs more than 40% between primary and confirmation analysis.
U = Analyte concentration was not above the detection level.
Y = Replicate/Duplicate precision outside acceptance limits.

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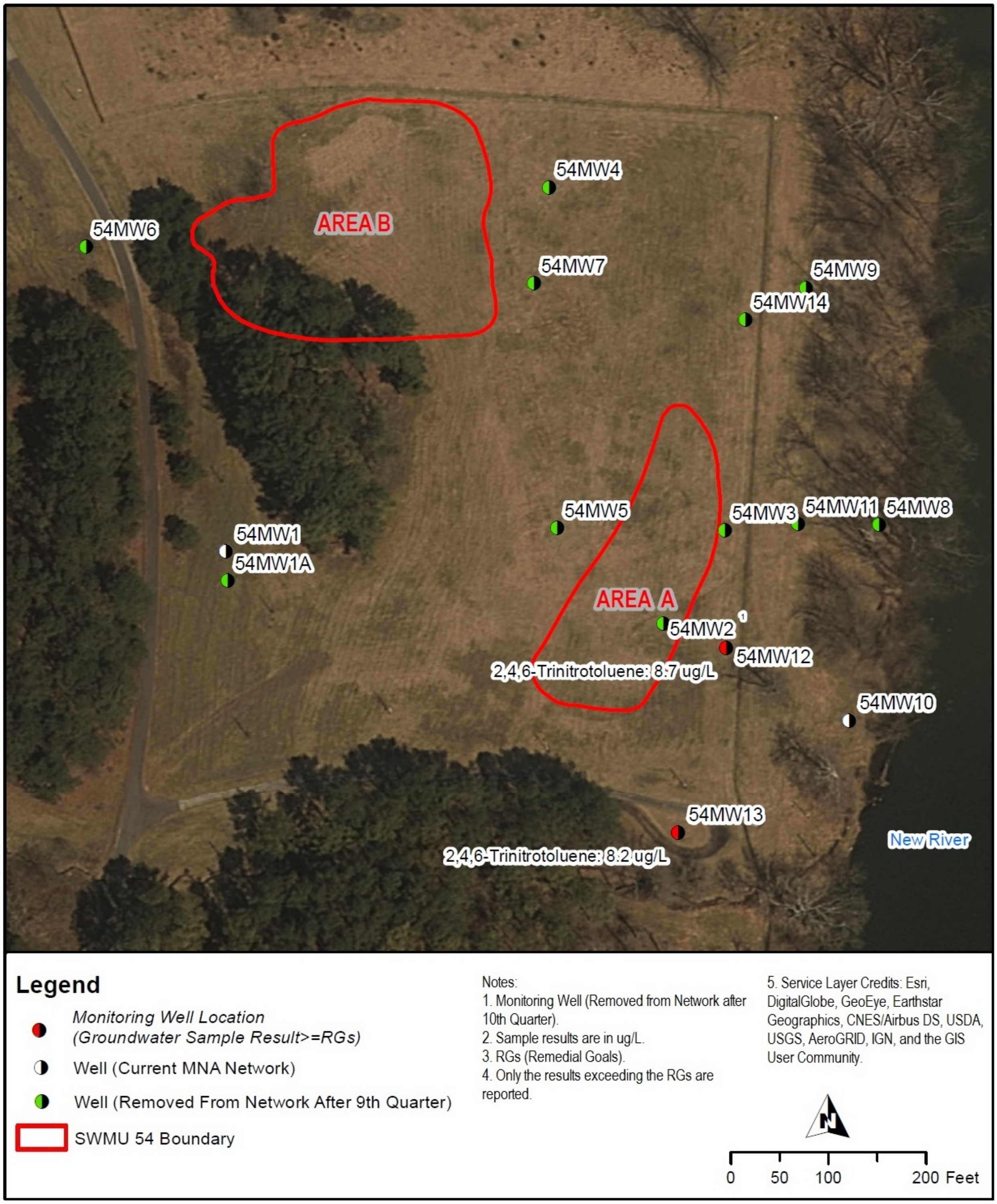
Figure 5-4 SWMU 54 July 2017 Groundwater Sample Results



Notes:
1. Monitoring Well (Removed from Network after 10th Quarter).
2. Sample results are in ug/L.
3. RGs (Remedial Goals).
4. Only the results exceeding the RGs are reported.

5. Service Layer Credits: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

FIGURE 5-4
SWMU 54 July 2017 Groundwater Sample Results

RADFORD ARMY AMMUNITION PLANT- SWMU 54 MNA YEAR FIVE REPORT

5.6 Year One Through Year Five Sample Results

Samples collected during the first two years were analyzed for explosives, perchlorate, and MNA indicators. The Year 2 MNA Report (CB&I, 2013) recommended elimination of the wells with no COI exceedances for the first two years, based on criteria established in the MNA work plan. The ninth quarter of sampling occurred prior to regulatory approval of the MNA report, and the original parameters were included in that sampling event. After approval of the Year 2 report, the sampling plan was modified to include RDX MNA indicators in the analytical suite, and reduce the sampling program from 14 monitoring wells to three wells with COI exceedances (54MW10, 12, and 13), and an upgradient well (54MW1) to monitor background conditions.

Multiple wells were removed from the monitoring network after the ninth and tenth quarters and were not sampled during the third, fourth, and fifth years. Monitoring wells that were included in these yearly events included 54MW1, 54MW10, 54MW12, and 54MW13, which monitor Area A at SWMU 54. This section discusses the results from the first five years (twenty quarters) of MNA sampling at these wells. The fifth year sampling included the analyses of explosives, perchlorate, RDX, RDX breakdown by-products (DNX, MNX and TNX), MNA indicator parameters, and water quality parameters.

5.6.1 Groundwater

<u>Explosives</u>

Samples from the four monitoring wells within SWMU 54 were analyzed for explosives for twenty quarters of sampling. During the year three sampling round (quarters 10 through 12), thirteen explosives were detected in the samples including DNX, MNX, and TNX. The limit of quantitation (LOQ) for all explosives during quarters 10 through 12 was 0.2 µg/L. The number of explosives detected during the fourth year of sampling was was reduced to five compounds. The explosives included 2,4,6-TNT, 2ADNT, 4ADNT, RDX, and the RDX breakdown by-product DNX. The limit of detection (LOD) during quarters 13 through 15 for 2,4,6-TNT, 2ADNT, 4ADNT, and RDX was 0.3 µg/L. The LOQ during quarters 13 through 15 for 2,4,6-TNT was 1.0 µg/L and 0.5 µg/L for 2ADNT, 4ADNT, and RDX. The LOD of RDX breakdown products of DNX, MNX, and TNX during quarters 13 and 14 was 0.2 µg/L, 0.1 µg/L, and 0.2 µg/L, respectively. The LOQ of RDX breakdown products of DNX, MNX, and TNX during quarters 13 and 14 was 0.4 µg/L , 0.2 µg/L , and 0.4 µg/L, respectively. During quarter 15, the LOD and LOQ for all RDX breakdown products decreased to 0.1 µg/L and 0.2 µg/L, respectively. During the fifth year of sampling the number of detected analytes was reduced once more to four compounds including 2,4,6-TNT, 2ADNT, 4ADNT, and RDX. The LOD and LOQ for 2,4,6-TNT, 2ADNT, 4ADNT, RDX, and RDX breakdown products during quarters 17 through 20 was 0.1 µg/L and 0.2 µg/L, respectively.

The explosive 2,4,6-TNT was detected at concentrations above the RGs at monitoring wells 54MW12 and 54MW13 while RDX was detected above the RGs only at monitoring well 54MW12. The explosive 2,4,6-TNT was detected above the RG at monitoring well 54MW12 during all four quarters (17-20) and at monitoring well 54MW13 during two sampling quarters (17 and 20) while RDX was detected above the RG only during the nineteenth quarter at monitoring well 54MW12. **Figures 5-5** through **5-8** depict time line series plots of concentrations at these sampling locations throughout the twenty quarters of sampling.

The explosive 2,4,6-TNT was detected at monitoring well 54MW10 above the RG during the tenth, eleventh, twelfth, and again during the sixteenth quarterly monitoring events (See **Figure 5-6**). Monitoring well 54MW12 has had detectable concentrations of 2,4,6-TNT above the RG during all sampling events, with the exception of quarters six, seven, and sixteen. Quarters eight and fourteen recorded the highest concentrations of 2,4,6-TNT at 108 µg/L and 110 µg/L, respectively (See **Figure 5-7**). 2,4,6-TNT concentrations at 54MW13 have typically been below the RG with the exception of the fifth, tenth, sixteenth, seventeenth, and twentieth quarters of sampling where it exceeds the RG. The detected concentration in the sixteenth quarter was the highest value recorded to date at this monitoring well (**Figure 5-8**).

Concentrations of RDX exceeds the RG in monitoring well 54MW10 during the fifth, tenth, twelfth, and sixteenth quarters. Monitoring well 54MW12 had detectable concentrations of RDX above the RG during seven of the first twelve quarters of sampling, and only one detection above the RG during year four (fourteenth quarter) and year five (nineteenth quarter) of sampling. It would appear that elevated concentrations of RDX at 54MW12 are cyclic with periods of lower concentrations in between. Historically, monitoring well 54MW13 has not had a detection of RDX above the RG through the first sixteen quarters of sampling; this trend continued during the year five monitoring event. Further, when compared to historic concentrations, the year five RDX concentrations appear to decrease.

DNX was detected once during the year four monitoring event. Monitoring well 54MW12 had an estimated concentration of 0.72 µg/L, which was fairly consistent with previous detections. The only other detections of DNX at 54MW12 occurred during the tenth and twelfth quarters, when the breakdown by-product was also detected at monitoring wells 54MW10 and 54MW13. The concentrations of these compounds were low (less than 1 µg/L), but generally mirrored the RDX concentrations in the wells. Detection of the RDX daughter products in these wells with elevated RDX concentrations suggests degradation and natural attenuation of RDX is a viable, ongoing remedial process at the site. During the year five monitoring event, DNX was not detected during any of the four sampling quarters.

Many of the intermediate and end-products of RDX degradation are relatively short-lived in the environment, and accumulation of these would not be expected. Studies on the fate and transport of explosives in the environment state that the nitroso intermediates of RDX (DNX, MNX, and TNX) have rarely been observed in the field at the few sites where analyses have been conducted for them (Brannon and Pennington, 2002). Many of these intermediates are observed only transiently due to their susceptibility to rapid mineralization, typically persisting only on the scale of several hours to several days. Significant observations of the final end-products are also not expected. Hydrazines, dimethylhydrazines, and methanol are not likely to accumulate in the environment, particularly at the low concentrations they would be produced as end-products, because these compounds biodegrade very rapidly. Therefore, the observation of intermediate and end-products of RDX biodegradation (DNX, MNX, and TNX), even at low concentrations, would be considered strong presumptive evidence of active and ongoing degradation processes.

The 2,4,6-TNT degradation intermediaries 2ADNT and 4ADNT have been detected with regularity at monitoring wells 54MW10, 54MW12, and 54MW13; the exceptions being the fourteenth quarter when 4ADNT went undetected in monitoring wells 54MW12 and 54MW13 and the twentieth quarter when 4ADNT went undetected in monitoring well 54MW10.

Analysis of the historic and recent data for monitoring wells 54MW10, 54MW12, and 54MW13 shows a correlation in 2,4,6-TNT concentration spikes with increasing concentrations of both 2ADNT and 4ADNT, indicating a limited transformation process from 2,4,6-TNT (**Figures 5-10** through **5-12**, respectively). 2,4,6-TNT degradation leading to amino-DNTs is likely occurring at localized zones within the soil matrix where the conditions are more favorable.

Perchlorate

Site-wide perchlorate concentrations have typically been steady and below the RG with the exception of the concentrations detected at 54MW12 during the fourth and eighth quarters. These spikes were reported as correlating with peaks in 2,4,6-TNT concentration. During the fourth and fifth years of monitoring, monitoring well 54MW12 continued to exhibit the highest concentrations, with the exception of the sixteenth quarter when the greatest values were detected at monitoring well 54MW10.

A summary of these results are provided in Table 6-1.

5.7 Lab Analysis, Data Validation, and Reporting

The RFAAP, VA LTM Year 5 sampling effort was collected, quarterly, in October 2016, January 2017, April 2017 and July 2017. Groundwater samples were collected in accordance with the Quality Assurance Project Plan (QAPP), revised August 2015. Documentation pertaining to COC and sample condition was filed in field and laboratory records. Table 5-9 summarizes the samples and analyses of the RFAAP, VA LTM Year 5 sampling effort.

Table 5-9 Summary of Samples and Analyses

Sampling Event ID	Data Packages	Matrix	Chloride Nitrate Sulfate pH	Explosives	Metals	TOC TIC COD	Chlorate Chlorite Perchlorates
October 2016	122845 122887 122907 122926	GW	X	X	X	X	X
January 2017	124700 124730 124775 124799 124825	GW	X	X	X	X	X
April 2017	126485 126533 126534 126555 126611	GW	X	X	X	X	X
July 2017	128820 128867 128923 128935	GW	X	X	X	X	X

Notes:
COD = chemical oxygen demand
TIC = total inorganic carbon
TOC = total organic carbon

Analytical methods are shown in **Table 5-10**.

Table 5-10 Analytical Methods

Analysis	Analytes	Method
Anions	Chloride Nitrate Sulfate	USEPA SW-846 Method 9056A
pH	pH	USEPA SW-846 Method 9040
Explosives	Numerous	USEPA SW-846 Method 8330B
Metals	Numerous	USEPA SW-846 Method 6010C USEPA SW-846 Method 7470A (Mercury)
TOC / TIC	TIC TOC	USEPA SW-846 Method 9060A
COD	COD	USEPA SW-846 Method 410.4
Chlorate / Chlorite	Chlorate Chlorite	USEPA SW-846 Method 300.1
Perchlorates	Perchlorates	USEPA SW-846 Method 6850

The samples were placed into coolers with ice at the time of collection. The COC forms were completed as the samples were packaged into coolers for transport. Trip blanks, temperature blanks, and ice were added as required. All coolers were shipped to the main laboratory, CT Laboratories in Baraboo, Wisconsin; this lab then repacked samples as necessary and shipped to the subcontractor labs (SGS Accutest in Orlando, Florida; Microbac Laboratories in Marietta, Ohio; Summit Environmental Technologies in Cuyahoga Falls, Ohio; and Eurofins/Eaton Analytical in South Bend, Indiana).

The analytic data was reviewed for consistency with the test methods as noted in **Table 5-10** and the Project QAPP (RFAAP, VA – LTM) to ensure that the data set met project data quality objectives and was usable for the purposes of the project. Validation was performed following the National Functional Guidelines for Inorganic Superfund Data Review (USEPA, August 2014); National Functional Guidelines for Superfund Organic Methods Data Review (August 2014); and professional judgment. Any anomalies to the requirements for precision, accuracy, representativeness, completeness, comparability, and sensitivity are discussed below and the data were flagged where appropriate.

Application of Data Flags

General data quality flagging conventions in **Table 5-11** were used to indicate quality control anomalies. Data was flagged, where appropriate, in accordance with the National Functional Guidelines and the project QAPP. A data quality summary is provided below.

Table 5-11: Data Qualifiers

Qualifier	Description
R	Rejected: The result is rejected due to deficiencies in the analytical system or the inability to meet QC criteria.
M	Matrix effect: The concentration is estimated due to a matrix effect.
J	Estimated: The analyte was positively identified, but the quantitation is an estimate due to discrepancies in meeting certain analyte-specific QC criteria.
J+	Estimated: The analyte was positively identified, but the quantitation is an estimate, possibly biased high, due to discrepancies in meeting certain analyte-specific QC criteria.
J-	Estimated: The analyte was positively identified, but the quantitation is an estimate, possibly biased low, due to discrepancies in meeting certain analyte-specific QC criteria.
B	Blank. The analyte was detected in an associated blank.
U	Undetected: The analyte was analyzed for but not detected.
UJ	The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific QC criteria.

Preservation, Temperature, and Hold Time

All sample preservation requirements were met.

Most sample analyses were within holding time, with these exceptions:

- Nitrate/Nitrogen analysis on the October 2016 samples was not performed within 48 hours of collection and sample results were qualified estimated (J).

One sample was analyzed for pH in the October 2016 event. The holding time for pH analysis is considered a field test parameter and should be analyzed immediately. Any analysis performed at a laboratory is considered outside of method criteria; therefore, analysis is considered estimated (J).

5.7.1 Precision

Precision was measured from the relative percent difference (RPD) between the parent sample/field duplicate (FD), laboratory duplicates, laboratory control sample (LCS), and the matrix spike and matrix spike duplicate (MS/MSD) pairs.

Field Duplicates

FDs were collected at a frequency of 10% of field samples. Most RPDs were within control limits. **Table 5-12** lists FD exceedances.

Table 5-12 Field Duplicate Precision Exceedances

Sample	Analyte	Flag	54MW10	54TM10	RPD (actual)	RPD
(Oct 2016) 54MW13	3,5-Dinitroaniline	J	0.43 ug/L	0.59 ug/L	31.4%	>20%
(Jan 2017)	No exceedances					
(Apr 2017) 54MW10	1,3,5-Trinitrobenzene	J	0.33 ug/L	0.41 ug/L	22%	>20%
(Jul 2017) 54MW10	HMX RDX 2,4,6-Trinitrotoluene Chloride Nitrate as N Sulfate Perchlorate	J	0.35 ug/L 0.76 ug/L 0.44 ug/L 8.9 mg/L 0.10 mg/L 110 mg/L 0.20 ug/L	1.8 ug/L 5.5 ug/L 4.5 ug/L 5.6 mg/L 0.21 mg/L 62 mg/L 0.40 ug/L	135% 151% 164% 46% 71% 56% 67%	>20%
(Jul 2017) 54MW10	4-Amino-2,6-dinitrotoluene 1,3,5-Trinitrobenzene	UJ	0.10U ug/L 0.10U ug/L	0.51 ug/L 0.79 ug/L	134% 155%	>20%

Notes:
J = estimated
UJ = non-detected estimated
HMX = High melting explosive
RDX = cyclotrimethylenetrinitramine

The positive results for all the above mentioned samples were qualified as estimated (J) or non-detected estimated (UJ) due to high relative percent differences (RPDs) in the evaluation of the field duplicate pairs. The direction of the bias cannot be determined from this nonconformance. The results can be used for project objectives as estimated values which may have a minor impact on the data usability.

Laboratory Duplicates

Laboratory duplicate analysis was performed at a frequency of 10% of laboratory samples, for inorganic analyses. All RPDs were within control limits. **Table 5-13** lists laboratory duplicate exceedances.

Table 5-13 Laboratory Duplicate Precision Exceedances

Sample/Method	Analyte	Flag	RPD
None			

Matrix Spike/Matrix Spike Duplicate RPD

MS/MSD analyses were run at a frequency of 5% of field samples. All results were within control limits. **Table 5-14** lists matrix spike/matrix spike duplicate RPD exceedances.

Table 5-14 MS/MSD RPD Exceedances

Sample/Method	Analyte	Flag	RPD
None			

5.7.2 Accuracy

Accuracy was measured from laboratory QC sample percent recoveries including LCS, MS, MSD, and surrogates. Accuracy was also evaluated by determining whether any deviations to method or laboratory requirements for internal standard (IS), initial calibration verification (ICV), and continuing calibration verification (CCV) recoveries were noted in the case narrative(s).

Laboratory Control Sample/Matrix Spike/Matrix Spike Duplicate Recovery

One LCS was analyzed for each batch of 20 samples or fewer.

Most recoveries were within control limits. **Table 5-15** lists the LCS recovery exceedances.

Table 5-15 LCS Recovery Exceedances

Method	Analyte	Flag	Qualified Samples
Oct 2016	No exceedances		
Jan 2017	No exceedances		
(Apr 2017) Explosives	TNX	UJ	54MW1 54MW10 54MW12 54MW13
Jul 2017	No exceedances		

Notes:
UJ = non-detected estimated
TNX = hexhydro-1,3,5-trinitroso- 1,3,5-triazine

MS/MSD analysis was performed at a frequency of 5% of field samples.

