FIVE YEAR REVIEW FOR BELTSVILLE AGRICULTURAL RESEARCH CENTER

Beltsville Agricultural Research Center
Beltsville, Maryland

Prepared for:
U.S. Department of Agriculture
Agricultural Research Center
Beltsville, Maryland

Prepared by:
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June 2018

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Five Year Review – Authorizing Signature

7/12/18

Howard Zhang, Center Director

Date

United States Department of Agriculture – Beltsville Agricultural Research Center

Five Year Review – Authorizing Signature

HOWARD ZHANG

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Date: 2018.07.02 12:58:15 -04'00'

Howard Zhang, Center Director **Date**

United States Department of Agriculture – Beltsville Agricultural Research Center

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List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirement
ARS	Agricultural Research Service
AWQC	Ambient Water Quality Criteria
BARC	Beltsville Agricultural Research Center
BDRLF	Beaverdam Road Landfill
BMT	BMT Designers & Planners, Inc.
BW	Biowall Well
CAHs	Chlorinated Aliphatic Hydrocarbons
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of Concern
COPC	Contaminant of Potential Concern
CWA	Clean Water Act
DCE	Dichloroethene
EPA	United States Environmental Protection Agency
ERA	Environmental Risk Assessment
FS	Feasibility Study
FYR	Five-Year Review
HHRA	Human Health Risk Assessment
ICs	Institutional Controls
LUCs	Land Use Controls
LUCIP	Land Use Control Implementation Plan
MCL	Maximum Contaminant Levels
MDE	Maryland Department of the Environment
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	Operation and Maintenance
OC	Organochlorine
ORP	Oxygen Reduction Potential
OU	Operable Unit
PA/SI	Preliminary Assessment/Site Inspection
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
PMP	Performance Monitoring Plan
PP	Proposed Plan
PRP	Potentially Responsible Party

List of Acronyms

RACR	Remedial Action Completion Report
RAO	Remedial Action Objectives
RBC	Risk Based Concentration
RD	Remedial Design
RI	Remedial Investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SDWA	Safe Drinking Water Act
SSP	Site Screening Process
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TBC	To be considered
TCE	Trichloroethylene
TCL	Target Compound List
TOC	Total Organic Carbon
TW	Transect Well
UMD	University of Maryland
USDA	United States Department of Agriculture
UU/UE	Unlimited Use/Unrestricted Exposure
VOC	Volatile Organic Compound

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Five Year Review Summary Form

SITE IDENTIFICATION		
Site Name: USDA Beltsville Agricultural Research Center		
EPA ID: MD0120508940		
Region: 3	**State:** MD	**City/County:** Beltsville, Prince Georges County

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

REVIEW STATUS
Lead agency: Other Federal Agency ***[If "Other Federal Agency", enter Agency name]*:** United States Department of Agriculture
Author name (Project Manager): Dana Jackson, P.G.
Author affiliation: USDA
Review period: 7/22/2013 - 12/31/2017
Date of site inspection: 11/21/2017
Type of review: Statutory
Review number: 1
Triggering action date: 7/22/2013
Due date *(five years after triggering action date)*: 7/22/2018

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1. Introduction

1.1. Objectives

As stated in EPA's *Comprehensive Five-Year Review Guidance,* OSWER Directive 9355.7-03B-P (EPA, 2001), "[t]he purpose of a Five-Year Review (FYR) is to evaluate the implementation and performance of a remedy in order to determine if the remedy is or will be protective of human health and the environment." The methods, findings, and conclusions of reviews are documented in FYR reports and these reports identify issues found during the review, if any, and document recommendations to address them.

This FYR has been prepared by the United States Department of Agriculture (USDA) Beltsville Agricultural Research Center (BARC) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121, consistent with the National Contingency Plan (NCP)(40 CFR Section 300.430(f)(4)(ii)), and considering EPA policy and guidance.

This is the first FYR for the BARC sites. The triggering action for this statutory review is the on-site construction start date (July 22, 2013) of the BARC 27 Beaverdam Road Landfill (BDRLF) Operable Unit (OU)-05 biowall remedial action. The FYR has been prepared due to the fact that hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure (UU/UE).

The BARC facility consists of eight (8) designated OUs, of which one (1) OU-05 will be addressed in this FYR. The BDRLF remedy addresses volatile organic compounds (VOCs) in groundwater; the specific VOCs that have been identified above their respective actions levels include trichloroethylene (TCE) groundwater contamination above its Maximum Contaminant Levels (MCLs), as well as TCE breakdown products (1,1 Dichlorothene (DCE), cis 1,2 DCE, and Vinyl Chloride), which are created by reductive dechlorination. Additional VOCs may be added to the COC list if they are present at concentrations greater than their MCL.

The seven (7) OUs that are not addressed in this FYR are:

- OU-11: BARC 4/19 (Remedial Investigation / Feasibility Study (RI/FS) ongoing)
- OU-01: BARC 6 Biodegradable Site (RI/FS underway)
- OU-04: BARC 12 Chemical Disposal Pits (RI/FS underway)
- OU currently unassigned: BARC 32 (RI/FS underway)
- OU currently unassigned: ENTECH 7 (RI/FS underway)
- OU currently unassigned: EPIC 7/8 (RI/FS underway)
- OU-02: College Park Landfill (Proposed Plan (PP) underway)

The BARC facility FYR has been led by Mr. Dana Jackson, PG USDA Agricultural Research Service (ARS) Remedial Project Manager (RPM). Participants included the contractor Program Manager David Kindig, P.E. (BMT), Remediation Engineer Jason Lorenzetti (BMT), Environmental Scientist David Schanzle (BMT), Research Microbiologist Birthe Veno Kjellerup University of Maryland (UMD), Research Microbiologist Cathleen Hapeman (USDA ARS), Engineering Research Alba Torrents (UMD), and Microbiology Graduate Student Shahrzad Saffari (UMD). The designated Environmental Protection Agency (EPA) RPM, Jeff Boylan (EPA Region 3) was notified of the initiation of the five-year review. The review process was initiated on October 2, 2017.

1.2. Report Organization

This FYR report has been organized in accordance with EPA guidance (EPA, 2001). The report includes the following sections, some of which are only partially applicable to the BARC facility at this time:

Section 1 – Introduction – Description of FYR requirement and facility background.

Section 2 – Response Action Summary – Description of the completed remedies and Operations and Maintenance (O&M) activities.

Section 3 – Progress Since Last Review – Descriptions of significant changes since previous FYR.

Section 4 – Five Year Review Process – Discussion of specific activities conducted in support of this FYR.

Section 5 – Technical Assessment – Review and assessment of each OU’s remedy performance in terms of protectiveness.

Section 6 – Issues/Recommendations – Summary of all issues and recommendations to address those issues.

Section 7 – Protectiveness Statement – The Protectiveness Statement for each OU based on the technical assessment and identified issues.

Section 8 – Next Review – When the next FYR will be completed.

Section 9 – References

1.3. Facility Background

BARC is operated by USDA ARS. It is a 6,600 acre facility located in the northwestern portion of Prince Georges County, Maryland which consists of agricultural fields, offices, and research laboratories. Due to historical operational practices, a number of areas within the BARC complex have been identified as being of environmental concern. BARC was proposed for inclusion on the National Priorities List (NPL) in May of 1993, and formally added to the NPL in 1994. A site map depicting the location of BARC is included as Figure 1.1.

1.4. Site Background

Based on analysis of historic records, the BDRLF was used for disposal of unidentifiable solid wastes, possibly as early as 1943 (ENTECH, 1997). BDRLF was reported in the 1991 Preliminary Assessment/Site Investigation (PA/SI) to have been used as a disposal site for nonhazardous substances such as building rubble (e.g., masonry and miscellaneous construction debris); vegetation such as tree clippings and wood; and broken asphalt (APEX, 1991). The 1991 PA/SI reviewed the history of the site, and found that the landfill had been poorly monitored and there are no records of actual disposal activity, or landfill contents. The PA/SI determined disposal operations continued through the 1980s, after which time the landfill was closed and covered with a geo-synthetic liner beneath a clay cap (ENTECH, 1997a and KCI, 1991). A site map depicting the location of the BDRLF OU within BARC is included as Figure 1.2.

An Industrial Waste Management Permit (permit number 85-16-26) was issued by the State of Maryland Department of Health and Mental Hygiene on March 1, 1985, a requirement of which included the installation of 4 monitoring wells to be sampled annually for pH, conductivity, hardness, chlorides, total dissolved solids, chemical oxygen demand, and total dissolved organic carbon (MDE, 1985). The BDRLF Post Closure Care and Monitoring Plan proposed a semi-annual groundwater sampling program (KCI, 1991); however, it is uncertain if the site was monitored on a regular basis.

At the time of the 1996 field reconnaissance, access to the BDRLF was limited, and maintenance operations designed to ensure the integrity of the cap were the only activities being conducted. A walk-over of the fill area did not reveal any evidence of debris at the surface or protruding from the landfill, although a small area of surface debris was observed in the woods just east of the landfill during the field reconnaissance. These materials, which were situated inside the eastern perimeter fence, were comprised primarily of construction and household wastes, including empty 55-gallon drums and a large compressed gas cylinder. Additionally, four monitoring wells, (one up-gradient and three down-gradient) on the perimeter of the landfill were observed (ENTECH, 1997a).

1.4.1. Hydrogeology

The BDRLF hydrogeology is discussed in depth in the Annual Sampling Reports; the following provides a short summary of the most important hydrogeological information for the BDRLF site as it pertains to the assessment of the remedy. The Year Four Annual Sampling Report has been included as Appendix A, and includes a detailed summary of hydrogeology of BARC in general with a focus on BDRLF.

Contamination is limited to a 200 foot wide plume within the near surface shallow aquifer. This aquifer lies within the unconfined Quaternary river terrace deposits found within the larger Beaverdam Creek stream valley and is underlain by the Arundel Clay formation. Groundwater within and directly adjacent to the biowall is typically encountered between 5 and 9 feet below ground surface (bgs). Groundwater flows southward from the landfill towards an unnamed tributary of Beaverdam Creek located approximately 300 feet south of the landfill site.

The downward vertical migration of groundwater within the contaminated shallow aquifer is limited by the presence of the underlying Arundel Clay formation. The Arundel Clay formation south of the BDRLF occurs between 20 to 25 feet bgs (BMT, 2011). The Arundel Clay has a low permeability and is a competent confining layer, segregating TCE-contaminated shallow groundwater from the underlying Patuxent aquifer, which is used for potable supply by BARC and surrounding populations and is not contaminated. Recharge of the Patuxent aquifer occurs by downward percolation of precipitation in the outcrop areas that trend northeast-southwest and are located several miles west of the BDRLF.

Based on post remedial aquifer testing using breakdown products and confirmed with a bromide dye tracer, the groundwater flows past the biowall at approximately 20 to 25 feet per year, significantly faster than pre-construction aquifer testing that found the groundwater velocity to be 2.4 feet per year. To date, no preferential pathway has been identified. The 2017 Aquifer Testing Report for BDRLF, which includes the bromide dye tracer study and assessment of groundwater velocity using transport of the breakdown products has been included as Appendix B.

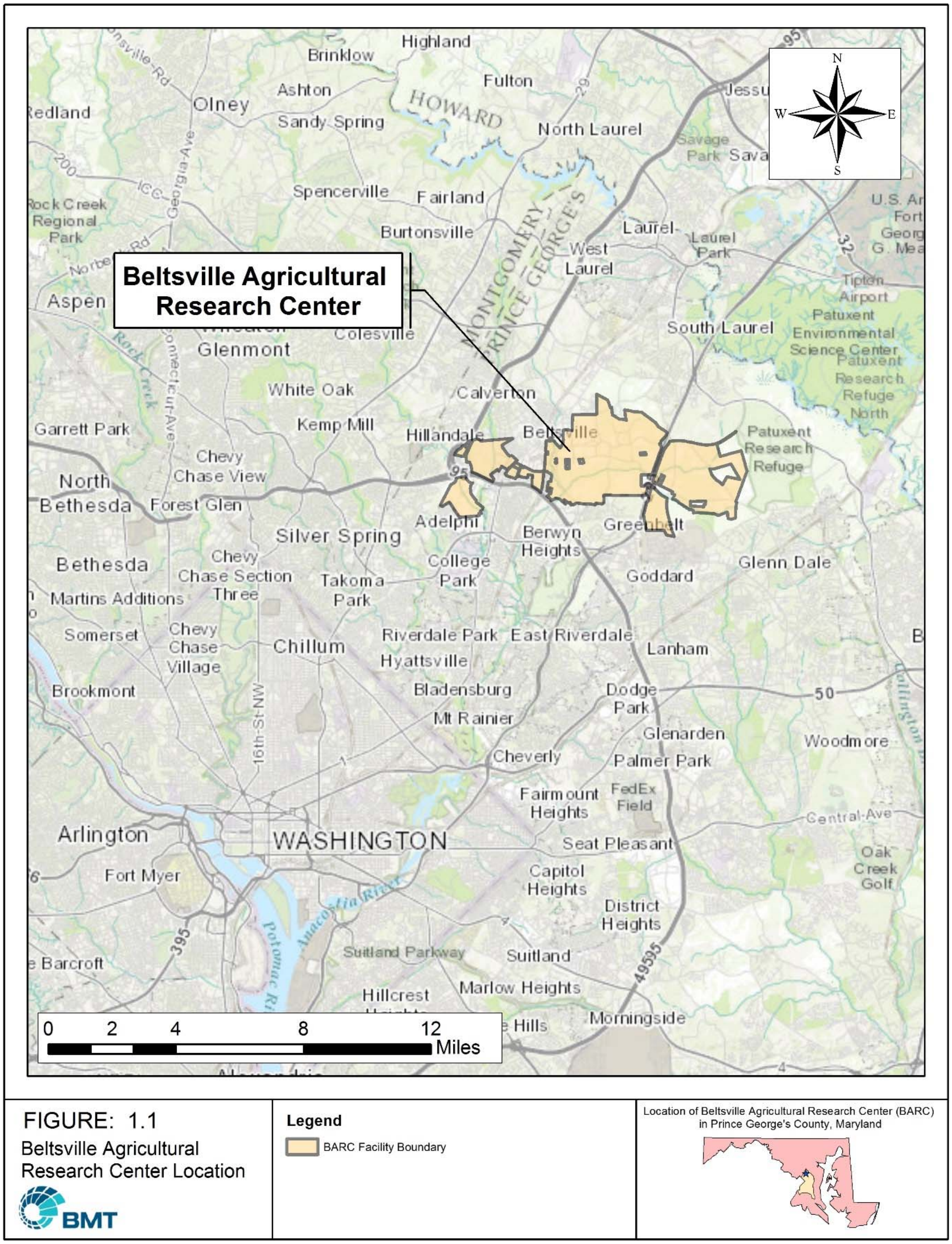

Figure 1.1 BARC Location Map

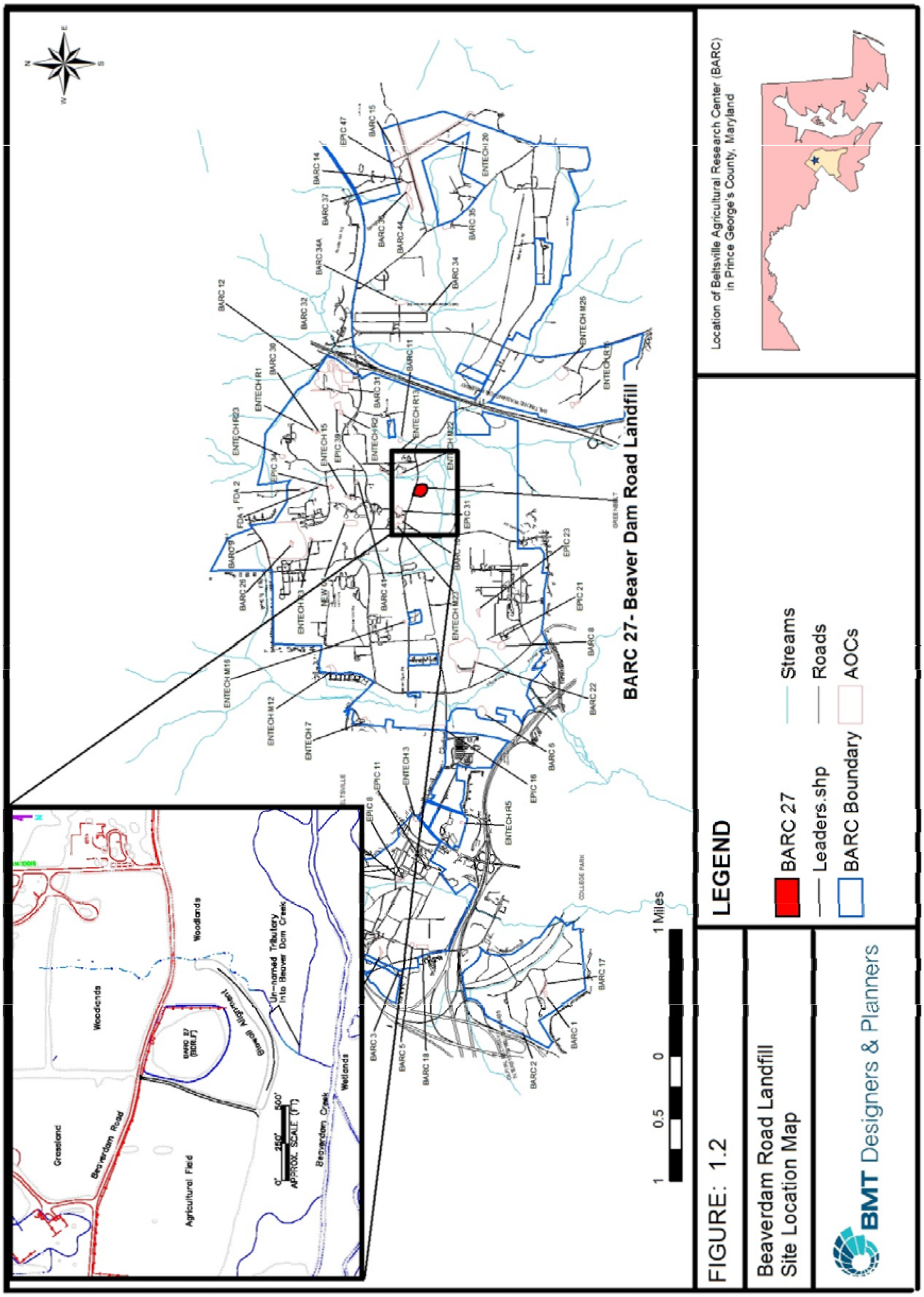

Figure 1.2 Site Location Map

2. Response Action Summary – Beaverdam Road Landfill

The following section summarizes response actions developed for and implemented at the BDRLF site as described in the site-specific Record of Decision (ROD) as well as the investigation, selection of the response action, and implementation of the selected response action for the BDRLF contaminated groundwater plume of TCE.

2.1. Basis for Taking Action

The RI conducted for the site examined groundwater, soils, surface water, and sediment; however, groundwater was the only environmental medium identified that posed an unacceptable risk. The RI identified a plume of groundwater contaminated with TCE. The plume was estimated to be approximately 650 feet wide by 450 feet long and was located southeast (downgradient) of the landfill (Figure 2.1). At the completion of the RI, the maximum observed concentration of TCE in the groundwater plume was in excess of 600 parts per billion (ppb), which is above its MCL and therefore presented an unacceptable risk to future site residents. Though unlikely to be present, the unacceptable risk and presence of TCE above its MCL precluded the site for closure under UU/UE.

2.1.1. Preliminary Assessment/Site Inspection (1991)

A PA/SI Report was completed for the BDRLF site in 1991. The PA/SI was initiated based on internal verbal reports from BARC staff regarding historic practice to dispose of unknown hazardous materials in the landfill. The PA/SI did not locate any records, nor was it able to identify the nature or volume of hazardous materials reportedly disposed of in BDRLF. The PA/SI report considered this landfill to have a low potential to release hazardous substances in the future; therefore, no sampling data was collected during the PA/SI (Apex, 1991).

2.1.2. Field Reconnaissance Study (1996)

A field reconnaissance was conducted in 1996; and included a review of landfill records, an inspection of the landfill cap, and adjacent areas. The reconnaissance identified waste outside of the primary landfill footprint, which indicated that dumping and disposals actions may have been conducted over a wider area than previously reported (ENTECH, 1997a). The identified surface debris included three 55-gallon motor oil drums and gas cylinders. The reconnaissance also identified four existing groundwater monitoring wells three down-gradient and one up-gradient of the site.

The field reconnaissance indicated the predominant potential migration pathway at BDRLF was shallow groundwater. The identified potential groundwater receptors included wildlife living in the vicinity of the site; and ecological receptors in the adjacent wetlands and Beaver Dam Creek which was identified as potentially to be receiving inflow from the shallow groundwater system. Other potential exposure pathways include down-gradient surface water and groundwater use.

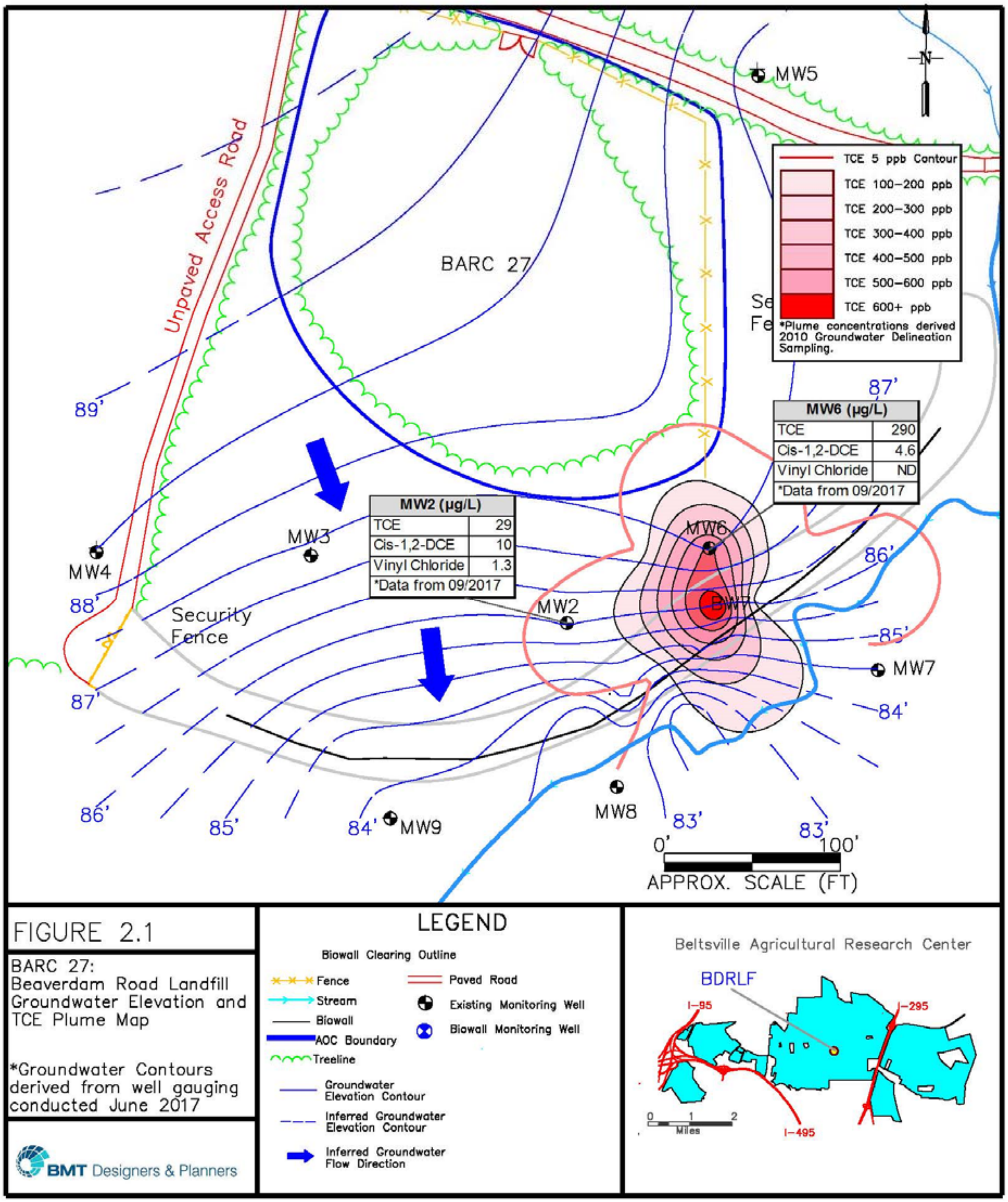

Figure 2.1 BDRLF TCE Groundwater Plume (2017)

2.1.3. Baseline Groundwater Sampling (1997)

Baseline groundwater sampling was conducted at BDRLF in June 1997. The purpose of the sampling event was to confirm the integrity of the groundwater monitoring wells and collect one round of samples to support site characterization and human health risk screening.

Baseline groundwater sampling of the existing well included:

- Inspection and development of existing wells,
- Location survey of monitoring wells,
- Groundwater gaging,
- Determination of groundwater flow direction,
- Groundwater sampling for:
  - target compound list (TCL) volatile organic compounds (VOCs),
  - semi-volatile organic compounds (SVOCs),
  - organochlorine (OC) pesticides,
  - polychlorinated biphenyls (PCBs), and
  - target analyte list (TAL) metals (filtered and unfiltered)

The analytical results indicated a number of VOC chlorinated ethene compounds were present in groundwater, with TCE being above the screening criteria. TCE and other VOCs were identified as Contaminants of Potential Concern (COPCs) for BDRLF.

2.1.4. Desktop Data Collection Study (1998)

A facility-wide Desktop Data Collection Report was completed in 1998. The report included interviews with BARC staff, who stated the BDRLF had received laboratory wastes (ENTECH, 1997). The Report recommended no additional action be taken at BDRLF; unless additional records were uncovered, or data collected, to suggest chemicals were historically disposed of at the site (USDA, 1988). An Industrial Waste Management Permit for March 1985 through March 1990 (MDE, 1985), and a state-approved Post Closure Care and Monitoring Plan (KCI, 1991), both for the BDRLF site, were obtained and reviewed as part of the facility-wide Desktop Data Collection Study. Limited groundwater analytical results (inorganics and water quality parameters) were reported (Kidde Consultants, 1990).

2.1.5. Site Screening Process (1999)

BARC included the BDRLF site in the SSP program, and the BDRLF Site Screening Process (SSP) investigation took place in January 1999. The SSP activities included full multimedia sampling:

- Sampling the four existing groundwater monitoring wells (including one upgradient well).

- Groundwater sampling using Geoprobe® direct push methods at nine locations, including seven along the perimeter of the landfill, and two between the existing down-gradient wells and the unnamed tributary to Beaver Dam Creek.
- Surface water and sediment sampling at five locations, including two in the wetland at the base of the landfill, and three in the unnamed creek (including 1 upgradient location).

Surface water and sediment samples were analyzed for TCL VOCs, SVOCs, OC pesticides, PCBs, and TAL metals. As previous sampling had not detected SVOCs, pesticides, or PCBs, the collected groundwater samples were analyzed for TCL VOCs and TAL metals only.

The sampling confirmed the presence of groundwater contamination. The COPCs identified during the SSP risk screen included the chlorinated VOCs, specifically TCE. The analyzed samples collected as part of the SSP report did not include detection of TCE degradation products DCE or VC, Other VOCs detected above EPA Region III risk-based concentrations (RBCs) included chloroform and methylene chloride, and low (below MCL) detections of pesticides and metals, which were not retained as COPCs (ENTECH, 1998).

2.1.6. Remedial Investigation (2003)

Based on the SSP findings that chlorinated solvents were present at concentrations above their screening criteria and MCLs, a RI was performed at the BDRLF (BMT, 2008). The RI included a soil gas survey, a soils investigation, a Geoprobe® groundwater investigation, a surface water and sediment investigation, installation of additional monitoring wells and sampling, wetlands delineation, and a baseline human health and ecological risk assessment. The RI work plan was submitted to the EPA for review and approval. Following EPA approval, the RI activities were carried out.

The soil gas survey was completed to identify likely locations of VOC contamination within the shallow aquifer, and provide data for assessing soil vapor risk to potential receptors. The survey included the collection of 62 soil gas samples from across the site from the toe of the landfill to the creek (BMT, 2008). The results of the soil gas sampling indicated the presence of two distinct high concentration VOC hot spots. Both were situated in the wooded area below the landfill; one approximately 140 feet south-southwest, and the other approximately 120 feet southeast. VOCs detected in soil gas at these locations included tetrachloroethylene (PCE), TCE, and related breakdown products. These results correlated with the groundwater investigation results.

Components of the RI soil investigation consisted of advancement of twenty soil borings, soil sampling, and conductivity measurement and logging. The purpose of the soil boring program was to characterize and delineate areas of suspected soil contamination due to VOCs, and identify optimal locations for placement of additional monitoring wells. The locations selected for soil boring was based on the existing groundwater data, results of the soil gas survey, and assessment of the site.

The results of the RI confirmed that the contaminants of concern (COC) at BDRLF were TCE and its breakdown products (1,1- DCE, trans-1,2-DCE, cis-1,2-DCE, and vinyl chloride) in groundwater. TCE and/or its breakdown products were detected in all environmental media sampled with the exception of stream sediment (i.e., soil gas, surface soil, subsurface soil, groundwater, and surface water). Only TCE was present in groundwater at concentrations in excess of its Safe Drinking Water Act (SDWA) MCL. No exceedances of the COCs were found in site surface water or soil.

A baseline human health risk assessment (HHRA) performed as part of the RI found no unacceptable cancer or non-cancer risks for exposure to any environmental media at BDRLF to existing receptor populations. Receptor populations assessed included adult and adolescent visitors and trespassers; however, unacceptable risks were estimated for hypothetical future residents' exposure to groundwater through ingestion and dermal contact through an activity such as showering.

The ecological risk assessment (ERA) found it was not necessary to establish clean-up levels and remediation goals for the BDRLF as there are no complete or potentially completed ecological exposure pathways to the groundwater contamination (SRC 2007 and BMT, 2008). Ecological pathways are evaluated annually as part of the annual performance monitoring and semi-annual BDRLF sampling. The groundwater impacts, and potential risks to future residents required remedial action at BDRLF.

2.1.7. Feasibility Study Report (2008)

The FS evaluated potential remedial action alternatives that address groundwater contamination in the vicinity of BDRLF. The FS report (BMT, 2008a) provided ARS and EPA with the information necessary to identify a preferred alternative, which was then presented to the public in a PP.

The remedial action objective (RAO) for the BDRLF is to prevent future human exposures to contaminated groundwater, specifically TCE and its breakdown products. To ensure that this RAO is met, a number of remedial alternatives were evaluated in the FS to assess their protectiveness.

Applicable, Relevant and Appropriate Requirements (ARARs) for addressing groundwater and surface water contamination at the site were identified and reviewed. The ARARs for BDRLF include Federal SDWA MCLs, Federal Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC), and State of Maryland Water Quality Standards. These ARARs were used for the design, analysis, and proposed remedial alternatives.

Remedial technologies associated with a list of general response actions were screened in the FS for effectiveness and applicability based on current BDRLF site conditions and possible future land use. Potentially applicable technologies were further screened based on effectiveness, reliability, implementability, and estimated cost. Based on the applicable technologies, the following remedial alternatives were developed in the FS to address groundwater contamination at the BDRLF:

1. Alternative 1 - No Action
2. Alternative 2 - Institutional controls and long term groundwater monitoring.
3. Alternative 3 - Monitored natural attenuation, institutional controls and long term groundwater monitoring.
4. Alternative 4 - Groundwater treatment via a permeable reactive barrier (e.g., a mulch biowall), and institutional controls.
5. Alternative 5 - Groundwater extraction and onsite treatment/discharge or recharge, and institutional controls.

2.1.8. Proposed Plan (2009)

The PP was issued as part of public participation requirements under Section 300.430(f)(2) of the NCP. The PP (USDA, 2009) identified the preferred alternative for cleaning up contaminated groundwater at the BDRLF and provides the rationale for this preference. In addition, the PP included summaries of other possible cleanup alternatives that were considered and evaluated for use at this site.

The PP identified a mulch biowall and land use controls (LUCs) as the preferred alternative for remediating groundwater at the BDRLF (Alternative 4). This alternative was selected because it is expected to achieve substantial and long-term risk reduction sooner and cost less than other alternatives. It does not require the construction or installation of complex engineering systems or equipment, requires minimal maintenance, uses readily available and inexpensive raw materials, and does not produce any toxic byproducts.

This remedial alternative included implementing LUCs until remedial action objectives are achieved. These controls were necessary to protect the integrity of the selected remedy and to prevent exposure to TCE as the remedial process progresses. LUCs are intended to safeguard against current or future exposure to contaminated groundwater by human populations. These include:

- A prohibition against the use of contaminated groundwater as a potable water source until cleanup levels are met.
- The prohibition of construction of buildings (industrial or residential) over the plume which may potentially be at risk due to vapor intrusion (the area of applicability for such ICs will be the known area of the groundwater plume that exceeds the MCL for TCE (5 µg/L). The applicability of ICs also extends to the area directly under the landfill.

- Other access restrictions including complete site enclosure enforced by fencing and signage.

2.1.9. Record of Decision (2011)

The BDRLF ROD was finalized in September 2011; the ROD presents the final selected remedy for addressing contaminated groundwater at BDRLF (USDA, 2011). The ROD document is the official record discussing the results of the RI/FS process, the community participation activities conducted as part of the PP and during the execution of the ROD, and the selection of the remedy by USDA, ARS and EPA.

The ROD presents the final RAOs for the site:

- Remediate groundwater quality to reduce concentrations of chlorinated VOCs below MCLs.
- Prevent unacceptable human health exposure to site-related COCs.
- Minimize future migration of groundwater contamination.

The ROD stipulated that LUCs were required; including physical barriers and institutional controls (ICs). ICs for the BDRLF site include notifications on applicable deeds, facility regulations to prohibit the transfer of contaminated land, and internal USDA processes that control and protect staff, visitors, and site workers from risks associated with the contaminated groundwater. The ROD includes the requirement that the LUCs be maintained and are inspected at regular intervals.

The ROD specifies the selected remedy (the design and construction of a biowall) for the treatment of VOCs in groundwater. The BDRLF ROD requires the completion of FYR until RAOs have been achieved and remediation goals (RGs) defined in the ROD have been met to allow for UU/UE (USDA, 2011).

Public comment and input was solicited throughout the PP and ROD, including multiple announcements and public meetings. Where appropriate, responses to questions from the public were included in the ROD. USDA maintains a website and physical data repository to inform the public, and publishes updated Fact Sheets on all sites, including BDRLF each year.

2.2. Status of Implementation

The BDRLF Biowall was installed on July 20, 2013 in accordance with the Remedial Design (RD) Work Plan (BMT, 2013), and described in the Remedial Action Completion Report (RACR) (BMT, 2017a). A Performance Monitoring Plan (PMP) was established in October, 2013 to measure and evaluate the effectiveness of the remedy, which included the installation of additional monitoring wells and the implementation of a regular monitoring and analysis program that is detailed in the PMP (BMT, 2014).

The PMP includes the following monitoring activities, which are ongoing at BDRLF:

- Biweekly water quality monitoring for select groundwater monitoring wells and biowall piezometers, including gathering the following data:
  - Water level, pH, Dissolved oxygen, Turbidity, Specific conductivity, Temperature, Salinity, Oxygen Reduction Potential (ORP)
- Quarterly groundwater reporting; summarizing the biweekly sampling and any other collected data or observations.
- Semi-annual sampling and reporting; including:
  - Water level monitoring and water quality parameters for all monitoring wells,
  - Analytical sampling for VOCs and nutrients in groundwater, and
  - Trend analysis for factors associated with anaerobic degeneration of TCE and breakdown products.

BARC published the Third Annual Sampling Report in March 2017, the Fourth Annual Sampling Report is in preparation, and the data for the Fifth Annual Sampling Report is currently being collected.

2.2.1. Summary of Land Use Controls (2013)

The ROD for the BDRLF site specified that LUCs were to be implemented to prevent potential unacceptable risks to human receptors from exposure to TCE and breakdown products in groundwater. The LUCs were implemented immediately following the installation of the biowall and include:

- Prohibitions against use of contaminated groundwater as a potable water source until cleanup levels are achieved.
- The prohibition of construction of buildings (industrial or residential) over the plume, which will eliminate the risk of vapor intrusion.
- Restrict access to the site through the use of fencing and signage.
- Prohibit disposal of hazardous and non-hazardous waste at the BDRLF.
- Maintain the integrity of any current or future remedial or monitoring systems.

A LUC Remedial Design (LUC RD) was prepared as the land use component of the Remedial Design following the completion of the remedy; a LUC Implementation Plan (LUCIP) was completed, and is currently the primary document in use for implementing LUCs. In accordance with the LUCIP, LUC Inspections have been conducted on an annual basis.

A review of the physical LUCs on November 21, 2017 determined the majority of the site fencing was in place, with some areas requiring repair and some areas need to be extended to fully fence the site. The entrance gate used to access the site is consistently locked and secured when authorized personnel are not present. Some of the site fencing backing on to undeveloped BARC owned woodlands was found to be in disrepair, though due to the difficult terrain, and full ownership by BARC, trespassing via this route is considered unlikely. BARC is developing additional signage for posting at the BDRLF.

Table 2.1 Summary of Planned and Implemented LUCs

Media, engineered controls, and areas that do not support Unrestricted Use/Unlimited Exposure (UU/UE) based on current conditions	Institutional Controls Required	ICs Called for in the Decision Documents	Impacted Parcel(s)	IC Objective	Title of IC Instrument Implemented and Date (or planned)
Groundwater (GW)	Yes	Yes	BDRLF – Central Farm, BARC	GW use restriction Restriction on well construction Restriction on activities with subsurface activities Restriction on construction	Land Use Control Implementation Plan (April 2016)

2.2.2. Systems Operations/Operation & Maintenance

Site Maintenance

Periodic site maintenance has been performed on the BDRLF site since the implementation of the remedy. The access road turn around area in front of the access gate to the biowall was filled with gravel and graded in 2016 to ensure safe vehicular access to the biowall alignment. Additional road improvements were conducted on the access road alongside the biowall to ensure safe access for monitoring equipment and personnel. These site activities were detailed in annual LUCIP inspection reports. The site is visited biweekly, at minimum, and changing conditions are identified and reported to BARC maintenance to be addressed.

Performance Monitoring Activities

Following installation of the remedy, a PMP was implemented to monitor the performance of the biowall over time. PMP activities included:

- Biweekly water quality monitoring of the biowall wells.
- Quarterly groundwater sampling of wells located within the biowall.
- Semi-annual groundwater sampling of biowall wells, downgradient surface water and monitoring wells installed during previous investigations.

Results of the monitoring and sampling program are detailed in quarterly monitoring reports and annual performance monitoring reviews that are prepared and submitted to ARS and EPA by the support contractor for review. Based on the findings of the PMP, additional investigations and research has been conducted at the biowall to fully evaluate performance. These investigations included:

- Aquifer testing to determine plume migration velocity
- Microbial sampling to identify key bacterial populations within the biowall.

The results from these additional monitoring activities are detailed in separate reports and included in the annual performance review reports.

3. Progress Since Last Review

This report presents the first FYR for BARC, and the first for the BDRLF OU-05. No previous FYRs or protectiveness determinations have been completed for BARC sites.

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4. Five Year Review Process

4.1. Community Notification, Involvement

BARC published a public notice titled *Commencement of Five Year Review for Environmental Restoration at Beltsville Agricultural Research Center* in the Prince George's Sentinel and The Prince George's Post, local newspapers of record that have hosted previous BARC CERCLA announcements. In addition, a copy of the announcement was posted in the ARS library. The announcement was published in both newspapers on February 8, 2018, stating a five-year review was being conducted and inviting the public to submit any comments to BARC. Copies of the published announcements from the Prince Georges Sentinel and the Prince George's Post are presented in Appendix C. The results of the review and the report will be made available at the BARC information repository located at:

Information Repository
Building 003, Room 014
10300 Baltimore Avenue
Beltsville Agricultural Research Center
Beltsville, MD 20705

4.2. Stakeholder Interviews

During the FYR process, interviews were conducted to document any perceived problems or successes with the remedy that has been implemented to date**.** The results of these interviews are summarized below, and the interview forms are included as Appendix D. BDRLF site is the only site undergoing review, and is fully located within the bounds of BARC, as such, stakeholder interviews were conducted with the following personnel; the names of the interviewees have been withheld for privacy:

- Security Officer – Manages gate access, fencing, and assures no trespassing or dumping on BARC property.
- Wildlife Management Officer – Manages public and USDA employee only hunting areas.
- Farm Services Manager – Manages plantings and agricultural activities at USDA field sites.
- Roads and Ground Manager – Manages access, snow removal, fence maintenance, and maintenance along county and private road right-of-ways.
- Primary On-Site Environmental Contractor – Accesses the site biweekly, performs environmental sampling and manages all environmental activities.

None of the personnel interviewed expressed reason to be concerned with the protectiveness of the site. None of the interviewees reported trespassers, hunting, or other issues associated with the BDRLF site. The Wildlife Management Officer stated hunting was allowed to the west and east of the BDRLF site, but since the implementation of the remedy, no hunting has been allowed on the site. The Farm Services

Manager was aware of the site, and reported no issues associated with the activities ongoing at the BDRLF site. No interviewees reported additional spills, staining, or odors associated with the BDRLF site or remedy implementation.

4.3. BDRLF Site Data Review

The performance of the biowall is evaluated by its effectiveness in degrading COCs (i.e., chlorinated aliphatic hydrocarbons [CAHs]) in groundwater as it flows through the biowall. In order to accurately evaluate the effectiveness of the biowall, CAH concentrations in groundwater are monitored over time from established transect wells and biowall wells (BW). The change in CAH concentrations in individual groundwater increments as they flow through the biowall over time is imperative to an accurate evaluation of contaminant reduction due to the biowall. This time-course data evaluation relies on known contaminant transport rates in the biowall and the surrounding formation.

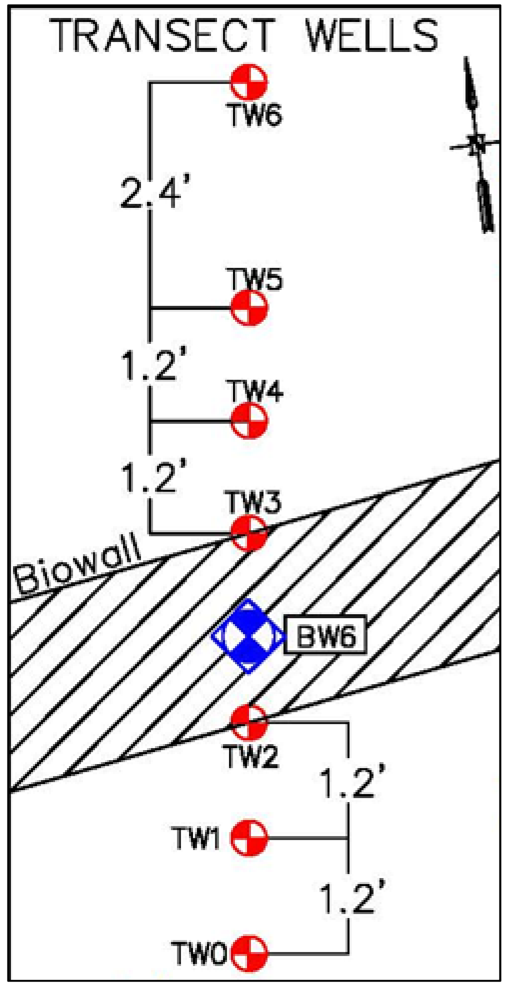

Figure 4.1 Biowall Transect Wells

In addition to CAH trends, the performance monitoring includes assessment of plume toxicity, groundwater conditions measurement and assessment, aquifer testing, and microbial sampling and analysis. Each of these activities is summarized below; with full review and analysis provided in the annual sampling reports. The Year Four Annual Sampling Report has been included as Appendix A and includes a detailed discussion of the performance of the remedy, current groundwater conditions, and a summary of the analytical sampling results.

4.3.1. CAH Groundwater Trends

Biowall performance has been derived from quarterly groundwater sampling events conducted at the biowall, specifically within a series of 'transect' wells (TW) that were installed orthogonal to the primary direction of groundwater flow within the TCE plume. TCE is the primary CAH by volume in upgradient groundwater and cis-1,2-DCE is the primary CAH in downgradient groundwater by volume. Vinyl chloride is present at low concentrations, but has a significantly lower MCL. DCE is also a precursor to vinyl chloride indicating significant vinyl chloride will need to be removed following the DCE dechlorination step. TW6 is considered representative of upgradient groundwater VOC concentrations, and TW1 and TW0 are considered representative of downgradient groundwater VOC concentrations. Figure 4.1, shows the existing Transect Wells used for performance monitoring and their approximate separation distance in feet. TW6, TW5, TW4, and TW3 are located upgradient (north) of the biowall, TW3, BW6, and TW2 are located within the wall, and TW1, and TW0 are located downgradient (south) of the biowall. These wells are located in the region of highest TCE groundwater concentration.

Trends for TCE, DCE, and VC from Remedy Installation to End of Year 4, have been tracked through time and from TW6 (upgradient) to TW1 (downgradient) (Figure 4.2); TW0 was installed after the start of the trend analysis data collection. Year Four data is provided in Appendix A and is generally consistent with previous monitoring results; increasing concentrations of downgradient DCE and VC; while TCE remains below detection limits. As shown below, TCE in upgradient well TW6 decreased to non-detectable levels in the downgradient well by March 2014, while DCE and VC increased in concentration. The DCE and VC trends are relatively consistent since March 2014, with some seasonal variation observed throughout the monitoring period. This trend data demonstrates the biowall is successfully dechlorinating TCE to the intermediate DCE compounds, and some DCE is being reduced to VC and ethene. However, DCE and VC are not completing the dechlorination cycle.

Based on groundwater gaging data, groundwater flows from TW6 to TW0 in approximately 60 to 100 days, depending on the season (Section 4.3.3, below), and has a biowall residence time of two to three months. This is considered sufficient to complete full degradation of TCE and its daughter products.

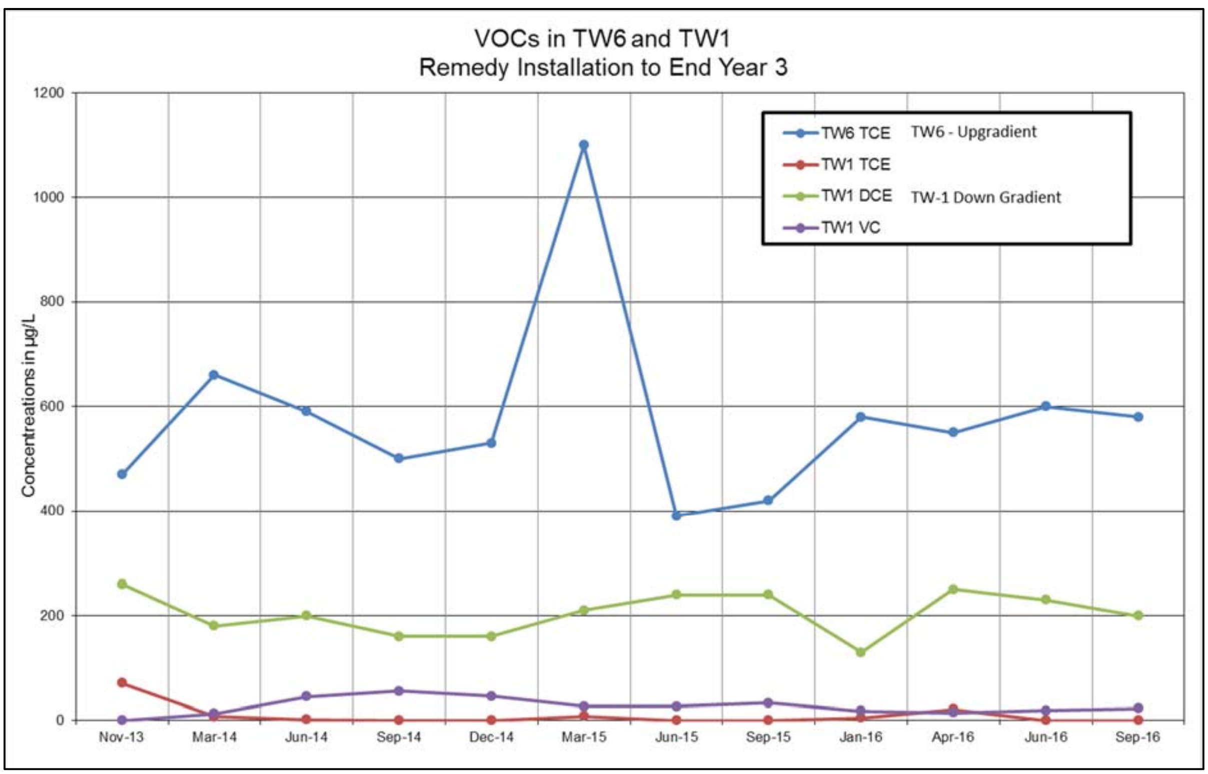

Figure 4.2 VOC Trends In Transect Wells

As the high concentration center mass of the TCE plume continues to move toward and through the biowall, the TCE upgradient concentrations in the TW6 upgradient transect well are expected to increase. Based on current trends, it is likely that the downgradient concentrations of DCE and VC will also increase without additional amendments or actions.

Though there is currently incomplete degradation of DCE and VC, there is a total reduction of contaminant mass. This reduction has been estimated by calculating the total molar mass of ethenes detected in the downgradient wells (TW1 or TW0) to the upgradient well (TW6). The downgradient total molar mass is less than the upgradient total molar mass (Figure 4.3) The reduction of total molar mass may be accounted for by a number of processes including: degradation of TCE to ethene (full degradation) via anaerobic digestion or, adsorption to the organic substrate of the biowall, or degradation products via β-elimination (dichloroacetylene, chloroacetylene, and acetylene). 1,1-DCE and VC are previously identified COCs for BDRLF AOC, and neither may remain in site media at concentrations over their respective remediation goals (MCLs for groundwater COCs), their presence in groundwater downgradient of the biowall requires improvements to the existing system to assure complete dechlorination of all COCs.

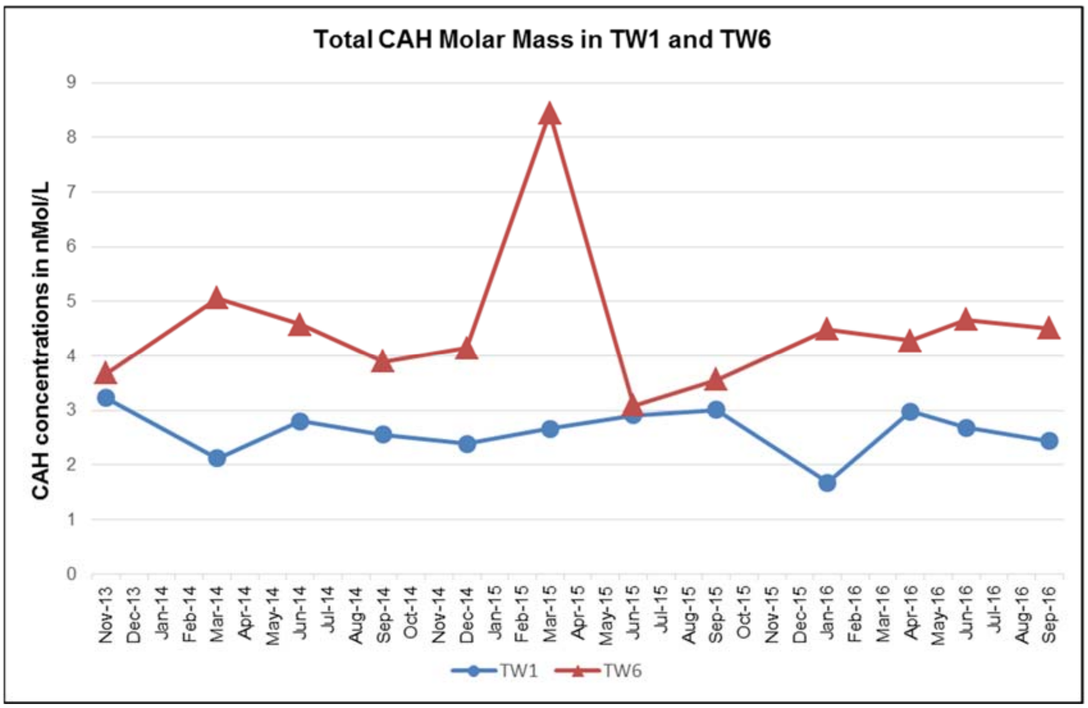

Figure 4.3 Reduction of Total Molar Mass Installation to End of Year 3

4.3.2. Groundwater Conditions

In addition to monitoring of TCE, DCE, and VC; a number of groundwater parameters are monitored and/or samples on a regular basis. The following performance indicators provide input to the selection of amendments for the biowall remedy. The full analysis for each of these parameters is presented in the Annual Sampling Reports (BMT, 2015, BMT, 2016, and BMT, 2017). The performance indicators include:

Alkalinity – The biowall groundwater has seen a reduction in groundwater alkalinity; which is associated with buffering capacity (Figure 4.4). As shown, there is some observed seasonal variation, but with an overall downward trend.

pH – Anaerobic degeneration pathway for TCE-DCE-VC-ethene requires pH of greater than 6.0, and laboratory analysis by USDA's partners at UMD have determined that pH of less than 6.5 indicates that the anaerobic process will be significantly slowed. Native groundwater conditions at BDRLF are acid (pH 3.0 to 5.0), with the biowall providing a significant basic buffering, increasing the pH to a range of 5.5 to 6.5; which remains too acidic for efficient performance (Figure 4.5). Though alkalinity continues to decline, the buffering effect from the wall has minimized the actual acidification within the wall to date. BARC is reviewing options to assure the biowall maintains its basic pH buffering capacity throughout the life of the remedy.

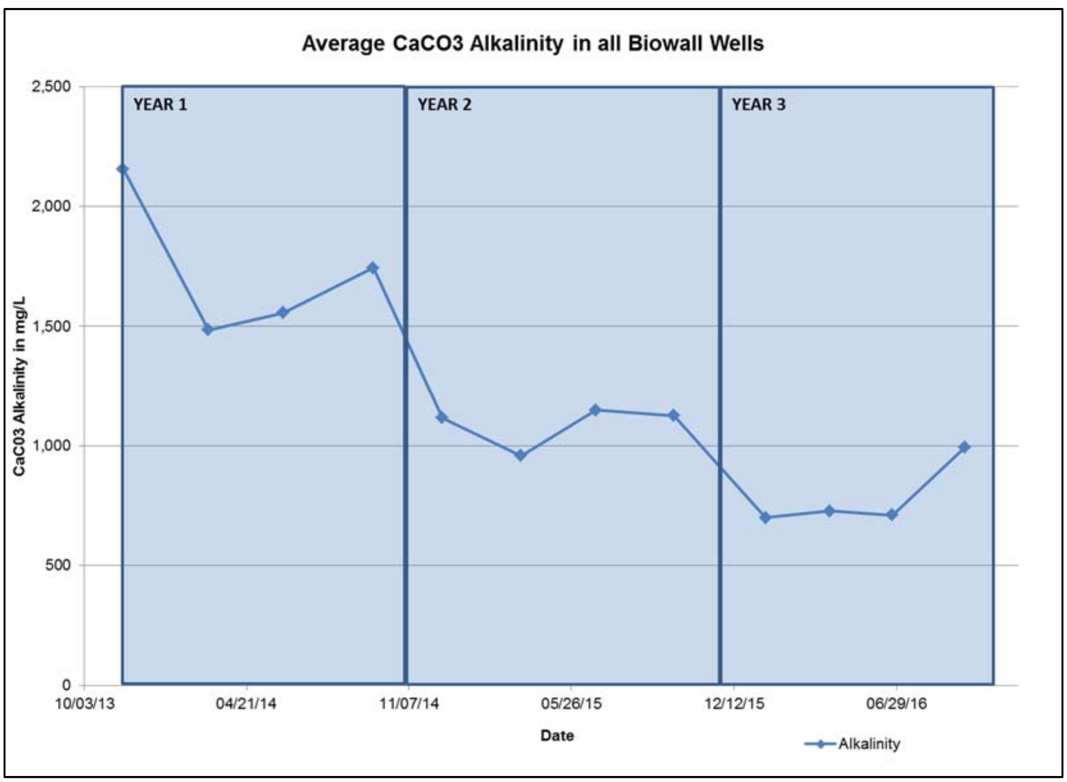

Figure 4.4 Alkalinity in Groundwater

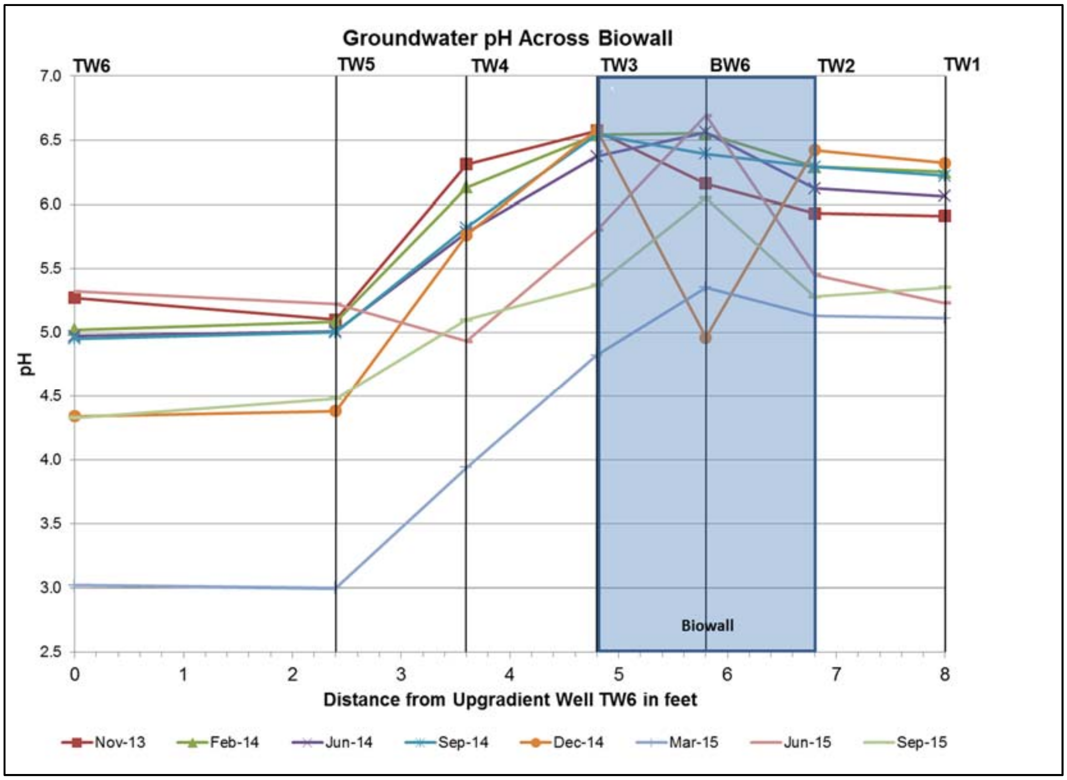

Figure 4.5 Groundwater pH Across Biowall

Total Organic Carbon (TOC) – For efficient degradation of TCE to ethene, sufficient electron donor material must be present in the groundwater. Total organic carbon (TOC) is a measure of electron donor material available suspended in groundwater. The biowall was constructed with compost and mulch to provide a high concentration of TOC. As shown in Figure 4.6, TOC concentration has been declining during the first three years as it is consumed during normal operation of the biowall, with some observed seasonal variation. Values of greater than 50 mg/L are desired to assure there are sufficient electron donors available to allow efficient dechlorination of TCE, DCE, and VC.