Most recoveries were within control limits. **Table 5-16** presents MS/MSD recoveries outside control limits. The data for the parent sample was flagged as indicated on the table. If no flag was indicated, the data were not flagged. Data was not flagged in cases where the parent sample concentration was greater than four times the spike concentration.

Only parent samples were qualified.

Table 5-16 MS/MSD Recovery Exceedances

Sample ID	Analyte	Recovery	Parent Flag
(Oct 2016) 54MW12	Chloride	High	J
(Jan 2017) 54MW10	Chloride Nitrate as N	Low	J J
(Jan 2017) 54MW10	HMX 2,4,6-Trinitrotoluene	Low	J J
(Apr 2017) 54MW10	Chloride	Low	J
(Apr 2017) 54MW13	Chloride	Low	J
(Jul 2017) 54MW12	Chloride	Low	J
(Jul 2017) 54MW12	HMX	High	J

Notes:
J = estimated
HMX = High melting explosive

The chloride and HMX results may be biased high due to high MS/MSD percent recoveries. The chloride, nitrate as N, HMX, and 2,4,6-Trinitrotoluene results may be biased low due to low MS/MSD percent recoveries. The results can be used for project objectives as estimated values (J) which may have a minor impact on the data usability. Non-detected results that are biased high may indicate that the results might not actually be non-detected.

Surrogates

All surrogate recoveries were within control limits. **Table 5-17** presents surrogates that exceeded acceptance criteria.

Table 5-17 Surrogate Recovery Exceedances

Method	Sample ID	Surrogate	Recovery	Qualifiers
None				

Internal Standards

There were no internal standards outside control limits.

Calibration Verification

Some calibration results were outside control limits. **Table 5-18** summarizes calibration exceedances.

Table 5-18 Calibration Exceedances

Sampling Event	Analysis	Analytes	Result	Samples	Qualifiers
Oct 2016	No exceedances				
Jan 2017	No exceedances				
Jul 2017	Explosives	Nitroglycerin	ICV high	54MW1 54MW10 54MW12 54MW13	UJ
Apr 2017	Explosives	PETN	ICV high	54MW1 54MW10 54MW12 54MW13	UJ
	Explosives	PETN	CCV high	54MW1 54MW10 54MW12 54MW13	UJ

Notes:
UJ = non-detected estimated
HMX =
PETN = Pentaerythritol tetranitrate

5.7.3 Representativeness

The data deliverables were consistent with the site conditions of the work plan. Samples were collected from locations specified in the approved work plan.

5.7.4 Comparability

Comparability was acceptable. Standard analytical methods were used. Standard preparatory and analytical methods were applied to the samples across sampling events. In all cases, the detection limitss and limits of detection attained were below the specified limits of quantitation (LOQs). All target compounds detected below the LOQs flagged (J) by the laboratory, should be considered estimated.

5.7.5 Completeness

Completeness was measured as the number of usable results versus the total number of results. The data set was 100% complete with no omissions or rejections with respect to analysis. The information fulfilled the data quality objectives of this investigation.

5.7.6 Sensitivity

Sensitivity was measured by evaluating whether the LODs and LOQs were less than the regulatory criteria. All LODs and LOQs were below the regulatory criteria.

Additionally, sensitivity was evaluated by determining whether method blank, trip blank, and rinsate blank results were less than the LOQ. Some analytes were detected in some blanks, leading to qualification of sample results, which is discussed in the Blanks section below.

Blanks (Calibration [Instrument], Method, Trip and Rinsate)

Calibration blanks were analyzed throughout analytical runs.

One method blank (MB) was analyzed with every batch of twenty samples or fewer for each matrix.

One rinsate blank was analyzed for each sample date.

Table 5-19 presents samples flagged for blank results. Sample results greater than two times the blank concentration were not qualified. Data quality and usability were not affected.

Table 5-19 Blank Flags

Sample Event	Type of Blank	Method	Analyte	Samples Qualified	Flag
Oct 2016	No exceedances				
Jan 2017	No exceedances				
Apr 2017	No exceedances				
Jul 2017	Rinsate	Anions	Chloride	54MW1 54MW10	U U

Notes:
U = non-detected

The chloride results in samples 54MW1 and 54MW10 might be biased high as a result of contamination detected in the rinsate blank. These potentially bised high chloride results are not thought to have any significant impact to the overall conclusions regarding MNA conclusions.

Reporting Limits

Reporting limits, before adjustments for dilutions, were below the regulatory criteria noted in the project QAPP.

Summary

In summary, all data was considered usable with the qualifications discussed above. No data were rejected and the completeness goals for the project were met. The data was considered of good quality for the project goals.

This Data Quality Assessment was prepared by: Katia Kiarashpoor, LDC, Inc.

Figure 5-5 SWMU 54: 54MW1 Explosives Concentrations Q1 through Q20

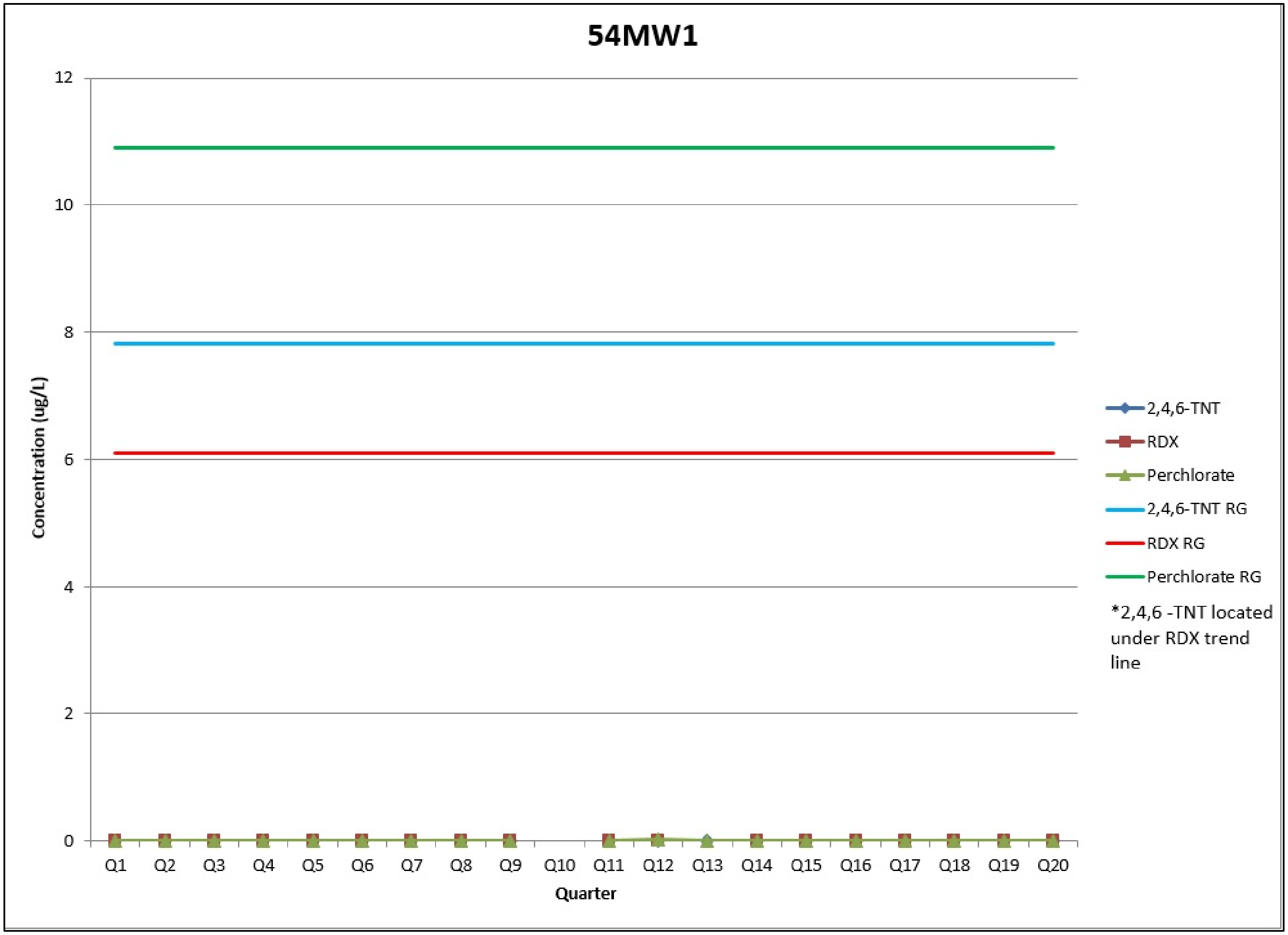


Figure 5-6 SWMU 54: 54MW10 Explosives Concentrations Q1 through Q20

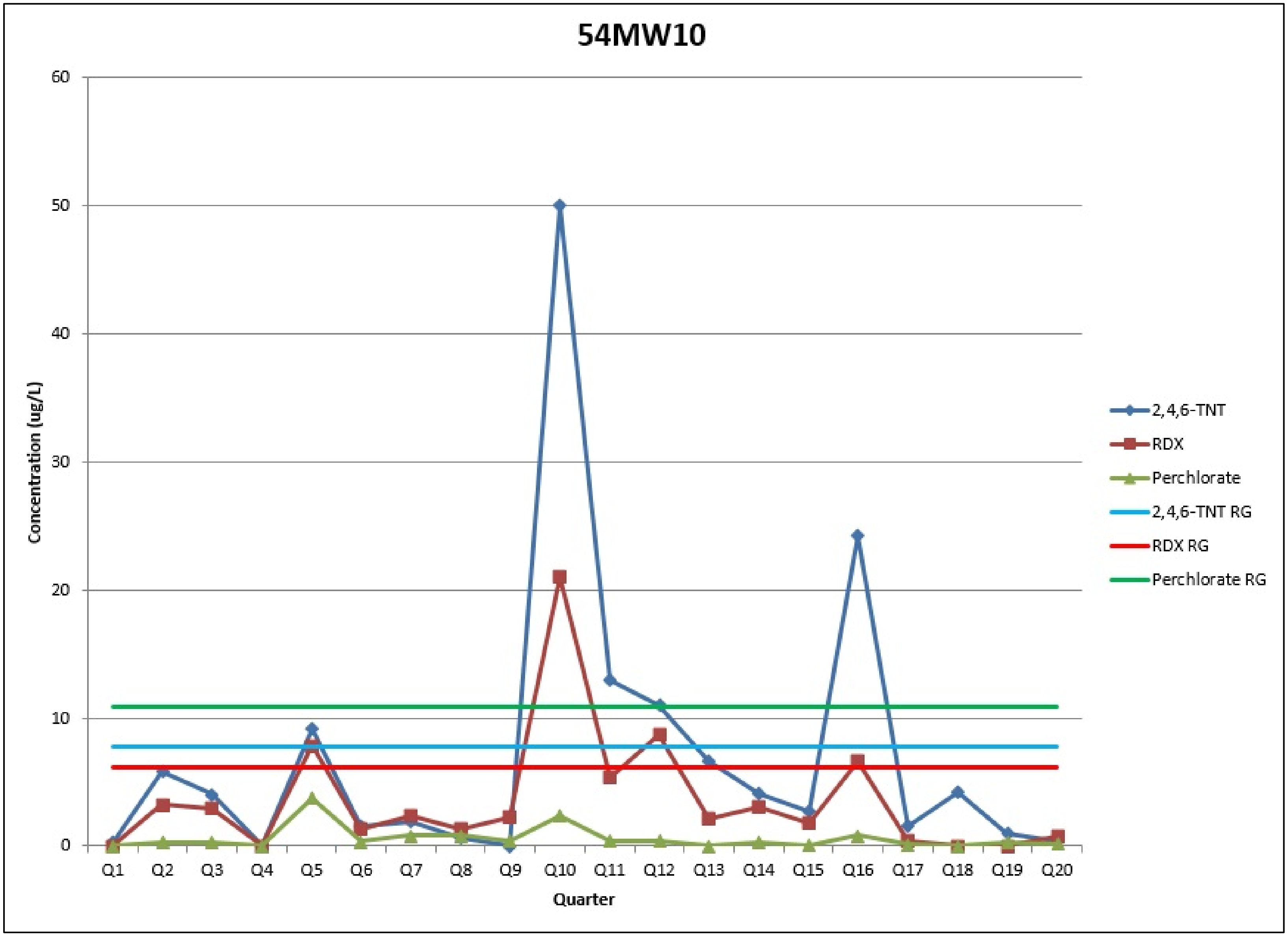


Figure 5-7 SWMU54: 54MW12 Explosives Concentrations Q1 through Q20

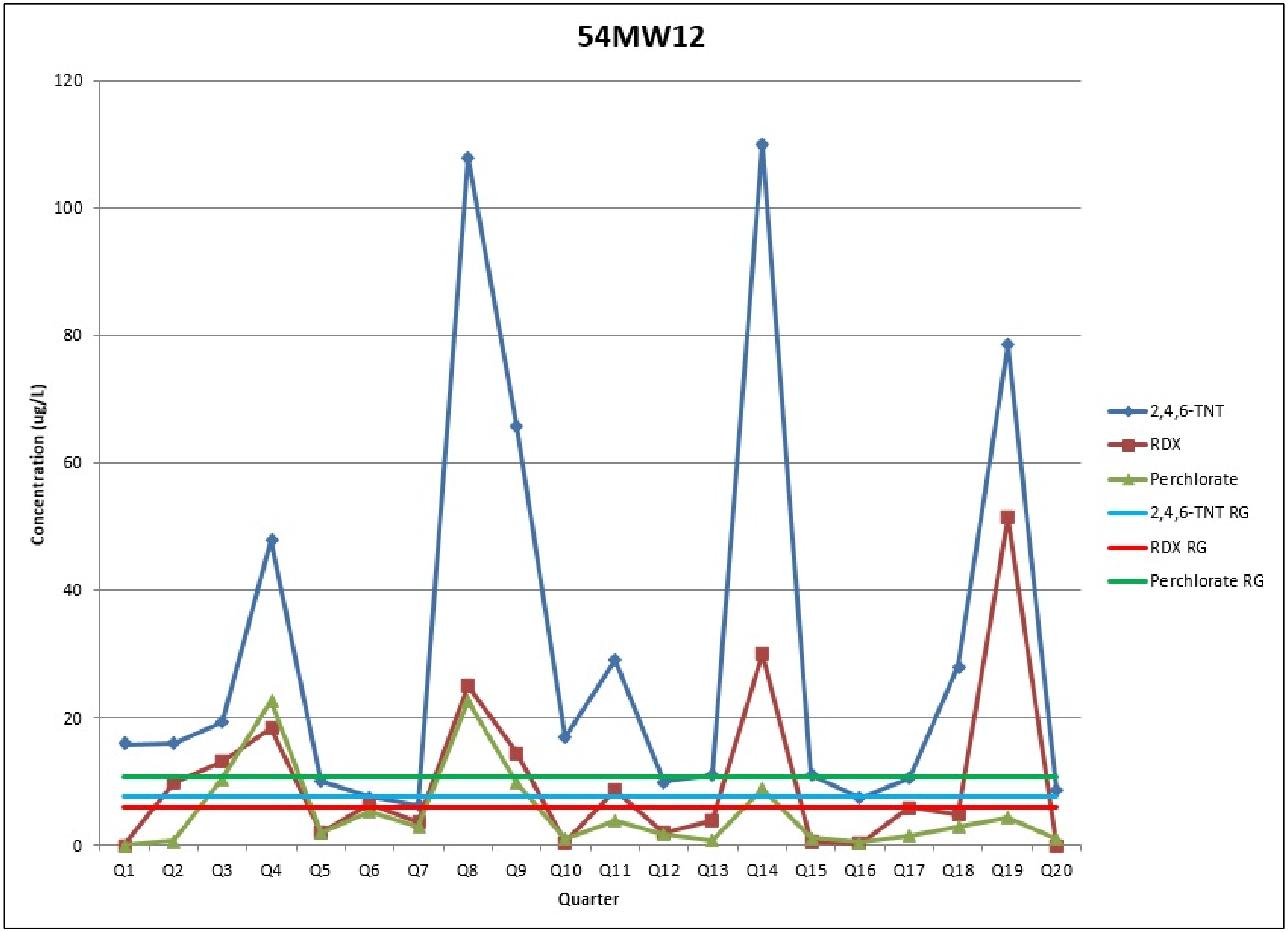


Figure 5-8 SWMU 54: 54MW13. Explosives Concentrations Q1 through Q20

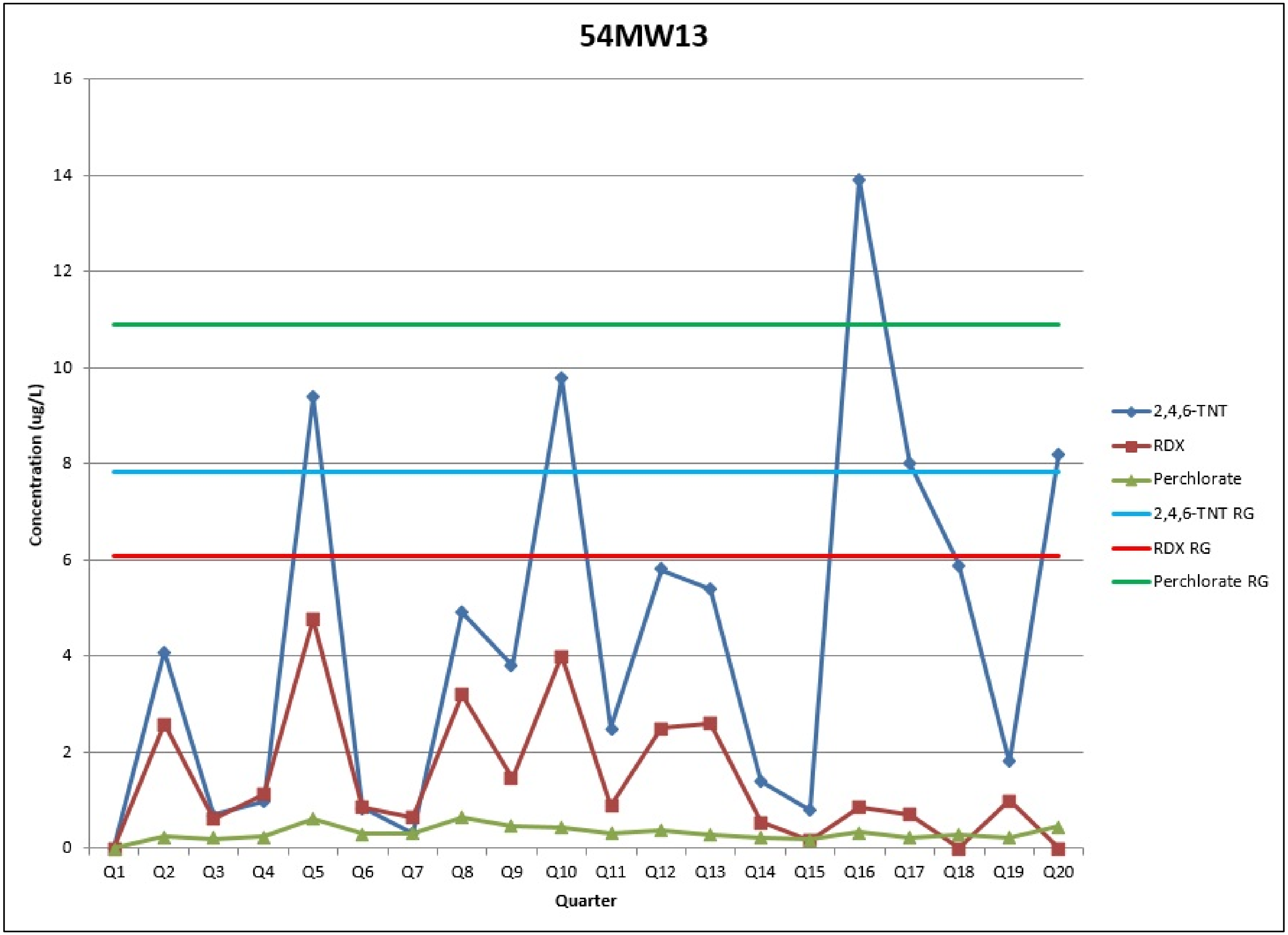


Figure 5-9 SWMU 54: 54MW1 2,4,6-TNT to Amino-DNT Correlation

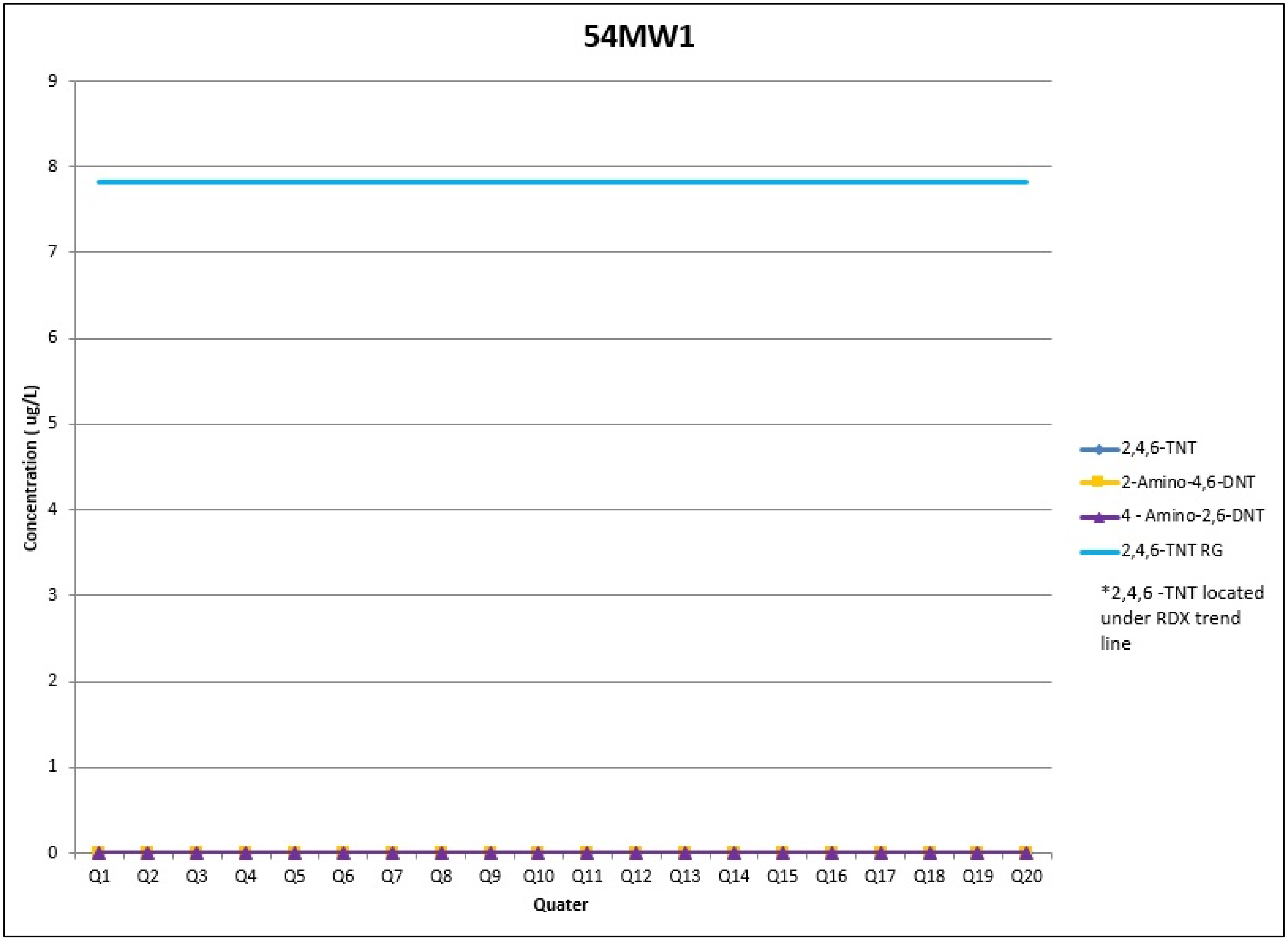


Figure 5-10 SWMU 54: 54MW10 2,4,6-TNT to Amino-DNT Correlation

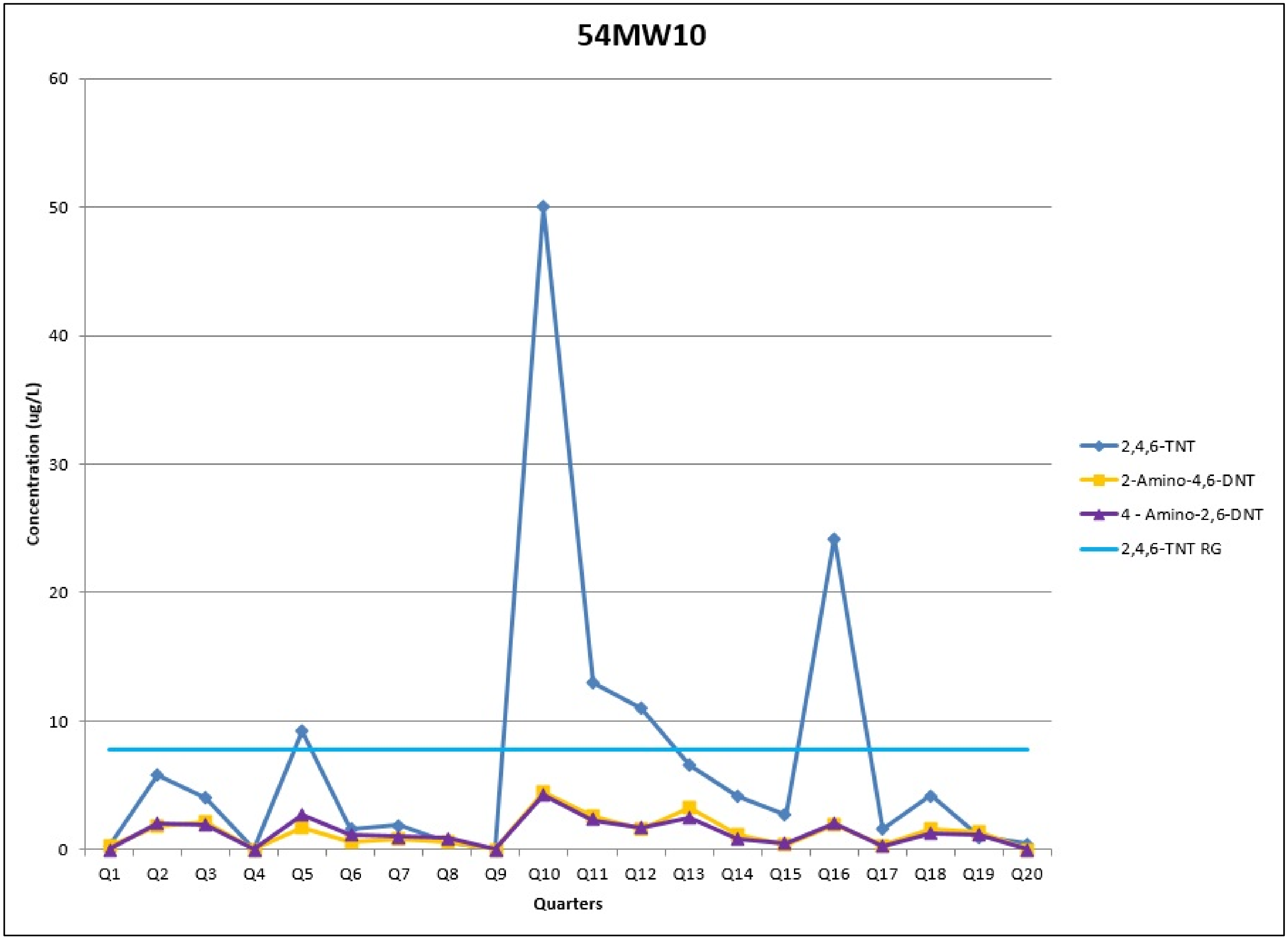


Figure 5-11 SWMU 54: 54MW12 2,4,6-TNT to Amino-DNT Correlation

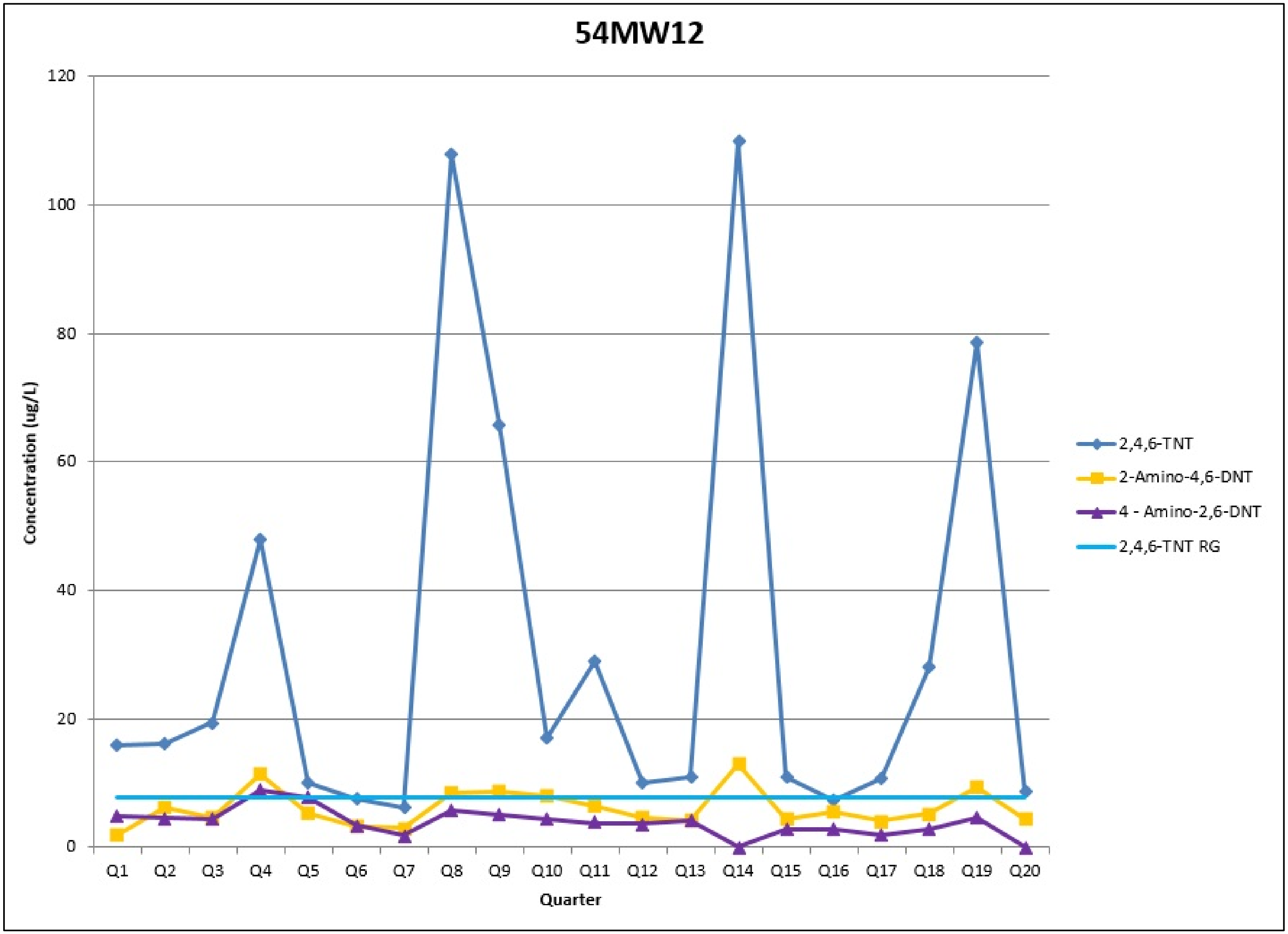
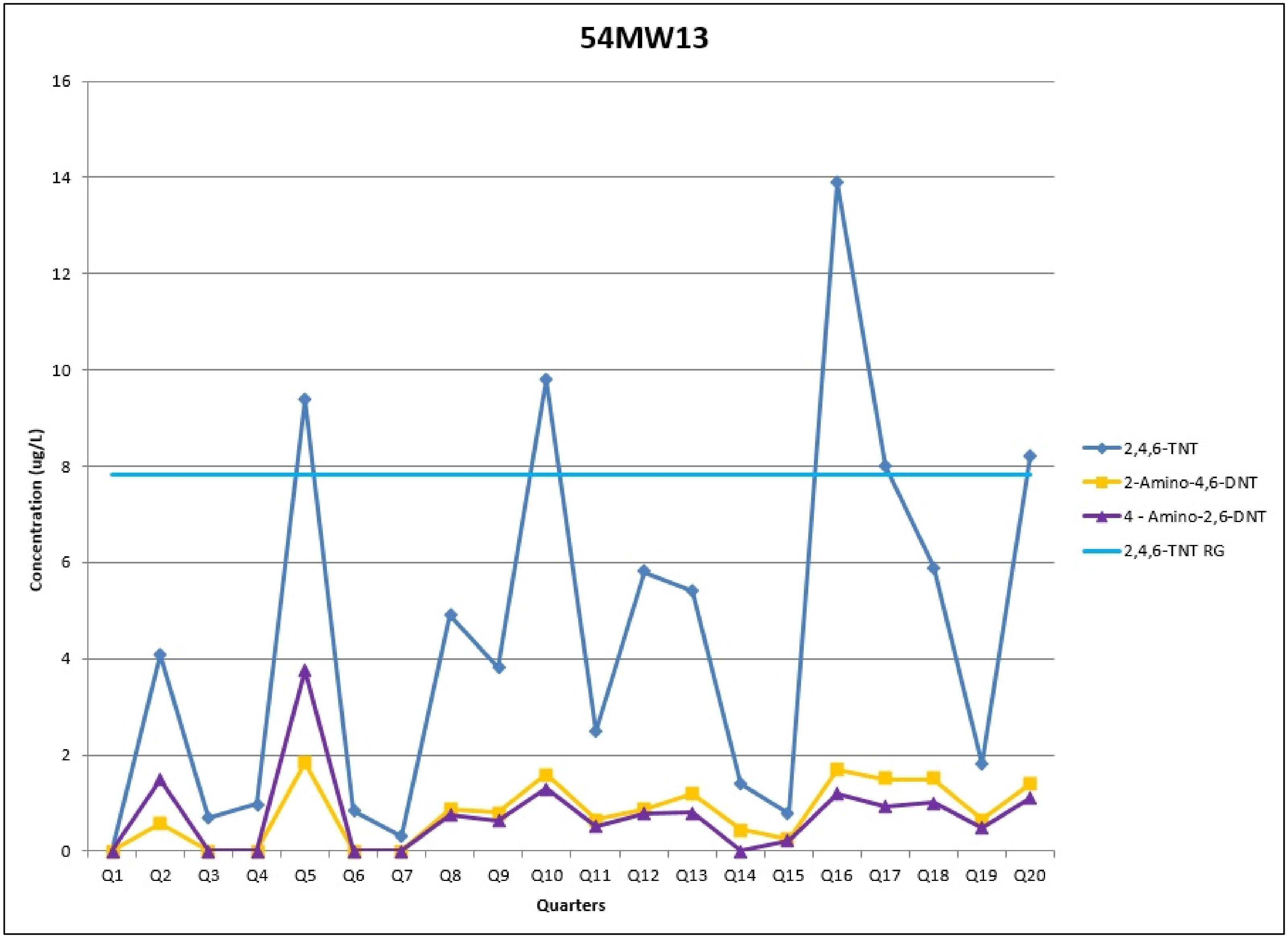


Figure 5-12 SWMU 54: 54MW13 2,4,6-TNT to Amino-DNT Correlation



6.0 MNA Evaluation of SWMU 54

MNA is a remedial approach in which physical, chemical, and biological processes occur under favorable conditions, without human interferences to reduce the mass, toxicity, volume, concentration, and mobility of contaminants in soil and groundwater. The physical, chemical, and biological processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization (USEPA, 1998). Analytical results from multiple groundwater sampling events at SWMU 54 were evaluated for qualitative indications of natural attenuation processes that may reduce the concentrations of nitroaromatics (specifically 2,4,6-TNT and RDX) and perchlorate (ClO4). The following sections present the results as they pertain to the lines of evidence used to demonstrate the potential for MNA.

6.1 First Line of Evidence: Occurrence of Contaminants

The first line of evidence consists of evaluating contaminant and daughter product concentrations for a downward trend in monitoring wells over time. SWMU 54 contains 14 wells (54MW1, 54MW2, 54MW3, 54MW4, 54MW5, 54MW6, 54MW7, 54MW8, 54MW9, 54MW10, 54MW11, 54MW12, 54MW13, and 54MW14), which targeted areas of potential nitroaromatic and perchlorate contamination. The target wells were reduced after the ninth and tenth quarters to 54MW1 (background), 54MW10, 54MW12, and 54MW13. Historical trends and the results of quarterly groundwater sampling are discussed below, and the data is provided in **Table 6-1**.

2,4,6-TNT. 2,4,6-TNT was detected above the RG of 7.82 µg/L in wells 54MW12 and 54MW13 during the year five monitoring period. Eight detections, including field duplicates, at these wells exceed the RG, including five at 54MW12 (quarters 17 through 20), and three at 54MW13 (quarters 17 and 20).

2,4,6-TNT concentrations have fluctuated in ground monitoring wells 54MW10, 54MW12, and 54MW13 during the twenty quarterly monitoring events. At monitoring well 54MW10, the 2,4,6-TNT concentration went from undetected in quarter nine to the highest concentration recorded (50 µg/L in quarter 10) in this well during the five years of monitoring. The following five quarters of sampling (quarters 11 – 15) saw concentrations decline dramatically until a spike was observed during the sixteenth quarter. The concentration spike of 24.2 µg/L at 54MW10 exceeds the RG. During the last four quarters of sampling, concentrations declined dramatically, reaching a low of 0.44 µg/L during the twentieth quarter. Monitoring well 54MW12 experienced the third highest detected concentration of 2,4,6-TNT during the year five monitoring period when a concentration of 78.6 µg/L was detected during the nineteenth quarter. Otherwise, the concentrations detected in 54MW12 in the remaining quarters were similar to historic concentrations. Similarly, monitoring well 54MW13 experienced the three highest detections of 2,4,6-TNT during the year five monitoring period when two detections (8 µg/L and 8.5 µg/L [field duplicate, 54TM13]) were observed during the seventeenth quarter, and one detection (8.2

µg/L) was observed during the twentieth quarter. As previously stated, the concentrations detected in 54MW13 in the remaining quarters were similar to historic concentrations.

DNT Mixture. Previous reports noted that DNT was detected in the fourth, tenth, eleventh and twelfth quarters of sampling at monitoring wells 54MW10, 54MW12 and 54MW13, yet the combined concentrations of 2,4- DNT and 2,6-DNT did not exceed the RG of 0.932 µg/L. During year five, neither 2,4-DNT nor 2,6-DNT were detected in any wells. Therefore, the combined concentrations of 2,4-DNT and 2,6-DNT do not exceed the RG in any of the four wells sampled.

RDX. RDX was detected above the RG of 6.1 µg/L only once in one monitoring well (54MW12) during the year five monitoring period. RDX concentrations have fluctuated in monitoring wells 54MW10 and 54MW12 during the previous sixteen quarterly sampling events. At monitoring well 54MW10, a sharp increase in RDX concentrations was observed from 2.23 µg/L in the ninth quarter to 21 µg/L in the tenth quarter. The tenth quarter concentration was the highest concentration reported in this well during the twenty quarters of sampling. Concentrations decreased during the next ten quarters of sampling (quarters 11 through 20) in 54MW10; however, during the twelfth and sixteenth quarters, RDX concentrations exceeded the RG. Monitoring well 54MW12 had eight reported concentrations of RDX above the RG of 6.1 µg/L in the first sixteen quarters of sampling. During the year five monitoring period, concentrations continued to remain below the RG, with the exception of the nineteenth quarter, when concentrations spiked to 51.4 µg/L. This concentration is the highest concentration observed at this well during all twenty quarters of sampling. However, in the twentieth quarter, the concentration fell below the detection limit of 0.1 µg/L.