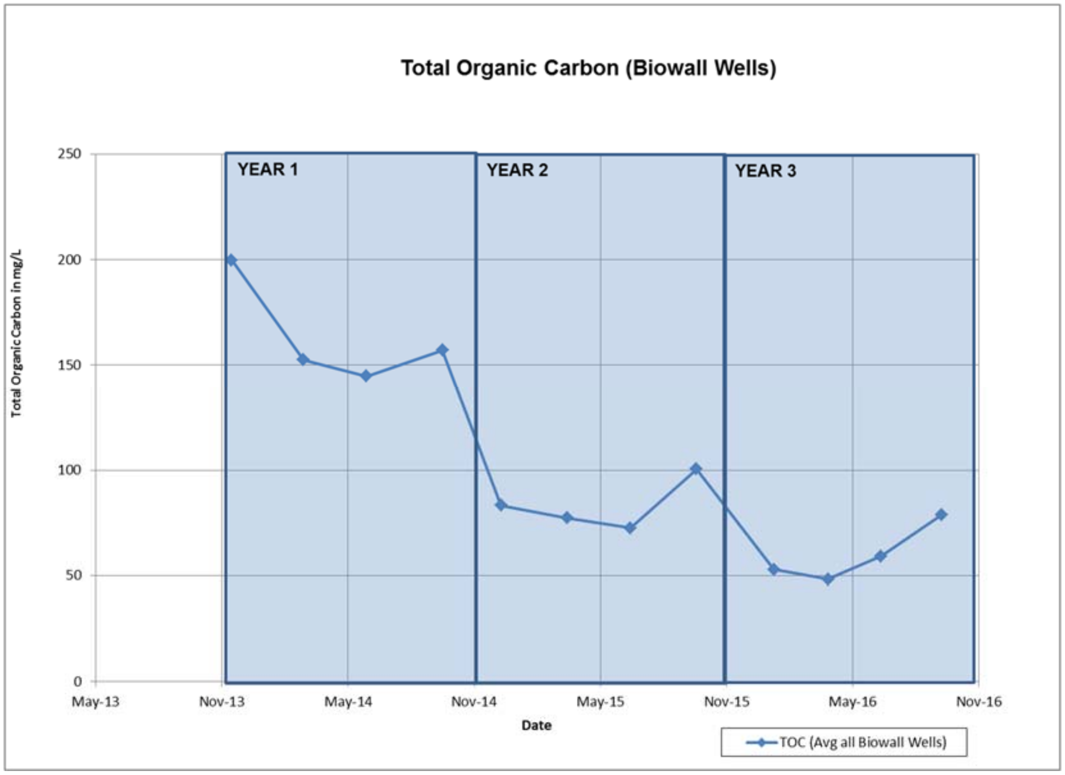

Figure 4.6 Average TOC in Biowall Wells

4.3.3. Aquifer Testing Program

Due to the incomplete degradation of TCE to ethene, and the presence of the breakdown products DCE and VC above their respective MCLs immediately downgradient of the biowall; an aquifer testing program was implemented in June 2016 to determine the groundwater velocity through the biowall. The supplemental investigations used four tests to provide evidence actual groundwater velocity in the vicinity of BW6 is significantly greater than the original design estimate of 2.4 feet per year that was used in developing the performance monitoring plan and in the original bench scale studies developed for the biowall. Based on slug tests, limited pumping tests downgradient groundwater samples, and tracer dye testing, actual groundwater velocities in the vicinity of BW6 are likely on the order of 30-50 feet per year with average residence time between 21 and 38 days (BMT, 2017a). The BDRLF Aquifer Testing Report has been included as Appendix B.

4.3.4. Microbial Sampling and Analysis

In preparation of amendments to the biowall, BARC has conducted a number of microbial analyses of the saturated biowall material and surrounding native soils to determine what microbial communities are present (microbial census). The microbial analysis included a census of specific genes associated with degeneration of CAHs, and specific compounds.

The microbial laboratory analyses completed to date have identified the presence of genes capable of reducing TCE, DCE, and VC are present in the site media. One of the common VC reducing genes, 'BAV1,' has not been detected in any of the samples. Though multiple genes capable of reducing VC are present, the absence of the 'BAV1' may be a contributing factor for the incomplete or delayed reduction of VC to ethene downgradient of the biowall as microorganisms with the 'BAV1' gene have been proven to be a key species for VC degeneration at other CAH groundwater sites. Based on assessment by BARC's research team, the genes present on the site are capable of reducing TCE through DCE and VC to ethene within the available biowall residence time.

Based on the analyses completed to date, the microbial populations present at the site are capable of full degradation of TCE to ethene given sufficient time and adequate environmental conditions. The ongoing sampling, research, and investigation into the bacteriological population and ecology within the biowall will be provided as the studies progress in the annual sampling reports.

4.3.5. BDRLF Data Review Conclusions

The data provided is being assessed by USDA research partners at the UMD and consulting engineers. Currently, there is no consensus on a primary cause for the incomplete degeneration of TCE to ethene; rather, a combination of factors has been identified as contributing to performance issues that include:

- Short residence time of 30 to 50 days, identified by the breakdown product transport analysis and bromide tracer study) (2017b)
- Low pH (6.0 or less) and decreasing buffering capacity (measured as alkalinity) as confirmed in the biweekly conditions assessment and semiannual sample. +(BMT, 2018)
- Missing or ineffective microbial population as confirmed with 2017 microbial census completed by MDE.
- Decreasing TOC concentrations, as confirmed in semiannual sampling. Organic carbon in mulch and compost is replacing existing TOC at a low rate.

Additional microbial analysis is being conducted by the UMD at this time to select a pH and alkalinity buffer solution for injection and an option for an amendment to increase retardation of VOCs. Selection of pH, alkalinity and carbon amendments is planned for mid-2018, with injections to follow within the calendar year. UMD is currently reviewing additional options for addition of selected microbial populations and options for upgradient groundwater conditioning amendments to optimize the biowall action, results from the bench scale modeling is expected to be completed by the end of 2018.

4.4. EPA and BARC FYR Site Inspection

The inspection of the site LUCs and onsite conditions was conducted on 11/21/2017. In attendance were Jeff Boylan (RPM), EPA Region 3 and Dana Jackson (RPM), BARC ARS.

4.4.1. BDRLF FYR Site Inspection and Conclusions

Mr. Jeff Boylan (EPA) and Mr. Dana Jackson (USDA) accompanied by Mr. David Kindig, Mr. Jason Lorenzetti, Ms. Lauren Weissenborn, and Mr. Justin Idzenga (BMT) performed a site inspection of BDRLF on November 21, 2017. The inspection included inspection of boundary controls (fencing and signage), the closed BDRLF area, the remedy implementation area, the groundwater monitoring network, the remedy monitoring network (biowall walls), and the down gradient tributary to Beaver Dam Creek. A summary of findings is provided as a LUCIP Inspection Report completed by BMT during the site walk and provided as Appendix E.

Overall, the Site Inspection found the BDRLF site to be in good repair, with no signs of dumping or trespassing. The remedy implementation area was maintained with access to the monitoring network wells. No observed damage to the biowall and no changes to the previously identified potential exposure and transport routes was observed. The Site Inspection found the following issues that need to be addressed:

- Site Maintenance
    - Repair of extend fencing around the site, specifically on the western side, where the barbed wire has been damaged by tree falls.
    - Repair and relocation of monitoring well MW4, which was struck by a USDA facility maintenance crew.
    - Repair of biowall well BW10, which was struck by BMT field team.
    - Replacement of two missing monitoring well locks
    - Removal of extraneous silt fencing associated with implementation of the remedy.
- LUCs
    - USDA to place additional signage.

No issues observed during the Site Inspection impacted current or future protectiveness of the remedy.

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5. Technical Assessment

The following presents the Technical Assessment for each site with a currently completed remedy or ROD, eligible for inclusion in the FYR.

5.1. Beaverdam Road Landfill (BDRLF)

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

The remedy is not currently meeting all intended remediation objectives, with some COCs remaining above remedial goals. TCE is undergoing microbially mediated reductive dechlorination as it passes through the biowall. As discussed in Section 4.3, complete dechlorination is not occurring, and some breakdown products in downgradient groundwater such as cis-1,2-DCE and VC, have consistently been detected at concentrations exceeding their respective MCLs.

Remedial Action Performance

The biowall has successfully degraded TCE to acceptable concentrations below the MCL, as required by the ROD. However, the biowall has not been able to fully degrade the breakdown products cis-1,2-DCE and VC. Both cis-1,2-DCE and VC remain at concentrations above their respective MCLs immediately downgradient of the biowall. The groundwater data collected as part of the performance monitoring indicates both cis-1,2-DCE and VC are trending downward as they move downgradient of the biowall. However, due to the presence of the unnamed tributary creek close to the biowall, it is priority to meet RGs for each COC within the biowall.

BARC is evaluating a number of amendments and actions to enhance degradation of cis-1,2-DCE and VC to achieve RAOs. Based on the site monitoring data, TOC is being consumed and pH is trending to non-ideal ranges for continual growth of the CAH degrading microorganisms. BARC is working to select an amendment type and schedule to bring both TOC and pH into their optimal ranges and provide long term buffering capacity for the biowall. Initial bench scale modeling completed at UMD, has assessed and advices against the addition of lactate or emulsified oils (EO) as these amendments have not been found to improve performance in the laboratory using biowall material and site groundwater. Additional assessments were conducted by UMD for injection of preselected microorganisms with the known genes for complete reduction of CAHs and for increased residence time; however the preselected populations did not show improvement over local conditions and increased residence time did not significantly improve the reduction of VC, as a majority of the reduction was completed quickly (within the first 7 to 14 days).

System Operations and Maintenance

The Biowall operation currently consists of ongoing groundwater monitoring; including biweekly sampling, quarterly and semi-annual groundwater monitoring events and semi-annual sampling of the downgradient creek. The Biowall is a “passive” system that currently requires no ongoing site maintenance or operational commitments; however, based on results from the performance monitoring, amendments to maintain buffering capacity (alkalinity) (Figure 4.4), ideal groundwater pH (Figure 4.5), and electron donor concentration (TOC) (Figure 4.6) will likely be required.

Implementation and Maintenance of LUCs

The BDRLF site has an approved LUCIP, and undergoes regular LUC inspections. Additional regular site maintenance is necessary to provide continued access for site monitoring activities. Maintenance to date has included regrading soil near the entrance of the south gate with mulch to better drain runoff. The regraded soil was also reseeded to provide erosion resistance. Approximately 100 tons of gravel was transported to the BDRLF to address ruts that developed over the fall and winter of 2014 and 2015. Additionally, ARS’ Farm Operations unit struck a monitoring well (MW-4) in the summer 2017, which is currently scheduled for repair/replacement.

Repairs and extension of the BDRLF perimeter fence were made in May 2018 to assure compliance with the ROD requirements that specify maintaining security fencing. Identified construction debris has been removed, and signage is to be installed in May 2018 to assure potential visitors are informed the site is off limits.

Early Indicators of Potential Remedy Problems

The two primary early indicators of remedy problems are breakthrough of COCs, including TCE, DCE, and/or VC; and the potential discharge of COC contaminated groundwater into the adjacent tributary creek. Groundwater monitoring is completed quarterly to track the breakthrough of TCE daughter products, and surface water sampling is completed semi-annually. Though TCE is non-detect or detected below its MCL, DCE and VC have been detected downgradient of the biowall. No COCs have been detected in the adjacent creek.

Secondary indicators of remedy problems are non-idealized biowall conditions, including low (acidic) pH, low dissolved available carbon, and short residence time. While non-ideal conditions do not preclude the remedy from operating, reduction in the rate of dechlorination is occurring. ARS has begun planning on how to improve these biowall conditions, including up gradient groundwater conditioning to buffer pH and increase available dissolved carbon.

5.1.2. Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives (RAOs) used at the time of the remedy selection still valid?

Exposure Assumptions and COC List

The cleanup goal in the ROD specified a groundwater concentration of TCE less than 5 µg/L, the current SWDA MCL for this contaminant. Since implementation, additional contaminants associated with the incomplete breakdown of TCE have been detected in downgradient groundwater at concentrations greater than their respective MCLs including cis-1,2-DCE (70 µg/L) and VC (2 µg/L). Overall COC concentrations and molar mass has been reduced indicating some TCE is being fully dechlorinated. Based on BARC's annual review of the site and vicinity conditions the exposure assumptions and site CSM developed in the RI remain valid and consistent with site conditions, and toxicity data for the TCE and its breakdown products remains consistent. BARC updates its MCL values and EPA screening criteria for other chlorinated and non-chlorinated VOCs in accordance with published data. As the site COCs are currently limited to compounds with promulgated MCL's, no additional risk assessment activities have been conducted though BARC reviews updated EPA toxicity data for the identified COCs and other toxic chemicals on a regular basis. BARC is aware of the mutagenic risks associated with TCE and VC; and will take these risks into account for future risk assessment associated with closure, or if new risk assessment is required based on changes to exposure pathways. Detection of a new COC would trigger a review of risk assumptions and appropriate remediation goals for the site.

Emerging Contaminants

Sampling conducted during the SSP investigations and the RI was used to identify the COPCs at the site based on likely possible disposal scenarios in the landfill. To date, no assessment has been completed to determine the presence or absence of EPA listed emerging contaminants potentially related to historic landfilling activities. ARS in collaboration with EPA will review the emergent contaminant list (EPA, 2018) to develop a plan to determine if emerging contaminants require additional investigation (Section 6.2).

Changes in Standards and TBCs

No ARARs specified in the ROD for the site have changed since implementation of the biowall in 2013. MCLs for the COCs, including the DCE and VC, have not been revised.

Changes COC Characteristics and Ratios

Total TCE concentration has been reduced to below the MCL in all wells, and below detection limit in some wells. In addition, the molar mass of CAHs has been reduced. However, downgradient cis-1,2-DCE and VC concentrations have increased from below detection limit to above MCLs (Figure 2.1 and Figure 4.3). At the time of the remedy implementation TCE was the only VOC detected in groundwater above its MCL, as the native conditions were not capable of significant degradation of TCE. The increase of cis-1,2-DCE and VC constitutes a change of contaminant characteristics and toxicity at the site, but is within the expected action of the remedy. Cis-1,2-DCE and VC VOCs with similar pathways and risks to TCE. VC has been identified as a carcinogen and a mutagen, Cis-1,2-DCE has not been assessed for carcinogenicity. Efforts are ongoing to assure that these COCs continue to degrade through reductive dechlorination to ethene and carbon dioxide.

Changes in Toxicity of Contaminants

The maximum detected concentrations for MW data reported in Table 4.7 of the May 2008 Final RI report were compared to the most recent human health risk based screening levels. EPA's Regional Screening Levels (RSLs) were last updated in May 2018. The RSL for tapwater associated with a Hazard Index (HI) = 0.1 for noncarcinogenic risk or a cancer target risk equal to 10E-06 are used as the screening values. Since the completion of the RI a significant number of screening values have changed as a result of changes to the underlying toxicity values, exposure factors, and other risk calculation factors or assumptions.

Though a majority of these changing screening values have no appreciable effect on the validity and protectiveness of the RI, the comparison of the updated RSLs to maximum detected concentrations in MWs as reported in Table 4.7 of the RI has determined that at least five contaminants require re-evaluation.

- Tetrachloroethylene - PCE should be re-evaluated on its historic low detection concentrations and recent non-detect results at the site during the first five year monitoring period.
- Chromium (total) – Based on current USEPA guidance, the historic (pre-ROD) chromium (total) should be re-evaluated.
- Nickel – The screening level for nickel (total and dissolved) has decreased, the analyte should be re-evaluated.
- Cobalt - The screening level for cobalt (total and dissolved) has decreased, the analyte should be re-evaluated.
- Butyl benzyl phthalate is now classified as a carcinogen, this may slightly alter HI and ILCR risks; the analyte should be re-evaluated.

Based on this review, the contaminants listed above should be reviewed; and their contribution to the overall risk assessment process determined.

Changes in Risk Assessment Methods

No requirement for changes to the risk assessment methods or background data (screening levels) have been identified. The BDRLF site undergoes annual assessment to determine the validity of the CSM and completed ecological and human health risk assessments completed during the RI. Though two breakdown products are present on the site, these are considered existing and previously identified COCs for the BDRLF as they are part of expected degradation processes. As both DCE and VC have promulgated remediation goals (MCLs), similar exposure pathways to TCE, and were included as COCs due to their expected creation as part of the dechlorination no change to the HHRA or ERA have been required and the RI human health and ecological risk assessments remain valid. Annual sampling includes sampling and screening of groundwater and surface water, and the new data is assessed to determine if new COPCs should be considered. Detection of COCs, or new COPCs, in site surface water or new COPCs in groundwater would create a need for an assessment of the site pathway and exposure assessment and a revision to the risk assessment methodologies, and would be included in the remedy Performance Monitoring Plan (PMP) (BMT, 2014).

Changes in Exposure Pathways

There are no changes in groundwater exposure pathways to report. BARC includes quarterly sampling of the adjacent Beaverdam Creek for VOCs to monitor for groundwater impacts to surface water. There have not been any changes in land use practices that would affect the protectiveness of the remedy as it was designed. No new human health or ecological routes of exposure or receptors have been identified for this OU since remedy installation.

Expected Progress Towards Meeting RAOs

The remedy has made expected progress toward reducing risk from groundwater exposure to COCs and meeting RAOs as defined in the ROD, though DCE and VC remain above RAOs downgradient of the biowall. Additional investigations are required to select and implement amendments to the implemented remedy to fully meet the RAOs. Since the determination that the biowall was not fully dechlorinating TCE to ethene, BARC has been looking to determine the root cause and apply an amendment to address the issue. Data collection and analysis by BARC's research partnership at UMD indicates the primary issues are linked to acidification (dropping pH), excessive methanogenesis, and low residence time. Plans to amend the biowall include injections of pH buffer solution (sodium hydroxide or magnesium hydroxide), injection of additional TOC to increase retardation of organic COCs via sorption/desorption, and consideration of a methanogenesis inhibitor. Additional proposals are being considered for options for increasing residence time and for the follow up injection of selected and engineered microbial populations with higher concentration of VC degrading genes, with the first amendments expected to be implemented in FY2019. However, until UMD research team is confident the subsurface conditions will favor dechlorinators over other microbial populations (pH, TOC) additional microbial injections are unlikely to address the underlying issues. Other microbial populations include non-VOC consuming natural soil bacteria and methanogens, which may out compete dechlorinators for available non-VOC carbon and electron sources, and create antagonistic groundwater conditions within the biowall by the over production of methane and acidification of the groundwater. At background concentrations, these other bacteria populations do not impact the performance of the biowall. Amendments are proposed for mid to late 2018. Upgradient injections to precondition the groundwater (including injection of carbon, nutrients, or pH buffer are currently under consideration.

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

Following the installation of the biowall, the groundwater flow velocity was recalculated using two tracer studies (one using breakdown products and one using a bromide dye). The groundwater velocity was calculated to be on the order of 20 to 30 feet per year, rather than the pre-installation estimate of 2.4 feet per year. The primary impact on the protectiveness is reduced residence time reduces the available time for the most recalcitrant CAH (VC) from having sufficient time to breakdown following reduction from TCE to DCE. Efforts are underway to increase retardation of the COCs, and improve upgradient groundwater conditions to increase efficiency of the biowall.

6. Issues/Recommendations

The following issues and recommendations for the BDRLF have been identified during the development and performance of this FYR.

6.1. Identified Issues

The following issues were identified for BDRLF. These are primarily associated with the identified incomplete dechlorination of TCE to ethene and CO_2. The remedy is currently protective, but future changes to exposure pathways, including potential future discharge of chlorinated VOCs to the adjacent creek would introduce additional potential receptors. The primary short-term goal is to address incomplete dechlorination of TCE by amendment of the biowall or groundwater conditioning.

Table 6.1 Identified Issues and Recommendations

Identified Issues and Recommendations				
OU(s): BARC 27 Beaver Damn Road Landfill	**Issue Category:** Remedy Performance			
	Issue: Incomplete degradation of TCE and daughter products			
	Recommendation: Identify and implement amendment or engineering solution to complete degeneration of daughter products to MCLs.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility BARC - ARS	EPA	7/1/2020
OU(s): BARC 27 Beaver Damn Road Landfill	**Issue Category:** Other			
	Issue: No assessment for emerging contaminants since completion of RI.			
	Recommendation: Develop a work plan to include assessment of emerging contaminants in groundwater associated with historical site activities.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility BARC - ARS	EPA	7/1/2020
OU(s): BARC 27 Beaver Damn Road Landfill	**Issue Category:** Other			
	Issue: Change in toxicity of contaminants			
	Recommendation: Review RI list of detected contaminants and determine if the current COC status of analytes should be revised.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Party Responsible**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility BARC - ARS	EPA	4/30/2019

6.2. Recommendations

Based on these findings, the following recommendations and schedule have been developed to specifically address the issues.

6.2.1. Remedy Performance

Selection of Amendments

Based on performance monitoring, pH and TOC will undergo amendment to assure the conditions in the biowall and the surrounding aquifer are optimal for dechlorinating VOCs. Specific selections of pH and carbon amendments, including options for increasing retardation of VOCs and passively increasing VOC resident times, and to be finalized in mid-2018 for implementation.

Design and Implementation of Amendment System

The method for short and long-term amendments to the biowall remedy must be chosen and implemented. The selection will be based on ability to deliver the selected amendments into the biowall or directly upgradient for those amendments intended to enhance biowall treatment by groundwater conditioning. Currently BARC is assessing the suitability for permanent unpacked “injection piezometers” within the biowall and temporary Geoprobe® well points for upgradient groundwater conditioning. Injection solutions under consideration include high-pressure injection, and low-pressure systems using gravity feed methods for consistent treatment, Final selection of methodology and system components and implementation/installation shall be completed upon selection of amendments and target zones, and is planned for mid-2018.

Follow On System Optimization

The biowall system is monitored regularly to assess the biome, conditions, and effectiveness of the remedy. Following the first round of amendments, the system will be optimized to assure all COCs are fully dechlorinated. This optimization may include additional injections upgradient or within the biowall, or a selected polishing injection at the downgradient face of the biowall.

6.2.2. Emerging Contaminants Assessment

In FY2019, ARS will develop a list of emerging contaminants that may present at the site based on historical activities. A sampling and analysis work plan will be developed, with reporting to be incorporated into the current BDRLF monitoring program. Sampling results will determine if additional remedial action is required to address any emerging contaminants at the site.

6.2.3. Change in Toxicity of Contaminants

In FY2019, ARS will review the RI list COCs and COPCs (including the list of detected contaminants) that have changed toxicity information since the completion of the RI. At a minimum, this would include PCE, chromium, nickel, cobalt, and butyl benzyl phthalate. Based on this review, the contaminant's contribution to the overall risk assessment process should be determined.

6.3. Other Findings

During the site walk with EPA, a number of minor issues that did not have significant impact on protectiveness of the remedy were identified. Incomplete and damaged fencing, some non-hazardous construction debris, and need for additional signage. These items will be addressed completely in 2018.

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7. Protectiveness Statement

BARC has developed the following Protectiveness Statement for the one OU, BDRLF, with completed ROD and implemented remedy.

Table 7.1 Protectiveness Statement

Protectiveness Statement	
Operable Unit: BARC 27 Beaverdam Road Landfill	*Protectiveness Determination:* Short-term Protective
Protectiveness Statement: The remedy at BDRLF currently protects human health and the environment as the biowall is degrading TCE to below remediation goals (i.e., MCLs). LUCs are implemented, and LTM confirms the continued operation of the remedy. However, in order for the remedy to be protective in the long-term, amendments need to be made to the biowall to assure all TCE daughter products are degraded.	

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8. Next Review

The next five-year review report for BARC is required five years from the planned completion date of this review, or July 22, 2023.

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Appendix A

Year Four Annual Sampling Report

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FOUR-YEAR PERFORMANCE MONITORING REPORT OCTOBER 2013 – SEPTEMBER 2017

for the

PERMEABLE REACTIVE BARRIER REMEDY AT THE BEAVERDAM ROAD LANDFILL (BARC 27)

Contract No. AG-32SC-P-15-0376

Prepared for:

U.S. Department of Agriculture
Agricultural Research Service
Beltsville, Maryland

Prepared by:

BMT Designers and Planners, Inc.
4401 Ford Avenue
Suite 1000
Alexandria, Virginia 22302

February 2018

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	microgram per liter (ppb)
AFCEE	Air Force Center for Engineering and the Environment
ARS	Agricultural Research Service
BARC	Beltsville Agricultural Research Center
BDRLF	Beaverdam Road Landfill
BMT	BMT Designers & Planners, Inc.
BW	Biowall Well
$CaCO_3$	calcium carbonate
CAH	chlorinated aliphatic hydrocarbons
CERCLA	Comprehensive Environmental Response, Compensation, and Recovery Act
COC	Contaminant of Concern
DCE	dichloroethene
DHC	Dehalococcoides
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
fbgs	feet below ground surface
MCL	Maximum Contaminant Level
MDE	Maryland Department of the Environment
mg/L	milligrams per liter
MW	Monitoring Well
MSL	mean sea level
mV	millivolts
NCP	National Contingency Plan
NPL	National Priority List
ORP	oxidation-reduction potential
PDBs	Passive Diffusion Bag Samplers
PP	Proposed Plan
ppb	parts per billion (µg/L)
PRB	Permeable Reactive Barrier
PMP	Performance Monitoring Plan
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

ROD	Record of Decision
SDWA	Safe Drinking Water Act
TCE	trichloroethene
TW	Transect Well
USDA	United States Department of Agriculture
VC	vinyl chloride
VOC	Volatile Organic Compound

1. INTRODUCTION

This Four-Year Performance Review is submitted by BMT Designers & Planners, Inc. (BMT) for the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) to detail the performance of the selected remedy at the Beaverdam Road Landfill (BDRLF) site after four years of performance monitoring. The BDRLF site is located at the Beltsville Agricultural Research Center (BARC) in Beltsville, MD. The selected remedy for the BDRLF was a Permeable Reactive Barrier (PRB) for the *in situ* treatment of contaminated groundwater (USDA, 2011). The PRB creates the conditions necessary for the biodegradation of trichloroethene (TCE) and its daughter compounds (commonly referred to as chlorinated aliphatic hydrocarbons [CAHs]) via microbial mediated reductive dechlorination. As a result, the PRB is commonly referred to as a 'biowall' and is referred to as a biowall in the balance of this document.

The PRB installation was completed in July of 2013 in accordance with the Record of Decision (ROD) (USDA, 2011) and the Remedial Design/ Remedial Action (RD/RA) Work Plan (BMT, 2013). Biowall performance monitoring was initiated in October of 2013 in accordance with an approved Performance Monitoring Plan (PMP) (BMT, 2014). A Performance Monitoring Plan (PMP) (BMT, 2014) was developed to evaluate remedy performance over time.

The objective of this four-year performance review is to evaluate the overall performance of the biowall including changes in contaminant concentrations and mass over time, changes in groundwater geochemistry, and to evaluate the efficiency and extent of biodegradation.

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2. SITE BACKGROUND

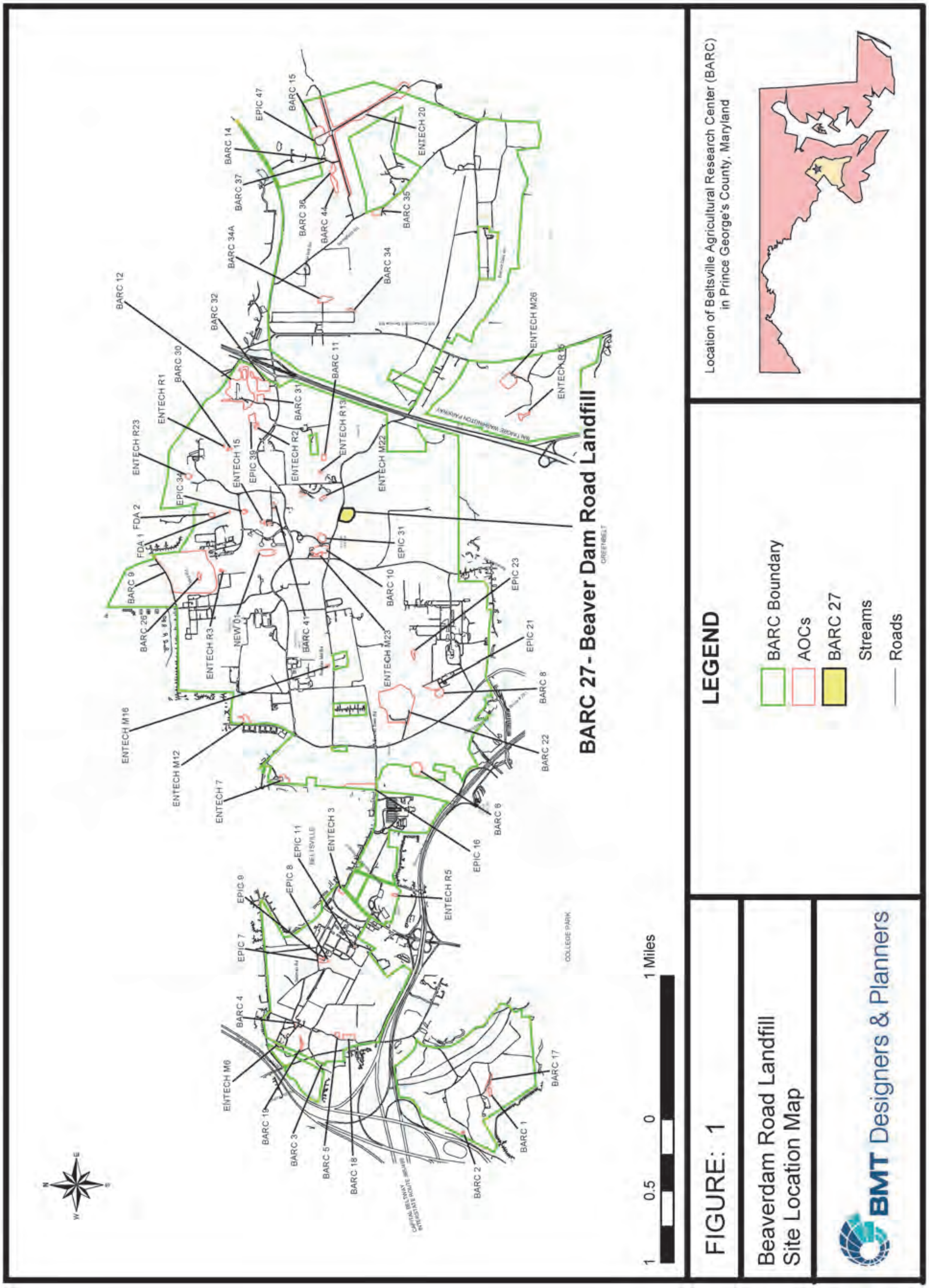
The BDRLF site is located within BARCs Central Farm on Beaverdam Road, approximately 1,700 feet east of the intersection of Beaverdam Road and Research Road (Figure 1). The site is a 2-acre dome shaped landfill with steeply sloped sides and is surrounded by woods to the east and south and a cultivated field to the west. The site borders Beaverdam Road to the north. The landfill is located north, and hydraulically upgradient, of the Beaverdam Creek stream valley (Figure 2).

2.1 Site History

The larger BARC facility is operated by USDA ARS. It is a 6,600 acre facility located in the northwestern portion of Prince George's County, Maryland which consists of agricultural fields, offices, and research laboratories. Due to historical operational practices, a number of areas within the BARC complex have been identified as being of environmental concern, including the BDRLF site. BARC was proposed for inclusion on the National Priorities List (NPL) in May of 1993, and formally added to the NPL in 1994.

From 1943 through the 1980s, the BDRLF site was reportedly used for disposal of non-hazardous materials including masonry construction debris, tree clippings, wood, and broken asphalt originating from BARC operations. Disposal operations continued through the early 1980s, after which time the landfill was closed and covered with a geo-synthetic liner beneath a clay cap in accordance with Maryland Department of the Environment (MDE) requirements. Fencing was placed along the vehicle accessible portion of the landfill – the north side of the landfill adjacent to Beaverdam Road – to prevent unauthorized access to the site. No subsequent use or access to the site has been permitted since that time accepting approved site maintenance and investigation activities.

Several environmental investigations were conducted at the BDRLF as part of the Remedial Investigation and Feasibility Study (RI/FS). The RI/FS identified a plume of groundwater contaminated with TCE. The plume was estimated to be approximately 650 feet wide by 450 feet long and located southeast (downgradient) of the landfill's toe (BMT ENTECH, 2008). The maximum observed concentration of TCE in the groundwater plume was greater than 600 parts per billion (ppb); however, concentrations have been observed to fluctuate over time based on several factors including seasonal rainfall.


BARC 27 - Beaver Dam Road Landfill
LEGEND
BARC Boundary
AOCs
BARC 27
Streams
Roads
Location of Beltsville Agricultural Research Center (BARC)
in Prince George's County, Maryland
1
0.5
0
1 Miles
FIGURE: 1
Beaverdam Road Landfill
Site Location Map
BMT Designers & Planners
BARC 12
BARC 32
BARC 34A
BARC 37
BARC 14
EPIC 47
BARC 15
ENTECH 20
BARC 35
BARC 44
BARC 36
BARC 34
BARC 30
ENTECH R1
ENTECH R23
BARC 31
BARC 11
ENTECH R13
ENTECH R2
EPIC 39
ENTECH 15
EPIC 34
FDA 2
FDA 1
BARC 9
BARC 26
ENTECH R3
NEW 01
BARC 41
ENTECH M23
BARC 10
EPIC 31
ENTECH M22
ENTECH M26
ENTECH R15
EPIC 23
EPIC 21
BARC 8
BARC 22
ENTECH M16
ENTECH M12
ENTECH 7
BARC 6
EPIC 16
ENTECH R5
ENTECH 3
EPIC 11
EPIC 8
EPIC 9
EPIC 7
BARC 4
ENTECH M6
BARC 19
BARC 3
BARC 5
BARC 18
BARC 2
BARC 1
BARC 17
COLLEGE PARK
BELTSVILLE
GREENBELT

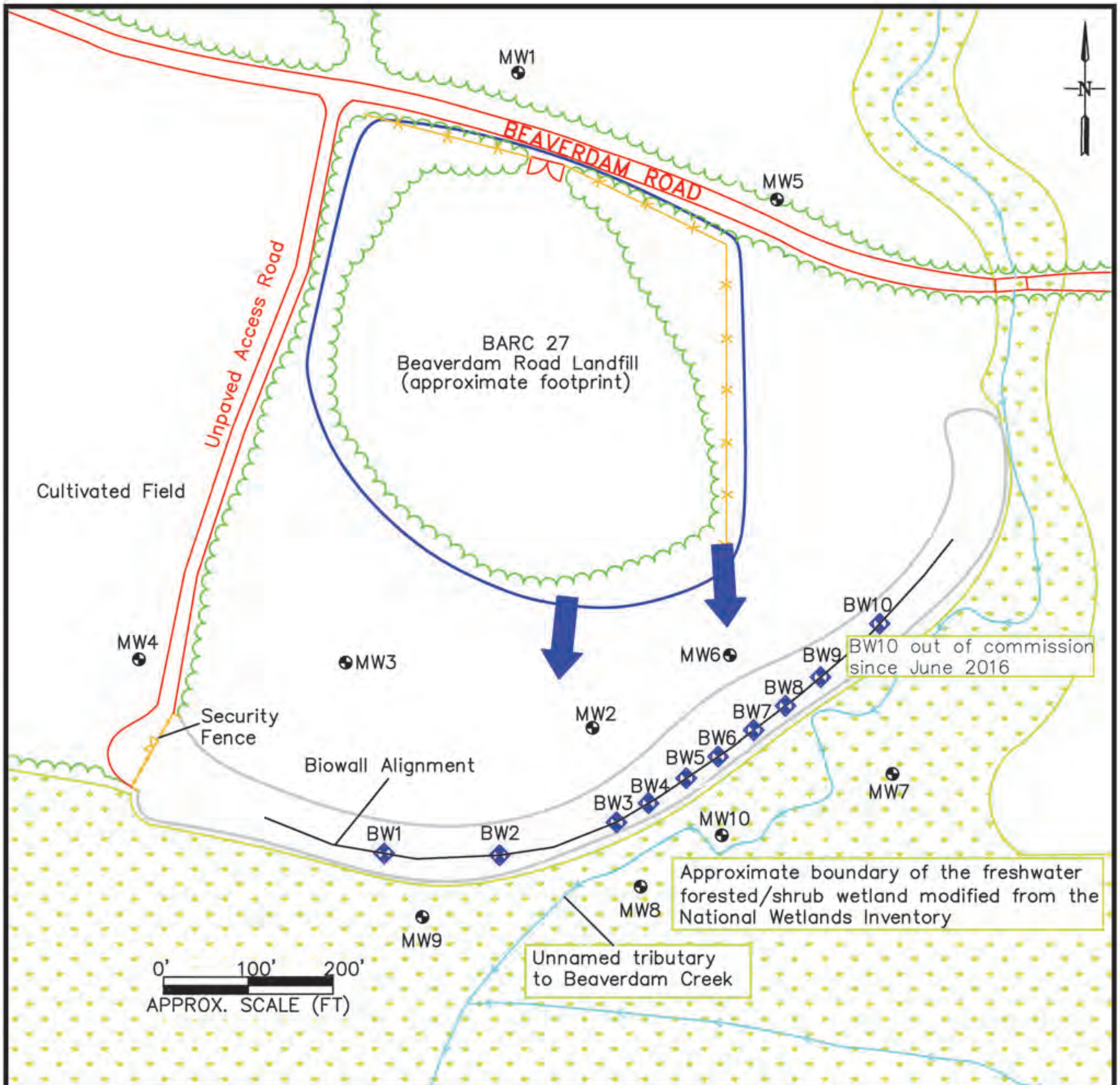


FIGURE 2

BARC 27:
Beaverdam Road Landfill
Biowall Location Map

BMT Designers & Planners

2.2 Topography and Site Features

The BARC facility lies in the central portion of the Atlantic Coastal Plain Physiographic Province. Natural elevations at BDRLF range from approximately 129 feet above mean sea level (MSL) at monitoring well MW1 (north of Beaverdam Road) to 86 feet above MSL near the unnamed tributary to Beaverdam Creek. Natural terrain at the site slopes gently toward the south and southeast. Elevations of the landfill range from approximately 124 feet above MSL at the northern margin, to a maximum of 125 feet above MSL at the peak, and to 92 feet above MSL along the southern margin. The existing cap is designed to convey runoff toward the eastern, southern, and western sides of the landfill, where the natural terrain would direct flow to the south and southeast.

Beaverdam Creek and its associated floodplain are located approximately 1,000 feet south of the southern toe of the BDRLF. Beaverdam Creek is the primary drainage course within BARCs Central Farm. Located within the wooded tract is an unnamed tributary to Beaverdam Creek to the east of the landfill that eventually drains into Beaverdam Creek to the south. There are no drainage courses or culverts that lead directly from the landfill to either Beaverdam Creek or the unnamed tributary. Beaverdam Creek lies within the Anacostia River Watershed and is part of the regional Chesapeake Bay watershed.

The wetlands on the BDRLF site are limited to undisturbed areas on the southern and southeastern edges of the landfill. The remainder of the site consists of filled uplands. The area east of BDRLF is characterized as transitional, with the wetland boundary generally following the topographical contour of the area. Wetland plant communities consisted of emergent and hardwood swamp types common to this area of Maryland (ENTECH, 2003).

2.2.1 Geology

In the area of the BDRLF site, the Coastal Plain sediments are approximately 200 to 350 feet thick and overlie a crystalline rock basement formation. On a regional scale, the Coastal Plain is underlain by a southeastward thickening wedge of sediments that reaches thicknesses greater than 1,500 feet in the southeastern portion of the Washington, DC, metropolitan area. The BDRLF site is directly underlain by the lower Cretaceous Arundel Clay Formation. The Arundel Clay is comprised of red to variegated and white clays (SCS, 1967, USGS 1977). Floodplain areas at the base of the landfill, where Beaverdam Creek and its tributaries have migrated over time, have 20 to 30 feet of alluvial sediment overlying the Arundel Clay. Groundwater contamination appears to be confined to the alluvial silts, sands, and gravels above the relatively impermeable Arundel formation.

2.2.2 Hydrology

Based on the RI, the shallow aquifer at the site occurs in the unconfined Quaternary river terrace deposits found within the larger Beaverdam Creek stream valley and is underlain by the Arundel Clay formation (BMT, 2008). Average depths to the water table varies seasonally and ranges from 10 feet below ground surface (fbgs) just north of the landfill to 1-foot or less near the foot of the landfill and within the adjacent floodplain to the south. Groundwater within and directly adjacent to the biowall is typically encountered between 5 and 9 feet bgs. Groundwater flows southward towards an unnamed tributary, located approximately 300 feet south of the landfill site.

The downward vertical migration of groundwater within the contaminated shallow aquifer is limited by the presence of the underlying Arundel Clay formation. Based on boring logs completed as part of supplemental characterization efforts in 2011, the Arundel Clay formation south of the BDRLF occurs between 20 to 25 feet bgs (BMT, 2011). The Arundel Clay has a low permeability and acts as a confining layer, segregating TCE-contaminated shallow groundwater from the underlying Patuxent aquifer, which is used for potable supply by BARC and surrounding populations. Recharge of the Patuxent aquifer occurs by downward percolation of precipitation in the outcrop areas that trend northeast-southwest and are located several miles west of the BDRLF.

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3. REMEDIAL ACTION IMPLEMENTATION

Upon completion and evaluation of the RI/FS, ARS and The U.S. Environmental Protection Agency (EPA) prepared a Proposed Plan (PP) that recommended, among other measures, the installation of a biowall as the preferred remedial alternative for the site (USDA, 2009). A public meeting was conducted to present the remedy to the community and stakeholders and receive feedback in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This remedy decision was finalized in the ROD for the BDRLF in 2011 (USDA, 2011). The mulch biowall was selected as the remedy of choice due to the high likelihood for success and its' relatively low cost. Site-specific factors that led to the selection of the biowall as the preferred remedy include:

- The presence of a competent clay confining layer within 18 to 23 fbgs that would serve as an aquitard that prevents the movement of contaminated groundwater beneath the biowall.
- The presence of a lightly contaminated plume (i.e., concentrations less than 1 ppm) without the presence of other contaminants that might require additional consideration or treatment.
- A slowly moving groundwater system that would allow for a sufficient residence time within the biowall for adequate treatment of the TCE.
- No presence of underground utilities that would complicate construction and potentially jeopardize treatment.

Biowalls have been shown to remain effective for many years with minimal post installation modification or amendments. The ability to replenish a biowall or bioreactor with fluid substrates or other amendments enables the treatment system to be modified to remain effective for extended periods of time.

3.1 Biowall Installation

An approximately 1,000-foot long by 18 to 23-foot deep biowall was installed at the BDRLF site in July of 2013 by BMT and subcontractor personnel (BMT, 2016). In preparing for the installation of the biowall, BMT performed site characterization and preparation activities that included, but were not limited to: a cultural resources survey, erosion control measures, vegetation clearing, construction preparation, and the mixing and testing of the biowall material. The biowall mixture composition was determined through bench-scale testing conducted by ARS research staff in conjunction with the University of Maryland Research. The findings of the bench scale study determined the optimal biowall mixture of 30% mulch, 30% compost, and 40% sand, by volume (BMT, 2013).

3.2 Monitoring Well Installation

In accordance with the remedial design, 2-inch diameter groundwater monitoring wells constructed with Geoprobe® prepacked well screens were installed within the biowall (BMT, 2013). Additional ¾-inch diameter groundwater monitoring wells (MW) constructed with Geoprobe® prepacked well screens were installed upgradient and downgradient of the biowall. All wells were installed using Geoprobe® direct push methods. These wells supplement the existing network of monitoring wells installed as part of RI activities, which are referred to as RI wells. The wells installed within the biowall are referred to as "biowall wells" (BW) and the wells installed upgradient and downgradient of the biowall are referred to as "transect wells". Ten (10) biowall wells and six (6) transect wells (TW) were installed in September of 2013. The biowall wells (BW1 through BW10) were installed within the biowall to monitor geochemical conditions and contaminant concentrations. The location of the biowall wells were biased toward the area of greatest observed contaminant concentrations. The observed plume area is approximately 300 feet in width with the plume centerline located approximately 570 feet east of the western end of the biowall. As a result, seven (7) biowall wells (BW3 through BW9) were installed within the areal extent of the observed contaminant plume. Biowall well BW6 was installed in the biowall at the plume centerline and six (6) additional biowall wells were installed at 50 foot intervals from BW6 in each direction. The three (3) remaining biowall wells (BW1, BW2, and BW10) were installed outside of the observed contaminant plume area. The locations of the biowall wells are depicted in Figure 3.

Transect wells (TW1 through TW6) were installed in line with the observed groundwater flow direction at the contaminant plume centerline, in line with biowall well BW6 and downgradient of RI well MW6. Transect wells were installed to a total depth of 20 fbgs, corresponding with the total depth of the biowall in the area of biowall well BW6, and set within the underlying clay formation. Transect well spacing was determined based on an estimated TCE travel velocity in the subsurface. Two (2) additional wells were installed in June 2016; TW0 and MW10. TW0 were installed downgradient of TW1 and MW10 was installed downgradient of the transect wells on the northern bank of the unnamed tributary to Beaverdam Creek. Transect well locations relative to the biowall and biowall well BW6 are depicted in Figure 3.

BW10 was damaged in June 2016, due to an incident with a field vehicle. MW4 was damaged in 2017 due to farm activities within the corn field that surrounded that well. Subsequent to the damaging of BW10, MW6 was incorporated into the quarterly monitoring program. All parameters that were sampled from biowall wells during quarterly monitoring were sampled from MW6, which provided background data to compare against biowall data. BW10 and MW4 are scheduled to be replaced in 2018.

3.3 Performance Monitoring

In order to assess conditions within the biowall, a PMP was developed by BMT and ARS research personnel. The PMP is intended to be flexible to allow for changes to the sampling frequency and analytical requirements based on a continuous evaluation of Program effectiveness. As a result, the PMP is considered a 'living document', which allows for the alteration of the sampling frequency or protocols in response to changing conditions observed within the biowall. The PMP was modified in 2014 to capture modifications in the procedure used for monitoring biowall dissolved oxygen (DO) and to remove the requirement for nitrite and nitrate analysis (BMT, 2014). The PMP was updated 2015 to include sulfate sampling in transect well TW6 to characterize the sulfate concentration in upgradient groundwater, and in 2017 to include ferrous iron and manganese analysis in groundwater samples. The PMP currently requires biweekly, quarterly, and semi-annual monitoring events. A total of sixty-seven (67) biweekly groundwater monitoring events, eight (8) quarterly monitoring events, and eight (8) semi-annual monitoring events were conducted between October 2013 and September 2017.

3.3.1 Biweekly Monitoring Program

Biweekly monitoring is performed to assess physical conditions within the wall and to identify changes in biowall conditions over time. Biweekly monitoring is completed for biowall wells only and includes biowall well gauging and the measurement of groundwater physical parameters including pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), salinity, turbidity, temperature, and specific conductivity using field portable water quality meters.

Quarterly monitoring is intended to assess physical and geochemical conditions within the biowall and to determine the concentrations of CAHs upgradient, within, and downgradient of the biowall. Quarterly monitoring includes gauging all site wells and the collection of groundwater samples from biowall wells and transect wells using low-flow methodology. In addition to the physical parameters measured during low-flow samples collection, biowall groundwater samples were submitted for laboratory analysis of VOCs, total organic carbon (TOC), total and dissolved iron, sulfate, sulfide, calcium carbonate alkalinity, methane, ethene, and ethane. Transect wells groundwater samples were submitted for laboratory analysis of VOCs only.

Semi-annual monitoring is conducted concurrently with quarterly monitoring and includes the collection of groundwater samples from RI wells (in addition to biowall wells and transect wells) and the collection of surface water samples from the unnamed tributary to Beaverdam Creek. Groundwater samples collected from biowall wells and transect wells are submitted for laboratory analysis of the same analytes as the quarterly monitoring event. Groundwater samples were collected from RI wells using Passive Diffusion Bag Samplers (PDBs) and were submitted for laboratory analysis of VOCs only. Surface water samples were submitted for laboratory analysis of VOCs only.

All groundwater quality data is validated in accordance with the BARC Quality Assurance Program Plan (BMT, 2016). Biowall well and transect well groundwater physical parameter results and geochemical results are summarized in Appendix A and B, respectively. RI well and surface water physical parameter results are summarized in Appendix C. VOC analytical results for surface water and groundwater samples collected from RI wells, biowall wells, and transect wells are summarized in Appendix D.

3.3.2 Microbial Sampling and Analysis Program

A microbial sampling and analysis program was implemented at the BDRLF biowall in March 2016 to determine the presence and concentrations of specific microbial species within the groundwater and material of the biowall. Both groundwater and soil samples were collected as part of this effort. Unfiltered groundwater was collected from a dedicated piezometer well, located approximately 10 feet west of BW6. Saturated and unsaturated soil and biowall material samples were collected immediately upgradient and downgradient and within the biowall. Samples were submitted to a third party lab for microbial census analysis. Additional samples were provided to UMD for additional analysis and evaluation.

In addition to these tasks, Bio-trap® samplers from a third party vendor and custom bio-char samplers were installed in BW6 and MW6. Bio-trap® samplers were installed in monitoring wells BW6 and MW6 for approximately 60 days each, and the bio-char samplers were installed for 105 days. A standard microbial census was conducted on the recovered bio-trap® samplers to determine the relative concentrations of microbes between the biowall (BW6) and the upgradient formation in the vicinity of the TCE plume (MW6). Subsequently, custom bio-char samplers were constructed in coordination with the UMD and were installed in BW6 and MW6 for approximately 60 days for detailed analysis by UMD. The results from this program were summarized in a separate report and submitted to the ARS (BMT, 2017) and in papers by UMD. The results of the microbial sampling and analysis program are discussed in Section 4.3.

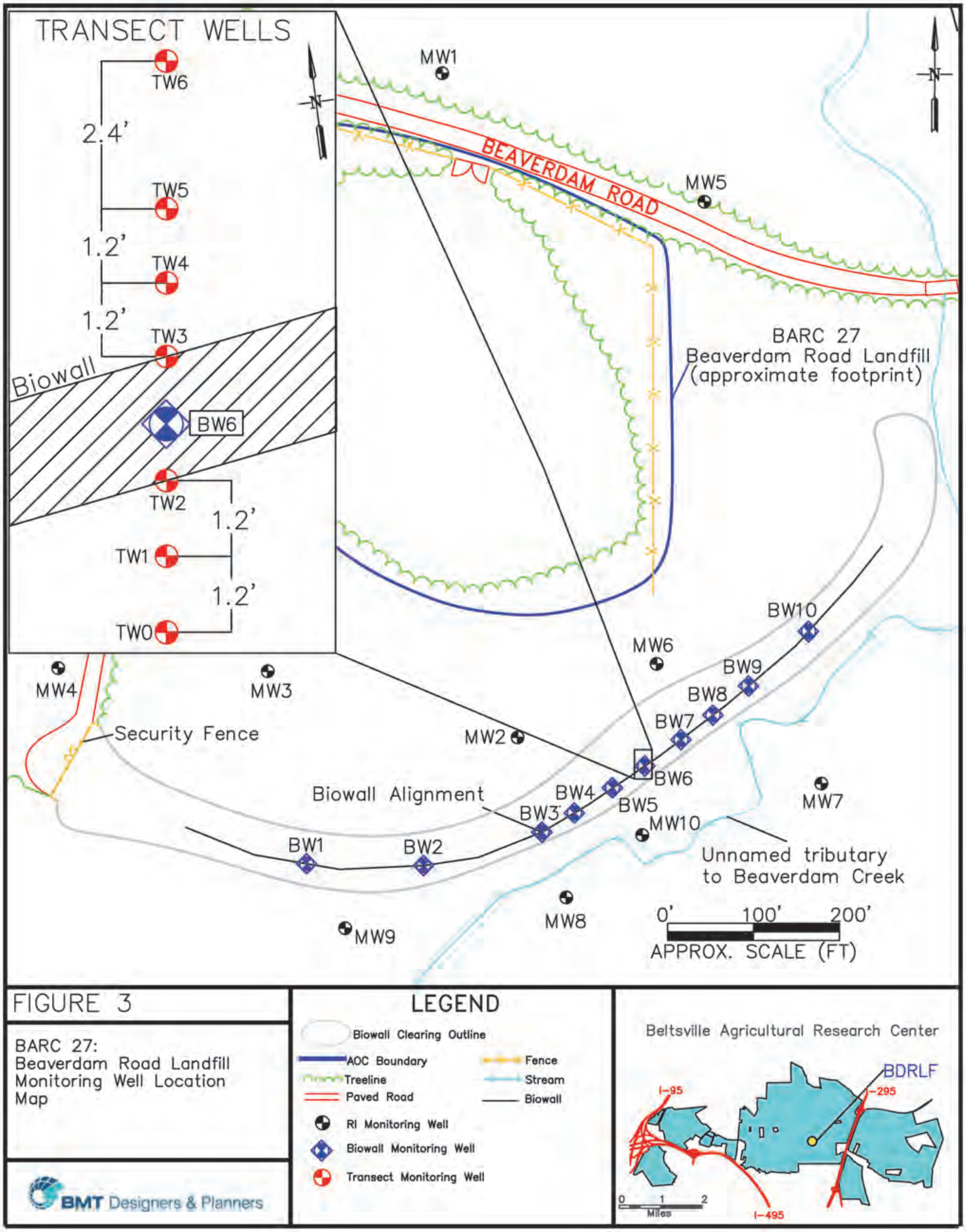

FIGURE 3

BARC 27:
Beaverdam Road Landfill
Monitoring Well Location
Map

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4. BIOWALL PERFORMANCE

Biowall performance monitoring results were used to assess the overall performance of the biowall by evaluating physical and geochemical conditions within the biowall, trends in contaminant concentrations, and the presence of contaminant degradation products. The following subsections detail performance monitoring results in the context of microbial metabolism including the conditions within the biowall, the relative abundance of specific terminal electron acceptors and metabolic byproducts, and trends identified in geochemical conditions and contaminant concentrations over the four-year performance monitoring period.

4.1 Assessment of Biowall Conditions

In order to evaluate if conditions within the biowall support complete degeneration of COCs, including TCE and daughter products, select physical and geochemical parameters were analyzed during performance monitoring. Select parameters measured in the field by direct reading field instrumentation and/or by fixed laboratory analysis include pH, calcium carbonate alkalinity, and TOC. This section summarizes select parameter results, changes in conditions over time, and their influence on the occurrence and completeness of the microbially mediated reductive dechlorination.

Biowall Alkalinity

Calcium carbonate ($CaCO_3$) alkalinity represents the acid neutralizing capacity of an aquifer and is important in the maintenance of groundwater pH because it buffers the groundwater system against acids generated during microbial metabolism. In general, increases in alkalinity may result from the dissolution of carbonate containing minerals present within a formation, driven by the presence of carbonic acid produced by microorganism metabolism. As a result, there is commonly a positive correlation between zones of microbial activity and increased alkalinity (relative to background concentrations) (EPA, 1998). The biowall is comprised of sand, compost, and mulch and does not include a carbonate rock component; however, organic components of the biowall may serve as a source of carbonate. Total alkalinity as $CaCO_3$ is measured in biowall wells on a quarterly basis and results are presented in Appendix B.

The background $CaCO_3$ alkalinity at the BDRLF was determined as part of the FS fieldwork using a field test kit and ranged from 0 to 40 mg/L $CaCO_3$ (BMT, 2008a). The annual average total alkalinity within the biowall wells during the performance monitoring period is approximately 1,075 mg/L $CaCO_3$. A general decreasing trend in $CaCO_3$ alkalinity has been observed within the biowall since performance monitoring began in 2013. Average biowall well $CaCO_3$ alkalinity over sixteen (16) quarters of biowall monitoring is shown in figure 4. Yearly average $CaCO_3$ concentrations in all biowall wells are shown in Figure 5. There is a season variation on measured concentrations with peak measured concentrations occurring during winter months on top of an overall trend of decreasing concentrations.

Figure 4. $CaCO_3$ in Biowall Wells during Performance Monitoring Period

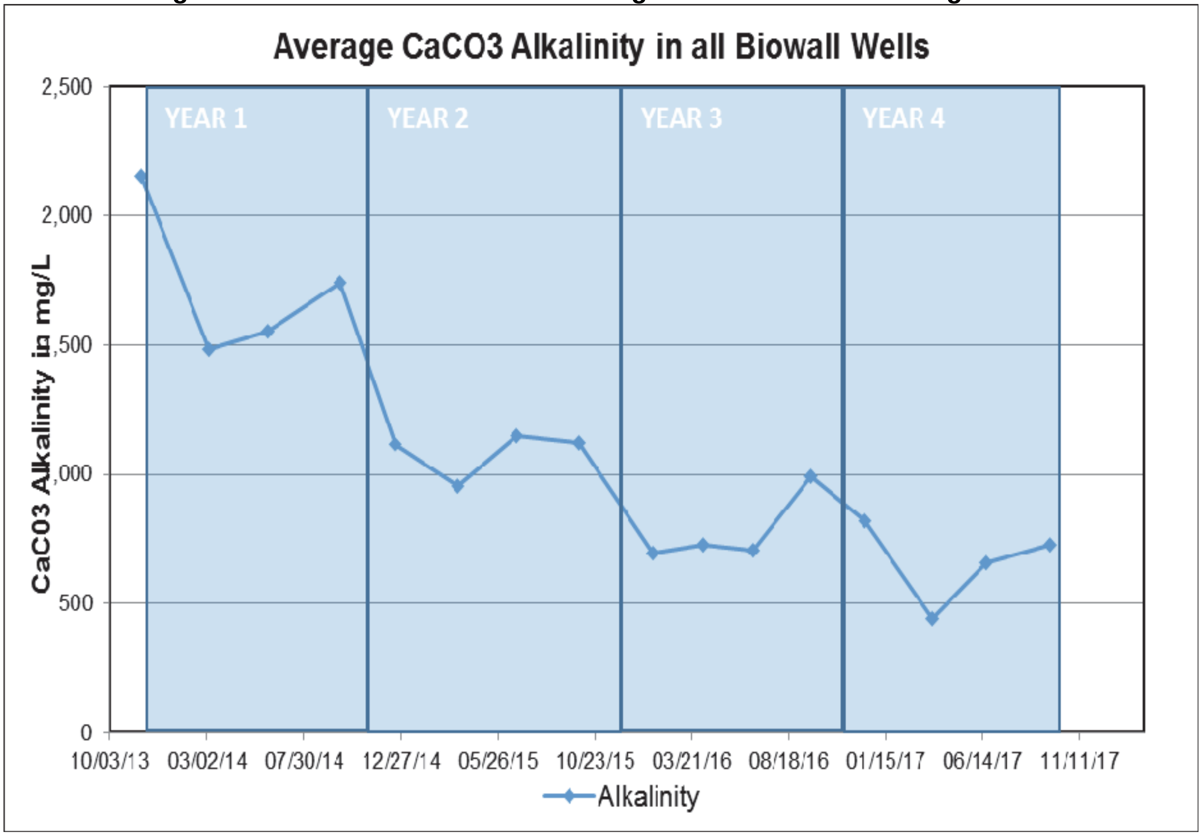
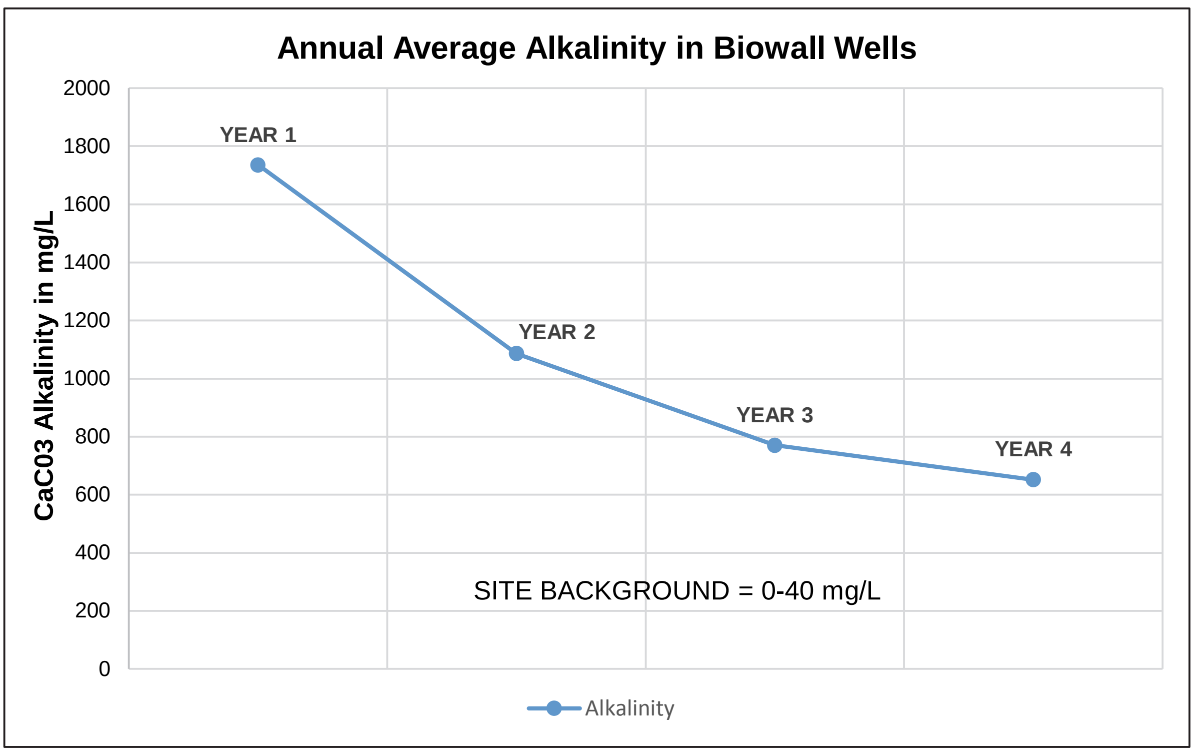


Figure 5. $CaCO_3$ in Biowall Wells during Performance Monitoring Period



Overall concentrations of $CaCO_3$ within biowall groundwater samples remain well above background concentrations. The elevated levels of $CaCO_3$ alkalinity within the biowall suggests that microbial metabolism is occurring within the biowall and that the organic components of the biowall material are serving as a source of carbonate. Decreasing buffering capacity has implications for the ability of the biowall to maintain conditions conducive to supporting microbial communities required to degrade TCE.

Biowall pH

Average pH values within the biowall have ranged from 5.96 to 6.21 over the course of the performance monitoring period. This is at the low end of the range needed for microbially reductive for bacteria needed to facilitate reductive dechlorination within the biowall (i.e., pH in the range of 6.0 to 8.0). There has been no observed trend in decreasing pH within the biowall. The pH of the shallow aquifer at the BDRLF was monitored as part of the Remedial Investigation (RI) and has historically been observed to be slightly acidic, ranging from 4.48 to 6.64 in RI wells (BMT, 2008). The average pH in RI wells MW2 and MW6 (located within the identified plume area between the landfill and the biowall) were 5.91 and 5.51, respectively. Groundwater pH remaining at approximately 6, may be limiting rates of reductive dechlorination.