No RDX breakdown by-products (DNX, MNX, or TNX) were detected during the year five monitoring period. Historically, RDX breakdown by-products have been observed in monitoring wells 54MW10, 54MW12 and 54MW13. These detections were observed in quarters ten through twelve. The highest total concentrations were observed in monitoring well 54MW10 during the tenth quarter when a spike in the RDX occurred. Thereafter, the RDX by-products concentrations steadily decreased. Similar correlations with RDX concentrations were observed in monitoring well 54MW12 and 54MW13. The highest concentrations of DNX, MNX and TNX were identified in 54MW12 and 54MW13 during the eleventh and tenth quarters, respectively, which coincides with the highest RDX concentrations recorded in these wells during that time period. There was no DNX, MNX, or TNX detected in well 54MW12 during the nineteenth quarter, when the spike of RNX was observed.

Amino DNT. As 2,4,6-TNT is biologically degraded, the two daughter products 2ADNT and 4ADNT are formed. During the year five monitoring period, the by-product 2ADNT was detected in monitoring wells 54MW10, 54MW12, and 54MW13 during all four quarters (quarters 17 – 20), with the exception of 54MW10 during the twentieth quarter. This is generally in agreement with the earlier quarterly monitoring results. During the five year monitoring period, the by-product 4ADNT was detected in all three monitoring wells with the exception of

54MW10 (detected in the field duplicate sample 54TM10 but not in the parent sample) and 54MW12 during the twentieth quarter. There is good correlation of 2ADNT and 4ADNT concentrations with 2,4,6-TNT concentrations; that is, as 2,4,6-TNT concentrations increase or decrease, a corresponding increase or decrease of 2ADNT and 4ADNT is observed. The presence of 2ADNT and 4ADNT along with the decreasing concentrations of 2,4,6-TNT continue to suggest biological degradation of 2,4,6-TNT is occurring at these locations.

Perchlorate. Perchlorate concentrations at monitoring wells 54MW10 and 54MW13 continued to remain well below the RG of 10.9 µg/L during year five of monitoring, and consistent with concentrations observed through the first four years of monitoring. Monitoring well 54MW12 continued to have the highest observed concentrations of perchlorate at SWMU 54 during year five of monitoring, but at concentrations below the RG. Concentrations decreased during the year four monitoring event; and this trend first was observed after the ninth quarterly sample event. However, one exception was observed during the fourteenth quarter when the concentration spiked to 8.85 µg/L. The fifteenth and sixteenth quarters saw a return to lower concentrations and a decreasing trend in perchlorate concentrations. During the year five monitoring, concentrations steadily rose through quarters seventeen to nineteen from 1.6 µg/L to 4.3 µg/L, though none of the concentrations are above the RG. The twentieth quarter saw a return to a lower concentration of 1.1 µg/L. Historically, monitoring well 54MW12 has had two detected concentrations above the RG: the first in the fourth quarter sampling event and again in the eighth quarter.

Chloride, chlorate, and chlorite are daughter products of perchlorate degradation. At SWMU 54, chloride is present within the groundwater system, including monitoring well 54MW1 (background). Based on the chloride background concentrations through year three of monitoring, a determination that any measureable change exists due to perchlorate reduction could not be established. However, while chloride was detected at monitoring well 54MW1 during all of the year four monitoring events, the concentrations detected at wells 54MW10, 54MW12, and 54MW13 during the same period were all slightly higher than the concentrations in 54MW1. During the year five monitoring event, chloride was detected at monitoring well 54MW1 during quarters seventeen through nineteen but was not detected during quarter twenty. The concentrations detected at wells 54MW10, 54MW12, and 54MW13 from quarter seventeen through quarter nineteen were all slightly higher than the concentrations in 54MW1. During quarter twenty of the monitoring event, chloride was not detected in 54MW10, but it was detected in monitoring wells 54MW12 and 54MW13 at concentrations similar to previous sampling quarters. Chlorate and chlorite were not detected during the year five monitoring period. This may suggest that chlorate and chlorite have been exhausted in the system and only residual amounts of chloride are being produced as perchlorate concentrations diminish.

The time series plots (**Figures 5-7** and **5-8**) show a large degree of variability in 2,4,6-TNT concentrations in wells 54MW12 and 54MW13. As such, Mann-Kendall tests were run for both monitoring wells. The results indicated no trend in either 54MW12 or 54MW13. While the 2,4,6-

TNT concentrations have shown variability over time, the first line of evidence indicates that the presence of daughter products, 2ADNT and 4ADNT, suggest that natural attenuation via biological degradation of 2,4,6-TNT is occurring at SWMU 54. Overall decreasing trends in RDX and perchlorate suggest natural attenuation of RDX and perchlorate is occurring.

The contaminant concentrations for 2,4,6-TNT, RDX, and perchlorate for the three impacted wells were plotted together to assess a possible correlation between the spike timing among the three wells; none was apparent. However, there were correlations in all three wells with regard to 2,4,6-TNT, RDX, and perchlorate spikes in that spikes in a given contaminant generally included spikes in the other two contaminants in each well. Contaminant concentrations for 2,4,6-TNT, RDX, and perchlorate were plotted against groundwater elevation to determine if the large spike seen in monitoring wells 54MW10, 54MW12, and 54MW13 may be related to water level changes. **Figures 6-1**, **6-2**, and **6-3** demonstrate there is no correlation between the contaminant concentrations at all three wells and groundwater elevation. However, at monitoring well 54MW10, when groundwater elevation rises, contaminant concentrations appear to decrease and when groundwater elevation rises at monitoring well 54MW12, so do contaminant concentrations. However, at monitoring well 54MW13, contaminant concentrations rise and fall with no relation to groundwater elevation. Additionally, Mann-Kendall tests were run for monitoring wells 54MW10, 54MW12, and 54MW13 to track the trend of perchlorate and the perchlorate biodegradation product of chloride. The results indicated no trend in any of the wells for perchlorate; however, there is significant evidence of a decreasing trend for chloride at all three wells.

Table 6-1 Analytical Results for Groundwater Performance Monitoring at SWMU 54

Parameter	Remediation Goal (RG)	July 2011 (Q1)	October 2011 (Q2)	January 2012 (Q3)	April 2012 (Q4)	August 2012 (Q5)	November 2012 (Q6)	February 2013 (Q7)	May 2013 (Q8)	August 2013 (Q9)	November 2013 (Q10)	February 2014 (Q11)	May 2014 (Q12)	September 2015 (Q13)	January 2016 (Q14)	April 2016 (Q15)	July 2016 (Q16)	October 2016 (Q17)	January 2017 (Q18)	April 2017 (Q19)	July 2017 (Q20)
54MW1																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Perchlorate	**10.9**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
54MW2																					
2,4,6-TNT	**7.82**	2.1	0.9	2.08	2.66	ND	ND	ND	0.749	0.974	0.46	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	0.572	ND	ND	0.384	ND	ND	ND	ND	ND	0.075	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	3.07	0.547	1.91	4.02	ND	0.842	1.41	1.82	1	0.26	--	--	--	--	--	--	--	--	--	--
54MW3																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	0.53	0.18	ND	ND	0.405	0.303	0.309	0.59	0.446	--	--	--	--	--	--	--	--	--	--	--
54MW4																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	--	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	ND	ND	ND	ND	0.141	ND	ND	ND	-	-	-	--	--	--	--	--	--	--	--
54MW5																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	0.311	0.393	0.313	0.301	0.42	0.28	0.255	0.309	0.389	--	--	--	--	--	--	--	--	--	--	--
54MW6																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	Dry	ND	ND	Dry	--	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	Dry	ND	ND	Dry	--	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	Dry	ND	ND	Dry	--	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	0.127	0.159	ND	0.175	Dry	0.16	0.171	Dry	--	--	--	--	--	--	--	--	--	--	--
54MW7																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	0.321	ND	ND	0.365	ND	0.103	0.162	0.103	0.37	--	--	--	--	--	--	--	--	--	--	--
54MW8																					
2,4,6-TNT	**7.82**	0.928	0.433	ND	0.301	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	0.761	0.567	0.493	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	0.408	0.355	0.388	0.392	0.286	0.484	0.118	0.334	--	--	--	--	--	--	--	--	--	--	--
54MW9																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	0.229	0.262	0.217	ND	ND	1.07	0.923	0.327	--	--	--	--	--	--	--	--	--	--	--
54MW10																					
2,4,6-TNT	**7.82**	0.305	5.84	4.05	ND	**9.17**	1.59	1.88	0.637	ND	**50**	**13**	**11**	6.6	4.1	2.7	**24.2**	1.6	4.2	1	0.44
RDX	**6.1**	ND	3.24	2.95	ND	**7.84**	1.35	2.36	1.29	2.23	**21**	5.3	**8.7**	2.1	3.1	1.8	**6.6**	0.4	1.1	ND	0.76
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	0.068	0.13	ND	ND	ND	ND	ND	ND	ND	ND
Perchlorate	**10.9**	ND	0.325	0.258	ND	3.74	0.344	0.832	0.835	0.365	2.3	0.42	0.44	ND	0.326	0.082	.84	0.12	0.1	0.24	0.2

Table 6-1 Analytical Results for Groundwater Performance Monitoring at SWMU 54 (Continued)

Parameter	Remediation Goal (RG)	July 2011 (Q1)	October 2011 (Q2)	January 2012 (Q3)	April 2012 (Q4)	August 2012 (Q5)	November 2012 (Q6)	February 2013 (Q7)	May 2013 (Q8)	August 2013 (Q9)	November 2013 (Q10)	February 2014 (Q11)	May 2014 (Q12)	September 2015 (Q13)	January 2016 (Q14)	April 2016 (Q15)	July 2016 (Q16)	October 2016 (Q17)	January 2017 (Q18)	April 2017 (Q19)	July 2017 (Q20)
54MW11																					
2,4,6-TNT	**7.82**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	ND	0.239	ND	ND	ND	0.263	0.43	0.132	--	--	--	--	--	--	--	--	--	--	--
54MW12																					
2,4,6-TNT	**7.82**	**15.9**	**16.1**	**19.4**	**48**	**10.1**	7.62	6.29	**108**	**65.9**	**17**	**29**	**10**	**11**	**110**	**11**	7.4	**10.6**	**28.1**	**78.6**	**8.7**
RDX	**6.1**	ND	**9.77**	**13.2**	**18.4**	1.95	**6.59**	3.79	**25**	**14.6**	0.54	**8.7**	2	3.9	**30**	0.62	.37	6	4.8	**51.4**	ND
DNT Mixture	**0.932**	ND	ND	ND	0.381	ND	ND	ND	ND	ND	0.2	0.31	0.93	ND	ND	ND	ND	ND	ND	ND	ND
Perchlorate	**10.9**	ND	0.726	10.5	**22.8**	2	5.31	2.98	**22.7**	9.88	1.1	4	1.7	0.737	8.85	1.2	.56	1.6	2.9	4.3	1.1
54MW13																					
2,4,6-TNT	**7.82**	ND	4.09	0.699	0.979	**9.4**	0.843	0.318	4.91	3.81	**9.8**	2.5	5.8	5.4	1.4	0.79	**13.9**	**8**	5.9	1.8	**8.2**
RDX	**6.1**	ND	2.59	0.614	1.14	4.77	0.855	0.642	3.2	1.46	4	0.88	2.5	2.6	0.54	0.17	.86	0.7	ND	1	ND
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.11	ND	0.099	ND	ND	ND	ND	ND	ND	ND	ND
Perchlorate	**10.9**	ND	0.244	0.206	0.243	0.627	0.308	0.313	0.64	0.477	0.43	0.32	0.37	0.270	0.216	0.18	.33	0.21	0.29	0.23	0.45
54MW14																					
2,4,6-TNT	**7.82**	0.928	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--
RDX	**6.1**	0.761	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--
DNT Mixture	**0.932**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--	--	--	--	--	--	--	--	--	--
Perchlorate	**10.9**	ND	ND	0.215	0.181	0.214	0.24	ND	ND	0.195	0.456	--	--	--	--	--	--	--	--	--	--

Figure 6-1 SWMU54: 54MW10 Contaminant Concentration to Groundwater Elevation Correlation

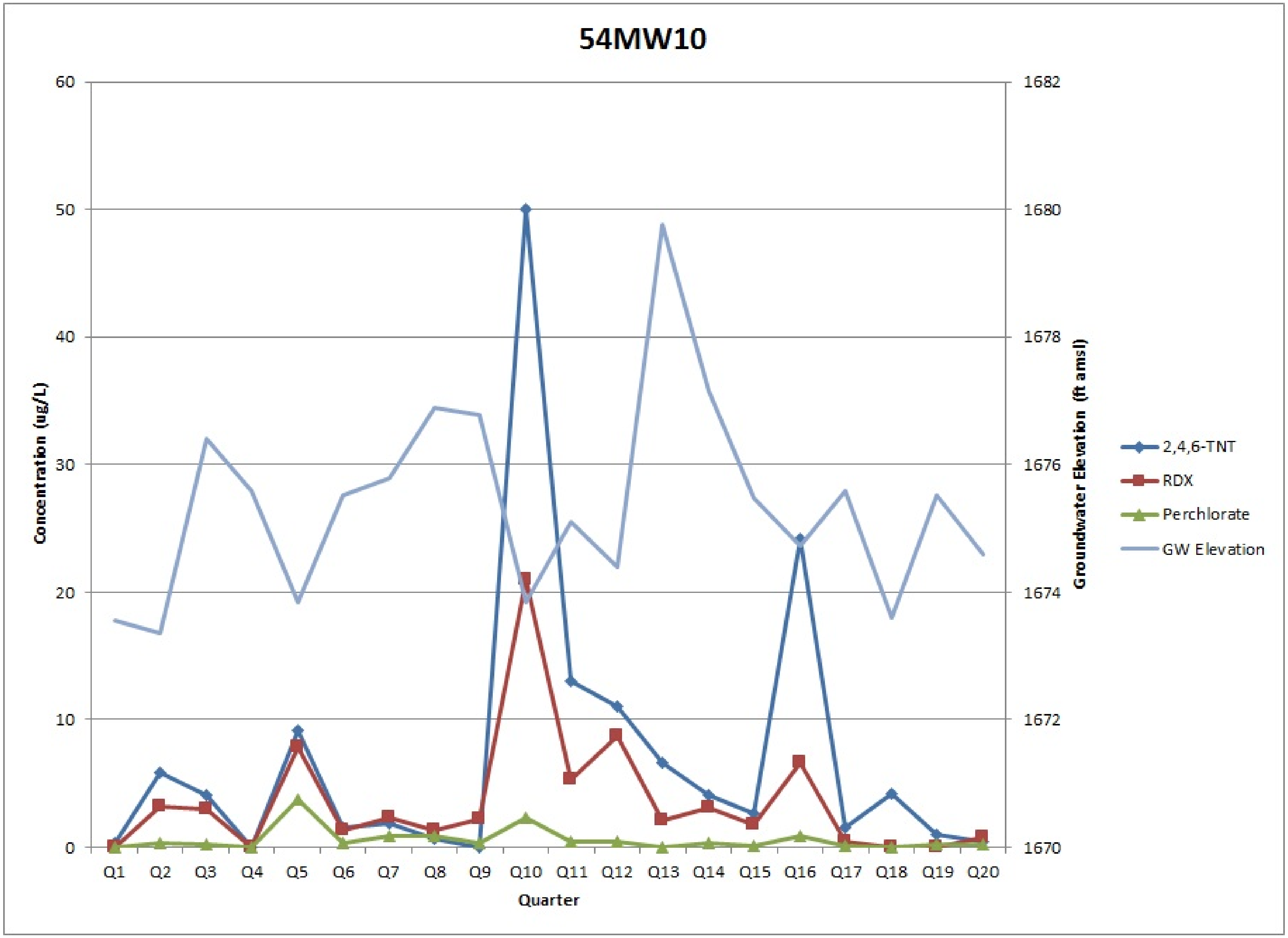


Figure 6-2 SWMU54: 54MW12 Contaminant Concentration to Groundwater Elevation Correlation

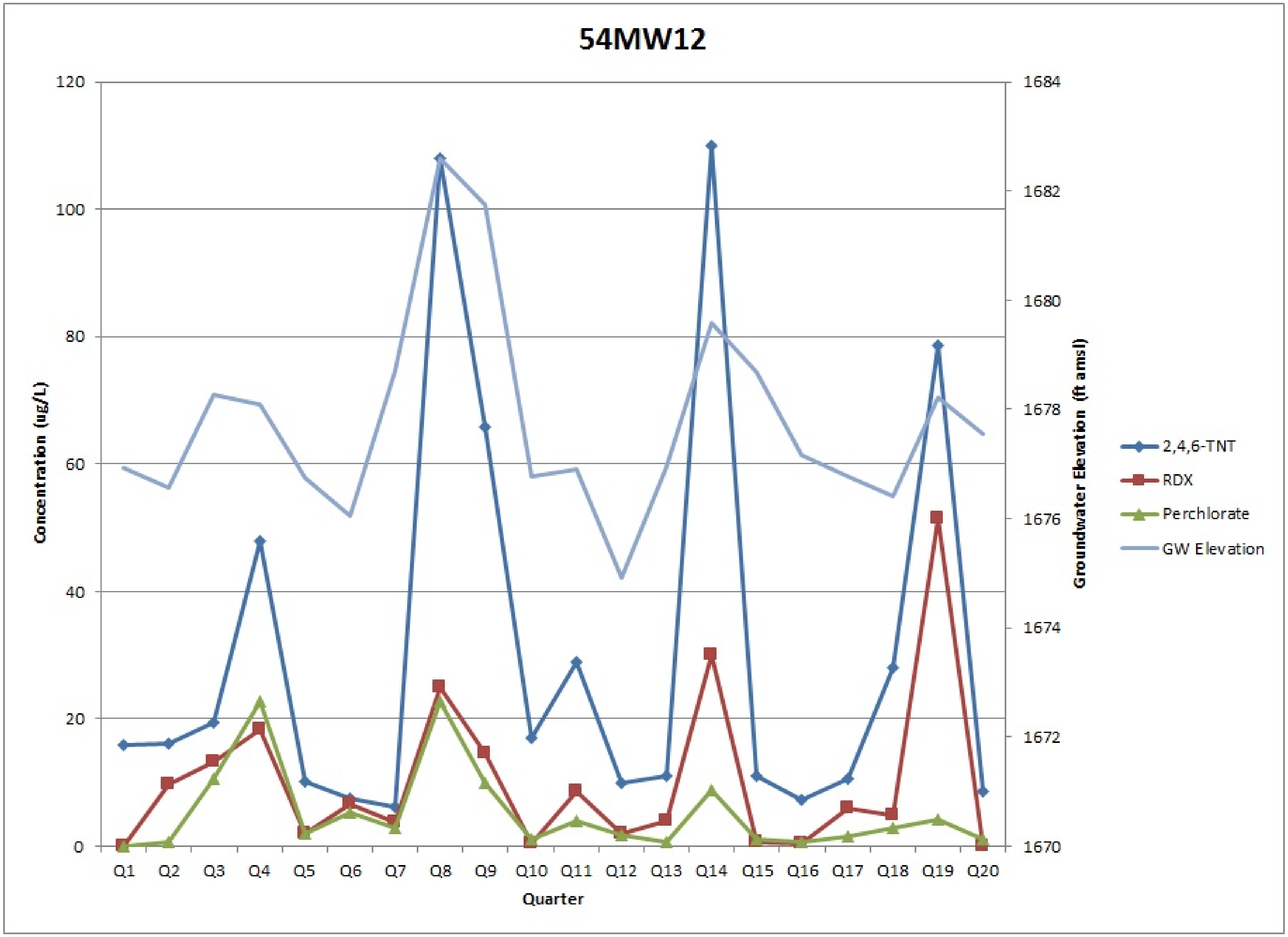
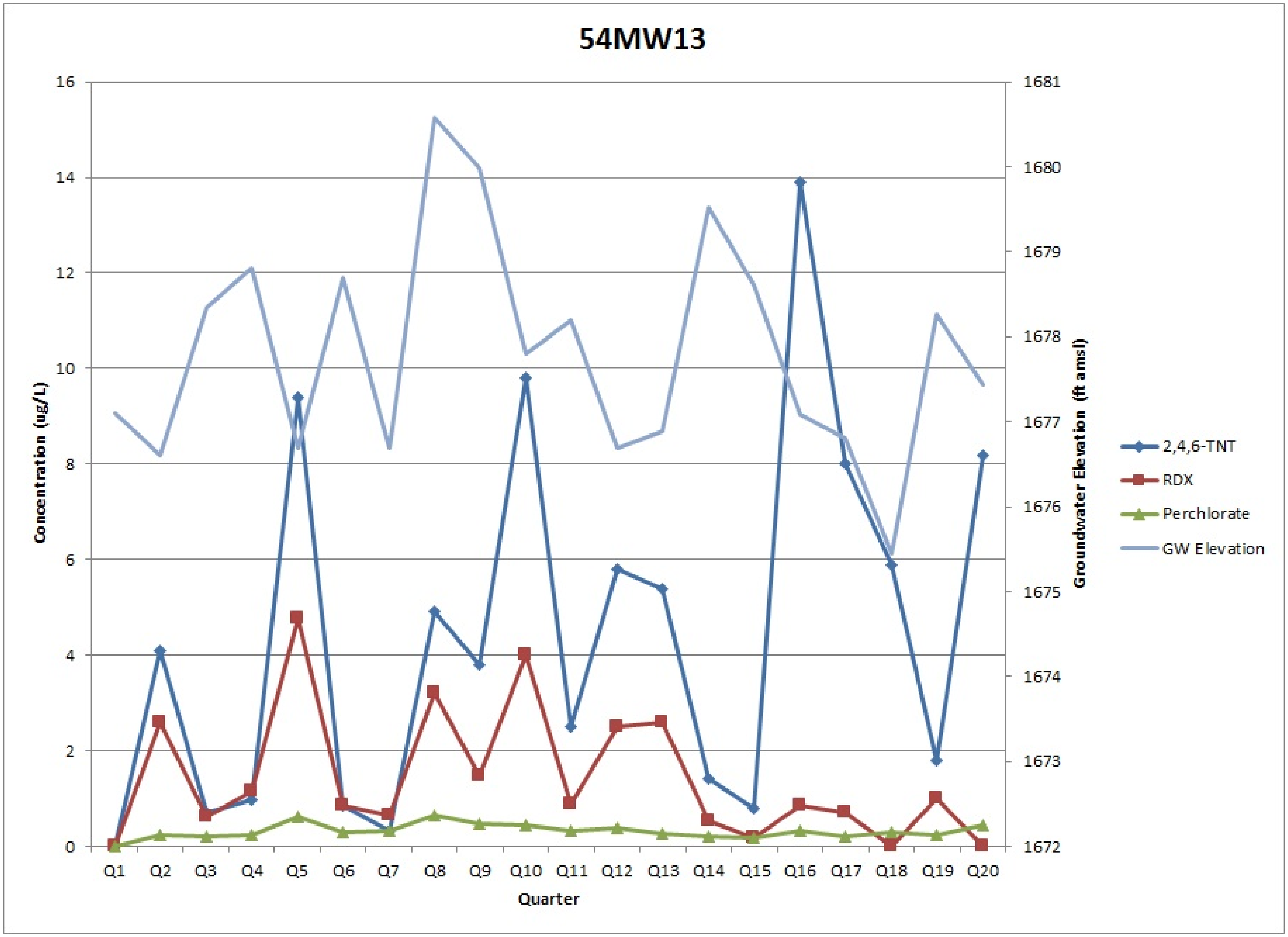


Figure 6-3 SWMU54: 54MW13 Contaminant Concentration to Groundwater Elevation Correlation



6.2 Second Line of Evidence: Geochemical Conditions

Respiratory substrates are used preferentially during microbial metabolism based on the amount of energy that can be derived from each of them. Respiratory substrates are used in the following order:

$$O_2 > NO_3^- > Fe^{+3} > ClO_4 > SO_4^{-2} > CO_2$$

Geochemical data is available for all twenty quarterly groundwater monitoring events at SWMU 54. Field parameters (DO, ORP, pH, temperature, and conductivity) have been collected since 2011 as part of the low-flow sampling procedures. Laboratory analyses for nitrate, sulfate, and TOC were conducted for all twenty quarterly groundwater monitoring events at SWMU 54. These geochemical data are discussed regarding the potential for biodegradation in the groundwater at SWMU 54.

The microbial degradation of nitro-aromatic compounds primarily occurs under nitrate-reducing conditions, whereas perchlorate requires sulfate reducing groundwater conditions.

Dissolved Oxygen (DO). The preferred terminal electron acceptor during aerobic microbial respiration is oxygen, and DO is measured to determine whether the groundwater is under aerobic or anaerobic conditions. Average DO values less than 1 mg/L, are supportive of anaerobic microbial activities. Further, DO values higher than 8 mg/L are considered biased high given their relative magnitude to oxygen solubility at field temperatures and are not included in this analysis.

DO concentrations during the first sixteen quarterly monitoring events (early 2011 to July 2016) ranged from 0.0 to 7.81 mg/L indicating both anaerobic and aerobic conditions were present at the site. During the year five monitoring period DO values ranged from 0.01 mg/L (54MW13) to 5.40 mg/L (54MW12). In wells where biological degradation products were observed (54MW10, 54MW12, and 54MW13), the DO concentrations (between 0.01 and 5.40 mg/L [54MW12]) indicate that aerobic conditions appear to be favored (**Table 6-2**). TNT has been known to be reduced under a variety of conditions (aerobic and anaerobic); however, further reduction of TNT breakdown products, including 2ADNT and 4ADNT, and reduction of RDX and perchlorate is more favorable under anaerobic conditions (Spain, 1995).

The increase in concentrations of explosive constituents at 54MW12 during the nineteenth quarter took place under aerobic conditions. Under aerobic conditions, biodegradation is not as effective in the reduction of explosives and perchlorates. As a result of the subsurface biochemistry, the decreased biological activity may have led to an increase in the explosives and perchlorate concentrations during this period. This trend was also noticed during the ninth, tenth, and fourteenth quarterly monitoring events.

Oxidation-Reduction Potential (ORP). ORP values indicate the groundwater's reductive potential and are used to confirm the DO measurements in groundwater. ORP values less than

+50 mV typically correspond to mildly reducing, anaerobic conditions, while ORP values less than -200 mV correspond to highly reducing, anaerobic conditions. As mentioned previously, TNT reduction can occur in aerobic systems, but the reduction of TNT breakdown products, RDX, and perchlorate are favored under anaerobic conditions (generally observed when ORP values are between -100 mV and 0 mV).

ORP concentrations during the first twelve quarterly sampling events (early 2011 to May 2014) ranged from -33 to 297 mV indicating both anaerobic and aerobic conditions were present at the site. However, it was reported that aerobic conditions appeared to be more prevalent (**Table 6-2**). Further, the year three ORP values and DO readings did not show a clear corresponding trend for samples taken at the same well and same sampling event. At monitoring wells with elevated concentrations of TNT and RDX (54MW10, 54MW12 and 54MW13), it was suggested that ORP readings were in agreement with DO concentrations, indicating aerobic conditions.

The year four ORP readings ranged from -10.1 mV to 264 mV indicating that both anaerobic and aerobic conditions were present at SWMU 54. However, there was only one reading (at 54MW1 in quarter 16) indicating reducing conditions; as such, it would appear that aerobic conditions are more prevalent at the SWMU. The year four ORP trends were generally in agreement with year three.

The year five ORP readings ranged from 15.5 mV (54MW13) to 138.2 mV (54MW1) indicating aerobic conditions were present at SWMU 54. The data suggests that aerobic conditions are more prevalent at the SWMU. The year five ORP trends are generally in agreement with year four.

pH. The pH for optimum microbial activity ranges from 5 to 9 standard units. Microbial activity may decrease at lower pH values. The first four years of pH data are within this optimal pH range (**Table 6-2**) and continued during year five. In general, the pH environment at SWMU 54 is suitable for microbial activity.

Nitrate. Following oxygen, microorganisms preferentially use nitrate (NO3-) as a terminal electron acceptor. Diminished nitrate concentrations may indicate nitrate-reducing conditions which promote the degradation of nitroaromatics (including 2,4,6-TNT) forming breakdown by-products. It should be noted that elevated nitrate concentrations (>1 mg/L) will inhibit perchlorate reduction (IRTC, 2008). Additionally, any nitrate would preferentially be reduced to nitrite before TNT and RDX could be reduced.

Nitrate concentrations during the first sixteen sampling events were generally low (overall <1 mg/L) with concentrations ranging from non-detect to 4.8 mg/L, suggesting that perchlorate reduction is not inhibited (**Table 6-2**). This trend continued during the year five monitoring period where 14 of 16 nitrate concentrations were well below 1 mg/L and nitrate concentrations ranged from 0.10 to 1.2 mg/L.

Monitoring well 54MW12, where the highest and more persistent perchlorate concentrations have been identified, consistently had nitrate concentrations greater than 1 mg/L during the first sixteen quarters of monitoring, but during the year five monitoring period the nitrate concentrations were only greater than or equal to 1 mg/L during two sampling events (quarter seventeen and quarter nineteen). In contrast, the corresponding accrual and reduction of 2,4,6-TNT concentrations and concentrations of 2ADNT and 4ADNT present suggest the biodegradation of TNT.

Ferrous Iron. Ferric iron is reduced to soluble ferrous iron in the groundwater where iron-reducing bacteria have been active. An increase in ferrous iron concentrations is indicative of iron-reducing conditions. Biological reduction of TNT is favored in nitrate-reducing conditions and therefore, elevated concentrations of ferrous iron are an indicator of favorable groundwater conditions for TNT degradation. However, the degradation of TNT breakdown products, 2ADNT and 4ADNT, RDX, and perchlorate are favored in iron-reducing conditions. Ferrous iron concentrations for all wells during the four previous years of monitoring have been less than 0.2 mg/L (non-detect) or equal to 0.2 mg/L indicating that iron-reducing conditions are not present at this time, or that the iron has been reduced previously. During the year five monitoring events, ferrous iron concentrations for all wells was less than 0.2 mg/L (non-detect) with the exception of monitoring well 54MW10 during quarter seventeen, when concentrations increased to 0.52 mg/L, and then decreased to 0.04 mg/L during quarter eighteen.

Sulfate. Biological degradation of TNT breakdown products, 2ADNT and 4ADNT, RDX, and perchlorate actively occurs under sulfate-reducing conditions. Sulfate concentrations greater than 20 µg/L may cause competitive exclusion (USEPA, 2008). Sulfate concentrations were measured in the groundwater during each of the first twelve quarterly monitoring events and were found to generally be greater than 20 mg/L (ranging from 15.0 to 403 mg/L), indicating that biological degradation of 2ADNT and 4ADNT may be inhibited at SWMU 54 (**Table 6-2**). During the fourth year of monitoring, sulfate concentrations were slightly lower (ranging from 19 to 93 mg/L), but again suggested inhibition of biological degradation of the 2,4,6-TNT by-products 2ADNT and 4ADNT. During the fifth year of monitoring, sulfate concentrations were found to be greater than 20 mg/L (ranging from 28.0 to 150.0 mg/L), again indicating that biological degradation of 2ADNT and 4ADNT are inhibited at SWMU 54.

Total Organic Carbon (TOC). Organic carbon is a required source of reduced carbon and energy needed to sustain microbial degradation of nitroaromatics and perchlorate. TOC concentrations greater than 20 mg/L are considered adequate to support microbial activity. For the majority of the first three years of monitoring, TOC concentrations were found to be considerably lower than what is consider adequate to support microbial activity. TOC concentrations during this time frame ranged from less than 0.50 (non-detect) to 7.47 mg/L (**Table 6-2**). However, measured TOC concentrations during the twelfth quarter exceed 20 mg/L in monitoring wells 54MW1 (51.0 mg/L) and 54MW10 (63.0 mg/L). The year four TOC results, however, again indicated low concentrations considered inadequate to support microbial activity. The range of TOC during the year four monitoring period ranged from 0.3 mg/L to 8.9 mg/L. This trend continued throughout the year five monitoring events, with concentrations ranging from 0.55 mg/L to 6.9 mg/L.

Figure 6-4 provides a time series plot of specific conductivity at all four wells. Specific conductivity is the indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, and Fe, all degradation by-products. **Figures 6-5, 6-6,** and **6-7** provide time series plots of MNA indicators sulfate and nitrate alongside water quality parameters Fe and Mn at monitoring wells 54MW10, 54MW12, and 54MW13 for all five years. Additionally, **Figures 6-8**, **6-9**, and **6-10** provide time series plots of MNA indicator TOC alongside water quality parameters DO and ORP at monitoring wells 54MW10, 54MW12, and 54MW13 for all five years. Data suggest that 2,4,6-TNT, RDX, and perchlorate are biodegrading and more dissolved inorganic ions (such as chlorides, nitrates, sulfates, and Fe) are creating the electrical current witnessed in the specific conductivity readings.

Monitoring wells 54MW10, 54MW12, and 54MW13 all appear to have similar specific conductivity activity according to **Figure 6-4**. Additionally, **Figures 6-5**, **6-6**, and **6-7**, demonstrate that Fe and dissolved Mn have been reduced to concentrations at or very near zero at all three wells. Overall, there are sulfate reducing conditions at all three wells which is indicative of biodegradation of 2 ADNT, 4ADNT, RDX and perchlorate.Nitrate concentrations at 54MW10 and 54MW13 have always been at or slightly above zero while nitrate reducing conditions are currently present at 54MW12.

Figures 6-8, **6-9**, and **6-10** demonstrate that ORP conditions at monitoring well 54MW10 support mildly anaerobic conditions. At monitoring wells 54MW12 and 54MW13, ORP is declining and beginning to support mildly reducing anaerobic conditions. DO conditions at all three wells are borderline anaerobic. Data suggests that conditions at the wells appears to be improving to be more favorably anaerobic. TOC conditions at 54MW10 fluctuate between inadequate and adequate conditions. Since quarter 17, TOC concentrations have steadily declined below 20 mg/L which is considered inadequate. Meanwhile, conditions at monitoring wells 54MW12 and 54MW13 have consistently been considered inadequate and have remained so since quarter 1. TOC concentrations at 54MW12 and 54MW13 have ranged between <0.5 mg/L and 8.3 mg/L, and <0.5 mg/L and 13 mg/L, respectively; considered inadequate for sustaining microbial degradation of nitroaromatics and perchlorate.

Overall, the data suggest that MNA conditions are still favorable at all three wells.

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 First Quarter (July 2011) Water Quality Parameters														
pH	7.7	6.36	6.86	7.19	6.36	7.33	6.6	6.98	6.29	7.13	7.14	6.67	6.75	7.23
Conductivity (mS/cm)	0.357	0.526	0.491	0.949	0.371	0.449	0.419	0.544	0.535	1.68	0.651	0.568	0.676	0.582
Turbidity (NTU)	5.6	0	1.5	1.9	3	0.2	0	4.6	6	89.8	62.6	100	94	16.9
Dissolved Oxygen (mg/L)	4.86	2.35	4.71	0	4.87	0.68	3.91	3.53	1.23	0.51	0	3.52	0.9	1.06
ORP (mV)	130	178	121	-18	178	110	170	134	198	67	96	152	29	73
Temperature (°C)	14.12	17.07	19.82	15.52	19.88	19.32	18.87	17.86	14.3	25.19	14.94	18.38	20.09	23.76
Dissolved Manganese	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	0.2	<0.05	0.05	<0.05	0.65	<0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	25.2	1.09	0.967	0	0.613	0	0.119	0.639	0.233	0	0	2.79	0.439	0.242
Sulfate (mg/L)	27.1	39.8	23.6	329	15.1	27.4	61.5	40	62.2	167	93.6	38.1	38.8	33.6
TOC (mg/L)	3.9	3.51	7.26	2.51	6.14	1.95	3.17	6.05	5.1	1.61	5.97	2.64	2.55	6.73
SWMU 54 Second Quarter (October 2011) Water Quality Parameters														
pH	7.49	7.02	7.05	7.27	6.78	7.49	7.3	7.09	7.2	6.83	7.31	6.7	7.05	7.16
Conductivity (mS/cm)	0.432	0.56	0.674	0.912	0.502	0.305	0.734	0.541	0.562	0.677	0.654	0.523	0.831	0.568
Turbidity (NTU)	164	167	160	81.1	231	107	155	104	79.9	236	685	69	--	157
Dissolved Oxygen (mg/L)	0	0	0	2.44	2.68	3.8	0.1	0.05	0.06	0	0	1.72	0.37	0
ORP (mV)	102	117	107	-15	143	122	66	151	146	82	-13	144	126	73
Temperature (°C)	18.04	14.77	14.16	14.32	15.48	13.18	18.01	14.94	14.75	14.75	13.73	14.81	14.63	14.93
Dissolved Manganese (mg/L)	<0.05	<0.05	0.1	0.05	0.1	0.05	0.4	0.05	0.2	0.15	0.3	<0.05	0.35	0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0	0.394	0.357	0	0.568	0.167	0	0.514	0.184	0.388	0	2	0.21	0.202
Sulfate (mg/L)	27.1	27	44.4	210	17.4	7.06	216	39.9	46.9	96.7	119	31.8	90.2	34.1
TOC (mg/L)	3.9	3.2	3.22	1.38	1.88	2.68	1.31	7.47	6.78	6.98	3.22	4.71	3.31	4.64
SWMU 54 Third Quarter (January 2011) Water Quality Parameters														
pH	7.59	7.48	7.4	7.36	7.15	7.53	7.43	7.08	7.4	7.46	7.59	6.09	7.45	7.48
Conductivity (mS/cm)	0.498	0.662	0.762	1.11	0.628	0.305	0.905	0.492	0.674	0.707	0.763	0.595	0.687	0.651
Turbidity (NTU)	8.9	15.3	19.2	55.6	32.1	72.4	26.8	66.7	36.8	1.1	6.8	---	226	0
Dissolved Oxygen (mg/L)	0	0	0	0	7.81	12.01	0	16.65	8.48	6.06	5.09	4.02	7.63	1.66
ORP (mV)	100	33	24	5	121	191	3	104	111	118	101	186	25	61
Temperature (°C)	13.2	13.91	13.26	13.04	13.58	11.93	12.73	9.72	9.65	11.16	11.4	12.86	11.53	12.91
Dissolved Manganese (mg/L)	<0.05	<0.05	0.1	0.05	0.1	0.05	0.4	0.05	0.2	0.15	0.3	<0.05	0.35	0.05
Dissolved Ferrous Iron (mg/L)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Nitrate (mg/L)	0	0.609	0	0	0.578	0.158	0	0.401	0.174	0.572	0.158	1.94	0.237	0.241
Sulfate (mg/L)	26.3	28.2	73.7	480	20.3	4.55	249	41.5	62.5	72.7	93	37.6	53.9	32.2
TOC (mg/L)	2.1	1.8	2.39	1.16	1.42	1.94	2.38	1.66	2.78	1.66	6.71	5.09	6.63	1.68