Total Organic Carbon

TOC content of the biowall is important for calculating factors that influence contaminant migration including sorption and solute retardation and can be used to determine the amount of organic material that may be available to serve as a primary substrate for microbial metabolism. TOC concentrations greater than 20 mg/L can serve as a carbon and energy source for microbial metabolism and may drive reductive dechlorination (AFCEE, 2008). TOC in biowall groundwater is measured via fixed laboratory analysis on a quarterly basis and TOC results are presented in Appendix B.

The biowall trench was filled with fill material that was comprised of four (4) parts sand, three (3) parts compost and three (3) parts wood mulch by volume. The compost fraction was comprised of aged leaf compost that was intended to provide a rapid release of available organic carbon after installation. The mulch fraction was intended to provide stable, long term source of organic carbon.

Average TOC concentrations in biowall groundwater have decreased since the biowall installation in 2013. Average TOC concentrations in biowall groundwater were 163.5 mg/L during the first year of performance monitoring and have reached 35.95 mg/L by the end of the fourth year. As with concentrations of CaCO3 alkalinity, available TOC concentrations show a seasonal variation. TOC concentrations with MW6, which is considered a background well, have had an average value of 1.84 mg/L for the last six (6) quarterly monitoring events. Average annual TOC concentrations in groundwater during the performance monitoring period are shown graphically in Figures 6 and 7.

Figure 6. Quarterly (TOC) Biowall Groundwater during Performance Monitoring Period

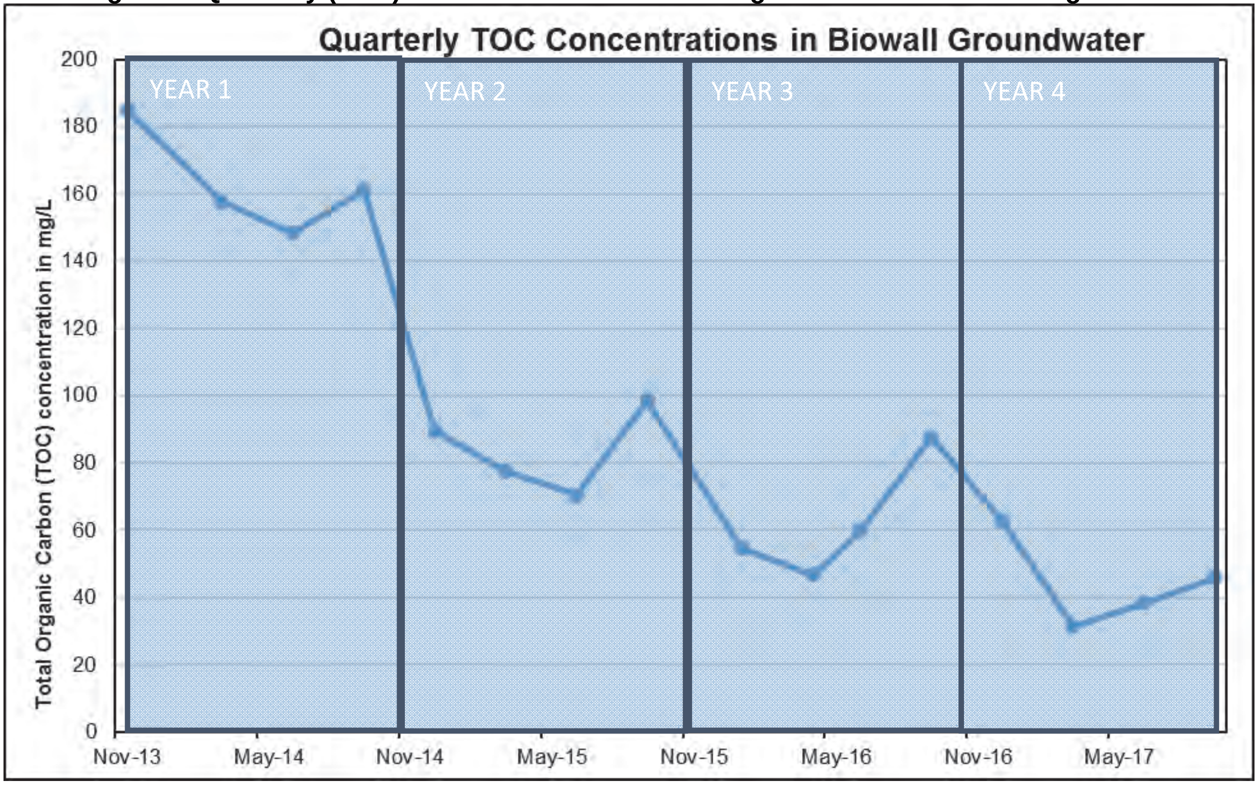
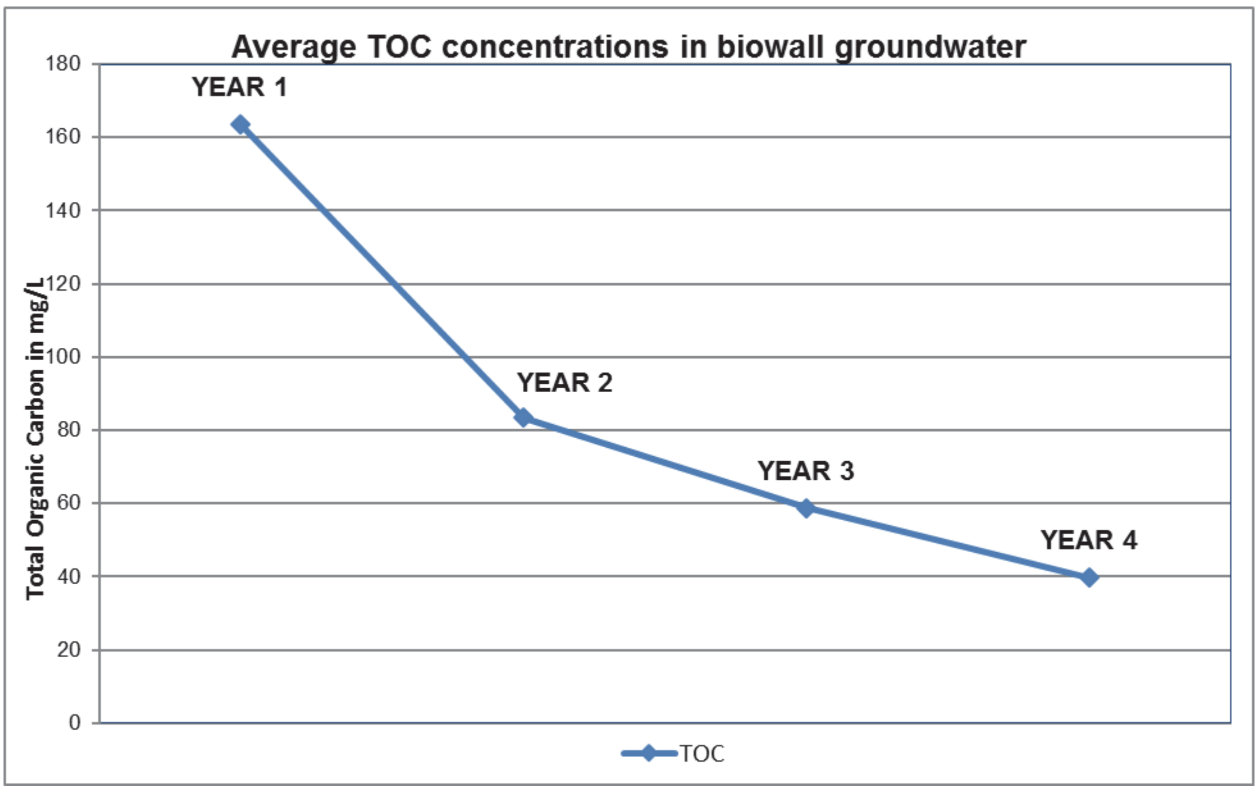


Figure 7. Annual (TOC) Biowall Groundwater during Performance Monitoring Period



The decrease in TOC concentrations follows a similar pattern as with concentrations of $CaCO_3$ alkalinity and may be related to the rapid degradation of compost after installation.

4.2 Assessment of Microbial Metabolism

Based on the pH, alkalinity, and TOC results, conditions within the biowall remain within the range of conditions conducive to support microbial metabolism, but there is a decreasing trend for key indicators.

The following subsections present the results of physical and geochemical parameters in the context of microbial metabolism modes. Physical and geochemical results are presented in an order corresponding to the most to least thermodynamically favorable terminal electron acceptors used for microbially mediated oxidation-reduction reactions. Each terminal electron acceptor corresponds to a specific mode of microbial metabolism and a detailed analysis of the relative abundance of terminal electron acceptors provides an indication of the predominant microbial metabolism mode within the biowall.

After dissolved oxygen and nitrate has been consumed, electron acceptors are consumed from most to least thermodynamically favorable in the following order:

Iron Reduction -> Manganese Reduction -> Sulfate Reduction ->

These metabolism modes are described in the following sections.

Iron

After the more thermodynamically favorable electron acceptors (oxygen and nitrate) are consumed, ferric iron, iron (III) or Fe^{3+}, becomes the preferred terminal electron acceptor. During anaerobic ferric iron reduction, ferric iron is reduced to ferrous iron, iron (II) or Fe^{2+}. Total iron concentrations in groundwater within the biowall ranged from 10 to 220 mg/L during the four-year performance monitoring period. Dissolved iron concentrations ranged from 0.081 to 190 mg/L. Average total iron and dissolved iron concentrations in biowall wells over the performance monitoring period were 116 mg/L and 92 mg/L, respectively. Iron analytical results for the monitoring period are presented in Appendix B.

An analysis of total and dissolved iron results was performed for the BDRLF One-Year Performance Review (BMT, 2015) to estimate the relative concentrations of ferric and ferrous iron in biowall groundwater. Based on that analysis, the following assumptions were used to determine the relative amount of ferrous and ferric iron in biowall groundwater:

- Ferric iron would only be present in biowall groundwater as ferric hydroxide.
- Ferric hydroxide is not soluble at the observed pH of site groundwater (slightly acidic pH ranging from 5 to 7).

- Ferric hydroxide would only be present in biowall groundwater as suspended particles or in colloidal form.
- Suspended particles and colloidal ferric hydroxide are removed by filtration through a 0.45 micron filter as part of sample collection procedures and are not present in the filtered or dissolved sample fraction.
- Only ferrous iron remains in the filtered sample fraction.

Considering these assumptions, ferrous iron concentrations were considered equal to the iron detected in the dissolved (filtered) sample fraction. The percentage of ferrous iron in biowall groundwater ranged from 17% to 100% with an average of 79%. Dissolved iron was not detected at concentrations above the Lowest Limits of Detection (LLOD) in BW4 and BW8 on January 20, 2016. These were the only samples with no detection for dissolved iron over the four-year performance monitoring period. The existing data that ferric iron reduction is occurring within the biowall.

During semi-annual sampling event in September, 2016, a groundwater sample was collected from MW6, located approximately 120 feet upgradient from the biowall, and analyzed for biochemical parameters, including total and dissolved iron, sulfate, total organic carbon, and $CaCO_3$ alkalinity. Total and dissolved iron concentrations in groundwater from MW6 were 27 mg/L and 19 mg/L respectively. Based on these results, dissolved iron concentrations in biowall groundwater are much greater than in the surrounding formation. The increase in iron concentrations in biowall groundwater may be the result of the reduction of insoluble ferric iron to more soluble ferrous iron through ferric iron reduction.

The PMP was updated after the 2-year review to specify filtering of dissolved iron samples during sample collection to reduce error caused by iron precipitating out of solution when exposed to oxygen. The PMP was subsequently updated after the 3-year review to include analysis of ferrous iron via EPA Method 3500 FE-B-11 to confirm existing assumptions concerning dissolved iron concentrations. Ferrous iron concentrations as measured using this method ranged from 75 mg/L in December 2016 to 100 mg/L in March, June and September of 2017. Unfiltered samples were submitted for ferrous iron analysis. Some ferrous iron may have precipitated out of solution during shipment to the analytical laboratory, but the high concentrations of ferrous iron detected support the assertion that dissolved iron concentrations are approximately equivalent to ferrous iron concentrations in biowall groundwater. Ferrous Iron concentrations analyzed using EPA Method 3500 FE-B-11 are shown below in Table 1.

Table 1.

Ferrous Iron Results – Year 4	
12/14/2016	75 mg/L
3/29/2017	100 mg/L
6/21/2017	100 mg/L
9/27/2017	100 mg/L

Manganese

Manganese is a potential terminal electron acceptor for anaerobic metabolism via manganese reduction. After dissolved oxygen is depleted, anaerobic microbes will use nitrate as an electron acceptor, followed by manganese, ferric iron, then sulfate, and finally carbon dioxide via methane fermentation (methanogenesis). During the first three years of monitoring, manganese was not included in the monitoring program. During the 3-year performance review, the need to examine the presence of manganese within the biowall and surrounding formation and its potential role in anaerobic metabolism within the biowall was identified (BMT, 2016c).

In Year 4, total and dissolved manganese were sampled from biowall wells concurrently with total and dissolved iron. Average total and dissolved manganese concentrations in biowall groundwater during Year 4 measured at 9.7 mg/L and 9.0 mg/L respectively. Dissolved manganese concentrations were a significant fraction of or equivalent to total manganese concentrations. Total manganese is a measure of all the manganese present in the groundwater sample including in-soluble (Mn^{4+}) and soluble divalent manganese (Mn^{2+}). Dissolved manganese is assumed to be comprised exclusively of divalent Manganese suggesting that significant manganese reduction is occurring at the site.

Total manganese concentrations detected in MW6, located approximately 100 feet upgradient of the biowall ranged from 1.4 mg/L to 1.9 mg/L. Dissolved manganese concentrations were equivalent. The lower total concentrations of manganese in MW6 as compared to the biowall wells is a potential indicator that most available manganese is in insoluble form. This would indicate an environment that is not comparatively conducive to manganese reduction as compared to the biowall.

Sulfate and Sulfide

After dissolved oxygen, nitrate, and ferric iron have been depleted from groundwater within the aquifer (through microbial metabolism), sulfate is the next most thermodynamically favorable electron acceptor for anaerobic metabolism (sulfate reduction). Sulfate has been detected in biowall groundwater at concentrations ranging from below detection limits to 150 mg/L. Sulfide was never detected in biowall groundwater and sulfide analysis was subsequently discontinued from biowall performance monitoring. Sulfate analytical results are included in Appendix B.

Although sulfide has not been detected in biowall groundwater, this does not mean that sulfate reduction is not occurring. As noted in the previous section, there are elevated concentrations of ferrous iron in biowall groundwater. As soon as sulfate reduction occurs, sulfide reacts with ferrous iron to form iron (II) sulfide, which precipitates from solution. Based on the first year monitoring results for sulfide, continued monitoring for sulfide in biowall groundwater via fixed laboratory analysis was discontinued.

Sulfate concentrations in RI wells were evaluated during the completion of the FS using field test kits and ranged from 250 to 500 mg/L (BMT, 2008a). During Year 4, sulfate was detected in MW6 at a concentration of 170 to 210 mg/L. Sulfate was detected in BW6, located downgradient of MW6, at concentrations of 71 to 110 mg/L during the same time period indicating some degree of sulfate reduction occurring within the biowall.

The highest concentrations of sulfate in groundwater have been detected in BW6, which is located at the center of the CAH contaminant plume. The second highest sulfate concentrations have been detected in BW8. High relative groundwater velocities were estimated at these two (2) biowall wells during the aquifer testing program as compared to the other biowall wells. The high relative sulfate concentrations in these two (2) wells may be indicative of low proximate residence times reducing the ability of the biowall to fully reduce sulfate in incoming groundwater.

Methane

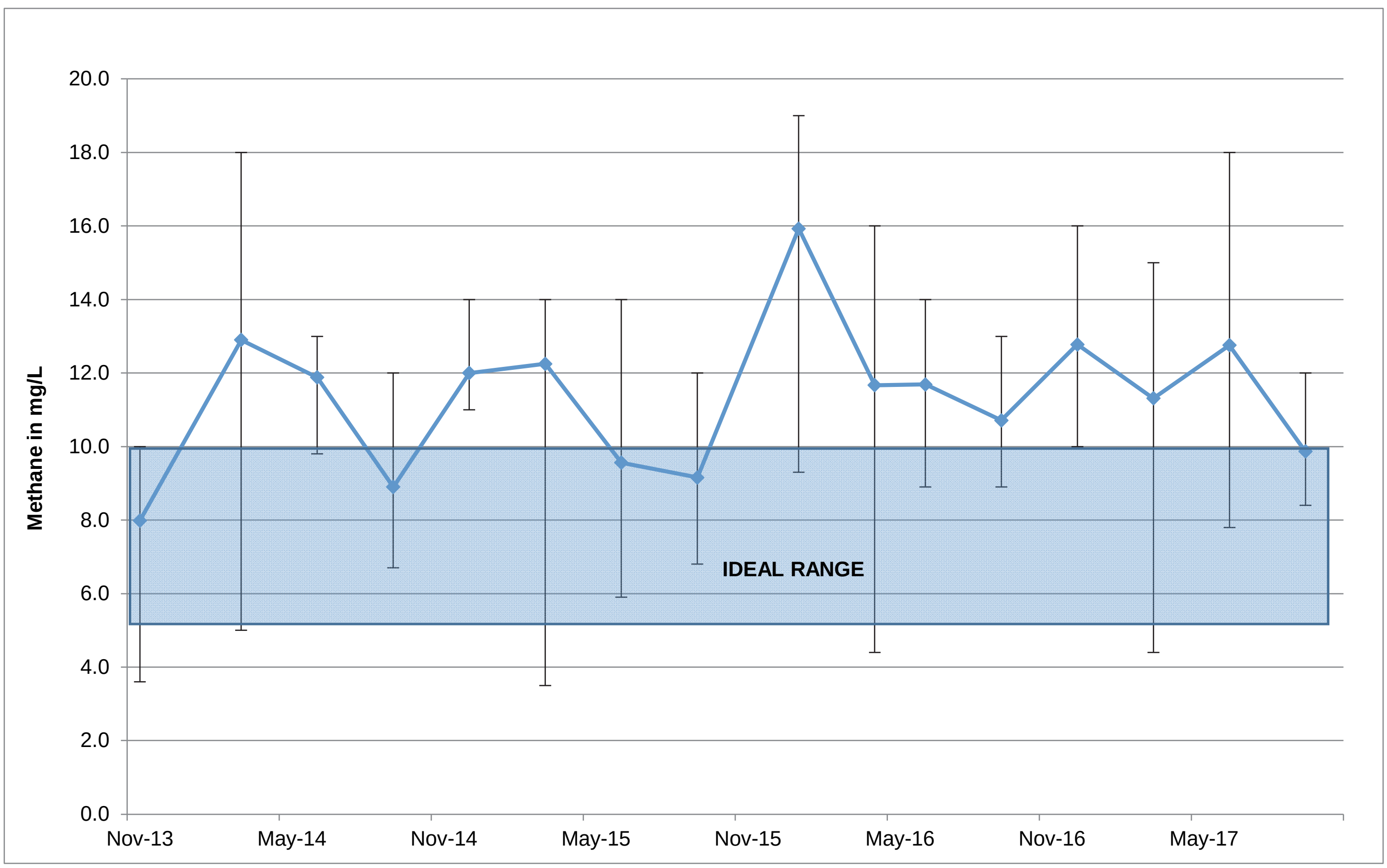
After depletion of dissolved oxygen, anaerobic microbes will use nitrate as an electron acceptor, followed by ferric iron, then sulfate, and finally carbon dioxide via methane fermentation (methanogenesis). During methanogenesis, carbon dioxide is used as an electron acceptor and is reduced to methane. The presence of methane in groundwater is indicative of the occurrence of methanogenesis resulting in the degradation of organic compounds (EPA, 1998). Methane concentrations greater than 1.0 mg/L are desirable for reductive dechlorination, but are not required for it to occur. Methane concentrations in biowall wells ranged from 3.5 mg/L to 19.0 mg/L with an average concentration of 11.3 mg/L during the four-year performance monitoring period. Methane concentrations in biowall groundwater fluctuates following a seasonal pattern with high relative methane concentrations detected during the winter and low relative methane concentrations recorded during the summer.

Groundwater samples collected from transect wells were analyzed for methane via fixed laboratory analysis during the second year of the performance monitoring period. Methane concentrations in transect well TW6, located hydraulically upgradient of the biowall, ranged from 0.003 to 0.89 mg/L with an average concentration of 0.194 mg/L during the second, third and fourth year of the performance monitoring period. Methane was detected concentrations ranging from 0.011 mg/L to 0.11 mg/L in MW6 between Quarter 11 and Quarter 16 monitoring. MW6 is located approximately 120 feet upgradient of the biowall. Methane concentrations in BW6, located immediately downgradient of TW6, ranged from 6.0 to 18.0 mg/L with an average concentration of 12.8 mg/L during the same performance monitoring period.

Methane concentrations within the biowall are significantly higher than background concentrations at the BDRLF, and have remained stable during the performance monitoring period. This suggests that methanogenesis is occurring within the biowall. Methanogenesis within the biowall is indicative of strongly reducing conditions. As with other biochemical parameters such as TOC and CaCO3 alkalinity, rates of methane production appear to experience seasonal variations.

The fastest rates of anaerobic dechlorination typically occur under sulfate-reducing or methanogenic conditions. However, highly elevated concentrations of methane (greater than 5 to 10 mg/L) also may indicate that organic substrate is being consumed by methanogens at the expense of microorganisms capable of degrading the target contaminants (e.g., *Dehalococcoides* species) (AFCEE 2008). Highly elevated methane concentrations that have been observed within the biowall may be indicative that methanogens are inhibiting the reductive dechlorination of TCE by dehalococcoides bacteria.

Figure 8. Average Methane Concentrations in Biowall Groundwater



4.2.1 Overview of Microbial Metabolism within the Biowall

The relative abundance of other terminal electron acceptors metabolic byproducts suggest that anaerobic microbial metabolism is occurring within the biowall. Multiple modes of microbial metabolism may be occurring simultaneously within the biowall; however, the predominant modes of microbial metabolism appear to be ferric iron reduction and sulfate reduction. Methanogenesis is also occurring within the biowall. The following lines of evidence support the conclusion that ferric iron reduction and sulfate reduction are the predominant modes of microbial metabolism:

- High dissolved iron concentrations within the biowall suggest the presence of ferrous iron in biowall groundwater. Furthermore, high concentrations of ferrous iron have been detected in groundwater samples collected from BW6 support the original assertion that ferrous iron concentrations are roughly analogous to dissolved iron concentrations.
- High dissolved manganese concentrations relative to total manganese concentrations support the assertion that manganese reduction is currently occurring within the biowall.
- Sulfate has been detected within the biowall at significantly lower average concentrations than in a well located immediately upgradient of the biowall.
- Methane has consistently been detected at concentrations well over 5 mg/L within the biowall. Upgradient concentrations have average 0.194 mg/L in TW6 and have been measured at an average concentration of 0.0685 mg/L further upgradient in MW6. High rates of methanogenisis are indicate of strongly reductive conditions within the biowall, but are also indicative of methanogen populations large enough to inhibit the activity of dehalococcoides microbes.

4.3 Microbial Sampling and Analysis

Two ‘data gaps’ were identified concerning the performance monitoring program in 2016: unknown groundwater velocity through the biowall, and the presence and concentration of beneficial microbes within the biowall. Groundwater velocity estimates were derived from multiple sources as part of the aquifer testing program that was completed in June 2016 (BMT, 2016b).

A comprehensive microbial sampling and analysis program was conducted by BMT in coordination with UMD researchers to determine presence and concentration of microbial populations within the biowall and within the general vicinity. The microbial sampling program included the following sampling and analysis activities:

- Groundwater was collected from a piezometer well located adjacent to BW6, and submitted for a bacterial census analysis via a third party analytical laboratory.
- A sample of saturated biowall material was collected in the vicinity of BW6, and submitted for a bacterial census analysis via a third party analytical laboratory.
- Bio-trap® samplers were installed within MW6 and BW6 for approximately 60 days and then shipped to a third party analytical laboratory for bacterial census.

- Samples of saturated and saturated material were collected from within the biowall, and immediately upgradient and downgradient of the biowall for further analysis by UMD.
- Custom bio-char samplers were developed using both bone and pine bio-char and installed in BW6 and MW6. These bio-char samplers were analyzed by UMD.

Third party bacterial census analysis was focused on detecting *Dehalococcoides* (DHC) and its' associated genes for the degradation of TCE, and various daughter compounds. *Dehalococcoides* is the only group of microbes isolated that are capable of complete reductive dechlorination of PCE to ethene (Maymo-Gatell et al. 1999). Dehaclococcoides strains are identified by genes that encode for the reduction of TCE, cis-1,2-DCE and vinyl chloride. DHC microbe populations greater than 10,000 cells/g or cells/ml are typically used as a screening criterion for sites that will produce a useful biodegradation rate (Lu et al. 2006).

4.3.1 Groundwater Microbial Analysis Results

DHC was detected at an approximately concentration of 11,900 cells/ml in the single unfiltered groundwater sample that was collected from the piezometer well. The total measured concentration of the TCEr was approximately 4,530 cells/ml. VCr was detected at a concentration of approximately 9,560 cells/ml. BAV1 vinyl chloride reductase (bvc) was not detected in the sample above the detection limit of 7 cells/ml.

4.3.2 Biowall Material Microbial Analysis

DHC was detected at an approximate concentration of 552,000 cells per gram (cells/g) in the saturated biowall material sample. The total measured concentration of the TCE A reductase gene (TCEr) was approximately 412,000 cells/g. Vinyl chloride reductase (VCr) was detected at a concentration of approximately 7,760 cells/g. BAV1 vinyl chloride reductase B (BVC) was not detected in the sample above the detection limit of 200 cells/g.

These results that sufficient populations of TCEr microbes are present within the biowall to consume TCE, which is consistent with performance monitoring results, but there may not be a critical mass of VCr microbes to fully consume vinyl chloride.

4.3.3 Groundwater Microbial Analysis Results

Bio-trap® samplers contain nomex beads within a passive sampler frame. Mircobes bind to the beads for subsequent analysis. DHC was detected cells were detected at concentrations of 910 cells per bead in BW6 and 18.5 cells per bead in MW6. TCEr was detected at a concentration of 86.5 cells/bead in BW6, and VCr was detected at a concentration of 245 cells/bead in BW6. BVC was not detected in BW6. TCEr, VCr and BVC were not detected in MW6. Concentrations in cells/bead are roughly comparable to concentrations of cells/ml in groundwater samples.

Unlike the groundwater samples that were collected from the unscreened piezometer well located next to BW6 (section 3.2), BW6 and MW6 are both environmental monitoring wells with sand packs around the well screen to filter out fine particles that microbes are likely to bind to. As a result, measured microbial concentrations from a Bio-Trap® samplers deployed in monitoring wells are likely to be lower than microbial populations collected from an unfiltered piezometer well.

4.3.4 UMD Batch Reactor Studies

A progress report was presented on October 3, 2017 detailing the progress of work in UMD labs. The report summarized progress that had been completed on batch reactors established on soil samples from the immediate vicinity of the biowall (Saffari, 2017).

Batch reactors seeded from 2” thick sections of Geoprobe® DT22 liner cores (1.375” inside diameter). Samples used in batch reactors were kept in nitrogen flushed anaerobic media bottles to simulate anaerobic conditions. Degradation of TCE occurred very quickly during the first week of the batch reactors, but degradation rates were reduced in subsequent weeks.

Key findings from the batch studies include discovery that the addition of lactate as an electron donor biowall material did not increase the degradation of TCE in the batch reactors, and the average measured pH in the bioreactors being less than 6 (5.6). The batch reactor research is important as it identifies potential remedial amendments that could be added to the biowall, such as buffering solutions, and eliminates other potential amendments that would not be productive, such as lactate.

WBC-2, a consortium of bacteria that has demonstrated an ability to degrade TCE to ethene in laboratory conditions, was added to batch reactors made from soil collected adjacent to TW3 (immediately upgradient of the biowall) and TW2 (immediately downgradient of the biowall).

4.4 Contaminant Degradation

The performance of the biowall is evaluated by its effectiveness in degrading contaminants of concern (COC) (e.g., CAHs) in groundwater as it flows through the biowall. In order to accurately evaluate the effectiveness of the biowall, CAH concentrations in groundwater are monitored over time from the established transect wells and biowall wells. The change in CAH concentrations in individual groundwater increments as they flow through the biowall over time is imperative to an accurate evaluation of contaminant reduction due to the biowall. This time-course data evaluation relies on known contaminant transport rates in the biowall and the surrounding formation.

As discussed in the Three-Year Performance Review (BMT, 2016c), TCE velocity was originally estimated to be approximately 2.4 feet per year through the biowall. Based on the results of the aquifer testing program conducted in 2016, actual groundwater velocity through the biowall is at least an order of magnitude greater than the original estimates. The transect wells TW0 through TW6 were installed based on the original groundwater velocity estimate of 2.4 feet per year with transect wells spaced on time intervals of six (6) months to one (1) year. Based on an estimated groundwater velocity of 30 to 50 feet per year, the distance from TW6 to TW0 represents a transit time of approximately 70 to 120 days, or within the time frame between quarterly and semi-annual monitoring events. This makes it feasible to evaluate biowall performance by comparing the concentration of VOCs in TW6 and TW1 (see figure 3.).

4.4.1 Trends in VOC Concentrations

Performance monitoring was initiated in October of 2013. During the period between the biowall installation and the initiation of the performance monitoring program, groundwater from the surrounding formation filled the pore space of the biowall, groundwater levels in and around the biowall returned to their pre-installation levels, and groundwater flow through the biowall and aquifer formation returned to pre-installation rates. During the first year of monitoring, four (4) quarterly sampling events were completed that included the collection of groundwater samples from biowall wells and transect wells for laboratory analysis of VOCs, including CAHs. Transect wells were sampled ethane and ethene in the second, third and fourth year. Analytical results for CAHs from the four-year performance monitoring period are presented in Appendix D.

Upgradient groundwater sampled from TW6 has consistently shown high concentrations of TCE (390 – 1,100 µg/L), low concentrations of cis-1,2-DCE (less than 35 µg/L) and trace concentrations of vinyl chloride (less than 1 µg/L). Downgradient groundwater that was sampled from TW1 has shown low concentrations of TCE (less than 15 µg/L) since March 2014, higher concentrations of cis-1,2-DCE (130 – 260 µg/L) and high concentrations of vinyl chloride (up to 56 µg/L). Low concentrations of ethene (up to 6.7 µg/l) were also detected in TW1.

Ethene readily degrades into carbon dioxide and water under hypoxic conditions in the environment through a number of biological pathways. Ethene is expected to have a short half-life within the groundwater aquifer under these conditions and higher concentrations of carbon-dioxide would expected. The presence of ethene in groundwater is indicative that reduction of vinyl chloride is occurring within the biowall, but rates of biodegradation cannot be determined from this data (U.S. Geological Survey, 2012).

TCE is the primary CAH in upgradient groundwater. Cis-1,2-DCE is the primary CAH in downgradient groundwater. TCE concentrations in TW6, and cis-1,2-DCE and vinyl chloride concentrations in TW1 are shown in Figure 7. There is no observable temporal trend in cis-1,2-DCE or vinyl chloride concentrations in TW1 during the three-year performance monitoring period. Trace concentrations of ethene have been detected in downgradient groundwater but there is no observable trend in the concentration of these contaminants over time.

TCE was detected in TW5 and TW6 at a concentration of 1,100 μg/L in March 2015, far higher than TCE concentrations detected in the upgradient transect wells before or after that sampling event. Concentrations of CAHs in downgradient groundwater during the March 2015 sampling event were not greater than CAH concentrations detected in TW1 or TW2 before or after this event. This data suggests that conditions within the biowall are conducive to the degradation of TCE into cis-1,2-DCE, and moderately conducive to the degradation of cis-1,2-DCE to vinyl chloride.

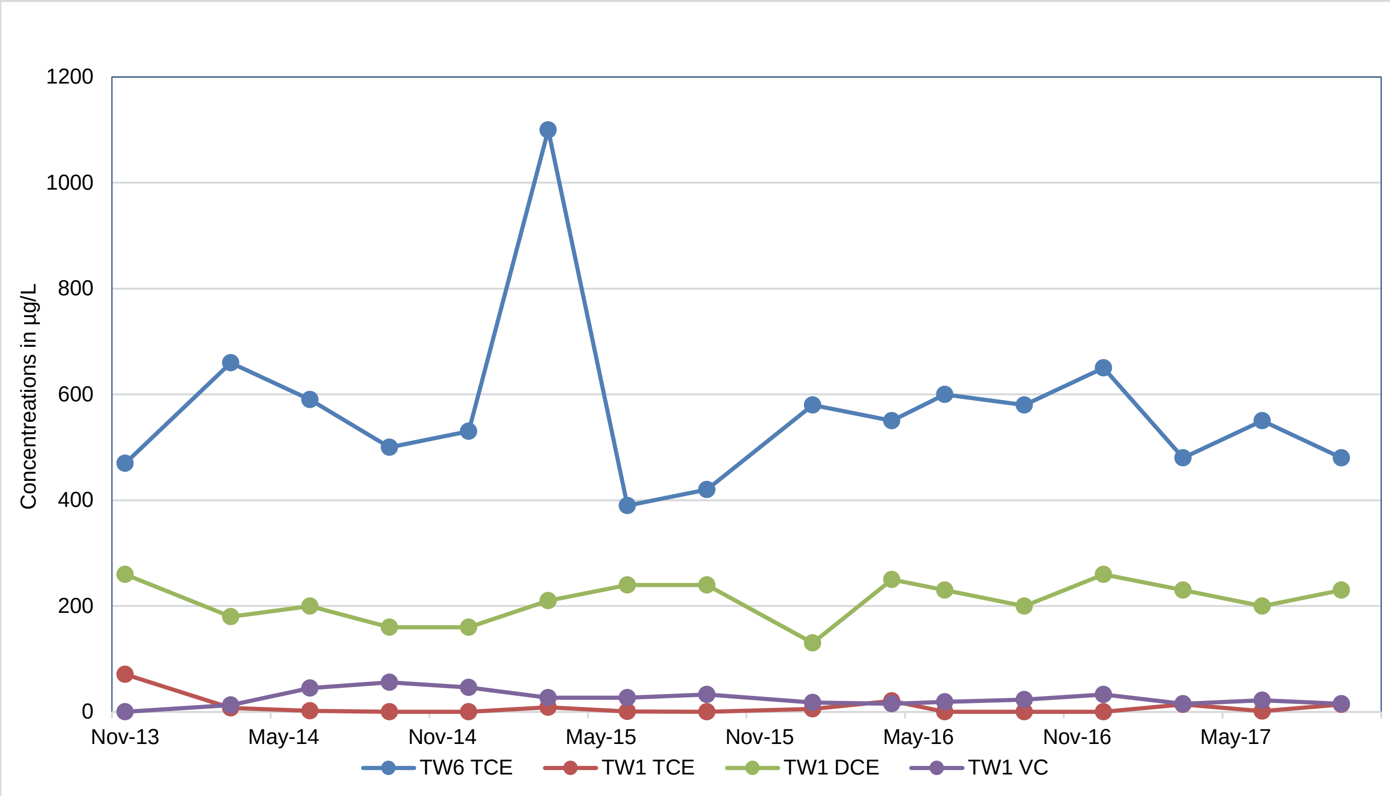
A reduction in the concentrations of parent compounds coupled with the presence of dechlorination products provides an indication that reductive dechlorination is occurring both upgradient and within the biowall. This is supported by the high concentrations of TCE and low concentrations of degradation products detected in upgradient groundwater, and the lower concentrations of TCE and higher concentrations of degradation products detected in downgradient groundwater. Relative concentrations of CAH degradation products, primarily cis-1,2-DCE, vinyl chloride and ethene have remained stable within biowall well BW6 and the downgradient transect wells during the second, third and fourth years of the performance monitoring period.

Concentrations of VOCs in TW6 and TW1 during the four-year performance monitoring period are shown in Figure 9.

The total molar mass of ethenes detected in TW1 is consistently lower than the molar mass of ethenes detected in TW6. This suggests that abiotic processes are contributing to the reduction in CAH concentrations; however, this does not provide any indication as to which abiotic process is predominant (e.g., adsorption or biogeochemical transformation). Adsorption to the organic substrate of the biowall, and the degradation products of the β-elimination (dichloroacetylene, chloroacetylene, and acetylene) may account for this discrepancy. Furthermore, degradation of VC may be underestimated due to the short half-life of ethene in groundwater.

The peak in CAH molar mass concentration in TW6 that was measured during the March 2015 quarterly monitoring event, does not appear to have affected the total molar mass concentrations of CAHs in groundwater downgradient of the biowall. This would support that some manner of adsorption or abiotic degradation is occurring within the biowall.

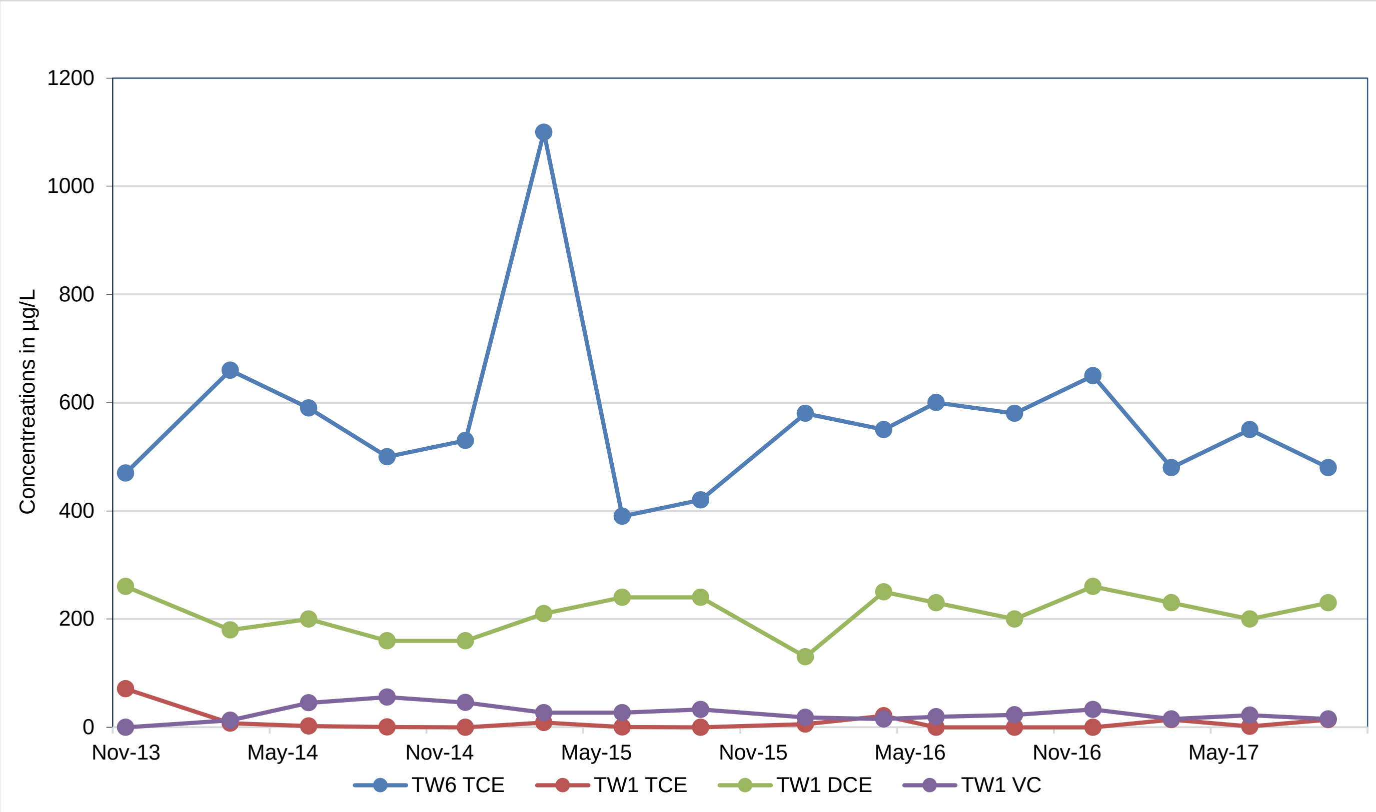
Figure 9. VOCs in Transect Wells TW1 and TW6 during Performance Monitoring Period



The peak in CAH molar mass concentration in TW6 that was measured during the March 2015 quarterly monitoring event, does not appear to have affected the total molar mass concentrations of CAHs in groundwater downgradient of the biowall. This would support that some manner of adsorption or abiotic degradation is occurring within the biowall.

Total molar mass of ethenes in TW6 and TW1 during the four-year performance monitoring period are shown in Figure 10. No temporal trends regarding the overall mass of ethenes measured upgradient and downgradient of the biowall were observed.

Figure 10. Total Ethenes Molar Mass in TW1 and TW6 during Performance Monitoring Period



4.4.2 Plume Toxicity

Incomplete microbially mediated (biotic) reductive dechlorination of TCE can result in the presence of degradation products (e.g., DCE and VC) in groundwater within and downgradient of the biowall. These degradation products are regulated under the Safe Drinking Water Act (SDWA) (i.e., they have established MCLs) and pose different risk to human health and the environment than their parent compound TCE. The determination of plume toxicity is a useful tool for evaluating the overall toxicity of the plume and how it changes within specific groundwater increments as they flow through the biowall. Plume toxicity is a good indicator of ultimately how effective the biowall is at reducing risk to human health and the environment. An example of a total plume toxicity calculation is presented in Table 2.

Plume toxicity is determined by first calculating toxicity equivalents for each COC within the plume by dividing the concentration of a COC by its MCL. The calculated toxicity equivalents for each of the COCs are summed to determine the total plume toxicity. Total plume toxicity for all transect wells, and BW6, during the performance monitoring period is presented in Figure 11.

Table 2: Plume Toxicity in Groundwater Upgradient and Downgradient of the Biowall

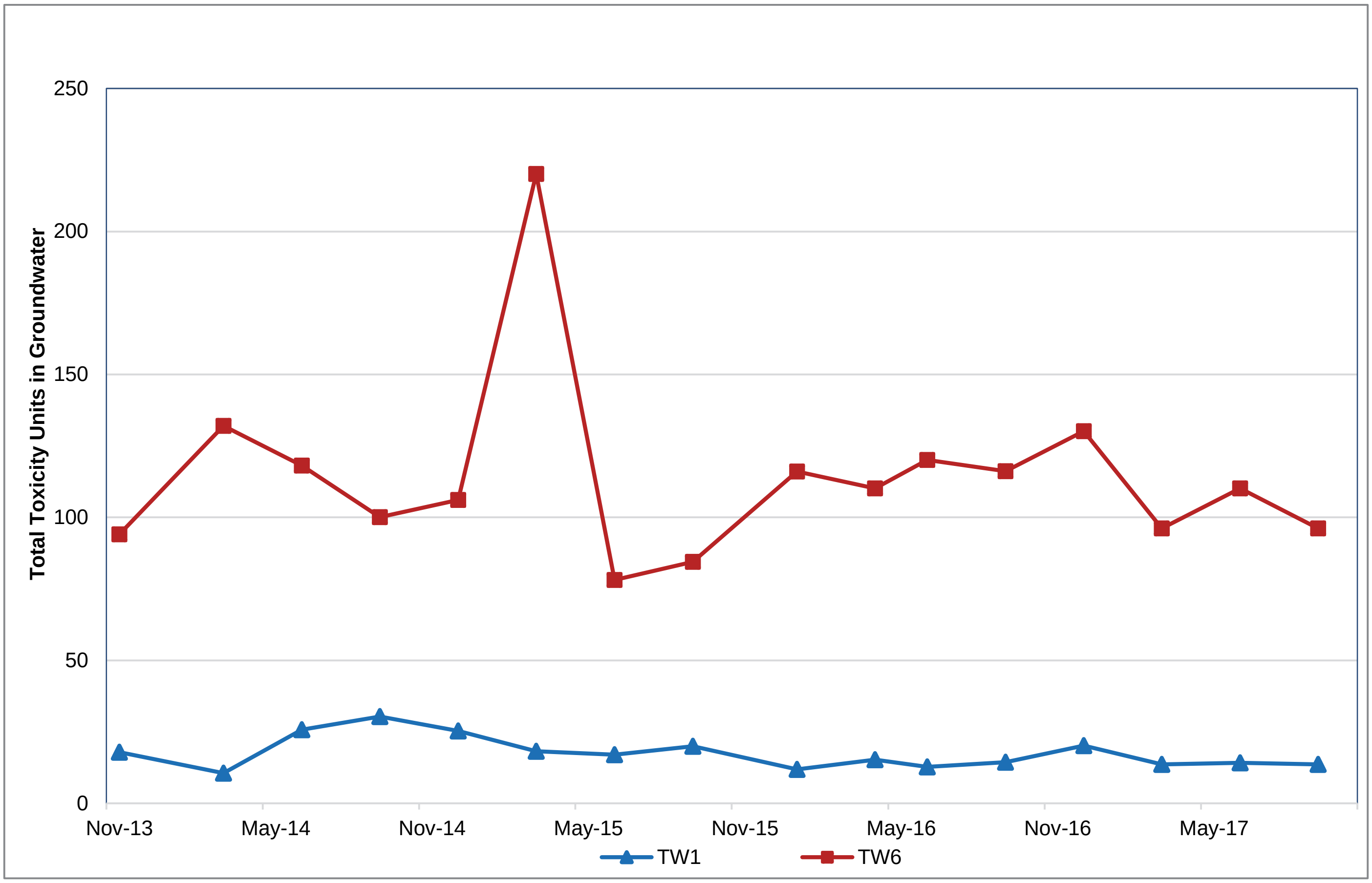
Contaminant	MCL (µg/L)	Upgradient Groundwater (transect well TW6) Concentration (µg/L)	Upgradient Groundwater (transect well TW6) Toxicity Equivalent (unitless)	Downgradient Groundwater (transect well TW1) Concentration (µg/L)	Downgradient Groundwater (transect well TW1) Toxicity Equivalent (unitless)	Percent Change (%)
TCE	5	600	120	Not Detected*	0	
cis-1,2-DCE	70	8.8	0.13	200	2.86	
vinyl chloride	2	Not Detected*	0	23	11.5	
		Total:	**120.13**	**Total:**	**14.36**	**88.05%**

Note: CAH concentrations from the eighth quarterly monitoring event (September 2015)
trans-1,2-DCE and 1,1-DCE were below MCLs and are not included in the plume toxicity evaluation
*Non-detect results are considered 0 µg/L for calculation of toxicity equivalents

The graph demonstrates that upgradient plume toxicity, as calculated from CAH concentrations detected in TW6 has been consistently higher than biowall and downgradient plume toxicity, as calculated from CAH concentrations detected in TW1. Total downgradient plume toxicity has remained stable during the span of the performance monitoring period. There does not appear to be any temporal trends in total plume toxicity over the four years of the performance monitoring period.

Average total plume toxicity calculated within TW6 was approximately 114 toxicity equivalents during the span of the performance monitoring period. Average total plume toxicity calculated within TW1 and TW2 was approximately 18 toxicity equivalents, or approximately 16% of the upgradient plume toxicity, during the same monitoring period. Upgradient plume toxicity is derived, primarily, from relatively high concentrations of TCE while downgradient plume toxicity is derived primarily from relatively high concentrations of cis-1,2-DCE and VC.

Figure 11. Total Groundwater Toxicity in TW1 and TW6 during Performance Monitoring Period



4.4.3 Overall Trends

As stated earlier, biowall performance in regards to facilitating microbial mediated reductive dechlorination of TCE in groundwater is approaching equilibrium. Though biochemical markers such as: buffering capacity and TOC concentrations have decreased since the installation of the biowall, overall performance has not changed significantly in the same time period.

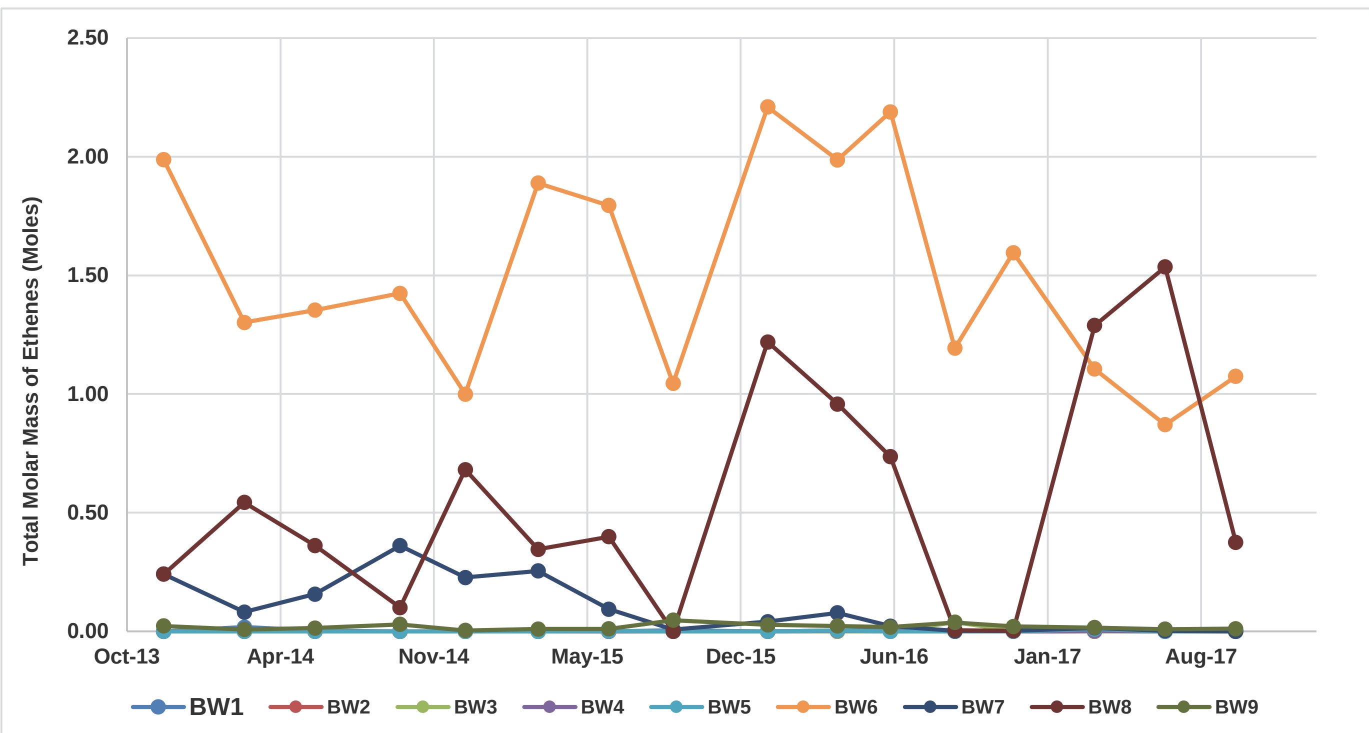
High concentrations of cis-1,2-DCE were detected in MW10 in March 2017 (73 µg/L) and in September 2017 (25 µg/L). MW10 is located approximately 85 feet downgradient of the biowall, on the northern bank of the unnamed tributary located south of the biowall. Cis-1,2-DCE was detected at a concentration of 14 µg/L in MW10 in September, 2016. This is indicative that the groundwater plume, previously identified during the RI, has reached the unnamed tributary south of the site. These data points are consistent with patterns derived from downgradient Geoprobe® groundwater sampling that was conducted in June 2016 in support of the biowall aquifer testing program. The detection of high concentrations of cis-1,2-DCE in Mary 2017 would be consistent with a TCE velocity of approximately 20-30 feet per year.

Based on current data, some form of supplemental bio-augmentation will need to be implemented at the biowall to achieve ARARs and overall protectiveness. ARARs established for the ROD specified achieving Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) for chlorinated solvents (TCE, cis-1,2-DCE, trans-1,2-DCE & vinyl chloride) (reference).

4.5 CAHs within the Biowall

Except for detections at trace concentrations, CAHs have not been detected in BW2, BW3, BW4, BW5, and BW10 during the four-year performance monitoring period. The highest concentrations for CAHs have been consistently been detected within BW6, located within the transect of wells established to trace the existing TCE plume. High concentrations of CAHs have also been consistently detected in BW7 and BW8. Based on slug tests that were performed as part of the aquifer testing program, BW6 and BW8 had the highest estimated hydraulic conductivities within the biowall. The total molar mass of ethenes (TCE, DCE, VC, and ethene) detected in each biowall well over the course of the performance monitoring period is shown in Figure 12.

Figure 12. Total Ethenes Detected in Biowall Wells During Performance Monitoring Period



CAH concentrations within BW6 and BW8 appear to show a seasonal pattern, indicating variability in the rates of biodegradation within the biowall. Overall trends indicate that the active part of the CAH plume intersect approximately linear 200 feet of biowall. Ethene concentrations, in molar mass for all detected CAHs in BW6 and BW8 are shown in Figures 13 & 14 respectively. Cis-1,2-DCE and VC are the primary

CAHs detected in BW6 during the length of the performance monitoring period while VC and ethene are the dominant CAHs detected in BW8. This may reflect the fact that higher concentrations of TCE are flowing through the biowall at BW6 than at BW8.

Figure 13. Total Ethenes Detected in BW6 During Performance Monitoring Period

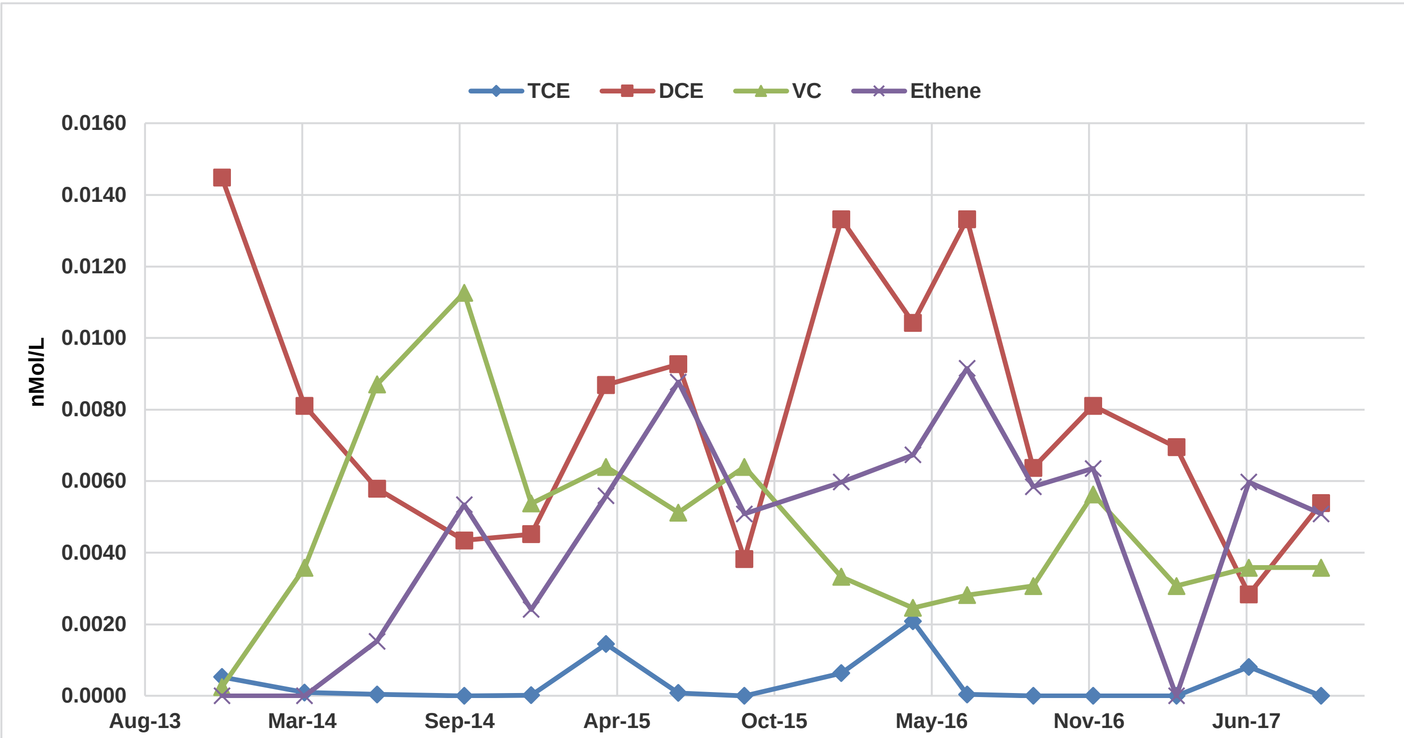
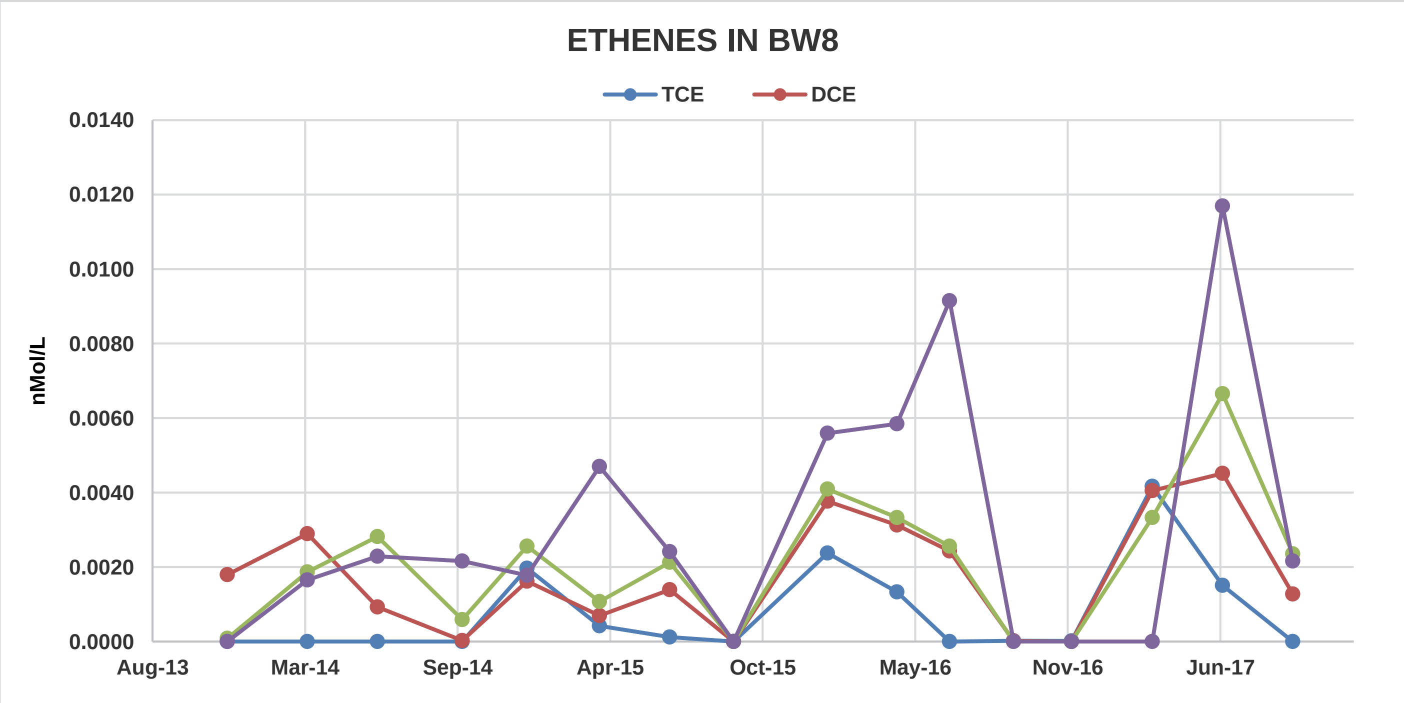


Figure 14. Total Ethenes Detected in BW8 During Performance Monitoring Period



5. SUMMARY AND RECOMMENDATIONS

The objective of the biowall as the selected remedy at the BDRLF site is to completely degrade TCE to ethene as groundwater flows through the biowall, reducing TCE and degradation products to concentrations below their respective MCLs. The biowall was designed to accomplish this by creating the conditions necessary for microbially mediated reductive dechlorination. Based on geochemical conditions and the relative abundance of terminal electron acceptors within the biowall, iron-reducing and sulfate-reducing conditions necessary for reductive dechlorination have been achieved. The biowall has been effective in reducing TCE to levels below MCLs, and in greatly reducing the toxicity of the groundwater plume. The presence of TCE degradation products DCE, VC, and ethene within and downgradient of the biowall indicates that microbially mediated reductive dechlorination is occurring. The presence of DCE and VC in downgradient groundwater suggests complete dechlorination of TCE is not occurring.

The reasons for only partial dechlorination of TCE within the biowall result from one or more of the following three conditions:

1. Insufficient residence time within the biowall to fully biodegrade TCE to ethene under present conditions due to higher than originally estimated groundwater velocity.
2. Conditions within the biowall (e.g., pH buffering capacity) are not in the optimal range for necessary bacterial populations necessary to fully degrade TCE to ethene.
3. Methanogens competing with dehalococcoides bacteria and inhibiting the potential reductive dechlorination of chlorinated ethenes in biowall groundwater. Consistently high rates of methane generation within the biowall are indicative of these conditions.