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	**54MW1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
SWMU 54 Fourth Quarter (April 2012) Water Quality Parameters														
pH	**5.42**	**5.19**	**5.38**	**5.33**	**4.99**	**5.76**	**5.57**	**5.38**	**5.46**	**5.48**	**5.59**	**5.05**	**5.32**	**5.5**
Conductivity (mS/cm)	**0.958**	**1.12**	**1.46**	**0.001**	**0.891**	**0.73**	**1.58**	**1.21**	**1.26**	**1.73**	**1.4**	**1.35**	**0.981**	**1.2**
Turbidity (NTU)	**2.5**	**4.4**	**2.4**	**125**	**70.1**	**318**	**38**	**3.4**	**65.3**	**30.8**	**94.7**	**37**	**312**	**36**
Dissolved Oxygen (mg/L)	**7.36**	**7.18**	**2.24**	**23.45**	**10.47**	**6.49**	**2.01**	**7.43**	**11.29**	**2.83**	**5.8**	**9.44**	**7.1**	**5.55**
ORP (mV)	**-30**	**236**	**225**	**180**	**168**	**132**	**162**	**134**	**145**	**61**	**36**	**267**	**116**	**149**
Temperature (°C)	**13.37**	**12.44**	**12.02**	**11.56**	**20.98**	**19.09**	**12.57**	**14.69**	**14.21**	**15.5**	**14.11**	**12.67**	**15.52**	**12.69**
Dissolved Manganese (mg/L)	**<0.05**	**<0.05**	**0.1**	**0.5**	**<0.05**	**0.05**	**0.4**	**0.05**	**0.2**	**0.1**	**0.3**	**<0.05**	**0.35**	**<0.05**
Dissolved Ferrous Iron (mg/L)	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**
Nitrate (mg/L)	**0**	**1.33**	**0**	**0**	**0.677**	**0.129**	**0.231**	**0.483**	**0.139**	**0**	**0**	**2.65**	**0.294**	**0.386**
Sulfate (mg/L)	**34.9**	**34.9**	**80**	**432**	**14**	**14.9**	**69.4**	**40.1**	**56**	**221**	**104**	**37.9**	**35.4**	**29.3**
TOC (mg/L)	**1.8**	**1.57**	**1.18**	**1.82**	**2.33**	**5.46**	**0.99**	**2.36**	**3.01**	**2.4**	**2.68**	**2.34**	**3.51**	**1.09**
SWMU 54 Fifth Quarter (August 2012) Water Quality Parameters														
pH	**7.08**	**6.94**	**6.71**	**7.05**	**6.71**	**7.47**	**7.03**	**6.87**	**6.84**	**6.71**	**7.06**	**6.61**	**6.97**	**7.05**
Conductivity (mS/cm)	**0.395**	**0.722**	**0.644**	**0.968**	**0.58**	**0.363**	**0.817**	**0.599**	**0.752**	**0.693**	**0.715**	**0.665**	**0.697**	**0.625**
Turbidity (NTU)	**4.1**	**43**	**19**	**14**	**23**	**0**	**7.4**	**19**	**5.2**	**0.8**	**10.8**	**48**	**95**	**9.2**
Dissolved Oxygen (mg/L)	**5.34**	**0**	**0**	**0.23**	**3.96**	**4.84**	**0**	**2.78**	**0.56**	**0.4**	**0**	**0.33**	**1.75**	**0**
ORP (mV)	**212**	**65**	**209**	**-33**	**200**	**134**	**128**	**125**	**-10**	**47**	**-22**	**226**	**135**	**-13**
Temperature (°C)	**13.89**	**13.49**	**12.93**	**15.06**	**13.44**	**16.52**	**13.66**	**13.7**	**14.09**	**13.93**	**13.64**	**13.71**	**16.12**	**14.08**
Dissolved Manganese (mg/L)	**<0.05**	**<0.05**	**0.05**	**0.05**	**<0.05**	**0.05**	**0.05**	**0.05**	**0.2**	**0.05**	**0.05**	**<0.05**	**0.3**	**<0.05**
Dissolved Ferrous Iron (mg/L)	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**
Nitrate (mg/L)	**0.600**	**0.190**	**0.613**	**3.00**	**0.728**	**0.120**	**3.00**	**0.581**	**1.80**	**0.594**	**1.80**	**1.06**	**0.681**	**0.214**
Sulfate (mg/L)	**26.1**	**95.5**	**23.8**	**378**	**18.0**	**15.7**	**186**	**41.8**	**87.2**	**102**	**97.6**	**27.0**	**38.2**	**31.8**
TOC (mg/L)	**0.721**	**2.00**	**2.00**	**1.10**	**2.00**	**1.00**	**1.02**	**2.00**	**2.00**	**1.37**	**2.00**	**2.00**	**1.05**	**2.04**
SWMU 54 Sixth Quarter (November 2012) Water Quality Parameters														
pH	**7.63**	**7.21**	**6.97**	**7.03**	**6.99**	**Dry**	**7.31**	**7.23**	**7.23**	**7.29**	**7.28**	**7.6**	**5.72**	**7.3**
Conductivity (mS/cm)	**0.443**	**0.62**	**0.561**	**1.01**	**0.612**	**Dry**	**0.826**	**0.628**	**0.784**	**0.779**	**0.698**	**0.635**	**0.918**	**0.6**
Turbidity (NTU)	**2.9**	**11.4**	**0.2**	**17**	**5.5**	**Dry**	**46**	**3.9**	**27.7**	**4.7**	**2.5**	**2.4**	**35**	**43**
Dissolved Oxygen (mg/L)	**1.44**	**0.86**	**4.09**	**1**	**1.01**	**Dry**	**0.56**	**2.71**	**1.14**	**0.38**	**1.1**	**0.26**	**0.95**	**0.45**
ORP (mV)	**148**	**141**	**145**	**72**	**167**	**Dry**	**59**	**101**	**-28**	**43**	**117**	**135**	**209**	**100**
Temperature (°C)	**10.03**	**13.43**	**12.22**	**11.27**	**11.21**	**Dry**	**10.83**	**11.98**	**11.35**	**13.61**	**12.95**	**13.99**	**12.26**	**10.61**
Dissolved Manganese (mg/L)	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**Dry**	**0.05**	**0.05**	**0.2**	**0.05**	**0.05**	**0.1**	**0.3**	**0.05**
Dissolved Ferrous Iron (mg/L)	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**Dry**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**
Nitrate (mg/L)	**0.600**	**0.327**	**0.656**	**3.00**	**0.944**	**Dry**	**1.80**	**0.403**	**1.80**	**0.381**	**0.600**	**2.86**	**0.369**	**0.600**
Sulfate (mg/L)	**31.3**	**35.4**	**22.9**	**403**	**21.5**	**Dry**	**179**	**60.3**	**199**	**151**	**99.1**	**49.8**	**76.7**	**39.0**
TOC (mg/L)	**1.96**	**2.68**	**3.29**	**2.93**	**4.31**	**Dry**	**3.72**	**4.90**	**6.73**	**5.55**	**5.88**	**3.41**	**2.00**	**2.12**

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Seventh Quarter (February 2013) Water Quality Parameters														
pH	**7.85**	**6.89**	**6.76**	**7.52**	**6.56**	**7.08**	**7.4**	**7.03**	**7.04**	**6.69**	**7.09**	**6.36**	**6.96**	**7.45**
Conductivity (mS/cm)	**0.465**	**0.682**	**0.504**	**1.01**	**0.417**	**0.293**	**0.474**	**0.498**	**0.487**	**0.542**	**0.687**	**0.464**	**0.37**	**0.619**
Turbidity (NTU)	**0**	**20**	**9**	**16**	**0**	**44.3**	**16**	**9.2**	**10.9**	**13.2**	**2**	**14.2**	**6.8**	**1.2**
Dissolved Oxygen (mg/L)	**0.71**	**1.43**	**6.97**	**0.53**	**9.19**	**9.28**	**2.83**	**5.36**	**8.28**	**2.97**	**0.58**	**1.27**	**8.39**	**0.47**
ORP (mV)	**-5**	**156**	**171**	**-56**	**168**	**72**	**12**	**168**	**194**	**125**	**169**	**168**	**158**	**56**
Temperature (°C)	**12.17**	**8.28**	**11.98**	**12.09**	**11.18**	**13.15**	**11.48**	**9.89**	**9.74**	**11.22**	**10.14**	**10.31**	**7.98**	**12.26**
Dissolved Manganese (mg/L)	**0.05**	**<0.05**	**0.1**	**0.05**	**<0.05**	**0.05**	**0.1**	**0.05**	**0.2**	**0.1**	**0.25**	**<0.05**	**0.2**	**<0.05**
Dissolved Ferrous Iron (mg/L)	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**
Nitrate (mg/L)	**0.600**	**0.315**	**0.423**	**3.00**	**0.636**	**0.209**	**0.205**	**0.336**	**0.510**	**0.477**	**0.346**	**1.95**	**0.501**	**0.600**
Sulfate (mg/L)	**27.1**	**36.8**	**25.3**	**340**	**15.5**	**4.29**	**34.2**	**44.6**	**117**	**70.1**	**120**	**35.8**	**23.1**	**41.1**
TOC (mg/L)	**1.19**	**0.916**	**1.07**	**1.35**	**1.00**	**1.50**	**0.791**	**1.00**	**2.09**	**1.14**	**1.88**	**1.21**	**0.683**	**1.46**
SWMU 54 Eighth Quarter (May 2013) Water Quality Parameters														
pH	**7.38**	**6.52**	**7.06**	**7.51**	**6.83**	**7.33**	**7.41**	**7.47**	**7.95**	**6.94**	**7.59**	**6.78**	**6.97**	**7.31**
Conductivity (mS/cm)	**0.398**	**0.315**	**0.499**	**1.021**	**0.4**	**0.494**	**0.674**	**0.596**	**0.521**	**0.537**	**0.592**	**0.665**	**0.44**	**0.608**
Turbidity (NTU)	**1.2**	**0.2**	**1.4**	**6.2**	**8.9**	**7.1**	**0.5**	**1.6**	**5.2**	**1.4**	**0.3**	**3.8**	**0.2**	**6.4**
Dissolved Oxygen (mg/L)	**4.13**	**2.74**	**3.55**	**1.05**	**3.28**	**1.29**	**3.24**	**0.4**	**7.58**	**2.43**	**1.17**	**2.54**	**1.4**	**4.13**
ORP (mV)	**122**	**254.3**	**273.6**	**257.1**	**283.1**	**128.4**	**282.7**	**255.1**	**244.2**	**287.8**	**255.8**	**292.4**	**284**	**296.5**
Temperature (°C)	**13.43**	**12.22**	**13.31**	**11.73**	**12.2**	**13.48**	**12.74**	**13.32**	**11.12**	**12.89**	**12.42**	**13.28**	**12.84**	**13.42**
Dissolved Manganese (mg/L)	**<0.05**	**0.05**	**0.05**	**0.05**	**<0.05**	**<0.05**	**0.05**	**0.05**	**0.1**	**0.05**	**0.05**	**<0.05**	**0.15**	**0.05**
Dissolved Ferrous Iron (mg/L)	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**
Nitrate (mg/L)	**0.368**	**0.988**	**0.911**	**3.00**	**1.60**	**0.600**	**1.10**	**0.600**	**0.637**	**0.740**	**0.647**	**4.03**	**1.05**	**0.543**
Sulfate (mg/L)	**26.1**	**24.1**	**29.0**	**329**	**15.7**	**14.0**	**137**	**41.1**	**96.7**	**48.8**	**89.4**	**47.6**	**29.2**	**37.0**
TOC (mg/L)	**0.949**	**1.68**	**1.36**	**0.619**	**1.06**	**2.41**	**0.793**	**1.00**	**1.38**	**1.00**	**0.635**	**1.36**	**0.817**	**0.583**
SWMU 54 Ninth Quarter (August 2013) Water Quality Parameters														
pH	**7.82**	**6.91**	**6.75**	**6.96**	**6.28**	**Dry**	**6.71**	**6.95**	**7.12**	**6.48**	**7.04**	**6.36**	**6.57**	**6.84**
Conductivity (mS/cm)	**0.452**	**0.592**	**0.617**	**0.937**	**0.333**	**Dry**	**0.478**	**0.559**	**0.419**	**0.496**	**0.637**	**0.491**	**0.351**	**0.554**
Turbidity (NTU)	**3**	**0**	**0**	**0**	**0**	**Dry**	**7.2**	**0**	**6.1**	**0**	**0**	**7.0**	**0**	**0**
Dissolved Oxygen (mg/L)	**0.136**	**0.8**	**1.69**	**0.39**	**6.28**	**Dry**	**2.4**	**0.67**	**2.36**	**0.86**	**4.65**	**2.85**	**6.57**	**0.52**
ORP (mV)	**223.2**	**84**	**96**	**-18**	**129**	**Dry**	**86**	**42**	**-13**	**35**	**68**	**91**	**146**	**50**
Temperature (°C)	**14.51**	**15.25**	**15.08**	**13.22**	**15.49**	**Dry**	**13.05**	**13.4**	**13.25**	**14.51**	**13.46**	**15.7**	**13.89**	**13.21**
Dissolved Manganese (mg/L)	**0.05**	**NM**	**<0.05**	**0.05**	**0.05**	**Dry**	**<0.05**	**<0.05**	**0.05**	**<0.05**	**0.05**	**0.05**	**0.15**	**0.05**
Dissolved Ferrous Iron (mg/L)	**<0.2**	**NM**	**<0.2**	**<0.2**	**<0.2**	**Dry**	**<0.2**	**<0.2**	**0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**	**<0.2**
Nitrate (mg/L)	**<0.600**	**0.326**	**0.521**	**<0.600**	**0.849**	**Dry**	**<0.600**	**0.273**	**0.194**	**0.206**	**0.12**	**4.8**	**0.591**	**0.29**
Sulfate (mg/L)	**26.7**	**30.8**	**26.1**	**322**	**15.0**	**Dry**	**27.3**	**38.0**	**39.2**	**44.3**	**91.8**	**39.6**	**23.3**	**28.2**
TOC (mg/L)	**3.32**	**1.5**	**1.11**	**2.7**	**0.91**	**Dry**	**0.822**	**2.30**	**4.17**	**4.28**	**3.11**	**3.27**	**2.35**	**3.64**

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Tenth Quarter (November 2013) Water Quality Parameters														
pH	--	7.45	--	--	--	--	--	--	--	6.89	--	NM	7.29	--
Conductivity (mS/cm)	--	0.635	--	--	--	--	--	--	--	0.615	--	0.469	0.643	--
Turbidity (NTU)	--	0	--	--	--	--	--	--	--	0	--	4.6	0.4	--
Dissolved Oxygen (mg/L)	--	2.7	--	--	--	--	--	--	--	2.45	--	1.17	1.32	--
ORP (mV)	--	51	--	--	--	--	--	--	--	18	--	108	25	--
Temperature (°C)	--	14.09	--	--	--	--	--	--	--	15.25	--	14.96	15.96	--
Dissolved Manganese (mg/L)	--	<0.05	--	--	--	--	--	--	--	<0.05	--	0.05	0.05	--
Dissolved Ferrous Iron (mg/L)	--	<0.2	--	--	--	--	--	--	--	<0.2	--	<0.2	<0.2	--
Nitrate (mg/L)	--	0.25	--	--	--	--	--	--	--	0.670	--	1.1	0.45	--
Sulfate (mg/L)	--	29.0	--	--	--	--	--	--	--	57.0	--	26.0	39.0	--
TOC (mg/L)	--	2.5	--	--	--	--	--	--	--	0.68	--	0.5	<0.50	--
SWMU 54 Eleventh Quarter (February 2014) Water Quality Parameters														
pH	8.1	--	--	--	--	--	--	--	--	6.89	--	7.21	7.21	--
Conductivity (mS/cm)	0.41	--	--	--	--	--	--	--	--	0.587	--	0.643	0.481	--
Turbidity (NTU)	0	--	--	--	--	--	--	--	--	0	--	3.8	14	--
Dissolved Oxygen (mg/L)	1.32	--	--	--	--	--	--	--	--	1.43	--	0.7	2.09	--
ORP (mV)	127	--	--	--	--	--	--	--	--	153	--	150	142	--
Temperature (°C)	12.34	--	--	--	--	--	--	--	--	13.2	--	14.11	12.04	--
Dissolved Manganese (mg/L)	<0.05	--	--	--	--	--	--	--	--	<0.05	--	<0.05	0.05	--
Dissolved Ferrous Iron (mg/L)	<0.2	--	--	--	--	--	--	--	--	0.2	--	0.2	<0.2	--
Nitrate (mg/L)	<0.025	--	--	--	--	--	--	--	--	0.470	--	3.1	0.44	--
Sulfate (mg/L)	30.00	--	--	--	--	--	--	--	--	89.0	--	36.0	31.0	--
TOC (mg/L)	1.00	--	--	--	--	--	--	--	--	0.53	--	1.00	<0.50	--
SWMU 54 Twelfth Quarter (May 2014) Water Quality Parameters														
pH	7.79	--	--	--	--	--	--	--	--	6.93	--	NM	NM	--
Conductivity (mS/cm)	0.469	--	--	--	--	--	--	--	--	0.582	--	0.453	0.47	--
Turbidity (NTU)	3	--	--	--	--	--	--	--	--	3.8	--	10	9	--
Dissolved Oxygen (mg/L)	1.65	--	--	--	--	--	--	--	--	1.56	--	2.25	1.14	--
ORP (mV)	222.3	--	--	--	--	--	--	--	--	127.4	--	272.1	71.3	--
Temperature (°C)	16.61	--	--	--	--	--	--	--	--	12.81	--	14.61	16.57	--
Dissolved Manganese (mg/L)	0.05	--	--	--	--	--	--	--	--	0.1	--	0.1	0.05	--
Dissolved Ferrous Iron (mg/L)	0.2	--	--	--	--	--	--	--	--	<0.2	--	0.2	0.2	--
Nitrate (mg/L)	0.031	--	--	--	--	--	--	--	--	0.330	--	1.6	0.41	--
Sulfate (mg/L)	29.0	--	--	--	--	--	--	--	--	58.0	--	31.0	27.0	--
TOC (mg/L)	51.0	--	--	--	--	--	--	--	--	62.0	--	<0.50	<0.50	--

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Thirteenth Quarter (September 2015) Water Quality Parameters														
pH	6.7	--	--	--	--	--	--	--	--	6.8	--	5.4	6.69	--
Conductivity (mS/cm)	0.471	--	--	--	--	--	--	--	--	329	--	0.557	0.529	--
Turbidity (NTU)	0.65	--	--	--	--	--	--	--	--	30.7	--	2.66	1.00	--
Dissolved Oxygen (mg/L)	0.75	--	--	--	--	--	--	--	--	8.2	--	6.0	6.53	--
ORP (mV)	180	--	--	--	--	--	--	--	--	71	--	264	198.0	--
Temperature (°C)	14.14	--	--	--	--	--	--	--	--	15.8	--	14.8	14.83	--
Dissolved Manganese (mg/L)	0.087	--	--	--	--	--	--	--	--	0.081	--	0.066	0.081	--
Dissolved Ferrous Iron (mg/L)	0	--	--	--	--	--	--	--	--	0.11	--	0.07	0.11	--
Nitrate (mg/L)	0.14	--	--	--	--	--	--	--	--	0.25	--	0.92	0.5	--
Sulfate (mg/L)	25	--	--	--	--	--	--	--	--	23	--	24	26	--
TOC (mg/L)	4.1	--	--	--	--	--	--	--	--	8.1	--	8.3	13	--
SWMU 54 Fourteenth Quarter (January 2016) Water Quality Parameters														
pH	7.60	--	--	--	--	--	--	--	--	6.16	--	6.79	7.01	--
Conductivity (mS/cm)	2.8	--	--	--	--	--	--	--	--	0.54	--	589.5	324.0	--
Turbidity (NTU)	0.78	--	--	--	--	--	--	--	--	0.88	--	5.8	7.99	--
Dissolved Oxygen (mg/L)	9.89	--	--	--	--	--	--	--	--	6.70	--	8.6	8.74	--
ORP (mV)	76.2	--	--	--	--	--	--	--	--	89.3	--	92.4	73.2	--
Temperature (°C)	9.6	--	--	--	--	--	--	--	--	12.7	--	12.4	11.6	--
Dissolved Manganese (mg/L)	0.063	--	--	--	--	--	--	--	--	0.054	--	0.030	0.063	--
Dissolved Ferrous Iron (mg/L)	0	--	--	--	--	--	--	--	--	0.0	--	0.10	0.05	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.45	--	2.5	0.46	--
Sulfate (mg/L)	26	--	--	--	--	--	--	--	--	76	--	45	20	--
TOC (mg/L)	1.5	--	--	--	--	--	--	--	--	0.97	--	1.8	1.8	--
SWMU 54 Fifteenth Quarter (April 2016) Water Quality Parameters														
pH	7.61	--	--	--	--	--	--	--	--	6.71	--	6.44	6.77	--
Conductivity (mS/cm)	440	--	--	--	--	--	--	--	--	602	--	353	229	--
Turbidity (NTU)	0.3	--	--	--	--	--	--	--	--	3.74	--	5.7	1.16	--
Dissolved Oxygen (mg/L)	4	--	--	--	--	--	--	--	--	0.61	--	5.8	6.86	--
ORP (mV)	51	--	--	--	--	--	--	--	--	73.5	--	93.4	76.8	--
Temperature (°C)	12.01	--	--	--	--	--	--	--	--	13.4	--	14.32	13.52	--
Dissolved Manganese (mg/L)	0.021	--	--	--	--	--	--	--	--	0.057	--	0.020	0.025	--
Dissolved Ferrous Iron (mg/L)	0.02	--	--	--	--	--	--	--	--	0.03	--	0.04	0.02	--
Nitrate (mg/L)	0.14	--	--	--	--	--	--	--	--	0.18	--	1.3	0.43	--
Sulfate (mg/L)	29	--	--	--	--	--	--	--	--	83	--	27	19	--
TOC (mg/L)	4.2	--	--	--	--	--	--	--	--	8.9	--	6.8	0.68	--