Insufficient microbial populations were identified as a potential biowall condition that could be causing insufficient dechlorination, but the microbial sampling program (Section 4.3) identified relatively high concentrations of DHC bacteria and reductase genes for TCE and VC. No BAV1, which also degrades VC genes were identified in any sampled media. Adequate microbial populations appear to be present, but optimum performance may be inhibited by other factors.

Limited Feasibility Study for Potential Biowall Amendments

Based on an analysis of CAH concentrations in downgradient groundwater, TCE is not undergoing complete degradation to ethane within the biowall. Current degradation performance has remained constant over the four-year performance monitoring period. Aquifer testing has indicated groundwater velocities of 25 - 45 feet per year, which corresponds to biowall residence times for CAHs of 30-60 days.

Data gaps concerning groundwater velocity and microbial populations within the biowall have been, to a large extent, addressed. Potential remedial amendments that could be assessed include:

- Buffering solutions, such as magnesium hydroxide, to increase the pH of water within the biowall.
- Injecting small scale carbon particles to increase the volume of biologically available carbon and to increase the effective surface area within the biowall for molecules of CAHs and microbes to bind to.
- Additional microbial blends containing DHC bacteria beneficial to the degradation of VC to ethene.
- Injecting low volumes of amendments intended to inhibit, to some degree, the activity of methanogens.

These remedial amendments are currently available in injectable form. Moving into year 5, research and analysis for the biowall will be focused on identifying and testing injectable amendments as standalone additions and in combinations to develop an amendment plan for future implementation.

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APPENDIX A

Cumulative Water Quality Data

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 1

BW1	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	8.56	83.02	6.26	>999	2.2	4.12	16.73	na	na	1.85	-78	136
11/14/2013	9.06	82.52	6.16	353	2.0	3.84	12.60	16.8	0.75	0.26	-70	144
*Q11/20/2013	10.85	80.73	6.52	>999	2.2	4.26	12.79	na	0.95	0.74	-118	96
12/3/2013	8.32	83.26	6.59	189	2.4	4.58	13.90	15.4	0.23	0.28	-68	146
12/18/2013	6.75	84.83	6.12	45.4	1.3	2.54	7.23	12.3	0.31	0.51	60	277
1/9/2014	5.98	85.60	5.86	217	0.3	0.603	4.66	12.6	0.14	0.24	128	345
2/4/2014	5.15	86.43	4.90	281	0.4	0.830	4.11	9.5	0.63	0.37	148	365
2/17/2014	5.35	86.23	5.26	44.3	0.2	0.416	3.04	7.9	0.54	0.32	127	344
*Q3/5/2014	5.34	86.24	5.54	255	0.2	0.489	5.48	8.9	na	0.07	-4	213
3/21/2014	5.41	86.17	5.55	0	0.2	0.407	5.96	9.2	0.20	0.14	117	334
4/2/2014	5.08	86.50	4.51	95	0.2	0.429	7.25	10.2	1.07	1.88 R	147	364
4/18/2014	5.15	86.43	6.06	266	0.2	0.319	10.39	10.3	1.23	1.65 R	167	384
4/28/2014	5.83	85.75	5.42	648	0.2	0.468	15.14	10.9	1.70	2.10 R	128	342
5/13/2014	5.97	85.61	5.46	63.8	0.1	0.309	24.26	12.0	1.85	2.28 R	109	316
*Q6/4/2014	6.14	85.44	6.32	359	0.5	1.100	26.01	na	na	2.82 R	-46	161
6/18/2014	6.61	84.97	6.16	0	0.3	0.614	22.50	12.3	1.27	3.91 R	15	222
7/2/2014	7.30	84.28	5.88	381	0.2	0.400	26.37	12.9	2.73	3.85 R	53	260
7/18/2014	7.72	83.86	5.94	160	0.2	0.343	22.65	15.1	4.63	2.86 R	-45	162
7/29/2014	8.04	83.54	6.00	221	0.2	0.384	21.68	13.3	5.70	3.41 R	-40	170
8/13/2014	8.18	83.40	6.14	315	0.4	0.896	21.76	13.9	3.66	4.75 R	-54	156
9/8/2014	8.62	82.96	6.00	160	0.8	1.60	20.59	15.0	4.76	7.37 R	-40	170
*Q9/24/2014	8.76	82.82	4.74	484	1.0	2.00	18.20	na	na	4.05 R	-39	171
10/7/2014	9.17	82.41	5.62	193	1.0	2.03	17.23	15.4	7.01	5.65 R	-32	182
10/21/2014	8.81	82.77	5.81	165	1.0	2.02	17.26	16.5	8.37	6.78 R	-27	187
11/3/2014	9.00	82.58	5.85	180	1.1	2.19	15.16	16.0	8.17	5.15 R	-77	137
11/20/2014	8.70	82.88	6.20	245	1.2	2.30	13.52	15.7	9.53	6.25 R	-61	153
12/2/2014	8.40	83.18	6.02	245	1.2	2.30	14.09	15.5	8.87	6.14 R	-46	168
*Q12/18/2014	7.60	83.98	5.04	373	1.6	3.12	8.75	na	na	6.36 R	-20	197
12/30/2014	6.76	84.82	5.94	60.5	0.3	0.602	8.86	13.4	8.70	5.32 R	10	227
1/13/2015	6.06	85.52	5.66	74.4	0.2	0.382	6.62	11.7	8.00	7.93 R	96	313
1/28/2015	5.50	86.08	7.41	81.1	0.2	0.386	5.83	12.9	4.26	4.91 R	-16	201
2/10/2015	6.02	85.56	7.12	73.2	0.1	0.278	5.48	13.1	6.75	4.74 R	-30	187
3/9/2015	5.05	86.53	5.22	61	0.1	0.320	5.32	12.0	8.12	5.50 R	-74	143
*Q3/23/2015	5.18	86.40	5.33	271	0.2	0.346	7.21	na	na	5.45 R	-10	207
4/8/2015	4.85	86.73	7.67	82.5	0.1	0.228	8.04	10.6	4.66	4.36 R	-58	159
4/24/2015	5.49	86.09	8.22	82.2	0.1	0.273	11.96	10.9	4.85	3.04 R	-53	164
5/7/2015	6.45	85.13	7.10	119	0.1	0.224	17.60	10.9	0.18	0.00	-42	175
5/20/2015	7.00	84.58	7.01	113	0.1	0.223	16.87	10.9	0.42	0.00	-56	161
6/5/2015	6.74	84.84	6.11	171	0.2	0.398	17.02	16.0	0.29	0.98	171	388
*Q6/24/2015	5.95	85.63	6.02	86.5	0.1	0.278	19.47	na	na	0.02	191	408
7/7/2015	4.98	86.60	4.73	135	0.3	0.595	23.56	20.0	0.80	1.01 R	238	455
7/23/2015	7.18	84.40	6.97	136	1.0	0.200	24.09	17.5	1.41	0.75 R	3	220
8/19/2015	8.28	83.30	4.73	199	0.5	0.957	23.15	15.9	2.15	2.15 R	-23	194

Notes:

DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
**DO concentrations are biased high due to sample collection and measurement methodology

R - Rejected DO data due to sensor malfunctions
na - not analyzed
NTU - Nephelometric Turbidity Units
ppt - parts per thousand
mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 1

BW1	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
9/9/2015	9.16	82.42	7.67	317	0.6	1.170	22.55	17.0	2.89	2.43 R	-84	133
*Q9/29/2015	9.60	81.98	5.42	663	1.0	2.010	19.90	na	na	0.00	-69	148
10/13/2015	7.88	83.7	5.77	427	1.0	2.090	17.01	15.7	0.00	0.04	-58	159
11/2/2015	8.31	83.27	5.65	409	0.8	1.620	15.86	16.3	0.46	0.04	-37	180
11/17/2015	7.84	83.74	5.57	441	0.7	1.390	14.30	16.1	0.45	0.57	-32	185
12/4/2015	7.36	84.22	na	na	na	na	na	na	0.67	na	na	na
12/21/2015	8.25	83.33	6.08	429	0.5	1.190	14.05	14.6	0.51	0.68	-45	172
*1/20/2016	5.98	85.6	5.57	482	0.3	0.745	7.69	na	na	0.26	-4	213
2/5/2016	4.52	87.06	6.89	>999	0.3	0.578	6.35	11.0	0.46	0.38	-8	209
2/18/2016	5.46	86.12	6.36	474	0.2	0.488	5.21	8.8	0.42	0.72	3	220
3/7/2016	5.82	85.76	5.73	>999	0.3	0.530	14.37	10.1	0.65	0.56	41	258
3/22/2016	6.02	85.56	5.53	214	0.2	0.359	9.70	9.2	0.68	0.50	34	251
*4/11/2016	6.29	85.29	5.65	419	0.2	0.349	11.44	na	na	0.01	20	237
5/24/2016	6.06	85.52	6.99	270	0.1	0.308	17.56	13.9	0.01	0.01	-36	181
6/8/2016	6.16	85.42	6.29	341	0.1	0.337	16.59	12.4	0.48	0.57	9	226
*6/24/2016	8.75	82.83	6.73	240	0.3	0.701	17.38	na	na	0.01	-20	197
7/13/2016	7.87	83.71	6.85	176	0.1	0.212	24.15	16.0	0.82	0.67	-9	208
7/27/2016	8.27	83.31	7.03	861	0.5	0.989	16.91	18.8	1.05	0.01	-51	166
8/18/2016	8.25	83.33	6.53	>1000	0.5	0.985	22.17	16.4	1.42	0.87	-49	168
8/31/2016	8.65	82.93	5.72	998	0.7	1.39	21.83	15.8	2.03	1.17	-60	157
*9/22/2016	9.94	81.64	5.80	663	0.7	1.46	18.57	na	na	1.49	0	217
10/5/2016	8.79	82.79	5.84	>1000	0.7	1.390	17.08	16.1	5.32	3.57	20	237
10/20/2016	9.43	82.15	6.01	>1000	0.7	1.480	21.40	15.9	6.21	4.15	14	231
11/3/2016	9.5	82.08	6.19	910	0.9	1.890	18.73	16.4	5.69	5.32	-2	215
11/17/2016	9.93	81.65	5.64	892	1	2.060	14.52	15.5	8.46	16.20	-5	212
12/2/2016	9.5	82.08	4.99	994	0.5	0.976	13.10	15.4	10.18	8.78	9	226
*12/14/2016	8.98	82.6	6.10	177	0.4	0.901	13.10	na	na	3.01	-3	214
1/12/2017	8.29	83.29	6.31	365	1.4	2.660	14.50	11.1	0.24	0.39	31	248
1/25/2017	7.73	83.85	6.23	676	0.6	1.240	12.53	12.1	1.15	0.77	24	241
2/7/2017	7.45	84.13	6.06	461	1.2	2.300	13.65	10.6	0.81	0.81	13	230
2/22/2017	7.55	84.03	6.06	551	0.6	1.130	13.26	9.9	2.04	0.75	11	228
3/6/2017	7.45	84.13	6.04	555	0.6	1.200	12.23	9.2	2.27	1.21	14	231
*3/29/2017	7.43	84.15	5.39	116	0.2	0.353	11.13	na	na	0.73	75	292
4/14/2017	6.05	85.53	5.66	546	0.6	1.140	11.54	11.1	1.71	1.12	133	350
4/27/2017	5.8	85.78	5.87	816	0.5	1.070	14.71	12.1	1.52	1.37	85	302
5/18/2017	6.26	85.32	5.64	781	0.7	1.480	19.09	16.5	1.84	1.51	137	354
6/1/2017	6.55	85.03	5.79	839	0.9	1.710	19.34	14.7	1.27	1.02	124	341
*6/20/2017	7.81	83.77	5.69	262	0.3	0.628	18.75	na	na	3.55	48	265
7/6/2017	8.48	83.1	5.9	794	0.4	0.956	15.81	na	na	0.89	47	264
7/21/2017	9.09	82.49	6.18	712	0.3	0.637	16.62	14.3	2.03	1.32	4	221

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 1

BW1	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	8.01	83.57	6.05	787	0.4	0.822	17.40	18.1	19.20	0.28	21	238
8/15/2017	7.09	84.49	5.88	871	0.4	0.861	16.44	19.4	0.31	0.56	35	252
8/30/2017	7.32	84.26	5.67	>1000	0.7	1.350	17.15	18.1	0.77	0.61	47	264
9/13/2017	7.39	84.19	5.74	>1000	0.6	1.140	15.53	17.3	0.98	0.87	39	256
*9/27/2017	7.82	83.76	4.51	812	0.2	0.395	19.28	na	na	0.66	66	283

Notes:

DTGW - Depth to groundwater (from top of casing)

U52 - Temeprature measurement outside of the well during bi-weekly monitoring

Down-hole - Temerpature measurement collected with downhole measurement instrumentation

*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology

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mS/cm - millisiemens per cm

fbgs - feet below ground surface

mV - millivolts

mg/L - milligrams per liter

◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 2

BW2	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	7.60	83.23	6.25	>999	1.9	3.32	16.92	na	na	1.30	-77	137
11/14/2013	8.48	82.35	6.03	583	2.0	3.90	12.48	15.7	0.49	0.21	-81	136
*Q11/20/2013	8.51	82.32	6.51	259	2.1	3.93	14.17	na	0.61	0.47	-122	92
12/3/2013	7.25	83.58	6.96	450	2.1	4.07	14.01	15.4	0.14	0.20	-91	123
12/18/2013	6.58	84.25	6.31	810	1.5	2.84	8.78	14.4	0.19	0.39	-33	184
1/9/2014	6.98	83.85	6.74	400	0.8	1.69	6.71	12.7	0.30	0.56	80	297
2/4/2014	5.40	85.43	5.13	168	0.5	1.07	4.16	11.0	na	0.40	56	273
2/17/2014	5.81	85.02	6.18	205	0.9	1.86	4.38	10.2	na	0.37	5	222
*Q3/5/2014	5.62	85.21	5.77	32.6	0.8	1.57	4.17	9.5	na	0.25	-3	214
3/21/2014	5.52	85.31	5.93	134	0.8	1.58	7.37	9.2	na	0.63	94	311
4/2/2014	5.40	85.43	5.59	173	0.8	1.53	8.59	9.9	na	1.50 R	7	224
4/18/2014	5.36	85.47	6.88	117	0.7	1.50	10.66	9.8	na	1.07 R	22	239
4/28/2014	5.76	85.07	6.47	241	0.9	1.80	11.12	11.2	na	1.35 R	-13	204
5/13/2014	5.76	85.07	6.28	260	0.8	1.58	19.09	11.8	na	2.05 R	-19	191
*Q6/4/2014	5.81	85.02	6.58	95.6	0.9	1.72	20.63	na	na	3.49 R	-69	141
6/18/2014	6.25	84.58	6.60	355	1.0	1.95	22.35	12.6	na	2.02 R	-56	154
7/2/2014	6.85	83.98	6.65	515	1.0	2.02	22.85	13.6	na	3.06 R	-78	129
7/18/2014	6.93	83.90	6.39	459	1.2	2.28	20.76	14.2	na	3.02 R	-88	122
7/29/2014	7.86	82.97	6.47	532	1.2	2.25	19.15	14.0	na	3.93 R	-84	126
8/13/2014	6.71	84.12	6.42	423	1.1	2.10	21.87	13.3	na	4.78 R	-69	141
9/8/2014	7.54	83.29	6.04	295	1.3	2.44	20.05	15.6	na	6.86 R	-53	157
*Q9/24/2014	8.20	82.63	4.93	386	1.4	2.76	17.65	na	na	4.38 R	-56	154
10/7/2014	8.53	82.30	5.68	281	1.4	2.67	17.11	15.9	na	5.80 R	-38	176
10/21/2014	7.81	83.02	5.81	202	1.3	2.54	17.28	16.6	na	6.93 R	-30	184
11/3/2014	8.18	82.65	5.89	248	1.3	2.54	15.18	16.1	na	5.15 R	-79	135
11/20/2014	7.56	83.27	6.20	254	1.3	2.52	13.16	15.8	na	6.27 R	-61	153
12/2/2014	7.22	83.61	6.05	312	1.0	1.96	13.84	15.5	na	6.20 R	-46	168
*Q12/18/2014	6.75	84.08	4.66	257	0.7	1.45	10.40	na	na	5.96 R	12	229
12/30/2014	6.67	84.16	6.20	260	0.7	1.38	9.59	13.9	na	5.49 R	-11	206
1/13/2015	5.45	85.38	5.79	116	0.3	0.63	5.46	12.6	na	7.05 R	72	289
1/28/2015	5.94	84.89	7.27	381	0.5	1.05	6.92	12.5	na	4.99 R	-19	198
2/10/2015	6.26	84.57	6.63	243	0.6	1.45	6.74	13.1	na	4.87 R	-12	205
3/9/2015	5.49	85.34	5.02	169	0.4	0.929	7.17	10.7	na	5.62 R	-67	150
*Q3/23/2015	5.89	84.94	5.60	161	0.5	1.12	10.46	na	na	5.61 R	-45	172
4/8/2015	5.22	85.61	7.25	171	0.6	1.15	7.87	10.2	na	4.79 R	-48	169
4/24/2015	5.79	85.04	7.70	187	0.8	1.57	12.46	10.1	na	2.99 R	-30	187
5/7/2015	6.25	84.58	7.12	245	0.9	1.69	16.54	11.3	na	0.00	-56	161
5/20/2015	6.70	84.13	6.65	251	0.9	1.70	15.61	11.1	na	0.00	-53	164
6/5/2015	6.10	84.73	6.95	194	1.0	1.92	17.86	12.2	na	0.17	-47	170
*Q6/24/2015	5.95	84.88	6.58	209	1.0	1.88	23.40	na	na	0.08	135	352
7/7/2015	5.45	85.38	5.70	259	0.1	0.190	23.97	16.5	na	1.41 R	126	343
7/23/2015	6.98	83.85	7.24	205	1.2	2.29	22.89	16.7	na	1.28 R	-8	209

DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
**DO concentrations are biased high due to sample collection and measurement methodology

R - Rejected DO data due to sensor malfunctions
na - not analyzed
NTU - Nephelometric Turbidity Units
ppt - parts per thousand
mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 2

BW2	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/19/2015	8.16	82.67	5.07	275	2.3	4.290	23.68	14.6	na	2.54 R	-57	160
9/9/2015	8.74	82.09	7.74	306	1.1	2.070	22.59	16.6	na	2.70 R	-104	113
*Q9/29/2015	9.57	81.26	5.52	411	1.4	2.650	18.10	na	na	0.00	-87	130
10/13/2015	6.95	83.88	5.92	462	1.2	2.910	17.04	15.80	na	0.08	-94	123
11/2/2015	7.68	83.15	5.61	343	1.0	1.930	15.89	16.90	na	0.08	-34	183
11/17/2015	7.35	83.48	5.68	379	0.7	1.480	14.33	16.30	na	0.51	-47	170
12/4/2015	6.64	84.19	6.10	478	0.5	1.090	13.00	15.40	na	0.51	-30	187
12/21/2015	7.65	83.18	6.29	513	0.7	1.150	13.87	15.10	na	0.66	-41	176
*1/20/2016	6.58	84.25	5.66	482	0.7	1.540	7.19	na	na	0.07	-21	196
2/5/2016	5.31	85.52	6.24	>999	0.9	1.89	6.23	10.2	na	0.41	-1	216
2/18/2016	5.95	84.88	6.02	508	0.8	1.58	6.24	9.4	na	0.19	-41	176
3/7/2016	6.09	84.74	5.95	>999	0.5	1.04	13.29	11.1	na	0.19	-61	156
3/22/2016	6.29	84.54	5.44	493	0.8	1.50	11.05	10.2	na	0.47	-67	150
*4/8/2016	6.11	84.72	7.43	547	1.2	2.36	12.19	na	na	0.01	-105	112
5/24/2016	5.88	84.95	6.89	300	0.7	1.46	18.37	13.1	na	0.01	-51	166
6/8/2016	6.06	84.77	6.93	204	0.5	1.05	17.07	11.5	na	0.11	-67	150
*6/24/2016	8.15	82.68	7.29	325	0.5	0.95	16.08	na	na	0.01	-50	167
7/13/2016	7.61	83.22	7.04	223	1.2	2.19	22.94	15.7	na	0.51	6	223
7/27/2016	8.25	82.58	7.08	833	0.6	1.15	17.43	15.1	na	0.01	-58	159
8/18/2016	7.17	83.66	6.82	>1000	0.4	0.78	22.59	16.4	na	0.86	-65	152
8/31/2016	8.30	82.53	5.96	>1000	0.6	1.15	20.87	16.7	na	1.68	-66	151
*9/22/2016	9.42	81.41	6.07	751	0.8	1.59	19.25	na	na	1.29	-21	196
10/5/2016	7.96	82.87	5.99	>1000	0.5	0.97	16.94	17.2	na	3.53	19	236
10/20/2016	8.75	82.08	6.05	>1000	0.7	1.480	20.22	16.8	na	4.22	6	223
11/3/2016	8.9	81.93	6.68	978	0.6	1.250	18.53	16.9	na	5.45	-19	198
11/17/2016	9.15	81.68	5.88	869	0.7	1.350	15.10	13.6	na	7.72	-24	193
12/2/2016	8.15	82.68	5.1	>1000	0.8	1.530	13.11	15.5	na	8.93	5	222
*12/14/2016	8.00	82.83	5.75	200	0.3	0.667	12.14	na	na	3.45	24	241
1/12/2017	7.43	83.4	6.27	238	1	2.020	12.74	na	na	0.36	34	251
1/25/2017	6.75	84.08	5.99	912	0.8	1.670	13.07	12.5	na	0.51	28	245
2/7/2017	7.16	83.67	6.06	545	1.2	2.320	13.66	11.8	na	0.74	6	223
2/22/2017	7.19	83.64	6.25	573	1.4	2.710	14.24	11.1	na	1.03	-5	212
3/6/2017	7.08	83.75	6.17	954	1.1	2.230	12.41	10.6	na	1.17	6	223
*3/29/2017	6.77	84.06	5.87	219	0.2	0.491	11.65	na	na	0.72	39	256
4/14/2017	6.42	84.41	6.21	509	1.3	2.620	13.84	11.1	na	1.07	19	236
4/27/2017	6.22	84.61	6.19	649	1.5	2.890	15.39	11.6	na	1.44	7	224
5/18/2017	6.5	84.33	6.25	696	1.6	3.130	14.99	12.4	na	0.29	12	229
6/1/2017	6.54	84.29	6.24	652	1.5	2.920	15.95	13.2	na	0.29	2	219
*6/20/2017	7.5	83.33	6.02	1000	0.7	1.310	21.42	na	na	1.85	21	238
7/6/2017	8.05	82.78	6.12	767	0.8	1.530	16.08	15.4	na	0.79	40	257
7/20/2017	8.85	81.98	6.3	754	0.3	0.706	19.09	16.2	na	1.01	0	217

DTGW - Depth to groundwater (from top of casing)
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fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 3

BW3	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	6.85	83.52	6.15	>999	2.3	4.39	16.50	na	na	1.15	-81	133
11/14/2013	8.04	82.33	6.08	110	2.4	4.62	12.75	15.6	0.40	0.23	-70	144
*Q11/20/2013	8.01	82.36	6.60	59.6	2.4	4.52	12.51	na	0.52	0.43	-124	90
12/3/2013	6.45	83.92	6.90	299	2.4	4.49	13.99	14.8	0.10	0.35	-92	122
12/18/2013	5.89	84.48	6.41	540	2.5	4.70	9.85	14.3	0.24	0.36	-61	156
1/9/2014	5.79	84.58	6.89	465	2.5	4.73	8.48	13.3	0.32	0.68	35	252
2/4/2014	5.59	84.78	5.93	658	2.5	4.73	7.27	12.5	na	0.42	-15	202
2/17/2014	5.70	84.67	6.42	4.69	2.4	4.69	6.48	11.2	na	0.35	-42	175
*Q3/5/2014	5.46	84.91	5.94	225	2.1	4.91	2.37	9.8	na	0.06	-19	198
3/21/2014	5.20	85.17	5.99	354	2.6	4.98	7.90	10.8	na	0.56	42	259
4/2/2014	5.01	85.36	5.41	391	2.6	5.02	8.30	10.6	na	1.65 R	14	231
4/18/2014	5.01	85.36	6.69	203	2.4	4.57	10.53	10.6	na	1.29 R	36	253
4/28/2014	5.34	85.03	6.34	274	2.5	4.66	11.06	10.9	na	0.97 R	-1	216
5/13/2014	5.31	85.06	6.27	256	2.2	4.08	17.19	11.4	na	1.82 R	-15	199
*Q6/4/2014	5.29	85.08	6.70	261	2.7	4.97	19.53	na	na	3.58 R	-73	137
6/18/2014	5.60	84.77	6.49	402	2.4	4.59	20.02	12.4	na	1.80 R	-51	159
7/2/2014	6.13	84.24	6.59	349	2.3	4.34	20.60	12.8	na	2.93 R	-72	138
7/18/2014	6.42	83.95	6.41	332	2.3	4.27	16.93	12.9	na	2.92 R	-78	136
7/29/2014	7.10	83.27	6.42	522	2.1	4.05	17.59	13.1	na	4.15 R	-75	139
8/13/2014	6.61	83.76	6.25	610	2.2	4.12	20.30	13.9	na	5.11 R	-60	150
9/8/2014	7.08	83.29	6.12	375	2.2	4.08	18.34	14.2	na	6.24 R	-50	160
*Q9/24/2014	7.50	82.87	5.07	>999	2.3	4.34	16.20	na	na	5.20 R	-64	150
10/7/2014	7.87	82.50	5.56	257	2.2	4.11	16.03	14.6	na	6.01 R	-26	188
10/21/2014	7.15	83.22	5.68	283	1.9	3.57	16.46	15.7	na	7.20 R	-17	197
11/3/2014	7.53	82.84	5.75	399	1.7	3.28	14.90	14.9	na	5.06 R	-73	141
11/20/2014	6.75	83.62	6.02	340	1.8	3.41	13.17	15.0	na	6.30 R	-47	167
12/2/2014	6.42	83.95	5.95	383	1.6	3.09	14.22	15.0	na	6.34 R	-42	172
*Q12/18/2014	5.83	84.54	5.01	386	1.4	2.81	9.64	na	na	6.85 R	0	217
12/30/2014	5.91	84.46	6.07	397	1.6	3.11	10.67	14.1	na	5.56 R	-12	205
1/13/2015	5.59	84.78	6.05	343	1.6	3.15	8.19	13.9	na	6.48 R	22	239
1/28/2015	5.63	84.74	6.87	419	1.9	3.75	8.56	13.4	na	5.08 R	-11	206
2/10/2015	5.82	84.55	6.19	375	2.0	3.92	8.10	13.0	na	5.06 R	2	219
3/9/2015	5.21	85.16	4.55	436	2.0	3.91	7.81	11.6	na	5.83 R	-52	165
*Q3/23/2015	5.54	84.83	5.76	669	2.2	4.29	9.72	na	na	7.05 R	-63	154
4/8/2015	5.46	84.91	6.76	339	1.8	3.57	7.93	10.4	na	4.87 R	-30	187
4/24/2015	5.35	85.02	7.30	256	1.9	3.65	11.07	11.8	na	2.99 R	-39	178
5/7/2015	5.65	84.72	6.70	284	1.8	3.49	14.99	11.2	na	0.00	-44	173
5/20/2015	5.69	84.68	6.25	363	1.6	3.13	12.19	11.2	na	0.00	-38	179
6/5/2015	5.40	84.97	6.70	296	1.6	3.16	15.46	11.8	na	0.07	-53	164
*Q6/24/2015	6.10	84.27	6.71	455	1.9	3.50	22.51	na	na	0.13	141	358
7/7/2015	5.02	85.35	4.68	320	4.8	8.79	21.49	14.7	na	1.38 R	156	373
7/23/2015	6.22	84.15	6.79	238	1.9	3.58	19.60	14.3	na	1.65 R	26	243
8/19/2015	7.43	82.94	4.47	290	4.0	7.28	19.62	14.5	na	2.72 R	-26	191

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 3

BW3	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
9/9/2015	7.97	82.40	7.43	404	0.8	3.18	20.41	15.3	na	3.67 R	-84	133
*Q9/29/15	8.18	82.19	5.41	853	1.8	3.36	19.29	na	na	0.00	-89	128
10/13/2015	6.62	83.75	5.51	823	1.6	3.28	17.31	16.3	na	0.00	-87	130
11/2/2015	6.76	83.61	5.39	470	1.6	3.09	15.61	16.1	na	0.01	-47	170
11/17/2015	6.46	83.91	5.53	477	1.0	2.07	14.18	15.4	na	0.48	-50	167
12/4/2015	5.97	84.40	6.07	712	1.1	2.22	12.63	15.0	na	0.73	-58	159
12/21/2015	6.74	83.63	6.24	722	1.1	2.30	13.09	14.5	na	0.78	-64	153
*1/15/2016	5.61	84.76	6.40	878	2.2	4.21	10.50	na	na	0.01	-55	162
2/5/2016	4.98	85.39	6.48	>999	1.4	2.74	6.49	11.2	na	0.33	-47	170
2/18/2016	6.67	83.70	5.36	565	0.7	1.45	7.64	11.7	na	0.23	-28	189
3/7/2016	5.66	84.71	5.40	101	0.6	1.25	11.49	12.4	na	0.17	-53	164
3/22/2016	5.78	84.59	4.88	554	1.6	3.20	10.79	10.9	na	0.45	-58	159
*4/8/2016	5.46	84.91	7.00	788	2.7	5.00	13.16	na	na	0.01	-111	106
5/24/2016	5.38	84.99	7.08	313	1.9	3.65	15.39	12.3	na	0.01	-102	115
6/8/2016	5.51	84.86	6.98	213	1.4	2.74	16.19	12.9	na	0.01	-117	100
*6/24/2016	7.61	82.76	7.35	583	1.1	2.22	19.01	na	na	0.01	-70	147
7/13/2016	6.78	83.59	6.59	239	1.9	3.56	20.15	14.7	na	0.65	26	243
7/27/2016	7.32	83.05	6.71	888	1.3	2.61	17.28	13.8	na	0.01	-54	163
8/18/2016	5.96	84.41	6.60	>1000	1.1	2.17	20.84	14.8	na	0.75	-84	133
8/31/2016	7.27	83.10	5.77	>1000	1.2	2.26	19.60	14.9	na	1.43	-82	135
*9/22/2016	8.97	81.40	5.82	714	1.6	2.98	18.90	na	na	1.64	-33	184
10/5/2016	7.11	83.26	5.73	740	1.4	2.670	17.86	16.1	na	3.60	2	219
10/20/2016	7.97	82.4	5.72	>1000	1.6	3.050	20.93	15.9	na	4.23	-8	209
11/3/2016	7.97	82.4	6.55	760	0.6	1.220	18.03	16.3	na	5.20	-49	168
11/17/2016	8.23	82.14	5.46	936	1.6	3.120	14.76	15.9	na	7.49	-13	204
12/2/2016	7.49	82.88	4.96	>1000	0.6	1.130	13.43	15.1	na	9.20	-8	209
*12/14/2016	7.16	83.21	6.07	111	0.9	1.820	12.55	na	na	2.15	-20	197
1/12/2017	6.61	83.76	6.51	256	1.7	3.370	12.73	na	na	0.32	24	241
1/25/2017	6.11	84.26	6.47	378	1.8	3.420	12.65	12.6	na	0.60	11	228
2/7/2017	6.48	83.89	6.43	333	2	3.800	13.16	11.5	na	0.87	-8	209
2/22/2017	6.46	83.91	6.49	398	2	3.780	13.88	11.5	na	0.77	-13	204
3/6/2017	6.33	84.04	6.46	402	1.9	3.630	13.38	11.0	na	1.85	-4	213
*3/29/2017	6	84.37	6.11	259	0.3	0.572	11.40	na	na	0.93	27	244
4/14/2017	5.97	84.4	6.45	523	2	3.840	12.92	11.1	na	1.39	26	243
4/27/2017	5.62	84.75	6.39	379	1.9	3.720	15.01	12.0	na	1.52	2	219
5/18/2017	5.87	84.5	6.25	517	1.9	3.560	14.95	12.6	na	0.29	26	243
6/1/2017	5.85	84.52	6.3	390	1.8	15.140	15.09	13.0	na	0.19	1.9	219
*6/20/2017	6.91	83.46	6.31	444	0.5	0.948	18.06	na	na	1.57	14	231
7/6/2017	7.47	82.9	6.17	411	0.4	0.810	15.96	13.6	na	1.21	47	264
7/20/2017	8.05	82.32	6.26	514	0.4	0.740	20.17	14.7	na	1.15	6	223

DTGW - Depth to groundwater (from top of casing)
U52 - Temepratura measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
**DO concentrations are biased high due to sample collection and measurement methodology

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na - not analyzed
NTU - Nephelometric Turbidity Units
ppt - parts per thousand
mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 3

BW3	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	6.56	83.81	6.26	998	1.0	1.960	18.29	16.4	na	0.17	10	227
8/15/2017	6.10	84.27	6.06	978	0.5	0.927	17.50	16.2	na	0.08	30	128
8/30/2017	5.94	84.43	5.98	>1000	0.4	0.837	16.09	17.4	na	0.27	32	249
9/13/2017	6.51	83.86	5.93	883	0.4	0.796	15.89	16.7	na	0.68	53	270
*9/27/2017	7.01	83.36	5.59	780	0.3	0.557	18.41	na	na	0.75	7	224

DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
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*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
**DO concentrations are biased high due to sample collection and measurement methodology

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NTU - Nephelometric Turbidity Units
ppt - parts per thousand
mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 4

BW4	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	6.51	83.58	6.19	>999	1.4	2.78	16.30	na	na	1.13	-59	155
11/14/2013	7.29	82.80	5.80	373	1.2	2.31	12.47	15.9	0.41	0.23	-31	186
*Q11/20/2013	7.55	82.54	6.48	82.9	1.8	3.38	12.71	na	0.50	0.43	-88	126
12/3/2013	5.98	84.11	6.95	152	1.0	2.04	13.24	14.8	0.20	0.35	-72	142
12/18/2013	5.45	84.64	6.38	422	1.0	2.07	10.05	14.1	0.15	0.33	-50	167
1/9/2014	5.44	84.65	6.95	103	0.9	1.83	7.97	13.7	0.30	0.48	8	225
2/4/2014	5.19	84.90	6.06	343	1.1	2.26	7.05	12.6	na	0.34	-3	214
2/17/2014	5.26	84.83	6.76	190	1.0	2.01	5.81	11.0	na	0.44	-36	181
*Q3/5/2014	5.09	85.00	5.79	68.5	1.3	6.63	3.10	9.1	na	0.05	48	265
3/21/2014	4.72	85.37	6.23	282	1.1	2.18	7.36	10.6	na	0.54	21	238
4/2/2014	4.55	85.54	5.51	324	1.2	2.30	8.04	10.6	na	1.75 R	18	235
4/18/2014	4.57	85.52	6.79	202	1.0	2.03	11.00	10.6	na	1.04 R	38	255
4/28/2014	4.93	85.16	6.39	181	1.1	2.17	11.50	11.7	na	1.05 R	5	222
5/13/2014	4.93	85.16	6.26	193	0.9	1.86	17.22	11.4	na	2.07 R	1	215
*Q6/4/2014	4.84	85.25	4.44	186	0.9	1.85	17.87	na	na	4.04 R	-39	171
6/18/2014	5.21	84.88	6.59	256	0.9	1.82	19.33	12.3	na	1.86 R	-46	164
7/2/2014	5.78	84.31	6.55	242	0.9	1.73	20.60	12.6	na	2.91 R	-56	154
7/18/2014	6.09	84.00	6.36	217	0.9	1.86	17.19	13.1	na	3.24 R	-70	144
7/29/2014	6.84	83.25	6.43	256	0.8	1.63	17.50	13.4	na	4.31 R	-65	145
8/13/2014	6.70	83.39	6.38	237	0.9	1.78	20.50	13.7	na	4.60 R	-68	142
9/8/2014	6.84	83.25	6.16	176	0.9	1.81	17.89	14.9	na	5.68 R	-36	174
*Q9/24/2014	7.37	82.72	4.95	978	1.5	2.96	15.62	na	na	5.79 R	-56	158
10/7/2014	7.62	82.47	5.67	163	1.0	2.05	15.99	14.7	na	6.12 R	-29	185
10/21/2014	7.00	83.09	5.81	142	0.9	1.80	16.05	14.6	na	7.45 R	-21	193
11/3/2014	7.14	82.95	5.90	175	0.8	1.68	14.70	14.5	na	4.92 R	-75	139
11/20/2014	6.38	83.71	6.19	198	0.8	1.67	12.50	15.0	na	6.08 R	-55	159
12/2/2014	5.89	84.20	6.11	195	0.7	1.49	13.95	14.7	na	6.43 R	-44	170
*Q12/18/2014	5.33	84.76	4.80	312	0.8	1.59	10.25	na	na	5.55 R	-2	215
12/30/2014	5.35	84.74	6.30	166	0.7	1.32	9.76	13.6	na	5.75 R	-16	201
1/13/2015	5.14	84.95	6.41	218	0.6	1.28	8.29	13.6	na	6.19 R	6	223
1/28/2015	4.96	85.13	7.27	256	0.7	1.38	7.79	12.6	na	5.22 R	-19	198
2/10/2015	5.24	84.85	6.68	271	0.5	1.13	7.65	12.9	na	12.90 R	-9	208
3/9/2015	4.61	85.48	5.04	268	0.5	1.10	7.44	10.7	na	5.97 R	-65	152
*Q3/23/2015	4.82	85.27	5.55	297	0.4	0.803	7.58	na	na	7.96 R	-16	201
4/8/2015	4.80	85.29	7.26	253	0.5	0.944	7.84	10.2	na	5.07 R	-41	176
4/24/2015	4.63	85.46	7.75	228	0.5	0.986	11.10	11.3	na	3.04 R	-42	175
5/7/2015	5.09	85.00	7.13	261	0.4	0.879	13.71	11.2	na	0.00	-41	176
5/20/2015	5.30	84.79	6.78	337	0.4	0.881	12.29	11.1	na	0.13	-43	174
6/5/2015	4.99	85.10	7.30	202	0.5	1.030	15.16	11.7	na	0.23	-65	152
*Q6/24/2015	5.40	84.69	6.58	229	0.4	0.836	19.64	na	na	0.09	160	377
7/7/2015	4.45	85.64	5.18	281	1.3	2.600	22.19	14.0	na	1.34 R	158	375
7/23/2015	5.72	84.37	7.72	230	0.4	0.766	19.75	14.4	na	1.67 R	13	230
8/19/2015	6.78	83.31	4.98	276	0.9	1.710	19.71	14.3	na	1.71 R	-25	192

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Appendix A:
Biweekly Monitoring Physical Parameter Summary - Biowall Well 4

BW4	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
9/9/2015	7.59	82.50	7.85	298	0.5	0.963	20.55	15.4	na	3.39 R	-86	131
*Q9/29/2015	8.08	82.01	5.24	675	0.5	1.040	19.62	na	na	0.05	-42	175
10/13/2015	5.85	84.24	5.89	712	0.8	1.310	16.12	15.2	na	0.02	-48	169
11/2/2015	6.38	83.71	5.70	344	0.7	1.470	15.12	15.5	na	0.10	-40	177
11/17/2015	5.97	84.12	5.79	380	0.5	1.070	13.83	15.3	na	0.43	-64	153
12/4/2015	5.44	84.65	6.07	>999	0.6	1.220	12.73	14.6	na	0.74	-33	184
12/21/2015	6.37	83.72	6.22	>999	0.5	1.310	12.84	14.1	na	0.78	-36	181
*1/15/2016	5.22	84.87	6.74	674	0.6	1.180	10.50	na	na	0.08	-31	186
2/5/2016	4.40	85.69	6.66	>999	0.7	2.120	6.51	10.8	na	0.48	-34	183
2/18/2016	5.06	85.03	5.92	609	0.5	1.010	6.80	11.0	na	0.40	-2	215
3/7/2016	5.04	85.05	5.90	>999	0.4	0.728	11.10	12.2	na	0.22	-47	170
3/22/2016	5.14	84.95	5.44	362	0.4	0.812	11.15	10.9	na	0.37	-51	166
*4/8/2016	4.86	85.23	7.40	479	0.4	0.841	12.52	na	na	0.68	-84	133
5/24/2016	4.72	85.37	7.70	214	0.6	1.13	16.84	12.3	na	0.19	-106	111
6/8/2016	4.82	85.27	7.09	391	0.4	0.806	16.53	11.6	na	0.63	-81	136
*6/24/2016	7.35	82.74	7.05	489	0.3	0.665	18.20	na	na	0.01	-42	175
7/13/2016	6.21	83.88	7.23	265	0.4	0.74	20.06	15.1	na	0.67	21	238
7/27/2016	6.76	83.33	7.09	973	0.4	0.89	17.18	14.2	na	0.01	-55	162
8/18/2016	6.51	83.58	6.94	933	0.5	1.03	19.86	16.3	na	0.87	-76	141
8/31/2016	7.76	82.33	6.12	867	0.6	1.18	18.70	15.1	na	1.71	-77	140
*9/22/2016	8.56	81.53	6.01	868	0.6	1.17	17.71	na	na	1.89	2	219
10/5/2016	6.91	83.18	5.98	924	0.8	1.500	17.19	16.0	na	3.68	8	225
10/20/2016	7.55	82.54	5.98	892	0.8	1.630	19.01	15.8	na	4.47	4	221
11/3/2016	7.57	82.52	6.06	>1000	0.9	1.780	17.81	15.9	na	5.41	-6	211
11/17/2016	7.83	82.26	5.89	903	0.9	1.750	13.89	16.0	na	7.81	-24	193
12/2/2016	7.36	82.73	5.07	990	1	1.974	13.42	15.0	na	9.49	-2	215
*12/14/2016	6.70	83.39	5.80	230	0.3	0.624	13.23	na	na	2.91	7	224
1/12/2017	5.65	84.44	5.98	162	0.7	1.370	12.73	na	na	0.34	50	267
1/25/2017	5.28	84.81	6.1	500	0.8	1.520	11.83	12.3	na	0.71	20	237
2/7/2017	5.67	84.42	5.94	489	0.8	1.530	12.49	11.6	na	0.91	14	231
2/22/2017	5.76	84.33	6.02	564	0.8	1.540	13.67	10.8	na	0.89	16	233
3/6/2017	5.7	84.39	6.13	565	0.8	1.520	12.18	11.4	na	1.13	5	222
*3/29/2017	5.51	84.58	5.8	252	0.2	0.491	10.85	na	na	0.76	43	260
4/14/2017	5.35	84.74	5.98	419	0.8	1.550	12.92	11.0	na	1.40	34	251
4/27/2017	5.02	85.07	5.89	339	0.7	1.470	15.60	11.7	na	1.71	20	237
5/18/2017	5.38	84.71	5.8	317	0.6	1.150	15.51	12.8	na	0.31	35	252
6/1/2017	5.32	84.77	5.83	333	0.5	1.050	14.96	12.9	na	0.37	27	244
*6/20/2017	6.59	83.5	5.69	294	0.3	0.543	20.19	na	na	3.89	68	285
7/6/2017	8.47	81.62	5.75	548	0.3	0.717	15.29	13.6	na	1.56	57	274
7/20/2017	9.5	80.59	5.73	536	0.3	0.661	27.20	13.8	na	0.91	38	255

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 4

BW4	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	6.06	84.03	6.04	531	0.4	0.876	18.39	17.5	na	0.78	20	237
8/15/2017	5.85	84.24	5.89	867	0.4	0.881	16.30	16.9	na	0.28	37	254
8/30/2017	7.22	82.87	5.94	794	0.4	0.774	15.58	16.3	na	0.52	32	249
9/13/2017	5.85	84.24	5.65	808	0.3	0.716	15.54	17.2	na	0.85	46	263
*9/27/2017	11.45	78.64	4.92	787	0.2	0.426	18.30	na	na	0.69	46	263

DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
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mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 5

BW5	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	8.13	82.60	6.40	>999	2.2	4.21	15.79	na	na	1.38	-78	136
11/14/2013	7.78	82.95	6.22	89.8	2.4	4.62	12.76	15.1	0.32	0.25	-67	147
*Q11/20/2013	8.35	82.38	6.59	113	2.5	4.74	11.72	na	0.47	0.47	-107	110
12/3/2013	6.42	84.31	6.76	122	2.3	4.35	13.17	14.7	0.22	0.32	-67	147
12/18/2013	5.80	84.93	6.37	547	2.3	4.43	9.82	13.7	0.14	0.30	-66	151
1/9/2014	5.86	84.87	7.06	358	2.4	4.57	8.39	13.2	0.35	0.50	-23	194
2/4/2014	5.55	85.18	6.10	387	1.8	3.54	9.57	12.7	na	0.26	-31	186
2/17/2014	5.74	84.99	6.58	217	2.2	4.33	5.65	11.0	na	0.39	-50	167
*Q3/5/2014	5.38	85.35	6.76	351	2.3	4.49	8.03	10.4	na	0.04	-91	126
3/21/2014	5.25	85.48	6.07	361	2.4	4.63	7.37	10.9	na	0.78	19	236
4/2/2014	5.19	85.54	5.40	638	2.5	4.73	7.78	10.1	na	1.70 R	15	232
4/18/2014	5.10	85.63	7.08	276	1.6	3.02	11.19	10.5	na	1.22 R	42	259
4/28/2014	5.46	85.27	6.36	337	2.3	4.46	11.47	10.9	na	1.02 R	5	222
5/13/2014	5.48	85.25	6.27	412	2.1	3.92	16.95	11.4	na	2.35 R	8	222
*Q6/4/2014	5.40	85.33	6.62	202	2.4	4.47	19.31	na	na	3.87 R	-48	162
6/18/2014	5.77	84.96	6.54	422	2.3	4.41	19.21	12.1	na	1.62 R	-55	155
7/2/2014	6.30	84.43	6.64	6.36	2.1	4.05	20.63	12.5	na	2.95 R	-66	144
7/18/2014	6.64	84.09	6.39	502	2.2	4.20	17.02	12.4	na	2.22 R	-81	133
7/29/2014	7.34	83.39	6.41	537	2.0	3.79	17.39	13.2	na	4.48 R	-76	138
8/13/2014	7.14	83.59	6.34	494	2.1	3.91	20.16	13.9	na	4.57 R	-73	137
9/8/2014	7.46	83.27	6.06	407	2.0	3.86	17.29	14.1	na	5.31 R	-39	175
*Q9/24/2014	8.21	82.52	6.55	865	2.4	4.43	16.72	na	na	1.37 R	-67	147
10/7/2014	8.18	82.55	5.59	328	2.1	3.96	15.73	14.3	na	6.34 R	-31	183
10/21/2014	7.61	83.12	5.71	287	1.7	3.63	15.85	15.0	na	7.70 R	-25	189
11/3/2014	7.66	83.07	5.73	284	1.9	3.66	14.41	14.7	na	4.84 R	-80	134
11/20/2014	7.01	83.72	6.11	317	1.9	3.60	12.31	14.5	na	6.01 R	-63	154
12/2/2014	6.40	84.33	5.96	351	1.8	3.43	13.95	14.7	na	6.51 R	-50	164
*Q12/18/2014	5.94	84.79	5.13	438	2.0	3.90	6.88	na	na	6.50 R	-31	186
12/30/2014	5.86	84.87	6.15	315	1.8	3.41	9.59	13.7	na	5.97 R	-22	195
1/13/2015	5.76	84.97	6.20	488	1.6	3.17	8.45	13.3	na	6.01 R	2	219
1/28/2015	5.62	85.11	6.89	624	1.8	3.52	7.74	12.8	na	5.40 R	-13	204
2/10/2015	5.85	84.88	6.17	479	1.8	3.57	7.72	12.5	na	5.43 R	5	222
3/9/2015	5.21	85.52	4.58	391	1.7	3.39	7.71	11.9	na	6.16 R	-55	162
*Q3/23/2015	5.45	85.28	5.66	350	1.7	3.41	7.30	na	na	8.71 R	-42	175
4/8/2015	5.44	85.29	6.71	428	2.1	3.28	7.92	11.1	na	5.25 R	-21	196
4/24/2015	5.25	85.48	7.21	386	1.6	3.12	11.15	11.5	na	3.08 R	-32	185
5/7/2015	5.73	85.00	6.74	363	1.5	2.87	14.16	11.2	na	0.00	-37	180
5/20/2015	5.90	84.83	6.39	635	1.3	2.54	12.99	11.0	na	0.00	-35	182
6/5/2015	5.53	85.20	6.74	320	1.4	2.73	14.27	11.7	na	0.12	-50	167
*Q6/24/2015	5.50	85.23	6.66	453	1.6	3.06	18.57	na	na	0.07	138	355
7/7/2015	5.12	85.61	4.46	406	4.3	7.76	21.37	14.0	na	0.43	172	389
7/23/2015	6.48	84.25	7.13	353	1.4	2.71	21.19	13.7	na	1.88 R	5	222
8/19/2015	7.68	83.05	4.72	454	2.5	4.62	21.37	13.9	na	3.03 R	-20	197

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NTU - Nephelometric Turbidity Units
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mS/cm - millisiemens per cm

fbgs - feet below ground surface
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mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 5

BW5	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
9/9/2015	8.22	82.51	7.71	551	1.2	2.29	21.21	15.3	na	3.30 R	-93	124
*Q9/29/2015	7.79	82.94	5.32	>999	1.3	2.60	17.86	na	na	0.00	-68	149
10/13/2015	6.58	84.15	5.36	>999	1.3	2.74	17.83	16.1	na	0.00	-72	145
11/2/2015	6.67	84.06	5.33	542	1.5	3.11	15.42	15.0	na	0.00	-35	182
11/17/2015	6.42	84.31	5.45	594	1.3	2.56	13.92	14.9	na	0.54	-62	155
12/4/2015	5.98	84.75	5.89	674	1.4	2.69	12.58	14.6	na	0.50	-56	161
12/21/2015	6.64	84.09	5.84	609	1.5	2.68	12.98	14.3	na	0.59	-51	166
*1/15/2016	5.81	84.92	6.51	895	2.3	4.44	10.05	na	na	0.01	-63	154
2/5/2016	4.93	85.80	6.49	>999	2.2	4.22	6.38	11.1	na	0.39	-54	163
2/18/2016	5.56	85.17	6.59	455	1.5	2.98	5.77	11.3	na	0.35	-55	162
3/7/2016	5.63	85.10	5.31	455	0.6	1.21	11.56	11.9	na	0.18	-50	167
3/22/2016	5.75	84.98	4.93	664	0.6	1.27	11.98	10.5	na	0.51	-37	180
*4/8/2016	6.04	84.69	7.10	677	1.8	3.39	11.31	na	na	0.01	-97	120
5/24/2016	5.28	85.45	7.11	344	1.9	3.61	16.64	12.2	na	0.01	-99	118
6/8/2016	5.35	85.38	6.79	247	1.4	2.89	17.43	12.1	na	0.36	-73	144
*6/24/2016	6.89	83.84	7.59	>999	1.5	2.93	14.07	na	na	0.01	-90	127
7/13/2016	6.85	83.88	6.92	364	1.4	2.64	21.61	13.9	na	0.88	24	241
7/27/2016	7.38	83.35	6.64	919	1.3	2.48	17.56	13.4	na	0.01	-46	171
8/18/2016	6.90	83.83	6.74	>1000	1.4	2.63	19.45	15.0	na	0.79	-97	120
8/31/2016	7.30	83.43	5.86	941	1.4	2.67	18.67	14.5	na	1.51	-95	122
*9/22/2016	8.80	81.93	6.03	868	1.5	2.92	16.40	na	na	2.28	-26	191
10/5/2016	7.37	83.36	5.71	934	1.2	2.41	18.10	16.4	na	3.76	8	225
10/20/2016	8.09	82.64	5.74	>1000	1.4	2.760	19.33	15.9	na	4.64	-5	212
11/3/2016	8.11	82.62	5.82	>1000	1.5	2.960	17.31	15.8	na	5.78	-13	204
11/17/2016	8.41	82.32	5.29	980	1.6	3.110	13.36	15.7	na	8.15	-6	211
12/2/2016	7.6	83.13	4.94	>1000	1.5	3.000	12.94	13.6	na	10.01	-16	201
*12/14/2016	7.29	83.44	6.20	476	0.4	0.753	13.26	na	na	1.73	-16	201
1/12/2017	6.49	84.24	6.56	324	2.1	4.070	13.65	na	na	0.31	21	238
1/25/2017	5.7	85.03	6.4	701	1.7	3.260	12.17	12.5	na	0.50	13	230
2/7/2017	6.2	84.53	6.31	638	1.6	3.170	13.02	12.1	na	0.54	-7	210
2/22/2017	6.33	84.40	6.38	514	1.6	3.160	13.85	11.4	na	0.78	-6	211
3/6/2017	6.18	84.55	6.37	645	1.6	3.120	12.42	11.2	na	1.41	-1	216
*3/29/2017	6.75	83.98	6.13	376	0.6	1.290	10.52	na	na	0.71	19	236
4/14/2017	5.88	84.85	6.34	390	1.8	3.380	13.31	11.1	na	1.47	30	247
4/27/2017	5.5	85.23	6.33	518	1.9	3.620	15.46	11.7	na	1.62	-1	216
5/18/2017	5.73	85	6.24	465	1.4	2.790	14.97	12.6	na	0.30	18	235
6/1/2017	5.79	84.94	6.15	539	1.3	2.530	16.37	12.5	na	0.22	8	225
*6/20/2017	7.18	83.55	5.94	408	0.5	1.090	16.43	na	na	4.01	40	257
7/6/2017	7.7	83.03	6.13	934	0.4	0.818	15.46	13.1	na	0.88	38	255
7/20/2017	8.5	82.23	6.06	653	0.8	1.570	22.63	13.9	na	0.90	13	230

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 5

BW5	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	6.96	83.77	6.32	877	0.5	0.990	18.31	15.3	na	0.03	10	227
8/15/2017	6.13	82.94	6.03	950	1.2	2.310	17.19	16.1	na	0.11	40	257
8/30/2017	6.61	84.12	6.21	>1000	0.4	0.835	14.98	15.4	na	0.41	27	244
9/13/2017	6.60	84.13	6.06	969	0.4	0.808	15.10	15.4	na	0.81	30	247
*9/27/2017	7.26	83.47	5.32	788	0.3	0.55	17.91	na	na	0.98	12	229

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 6

BW6	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	6.82	83.85	5.72	>999	0.8	1.69	15.13	na	na	1.56	-35	179
11/14/2013	7.56	83.11	5.88	460	1.5	2.96	11.87	15.1	0.26	0.55	-45	172
*Q11/21/2013	7.44	83.23	6.16	109	0.9	1.88	12.04	na	0.75	0.59	-31	186
12/313013	6.10	84.57	6.19	0	0.8	1.58	12.72	14.5	0.30	0.94	-7	207
12/18/2013	5.48	85.19	6.16	185	1.0	2.02	8.06	13.5	0.12	0.82	10	227
1/9/2014	5.60	85.07	6.78	1000	1.3	2.48	8.61	12.5	0.44	1.84	35	252
2/4/2014	5.15	85.52	6.26	94.4	1.4	2.78	7.43	11.4	0.46	2.20	-26	191
2/17/2014	5.33	85.34	5.93	67.3	1.4	2.70	6.94	9.8	0.48	1.93	15	232
*Q3/5/2014	5.08	85.59	6.55	121	1.6	3.07	7.76	10.5	na	0.07	-72	145
3/21/2014	4.98	85.69	5.97	>999	1.4	2.73	8.69	10.0	0.48	1.38	74	291
4/2/2014	4.92	85.75	4.97	122	1.4	2.70	8.16	9.4	0.90	3.46 R	88	305
4/18/2014	4.94	85.73	6.39	>999	1.3	2.56	9.98	10.0	1.30	4.58 R	145	362
4/28/2014	5.41	85.26	6.14	105	1.3	2.52	12.72	12.7	1.35	3.72 R	45	259
5/13/2014	5.58	85.09	6.05	49.3	1.1	2.21	19.74	11.2	1.39	4.07 R	22	232
*Q6/4/2014	5.51	85.16	6.56	133	1.3	2.50	22.87	na	na	1.90 R	-76	131
6/18/2014	5.90	84.77	6.47	901	1.1	2.10	18.92	12.5	1.20	3.68 R	-25	185
7/2/2014	6.53	84.14	6.44	90.7	1.0	1.99	21.88	13.2	2.87	4.80 R	-10	200
7/18/2014	6.67	84.00	6.34	129	1.0	2.03	18.51	13.0	3.85	3.31 R	-68	142
7/29/2014	7.46	83.21	6.44	200	1.0	2.04	18.90	13.2	na	4.32 R	-74	136
8/13/2014	6.76	83.91	6.25	0	1.2	2.31	21.26	14.3	3.68	6.39 R	-58	152
9/8/2014	7.41	83.26	6.17	84.4	1.1	2.23	17.89	14.1	5.71	4.94 R	-45	165
*Q9/24/2014	8.22	82.45	6.39	176	1.4	2.80	15.93	na	na	1.22 R	-53	161
10/7/2014	8.16	82.51	5.63	112	1.2	2.32	16.45	15.1	6.63	6.46 R	-27	187
10/21/2014	7.52	83.15	5.79	89.7	1.1	2.08	16.05	15.3	7.92	8.07 R	-17	197
11/3/2014	7.51	83.16	5.88	116	1.1	2.16	14.59	14.9	7.77	4.56 R	-74	140
11/20/2014	6.65	84.02	6.14	120	1.1	2.09	11.93	14.8	9.16	5.77 R	-51	166
12/2/2014	6.06	84.61	5.99	98.8	0.9	1.79	13.34	14.7	8.58	6.59 R	-36	178
*Q12/18/2014	5.53	85.14	4.96	248	1.3	2.63	8.95	na	na	7.51 R	-16	201
12/30/2014	5.63	85.04	6.19	73.6	1.0	2.04	8.82	13.6	7.78	6.20 R	-13	204
1/13/2015	5.19	85.48	5.92	301	1.0	1.98	8.41	12.3	6.02	5.85 R	37	254
1/28/2015	5.38	85.29	5.52	97.1	1.0	2.06	5.52	12.4	4.01	5.67 R	-1	216
2/10/2015	5.75	84.92	6.36	87	1.0	1.92	5.65	12.2	6.01	5.75 R	11	228
3/9/2015	4.90	85.77	4.75	75.8	0.9	1.79	6.04	10.9	7.13	6.56 R	-44	173
*Q3/23/2015	5.30	85.37	5.35	178	1.0	2.06	7.95	na	na	4.32 R	-48	169
4/8/2015	4.92	85.75	6.93	99.5	0.8	1.65	7.63	10.4	4.50	5.51 R	-15	202
4/24/2015	5.14	85.53	7.38	386	0.8	3.12	11.69	11.7	4.69	3.11 R	-20	197
5/7/2015	5.79	84.88	6.96	117	0.7	1.44	15.20	10.6	0.13	0.64	-32	185
5/20/2015	5.89	84.78	6.50	114	0.7	1.32	14.12	10.8	0.78	0.64	-27	190
6/5/2015	5.21	85.46	6.50	595	0.8	1.58	15.08	11.6	0.36	1.14	54	271
*Q6/24/2015	5.45	85.22	6.69	138	0.9	1.81	15.07	na	na	0.00	151	368
7/7/2015	4.90	85.77	4.49	197	1.8	3.44	24.22	13.5	0.48	1.48 R	278	495
7/23/2015	6.78	83.89	6.89	162	0.7	1.39	18.01	14.1	1.34	2.13 R	93	310
8/19/2015	7.77	82.90	4.42	143	1.6	3.07	21.07	15.4	1.49	3.00 R	22	239