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

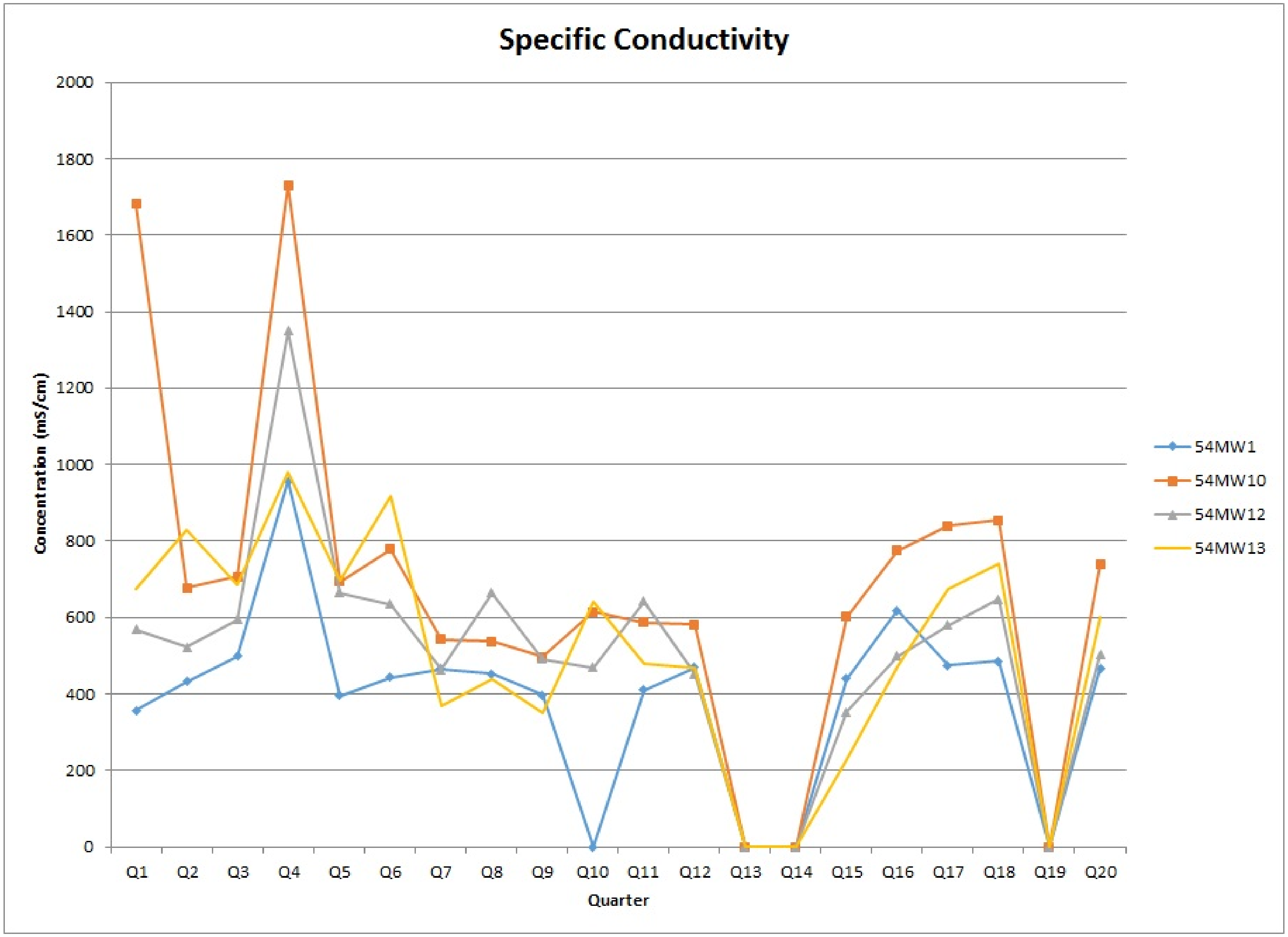
Well ID	54MW1	2	3	4	5	6	7	8	9	10	11	12	13	14
SWMU 54 Sixteenth Quarter (July 2016) Water Quality Parameters														
pH	6.82	--	--	--	--	--	--	--	--	7.39	--	6.32	7.27	--
Conductivity (mS/cm)	619	--	--	--	--	--	--	--	--	775	--	499	473.0	--
Turbidity (NTU)	4.62	--	--	--	--	--	--	--	--	5.36	--	6.50	0.72	--
Dissolved Oxygen (mg/L)	3.14	--	--	--	--	--	--	--	--	0.37	--	4.60	2.09	--
ORP (mV)	-10.1	--	--	--	--	--	--	--	--	109	--	8.2	12.0	--
Temperature (°C)	16.56	--	--	--	--	--	--	--	--	13.79	--	14.33	15.2	--
Dissolved Manganese (mg/L)	0.062	--	--	--	--	--	--	--	--	0.048	--	0.033	0.031	--
Dissolved Ferrous Iron (mg/L)	0.14	--	--	--	--	--	--	--	--	0.02	--	0.02	0.00	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.47	--	0.81	0.60	--
Sulfate (mg/L)	29	--	--	--	--	--	--	--	--	93	--	25	36	--
TOC (mg/L)	0.92	--	--	--	--	--	--	--	--	0.58	--	1.2	0.78	--
SWMU 54 Seventeenth Quarter (October 2016) Water Quality Parameters														
pH	7.28	--	--	--	--	--	--	--	--	5.91	--	6.34	6.92	--
Conductivity (mS/cm)	474	--	--	--	--	--	--	--	--	839	--	579	673	--
Turbidity (NTU)	0.14	--	--	--	--	--	--	--	--	3.22	--	3.02	9.98	--
Dissolved Oxygen (mg/L)	2.60	--	--	--	--	--	--	--	--	0.54	--	5.05	3.40	--
ORP (mV)	138.2	--	--	--	--	--	--	--	--	69.1	--	30.4	44.8	--
Temperature (°C)	14.48	--	--	--	--	--	--	--	--	14.63	--	15.55	13.10	--
Dissolved Manganese (mg/L)	0.049	--	--	--	--	--	--	--	--	0.003	--	0.038	0.061	--
Dissolved Ferrous Iron (mg/L)	0.05	--	--	--	--	--	--	--	--	0.52	--	0.00	0.08	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.26	--	1.2	0.49	--
Sulfate (mg/L)	30	--	--	--	--	--	--	--	--	150	--	41	38	--
TOC (mg/L)	1.5	--	--	--	--	--	--	--	--	0.55	--	0.99	1.5	--
SWMU 54 Eighteenth Quarter (January 2017) Water Quality Parameters														
pH	7.43	--	--	--	--	--	--	--	--	7.19	--	6.70	7.04	--
Conductivity (mS/cm)	486.2	--	--	--	--	--	--	--	--	854	--	647.5	740	--
Turbidity (NTU)	0.28	--	--	--	--	--	--	--	--	1.39	--	1.04	8.20	--
Dissolved Oxygen (mg/L)	2.21	--	--	--	--	--	--	--	--	1.40	--	5.40	3.29	--
ORP (mV)	74.8	--	--	--	--	--	--	--	--	49	--	75	71	--
Temperature (°C)	12.8	--	--	--	--	--	--	--	--	12.5	--	11.8	11.7	--
Dissolved Manganese (mg/L)	0.036	--	--	--	--	--	--	--	--	0.069	--	0.040	0.060	--
Dissolved Ferrous Iron (mg/L)	0.00	--	--	--	--	--	--	--	--	0.04	--	0.00	0.03	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.38	--	0.94	0.48	--
Sulfate (mg/L)	31	--	--	--	--	--	--	--	--	110	--	38	42	--
TOC (mg/L)	0.56	--	--	--	--	--	--	--	--	1.5	--	1.4	1.5	--

Table 6-2 Water Quality Parameters for Groundwater Performance Monitoring at SWMU 54 (Continued)

SWMU 54 Nineteenth Quarter (April 2017) Water Quality Parameters														
pH	7.65	--	--	--	--	--	--	--	--	6.88	--	6.70	6.97	--
Conductivity (mS/cm)	0.443	--	--	--	--	--	--	--	--	0.614	--	0.627	0.474	--
Turbidity (NTU)	0.25	--	--	--	--	--	--	--	--	0.71	--	1.92	14.2	--
Dissolved Oxygen (mg/L)	8.38	--	--	--	--	--	--	--	--	3.2	--	5.39	4.74	--
ORP (mV)	91.0	--	--	--	--	--	--	--	--	57.3	--	93.4	77.5	--
Temperature (°C)	13.1	--	--	--	--	--	--	--	--	13.80	--	13.1	14	--
Dissolved Manganese (mg/L)	0.049	--	--	--	--	--	--	--	--	0.039	--	0.036	0.067	--
Dissolved Ferrous Iron (mg/L)	0.00	--	--	--	--	--	--	--	--	0.04	--	0.02	0.14	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.3	--	1	0.44	--
Sulfate (mg/L)	33	--	--	--	--	--	--	--	--	65	--	47	30	--
TOC (mg/L)	3.3	--	--	--	--	--	--	--	--	6.9	--	6.7	4.4	--
SWMU 54 Twentieth Quarter (July 2017) Water Quality Parameters														
pH	7.43	--	--	--	--	--	--	--	--	7.00	--	6.63	7.00	--
Conductivity (mS/cm)	468	--	--	--	--	--	--	--	--	740	--	505	600	--
Turbidity (NTU)	0.52	--	--	--	--	--	--	--	--	0.52	--	0.71	1.36	--
Dissolved Oxygen (mg/L)	0.69	--	--	--	--	--	--	--	--	0.83	--	0.11	0.01	--
ORP (mV)	116.5	--	--	--	--	--	--	--	--	24.1	--	85.5	15.5	--
Temperature (°C)	14.8	--	--	--	--	--	--	--	--	14.9	--	13.7	14.8	--
Dissolved Manganese (mg/L)	0.031	--	--	--	--	--	--	--	--	0.060	--	0.073	0.084	--
Dissolved Ferrous Iron (mg/L)	0.00	--	--	--	--	--	--	--	--	0.05	--	0.07	0.08	--
Nitrate (mg/L)	0.15	--	--	--	--	--	--	--	--	0.10	--	0.75	0.56	--
Sulfate (mg/L)	28	--	--	--	--	--	--	--	--	110	--	32	32	--
TOC (mg/L)	0.71	--	--	--	--	--	--	--	--	2.6	--	1.5	1.9	--

Notes:
-- = Wells eliminated from monitoring program
°C = degrees Celsius
mg/L =- milligrams per liter
mS/cm = milliseimens per centimeter
NM = not measured
NTU = Nephelometric Turbidity Unit mV - millivolts

Figure 6-4 SWMU54: Specific Conductivity



Notes:

1. Specific conductivity was not measured at 54MW1 during Quarter 10.

2. Specific conductivity readings for quarters 13, 14, and 19 for all four wells were not used due to possible unit entry error.

Figure 6-5 SWMU54: 54MW10 Ferrous Iron, Dissolved Manganese, Nitrate, and Sulfate Concentrations

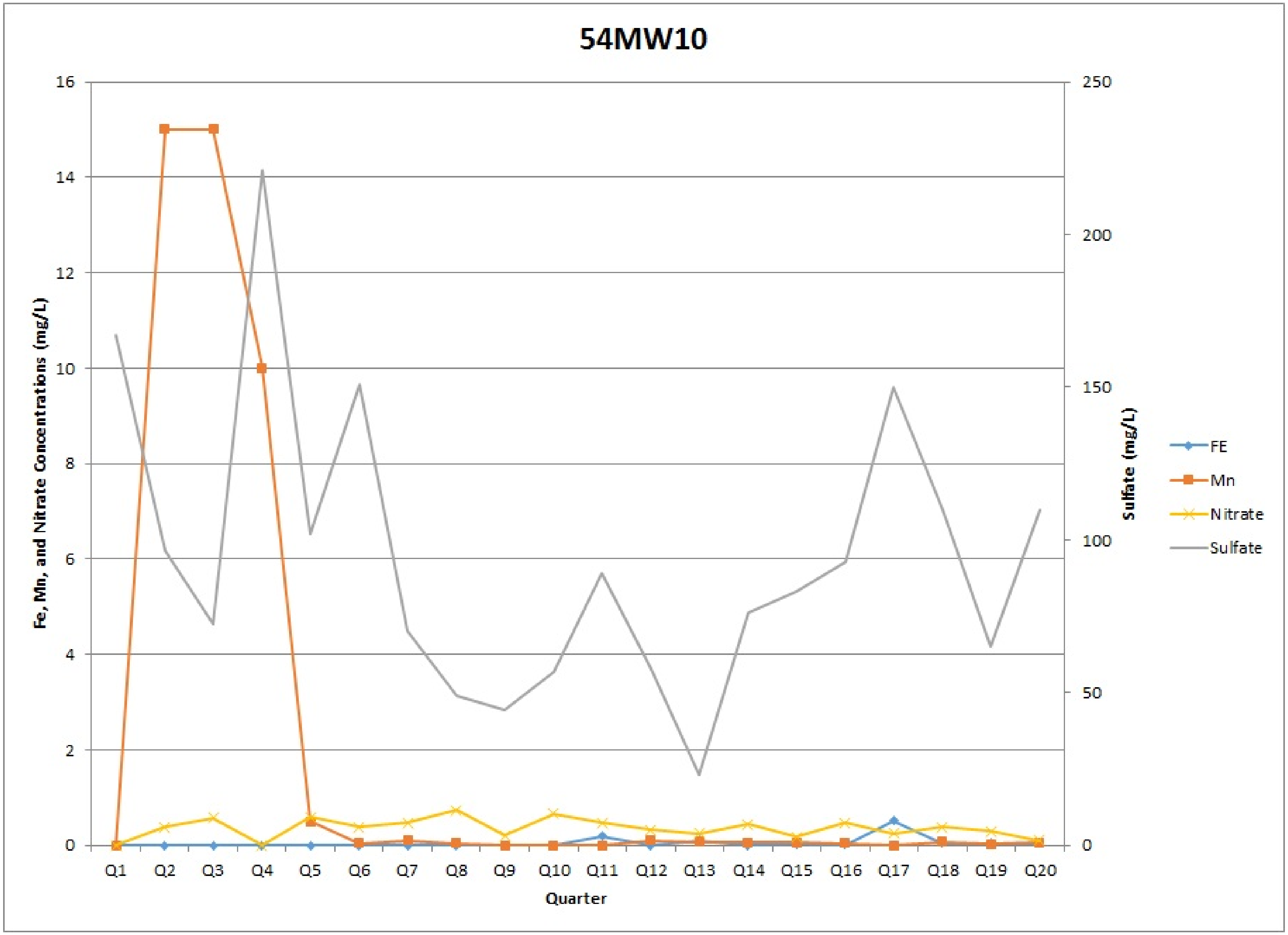


Figure 6-6 SWMU54: 54MW12 Ferrous Iron, Dissolved Manganese, Nitrate, and Sulfate Concentration

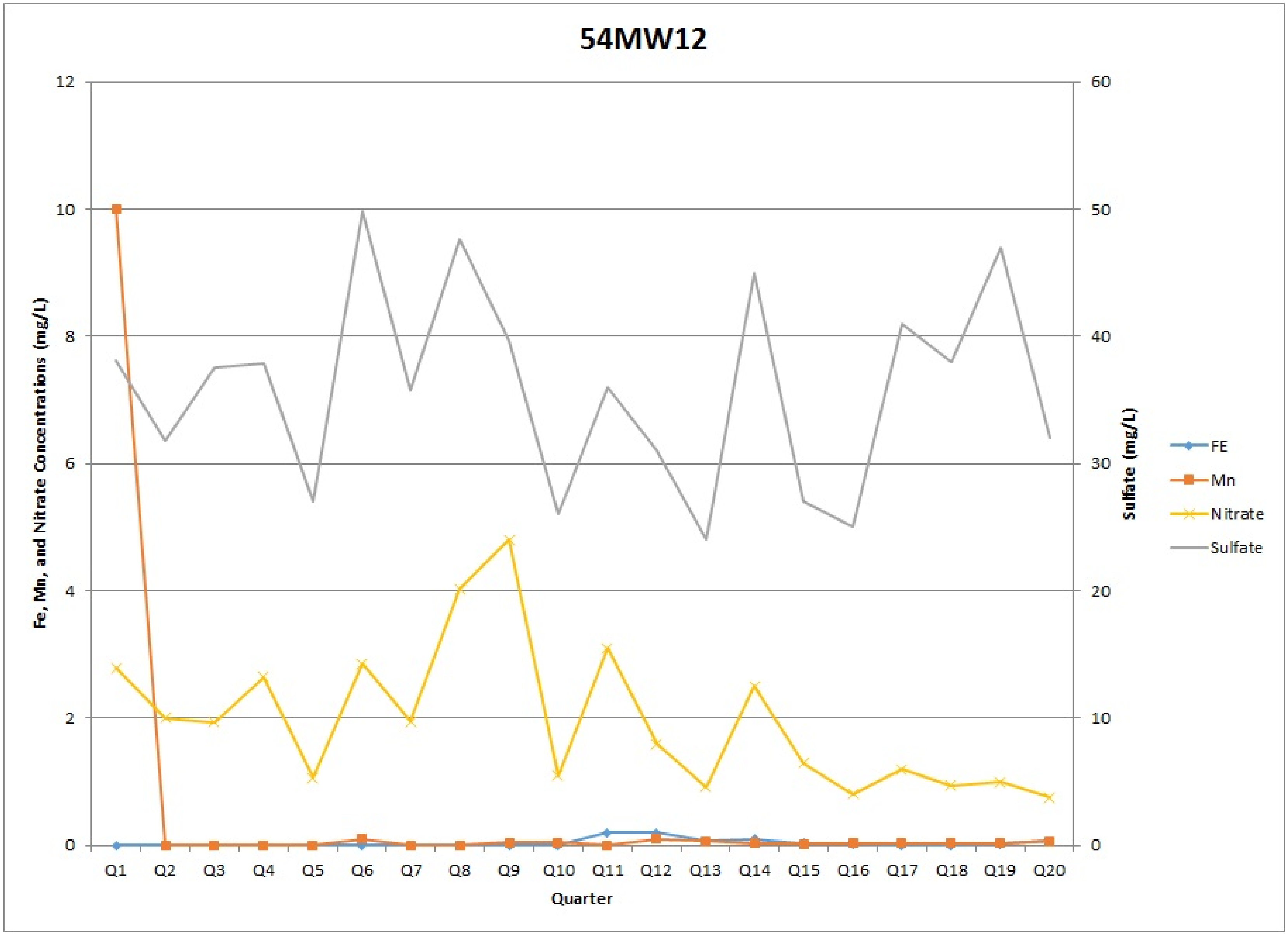


Figure 6-7 SWMU54: 54MW13 Ferrous Iron, Dissolved Manganese, Nitrate, and Sulfate Concentrations