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 6

BW6	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
9/9/2015	8.16	82.51	7.26	175	0.8	1.55	23.16	15.7	3.11	4.55 R	-59	158
*Q9/28/2015	8.52	82.15	6.05	>999	0.9	1.82	18.08	na	na	3.82 R	-46	171
10/13/2015	5.99	84.68	5.22	>999	0.8	1.64	16.20	15.3	0.00	0.16	37	254
11/2/2015	6.67	84.00	5.13	241	0.8	1.68	16.13	15.5	0.48	0.55	55	272
11/17/2015	6.24	84.43	5.62	305	0.7	1.39	13.66	14.9	0.19	0.68	-51	166
12/4/2015	5.52	85.15	6.29	660	0.8	1.53	12.92	14.5	0.98	0.74	-32	185
12/21/2015	6.63	84.04	6.32	468	0.7	1.54	12.97	13.8	0.67	0.81	-42	175
*1/15/2016	5.84	84.83	6.63	502	1.3	2.64	10.94	na	na	0.04	-35	182
2/5/2016	4.74	85.93	6.22	>1000	1.1	2.17	8.33	11.8	0.23	0.72	19	236
2/18/2016	5.38	85.29	5.66	455	0.9	1.73	7.15	12.0	0.34	0.80	51	268
3/7/2016	5.59	85.08	5.07	609	0.5	0.959	9.17	11.3	na	0.49	80	297
3/22/2016	5.56	85.11	5.13	245	0.6	1.20	10.17	10.2	0.32	0.37	37	254
*4/8/2016	5.29	85.38	7.16	604	1.3	2.650	10.06	na	na	0.27	-86	131
5/24/2016	5.10	85.57	7.55	508	0.9	1.72	20.22	12.0	na	0.53	13	230
6/8/2016	5.27	85.40	6.19	425	0.7	1.37	17.21	12.2	0.42	0.51	27	244
*6/24/2016	8.25	82.42	7.42	505	0.9	1.73	13.04	na	na	0.01	-66	151
7/13/2016	6.76	83.91	7.02	361	1.5	2.79	21.23	14.6	0.94	0.48	17	234
7/27/2016	7.60	83.07	6.54	439	0.7	1.43	20.99	14.4	1.30	0.01	81	298
8/18/2016	6.39	84.28	5.69	>1000	0.7	1.42	18.69	18.8	0.91	1.51	50	267
8/31/2016	7.53	83.14	5.16	>1000	0.7	1.42	19.78	16.9	1.51	2.04	-34	183
*9/22/2016	9.19	81.48	6.79	621	1.0	1.91	16.45	na	na	2.99	-4	213
10/5/2016	7.42	83.25	5.44	800	0.8	1.620	16.40	16.7	na	6.84	81	298
10/20/2016	7.84	82.83	6.06	972	0.9	1.760	16.99	16.5	9.80	7.55	60	277
11/3/2016	7.83	82.84	6.02	956	0.9	1.790	15.49	17.3	10.01	9.55	57	274
11/17/2016	8.02	82.65	4.57	708	0.9	1.830	9.59	15.5	9.89	9.72	92	309
12/2/2016	7.36	83.31	5.15	917	0.9	1.840	12.61	14.4	11.12	9.36	47	264
*12/14/2016	6.94	83.73	5.87	126	0.6	1.300	12.78	na	na	3.18	19	236
1/12/2017	6.07	84.60	6.31	213	1.3	2.620	11.66	11.5	0.28	0.63	98	315
1/25/2017	5.4	85.27	6.27	512	1.5	2.930	12.68	12.8	4.37	0.87	50	267
2/7/2017	6.11	84.56	6.24	417	1.6	3.100	11.59	12.1	1.91	2.60	54	271
2/22/2017	6.22	84.45	6.26	620	1.4	2.740	12.24	11.4	1.81	2.40	29	246
3/6/2017	6.05	84.62	6.71	715	1.5	2.880	10.94	11.1	1.31	1.31	8	225
*3/29/2017	6.67	84.00	6.12	269	0.3	0.588	9.81	na	na	0.85	25	242
4/14/2017	5.85	84.82	6.42	665	1.6	3.160	11.09	10.8	1.32	1.12	94	311
4/27/2017	5.56	85.11	6.39	956	1.6	3.150	13.15	11.6	1.65	1.19	27	244
5/18/2017	6.1	84.57	6.47	381	1.3	2.620	16.80	12.5	1.43	1.41	77	294
6/1/2017	6.04	84.63	6.14	300	1.2	2.300	14.48	14.7	1.33	1.25	51	268
*6/21/2017	7.51	83.16	6.16	325	0.7	1.480	19.72	na	na	3.33	57	274
7/6/2017	7.99	82.68	6.01	296	0.9	1.700	17.78	13.7	1.95	1.88	167	384
7/20/2017	8.45	82.22	6.11	275	0.4	0.875	19.71	14.4	1.88	1.43	87	304

DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
**DO concentrations are biased high due to sample collection and measurement methodology

R - Rejected DO data due to sensor malfunctions
na - not analyzed
NTU - Nephelometric Turbidity Units
ppt - parts per thousand
mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 6

BW6	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	6.79	83.88	6.09	755	0.9	1.85	18.61	14.0	1.10	1.60	72	289
8/15/2017	6.39	82.15	5.79	678	0.8	1.62	17.69	16.1	0.31	0.08	129	346
8/30/2017	6.71	83.96	5.92	708	0.8	1.55	15.92	15.8	1.90	1.99	106	323
9/13/2017	6.77	83.90	5.83	935	0.8	1.57	16.81	14.7	1.17	0.59	121	338
*9/27/2017	7.49	83.18	5.39	682	0.3	0.58	16.66	na	na	0.61	19	236

DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
**DO concentrations are biased high due to sample collection and measurement methodology

R - Rejected DO data due to sensor malfunctions
na - not analyzed
NTU - Nephelometric Turbidity Units
ppt - parts per thousand
mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 7

BW7	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	7.33	83.90	6.04	>999	1.8	3.43	15.74	na	na	1.16	-67	147
11/14/2013	8.04	83.19	6.04	>999	2.0	3.84	12.54	15.7	0.26	0.20	-67	147
*Q11/21/2013	8.32	82.91	6.54	631	2.1	3.92	12.45	na	0.43	0.32	-122	95
12/3/2013	6.53	84.70	6.84	122	1.7	3.27	12.09	14.5	0.20	0.31	-60	157
12/18/2013	5.63	85.60	6.53	174	1.5	3.03	8.08	13.9	0.11	0.38	-64	153
1/9/2014	5.85	85.38	7.08	175	1.9	3.62	7.08	12.4	0.25	0.57	-25	192
2/4/2014	5.33	85.90	6.25	276	1.8	3.55	4.84	11.5	na	0.38	-12	205
2/17/2014	5.74	85.49	6.70	66.8	1.9	3.76	4.39	10.3	na	0.32	-51	166
*Q3/5/2014	5.32	85.91	6.70	101	2.1	3.97	7.62	11.2	na	0.10	-85	132
3/21/2014	5.22	86.01	6.20	130	2.0	3.83	6.52	11.3	na	0.71	8	225
4/2/2014	5.08	86.15	5.32	113	1.9	3.69	7.05	9.5	na	1.41 R	29	246
4/18/2014	5.19	86.04	6.64	112	1.7	3.31	10.20	10.2	na	1.33 R	57	274
4/28/2014	5.72	85.51	6.29	115	1.8	3.38	11.84	11.3	na	1.12 R	19	236
5/13/2014	6.08	85.15	6.18	97.9	1.5	2.87	18.21	11.6	na	2.00 R	13	223
*Q6/4/2014	6.00	85.23	6.62	267	2.1	3.95	17.38	na	na	1.90 R	-83	131
6/18/2014	6.36	84.87	6.50	252	1.8	3.42	21.37	12.2	na	1.53 R	-51	159
7/2/2014	7.14	84.09	6.55	246	1.8	3.40	22.49	12.5	na	2.76 R	-52	158
7/18/2014	7.26	83.97	6.33	240	1.9	3.71	18.09	12.9	na	3.39 R	-68	142
7/29/2014	8.06	83.17	6.38	385	1.8	3.50	18.01	12.9	na	4.60 R	-73	137
8/13/2014	7.51	83.72	6.38	530	1.9	3.63	19.38	14.1	na	4.60 R	-71	139
9/8/2014	8.08	83.15	6.07	180	2.0	3.77	17.56	14.0	na	4.91 R	-40	170
*Q9/24/2014	8.83	82.40	6.53	323	2.3	4.39	17.83	na	na	na	-60	150
10/7/2014	8.85	82.38	5.52	240	2.0	3.80	16.27	15.5	na	6.68 R	-27	187
10/21/2014	8.16	83.07	5.58	193	1.9	3.53	16.36	14.9	na	8.40 R	-9	205
11/3/2014	8.11	83.12	5.80	288	1.9	3.61	14.80	15.0	na	4.23 R	-86	128
11/20/2014	7.25	83.98	6.04	235	1.8	3.47	12.63	14.6	na	5.86 R	-53	161
12/2/2014	6.45	84.78	5.92	176	1.5	2.84	13.80	14.7	na	6.72 R	-39	175
*Q12/18/2014	5.78	85.45	6.67	307	1.7	3.38	9.96	na	na	3.00 R	-44	173
12/30/2014	6.91	84.32	6.15	146	1.4	3.22	7.93	13.6	na	6.55 R	-17	200
1/13/2015	5.44	85.79	6.50	147	1.5	2.94	6.58	13.4	na	5.79 R	-12	205
1/28/2015	5.60	85.63	6.66	213	1.7	3.41	5.55	12.2	na	5.94 R	10	227
2/10/2015	6.13	85.10	6.08	208	1.7	3.40	5.95	11.8	na	6.13 R	23	240
3/9/2015	5.04	86.19	4.43	120	1.6	3.18	5.84	10.2	na	6.70 R	-35	182
*Q3/23/2015	5.49	85.74	5.39	329	1.7	3.28	7.14	na	na	4.03 R	-64	153
4/8/2015	5.17	86.06	6.48	138	1.4	2.70	7.57	9.8	na	5.89 R	11	228
4/24/2015	5.45	85.78	7.02	99	1.3	2.54	11.81	11.5	na	3.16 R	-15	202
5/7/2015	6.25	84.98	6.59	190	1.4	2.65	14.53	11.3	na	0.00	-22	195
5/20/2015	6.41	84.82	6.00	201	1.3	2.52	14.05	10.9	na	0.01	-10	207
6/5/2015	5.71	85.52	6.92	211	1.5	2.84	15.68	11.6	na	0.09	-61	156
*Q6/24/2015	5.55	85.68	6.63	180	1.7	3.26	16.37	na	na	0.00	147	364
7/7/2015	5.22	86.01	5.07	256	1.3	2.48	24.32	15.6	na	1.20	192	409
7/23/2015	7.23	84.00	6.77	266	1.7	3.23	21.39	15.4	na	0.44	6	223
8/19/2015	8.21	83.02	4.45	338	3.7	6.78	22.15	13.7	na	1.86 R	-37	180

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 7

BW7	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
9/9/2015	8.59	82.64	7.37	386	1.6	3.10	22.78	14.6	na	3.26 R	-91	126
*Q9/28/2015	9.42	81.81	6.17	343	1.8	3.43	20.55	na	na	1.83 R	-93	124
10/13/2015	7.32	83.91	6.48	385	1.8	3.32	18.23	16.1	na	0.25	-88	129
11/2/2015	7.24	83.99	5.28	429	1.7	3.31	15.36	15.7	na	0.00	-40	177
11/17/2015	6.56	84.67	5.39	398	1.4	2.68	13.89	14.7	na	0.49	-58	159
12/4/2015	5.75	85.48	5.94	594	1.5	2.83	12.24	14.1	na	0.77	-57	160
12/21/2015	7.19	84.04	6.02	628	1.0	2.74	12.93	14.6	na	0.81	-46	171
*1/15/2016	6.05	85.18	6.34	698	2.1	4.08	10.27	na	na	0.00	-65	152
2/5/2016	4.71	86.52	6.69	>999	1.4	3.74	6.37	10.5	na	0.35	-43	174
2/18/2016	5.57	85.66	6.23	398	1.8	3.61	6.28	11.5	na	0.41	-13	204
3/7/2016	5.85	85.38	5.21	181	0.5	0.935	10.69	11.4	na	0.25	-27	190
3/22/2016	5.92	85.31	4.64	387	0.5	1.06	9.95	10.0	na	0.33	-4	213
*4/8/2016	5.46	85.77	6.90	605	1.7	3.32	9.93	na	na	0.01	-88	129
5/24/2016	4.95	86.28	6.88	88.9	1.4	3.10	16.89	12.7	na	0.04	-76	141
6/8/2016	4.97	86.26	6.83	232	1.4	3.19	16.23	13.1	na	0.42	-52	165
*6/24/2016	8.15	83.08	6.99	593	1.8	3.47	19.74	na	na	0.01	-67	150
7/13/2016	7.20	84.03	6.77	362	1.4	2.65	20.67	15.6	na	0.53	4	221
7/27/2016	7.75	83.48	6.28	813	1.5	2.95	17.53	13.9	na	0.01	-14	203
8/18/2016	7.03	84.20	6.45	877	1.6	3.07	20.44	15.0	na	0.97	-86	131
8/31/2016	7.52	83.71	5.66	>1000	1.7	3.25	19.67	15.8	na	1.51	-95	122
*9/22/2016	9.51	81.72	5.68	736	1.9	3.62	19.72	na	na	1.20	-36	181
10/5/2016	7.89	83.34	5.47	>1000	1.7	3.330	17.29	15.9	na	4.10	9	226
10/20/2016	8.3	82.93	5.49	777	1.9	3.550	19.18	15.8	na	4.80	-1	216
11/3/2016	8.3	82.93	5.62	>1000	1.7	3.300	16.72	16.0	na	6.40	-3	214
11/17/2016	8.57	82.66	5.86	927	0.6	1.210	13.29	15.5	na	8.43	-17	200
12/2/2016	8.07	83.16	4.82	929	1.6	3.130	13.03	15.0	na	10.04	0	217
*12/13/2016	7.36	83.87	5.51	230	1.2	2.280	13.04	na	na	3.05	-28	189
1/12/2017	6.38	84.85	6.46	145	1.6	3.110	11.19	na	na	0.37	44	261
1/25/2017	5.6	85.63	6.46	387	0.7	1.330	11.63	11.4	na	0.57	26	243
2/7/2017	6.35	84.88	6.44	426	2.1	3.430	13.32	11.1	na	0.42	-2	215
2/22/2017	6.53	84.70	6.45	385	1.9	3.660	14.01	11.4	na	0.74	-2	215
3/6/2017	6.32	84.91	6.43	572	2	3.820	12.78	10.7	na	1.75	5	222
*3/29/2017	6.05	85.18	6.23	375	0.3	0.614	9.85	na	na	1.02	32	249
4/14/2017	6.11	85.12	6.42	420	0.6	1.550	13.55	10.6	na	1.12	40	257
4/27/2017	5.69	85.54	6.43	578	2	3.790	14.78	11.3	na	1.41	3	220
5/18/2017	6.25	84.98	6.28	541	2	3.830	15.26	12.4	na	0.24	35	252
6/1/2017	5.82	85.41	6.34	572	2.1	3.930	16.55	13.3	na	0.30	12	229
*6/20/2017	10.6	80.63	6.37	430	1.5	2.870	16.78	na	na	0.93	11	228
7/6/2017	8.25	82.98	6.28	698	0.4	0.881	16.10	14.1	na	0.96	68	285
7/20/2017	8.74	82.49	6.36	631	0.4	0.914	20.40	14.3	na	1.40	3	220

Notes:

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Appendix A:
Biweekly Monitoring Physical Parameter Summary - Biowall Well 7

BW7	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	7.02	84.21	6.30	943	1.4	2.76	18.02	16.5	na	-0.05	16	233
8/15/2017	6.37	81.81	6.09	857	0.4	0.89	16.25	17.4	na	0.05	45	262
8/30/2017	6.78	84.45	6.11	>1000	0.4	0.839	16.46	17.2	na	0.25	60	277
9/13/2017	6.93	84.3	5.96	>1000	0.4	0.814	15.44	15.8	na	0.74	47	264
*9/27/2017	7.69	83.54	5.66	712	0.3	0.649	16.61	na	na	0.52	7	224

DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
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fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 8

BW8	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	7.55	84.29	6.06	>999	2.1	3.97	15.63	na	na	0.99	-72	142
11/14/2013	8.01	83.83	6.05	205	2.4	4.47	12.80	16.2	0.29	0.19	-84	130
*Q11/21/2013	8.24	83.60	6.52	442	2.3	4.31	12.93	na	0.49	0.35	-115	99
12/3/2013	6.99	84.85	6.85	151	2.1	4.02	12.19	14.6	0.06	0.37	-66	151
12/18/2013	5.73	86.11	6.45	228	2.4	4.54	7.80	13.6	0.03	0.31	-67	150
1/9/2014	5.74	86.10	7.10	103	2.2	4.10	7.24	12.5	0.27	0.57	-34	183
2/4/2014	5.25	86.59	6.36	370	1.8	3.55	5.47	12.1	na	0.36	-41	176
2/17/2014	5.50	86.34	6.73	83	1.6	3.22	4.82	11.3	na	0.58	-51	166
*Q3/5/2014	5.16	86.68	6.46	252	2.0	3.87	6.70	9.3	na	0.07	-80	137
3/21/2014	5.06	86.78	6.25	80.2	1.6	3.15	6.55	12.1	na	0.72	-1	216
4/2/2014	4.97	86.87	5.22	96.2	1.5	2.95	7.13	10.8	na	1.16 R	37	254
4/18/2014	5.03	86.81	6.53	82.4	1.4	2.66	10.37	10.5	na	1.45 R	74	291
4/28/2014	5.39	86.45	6.19	109	1.4	2.65	12.76	11.0	na	1.40 R	37	251
5/13/2014	5.60	86.24	6.14	102	1.1	2.18	20.09	11.0	na	1.90 R	9	219
*Q6/4/2014	5.56	86.28	6.73	215	2.3	4.24	19.91	na	na	1.06 R	-85	125
6/18/2014	5.81	86.03	6.45	167	1.4	2.79	22.52	12.4	na	1.42 R	-45	162
7/2/2014	6.49	85.35	6.57	294	1.4	2.70	23.60	12.7	na	2.38 R	-47	160
7/18/2014	6.72	85.12	6.23	267	1.7	3.26	18.62	12.6	na	4.02 R	-48	162
7/29/2014	7.31	84.53	6.22	281	1.3	2.44	19.56	13.2	na	4.86 R	-52	158
8/13/2014	6.13	85.71	6.20	215	1.5	2.83	23.47	13.4	na	4.54 R	-56	151
9/8/2014	7.64	84.20	6.18	459	1.5	2.92	17.62	14.5	na	4.74 R	-44	166
*Q9/24/2014	8.23	83.61	6.50	0	2.0	3.87	18.85	na	na	1.47 R	-54	156
10/7/2014	8.33	83.51	5.42	224	1.6	2.99	16.76	15.2	na	6.92 R	-16	198
10/21/2014	7.90	83.94	5.49	272	1.4	2.68	17.03	15.0	na	8.62 R	1	215
11/3/2014	8.19	83.65	5.58	296	1.6	3.00	14.56	15.0	na	4.31 R	-59	155
11/20/2014	7.39	84.45	5.88	289	1.5	2.82	12.68	14.9	na	5.59 R	-38	176
12/2/2014	6.96	84.88	5.82	239	1.4	2.71	14.34	14.9	na	6.87 R	-31	183
*Q12/18/2014	5.75	86.09	6.45	353	1.0	1.96	10.56	na	na	2.90 R	-25	192
12/30/2014	5.76	86.08	6.00	144	1.2	2.34	7.56	13.9	na	6.99 R	2	219
1/13/2015	5.35	86.49	6.72	146	0.8	1.57	6.17	13.8	na	5.60 R	-14	203
1/28/2015	5.48	86.36	6.55	146	0.9	1.86	4.74	13.2	na	6.26 R	34	251
2/10/2015	5.78	86.06	6.04	109	0.7	1.44	5.01	12.2	na	6.57 R	51	268
3/9/2015	5.10	86.74	4.29	95	0.7	1.42	5.87	10.0	na	7.21 R	-2	215
*Q3/23/2015	5.35	86.49	5.25	227	1.0	1.94	6.85	na	na	3.54 R	-50	167
4/8/2015	4.99	86.85	6.64	98.2	0.5	0.971	7.97	9.7	na	6.21 R	24	241
4/24/2015	5.25	86.59	6.93	78.6	0.5	0.974	12.19	10.7	na	3.52 R	11	228
5/7/2015	5.81	86.03	6.63	112	0.4	0.819	16.20	11.0	na	0.12	5	222
5/20/2015	5.89	85.95	6.13	131	0.4	0.812	16.13	11.4	na	0.07	14	231
6/5/2015	5.38	86.46	7.29	116	0.4	0.902	16.93	12.0	na	0.06	-68	149
*Q6/23/2015	4.75	87.09	6.46	150	0.5	0.988	21.89	na	na	0.02	161	378
7/7/2015	4.85	86.99	4.49	172	1.1	2.110	22.64	13.6	na	1.16	221	438
7/23/2015	6.56	85.28	6.70	139	0.3	0.703	21.67	15.2	na	0.86	59	276
8/19/2015	7.61	84.23	4.31	199	1.3	2.480	22.67	15.6	na	1.97 R	10	227

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fbgs - feet below ground surface
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mg/L - milligrams per liter
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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 8

BW8	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
9/9/2015	8.17	83.67	7.38	318	0.8	1.680	22.25	15.1	na	1.68 R	-71	146
*Q9/28/2015	8.51	83.33	6.02	643	1.2	2.390	20.61	na	na	1.83 R	-69	148
10/13/2015	6.68	85.16	6.09	752	0.7	2.310	17.31	15.9	na	0.18	-48	169
11/2/2015	7.20	84.64	5.45	413	1.0	2.030	15.56	16.0	na	0.00	-34	183
11/17/2015	6.59	85.25	5.58	352	0.7	1.490	14.17	15.6	na	0.51	-42	175
12/4/2015	5.71	86.13	6.25	345	0.5	0.931	11.48	14.6	na	0.65	-39	178
12/21/2015	7.17	84.67	6.36	371	0.5	0.899	12.64	14.1	na	0.69	-47	170
*1/15/2016	5.77	86.07	6.26	514	0.8	1.020	9.89	na	na	0.07	-28	189
2/5/2016	4.86	86.98	6.79	>999	0.4	0.992	6.13	11.3	na	0.51	-44	173
2/18/2016	5.58	86.26	5.58	365	0.4	0.917	5.47	11.1	na	0.17	1	218
3/7/2016	5.72	86.12	5.36	85	0.3	0.627	10.75	11.0	na	0.26	4	221
3/22/2016	5.71	86.13	4.80	254	0.3	0.685	9.56	9.7	na	0.29	9	226
*4/8/2016	5.70	86.14	6.85	445	0.5	1.11	9.85	na	na	0.29	-51	166
5/24/2016	5.23	86.61	7.21	355	0.5	0.961	17.32	12.2	na	0.01	-56	161
6/8/2016	6.25	85.59	6.95	356	0.3	0.708	17.01	12.2	na	0.36	-1	216
*6/23/2016	6.55	85.29	6.81	633	0.7	1.42	16.13	na	na	0.01	-44	173
7/13/2016	6.84	85.00	6.75	172	0.3	0.71	22.01	15.5	na	0.86	59	276
7/27/2016	7.30	84.54	6.35	796	0.8	1.53	18.88	15.5	na	0.01	10	227
8/18/2016	7.03	84.81	6.18	829	0.8	1.67	20.79	17.5	na	1.20	-49	168
8/31/2016	7.37	84.47	5.49	901	1.1	2.29	21.20	16.2	na	1.81	-67	150
*9/22/2016	8.86	82.98	5.40	986	1.3	2.59	18.77	na	na	1.20	-2	215
10/5/2016	7.67	84.17	5.51	>1000	1.1	2.100	18.29	17.1	na	4.13	25	242
10/20/2016	8.11	83.73	5.65	>1000	1	1.900	18.50	16.9	na	5.26	26	243
11/3/2016	8.02	83.82	5.58	>1000	0.6	0.980	15.44	16.5	na	5.15	8	225
11/17/2016	8.35	83.49	4.94	966	1	1.960	13.61	16.6	na	8.77	23	240
12/2/2016	7.83	84.01	5	>1000	1	2.030	13.06	15.3	na	10.31	20	237
*12/13/2016	7.66	84.18	5.20	278	0.8	1.620	13.16	na	na	4.15	-9	208
1/12/2017	6.58	85.26	6.32	673	1.3	2.590	11.79	na	na	0.37	57	274
1/25/2017	5.85	85.99	6.04	369	0.6	1.200	12.24	10.9	na	0.62	45	262
2/7/2017	7.21	84.63	5.88	554	0.6	1.190	13.11	10.6	na	0.57	41	258
2/22/2017	6.55	85.29	6.09	277	1.2	2.260	13.84	10.1	na	0.95	24	241
3/6/2017	6.41	85.43	6.02	528	1.1	2.210	11.75	10.5	na	2.15	37	254
*3/28/2017	5.71	86.13	5.6	167	0.3	0.534	10.64	na	na	0.82	59	276
4/14/2017	6.01	85.83	5.99	240	1.2	2.330	13.80	10.5	na	1.29	77	294
4/27/2017	5.56	86.28	6.03	420	1.2	2.420	13.78	11.1	na	1.44	47	264
5/18/2017	5.98	85.86	5.95	333	1.3	2.540	15.60	12.4	na	0.98	66	283
6/1/2017	5.94	85.9	5.98	363	1.4	2.650	16.34	13.3	na	0.38	59	276
*6/20/2017	7.35	84.49	5.74	262	0.3	0.654	18.33	na	na	1.68	68	285
7/6/2017	8.18	83.66	6.05	526	0.4	0.786	15.92	13.8	na	1.38	90	307
7/20/2017	8.33	83.51	5.92	>1000	0.4	0.756	21.20	15.0	na	1.45	53	270

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 8

BW8	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	6.76	85.08	6.14	791	0.4	0.865	18.79	17.5	na	0.80	45	262
8/15/2017	6.01	83.33	5.73	811	0.4	0.756	16.36	19.1	na	1.06	97	314
8/30/2017	6.40	85.44	5.90	879	0.4	0.767	16.86	17.1	na	0.43	80	297
9/13/2017	6.40	85.44	5.68	968	0.9	1.780	15.67	17.4	na	0.92	86	303
*9/27/2017	7.09	84.75	5.28	688	0.6	1.120	16.44	na	na	0.67	47	264

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Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 9

BW9	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	7.96	84.41	5.38	>999	0.6	1.21	16.65	na	na	0.60	-18	196
11/14/2013	8.38	83.99	5.49	233	0.4	0.77	13.01	16.1	0.27	0.50	30	244
*Q11/21/2013	8.42	83.95	5.85	205	0.5	1.05	12.85	na	0.97	0.43	-11	203
12/3/2013	9.53	82.84	6.10	488	0.6	1.16	12.48	14.6	0.13	0.50	20	237
12/18/2013	6.23	86.14	6.57	189	0.6	1.27	6.90	12.7	0.11	0.40	-47	170
1/9/2014	6.01	86.36	6.89	20	0.5	0.970	6.10	11.3	0.30	0.60	-9	208
2/4/2014	5.38	86.99	6.15	253	0.5	1.06	6.32	8.4	0.34	3.58	21	238
2/17/2014	5.54	86.83	6.11	201	0.4	0.910	5.85	8.5	0.41	4.45	34	251
*Q3/5/2014	5.25	87.12	6.36	12.4	0.4	0.812	6.37	7.6	na	0.04	-26	191
3/21/2014	5.11	87.26	5.94	>999	0.5	0.992	7.79	9.3	0.52	2.51	35	252
4/2/2014	5.08	87.29	5.05	95.7	0.4	0.920	7.53	8.4	na	4.88 R	80	297
4/18/2014	5.11	87.26	6.42	>999	0.5	0.943	9.82	9.7	1.08	5.68 R	111	328
4/28/2014	5.42	86.95	6.06	84.6	0.5	0.957	12.46	10.3	1.50	4.36 R	58	275
5/13/2014	5.71	86.66	5.87	142	0.4	0.873	19.72	12.2	1.65	4.70 R	43	253
*Q6/4/2014	5.85	86.52	6.21	46.5	0.4	0.907	17.41	na	na	1.04 R	-25	189
6/18/2014	6.01	86.36	6.38	>999	0.6	1.17	20.13	13.1	1.39	4.22 R	-21	189
7/2/2014	6.67	85.70	6.31	0	0.7	1.32	22.74	12.9	2.95	4.06 R	-21	186
7/18/2014	7.02	85.35	5.92	126	0.5	0.98	22.29	13.4	3.70	3.99 R	-15	195
7/29/2014	7.79	84.58	6.01	188	0.6	1.12	22.64	13.8	na	4.74 R	-36	171
8/13/2014	7.11	85.26	6.42	143	0.5	0.982	25.29	14.1	3.37	4.33 R	-20	187
9/8/2014	7.93	84.44	5.94	101	0.6	1.12	19.08	14.9	5.82	4.66 R	-23	187
*Q9/24/2014	8.52	83.85	5.97	538	0.7	1.47	17.22	na	na	1.75 R	-11	203
10/7/2014	8.65	83.72	5.48	77.8	0.6	1.17	17.70	16.1	5.99	7.01 R	-14	196
10/21/2014	8.22	84.15	5.30	98	0.5	0.974	17.65	16.1	7.13	9.05 R	30	240
11/3/2014	8.19	84.18	5.49	98.3	0.4	0.859	14.81	15.5	7.30	5.51 R	-10	204
11/20/2014	7.69	84.68	5.45	133	0.3	0.538	11.63	15.3	8.59	6.36 R	35	249
12/2/2014	7.12	85.25	5.59	108	0.4	0.761	14.46	15.2	8.03	7.44 R	11	225
*Q12/18/2014	6.11	86.26	6.08	188	0.6	1.18	10.38	na	na	2.97 R	3	220
12/30/2014	5.98	86.39	5.92	130	0.4	0.909	7.68	13.5	6.26	8.01 R	21	238
1/13/2015	5.44	86.93	6.78	69.1	0.3	0.652	4.95	12.8	5.40	5.43 R	-14	203
1/28/2015	5.41	86.96	6.61	85.2	0.3	0.662	2.82	11.3	3.81	7.32 R	50	264
2/10/2015	5.73	86.64	6.12	72.2	0.3	0.618	2.91	11.3	5.47	7.60 R	66	280
3/9/2015	4.95	87.42	4.26	54.9	0.3	0.573	4.36	9.6	6.23	8.00 R	12	229
*Q3/23/2015	5.19	87.18	4.96	207	0.3	0.639	5.82	na	na	5.50 R	-13	204
4/8/2015	4.86	87.51	6.76	95.4	0.3	0.539	8.61	9.9	3.65	7.24 R	30	247
4/24/2015	5.29	87.08	7.02	95.3	0.2	0.493	13.55	10.4	3.70	4.10 R	15	232
5/7/2015	5.96	86.41	6.80	104	0.2	0.483	17.49	11.1	0.27	1.89	8	225
5/20/2015	6.20	86.17	6.24	107	0.2	0.484	16.97	11.2	0.34	1.15	19	236
6/5/2015	5.72	86.65	6.94	97.7	0.3	0.670	17.68	12.6	0.41	0.49	-44	173
*Q6/23/2015	5.65	86.72	6.16	256	0.3	0.701	22.45	na	na	0.14	188	405
7/72015	5.35	87.02	4.60	269	0.9	1.800	23.94	15.7	1.39	0.94	215	432
7/23/2015	6.88	85.49	6.80	124	0.3	0.682	24.07	17.5	1.41	0.91	66	283
8/19/2015	8.11	84.26	4.32	160	1.2	2.320	23.68	15.8	1.25	2.38 R	11	228

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Biweekly Monitoring Physical Parameter Summary - Biowall Well 9

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9/9/2015	8.66	83.71	7.26	185	0.6	1.170	24.73	15.9	2.94	4.23 R	-59	158
*Q9/28/2015	8.90	83.47	5.84	396	0.5	1.020	20.22	na	na	1.76 R	-34	183
10/13/2015	6.94	85.43	5.81	398	0.8	1.340	17.92	16.4	0.09	0.19	-38	179
11/2/2015	7.56	84.81	5.59	283	0.7	1.490	15.99	16.5	0.68	0.00	-22	195
11/17/2015	6.88	85.49	5.86	304	0.4	0.847	14.24	15.8	0.40	0.53	-37	180
12/4/2015	5.97	86.40	6.52	340	0.4	0.753	11.34	14.6	0.78	0.86	-59	158
12/21/2015	7.53	84.84	6.49	371	0.5	0.744	12.33	14.4	0.76	0.81	-62	155
*1/15/2016	6.01	86.36	6.39	500	0.5	1.080	9.14	na	na	0.19	-31	186
2/5/2016	4.91	87.46	6.09	>999	0.4	0.898	5.84	9.5	0.36	0.58	41	258
2/18/2016	5.62	86.75	6.23	370	0.4	0.743	4.50	11.8	0.41	0.84	-7	210
3/7/2016	5.85	86.52	5.76	50	0.3	0.543	10.52	9.3	0.67	0.43	-13	204
3/22/2016	5.86	86.51	5.23	254	0.2	0.511	9.51	9.6	0.54	0..38	-6	211
*4/8/2016	5.70	86.67	7.13	495	0.4	0.770	9.90	na	na	0.08	-66	151
5/24/2016	5.69	86.68	7.71	381	0.4	0.797	18.78	13.0	0.03	0.48	-75	142
6/8/2016	5.71	86.66	6.25	389	0.4	0.559	18.19	12.7	0.41	0.51	-37	180
*6/23/2016	7.09	85.28	6.69	574	0.4	0.837	18.78	na	na	0.01	-36	181
7/13/2016	7.16	85.21	6.72	137	0.3	0.68	23.15	15.1	0.91	0.83	77	294
7/27/2016	7.79	84.58	6.79	760	0.5	1.10	21.72	17.1	0.90	1.05	22	239
8/18/2016	6.86	85.51	6.14	800	0.6	1.21	21.46	18.0	1.20	1.67	-31	186
8/31/2016	7.81	84.56	5.50	883	0.6	1.24	23.94	19.3	1.22	1.04	-37	180
*9/22/2016	10.07	82.30	5.27	712	0.7	1.44	20.67	na	na	1.35	25	242
10/5/2016	8.00	84.37	5.66	760	0.8	1.00	19.64	16.7	7.55	4.80	53	270
10/20/2016	8.45	83.92	5.62	778	0.9	1.450	20.13	16.8	6.52	3.72	41	258
11/3/2016	8.4	83.97	6.17	902	0.7	1.400	18.16	16.3	9.41	7.40	30	247
11/17/2016	8.64	83.73	5.15	745	0.4	0.902	13.70	16.1	8.64	9.36	25	242
12/2/2016	8.27	84.1	5.17	994	0.7	1.400	13.24	14.8	11.01	11.00	35	252
*12/13/2016	7.89	84.48	5.09	170	0.4	0.766	12.19	na	na	5.11	8	225
1/12/2017	6.06	86.31	6.13	122	0.9	1.730	10.93	na	0.47	1.01	94	311
1/25/2017	5.84	86.53	6.38	344	1	1.930	12.47	11.0	1.17	0.98	45	262
2/7/2017	6.45	85.92	6.01	360	0.9	1.730	13.28	12.0	1.71	1.11	39	256
2/22/2017	6.75	85.62	6.01	540	0.8	1.610	14.58	9.7	2.55	1.35	39	256
3/6/2017	6.55	85.82	6.14	785	0.8	1.650	10.47	9.7	2.79	2.21	25	242
*3/28/2017	5.9	86.47	5.75	163	0.3	0.550	9.89	na	na	9.10	36	253
4/14/2017	6.02	86.35	5.78	931	0.8	1.590	15.70	10.7	1.55	1.33	97	314
4/27/2017	5.55	86.82	5.86	864	0.6	1.130	13.72	11.6	11.80	11.60	64	281
5/18/2017	5.92	86.45	5.76	941	0.8	1.570	16.84	13.7	0.37	0.33	96	313
6/1/2017	6.11	86.26	5.91	857	0.8	1.590	17.06	13.2	1.47	0.55	99	316
*6/20/2017	8.59	83.78	5.81	266	0.3	0.680	16.80	na	na	3.95	85	302
7/6/2017	8.11	84.26	5.86	548	0.4	0.758	18.91	15.5	1.57	1.40	148	365
7/20/2017	8.81	83.56	5.91	644	0.4	0.769	20.75	14.3	2.13	1.77	72	289

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Appendix A:
Biweekly Monitoring Physical Parameter Summary - Biowall Well 9

BW9	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
8/3/2017	7.00	85.37	5.97	698	0.6	1.290	18.71	19.2	1.90	0.43	71	288
8/15/2017	6.40	83.47	5.69	795	0.6	1.180	17.52	19.6	0.27	0.46	121	338
8/30/2017	6.75	85.62	6.85	>1000	0.6	1.170	15.31	17.0	0.51	0.33	188	405
9/13/2017	6.76	85.61	5.64	>1000	0.4	0.722	16.32	17.6	0.98	0.98	144	361
*9/27/2017	7.60	84.77	5.74	629	0.3	0.568	17.87	na	na	0.39	54	271

Notes:
DTGW - Depth to groundwater (from top of casing)
U52 - Temeprature measurement outside of the well during bi-weekly monitoring
Down-hole - Temerpature measurement collected with downhole measurement instrumentation
*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology
**DO concentrations are biased high due to sample collection and measurement methodology

R - Rejected DO data due to sensor malfunctions
na - not analyzed
NTU - Nephelometric Turbidity Units
ppt - parts per thousand
mS/cm - millisiemens per cm

fbgs - feet below ground surface
mV - millivolts
mg/L - milligrams per liter
◦C - degrees celsius

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 10 MW6

BW10	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
10/22/2013**	7.96	85.27	5.62	>999	1.1	2.08	17.05	na	na	0.93	-21	193
11/14/2013	8.95	84.28	5.75	511	1.3	2.59	13.19	15.8	0.26	0.19	-36	178
*Q11/21/2013	9.20	84.03	6.31	291	1.5	2.95	12.10	na	1.16	0.87	-74	143
12/3/2013	7.55	85.68	6.78	242	1.1	2.24	13.19	14.6	0.29	0.34	-57	157
12/18/2013	5.82	87.41	6.35	110	1.6	3.16	7.08	13.8	0.11	0.26	-38	179
1/9/2014	5.65	87.58	6.87	93	1.1	2.20	5.84	12.6	0.29	0.56	-13	204
2/4/2014	5.15	88.08	6.34	134	0.8	1.73	4.22	11.2	na	0.33	-5	212
2/17/2014	5.21	88.02	6.82	34.6	0.7	1.44	3.56	10.4	na	0.48	-41	176
*Q3/5/2014	4.82	88.41	6.70	96.8	1.3	2.54	5.00	7.7	na	0.10	-46	171
3/21/2014	4.74	88.49	6.37	67.8	0.9	1.90	6.36	10.7	na	0.82	-2	215
4/2/2014	4.94	88.29	4.98	48.7	0.5	0.954	7.26	10.7	na	1.62 R	67	284
4/18/2014	5.24	87.99	6.18	95.9	0.3	0.621	10.77	10.8	na	1.90 R	93	310
4/28/2014	5.66	87.57	5.84	54.8	0.3	0.610	13.69	11.0	na	2.26 R	78	292
5/13/2014	5.95	87.28	5.75	48.6	0.3	0.643	20.95	11.7	na	2.05 R	41	251
*Q6/4/2014	5.83	87.40	6.56	360	0.8	1.66	18.61	na	na	1.07 R	-46	164
6/18/2014	6.15	87.08	6.41	130	0.6	1.20	23.31	12.9	na	1.50 R	-28	179
7/2/2014	6.85	86.38	6.49	215	0.9	1.74	25.24	13.1	na	2.18 R	-38	169
7/18/2014	7.12	86.11	6.24	142	1.1	2.14	22.02	13.3	na	3.66 R	-46	164
7/29/2014	7.98	85.25	6.31	175	1.1	2.12	21.06	14.0	na	5.73 R	-59	151
8/13/2014	7.50	85.73	6.17	201	1.1	2.13	24.87	14.5	na	4.55 R	-39	168
9/8/2014	8.39	84.84	5.90	128	1.0	1.95	18.74	15.2	na	4.74 R	-24	186
*Q9/24/2014	9.26	83.97	6.26	423	1.3	2.52	18.14	na	na	1.62 R	-33	177
10/7/2014	9.32	83.91	6.18	88.2	0.8	1.64	18.03	16.2	na	7.39 R	-47	163
10/21/2014	8.58	84.65	5.18	111	0.6	1.21	19.15	16.0	na	9.49 R	55	265
11/3/2014	8.73	84.50	6.31	108	0.6	1.24	15.17	15.6	na	6.13 R	-50	164
11/20/2014	8.12	85.11	5.61	163	0.6	1.22	12.06	15.7	na	7.87 R	11	228
12/2/2014	7.52	85.71	5.66	109	0.6	1.19	16.39	15.4	na	8.17 R	19	233
*Q12/18/2014	6.45	86.78	6.45	179	1.1	2.23	11.59	na	na	3.29 R	-8	209
12/30/2014	6.14	87.09	6.04	102	0.7	1.38	6.41	13.6	na	9.74 R	60	277
1/13/2015	5.58	87.65	6.23	75.7	0.3	0.626	4.35	13.1	na	5.34 R	20	237
1/28/2015	5.49	87.74	6.32	91	0.3	0.731	1.75	11.1	na	9.43 R	91	308
2/10/2015	6.01	87.22	5.88	75.1	0.5	0.991	3.04	11.7	na	8.90 R	93	310
3/9/2015	4.95	88.28	4.14	68.6	0.3	0.558	4.03	10.7	na	8.82 R	51	268
*Q3/23/2015	5.55	87.68	5.12	75.1	0.5	1.02	6.15	na	na	3.07 R	-24	193
4/8/2015	5.25	87.98	6.66	75	0.3	0.597	9.15	10.6	na	8.35 R	67	284
4/24/2015	5.46	87.77	6.71	75.7	0.3	0.574	14.05	11.2	na	4.86 R	51	268
5/7/2015	6.39	86.84	6.75		0.3	0.665	19.23	11.6	na	0.85	45	262
5/20/2015	6.78	86.45	6.31	119	0.3	0.629	18.24	11.8	na	0.60	43	260
6/5/2015	6.13	87.10	6.67	131	0.5	1.090	18.04	13.4	na	0.16	-33	184
*Q6/23/2015	4.78	88.45	6.39	82	0.5	1.030	20.54	na	na	0.00	153	370

DTGW - Depth to groundwater (from top of casing)

U52 - Temeprature measurement outside of the well during bi-weekly monitoring

Down-hole - Temerpature measurement collected with downhole measurement instrumentation

*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology

**DO concentrations are biased high due to sample collection and measurement methodology

R - Rejected DO data due to sensor malfunctions

***BW-10 Out of Commission since June 2016. MW-6 sampled in place of the decommissioned BW-10

na - not analyzed

NTU - Nephelometric Turbidity Units

ppt - parts per thousand

mS/cm - millisiemens per cm

◦C - degrees celsius

fbgs - feet below ground surface

mV - millivolts

mg/L - milligrams per liter

Appendix A:

Biweekly Monitoring Physical Parameter Summary - Biowall Well 10 MW6

BW10	DTGW (fbgs)	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C) U52	Temperature (◦C) Down-hole	Dissolved Oxygen: Pre-purge (mg/L)	Dissolved Oxygen: Post-purge (mg/L)	Oxidation-Reduction Potential (mV)	Oxidation-Reduction Potential (mV) (Eh)
7/7/2015	5.35	87.88	4.61	>999	1.3	2.470	24.51	16.3	na	0.91	240	457
7/23/2015	7.27	85.96	7.16	186	0.5	1.090	23.28	15.7	na	1.71 R	88	305
8/19/2015	8.66	84.57	4.53	163	1.5	2.950	24.63	16.2	na	2.26 R	0	217
9/9/2015	9.37	83.86	7.20	204	0.7	1.460	26.50	20.3	na	4.36 R	-51	166
*Q9/28/2015	9.92	83.31	5.97	408	1.0	1.950	21.04	na	na	1.67 R	-57	160
10/13/2015	7.25	85.98	6.12	322	0.7	1.990	18.20	16.2	na	0.54	-62	155
11/2/2015	8.19	85.04	5.55	392	1.0	1.940	16.46	16.6	na	0.00	-5	212
11/17/2015	7.26	85.97	6.09	320	0.9	1.740	14.64	15.6	na	0.29	-62	155
12/4/2015	5.89	87.34	na	na	na	na	na	na	na	na	na	na
12/21/2015	8.15	85.08	6.13	367	0.5	1.730	14.48	14.1	na	0.64	-65	152
*1/15/2016	4.68	88.55	6.42	515	1.2	2.290	9.04	na	na	0.01	-56	161
2/5/2016	4.40	88.83	6.82	>999	0.7	1.43	6.38	10.8	na	0.48	-42	175
2/18/2016	5.41	87.82	6.32	387	0.8	1.73	4.83	11.2	na	0.33	-5	212
3/7/2016	5.81	87.42	5.81	>999	0.3	0.639	11.27	9.3	na	0.33	7	224
3/22/2016	6.04	87.19	5.30	246	0.2	0.496	9.58	9.4	na	0.46	18	235
*4/8/2016	5.90	87.33	7.18	481	1.2	2.46	9.32	na	na	0.01	-78	139
5/24/2016	5.58	87.65	7.91	328	0.5	0.958	18.63	12.7	na	0.70	-76	141
6/8/2016	5.65	87.58	6.85	316	0.5	0.899	18.27	12.1	na	0.56	-14	203
*6/24/2016	7.82	85.41	6.88	600	0.6	1.23	19.68	na	na	0.01	-52	165
***9/22/2016	6.75	86.48	4.28	610	0.3	0.708	17.22	na	na	1.18	160	377
MW6* **	**DTGW (fbgs)**	**Groundwater Elevation**	**pH**	**Turbidity (NTU)**	**Salinity (ppt)**	**Specific Conductivity (mS/cm)**	**Temperature (◦C) U52**	**Temperature (◦C) Down-hole**	**Dissolved Oxygen: Pre-purge (mg/L)**	**Dissolved Oxygen: Post-purge (mg/L)**	**Oxidation-Reduction Potential (mV)**	**Oxidation-Reduction Potential (mV) (Eh)**
*12/13/2016	5.94	87.29	3.27	85.9	0.4	0.78	10.21	na	na	3.72	231	448
*3/28/2017	2.69	90.54	3.91	141	0.3	0.69	10.80	na	na	4.53	285	502
*6/21/2017	5.32	87.91	5.24	168	0.3	0.55	16.31	na	na	5.33	164	381
*9/26/2017	4.98	88.25	4.63	582	0.3	0.61	17.30	na	na	0.43	263	480

DTGW - Depth to groundwater (from top of casing)

U52 - Temepraturе measurement outside of the well during bi-weekly monitoring

Down-hole - Temerpature measurement collected with downhole measurement instrumentation

*Q - Quarterly Monitoring event. Values collected using low flow sampling methodology

**DO concentrations are biased high due to sample collection and measurement methodology

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***BW-10 Out of Commission since June 2016. MW-6 sampled in place of the decommissioned BW-10

na - not analyzed

NTU - Nephelometric Turbidity Units

ppt - parts per thousand

mS/cm - millisiemens per cm

◦C - degrees celsius

fbgs - feet below ground surface

mV - millivolts

mg/L - milligrams per liter

Appendix A:

Quarterly Monitoring Physical Parameter Summary - Transect Wells

Well	Date	DTGW	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C)	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)
TW6	11/20/2013	6.83	83.58	5.27	>999	0.3	0.657	12.55	0.66	83
	2/26/2014	4.38	86.03	5.02	691	0.3	6.89	7.60	0.08	107
	6/4/2014	4.74	85.67	4.97	977	0.3	0.620	14.18	0.62	105
	9/24/2014	7.80	82.61	4.95	0	0.3	0.671	16.05	1.25 R	117
	12/18/2014	4.90	85.51	4.34	0	0.3	0.621	11.44	3.58 R	142
	3/23/2015	4.49	85.92	3.02	0	0.3	0.718	7.76	1.36 R	125
	6/23/2015	4.61	85.80	5.32	>999	0.3	0.571	21.76	0.14	99
	9/30/2015	7.37	83.04	4.33	>999	0.3	0.624	17.72	0.01	123
	1/14/2016	5.14	85.27	3.63	>999	0.3	0.702	11.24	0.01	91
	4/6/2016	5.27	85.14	3.76	>999	0.3	0.620	10.35	0.01	51
	6/30/2016	5.86	84.55	5.18	>999	0.3	0.678	17.96	0.43	130
	9/21/2016	8.56	81.85	4.11	>1000	0.3	0.648	17.48	1.34	153
	12/14/2016	6.41	84.00	4.71	>1000	0.2	0.514	11.41	1.44	130
	3/30/2017	5.35	85.06	4.91	>1000	0.5	0.979	9.15	6.05	247
	6/15/2017	6.71	83.70	4.96	>1000	0.3	0.696	15.31	4.80	181
	9/28/2017	6.98	83.43	3.69	>1000	0.2	0.358	16.68	5.96	276
TW5	11/20/2013	7.13	83.58	5.10	0	0.3	0.660	12.75	0.77	111
	2/26/2014	4.62	86.09	5.08	0	0.3	0.674	5.61	0.14	106
	6/4/2014	5.02	85.69	5.01	0	0.3	0.613	16.81	0.71	73
	9/24/2014	8.06	82.65	5.00	0	0.3	0.677	15.58	1.70 R	103
	12/18/2014	5.20	85.51	4.38	>999	0.3	0.611	11.16	2.20 R	144
	3/23/2015	4.80	85.91	3.00	>999	0.3	0.714	8.02	1.17 R	128
	6/23/2015	4.80	85.91	5.22	322	0.3	0.592	17.80	0.01	114
	9/30/2015	7.69	83.02	4.48	>999	0.3	0.636	18.28	0.01	87
	1/14/2016	5.39	85.32	3.94	>999	0.3	0.700	11.54	0.01	65
	4/6/2016	5.51	85.20	3.96	>999	0.3	0.619	11.26	0.01	21
	6/29/2016	6.20	84.51	5.16	>999	0.3	0.696	14.10	0.09	125
	9/21/2016	8.80	81.91	4.38	>1000	0.3	0.669	17.65	1.15	131
	12/15/2016	6.80	83.91	4.99	>1000	0.6	1.260	9.56	NM	204
	3/30/2017	5.64	85.07	5.12	>1000	0.5	0.947	9.43	5.44	204
	6/15/2017	7.20	83.51	5.27	>1000	0.3	0.661	15.55	4.81	143
	9/28/2017	7.55	83.16	3.98	>1000	0.2	0.334	16.26	6.33	200
TW4	11/20/2013	6.82	83.56	6.31	0	1.5	2.92	16.08	0.23	-144
	2/26/2014	5.72	84.66	6.13	0	0.7	1.41	7.63	0.23	-51
	6/4/2014	4.75	85.63	5.78	>999	0.6	1.05	14.83	0.83	-28
	9/24/2014	7.80	82.58	5.82	0	0.5	1.00	20.13	1.24 R	-26
	12/18/2014	4.92	85.46	5.76	>999	0.8	1.59	11.44	2.85 R	-8
	3/23/2015	4.52	85.86	3.94	557	0.6	1.18	9.11	0.83 R	14
	6/22/2015	5.05	85.33	4.93	222	0.3	0.659	20.83	0.01	6
	9/30/2015	7.12	83.26	5.10	775	0.6	1.28	18.04	0.01	13
	1/14/2016	6.14	84.24	4.88	>999	0.5	1.02	11.76	0.01	-21
	4/6/2016	5.97	84.41	5.04	>999	0.4	0.759	13.80	0.01	-50
	6/29/2016	5.88	84.5	6.00	>999	0.4	0.906	14.61	0.31	34
	9/21/2016	7.91	82.47	5.43	>1000	0.5	0.934	16.05	1.40	42
	12/15/2016	6.85	83.53	5.76	377	0.6	1.34	8.69	NM	82
	3/30/2017	5.35	85.03	5.74	575	0.5	1.02	10.07	5.47	119
	6/15/2017	6.83	83.55	5.60	561	0.3	0.611	14.55	4.95	105
	9/28/2017	7.16	83.22	4.54	<1000	0.2	0.34	15.62	5.63	144

Notes:

NTU - Nephelometric Turbidity Units

Dissolved Oxygen measurements taken with a YSI PRO ODO water quality meter

NM - Not Measured

ppt - parts per thousand

mV - millivolts

mS/cm - millisiemens per cm

mg/L - milligrams per liter

◦C - degrees celsius

R - Rejected DO data due to sensor malfunctions

Appendix A:

Quarterly Monitoring Physical Parameter Summary - Transect Wells

Well	Date	DTGW	Groundwater Elevation	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C)	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)
TW3	11/20/2013	7.18	83.32	6.57	>999	2.1	3.91	15.96	0.86	-187
	2/26/2014	4.71	85.79	6.54	0	1.9	3.65	6.97	0.26	-98
	6/4/2014	5.13	85.37	6.37	0	1.6	3.08	16.16	0.82	-95
	9/24/2014	8.25	82.25	6.54	>999	1.9	3.52	19.56	1.20 R	-86
	12/18/2014	5.18	85.32	6.58	684	1.8	3.47	11.45	3.28 R	-40
	3/23/2015	4.80	85.70	4.82	>999	1.5	2.98	10.05	1.05 R	-73
	6/22/2015	5.90	84.60	5.80	592	1.2	2.39	20.19	0.00	-92
	9/29/2015	8.56	81.94	5.37	>999	1.5	2.87	18.38	0.00	-71
	1/14/2016	5.29	85.21	5.03	891	1.3	2.58	10.60	0.01	-63
	4/6/2016	5.51	84.99	5.26	848	1.1	2.11	13.73	0.01	-95
	6/30/2016	6.06	84.44	6.14	>999	1	1.96	13.17	0.55	-31
	9/21/2016	8.5	82	5.65	>1000	1	2	17.92	1.38	-10
	12/15/2016	6.9	83.6	6.22	>1000	2.2	4.25	8.60	NM	16
	3/30/2017	5.59	84.91	6.25	>1000	1.3	2.57	10.12	4.40	37
	6/15/2017	6.98	83.52	6.16	565	0.6	1.19	15.63	3.69	43
	9/28/2017	8.14	82.36	5.17	>1000	0.2	0.393	16.10	5.64	67
TW2	11/20/2013	7.22	83.47	5.93	0	0.7	1.45	15.86	0.48	-67
	2/26/2014	5.34	85.35	6.29	0	1.2	2.34	6.94	0.22	-54
	6/4/2014	5.60	85.09	6.12	>999	0.8	1.61	19.29	0.84	-56
	9/24/2014	8.25	82.44	6.29	796	1.1	2.14	18.19	1.13 R	-68
	12/18/2014	5.57	85.12	6.42	661	1.0	1.98	12.11	2.80 R	-17
	3/23/2015	5.22	85.47	5.13	486	0.8	1.64	6.56	2.34 R	-23
	6/22/2015	5.51	85.18	5.45	703	0.6	1.14	22.73	0.21	-46
	9/29/2015	9.20	81.49	5.28	896	0.7	1.38	17.39	0.21	-37
	1/14/2016	5.80	84.89	4.95	>999	0.6	1.27	11.07	0.01	-32
	4/6/2016	6.05	84.64	5.1	952	0.5	1.02	10.94	0.01	-45
	6/30/2016	6.49	84.2	6.15	926	0.6	1.26	12.92	0.31	-32
	9/21/2016	8.51	82.18	5.49	>1000	0.7	1.49	16.61	1.75	18
	12/15/2016	7.05	83.64	5.99	432	1.5	2.96	10.57	NM	34
	3/30/2017	5.97	84.72	6.09	>1000	1.1	2.14	9.3	4.7	51
	6/15/2017	7.36	83.33	6.08	857	0.3	0.668	16.99	4.22	42
	9/28/2017	7.78	82.91	5.05	>1000	0.2	0.396	16.28	5.15	68
TW1	11/20/2013	7.28	83.46	5.91	>999	0.7	1.32	16.41	0.55	-79
	2/26/2014	5.00	85.74	6.25	0	1.2	2.37	6.78	0.23	-48
	6/4/2014	5.58	85.16	6.06	0	0.9	1.76	16.19	0.76	-47
	9/24/2014	8.30	82.44	6.22	381	1.1	2.08	16.97	1.51 R	-55
	12/18/2014	5.62	85.12	6.32	962	1	1.99	12.2	2.79 R	-16
	3/23/2015	5.83	84.91	5.11	>999	0.8	1.63	6.24	1.94 R	-28
	6/22/2015	5.22	85.52	5.23	>999	0.5	1.08	15.59	0.01	-21
	9/29/2015	8.55	82.19	5.35	>999	0.7	1.35	17.39	0.01	-39
	1/14/2016	5.50	85.24	5.16	>999	0.7	1.36	10.72	0.01	-32
	4/6/2016	5.91	84.83	5.19	>999	0.5	1.02	9.88	0.01	-36
	6/30/2016	6.56	84.18	6.07	>999	0.6	1.27	13.31	0.29	-28
	9/20/2016	8.60	82.14	6.9	>1000	0.7	1.4	18.02	1.30	13
	12/15/2016	7.64	83.1	5.98	>1000	1.5	2.88	9.32	NM	39
	3/30/2017	6.01	84.73	6.06	>1000	0.6	1.17	9.27	NM	50
	6/15/2017	7.40	83.34	6.18	>1000	0.3	0.642	15.27	3.49	37
	9/28/2017	8.25	82.46	5.14	>1000	0.2	0.410	16.60	4.91	58
TW0	9/20/2016	7.99	82.46	6.77	>1000	0.7	1.34	17.96	1.19	21
	12/15/2016	7.18	83.27	6.07	>1000	1.5	2.93	9.28	NM	34
	3/30/2017	6.00	84.45	6.15	>1000	0.6	1.21	9.29	NM	42
	6/15/2017	7.29	83.16	6.15	>1000	0.3	0.645	14.97	3.45	38
	9/28/2017	7.58	82.83	5.17	>1000	0.2	0.409	16.26	3.45	54

Notes:

NTU - Nephelometric Turbidity Units

NM - Not Measured

ppt - parts per thousand

mS/cm - millisiemens per cm

◦C - degrees celsius

Dissolved Oxygen measurements taken with a YSI PRO ODO water quality meter

mV - millivolts

mg/L - milligrams per liter

R - Rejected DO data due to sensor malfunctions

APPENDIX B

Geochemical Parameters Summary

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Appendix B:

Quarterly Monitoring Iron Summary

Well	Date	Total Iron (unfiltered) (mg/L)	Dissolved Iron* (filtered) (mg/L)	Ferrous Iron (Fe^{2+})** (% of total iron)	Ferrous Iron (Fe^{2+})*** (unfiltered) (mg/L)	Ferrous Iron (Fe^{2+})*** (filtered) (mg/L)
BW1	11/20/13	87	43	49.4%	4.6	na
	03/05/14	31	15	48.4%	3.5	5.7
	06/05/14	49	37	75.5%	6.0	7.0
	09/24/14	140	100	71.4%	4.3	4.5
	12/18/14	190	150	78.9%	1.4	na
	03/25/15	14	14	100.0%	1.0	1.0
	06/25/15	16	16	100.0%	na	na
	09/29/15	170	120	70.6%	na	na
	01/20/16	22	22	100.0%	na	na
	04/08/16	10	10	100.0%	na	na
	06/24/16	45	42	93.3%	na	na
	09/21/16	120	140	116.7%	na	na
	12/14/16	140	140	100.0%	na	na
	03/30/17	24	23	95.8%	na	na
	06/20/17	31	33	106.5%	na	na
	09/27/17	32	36	112.5%	na	na
BW2	11/20/13	110	83	75.5%	9.2	na
	03/05/14	110	88	80.0%	2.6	6.3
	06/05/14	110	89	80.9%	5.6	5.4
	09/24/14	190	160	84.2%	3.9	3.4
	12/18/14	150	140	93.3%	1.9	na
	03/25/15	100	100	100.0%	4.8	4.8
	06/25/15	220	190	86.4%	na	na
	09/29/15	210	160	76.2%	na	na
	01/20/16	130	120	92.3%	na	na
	04/08/16	180	170	94.4%	na	na
	06/24/16	94	91	96.8%	na	na
	09/21/16	150	160	106.7%	na	na
	12/14/16	100	110	110.0%	na	na
	03/30/17	120	130	108.3%	na	na
	06/20/17	140	150	107.1%	na	na
	09/27/17	150	150	100.0%	na	na
BW3	11/20/13	83	51	61.4%	4.8	na
	03/05/14	100	41	41.0%	2.5	4.6
	06/05/14	130	79	60.8%	4.4	4.3
	09/24/14	150	89	59.3%	4.1	4.4
	12/18/14	85	54	63.5%	0.4	na
	03/25/15	140	93	66.4%	1.4	3.9
	06/25/15	120	69	57.5%	na	na
	09/29/15	170	80	47.1%	na	na
	01/15/16	120	20L	16.7% L	na	na
	04/08/16	150	130	86.7%	na	na
	06/24/16	170	120	70.6%	na	na
	09/21/16	150	150	100.0%	na	na
	12/14/16	160	150	93.8%	na	na
	03/30/17	110	100	90.9%	na	na
	06/20/17	120	130	108.3%	na	na
	09/27/17	150	150	100.0%	na	na
BW4	11/20/13	71	40	56.3%	7.2	na
	03/05/14	70	41	58.6%	3	3.6
	06/05/14	62	38	61.3%	4.9	5.6
	09/24/14	160	98	61.3%	3.5	5.2
	12/18/14	93	64	68.8%	0.0	na
	03/25/15	56	39	69.6%	1.9	1.7
	06/25/15	74	39	52.7%	na	na
	09/29/15	110	29	26.4%	na	na
	01/15/16	80	0.1L-R	0.1% L-R	na	na
	04/08/16	62	55	88.7%	na	na
	06/24/16	70	66	94.3%	na	na
	09/21/16	120	110	91.7%	na	na
	12/14/16	150	130	86.7%	na	na
	03/30/17	89	82	92.1%	na	na
	06/20/17	61	59	96.7%	na	na
	09/27/17	65	65	100.0%	na	na
BW5	11/20/13	110	65	59.1%	3.6	na
	03/05/14	140	81	57.9%	2.2	3.9
	06/05/14	150	100	66.7%	6.4	2.9
	09/24/14	160	95	59.4%	3.8	3.6
	12/18/14	160	120	75.0%	0.0	na
	03/25/15	140	120	85.7%	2.8	2.2
	06/25/15	150	99	66.0%	na	na
	09/29/15	150	69	46.0%	na	na
	01/15/16	170	82L	48.2% L	na	na
	04/08/16	150	97	64.7%	na	na
	06/24/16	190	150	78.9%	na	na
	09/21/16	180	160	88.9%	na	na
	12/14/16	170	170	100.0%	na	na
	03/30/17	150	140	93.3%	na	na
	06/20/17	97	100	103.1%	na	na
	09/27/17	140	150	107.1%	na	na

Notes:

*Ferrous iron is assumed to be equal to the iron detected in the dissolved sample fraction.

**The percent ferrous iron is determined by dividing the dissolved iron result by the total iron result and multiplying by 100.

***Ferrous iron is measured using a field test kit (Hach Test Kit, Model IR-18C, Color Disc Kit 26672-00). Test kit ferrous iron results are not considered representative of actual ferrous iron concentrations in biowall groundwater.

L - Analyte present. Reported value may be biased low. Actual value is expected to be higher.

L-R - Analyte present. Reported value may be biased low and dissolved iron data is rejected.

na - not analyzed. Use of field test kits discontinued in June 2015.

mg/L - milligrams per liter

Appendix B:
Quarterly Monitoring Iron Summary

Well	Date	Total Iron (unfiltered) (mg/L)	Dissolved Iron* (filtered) (mg/L)	Ferrous Iron (Fe^{2+})** (% of total iron)	Ferrous Iron (Fe^{2+})*** (unfiltered) (mg/L)	Ferrous Iron (Fe^{2+})*** (filtered) (mg/L)
BW6	11/20/13	88	87	98.9%	5.0	na
	03/05/14	120	84	70.0%	3.6	4.8
	06/05/14	100	75	75.0%	4.0	6.4
	09/24/14	120	86	71.7%	5.0	5.2
	12/18/14	140	120	85.7%	0.0	na
	03/24/15	95	63	66.3%	3.2	1.4
	06/25/15	100	75	75.0%	na	na
	09/28/15	120	64	53.3%	na	na
	01/15/16	110	24L	21.8% L	na	na
	04/08/16	110	97	88.2%	na	na
	06/24/16	95	94	98.9%	na	na
	09/21/16	110	110	100.0%	na	na
	12/14/16	100	100	100.0%	na	na
	03/30/17	130	100	76.9%	na	na
	06/21/17	140	140	100.0%	na	na
	09/27/17	120	120	100.0%	na	na
BW7	11/20/13	140	97	69.3%	5.2	na
	03/05/14	110	79	71.8%	4.0	3.1
	06/05/14	140	120	85.7%	4.3	8.2
	09/24/14	180	140	77.8%	5.0	4.4
	12/18/14	150	87	58.0%	0.0	na
	03/24/15	120	84	70.0%	0.8	2
	06/25/15	140	120	85.7%	na	na
	09/28/15	180	130	72.2%	na	na
	01/15/16	150	84L	56% L	na	na
	04/08/16	150	150	100.0%	na	na
	06/24/16	160	150	93.8%	na	na
	09/21/16	180	180	100.0%	na	na
	12/13/16	160	160	100.0%	na	na
	03/30/17	110	110	100.0%	na	na
	06/20/17	180	180	100.0%	na	na
	09/27/17	190	180	94.7%	na	na
BW8	11/20/13	140	120	85.7%	4.6	na
	03/05/14	110	62	56.4%	2.8	2.9
	06/05/14	150	75	50.0%	5.6	6.4
	09/24/14	190	130	68.4%	6.1	4.8
	12/18/14	110	78	70.9%	0.0	na
	03/24/15	81	50	61.7%	1.4	3.8
	06/25/15	110	69	62.7%	na	na
	09/28/15	170	120	70.6%	na	na
	01/15/16	66	0.081L-R	0.1% L-R	na	na
	04/08/16	55	50	90.9%	na	na
	06/23/16	84	73	86.9%	na	na
	09/21/16	160	160	100.0%	na	na
	12/13/16	150	150	100.0%	na	na
	03/30/17	53	52	98.1%	na	na
	06/20/17	41	40	97.6%	na	na
	09/27/17	70	65	92.9%	na	na
BW9	11/20/13	42	40	95.2%	4.2	na
	03/05/14	49	28	57.1%	2.0	4.0
	06/05/14	78	45	57.7%	3.0	10
	09/24/14	88	62	70.5%	4.8	3.8
	12/18/14	120	100	83.3%	2.9	na
	03/24/15	57	42	73.7%	2.6	1.2
	06/25/15	110	81	73.6%	na	na
	09/28/15	100	66	66.0%	na	na
	01/15/16	91	24L	26.4% L	na	na
	04/08/16	70	65	92.9%	na	na
	06/23/16	97	93	95.9%	na	na
	09/21/16	150	150	100.0%	na	na
	12/13/16	130	130	100.0%	na	na
	03/30/17	110	96	87.3%	na	na
	06/20/17	110	109	99.1%	na	na
	09/26/17	130	140	107.7%	na	na
BW10	11/20/13	120	96	80.0%	4.8	na
	03/05/14	84	41	48.8%	2.4	3.4
	06/05/14	83	40	48.2%	4.4	8.6
	09/24/14	130	87	66.9%	5.2	4.2
	12/18/14	31	19	61.3%	1.4	na
	03/24/15	63	41	65.1%	2.7	1.2
	06/25/15	100	100	100.0%	na	na
	09/28/15	150	77	51.3%	na	na
	01/15/16	140	79L	56.4% L	na	na
	04/08/16	76	71	93.4%	na	na
	06/23/16	100	99	99.0%	na	na
MW-6****	09/21/16	27	19	70.4%	na	na
	12/13/16	11	9.4	85.5%	na	na
	03/30/17	7.6	3.4	44.7%	na	na
	06/21/17	40	39	97.5%	na	na
	09/26/17	16	18	112.5%	na	na

Notes:

*Ferrous iron is assumed to be equal to the iron detected in the dissolved sample fraction.

**The percent ferrous iron is determined by dividing the dissolved iron result by the total iron result and multiplying by 100.

***Ferrous iron is measured using a field test kit (Hach Test Kit, Model IR-18C, Color Disc Kit 26672-00). Test kit ferrous iron results are not considered representative of actual ferrous iron concentrations in biowall groundwater.

****MW-6 sampled in place of the decommissioned BW-10

L - Analyte present. Reported value may be biased low. Actual value is expected to be higher.

L-R - Analyte present. Reported value may be biased low and dissolved iron data is rejected.

na - not analyzed. Use of field test kits discontinued in June 2015.

Appendix B:
Quarterly Monitoring Geochemical Parameter Summary

Well	Date	Total Alkalinity (mg/L $CaCO_3$)	Total Organic Carbon (TOC) (mg/L)	Nitrate (mg/L)*	Nitrite (mg/L)*	Sulfate (mg/L)	Sulfide (mg/L)	Methane (mg/L)	Manganese (mg/L)	Dissovled Manganese (mg/L)
BW1	11/20/13	2,800	250	<0.3	<0.15	6.7	<2.0	3.6	na	na
	03/05/14	60	130	<0.06	<0.03	98	<2.0	5.0	na	na
	06/05/14	420	23	<0.3	<0.15	32	<2.0	13	na	na
	09/24/14	1,000	57	<1.2	<0.6	<6.0	<2.0	9.0	na	na
	12/18/14	1,300	64-D	na	na	9.6-D	<2.0	11	na	na
	03/25/15	34	4.0	na	na	74	<2.0	3.5	na	na
	06/25/15	0	4.7	na	na	53	na	5.9	na	na
	09/29/15	980	74	na	na	2.4	na	9.0	na	na
	01/20/16	50	6.4	na	na	83-D	na	9.3-J	na	na
	04/08/16	350	3.9	na	na	60N-L	na	4.4	na	na
	06/24/16	250	13	na	na	24	na	14.0	na	na
	09/21/16	680	33-D	na	na	2.7	na	9.1	na	na
	12/14/16	770	37-D	na	na	21-D	na	10.0	10	na
	03/29/17	23	5.4	na	na	77	na	4.4	6.5	6.2
	06/20/17	140	7.9	na	na	41	na	13.0	2.9	3.1
	09/27/17	140	8.4	na	na	42	na	9.7	4.3	4.5
BW2	11/20/13	2,400	220	<0.3	<0.15	1.9	<2.0	9.2	na	na
	03/05/14	730	23	<0.06	<0.03	3.5	<2.0	17	na	na
	06/05/14	880	120	<0.3	<0.15	<1.5	<2.0	13	na	na
	09/24/14	1,500	120	<1.2	<0.6	<6.0	<2.0	9.3	na	na
	12/18/14	520	75-D	na	na	26-D	<2.0	13	na	na
	03/25/15	510	75	na	na	4.1	<2.0	13	na	na
	06/25/15	1,100	93	na	na	<0.6	na	12	na	na
	09/29/15	1,300	110	na	na	3.9	na	9.4	na	na
	01/20/16	540	55-D	na	na	3.5-D	na	19-JD	na	na
	04/08/16	810	65-D	na	na	<0.3	na	16	na	na
	06/24/16	410	46	na	na	3.5	na	13	na	na
	09/21/16	640	50-D	na	na	2	na	11	na	na
	12/14/16	410	29-D	na	na	8.4-D	na	15-D	12	na
	03/29/17	330	30	na	na	2.6	na	12	15	15
	06/20/17	690	26	na	na	11	na	13	13	14
	09/27/17	660	34	na	na	<0.15	na	8.4	14	14
BW3	11/20/13	2,800	260	<0.3	<0.15	<0.3	<2.0	9.1	na	na
	03/05/14	3,100	260	<0.3	<0.15	<1.5	<2.0	13	na	na
	06/05/14	3,100	270	<0.3	<0.15	<1.5	<2.0	11	na	na
	09/24/14	2,700	250	<3.0	<1.5	<1.5	<2.0	9.6	na	na
	12/18/14	1,400	92-D	na	na	45-D	<2.0	13	na	na
	03/25/15	2,500	190	na	na	1.1	<2.0	12	na	na
	06/25/15	2,200	160	na	na	<0.6	na	6.6	na	na
	09/29/15	1,900	180	na	na	1.3	na	8.6	na	na
	01/15/16	1,500	110-D	na	na	3.5-D	na	15-D	na	na
	04/08/16	2,000	140-D	na	na	1.9	na	13	na	na
	06/24/16	1,200	150	na	na	<0.3	na	12	na	na
	09/21/16	1,600	140-D	na	na	1.1	na	13	na	na
	12/14/16	1,100	64-D	na	na	43-D	na	12	11	na
	03/29/17	880	66	na	na	3.2	na	11	7.8	7.5
	06/20/17	1,500	68	na	na	5.4	na	10	9.4	10
	09/27/17	1,500	81	na	na	<0.15	na	8.5	12	12

Notes:

mg/L: milligram per liter

na: not analyzed

D. Result detected in sample with laboratory dilution.

ND: Chemical parameter was below the detection limit

J: Estimated Concentration

L: Result detected in sample is biased low

*nitrate/nitrite analysis was discontinued after first year of monitoring

Appendix B:
Quarterly Monitoring Geochemical Parameter Summary

Well	Date	Total Alkalinity (mg/L $CaCO_3$)	Total Organic Carbon (TOC) (mg/L)	Nitrate (mg/L)*	Nitrite (mg/L)*	Sulfate (mg/L)	Sulfide (mg/L)	Methane (mg/L)	Manganese (mg/L)	Dissovled Manganese (mg/L)
BW4	11/20/13	2,800	120	<0.3	<0.15	11	<2.0	9.6	na	na
	03/05/14	1500	110	<0.12	<0.06	5.3	<2.0	14	na	na
	06/05/14	970	65	<0.3	<0.15	<1.5	<2.0	13	na	na
	09/24/14	1,700	150	<.0015	<0.75	<7.5	<2.0	11	na	na
	12/18/14	640	35-D	na	na	43-D	<2.0	14	na	na
	03/25/15	330	16	na	na	1.7	<2.0	14	na	na
	06/25/15	410	21	na	na	<5.9	na	10	na	na
	09/29/15	440	43	na	na	1.2	na	12	na	na
	01/15/16	290	14	na	na	3.6-D	na	17-D	na	na
	04/08/16	220	9.7	na	na	1.1	na	12	na	na
	06/24/16	220	8.8	na	na	1.8	na	12	na	na
	09/21/16	410	22-D	na	na	2.3	na	12	na	na
	12/14/16	450	22-D	na	na	24-D	na	14	6.2	na
	03/29/17	210	12	na	na	27	na	15	3.1	3.2
	06/20/17	170	2.9	na	na	1.8	na	13	2	2.1
	09/27/17	180	6.1	na	na	1.8	na	12	2.2	2.1
BW5	11/20/13	2,900	350	<0.3	<0.15	<0.3	<2.0	10	na	na
	03/05/14	2,600	290	<0.12	<1.5	<0.6	<2.0	12	na	na
	06/05/14	2,600	280	<0.3	<0.15	<1.5	<2.0	9.8	na	na
	09/24/14	2,500	270	<.0003	<0.15	<1.5	<2.0	8.7	na	na
	12/18/14	1,900	190-D	na	na	5.6-D	<2.0	11	na	na
	03/25/15	1,800	170	na	na	7.7	<2.0	12	na	na
	06/25/15	1,700	160	na	na	<4.9	na	14	na	na
	09/29/15	1,400	150	na	na	1.2	na	12	na	na
	01/15/16	1,600	130-D	na	na	2.5-D	na	17-D	na	na
	04/08/16	1,200	90-D	na	na	2.7	na	11	na	na
	06/24/16	1,500	130	na	na	<0.3	na	8.9	na	na
	09/21/16	1,400	120-D	na	na	2.2	na	12	na	na
	12/14/16	1,400	130-D	na	na	1.4	na	13	15	na
	03/29/17	800	60	na	na	26	na	12	9.3	9.4
	06/20/17	430	18	na	na	1.4	na	16-D	5.5	6.1
	09/27/17	760	41	na	na	5.5	na	10	9	9
BW6	11/20/13	880	95	<0.06	<0.15	74	<2.0	7.7	na	na
	03/05/14	870	98	<0.06	<0.15	75	<2.0	6.0	na	na
	06/05/14	1,700	110	<0.12	<0.75	25	<2.0	12	na	na
	09/24/14	1,700	110	<0.12	<0.75	25	<2.0	12	na	na
	12/18/14	1,300	90	<0.12	<0.06	31	<2.0	11	na	na
	03/24/15	1,300	88	<0.12	<0.07	29	<2.0	13	na	na
	06/25/15	700	36	na	na	89	na	14	na	na
	09/28/15	750	51	na	na	33	na	11	na	na
	01/15/16	550	32-D	na	na	110	na	18-D	na	na
	04/08/16	750	31-D	na	na	99-D	na	15	na	na
	06/24/16	600	33	na	na	100	na	13	na	na
	09/21/16	590	40-D	na	na	95-D	na	12	na	na
	12/14/16	530	24-D	na	na	71-D	na	16-D	8.2	na
	03/29/17	510	24	na	na	110	na	14	7.8	7.6
	06/21/17	680	24	na	na	71	na	18-D	9.6	9.8
	09/27/17	540	26	na	na	81	na	12	7.7	7.6

Notes:

mg/L: milligram per liter

na: not analyzed

D. Result detected in sample with laboratory dilution.

ND: Chemical parameter was below the detection limit

J: Estimated Concentration

L: Result detected in sample is biased low

*nitrate/nitrite analysis was discontinued after first year of monitoring

Appendix B:

Quarterly Monitoring Geochemical Parameter Summary

Well	Date	Total Alkalinity (mg/L $CaCO_3$)	Total Organic Carbon (TOC) (mg/L)	Nitrate (mg/L)*	Nitrite (mg/L)*	Sulfate (mg/L)	Sulfide (mg/L)	Methane (mg/L)	Manganese (mg/L)	Dissovled Manganese (mg/L)
BW7	11/20/13	2,300	240	<0.06	<0.15	<0.3	<2.0	6.9	na	na
	03/05/14	2,400	250	<0.12	<1.5	5.8	<2.0	13	na	na
	06/05/14	2,200	240	<0.3	<0.15	<1.5	<2.0	12	na	na
	09/24/14	2,400	260	<3.0	<0.15	<1.5	<2.0	8	na	na
	12/18/14	1,700	150-D	na	na	27-D	<2.0	12	na	na
	03/24/15	1,700	130	na	na	12	<2.0	14	na	na
	06/25/15	1,800	150	na	na	<0.6	na	12	na	na
	09/28/15	1,800	220	na	na	na	na	6.8	na	na
	01/15/16	1,400	110-D	na	na	8.1-D	na	15-D	na	na
	04/08/16	1,200	89-D	na	na	31-D	na	9.6	na	na
	06/24/16	1,500	120	na	na	1.9	na	11	na	na
	09/21/16	2,000	200-D	na	na	1.4	na	8.9	na	na
	12/13/16	1,400	130-D	na	na	27-D	na	11	15	na
	03/29/17	1,000	65	na	na	72	na	13	19	19
	06/20/17	1,900	120	na	na	4.4	na	12	16	16
	09/27/17	1,700	130	na	na	<0.15	na	9.3	15	15
BW8	11/20/13	2,600	230	<0.06	<0.15	<0.3	<2.0	7.6	na	na
	03/05/14	2,000	210	<0.12	<0.06	6.1	<2.0	17	na	na
	06/05/14	2,500	230	<0.3	<0.15	<1.5	<2.0	10	na	na
	09/24/14	2,100	230	<3.0	<0.15	<1.5	<2.0	7.7	na	na
	12/18/14	800	69-D	na	na	69-D	<2.0	12	na	na
	03/24/15	820	62	na	na	87	<2.0	14	na	na
	06/25/15	2,700	47	na	na	63	na	6.3	na	na
	09/28/15	1,300	85	na	na	<0.3	na	7.4	na	na
	01/15/16	210	18	na	na	110-D	na	13	na	na
	04/08/16	190	15	na	na	93-D	na	6.7	na	na
	06/23/16	440	35	na	na	57	na	10	na	na
	09/21/16	1,100	79-D	na	na	1.5	na	9.1	na	na
	12/13/16	930	46-D	na	na	1.3	na	12	11	na
	03/29/17	86	8.9	na	na	150	na	6.4	2.8	2.9
	06/20/17	130	6.4	na	na	100	na	7.8	2.2	2.2
	09/27/17	380	20	na	na	49	na	8.9	4.6	4.3
BW9	11/20/13	380	32	<0.06	<0.15	78	<2.0	7.0	na	na
	03/05/14	291	24	<0.06	<0.03	59	<2.0	14	na	na
	06/05/14	360	33	<0.06	<0.03	10	<2.0	12	na	na
	09/24/14	640	39	<0.6	<0.3	42	<2.0	6.7	na	na
	12/18/14	390	20-D	na	na	48-D	<2.0	12	na	na
	03/24/15	160	13	na	na	45	<2.0	13	na	na
	06/25/15	320	19	na	na	16	na	6.6	na	na
	09/28/15	410	23	na	na	20	na	7.2	na	na
	01/15/16	190	14	na	na	20-D	na	18-D	na	na
	04/08/16	140	9.8	na	na	30-D	na	14	na	na
	06/23/16	380	18	na	na	22	na	10	na	na
	09/21/16	500	26-D	na	na	9.6	na	9.3	na	na
	12/13/16	400	14	na	na	42-D	na	12	19	na
	03/29/17	150	11	na	na	41	na	14	13	13
	06/20/17	270	18.6	na	na	40.9	na	12	12.7	12.4
	09/27/17	330	14	na	na	14	na	10	15	15

Notes:

mg/L: milligram per liter

na: not analyzed

D. Result detected in sample with laboratory dilution.

ND: Chemical parameter was below the detection limit

J: Estimated Concentration

L: Result detected in sample is biased low

*nitrate/nitrite analysis was discontinued after first year of monitoring

**MW-6 Sampled in place of the decommissioned BW-10

Appendix B:

Quarterly Monitoring Geochemical Parameter Summary

Well	Date	Total Alkalinity (mg/L $CaCO_3$)	Total Organic Carbon (TOC) (mg/L)	Nitrate (mg/L)*	Nitrite (mg/L)*	Sulfate (mg/L)	Sulfide (mg/L)	Methane (mg/L)	Manganese (mg/L)	Dissovled Manganese (mg/L)
BW10	11/20/13	1,700	200	<0.06	<0.15	<0.3	<2.0	9.1	na	na
	03/05/14	1,300	130	<0.12	<0.06	8.6	<2.0	18	na	na
	06/04/14	830	77	<0.06	<0.03	2.8	<2.0	13	na	na
	09/24/14	1,200	85	<1.2	<0.6	<6.0	<2.0	7.0	na	na
	12/18/14	1,200	48-D	na	na	49-D	<2.0	11	na	na
	03/23/15	420	25	na	na	22	<2.0	14	na	na
	06/25/15	550	35	na	na	4.1	na	8.2	na	na
	09/28/15	970	69	na	na	2.3	na	8.2	na	na
	01/15/16	650	39-D	na	na	<0.3	na	18-D	na	na
	04/08/16	410	30-D	na	na	15-D	na	15	na	na
	06/23/16	590	37	na	na	<0.3	na	13	na	na
MW-6**	09/21/16	35	1.8	na	na	250	na	0.11	na	na
	12/13/16	13	1.7	na	na	210-D	na	0.011	1.5	na
	03/29/17	<5	1.7	na	na	190	na	0.082	1.7	1.7
	06/21/17	55	1.8	na	na	210	na	0.071	1.9	1.9
	09/27/17	13	2.2	na	na	170	na	0.067	1.4	1.5

Notes:

mg/L: milligram per liter

na: not analyzed

D. Result detected in sample with laboratory dilution.

ND: Chemical parameter was below the detection limit

J: Estimated Concentration

L: Result detected in sample is biased low

*nitrate/nitrite analysis was discontinued after first year of monitoring

**MW-6 Sampled in place of the decommissioned BW-10

APPENDIX C

RI Monitoring Well and Surface Water Data Summary

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Appendix C:
Quarterly Monitoring Physical Parameter Summary - Dissolved Oxygen in RI Wells

Well	Date	Dissolved Oxygen (mg/L)	Temperature
MW2	2/26/2014	2.10	10.1
	6/4/2014	2.10 R	10.1
	9/24/2014	4.38 R	14.0
	12/18/2014	5.93 R	13.7
	3/23/2015	9.19 R	10.8
	6/19/2015	0.56	12.9
	9/25/2015	2.86 R	14.2
	1/20/2016	3.94	12.7
	4/6/2016	3.91	11.4
	6/23/2016	3.91	16.2
	9/20/2016	4.79	17.3
	12/13/2016	5.02	13.8
	3/28/2017	8.47	10.8
	6/13/2017	3.06	16.8
	9/28/2017	1.97	15.7
MW3	2/26/2014	9.23	NM*
	6/4/2014	8.46 R	11.6
	9/24/2014	7.73 R	13.3
	12/18/2014	9.43 R	13.3
	3/23/2015	10.59 R	10.6
	6/19/2015	7.71	12.1
	9/25/2015	7.02 R	15.9
	1/20/2016	8.06	11.4
	4/6/2016	9.06	11.1
	6/23/2016	8.12	13.3
	9/20/2016	7.8	16.9
	12/13/2016	7.87	13.9
	3/28/2017	10.3	10.8
	6/13/2017	6.18	13.3
	9/28/2017	8.62	13.5
MW4	2/26/2014	5.50	NM*
	6/4/2014	3.70 R	11.8
	9/24/2014	3.67 R	13.8
	12/18/2014	9.29 R	13.7
	3/23/2015	10.69 R	9.1
	6/19/2015	3.23	13.5
	9/25/2015	4.02 R	16.5
	1/20/2016	6.37	11.6
	4/6/2016	6.07	10.8
	6/23/2016	3.13	14.0
	9/20/2016	4.27	20.4
	12/13/2016	6.26	12.8
	3/28/2017	10.8	11.0
	6/13/2017	6.88	20.1
	9/28/2017	2.48	18.5
MW5	2/26/2014	7.07	12.6
	6/4/2014	4.07 R	13.2
	9/24/2014	8.87 R	13.4
	12/18/2014	9.75 R	13.0
	3/23/2015	10.71 R	12.8
	6/19/2015	8.87	13.3
	9/25/2015	3.25 R	15.3
	1/20/2016	5.26	12.4
	4/6/2016	5.02	12.9
	6/23/2016	6.11	16.8
	9/20/2016	7.8	13.3
	12/13/2016	5.66	12.6
	3/28/2017	10.24	14.2
	6/13/2017	7.27	15.9
	9/28/2017	8.62	16.1

Notes:
* N/A* Not analyzed.   Downhole DO temperature probe cable is too short to reach water table
* NM* Temperature measurement no taken due to thermometer malfunction
* DO measurements from MW1 not collected due depth to water typically being greater than down-hole meter cable length.

R - Rejected DO data due to sensor malfunctions

Appendix C:
Quarterly Monitoring Physical Parameter Summary - Dissolved Oxygen in RI Wells

MW6	2/26/2014	1.36	10.7
	6/4/2014	2.80	11.8
	9/24/2014	4.88	14.9
	12/18/2014	5.89	13.6
	3/23/2015	9.13	10.0
	6/19/2015	0.50	12.3
	9/25/2015	3.25	15.3
	1/20/2016	2.01	10.6
	4/6/2016	0.34	11.3
	6/23/2016	4.36	17.2
	9/20/2016	4.56	18.5
	12/13/2016	3.72	10.21
	3/28/2017	4.53	10.8
	6/13/2017	5.33	16.3
	9/26/2017	0.43	17.3
MW7	2/26/2014	3.57	11.3
	6/4/2014	2.69 R	11.7
	9/24/2014	5.97 R	13.2
	12/18/2014	5.95 R	13.3
	3/23/2015	5.97 R	11.5
	6/19/2015	0.45	12.1
	9/25/2015	3.91 R	13.6
	1/20/2016	3.87	11.3
	4/6/2016	2.07	10.8
	6/23/2016	4.66	20.3
	9/20/2016	3.48	16.2
	12/13/2016	3.88	13.5
	3/28/2017	5.65	12
	6/13/2017	4.96	19.4
	9/28/2017	2.47	18.9
MW8	2/26/2014	3.70	10.6
	6/4/2014	3.05 R	11.6
	9/24/2014	7.43 R	14.0
	12/18/2014	7.02 R	12.9
	3/23/2015	9.32 R	11.1
	6/19/2015	0.53	11.9
	9/25/2015	3.43 R	15.4
	1/20/2016	3.60	11.4
	4/6/2016	2.74	10.6
	6/23/2016	3.61	18.0
	9/20/2016	4.35	17.4
	12/13/2016	3.47	13.2
	3/28/2017	9.75	11.2
	6/13/2017	0.76	14.3
	9/28/2017	2.53	14.1
MW9	2/26/2014	0.65	11.0
	6/4/2014	2.73 R	11.0
	9/24/2014	4.99 R	14.2
	12/18/2014	6.88 R	13.2
	3/23/2015	9.26 R	10.6
	6/19/2015	0.60	12.0
	9/25/2015	3.09 R	14.6
	1/20/2016	0.56	12.6
	4/6/2016	0.14	10.4
	6/23/2016	4.99	19.4
	9/20/2016	4.54	17.2
	12/13/2016	0.53	13.6
	3/28/2017	4.48	10.8
	6/13/2017	0.6	15.9
	9/28/2017	2.45	14.5

Notes:

* N/A* Not analyzed.   Downhole DO temperature probe cable is too short to reach water table

* NM* Temperature measurement no taken due to thermometer malfunction

* DO measurements from MW1 not collected due depth to water typically being greater than down-hole meter cable length.

R - Rejected DO data due to sensor malfunctions

Appendix C:

Year One Physical Parameter Summary - Surface Water

Sample ID	Date	pH	Turbidity (NTU)	Salinity (ppt)	Specific Conductivity (mS/cm)	Temperature (◦C)	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)
SW1	2/25/2014	6.04	1.3	0.1	0.323	2.58	10.27	102
	9/24/2104	7.75	80	0.1	0.166	14.88	12.48	83
	3/23/2015	4.68	69.7	0.2	0.323	6.17	8.50	123
	9/25/2015	5.97	156	0.1	0.205	16.83	8.46	203
	4/6/2016	4.95	200	0.1	0.249	8.05	12.73	200
	9/20/2016	7.87	598	0.1	0.213	20.30	8.07	233
	3/29/2017	6354	77.9	0.1	0.261	14.47	3.73	158
	9/26/2017	7.19	592	0.1	0.303	18.45	8.82	302
SW2	2/25/2014	5.93	11.1	0.1	0.275	2.54	10.65	93
	9/24/2104	7.89	62.4	0.1	0.169	14.07	12.32	79
	3/23/2015	4.47	67	0.2	0.350	5.50	10.44	132
	9/25/2015	5.98	213	0.1	0.217	16.91	7.56	198
	4/6/2016	5.53	807	0.1	0.260	6.92	12.91	180
	9/20/2016	8.09	607	0.1	0.194	21.12	8.07	607
	3/29/2017	6.56	1000	0.1	0.298	14.28	4.20	1000
	9/26/2017	8.53	642	0.1	0.287	18.93	8.56	280
SW3	2/25/2014	5.87	71.6	0.1	0.253	3.17	4.90	109
	9/24/2104	8.32	95.7	0.1	0.171	13.96	12.10	53
	3/23/2015	4.74	114	0.1	0.275	4.44	11.54	127
	9/25/2015	5.95	224	0.1	0.220	16.69	6.13	204
	4/6/2016	5.44	447	0.1	0.256	12.63	12.63	189
	9/20/2016	8.22	823	0.1	0.272	21.15	5.81	231
	3/29/2017	6.84	106	0.1	0.276	14.52	1.82	77
	9/26/2017	9.04	694	0.1	0.311	18.64	6.47	256
SW4	2/25/2014	5.73	75.5	0.2	0.334	2.10	12.78	198
	9/24/2104	8.51	151	0.1	0.225	15.51	9.73	42
	3/23/2015	4.93	58.4	0.2	0.361	3.53	10.40	151
	9/25/2015	5.85	197	0.1	0.216	18.35	5.26	210
	4/6/2016	5.51	964	0.1	0.246	7.23	12.36	173
	9/20/2016	8.02	619	0.1	0.272	20.80	4.40	247
	3/29/2017	7.39	111	0.1	0.279	15.12	6.03	155
	9/26/2017	9.78	970	0.1	0.289	19.95	19.95	226

Notes:

NTU - Nephelometric Turbidity Units

ppt - parts per thousand

mS/cm - millisiemens per cm

◦C - degrees celsius

mg/L - milligrams per liter

mV - millivolts

U52 - Temepråture measurement outside of the well using a Horiba U52 milti-parameter water quality meter during

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APPENDIX D

Volatile Organic Compound (VOC) Data Summary

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Attachment D
Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
Biowall Wells							
BW1	Nov-13	ND	ND	10	ND	ND	ND
	Mar-14	2.4	ND	ND	ND	ND	ND
	Jun-14	0.46	ND	ND	ND	ND	ND
	Sep-14	ND	ND	ND	ND	ND	ND
	Dec-14	ND	ND	ND	ND	ND	ND
	Mar-15	0.62	ND	ND	ND	ND	ND
	Jun-15	ND	ND	ND	ND	ND	ND
	Sep-15	ND	0.66J	ND	ND	ND	ND
	Jan-16	ND	ND	ND	ND	ND	ND
	Apr-16	0.51J	ND	ND	ND	ND	ND
	Jun-16	0.32J	0.63J	ND	ND	ND	ND
	Sep-16	ND	0.43J	ND	ND	ND	ND
	Dec-16	ND	ND	ND	ND	ND	ND
	Mar-17	ND	ND	ND	ND	ND	ND
	Jun-17	0.69J	0.39J	ND	ND	ND	ND
	Sep-17	ND	ND	ND	ND	ND	ND
BW2	Nov-13	ND	ND	ND	ND	ND	ND
	Mar-14	ND	ND	ND	ND	ND	ND
	Jun-14	ND	ND	ND	ND	ND	ND
	Sep-14	ND	ND	ND	ND	ND	ND
	Dec-14	ND	ND	ND	ND	ND	ND
	Mar-15	ND	ND	ND	ND	ND	ND
	Jun-15	ND	ND	ND	ND	ND	ND
	Sep-15	ND	ND	ND	ND	ND	ND
	Jan-16	ND	ND	ND	ND	ND	ND
	Apr-16	ND	ND	ND	ND	ND	ND
	Jun-16	ND	ND	ND	ND	ND	ND
	Sep-16	ND	ND	ND	ND	ND	ND
	Dec-16	ND	ND	ND	ND	ND	ND
	Mar-17	ND	ND	ND	ND	ND	ND
	Jun-17	ND	ND	ND	ND	ND	ND
	Sep-17	ND	ND	ND	ND	ND	ND
BW3	Nov-13	ND	ND	ND	ND	ND	ND
	Mar-14	ND	ND	ND	ND	ND	ND
	Jun-14	ND	ND	ND	ND	ND	ND
	Sep-14	ND	ND	ND	ND	ND	ND
	Dec-14	ND	ND	ND	ND	ND	ND
	Mar-15	ND	ND	ND	ND	ND	ND
	Jun-15	ND	ND	ND	ND	ND	ND
	Sep-15	ND	ND	ND	ND	ND	ND
	Jan-16	ND	ND	ND	ND	ND	ND
	Apr-16	ND	ND	ND	ND	ND	ND
	Jun-16	ND	ND	ND	ND	ND	ND
	Sep-16	ND	ND	ND	ND	ND	1.1-L
	Dec-16	ND	0.51J	ND	ND	ND	ND
	Mar-17	ND	ND	ND	ND	ND	ND
	Jun-17	ND	ND	ND	ND	ND	ND
	Sep-17	ND	ND	ND	ND	ND	ND

Notes:
µg/L - micrograms per liter
ND - non detect
na - Not Analyzed
NA - Not Applicable
MCL Exceedances in bold
J - Estimated Concentration

Attachment D
Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
Biowall Wells							
BW4	Nov-13	ND	ND	ND	ND	ND	ND
	Mar-14	ND	ND	ND	ND	ND	ND
	Jun-14	ND	ND	ND	ND	ND	ND
	Sep-14	ND	ND	ND	ND	ND	ND
	Dec-14	ND	ND	ND	ND	ND	ND
	Mar-15	ND	ND	ND	ND	ND	ND
	Jun-15	ND	ND	ND	ND	ND	ND
	Sep-15	ND	ND	ND	ND	ND	ND
	Jan-16	ND	ND	ND	ND	ND	ND
	Apr-16	ND	0.36J	ND	ND	ND	ND
	Jun-16	ND	0.34J	ND	ND	ND	ND
	Sep-16	ND	ND	ND	ND	ND	ND
	Dec-16	ND	ND	ND	ND	ND	ND
	Mar-17	ND	0.31	ND	ND	ND	ND
	Jun-17	ND	ND	ND	ND	ND	ND
	Sep-17	ND	ND	ND	ND	ND	ND
BW5	Nov-13	ND	ND	ND	ND	ND	ND
	Mar-14	ND	ND	ND	ND	ND	ND
	Jun-14	ND	ND	ND	ND	ND	ND
	Sep-14	ND	ND	ND	ND	ND	ND
	Dec-14	ND	ND	ND	ND	ND	ND
	Mar-15	ND	ND	ND	ND	ND	ND
	Jun-15	ND	0.32J	ND	ND	ND	ND
	Sep-15	ND	ND	ND	ND	ND	ND
	Jan-16	ND	ND	ND	ND	ND	ND
	Apr-16	ND	0.57J	ND	ND	ND	ND
	Jun-16	ND	ND	ND	ND	ND	ND
	Sep-16	ND	ND	ND	ND	ND	ND
	Dec-16	ND	ND	ND	ND	ND	ND
	Mar-17	0.41	0.93	ND	ND	ND	ND
	Jun-17	ND	ND	ND	ND	ND	ND
	Sep-17	ND	ND	ND	ND	ND	ND
BW6	Nov-13	**9.1**	**250**	1.3	ND	0.96	ND
	Mar-14	1.6	**140**	1.2	ND	**14**	ND
	Jun-14	0.7	**100**	0.66	ND	**34**	1.2
	Sep-14	ND	**75**	0.31	ND	**44**	4.2
	Dec-14	0.33	**78**	0.33	ND	**21**	1.9
	Mar-15	**25**	**150**	1.0	4.7	**25**	4.4
	Jun-15	1.4	**160**	0.71J	3.3	**20**	6.9
	Sep-15	ND	66	ND	0.73J	**25**	4.0
	Jan-16	**11J**	**230-D**	0.65J	2	**13**	4.7
	Apr-16	**36**	**180-D**	0.54J	1.5	**9.6**	5.3
	Jun-16	**0.68J**	**230D**	0.51J	1.3	**11**	7.2
	Sep-16	ND	**110-D**	ND	ND	**12-D**	4.6-L
	Dec-16	ND	**140-D**	ND	0.63J	**22**	5-L
	Mar-17	ND	**120**	0.41J	0.54J	**12**	ND
	Jun-17	**14**	49	ND	ND	**14**	4.7
	Sep-17	ND	**93**	ND	ND	**14**	4.0

Notes:
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MCL Exceedances in bold
J - Estimated Concentration

Attachment D
Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	**MCL - 70µg/L**	**MCL - 100µg/L**	**MCL - 7µg/L**	**MCL - 2µg/L**	**MCL - NA**
Biowall Wells							
BW7	Nov-13	ND	31	0.37	ND	0.36	ND
	Mar-14	ND	8.2	ND	ND	1.2	ND
	Jun-14	ND	16	ND	ND	**2.2**	ND
	Sep-14	0.79	21	ND	ND	**10**	1.0
	Dec-14	ND	5.3	ND	ND	**9.0**	1.2
	Mar-15	1.1	4.7	ND	ND	**8.7**	2.0
	Jun-15	ND	ND	ND	ND	1.4	2.0
	Sep-15	ND	ND	ND	ND	0.47J	ND
	Jan-16	ND	ND	ND	ND	0.33J	1.0
	Apr-16	0.47J	7.1	0.33J	ND	1.3	ND
	Jun-16	ND	0.68J	ND	ND	0.33J	0.3
	Sep-16	0.32J	ND	ND	ND	ND	ND
	Dec-16	ND	0.36J	ND	ND	ND	ND
	Mar-17	ND	0.89J	ND	ND	0.53J	ND
	Jun-17	ND	0.36J	ND	ND	ND	ND
	Sep-17	ND	ND	ND	ND	ND	ND
BW8	Nov-13	ND	31	0.32	ND	0.34	ND
	Mar-14	ND	50	0.55	ND	**7.3**	1.3
	Jun-14	ND	16	0.36	ND	**11**	1.8
	Sep-14	ND	0.44	ND	ND	**2.3**	1.7
	Dec-14	**34**	28	ND	3.6	**10**	1.4
	Mar-15	**7.3**	12	0.41	0.84	**4.2**	3.7
	Jun-15	2.1	24	ND	0.69J	**8.3**	1.9
	Sep-15	ND	ND	ND	ND	ND	ND
	Jan-16	**41**	65-D	0.55J	1.3	**16**	4.4
	Apr-16	**23**	54	0.45J	0.44J	**13**	4.6
	Jun-16	ND	42	ND	ND	**10**	7.2
	Sep-16	0.4J	0.32J	ND	ND	ND	ND
	Dec-16	0.33J	ND	ND	ND	ND	ND
	Mar-17	**72**	70	0.44J	0.57J	**13**	ND
	Jun-17	**26**	**78-D**	ND	ND	**26**	9.2
	Sep-17	ND	**22**	ND	ND	**9.2**	1.7J
BW9	Nov-13	ND	3.0	ND	ND	ND	ND
	Mar-14	1.1	ND	ND	ND	ND	ND
	Jun-14	1.0	0.89	ND	ND	ND	ND
	Sep-14	0.47	3.4	ND	ND	ND	ND
	Dec-14	ND	0.56	ND	ND	ND	ND
	Mar-15	1.0	0.32	ND	ND	ND	ND
	Jun-15	0.4J	1.0	ND	ND	ND	ND
	Sep-15	ND	6.2	ND	ND	ND	ND
	Jan-16	2.7	0.93J	ND	ND	ND	ND
	Apr-16	2.2	0.85J	ND	ND	ND	ND
	Jun-16	0.72J	1.7	ND	ND	ND	ND
	Sep-16	0.61J	4.4	ND	ND	ND	ND
	Dec-16	0.8J	2	ND	ND	ND	ND
	Mar-17	1.4	0.73J	ND	ND	ND	ND
	Jun-17	ND	1.3	ND	ND	ND	ND
	Sep-17	ND	1.5	ND	ND	ND	ND

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Attachment D
Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
Biowall Wells							
BW10	Nov-13	ND	ND	ND	ND	ND	ND
	Mar-14	ND	ND	ND	ND	ND	ND
	Jun-14	ND	ND	ND	ND	ND	ND
	Sep-14	ND	ND	ND	ND	ND	ND
	Dec-14	ND	ND	ND	ND	ND	ND
	Mar-15	ND	ND	ND	ND	ND	ND
	Jun-15	ND	ND	ND	ND	ND	ND
	Sep-15	ND	ND	ND	ND	ND	ND
	Jan-16	ND	ND	ND	ND	ND	ND
	Apr-16	ND	ND	ND	ND	ND	ND
	Jun-16	ND	ND	ND	ND	ND	ND
MW6	Jun-17	**350**	11	ND	0.81J	ND	ND
	Sep-17	**290**	4.6	ND	0.52J	ND	ND
Transect Wells							
TW6	Nov-13	**470**	10	ND	ND	ND	na
	Mar-14	**660**	4.0	ND	0.99	ND	na
	Jun-14	**590**	8.0	ND	0.93	ND	na
	Sep-14	**500**	9.0	ND	0.75	ND	na
	Dec-14	**530**	10	ND	0.83	ND	ND
	Mar-15	**1,100**	7.6	ND	1.1	ND	ND
	Jun-15	**390**	11	ND	0.96J	ND	ND
	Sep-15	**420**	35	0.39J	1.0	ND	ND
	Jan-16	**580-D**	7.2	ND	ND	ND	ND
	Apr-16	**550-D**	9.5	ND	1.0	ND	ND
	Jun-16	**600**	9.7	ND	1.1	ND	ND
	Sep-16	**580-D**	8.8J-RD	ND	ND	ND	ND
	Dec-16	**650-D**	12	0.44J	1.1	ND	ND
	Mar-17	**480**	9.2	0.32J	1.1	ND	ND
	Jun-17	**550-D**	9.6	ND	1.2	ND	9.6
	Sep-17	**460**	9.2	ND	1.1	ND	ND
TW5	Nov-13	**450**	9.9	ND	ND	ND	na
	Mar-14	**660**	8.5	0.33	0.97	ND	na
	Jun-14	**540**	11	ND	0.98	ND	na
	Sep-14	**470**	32	0.32	0.84	**2.4**	na
	Dec-14	**510**	20	ND	0.81	0.97	ND
	Mar-15	**1,100**	26	ND	1.1	ND	ND
	Jun-15	**410**	16	ND	1.2	ND	ND
	Sep-15	**400**	29	ND	1.2	**2.0**	1.5
	Jan-16	**590-D**	7.5	ND	1.1	ND	ND
	Apr-16	**530-D**	19	0.35J	1.1	ND	ND
	Jun-16	**610**	26 D,J	0.43J	1.1	ND	ND
	Sep-16	**540-D**	25	ND	ND	ND	ND
	Dec-16	**620-D**	33	0.66J	1.1	1.8	1.4-L
	Mar-17	**450**	27	0.65J	1.1	0.45J	ND
	Jun-17	**430-D**	35	0.78J	1.2	0.74J	35
	Sep-17	**400**	31	0.52J	1.1	0.61J	1-J

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Attachment D
Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
Transect Wells							
TW4	Nov-13	**44**	**92**	ND	ND	0.69	na
	Mar-14	**240**	**120**	0.76	0.58	**9.9**	na
	Jun-14	**380**	**110**	0.51	0.96	**25**	na
	Sep-14	**200**	**130**	0.38	0.52	**38**	na
	Dec-14	**160**	64	ND	0.41	**24**	3.5
	Mar-15	**340**	**92**	0.34	0.96	**16**	4.1
	Jun-15	**280**	**98**	0.42J	0.99J	**16**	3.6
	Sep-15	**71**	**140**	0.35J	0.42J	**15**	4.9
	Jan-16	**300-D**	**120**	0.39J	0.82J	**9.1**	4.3
	Apr-16	**340-D**	**120-D**	0.40J	0.93J	**6.8**	4.1
	Jun-16	**260**	**150**	0.43J	0.7J	**9**	7.5
	Sep-16	**220-D**	**150-D**	ND	ND	**9.4**	5.8-L
	Dec-16	**110-D**	**160-D**	0.41J	0.44J	**8.1**	3.5-L
	Mar-17	**290**	**110**	0.47J	0.83J	**8.4**	3.9J
	Jun-17	**230-D**	**150-D**	0.63J	0.95J	**13**	150-D
	Sep-17	**190**	**140**	0.39J	0.9J	**8.5**	4.5-J
TW3	Nov-13	0.82	**88**	ND	ND	0.34	na
	Mar-14	ND	62	0.58	ND	**7.5**	na
	Jun-14	ND	54	0.39	ND	**31**	na
	Sep-14	0.39	39	ND	ND	**40**	na
	Dec-14	1.6	12	ND	ND	**36**	4.2
	Mar-15	2.3	31	ND	0.33	**9.8**	5.6
	Jun-15	ND	36	ND	ND	**9.8**	5.3
	Sep-15	ND	1.6	ND	ND	1.5	2.6
	Jan-16	3.5	33	ND	0.82J	**6.7**	4.4
	Apr-16	3.3	35	ND	ND	**5.8**	4.6
	Jun-16	**13**	40	ND	ND	**8.3**	7.4
	Sep-16	3.6	31	ND	ND	**5.9**	3.6-L
	Dec-16	0.56J	6.6	ND	ND	1.4	ND
	Mar-17	**25**	59	ND	ND	**15**	5.7J
	Jun-17	**4.2**	57	ND	ND	**26**	57
	Sep-17	**2.7**	33	ND	ND	**18**	4.3-J
BW6*	Nov-13	**9.1**	**250**	1.3	ND	0.96	ND
	Mar-14	1.6	**140**	1.2	ND	**14**	ND
	Jun-14	0.7	**100**	0.66	ND	**34**	1.2
	Sep-14	ND	**75**	0.31	ND	**44**	4.2
	Dec-14	0.33	**78**	0.33	ND	**21**	1.9
	Mar-15	**25**	**150**	1.0	4.7	**25**	4.4
	Jun-15	1.4	**160**	0.71J	3.3	**20**	6.9
	Sep-15	ND	66	ND	0.73J	**25**	4.0
	Jan-16	**11J**	**230-D**	0.65J	2	**13**	4.7
	Apr-16	**36**	**180-D**	0.54J	1.5	**9.6**	5.3
	Jun-16	**0.68J**	**230-D**	0.51J	1.3	**11**	7.2
	Sep-16	ND	**110-D**	ND	ND	**12-D**	4.6-L
	Dec-16	ND	**140-D**	ND	0.63J	**22**	5-L
	Mar-17	ND	**120**	0.41J	0.54J	**12**	ND
	Jun-17	**14**	49	ND	ND	**14**	4.7
	Sep-17	ND	**93**	ND	ND	**14**	4.0

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Attachment D
Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
Transect Wells							
TW2	Nov-13	**64**	**240**	ND	ND	ND	na
	Mar-14	4.2	**200**	1.2	0.37	**13**	na
	Jun-14	2.2	**200**	1.1	2.4	**46**	na
	Sep-14	ND	**150**	ND	0.74	**56**	na
	Dec-14	0.71	**170**	0.39	0.67	**46**	3.9
	Mar-15	**9.5**	**210**	0.96	4.3	**26**	4.5
	Jun-15	ND	**220**	0.85J	4.1	**26**	3.6
	Sep-15	ND	**160**	0.38J	2.4	**32**	7.2
	Jan-16	**5.1**	**280-D**	0.80J	3.1	**20**	4.4
	Apr-16	**29**	**260-D**	0.73J	2.6	**15**	5.0
	Jun-16	ND	**250D**	0.47J	2	**19**	5.7
	Sep-16	ND	**190-D**	ND	ND	**26**	6-L
	Dec-16	0.39J	**240-D**	0.32J	1.7	**35**	5.1-L
	Mar-17	**13**	**230**	0.83J	3.2	**16**	3.7J
	Jun-17	**3.7**	**170-D**	0.44J	1.3	**20**	6.3
	Sep-17	**0.47J**	**180**	ND	0.74J	**24**	5.8-J
TW1	Nov-13	**71**	**260**	ND	ND	ND	na
	Mar-14	**7.5**	**180**	1.3	0.31	**13**	na
	Jun-14	2.2	**200**	1.0	2.2	**45**	na
	Sep-14	0.34	**160**	ND	0.70	**56**	na
	Dec-14	ND	**160**	0.34	0.54	**46**	4.0
	Mar-15	**8.6**	**210**	1.0	4.3	**27**	4.7
	Jun-15	0.48	**240**	1.0	4.7	**27**	2.6
	Sep-15	ND	**240**	ND	2.7	**33**	6.7
	Jan-16	**5.4**	**130-D**	0.71J	2.9	**18**	4.3
	Apr-16	**21-L**	**250-D**	0.71J	2.5	**15-L**	4.6-L
	Jun-16	ND	**230-D**	0.52J	2.1	**19**	5
	Sep-16	ND	**200-D**	ND	ND	**26**	4.8-L
	Dec-16	ND	**260-D**	0.36J	1.7	**33**	5.4-L
	Mar-17	**14**	**230**	0.98J	3.4	**15**	3.6
	Jun-17	**1.4**	**200-D**	0.4J	1.9	**22**	6
	Sep-17	**ND**	**160**	ND	0.89J	**22**	5.7-J
TW0	Jun-16	**4.3**	**270**	0.55J	2.3	**19**	5.5
	Sep-16	ND	**270-D**	ND	ND	**25**	4.8-L
	Dec-16	ND	**270-D**	0.52J	1.9	**24**	5.9-L
	Mar-17	**2**	**180**	0.71J	2.2	**16**	3.1J
	Jun-17	1.4	**210-D**	0.46J	2	**21**	5
	Sep-17	0.84J	**180**	ND	1.1	**26**	6.2-J

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Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
RI Wells							
MW1	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	0.85J	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
MW2	Mar-14	**41**	4.6	ND	ND	ND	na
	Sep-14	**46**	13	ND	ND	0.60	na
	Mar-15	**42**	3.7	ND	ND	ND	na
	Sep-15	**41**	15	ND	ND	0.79	na
	Apr-16	**47**	4.3	ND	ND	ND	na
	Sep-16	**19**	22	ND	ND	1.1	na
	Mar-17	**32**	5	ND	ND	ND	na
	Sep-17	**29**	10	ND	ND	1.3	na
MW3	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
MW4	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
MW5	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
MW6	Mar-14	**430**	2.8	ND	0.79	ND	na
	Sep-14	**510**	5.5	ND	0.81	ND	na
	Mar-15	**410**	2.5	ND	0.61	ND	na
	Sep-15	**420**	12	ND	0.84J	ND	na
	Apr-16	**410-D**	8.7	ND	0.64J	ND	na
	Sep-16	**580-D**	ND	ND	ND	ND	na
	Mar-17	**460**	2	ND	0.72J	ND	na
	Sep-17	**290**	4.6	ND	0.52J	ND	na

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		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
RI Wells							
MW7	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	0.36J	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
MW8	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	0.33J	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	0.35J	ND	ND	ND	na
MW9	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
MW10	Sep-16	ND	14	ND	ND	1.7	na
	Mar-17	4.7	**73**	0.52J	0.39J	**4.8**	na
	Sep-17	ND	25	ND	ND	**7.1**	na

Notes:
µg/L - micrograms per liter
ND - non detect
na - Not Analyzed
NA - Not Applicable
MCL Exceedances in bold
J - Estimated Concentration

Attachment D
Summary of VOCs in Groundwater and Surface Water at BARC 27

Well	Sample Date	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)	1,1-DCE (µg/L)	Vinyl Chloride (µg/L)	Ethene (µg/L)
		MCL - 5µg/L	MCL - 70µg/L	MCL - 100µg/L	MCL - 7µg/L	MCL - 2µg/L	MCL - NA
Surface Water							
SW1	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
SW2	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
SW3	Mar-14	1.1	1.3	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na
SW4	Mar-14	ND	ND	ND	ND	ND	na
	Sep-14	ND	ND	ND	ND	ND	na
	Mar-15	ND	ND	ND	ND	ND	na
	Sep-15	ND	ND	ND	ND	ND	na
	Apr-16	ND	ND	ND	ND	ND	na
	Sep-16	ND	ND	ND	ND	ND	na
	Mar-17	ND	ND	ND	ND	ND	na
	Sep-17	ND	ND	ND	ND	ND	na

Notes:
µg/L - micrograms per liter
ND - non detect
na - Not Analyzed
NA - Not Applicable
MCL Exceedances in bold
J - Estimated Concentration

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Appendix B

Aquifer Testing Report

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BMT Designers & Planners

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7003-16-005

July 18,2017

Mr. Dana Jackson, PG
Beltsville Agricultural Research Center
Safety, Occupational Health and Environmental Staff
10300 Baltimore Ave, Bldg. 003, Rm 117
Beltsville, Maryland 20705

SUBJECT: FinalAquifer Testing Findings Report

Dear Mr. Jackson:

BMT Designers & Planners, Inc. (BMT) is pleased to submit this letter report detailing the aquifer testing program conducted in June 2016. This report incorporates comments received from EPA Region III on June 26, 2017 and is now considered to be a final document.

SITE DESCRIPTION AND BACKGROUND

The BDRLF site is located within BARCs Central Farm on Beaverdam Road, approximately 1,700 feet east of the intersection of Beaverdam Road and Research Road (Figure 1). The site is a 2-acre dome shaped landfill with steeply sloped sides and is surrounded by woods to the east and south and a cultivated field to the west. The site borders Beaverdam Road to the north, and hydraulically downgradient unnamed tributary to Beaverdam Creek to the south.

Several environmental investigations were conducted at the BDRLF as part of the Remedial Investigation and Feasibility Study (RI/FS). The RI/FS identified a plume of groundwater contaminated with trichloroethylene (TCE) southeast (downgradient) of the landfill's toe (BMT, 2008). The maximum observed concentration of TCE in the groundwater plume was greater than 600 parts per billion (ppb); however, concentrations fluctuate over time based on several factors including seasonal rainfall.

A permeable reactive barrier (PRB) was selected as the preferred method to address groundwater contamination at the BDRLF (Figure 2). The PRB used compost as the bioreactive component of the biowall, and also included sand, and woodchips. In July of 2013, a 1,000 foot long by 18 to 23 foot deep biowall, was installed to capture and treat the TCE plume at the BDRLF site (USDA, 2011). Biowall performance monitoring was initiated in October of 2013 in accordance with an approved Performance Monitoring Plan (PMP) (BMT, 2014). Ten (10) 2-inch diameter groundwater monitoring wells were installed within the biowall (biowall wells) and six (6) additional 3/4-inch diameter groundwater wells were installed perpendicular to the biowall (i.e., transect wells) and are included in the ongoing PMP. Existing monitoring and transect well locations are depicted in Figure 3.

Groundwater at the BDRLF flows from the landfill to the southeast toward an unnamed tributary to Beaverdam Creek and an associated wetland area. The need to gain a better understanding of groundwater movement throughout the area has been a topic of discussion since the installation of the PRB because the PRB design assumed that groundwater velocity was on the order of 2.4 feet per year based on studies completed as part of the RI. These studies were, however, limited and had exhibited a good deal of variability. It was decided that additional aquifer testing would be completed to supplement our knowledge of the site and our ability to further evaluate effects of groundwater movement on biowall performance. This may allow us to make needed adjustments to improve future performance.

AQUIFER TESTING PROGRAM

A series of aquifer tests were performed at the BDRLF site in 2016 consisting of:

- Slug Testing
- Limited Pump Testing
- Groundwater sampling comparisons, and
- Tracer Dye Testing

These tests were completed to provide better groundwater movement data in the vicinity of the biowall. The different methods provide more comprehensive and reinforcing knowledge of the subsurface. These activities are summarized in the following sections.

1. Slug Testing

On June 27, 2016, BMT conducted slug testing on biowall wells BW3, BW4, BW5, BW6, BW7, and BW8 in accordance with the Work Plan. Slug tests (rising head and falling head) were performed on biowall wells BW3, BW4, BW5, BW6, BW7, and BW8 to determine hydraulic conductivity, which is used to estimate groundwater velocity across the biowall.

Slug tests were conducted using a pressure transducer and a 5.25-foot by 1.25 inch PVC slug. The transducer is a combined data logger and pressure transducer that records water levels at half-second intervals based upon pressure changes. At each well, the initial depth to water was measured using a water level indicator. The transducer, attached to a 1/8-inch steel cable, was placed one foot from the bottom of the well, and was left in the well for the duration of slug testing activities.

Both rising and falling head slug tests were performed on each well. After the transducer was placed in the well and the original water level was restored, slug testing began. The slug was lowered into the well until the top of the slug was below the static water level depth. Water levels were manually monitored to determine when the static water level was regained, or until it became apparent that static level would not be regained due to the low conductivity of subsurface materials. Once static water levels or near static water levels were regained, the slug was removed from the well. After approximately one minute, the depth to water was manually measured every minute until the static water level was restored. After static water level was restored, the transducer was removed from the well and data was downloaded and verified in the field.

Slug test data from each transducer was uploaded using AQUIFERTEST software and plotted as a logarithmic curve to identify the beginning and end of each test (rising and falling). Each test was then isolated and entered analyzed with the Bouwer-Rice and Hvorslev methods. Slug test analyses are included as Attachment A. A summary of hydraulic conductivity derived K-values are included in Table 1.

The highest hydraulic conductivities were measured within BW6, located within the center of the TCE plume that biowall was installed to remedy. BW8 also exhibited high hydraulic conductivity as compared to other biowall wells. BW6 and BW8 have historically been wells that produced detections for VOCs such as (cis-1,2-DCE and vinyl chloride). BW6 and BW8 are presumably located within surrounding geologic formations with higher transmissivity rates than that surrounding other biowall wells.

Table 1. Hydraulic Conductivity Values Derived from Slug Testing

Biowall Well	Units	Slug Test - Bouwer-Rice			Slug Test - Hvorslev			Avg (All)
		Rising	Falling	Average	Rising	Falling	Average	
BW3	ft/sec	4.38E-07	3.33E-07	3.85E-07	6.31E-07	4.44E-07	5.38E-07	5.84E-07
	ft/yr	13.81	10.52	12.16	19.91	14.03	16.97	18.44
BW4	ft/sec	5.07E-07	5.12E-07	5.09E-07	3.63E-07	5.35E-07	4.49E-07	4.06E-07
	ft/yr	16.00	16.14	16.07	11.47	16.87	14.17	12.82
BW5	ft/sec	9.83E-07	5.43E-07	7.63E-07	1.20E-06	6.72E-07	9.38E-07	1.07E-06
	ft/yr	1.66	2.42	2.04	2.16	3.25	2.71	2.43
BW6	ft/sec	6.79E-06	5.19E-06	5.99E-06	3.50E-06	2.58E-06	3.04E-06	3.27E-06
	ft/yr	214.40	163.63	189.02	110.31	81.45	95.88	103.09
BW7	ft/sec	6.63E-07	3.39E-07	5.01E-07	7.45E-07	4.34E-07	5.90E-07	6.68E-07
	ft/yr	20.93	10.70	15.82	23.52	13.70	18.61	21.07
BW8	ft/sec	2.31E-06	2.62E-06	2.47E-06	2.49E-06	2.29E-06	2.39E-06	2.44E-06
	ft/yr	73.05	82.55	77.80	78.53	72.32	75.42	76.98

Velocity estimates were calculated by using the equation v = k(i/n) where:

v = is groundwater velocity
i = is the groundwater gradient in the direction of groundwater flow (ft/ft)
n = porosity (unitless)

For the gradient variable, a value of 0.084308 was measured between TW2 and TW3 prior to the event, and assumed to be roughly representative of the gradient across the biowall. A porosity of 0.30 was used for n based on the measured porosity within established permeable reactive barriers (PRBs) (Lin et. al 2005).

Estimated velocities ranged from 2.04 to 53.12 feet per year. The highest estimated groundwater velocities were measured within BW6. Slug tests within BW6 also created the greatest variation on estimated groundwater velocities, producing a range of 26.94 to 53.12 feet per year.

A summary of slug testing groundwater velocity calculations is presented in Table 2.

Table 2. Slug Testing Groundwater Velocity Data Summary

Biowall Well	Units	Bouwer-Rice Avg. (Rising/Falling)	Hvorslev Avg. (Rising/Falling)	Avg (All)
BW3	ft/yr	3.42	4.77	4.09
BW4	ft/yr	4.52	3.98	4.25
BW5	ft/yr	2.04	2.71	2.37
BW6	ft/yr	53.12	26.94	40.03
BW7	ft/yr	4.44	5.23	4.84
BW8	ft/yr	21.86	21.20	21.53

All biowall wells were advanced into the underlying Arundel clay layer, and are considered to be fully penetrating wells within an unconfined aquifer. The aquifer in the immediate vicinity of the biowall wells is presumed to be homogenous and isotropic based on the construction of the biowall consisting of a uniform mixture of sand, mulch and compost. The Bouwer-Rice method is considered more accurate for slug tests performed in this kind of aquifer (Todd & Mays, 2005).

2. Limited Pumping Test

A limited pumping test was conducted at biowall well BW6 on June 28, 2016 in association with transect wells TW2 and TW3 as observation wells to determine transmissivity, which is used to estimate hydraulic conductivity and velocity across the biowall.

The limited pumping test was conducted using pressure transducers and a manually controlled submersible pump. The transducers were placed at the bottom of transect wells TW2 and TW3 and the pump was placed five feet from the bottom of biowall well BW6. At each observation well and at the pumping well, initial depths to water was recorded using a water level indicator.