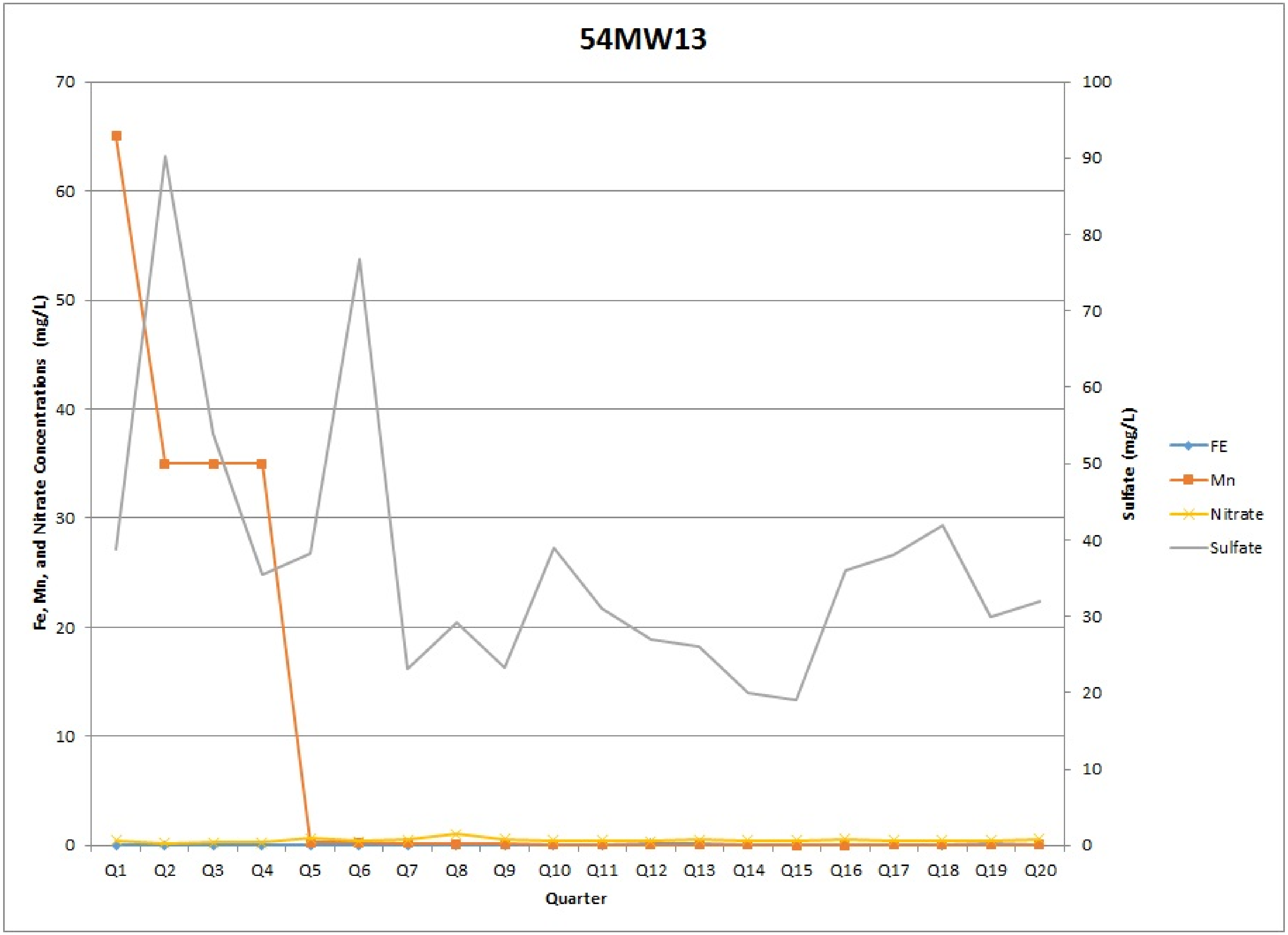


Figure 6-8 SWMU54: 54MW10 TOC, DO, and ORP Concentrations

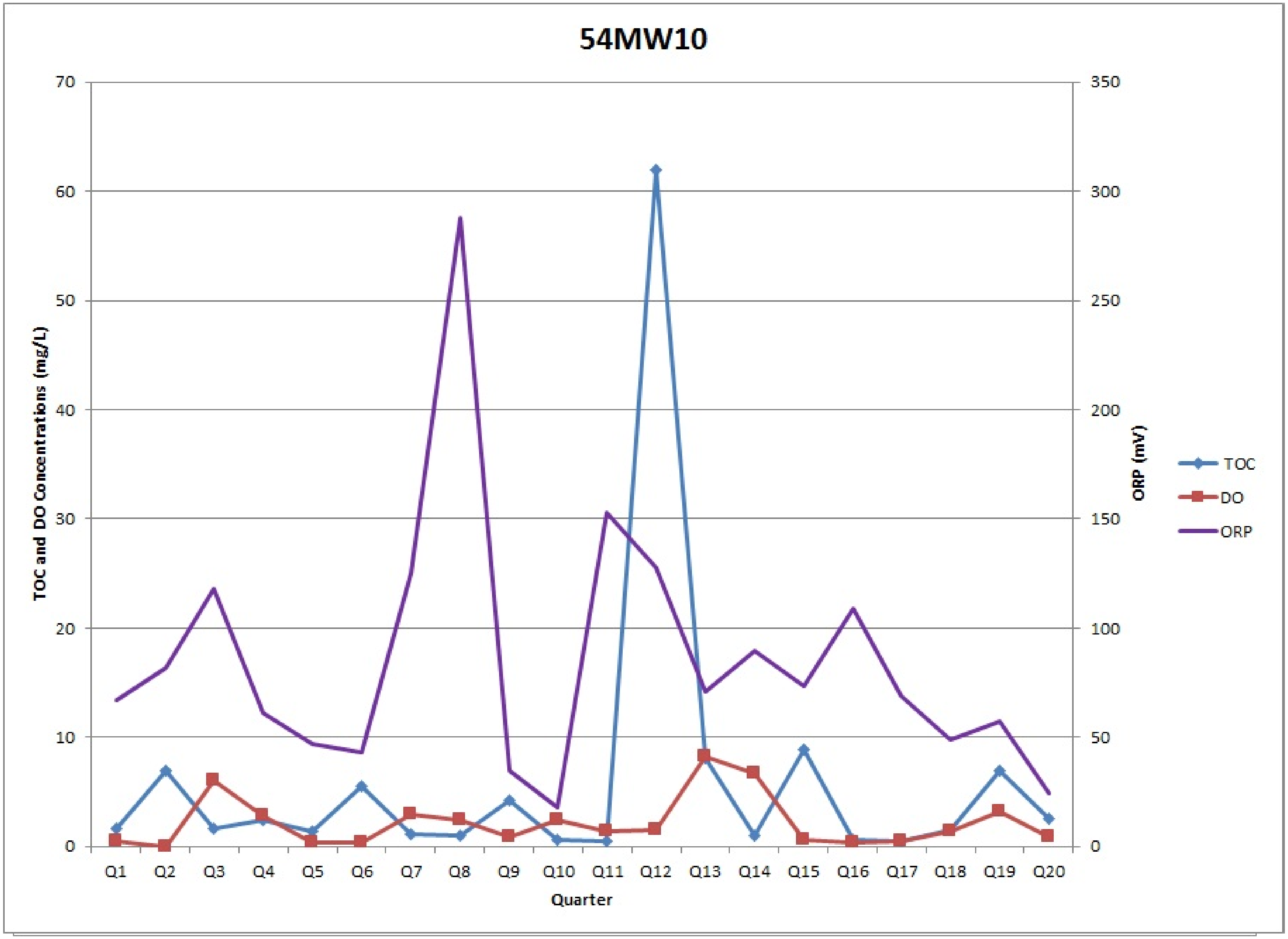


Figure 6-9 SWMU54: 54MW12 TOC, DO, and ORP Concentrations

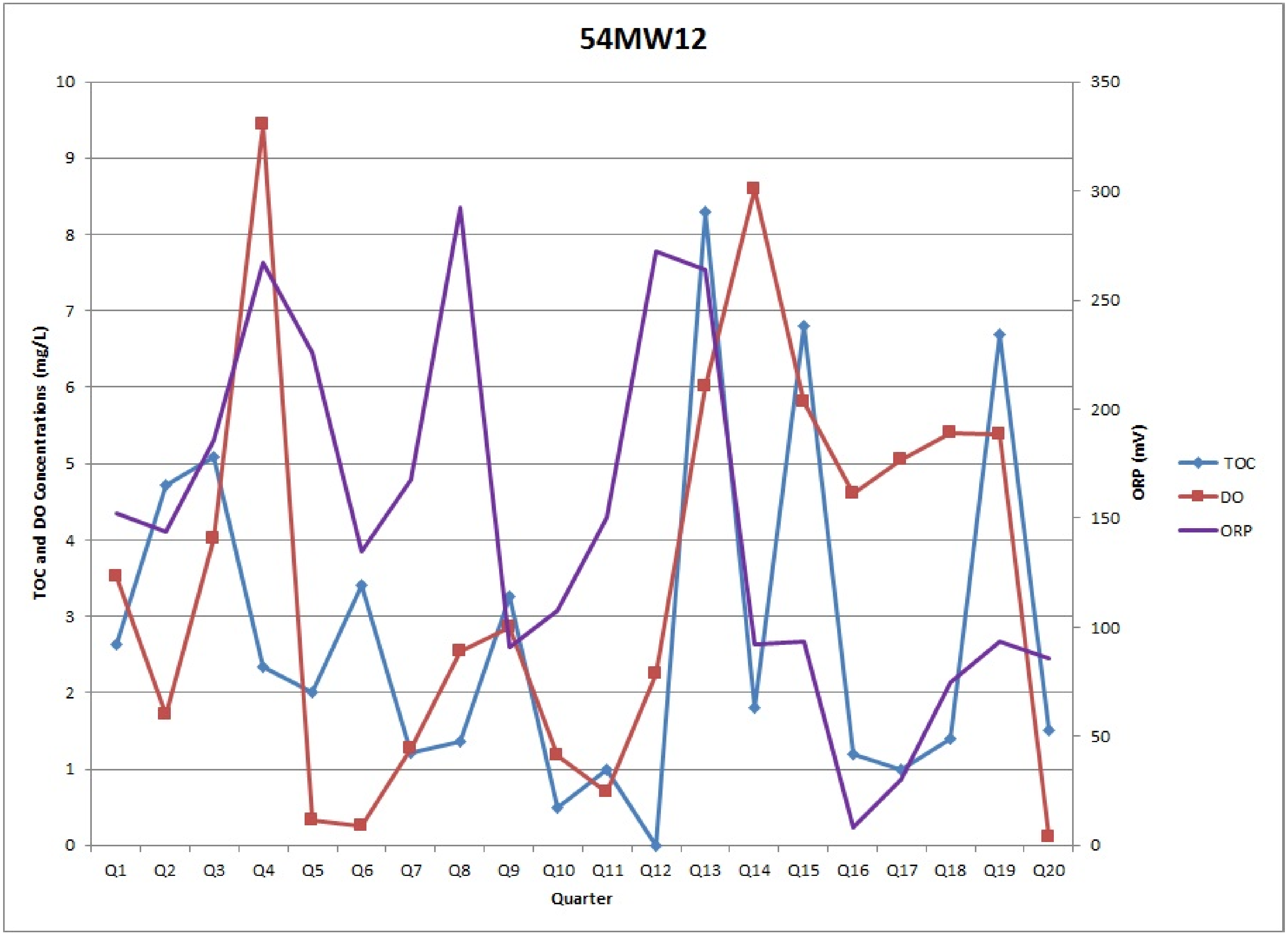
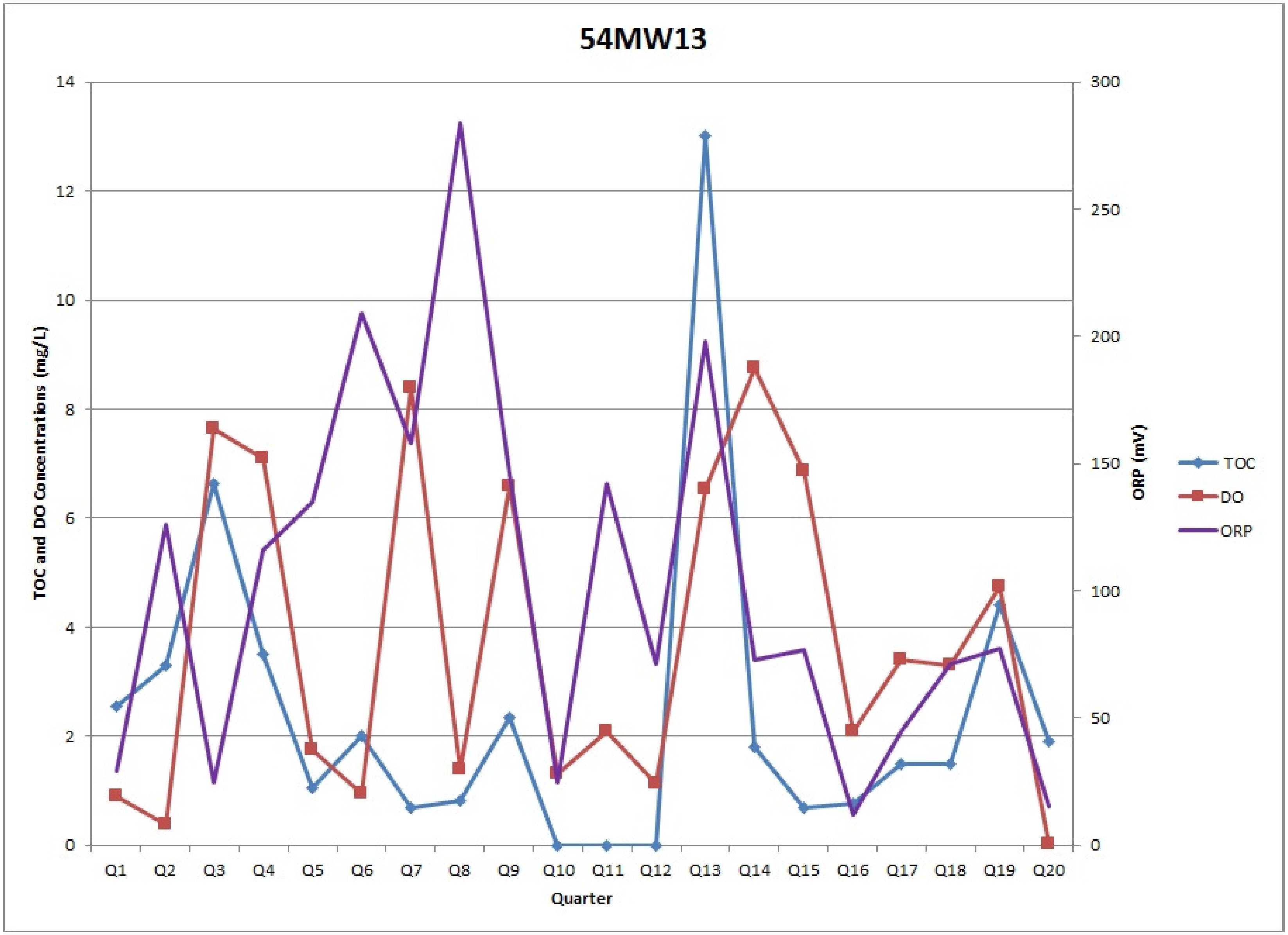


Figure 6-10 SWMU54: 54MW13 TOC, DO, and ORP Concentrations



7.0 Summary and Conclusions

This report covers 5 years of groundwater monitoring. Fourteen (14) groundwater monitoring wells were sampled on a quarterly basis for over 2 years (nine quarters) at SWMU 54. After the ninth and tenth quarters, the monitoring program was reduced to the three wells (54MW10, 54MW12, and 54MW13), which have had COI concentrations above RGs, and an upgradient well (54MW1). Samples collected during the first twelve quarters were analyzed for explosives, perchlorate, and MNA indicators. During quarters 10 through 20, samples were also analyzed for RDX breakdown products. Sample results were compared to RGs and evaluated to determine whether MNA is occurring at the SWMU. This report presents and summarizes the analytical results of the first five years (twenty quarters) of monitoring.

Based on contaminant concentrations and biological indicator parameters measured in groundwater at SWMU 54, MNA processes are reducing the concentrations of 2,4,6-TNT and RDX. These processes include biodegradation and to a lesser extent sorption, dilution, dispersion, and chemical stabilization. The data also suggest that the MNA processes are preventing downgradient plume expansion and decreasing nitroaromatic and perchlorate mass.

In summary, the following conclusions and recommendations are made regarding the potential for MNA in contaminated groundwater at SWMU 54:

- Presence of 2,4,6-TNT daughter products 2ADNT and 4ADNT is further evidence that biological degradation has occurred, which may be aiding in removing mass in the groundwater.
- Identification of RDX breakdown products DNX, MNX, and TNX indicate active degradation of RDX, although breakdown products were less prevalent during the year four monitoring period and not detected during the year five monitoring period.
- All perchlorate concentrations in the third, fourth, and fifth years of monitoring are below the RG and showed a steady decline in concentrations during this three year period.

Observed concentrations of DO (0.01 mg/L to 8.38 mg/L) and ORP (15.5 mV to 138.2 mV) during year five indicated both aerobic and anaerobic conditions exist at SWMU 54. However, aerobic conditions were determined to be more prevalent. While TNT has been known to be degraded under a variety of conditions (aerobic and anaerobic), further degradation of 2ADNT, 4ADNT, and reduction of RDX and perchlorate is more favorable under anaerobic conditions (Spain, 1995).

The source removal efforts at SWMU 54 appear to have been effective in significantly lowering the site-wide COIs in groundwater. This is evident by the fact that eleven of the fourteen monitoring well locations (54MW1 through 54MW9, 54MW11, and 54MW14) had observed concentrations below site selected RGs for eight consecutive quarters for 2,4,6-TNT, DNT mixture, RDX, and perchlorate. As recommended in the *Final SWMU 54 MNA IMWP* (Shaw, 2011a), and *SWMU 54 MNA Sampling Year 2 Report* (CB&I, 2013) these wells were removed from the MNA sampling program after the ninth and tenth quarters.

Historic pore water samples PW-1, PW-3, PW-5, PW-8, and PW-9 from the New River sediments directly downgradient from SWMU54 had no detections of explosives or perchlorate in two years of sampling, indicating no measurable influence of contaminated groundwater on the New River. As recommended in the *Final SWMU 54 MNA IMWP* (Shaw, 2011a) and *SWMU 54 MNA Sampling Year 2 Report* (CB&I, 2013), the pore water sample locations were removed from the MNA sampling program after quarter 9 (August 2013).

Explosives concentrations through twenty quarters of groundwater monitoring indicate that limited biodegradation at well locations 54MW10, 54MW12, and 54MW13 (SWMU 54 Area A wells) is occurring. Based on the localized distribution of elevated constituents and the generally declining concentrations site-wide and the fact that groundwater is bounded within RFAAP by the New River and its use can be controlled by RFAAP, an active groundwater remedy at SWMU54 does not appear necessary at this time. However, the nineteenth quarter of sample collection included the third most elevated concentrations of explosive COIs reported at monitoring well 54MW12, warranting continued monitoring. The sharp increase in explosive concentrations at 54MW12 during the nineteenth quarter occurred under aerobic conditions. Biodegradation is not as effective under aerobic conditions to reduce explosives and perchlorates concentrations. As a result of the subsurface biochemistry, the decreased biological activity may have led to an increase in the explosives and perchlorate concentrations during this period.

The direction and speed of groundwater flow is consistent across all reporting periods and the current network of groundwater monitoring wells are adequate for future groundwater monitoring events. It is our recommendation that groundwater monitoring continues on a quarterly basis at well locations 54MW10, 54MW12, and 54MW13. In addition to monitoring wells 54MW10, 54MW12, and 54MW13, monitoring well 54MW1 will continue to be monitored as an upgradient well, despite meeting the criteria for being removed from the network.

8.0 References

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Appendix A
Field Sampling Logs
(electronic only)

Appendix B-1
Data Validation Reports
(electronic only)

Appendix B-2

Laboratory Analytical Reports

(electronic only)