The pumping test was initiated after the transducers and the pump were set in their respective wells, and the original water levels were restored. The pumping rate was checked every five minutes for the duration of the test and adjustments were made accordingly in order to maintain a semi-constant rate. Water levels were manually measured and recorded in BW6. After one hour of semi-constant pumping, the pump was turned off and the water level in BW6 was allowed to recharge. After the static water level was nearly regained in BW6, the pump was removed from BW6. At this time the transducers were removed from the observation wells TW2 and TW3 and the data was downloaded.

The data received from the transducers in the observation wells was analyzed using the Neuman and Theis methods for pumping tests. Using the AQTESOLV® program, transmissivities were calculated, which allowed for the calculation of hydraulic conductivity and velocity estimations. Hydraulic conductivity values of 4.8×10^{-6} ft/sec and 5.2×10^{-6} ft/sec were calculated using the Neuman and Theis methods, respectively. Porosity was estimated to be 0.3. A hydraulic gradient of 0.084 was calculated by measuring gradient from TW2 to TW3. Estimated velocities across the biowall using these values are 42.8 ft/yr and 46.8 ft/yr using the hydraulic conductivities calculated using the Neuman and Theis methods, respectively. These derived groundwater velocities are similar to values derived from slug tests using the Bouwer Rice method.

Data from the transducers were plotted on logarithmic axes in order to analyze the data. Pumping test analyses are included as Attachment B, and summarized in Table 3. Groundwater velocities estimated from the limited pumping test were lower than groundwater velocities estimated from slug tests.

Table 3. Limited Pumping Test Summary of Results

Biowall Well	BW6	
Test Method	**Neuman**	**Theis**
Transmissivity (ft^2/sec)	7.7E-05	8.4E-05
Hydraulic Conductivity (ft/sec)	4.8E-06	5.3E-06
Linear Velocity (ft/yr)	42.8	46.8

3. Downgradient Groundwater Sampling

A series of ten (10) groundwater samples were collected in a transect extending downgradient from transect well TW1 on June 27, 2016 in accordance with the Work Plan. Groundwater samples were collected at each sampling location using an SP22 Geoprobe® temporary well screen. Sample depths were between 8 and 10 feet below ground surface (bgs). The first sample location was seven (7) feet downgradient from BW6, and approximately 5.5 feet from the downgradient edge of the biowall. Subsequent sampling points were located on three (3), five (5), eight (8) and ten (10) foot intervals downgradient from the first point. Groundwater data from the soil borings is included in Table 4. Soil boring locations are depicted in Figure 4.

Groundwater samples consisting primarily of TCE with relative low concentrations of biodegradation products (cis-1,2-DCE and vinyl chloride) were considered part of the contaminant plume that predates the installation of the biowall. Those samples, which contain high concentrations of the degradation products in comparison to concentrations of TCE, were considered part of the contaminant plume that was produced after the installation of the biowall.

Due to the "halo" effect of the zone conducive to reductive dechlorination, approximately 2-3 feet upgradient and downgradient of the biowall, velocity estimates were not precise, and are compared against data collected during the concurrent bromide tracer and aquifer testing conducted. Data for identified COCs from the investigations are summarized and compared to their respective maximum contaminant level (MCL) in Table 4. Complete analytical data from the June 2016 soil boring groundwater sampling event is included as Attachment C.

With the exception of SB09, all groundwater samples collected for the downgradient biowall groundwater sampling contain high relative concentrations of TCE breakdown products cis-1,2-DCE and vinyl chloride which is consistent with VOC concentrations detected in downgradient transect wells during BDRLF quarterly monitoring events.

Table 4. BDRLF COC Detections, June 2016

Parameter	**TCE** (µg/L)	**Cis-1,2-DCE** (µg/L)	**Trans-1,2-DCE** (µg/L)	**1,1-DCE** (µg/L)	**Vinyl Chloride** (µg/L)
MCL (µg/L)	**5**	**70**	**100**	**7**	**2**
SB01	**5.5**	**220-D**	**0.65J**	**1.9**	**18**
SB02	**4.1**	**220-D**	**0.67J**	**2.0**	**20**
SB03	**11**	**160-D**	**0.43J**	**1.5**	**16**
SB04	**0.67J**	**140-D**	**0.42J**	**1.7**	**18**
SB05	**13**	**140-D**	**0.33J**	**1.1**	**13**
SB06	**8.5**	**98-D**	ND	**0.6J**	**8.9**
SB07	**3.7**	**130-D**	ND	**0.78J**	**11**
SB08	**0.91J**	**190-D**	**0.43J**	**1.3**	**17**
SB09	**160D**	**34-D**	**0.49J**	**0.33J**	**1.3**
SB10	**2.2**	**180-D**	**0.4J**	**0.87J**	**9.2**

Notes:
Analyte detections are bolded
MCL exceedances are shaded
J – estimated value
D – Result detected in sample with laboratory dilution
L – Reported value may be biased low
ND – analyte not detected above method detection limit
A duplicate sample was collected from SB02

The BDRLF biowall was installed on July 20, 2013 in a single day. SB10 was collected on June 28, 2016, or 709 days after the installation of the biowall. A TCE transit velocity of at least 29 feet per year (ft/yr) is calculated. There is no upper bound on the estimated TCE transit velocity downgradient of the biowall that can be derived from the downgradient groundwater sampling due to the lack of downgradient delineation.

4. Tracer Dye Testing

Groundwater samples were also collected from ten (10) temporary boring locations downgradient of the biowall and a pilot study was conducted using a bromide ion dye sensor in BW6 in addition to the aquifer testing activities. Tracer dye tests are typically conducted over much larger distances to identify preferential groundwater pathways and entry points into surface water systems (Aley, 2002). There are few instances of tracer dye testing over short distances and within low permeability formations. For this tracer dye test, the goal was to evaluate whether the tracer dye can be utilized to provide an additional line of evidence to determine groundwater velocity as groundwater moves from the upgradient side of the biowall, through the biowall, and further downgradient where the natural groundwater pathways have been disrupted by the installation of the biowall.

In accordance with the Work Plan, the tracer dye test was conducted using a bromide tracer dye solution and an AquiStar® TempHion™ Submersible Smart ISE Bromide Sensor. Three (3) liters of 0.1 mol per liter (0.01M) bromide dye solution was disbursed into transect well TW3 (Figure 3), located immediately upgradient of biowall well BW6, on July 12, 2016. The bromide dye was injected into TW3 using a narrow gauge polyethylene tubing to evenly distribute the dye throughout the water column. The bromide sensor was deployed in BW6 at a depth of 12 feet bgs and set to record bromide concentrations every 3 hours.

Prior to injection into TW3, the bromide sensor was immersed into the bromide ion dye solution and read 352 parts per million (ppm) bromide solution. There is no data from July 12 to July 27, 2016, due to an error experienced with the sensor software. The sensor was successfully programmed to record bromide concentrations in groundwater and re-installed in BW6.

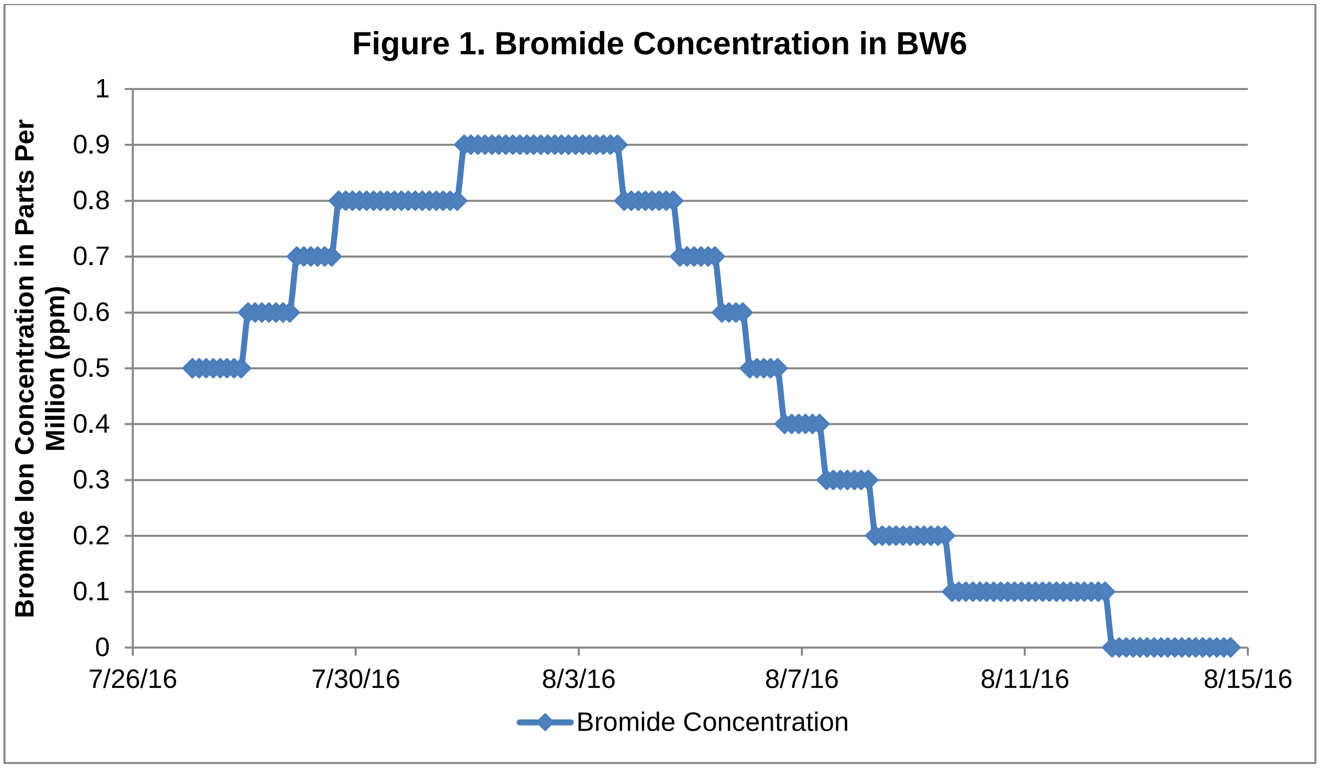
Data was subsequently downloaded on August 18, 2016. Bromide ion concentrations within BW6 reached a peak concentration of 0.9 ppm between 08/01/2016 and 08/04/2016. The AquiStar® TempHion™ Submersible Smart ISE Bromide Sensor has a maximum resolution of 0.1 ppm and bromide ion concentrations are likely to have peaked on 08/02/2016, twenty-two (22) days after dye was injected into TW3, with a concentration between 0.9 and 0.95 ppm. The center of the bromide ion plume may been slightly side gradient to BW6 due to the fact that the transect wells may not have been lined up exactly parallel with the direction of groundwater flow.

BW6 is located at the center of the biowall, equidistant between TW2 and TW3. TW2 is located 2.5 feet upgradient of BW6. This translates into an approximate groundwater velocity of approximately 41 feet per year. A graph showing bromide ion concentrations over time within BW6 is provided as Figure 1.

SUMMARY AND CONCLUSIONS

The slug test results summarized in Appendix B indicate that the hydraulic conductivity values for the BDRLF have a wide range, indicating that there is some variability in hydraulic conductivity across the site. Results from the slug tests and the limited pumping tests that were performed at BW6 both produced estimated groundwater velocities of approximately 40-50 feet per year. BW6 produced the highest estimated groundwater velocity, based on slug tests performed on biowall wells BW3-BW8. BW-6 and BW-8 contained TCE above MCLs, as well as the highest concentrations of daughter products. It should also be noted that these two wells showed higher hydraulic conductivity than other areas. The highest concentrations of cis-1,2-DCE and vinyl chloride were also detected in these wells during the performance monitoring period.

These results suggest that there may be preferential pathways and varying hydraulic conductivities upgradient of the biowall. Biowall wells BW6 and BW8 show areas of higher hydraulic conductivity.



The downgradient groundwater sampling reveals a groundwater velocity of at least 29 feet per year. Groundwater samples collected from nine (9) out of ten (10) downgradient temporary well points contained high concentrations of cis-1,2-DCE and vinyl chloride and low concentrations of TCE. The biowall has a thickness of 2.25 feet, but in the vicinity of BW6, the biowall is not oriented orthogonal to the primary direction of groundwater flow, but at an angle of roughly 40 degrees from perpendicular. This gives the biowall an effectiveness thickness of approximately three (3) feet in the vicinity of BW6. A groundwater flow rate of 30-50 feet per year corresponds to a residence time of 22-36 days for groundwater entering the biowall in the vicinity of BW6.

The pilot test that was conducted using bromide solution and a bromide ion sensor to assess the efficacy of using tracer dyes to measure actual groundwater velocities over short distances. The estimated groundwater velocity of 41 feet per year that was derived from measuring the transit time of bromide ions from TW3 is comparable to groundwater velocities estimates derived from other methods described in this report. As stated previously in this report, TW3 and BW6 are 2.5 feet apart, a distance short enough that there the actual well screen packs and the localized disturbance to the surrounding formation from the original installation of these wells could have introduced potential inaccuracies. A future test can be conducted by injecting a bromide ion solution with a greater bromide concentration into a transect well located further upgradient, such as TW5 or TW6, and placing the bromide ion sensor in BW6.

Taken together, these four lines of evidence suggest that actual groundwater velocity in the vicinity of BW6 is far greater than the original estimate of 2.4 feet per year that was used in developing the performance monitoring plan and in the original bench scale studies developed for the biowall. Based on slug tests, limited pumping tests downgradient groundwater samples, and tracer dye testing, actual groundwater velocities in the vicinity of BW6 are likely on the order of 30-50 feet per year (Table 5).

Table 5 – Aquifer Test Summary

Method	Calculated K value	Calculated velocity	Estimated Biowall Residence Time (days)
1 Slug Testing	96 to 189 ft/yr	27 to 53 ft/yr	21 to 41 days
2 Pumping Test	152 to 167 ft/yr	43 to 47 ft/yr	23 to 25 days
3 Downgradient GW Sampling	Not Applicable	29 ft/yr or greater	38 days or less
4 Tracer Dye Test	Not Applicable	33 ft/yr	33 days

The actual velocity of the TCE plume may be considerably slower than the values calculated from slug test and pumping test data due to retardation of TCE in the organic substrate of the biowall. Retardation factors of 1.1 to 2 were estimated based on the organic carbon fraction in the biowall, with values of 1.2-1.5 being considered the most reasonable (BMT, 2013)

A retardation factor of 1.5 would reduce the range of groundwater velocities calculated from slug testing data from 27 to 53 ft/year to 18 to 35 ft/year. The range of residence times for TCE would increase to 31 to 60 days in this scenario. Nevertheless, estimated TCE velocities derived from these four (4) lines of evidence are an order of magnitude greater than the original estimate of 2.4 ft/year.

The implications of these groundwater velocity estimates will be discussed as part of the BDRLF Three-year performance review.

If you have further questions, please do not hesitate to contact me at (703) 920-7070 (x204).

Sincerely,

BMT Designers & Planners

David R. Kindig, P.E.
Program Manager

David Schanzle
Project Manager

cc: File

Enclosures: Figure 1. BDRLF Location Map
Figure 2. BDRLF Site Map
Figure 3. BDRLF Soil Boring Well Location Map

Attachment A - Slug Test Analyses
Attachment B – Pumping Test Analyses
Attachment C – COC Data

References:
Aley, 2002. *A handbook prepared for the use of clients and colleagues of the Ozark Underground Laboratory.* 2002

BMT, 2013. *Internal Memorandum: Beaverdam Road Landfill – BDRLF Updated TCE Velocity Estimates.* November 26.

Bear, 1979. *Dynamics of Fluids in Porous Media.* Jacob Bear. 1972

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Todd and Mays, 2005. *Groundwater Hydrology, Third Edition, David K. Todd and Larry W. Mays,* 2005.

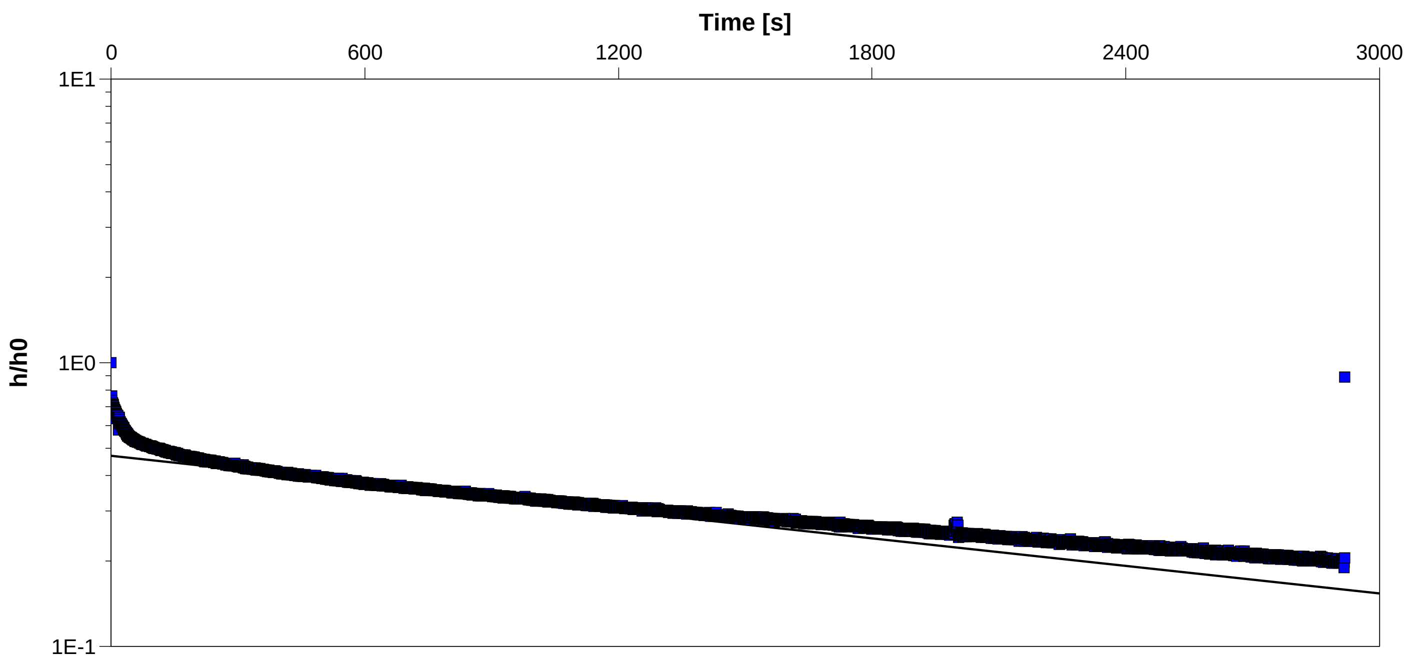
USDA, 2011. USDA, 2011. *EPA Superfund Record of Decision: U.S. Department Of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center, Maryland, EPA ID: MD0120508940, Beaverdam Road Landfill.* September.

Attachment A

Slug Test Data

Waterloo HYDROGEOLOGIC	**Contact Info** **Address** **Company Name** **City, State/Province**	**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW3_Falling Head	Test Well: BW3
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

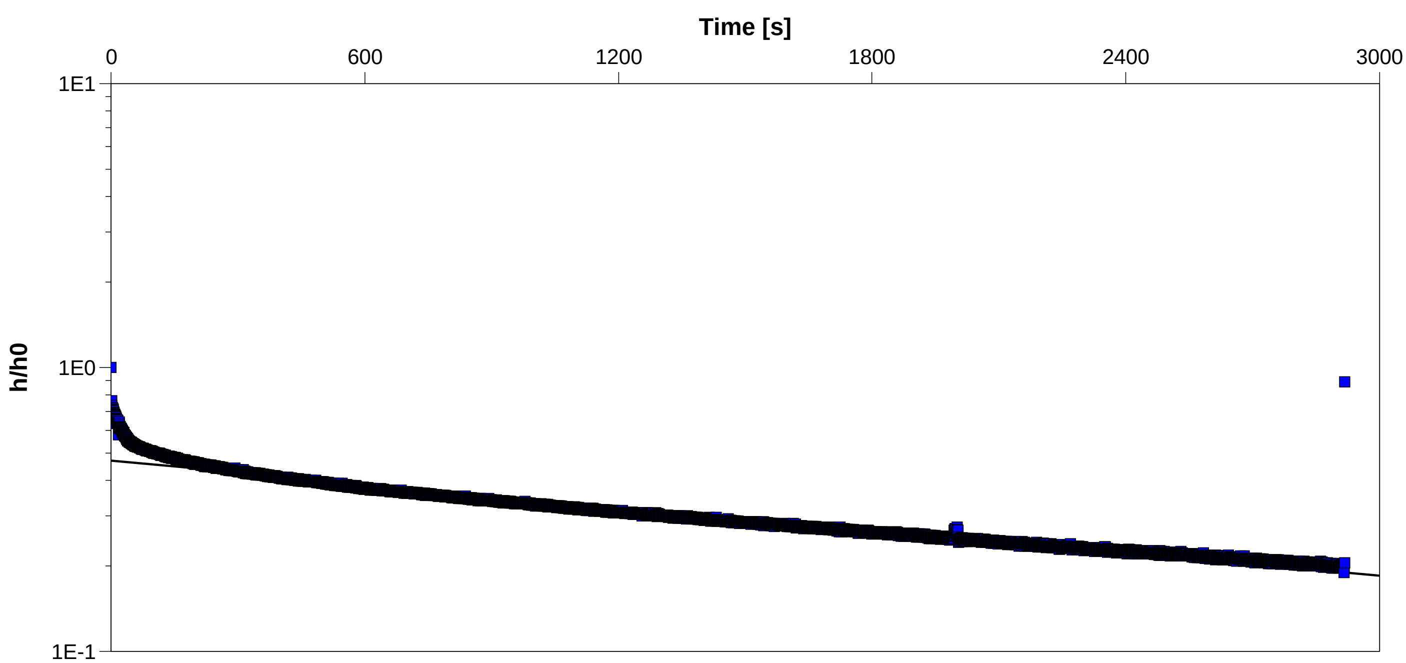


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW3	2.88×10^{-2}	

	Contact Info Address Company Name City, State/Province	Slug Test Analysis Report
		Project: BDRLF Aquifer Testing
		Number: 7003
		Client: ARS

Location: BDRLF	Slug Test: BW3_Falling Head	Test Well: BW3
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

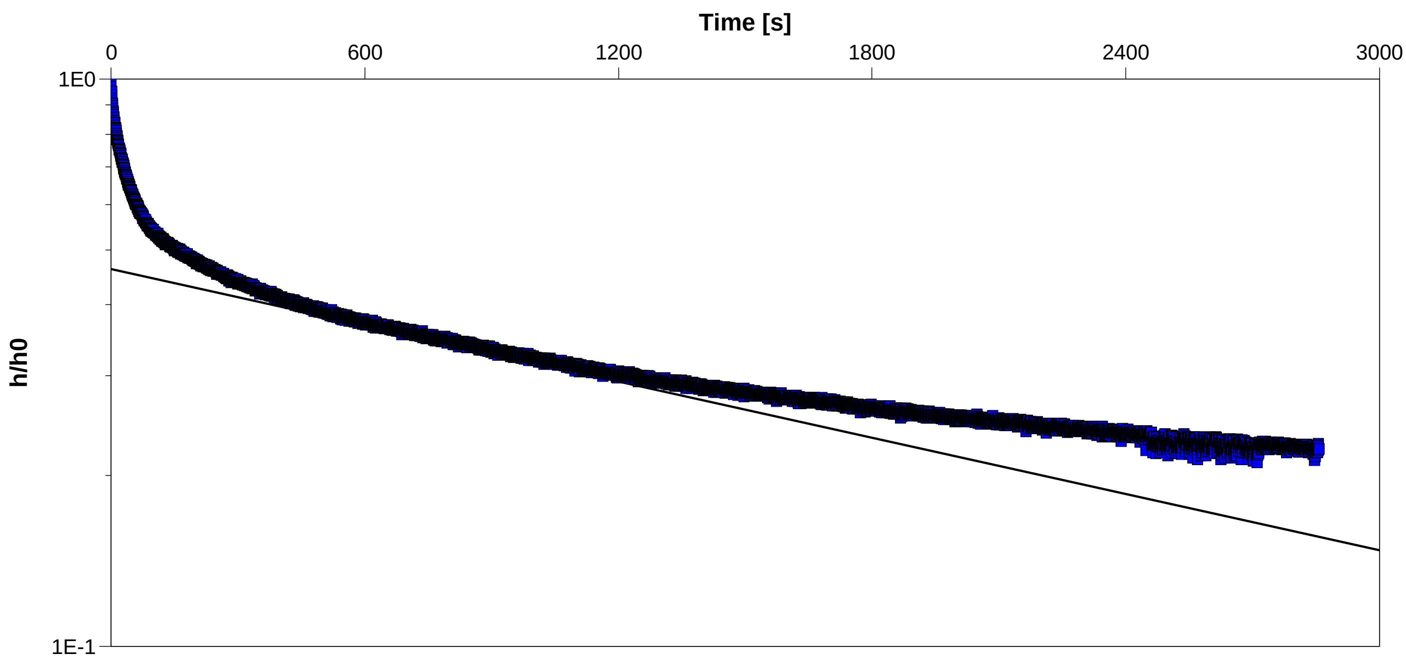


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW3	3.08×10^{-2}	

Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW3_Falling Head	Test Well: BW3
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hsorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

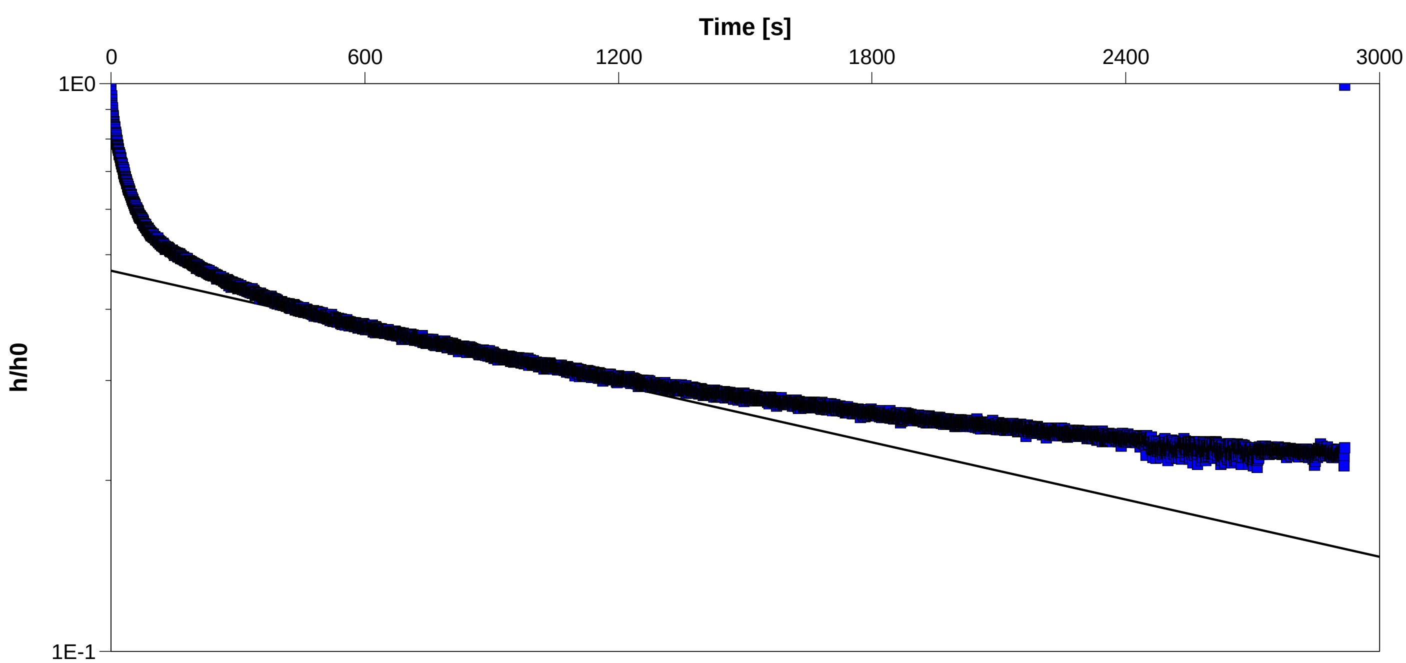


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW3	3.78×10^{-2}	

	Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report**
		Project: BDRLF Aquifer Testing
		Number: 7003
		Client: ARS

Location: BDRLF	Slug Test: BW3_Falling Head	Test Well: BW3
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

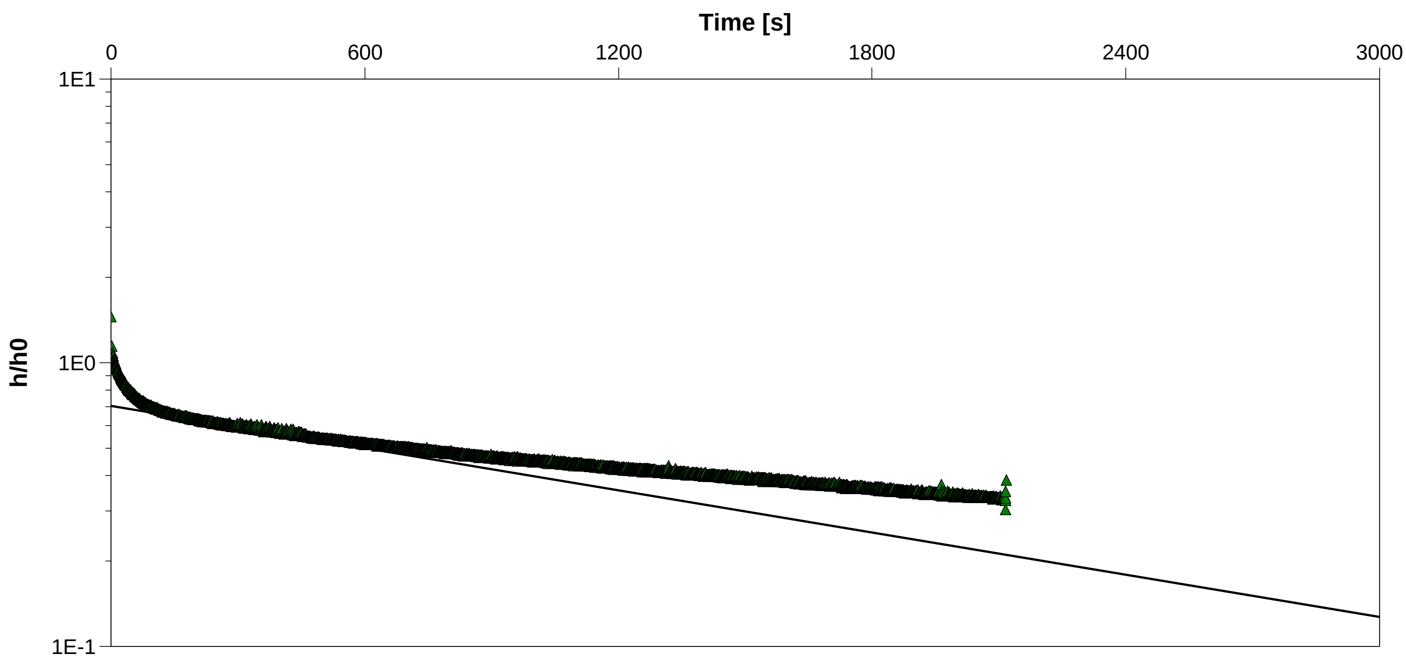


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW3	3.84×10^{-2}	

Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW4_Rising Head	Test Well: BW4
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

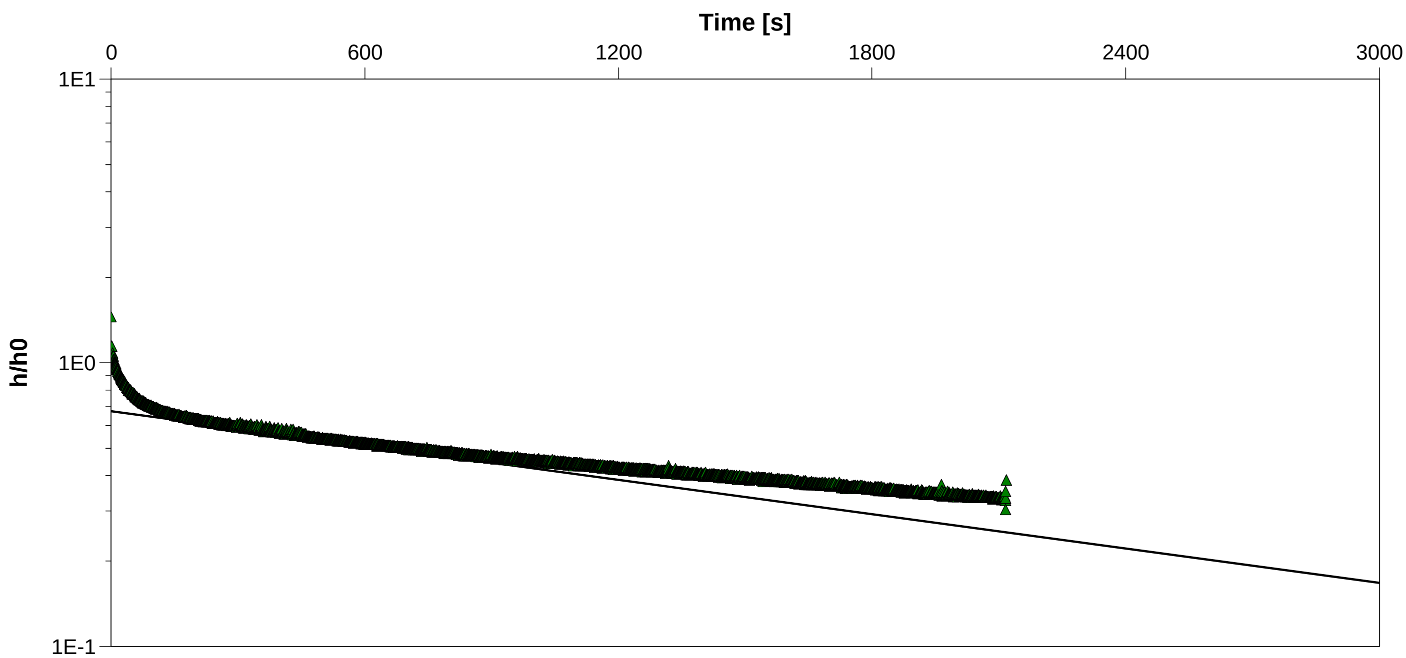


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW4	4.42×10^{-2}	

Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report**
	Project: BDRLF Aquifer Testing
	Number: 7003
	Client: ARS

Location: BDRLF	Slug Test: BW4_Rising Head	Test Well: BW4
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [ft/d]	
BW4	4.62×10^{-2}	

Contact Info
Address
Company Name
City, State/Province

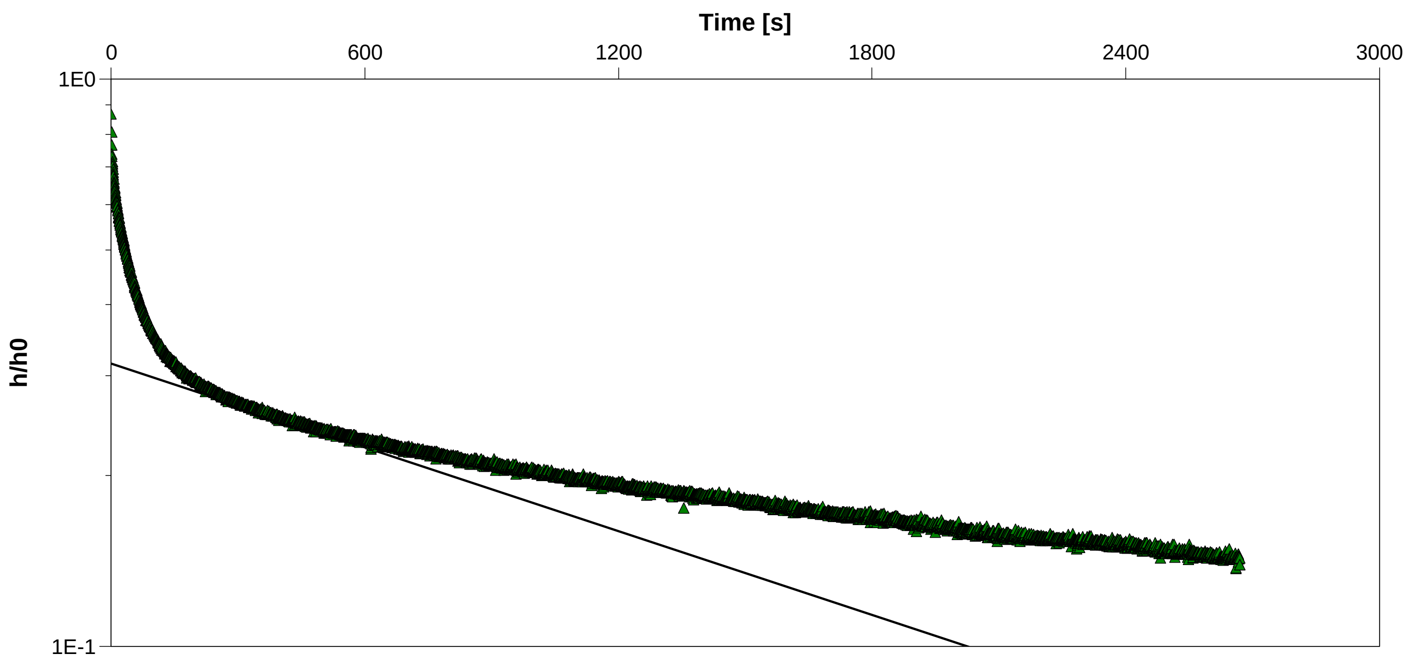
Slug Test Analysis Report

Project: BDRLF Aquifer Testing

Number: 7003

Client: ARS

Location: BDRLF	Slug Test: BW4_Rising Head	Test Well: BW4
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

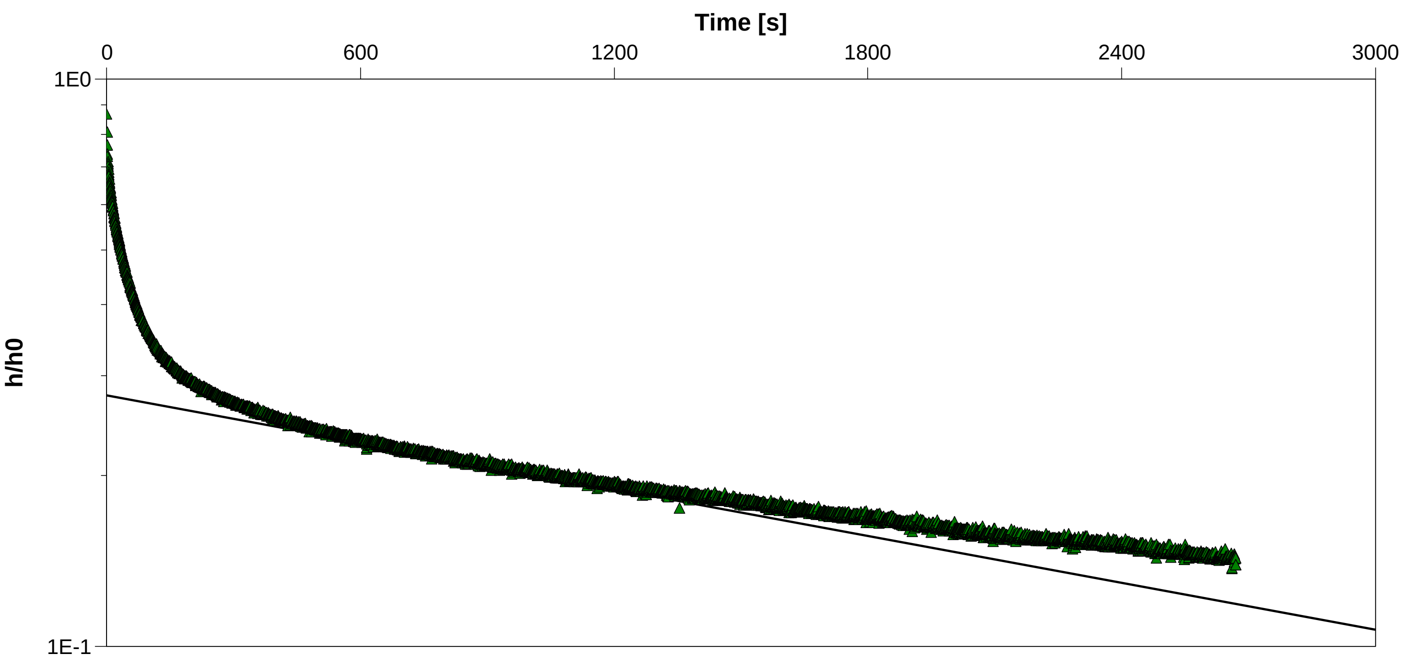


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW4	4.38×10^{-2}	

Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report**
	Project: BDRLF Aquifer Testing
	Number: 7003
	Client: ARS

Location: BDRLF	Slug Test: BW4_Rising Head	Test Well: BW4
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hsorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

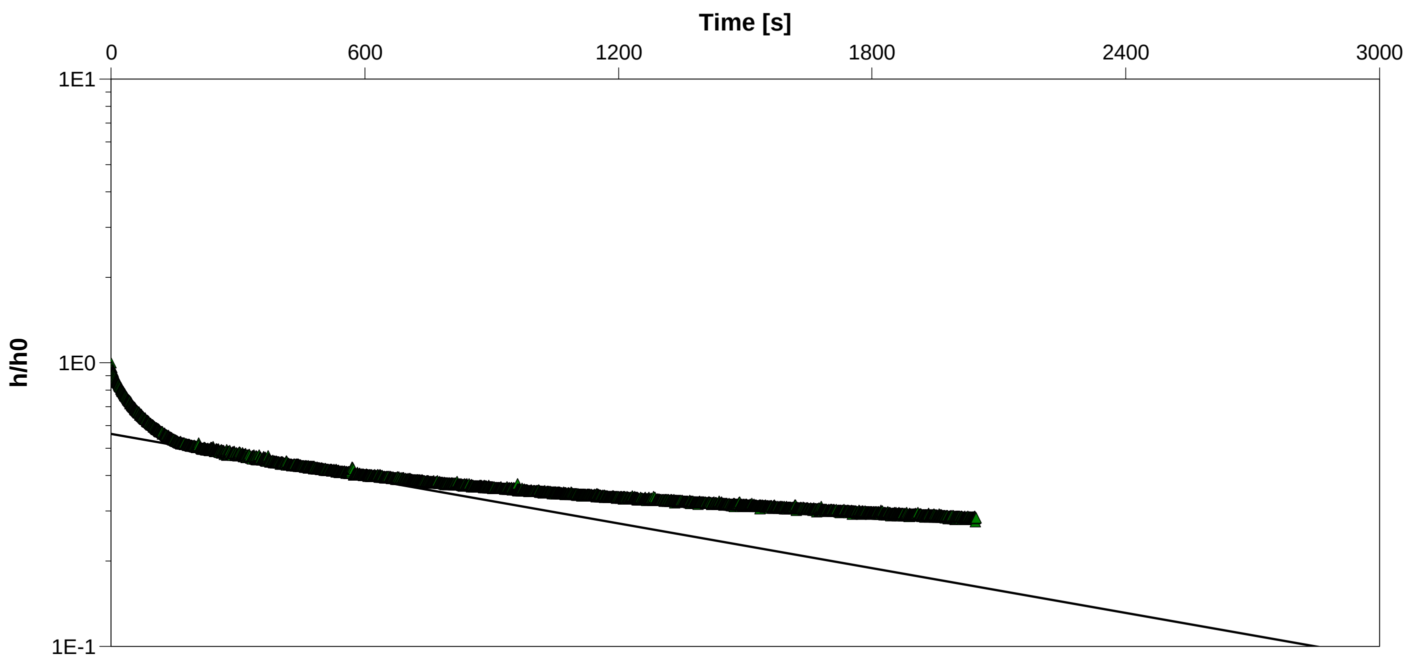


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW4	3.14×10^{-2}	

	Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report**
		Project: BDRLF Aquifer Testing
		Number: 7003
		Client: ARS

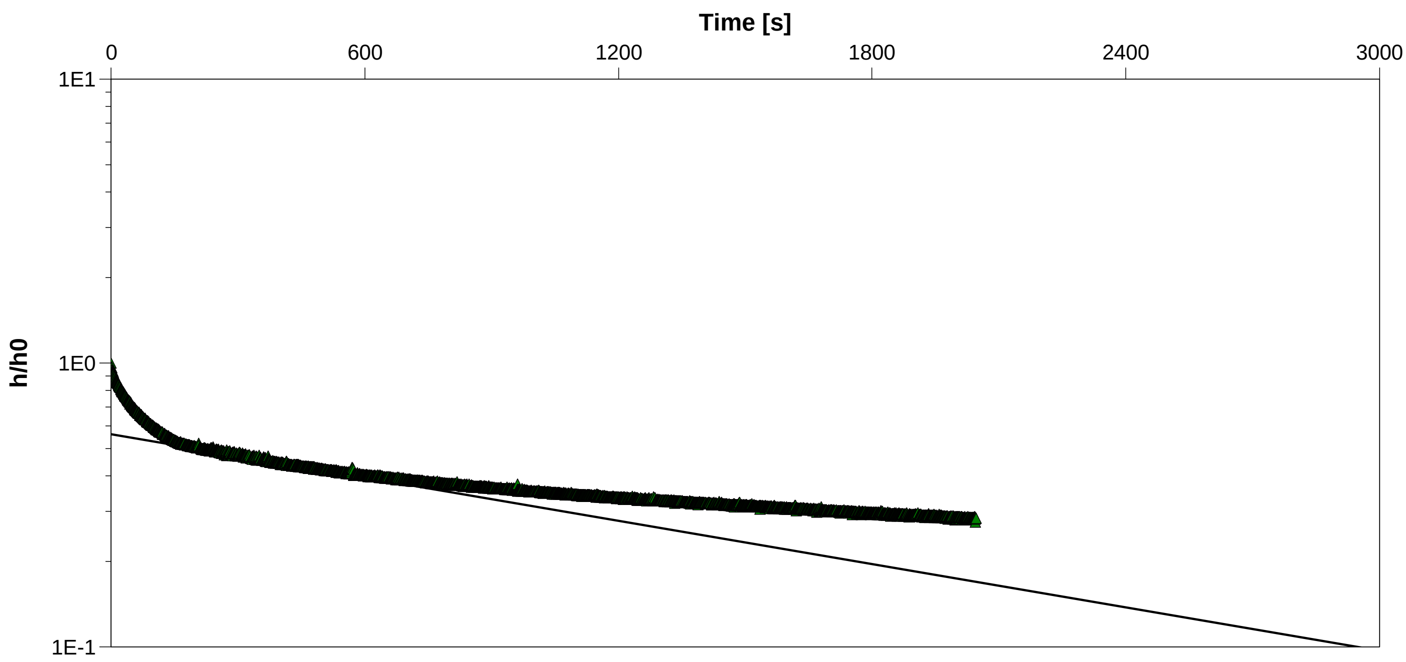
Location: BDRLF	Slug Test: BW5_Falling Head	Test Well: BW5
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		



Calculation using Bouwer & Rice		
Observation Well	Hydraulic Conductivity [ft/d]	
BW5	4.69×10^{-2}	

Contact Info **Address** **Company Name** **City, State/Province**		**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

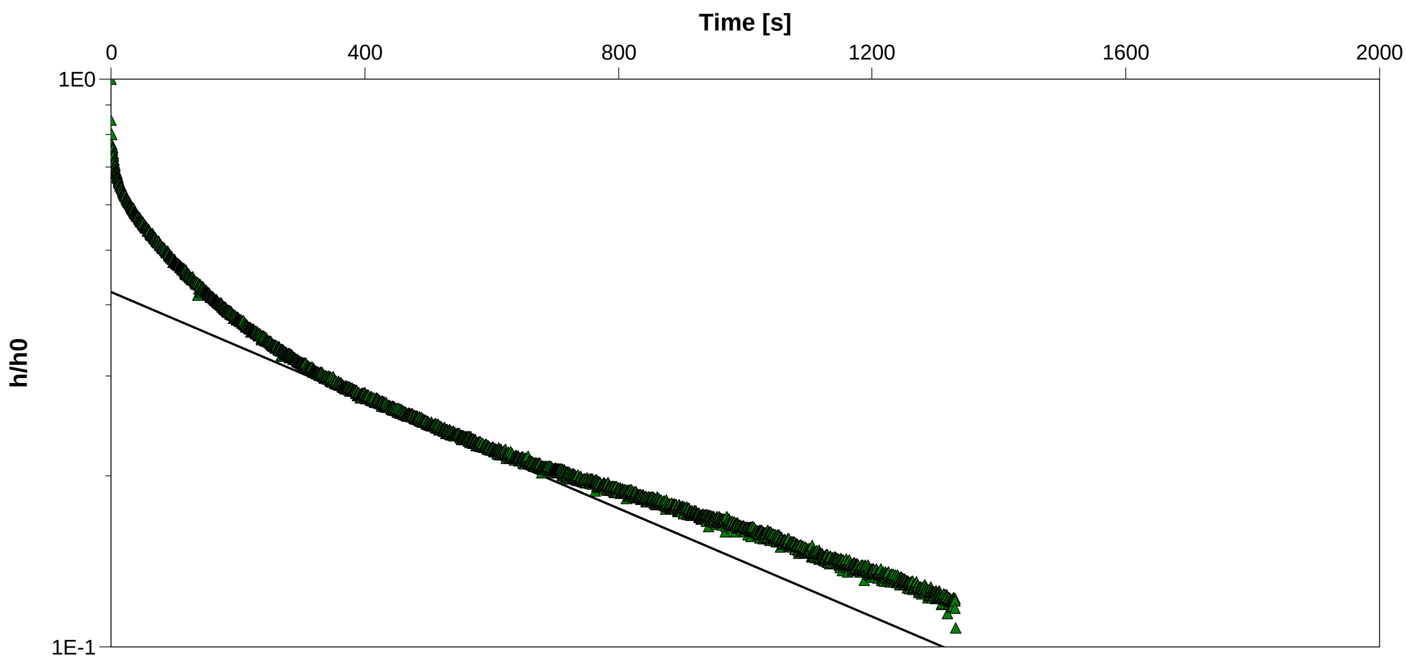
Location: BDRLF	Slug Test: BW5_Falling Head	Test Well: BW5
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [ft/d]	
BW5	5.81×10^{-2}	

Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW5_Rising Head	Test Well: BW5
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

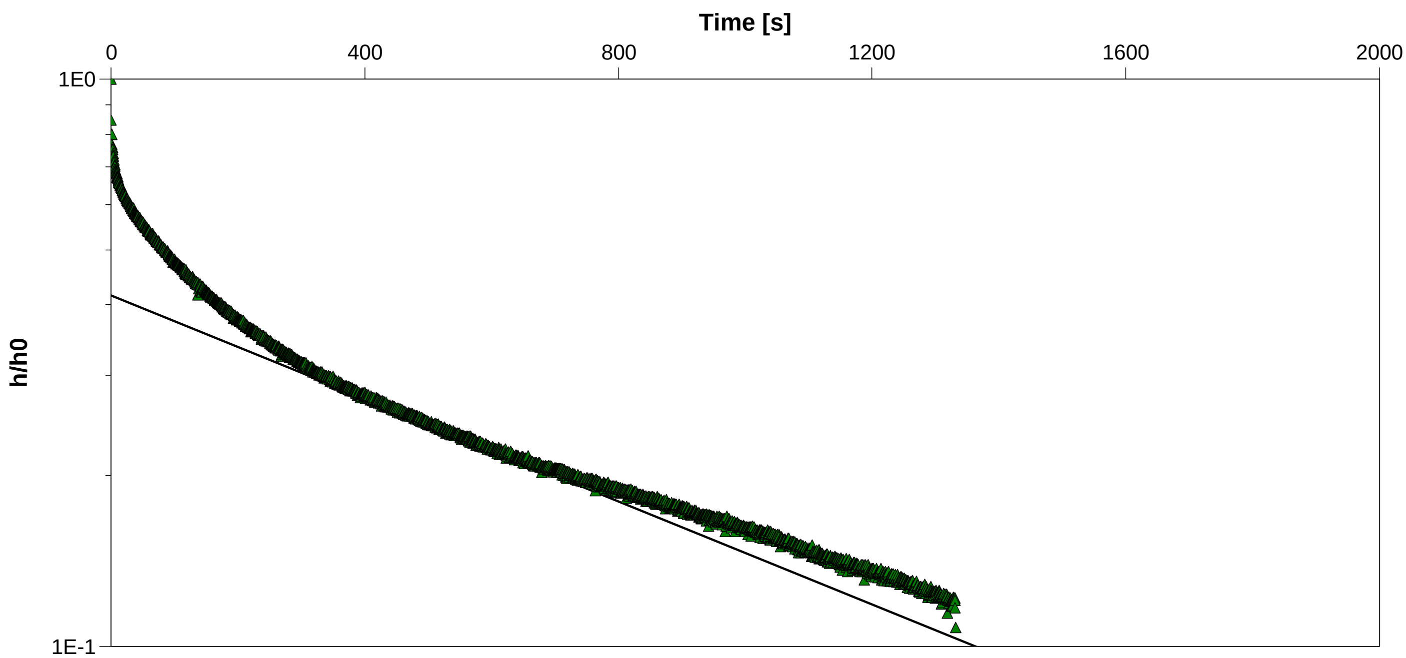


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW5	8.49×10^{-2}	

Contact Info Address Company Name City, State/Province	Slug Test Analysis Report Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW5_Rising Head	Test Well: BW5
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

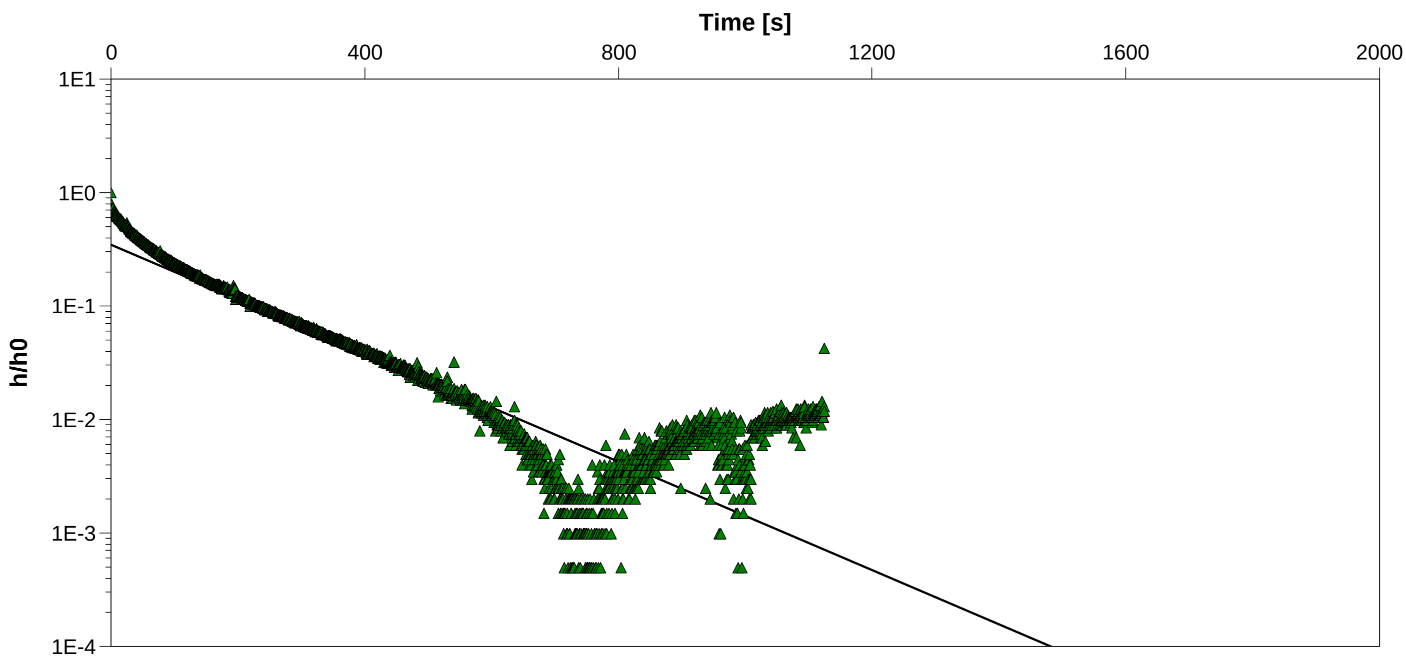


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW5	1.04×10^{-1}	

Contact Info Address Company Name City, State/Province	Slug Test Analysis Report
	Project: BDRLF Aquifer Testing
	Number: 7003
	Client: ARS

Location: BDRLF	Slug Test: BW6_Falling Head	Test Well: BW6
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

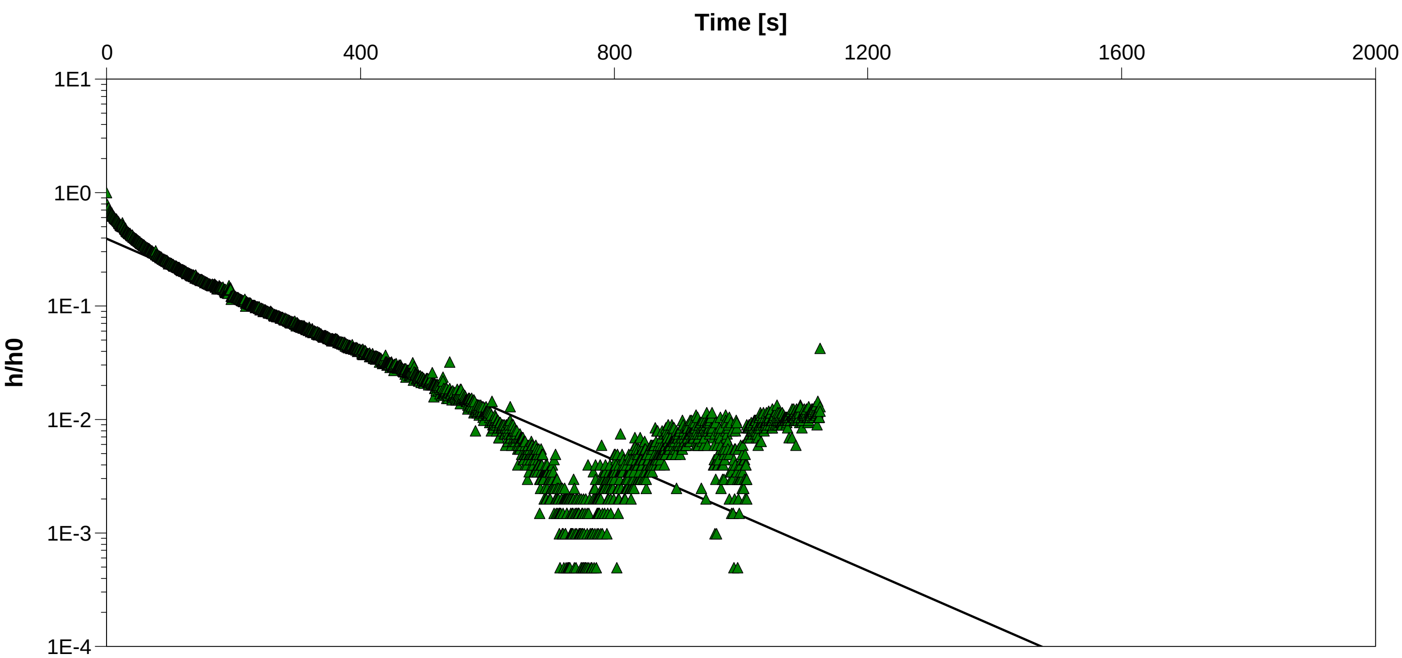


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW6	4.48×10^{-1}	

	Contact Info Address Company Name City, State/Province	Slug Test Analysis Report
		Project: BDRLF Aquifer Testing
		Number: 7003
		Client: ARS

Location: BDRLF	Slug Test: BW6_Falling Head	Test Well: BW6
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

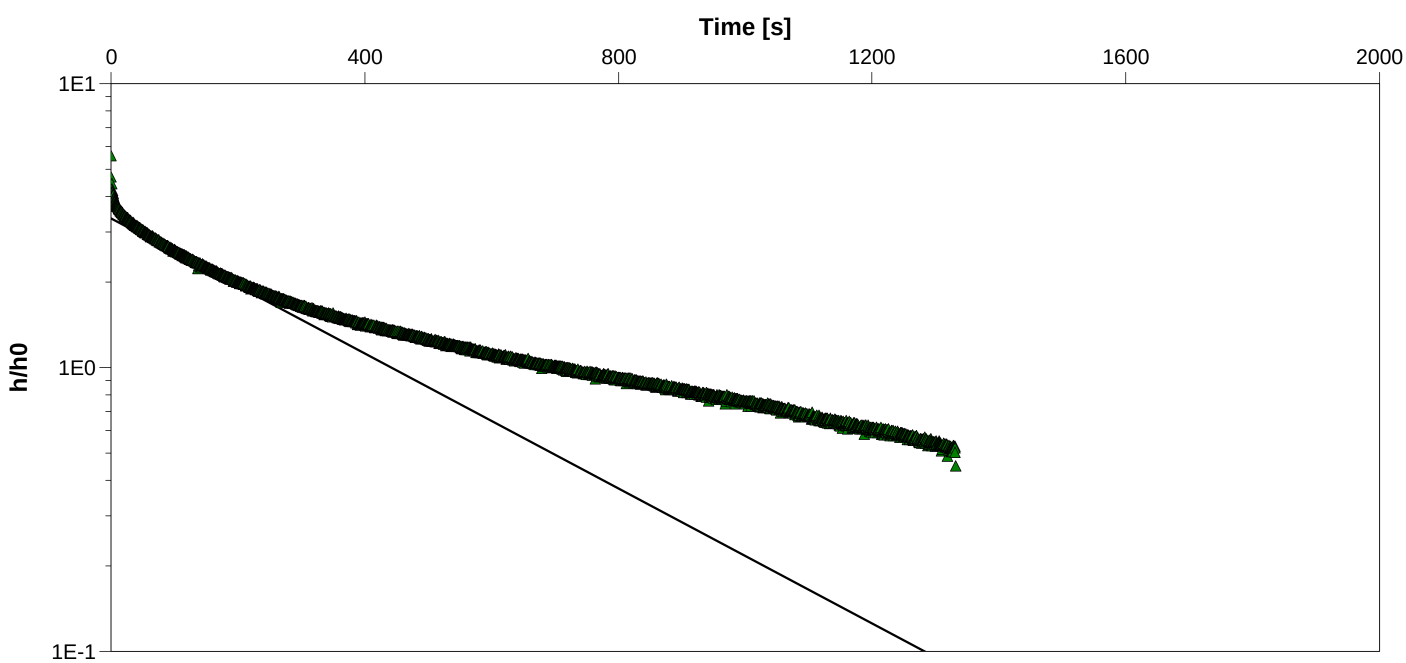


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW6	5.87×10^{-1}	

Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report**
	Project: BDRLF Aquifer Testing
	Number: 7003
	Client: ARS

Location: BDRLF	Slug Test: BW6_Rising Head	Test Well: BW6
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		

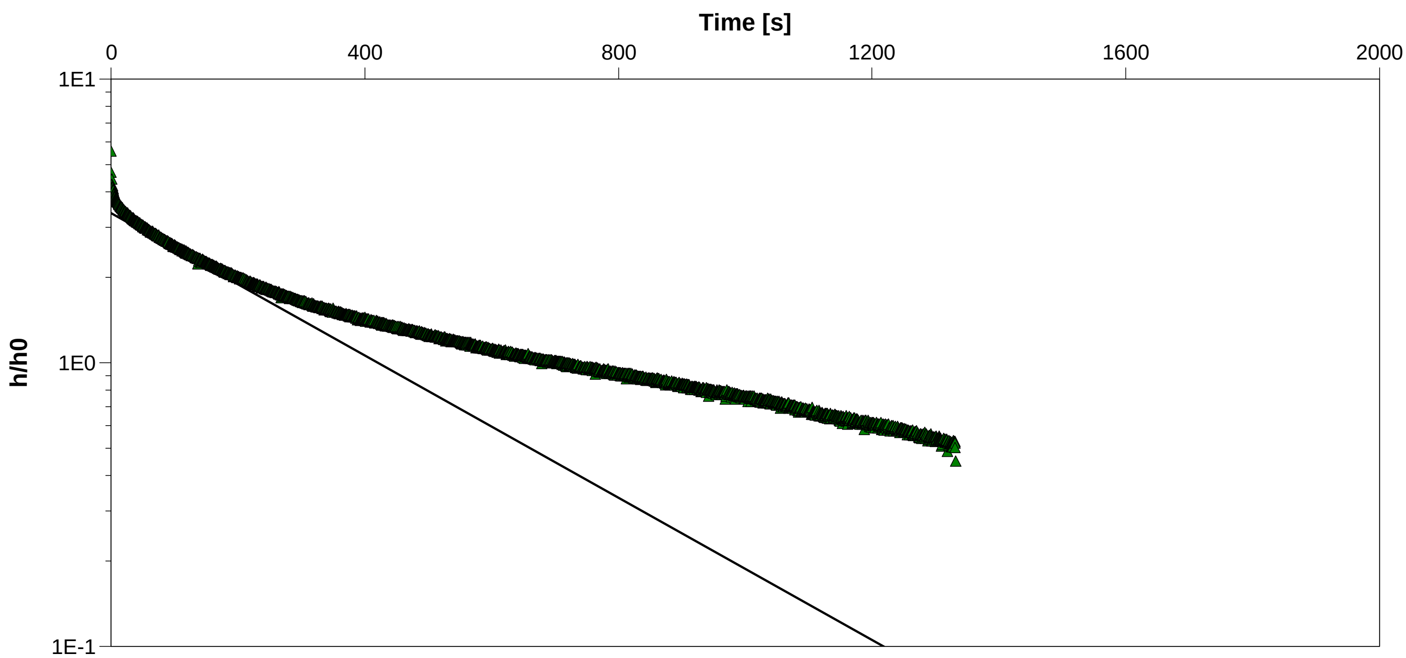


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW6	2.23×10^{-1}	

	Contact Info Address Company Name City, State/Province	Slug Test Analysis Report
		Project: BDRLF Aquifer Testing
		Number: 7003
		Client: ARS

Location: BDRLF	Slug Test: BW6_Rising Head	Test Well: BW6
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 16.00 ft		



Calculation using Hvorslev

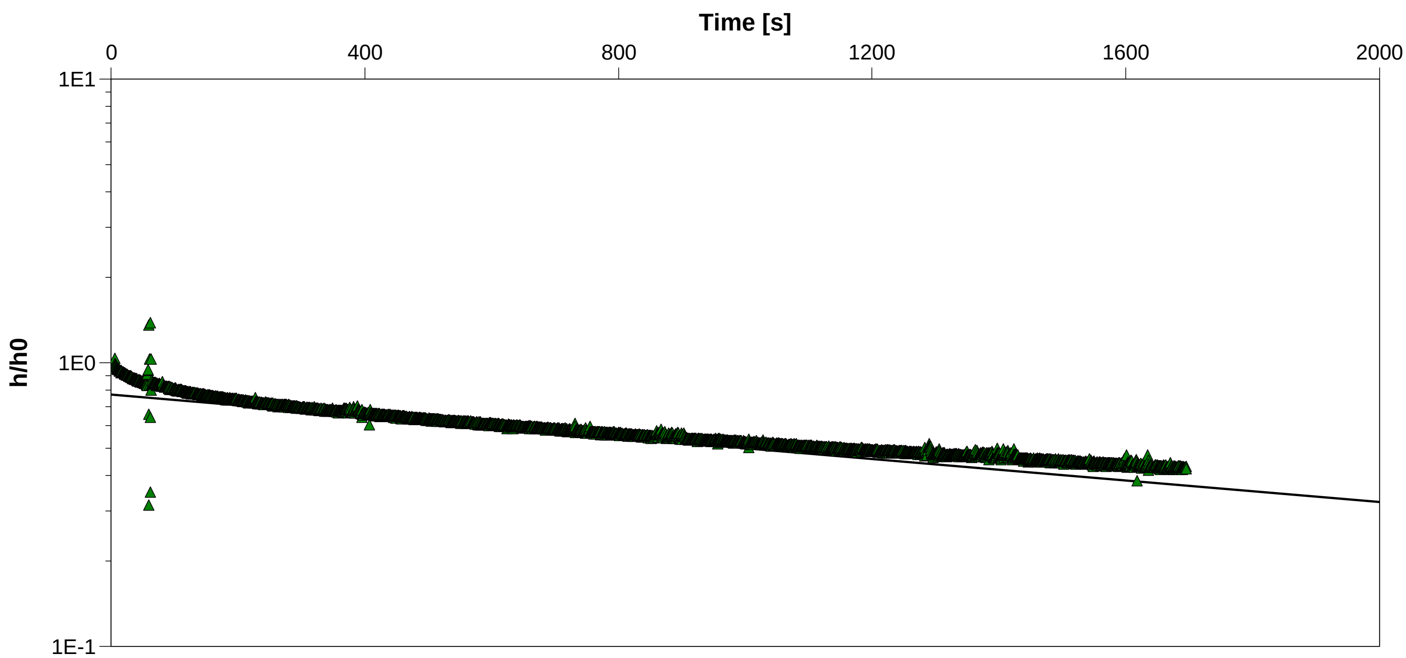
Observation Well	Hydraulic Conductivity [ft/d]	
BW6	3.02×10^{-1}	

Contact Info
Address
Company Name
City, State/Province

Slug Test Analysis Report

Project:	BDRLF Aquifer Testing
Number:	7003
Client:	ARS

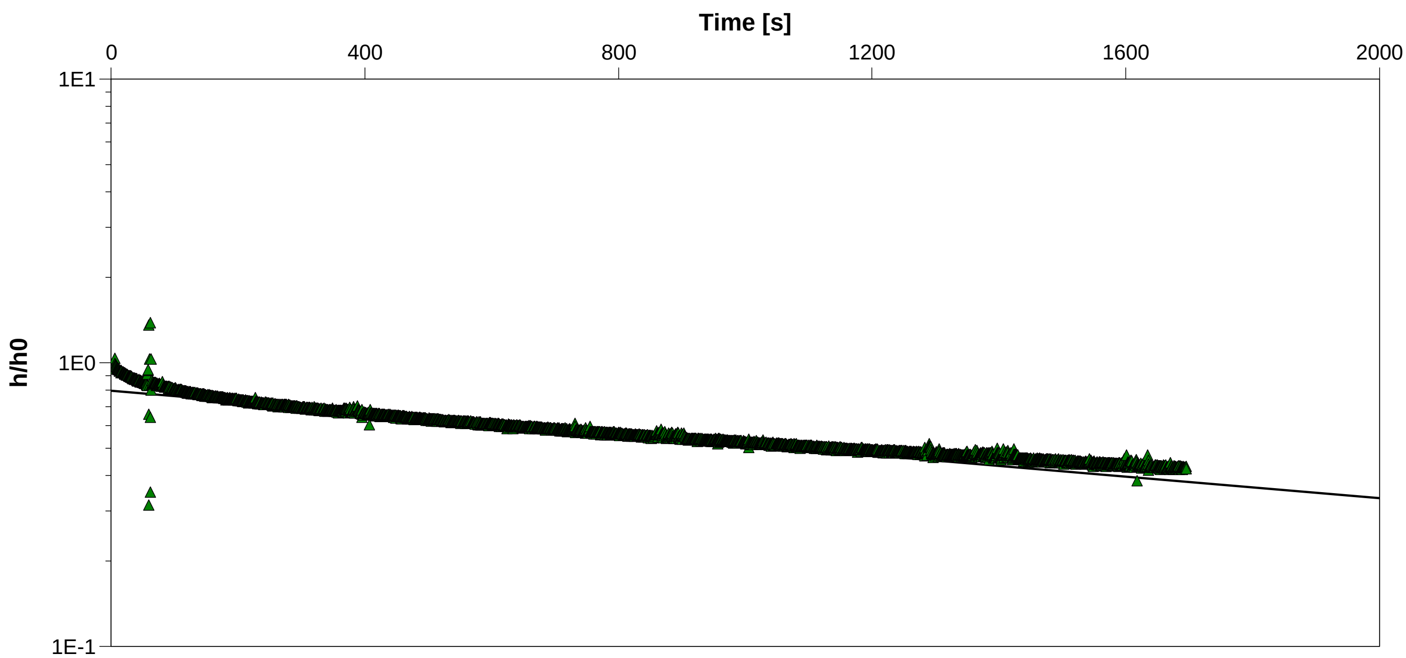
Location: BDRLF	Slug Test: BW7_Falling Head	Test Well: BW7
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 19.00 ft		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW7	2.93×10^{-2}	

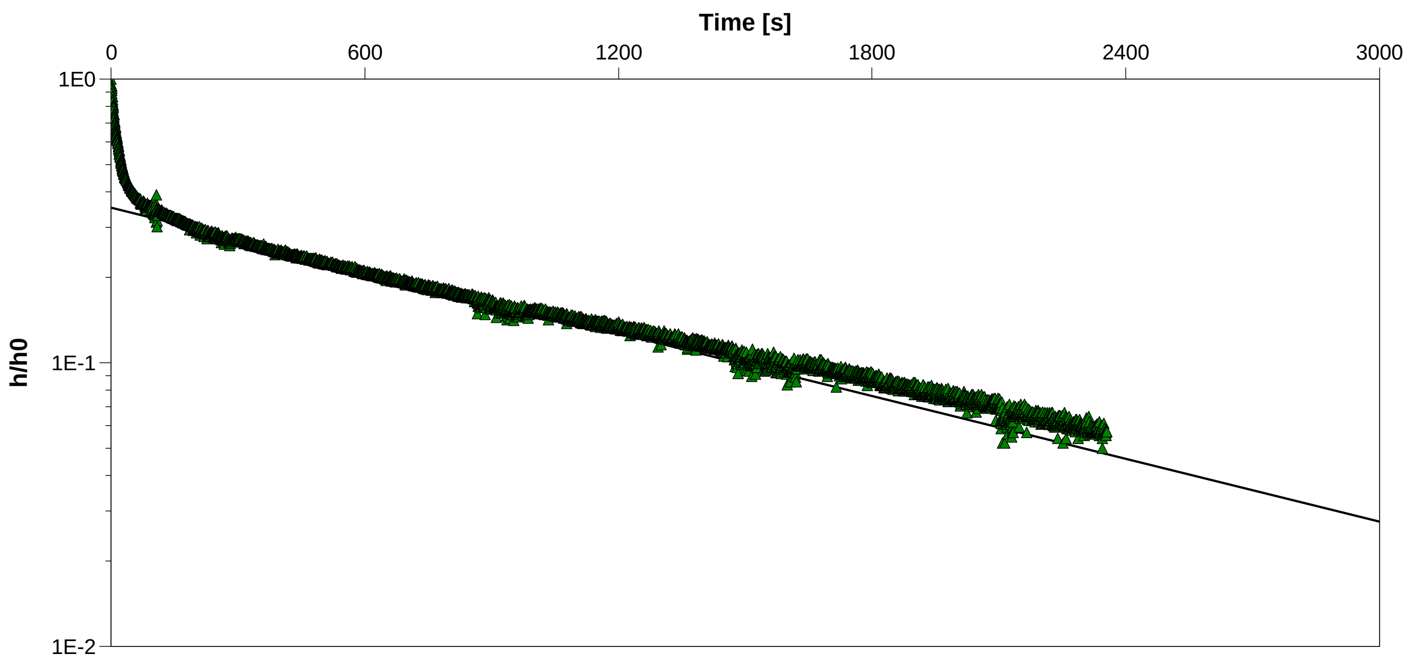
Contact Info Address Company Name City, State/Province		**Slug Test Analysis Report**
		Project: BDRLF Aquifer Testing
		Number: 7003
		Client: ARS
Location: BDRLF	Slug Test: BW7_Falling Head	Test Well: BW7
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 19.00 ft		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [ft/d]	
BW7	3.75×10^{-2}	

Contact Info Address Company Name City, State/Province	**Slug Test Analysis Report**
	Project: BDRLF Aquifer Testing
	Number: 7003
	Client: ARS

Location: BDRLF	Slug Test: BW7_Rising Head	Test Well: BW7
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 19.00 ft		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW7	5.73×10^{-2}	

Waterloo HYDROGEOLOGIC	**Contact Info** **Address** **Company Name** **City, State/Province**

Slug Test - Analyses Report

Project: BDRLF Aquifer Testing

Number: 7003

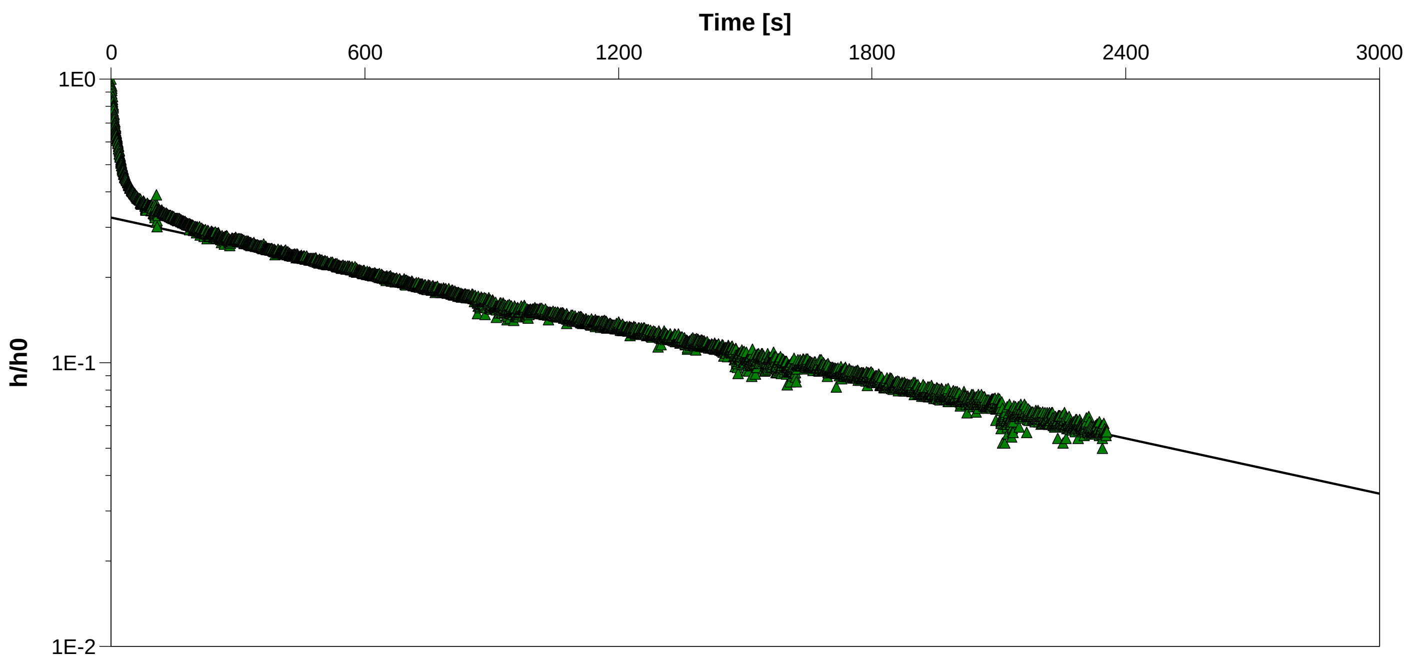
Client: ARS

Location: BDRLF	Slug Test: BW7_Rising Head	Test Well: BW7
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Aquifer Thickness: 19.00 ft		

	Analysis Name	Analysis Performed by	Analysis Date	Method name	Well	T [ft²/d]	K [ft/d]	S
1	Rising Head - Hvorslev	D. Schanzle	9/12/2016	Bouwer & Rice	BW7		5.73×10^{-2}	

Waterloo HYDROGEOLOGIC	**Contact Info** **Address** **Company Name** **City, State/Province**	**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW7_Rising Head	Test Well: BW7
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 19.00 ft		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW7	6.44×10^{-2}	

Waterloo HYDROGEOLOGIC	**Contact Info** **Address** **Company Name** **City, State/Province**

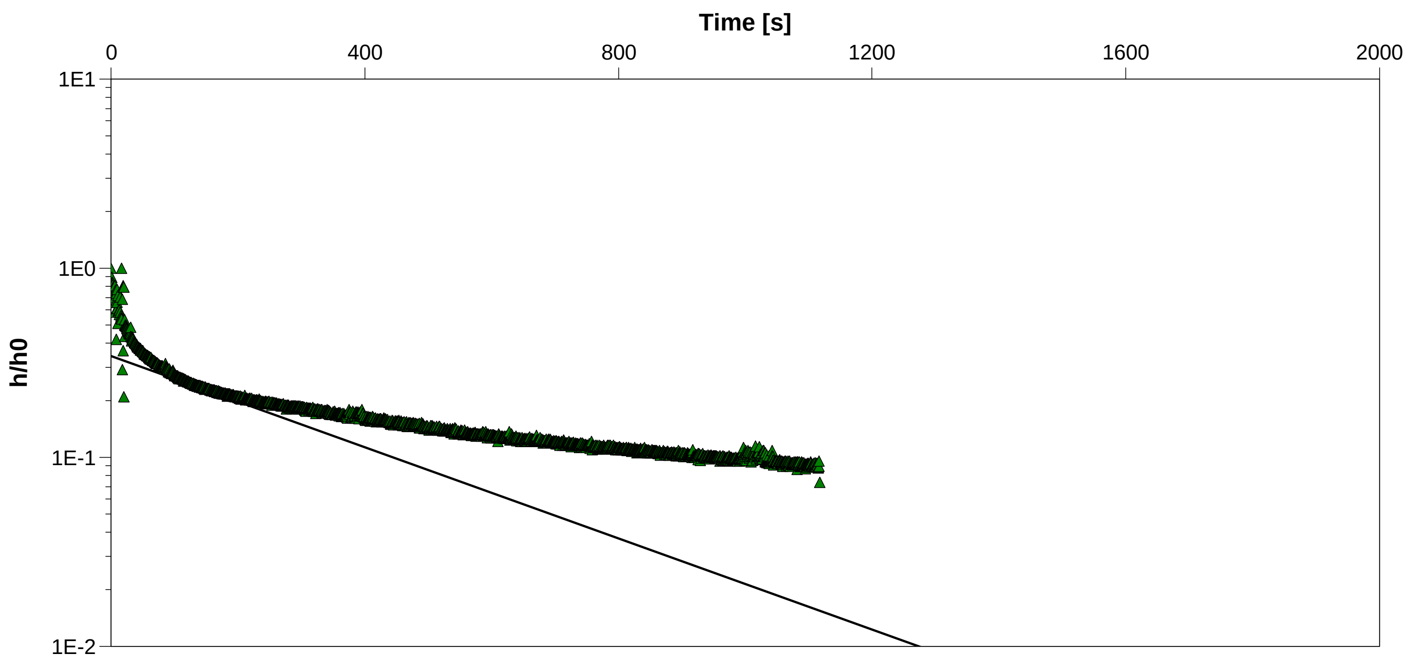
Slug Test - Analyses Report
Project: BDRLF Aquifer Testing
Number: 7003
Client: ARS

Location: BDRLF	Slug Test: BW7_Rising Head	Test Well: BW7
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Aquifer Thickness: 19.00 ft		

	Analysis Name	Analysis Performed by	Analysis Date	Method name	Well	T [ft²/d]	K [ft/d]	S
1	Rising Head - Hvorslev	D. Schanzle	9/12/2016	Hvorslev	BW7		6.44×10^{-2}	

Contact Info **Address** **Company Name** **City, State/Province**	**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW8_Falling Head	Test Well: BW8
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 15.00 ft		

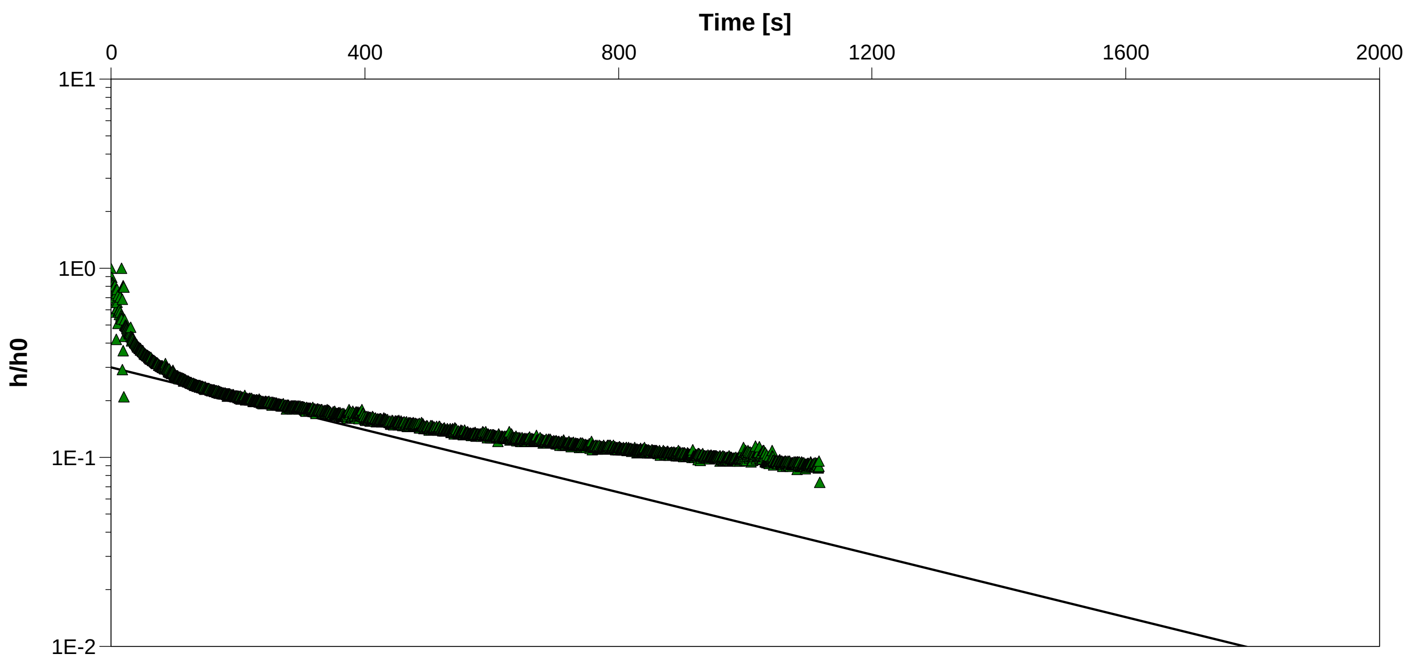


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]	
BW8	2.26×10^{-1}	

Contact Info Address Company Name City, State/Province		**Slug Test - Analyses Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW8_Falling Head	Test Well: BW8
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Falling Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 15.00 ft		

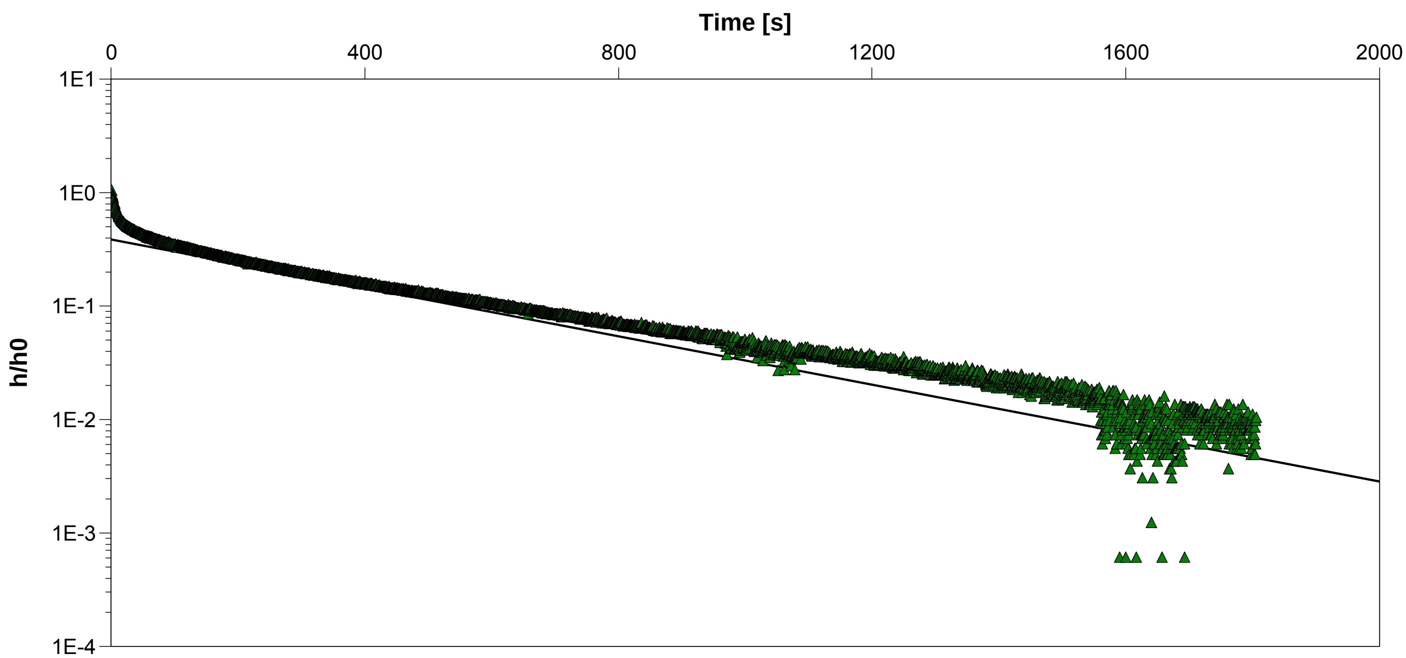


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW8	1.98×10^{-1}	

Waterloo HYDROGEOLOGIC **Contact Info** **Address** **Company Name** **City, State/Province**	**Slug Test Analysis Report** Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW8_Rising Head	Test Well: BW8
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Bouwer Rice	Analysis Date: 9/12/2016
Aquifer Thickness: 15.00 ft		

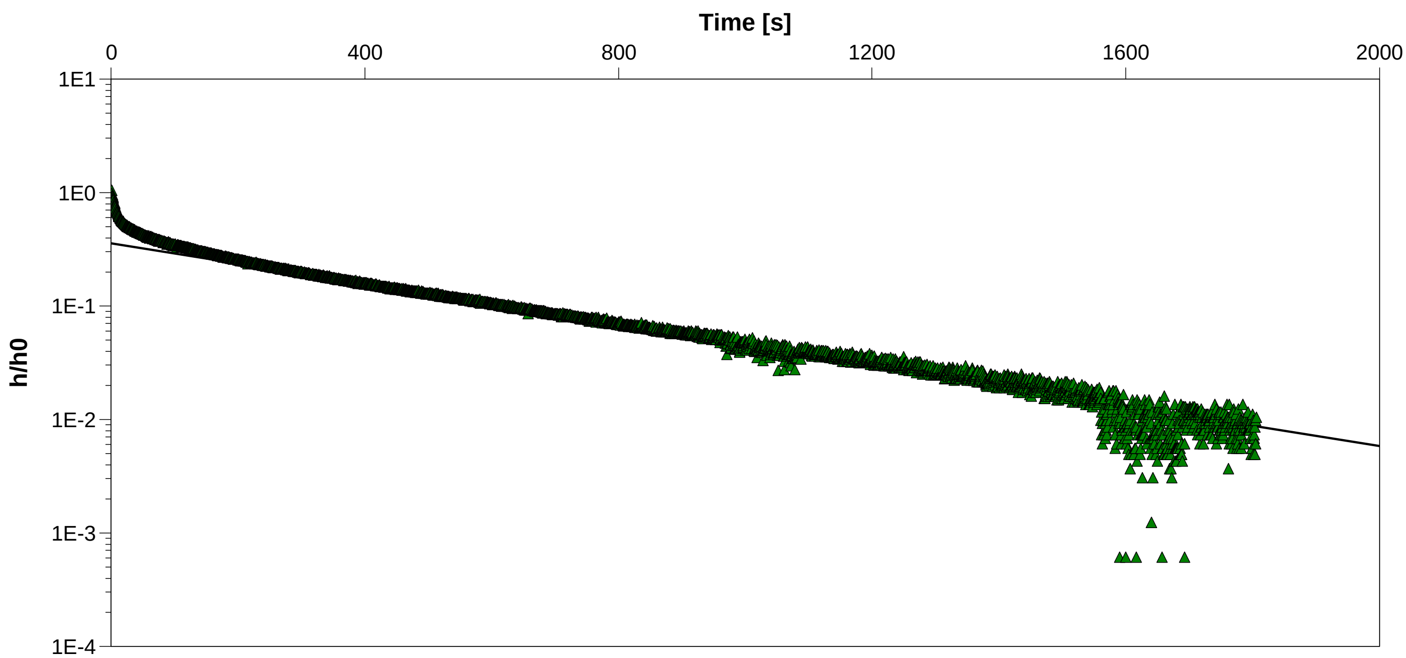


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [ft/d]
BW8	2.00×10^{-1}

	Contact Info Address Company Name City, State/Province	Slug Test Analysis Report Project: BDRLF Aquifer Testing Number: 7003 Client: ARS

Location: BDRLF	Slug Test: BW8_Rising Head	Test Well: BW8
Test Conducted by: D. Kmiotek		Test Date: 6/28/2016
Analysis Performed by: D. Schanzle	Rising Head - Hvorslev	Analysis Date: 9/12/2016
Aquifer Thickness: 15.00 ft		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
BW8	2.15×10^{-1}	

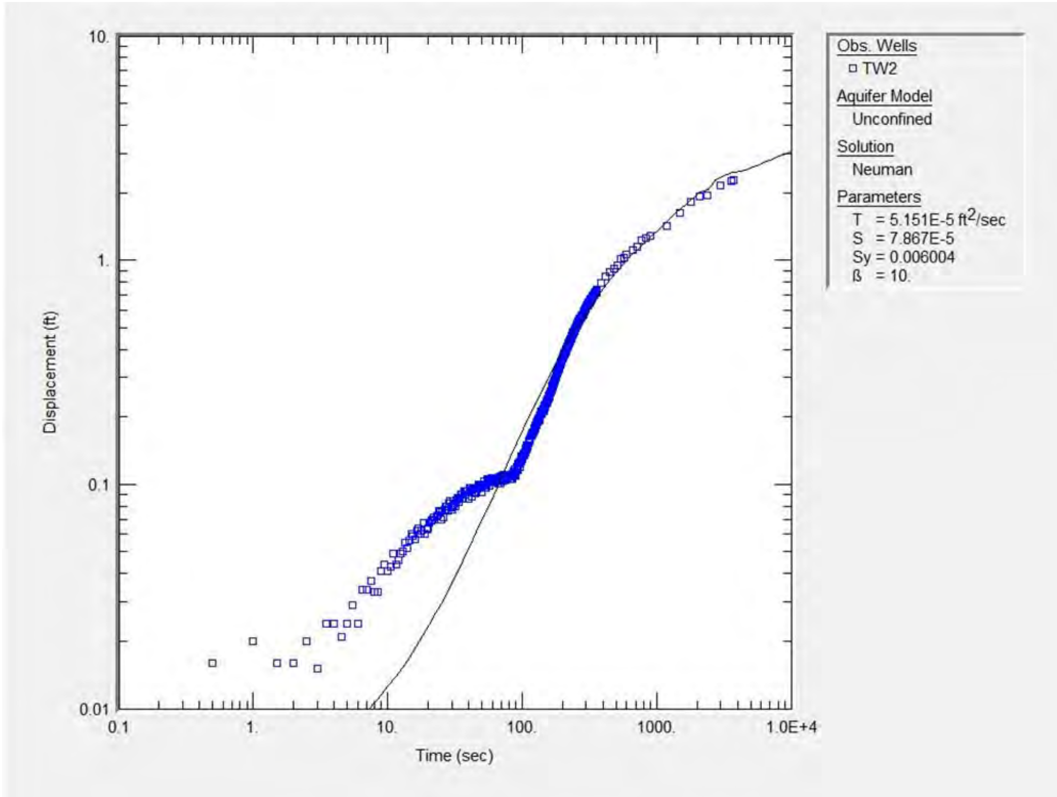
Attachment B

Pumping Test Data

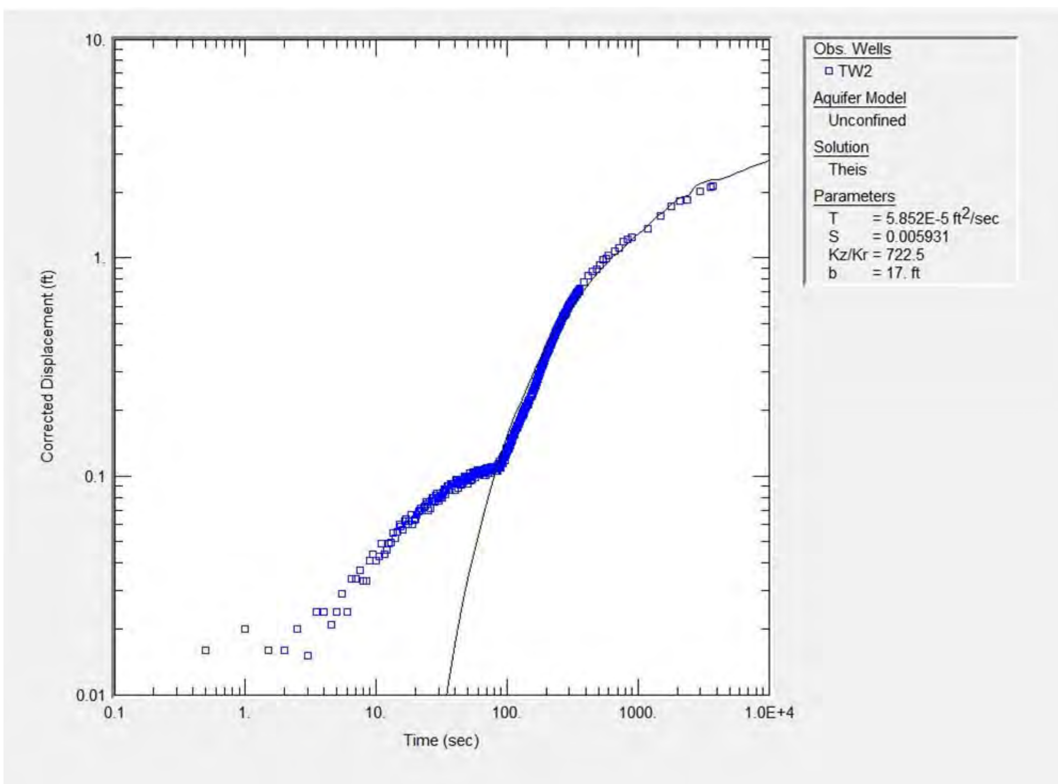
Limited Pump Test Notes from BW6. Test Performed on 06/29/2016

TIME	**NOTES**
1155	Begin setting up pump test. Set transducers in TW2 and TW3
1215	Begin pump test. Initial pumping rate is 0.441 L/min
1220	BW6 DTW = 9.05'
1225	BW6 DTW = 9.62'
1232	Readjust flow rate to 0.467 L/min
1240	BW6 DTW = 10.60'
1245	BW6 DTW = 10.50' Adjust flow rate to 0.484 L/min
1250	BW6 DTW = 10.48' Adjust flow rate to 0.428 L/min
1255	Adjust flowrate to 0.535 L/min
1300	BW6 DTW = 10.91' Flow rate = 0.476 L/min
1305	BW6 DTW = 11.01'
1310	BW6 DTW = 11.02' Flow rate = 0.461 L/min
1315	BW6 DTW = 11.05' Pump turned off
1330	BW6 DTW = 7.57'
1340	BW6 DTW = 7.27'
1355	BW6 DTW = 6.99'
1405	BW6 DTW = 6.89'
1415	BW6 DTW = 6.82'

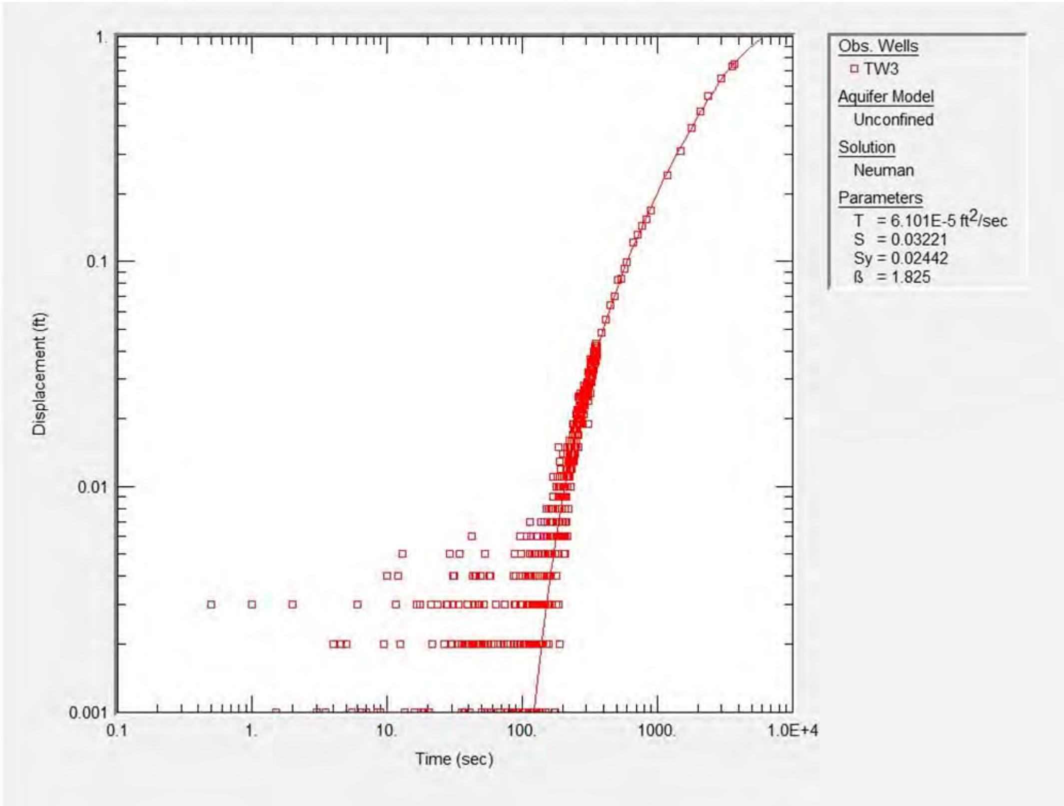
END OF PUMP TEST



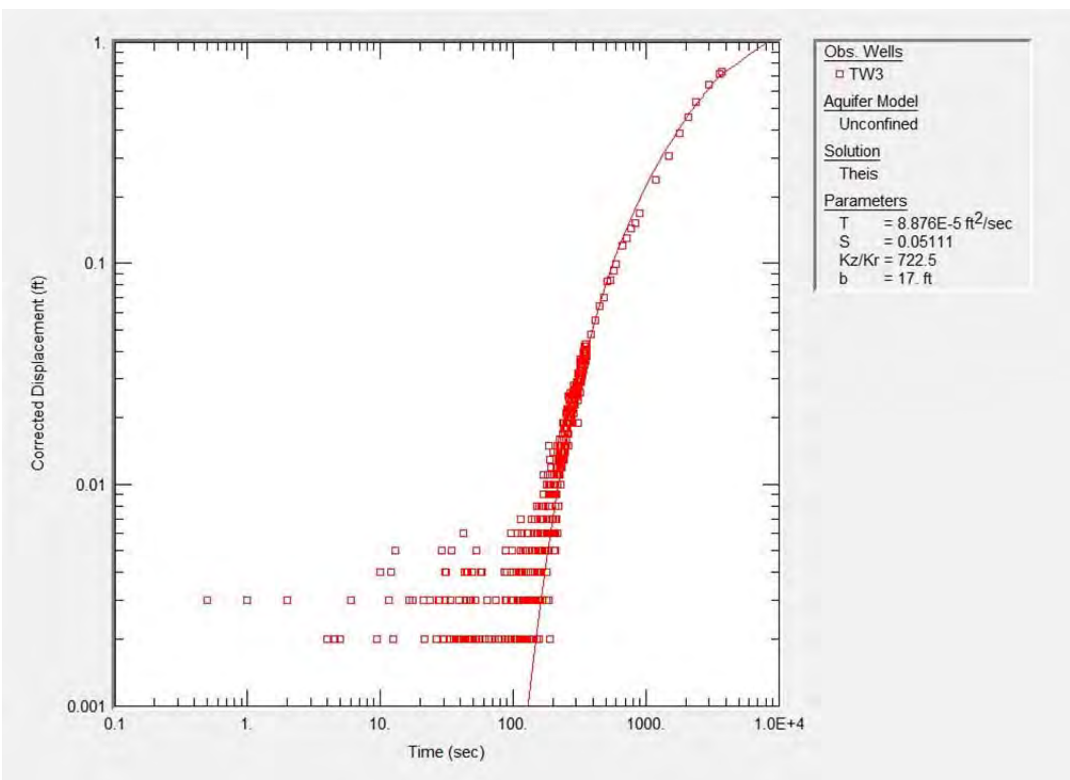
10.
1.
0.1
0.01
Displacement (ft)
0.1
1.
10.
100.
1000.
1.0E+4
Time (sec)
Obs. Wells
TW2
Aquifer Model
Unconfined
Solution
Neuman
Parameters
T = 5.151E-5 ft2/sec
S = 7.867E-5
Sy = 0.006004
ß = 10.



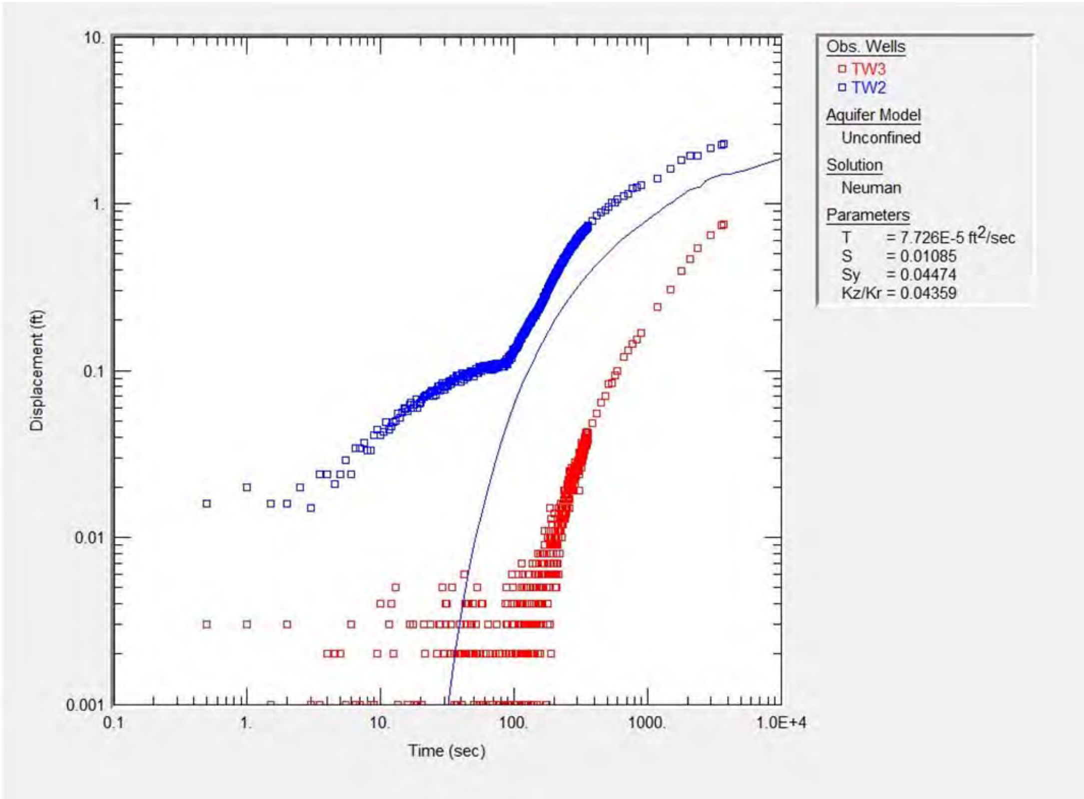
10.
1.
0.1
0.01
Corrected Displacement (ft)
0.1
1.
10.
100.
1000.
1.0E+4
Time (sec)
Obs. Wells
TW2
Aquifer Model
Unconfined
Solution
Theis
Parameters
T = 5.852E-5 ft2/sec
S = 0.005931
Kz/Kr = 722.5
b = 17. ft



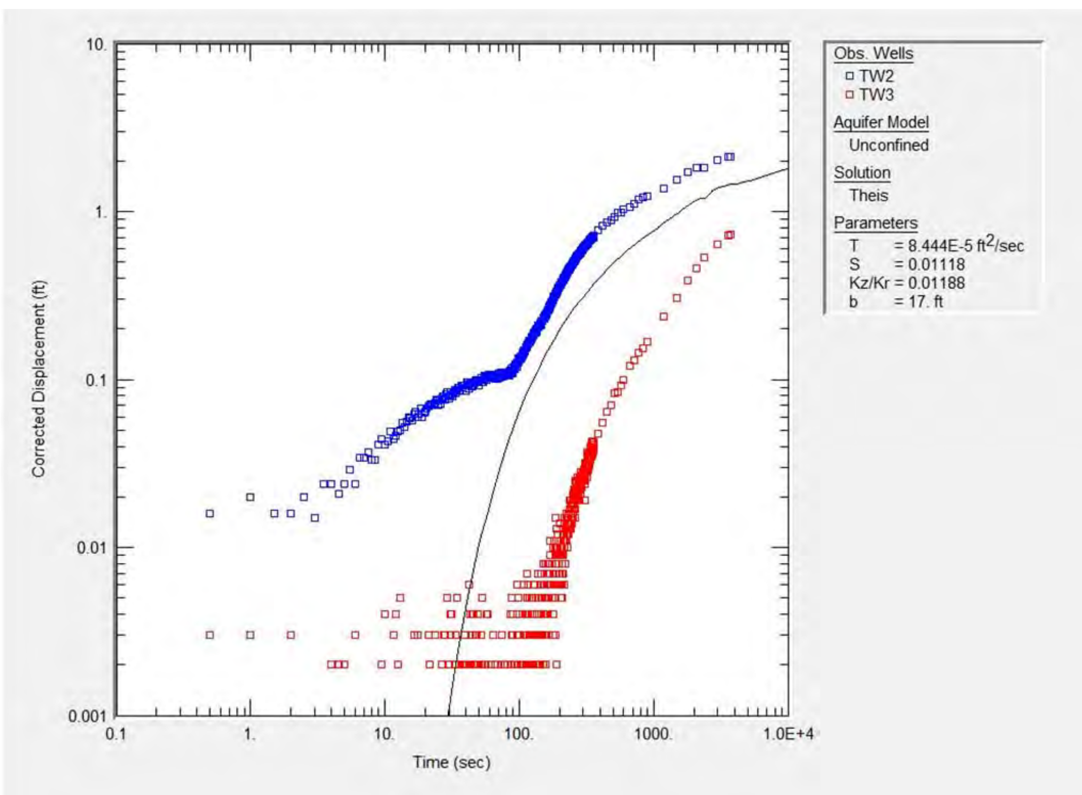
Displacement (ft)
Time (sec)
1.
0.1
0.01
0.001
0.1
1.
10.
100.
1000.
1.0E+4
Obs. Wells
TW3
Aquifer Model
Unconfined
Solution
Neuman
Parameters
T = 6.101E-5 ft2/sec
S = 0.03221
Sy = 0.02442
ß = 1.825



Corrected Displacement (ft)
Time (sec)
1.
0.1
0.01
0.001
0.1
1.
10.
100.
1000.
1.0E+4
Obs. Wells
TW3
Aquifer Model
Unconfined
Solution
Theis
Parameters
T = 8.876E-5 ft2/sec
S = 0.05111
Kz/Kr = 722.5
b = 17. ft



Obs. Wells
TW3
TW2
Aquifer Model
Unconfined
Solution
Neuman
Parameters
T = 7.726E-5 ft2/sec
S = 0.01085
Sy = 0.04474
Kz/Kr = 0.04359
Displacement (ft)
Time (sec)



Obs. Wells
TW2
TW3
Aquifer Model
Unconfined
Solution
Theis
Parameters
T = 8.444E-5 ft2/sec
S = 0.01118
Kz/Kr = 0.01188
b = 17. ft
Corrected Displacement (ft)
Time (sec)

Attachment C

Downgradient Groundwater Sampling VOC Data Summary

Attachment C

Downgradient Groundwater Sampling VOC Data Summary

Attachment C - Downgradient Groundwatet Sampling VOC Data

PARAMETER	MCL	SB01		SB02		SB02-DUP		SB03		SB04		SB05	
		Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
1,1,1,2-TETRACHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,1,1-TRICHLOROETHANE	200	1	U	1	U	1	U	1	U	1	U	1	U
1,1,2,2-TETRACHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,1,2-TRICHLOROETHANE	5	1	U	1	U	1	U	1	U	1	U	1	U
1,1-DICHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,1-DICHLOROETHENE	7	**1.9**		**2**		**1.9**		**1.5**		**1.7**		**1.1**	
1,1-DICHLOROPROPENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,2,3-TRICHLOROBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,2,3-TRICHLOROPROPANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,2,4-TRICHLOROBENZENE	70	1	U	1	U	1	U	1	U	1	U	1	U
1,2,4-TRIMETHYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,2-DIBROMO-3-CHLOROPROPANE	0.2	2	U	2	U	2	U	2	U	2	U	2	U
1,2-DIBROMOETHANE	0.05	1	U	1	U	1	U	1	U	1	U	1	U
1,2-DICHLOROBENZENE	600	1	U	1	U	1	U	1	U	1	U	1	U
1,2-DICHLOROETHANE	5	1	U	1	U	1	U	1	U	1	U	1	U
1,2-DICHLOROPROPANE	5	1	U	1	U	1	U	1	U	1	U	1	U
1,3,5-TRIMETHYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,3-DICHLOROBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,3-DICHLOROPROPANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
1,4-DICHLOROBENZENE	75	1	U	1	U	1	U	1	U	1	U	1	U
1-CHLOROHEXANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
2,2-DICHLOROPROPANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
2-BUTANONE	NA	10	U	10	U	10	U	10	U	10	U	10	U
2-CHLOROTOLUENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
2-HEXANONE	NA	10	U	10	U	10	U	10	U	10	U	10	U
4-CHLOROTOLUENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
4-METHYL-2-PENTANONE	NA	10	U	10	U	10	U	10	U	10	U	10	U
ACETONE	NA	**5**	**J**	**4**	**J**	**5.3**	**J**	**3.3**	**J**	**4.7**	**J**	**3.7**	**J**
BENZENE	5	1	U	1	U	1	U	1	U	1	U	1	U
BROMOBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
BROMOCHLOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
BROMODICHLOROMETHANE	*80	1	U	1	U	1	U	1	U	1	U	1	U
BROMOFORM	*80	1	U	1	U	1	U	1	U	1	U	1	U
BROMOMETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
CARBON DISULFIDE	NA	**3.2**		**1.4**		**2.2**		**1.6**		**2.4**		**2.5**	
CARBON TETRACHLORIDE	5	1	U	1	U	1	U	1	U	1	U	1	U
CHLOROBENZENE	100	1	U	1	U	1	U	1	U	1	U	1	U
CHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
CHLOROFORM	80	1	U	1	U	1	U	1	U	1	U	1	U
CHLOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
CIS-1,2-DICHLOROETHENE	70	**220**		**210**		**220**		**160**		**140**		**140**	
CIS-1,3-DICHLOROPROPENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
DIBROMOCHLOROMETHANE	80	1	U	1	U	1	U	1	U	1	U	1	U
DIBROMOMETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
DICHLORODIFLUOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
ETHYLBENZENE	700	1	U	1	U	1	U	1	U	1	U	1	U
HEXACHLOROBUTADIENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
IODOMETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
ISOPROPYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
M+P-XYLENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
METHYL TERTIARY BUTYL ETHER	NA	1	U	1	U	1	U	1	U	1	U	1	U
METHYLENE CHLORIDE	5	1	U	1	U	1	U	1	U	1	U	1	U
NAPHTHALENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
N-BUTYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
N-PROPYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
O-XYLENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
P-ISOPROPYLTOLUENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
SEC-BUTYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
STYRENE	100	1	U	1	U	1	U	1	U	1	U	1	U
TERT-BUTYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
TETRACHLOROETHENE	5	1	U	1	U	1	U	1	U	1	U	1	U
TOLUENE	1,000	**0.43**	**J**	**0.41**	**J**	**0.43**	**J**	**0.68**	**J**	**0.81**	**J**	**0.69**	**J**
TRANS-1,2-DICHLOROETHENE	100	**0.65**	**J**	**0.67**	**J**	**0.61**	**J**	**0.43**	**J**	**0.42**	**J**	**0.33**	**J**
TRANS-1,3-DICHLOROPROPENE	NA	1	U	1	U	1	U	1	U	1	U	1	U
TRICHLOROETHENE	5	**5.5**		**1.9**		**4.1**		**11**		**0.67**	**J**	**13**	
TRICHLOROFLUOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U	1	U
VINYL ACETATE	NA	2	U	2	U	2	U	2	U	2	U	2	U
VINYL CHLORIDE	2	**18**		**20**		**19**		**16**		**18**		**13**	

Notes

Values reported in ug/L

Detections are shown in bold font.

MCL exceedances are shown in shaded cells

NA = Not Applicable. No established MCL.

Laboratory Data Qualifiers

(stand to the left of dash, or alone. e.g. "U-D", or "N")

J. Estimated concentration.

U. Parameter not detected above method detection limit.

Attachment C - Downgradient Groundwatet Sampling VOC Data

PARAMETER	MCL	SB06		SB07		SB08		SB09		SB10	
		Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
1,1,1,2-TETRACHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U
1,1,1-TRICHLOROETHANE	200	1	U	1	U	1	U	1	U	1	U
1,1,2,2-TETRACHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	NA	1	U	1	U	1	U	1	U	1	U
1,1,2-TRICHLOROETHANE	5	1	U	1	U	1	U	1	U	1	U
1,1-DICHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U
1,1-DICHLOROETHENE	7	**0.6**	**J**	**0.78**	**J**	**1.3**		**0.33**	**J**	**0.87**	**J**
1,1-DICHLOROPROPENE	NA	1	U	1	U	1	U	1	U	1	U
1,2,3-TRICHLOROBENZENE	NA	1	U	1	U	1	U	1	U	1	U
1,2,3-TRICHLOROPROPANE	NA	1	U	1	U	1	U	1	U	1	U
1,2,4-TRICHLOROBENZENE	70	1	U	1	U	1	U	1	U	1	U
1,2,4-TRIMETHYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U
1,2-DIBROMO-3-CHLOROPROPANE	0.2	2	U	2	U	2	U	2	U	2	U
1,2-DIBROMOETHANE	0.05	1	U	1	U	1	U	1	U	1	U
1,2-DICHLOROBENZENE	600	1	U	1	U	1	U	1	U	1	U
1,2-DICHLOROETHANE	5	1	U	1	U	1	U	1	U	1	U
1,2-DICHLOROPROPANE	5	1	U	1	U	1	U	1	U	1	U
1,3,5-TRIMETHYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U
1,3-DICHLOROBENZENE	NA	1	U	1	U	1	U	1	U	1	U
1,3-DICHLOROPROPANE	NA	1	U	1	U	1	U	1	U	1	U
1,4-DICHLOROBENZENE	75	1	U	1	U	1	U	1	U	1	U
1-CHLOROHEXANE	NA	1	U	1	U	1	U	1	U	1	U
2,2-DICHLOROPROPANE	NA	1	U	1	U	1	U	1	U	1	U
2-BUTANONE	NA	10	U	10	U	10	U	10	U	10	U
2-CHLOROTOLUENE	NA	1	U	1	U	1	U	1	U	1	U
2-HEXANONE	NA	10	U	10	U	10	U	10	U	10	U
4-CHLOROTOLUENE	NA	1	U	1	U	1	U	1	U	1	U
4-METHYL-2-PENTANONE	NA	10	U	10	U	10	U	10	U	10	U
ACETONE	NA	**3.7**	**J**	**4.6**	**J**	**5.4**	**J**	10	U	**6.6**	**J**
BENZENE	5	1	U	1	U	1	U	1	U	1	U
BROMOBENZENE	NA	1	U	1	U	1	U	1	U	1	U
BROMOCHLOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U
BROMODICHLOROMETHANE	*80	1	U	1	U	1	U	1	U	1	U
BROMOFORM	*80	1	U	1	U	1	U	1	U	1	U
BROMOMETHANE	NA	1	U	1	U	1	U	1	U	1	U
CARBON DISULFIDE	NA	**1.8**		**2.2**		**2**		1	U	1	U
CARBON TETRACHLORIDE	5	1	U	1	U	1	U	1	U	1	U
CHLOROBENZENE	100	1	U	1	U	1	U	1	U	1	U
CHLOROETHANE	NA	1	U	1	U	1	U	1	U	1	U
CHLOROFORM	80	1	U	1	U	1	U	1	U	1	U
CHLOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U
CIS-1,2-DICHLOROETHENE	70	**98**		**130**		**190**		**33**		**180**	
CIS-1,3-DICHLOROPROPENE	NA	1	U	1	U	1	U	1	U	1	U
DIBROMOCHLOROMETHANE	80	1	U	1	U	1	U	1	U	1	U
DIBROMOMETHANE	NA	1	U	1	U	1	U	1	U	1	U
DICHLORODIFLUOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U
ETHYLBENZENE	700	1	U	1	U	1	U	1	U	1	U
HEXACHLOROBUTADIENE	NA	1	U	1	U	1	U	1	U	1	U
IODOMETHANE	NA	1	U	1	U	1	U	1	U	1	U
ISOPROPYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U
M+P-XYLENE	NA	1	U	1	U	1	U	1	U	1	U
METHYL TERTIARY BUTYL ETHER	NA	1	U	1	U	1	U	1	U	1	U
METHYLENE CHLORIDE	5	1	U	1	U	1	U	1	U	1	U
NAPHTHALENE	NA	1	U	1	U	1	U	1	U	1	U
N-BUTYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U
N-PROPYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U
O-XYLENE	NA	1	U	1	U	1	U	1	U	1	U
P-ISOPROPYLTOLUENE	NA	1	U	1	U	1	U	1	U	1	U
SEC-BUTYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U
STYRENE	100	1	U	1	U	1	U	1	U	1	U
TERT-BUTYLBENZENE	NA	1	U	1	U	1	U	1	U	1	U
TETRACHLOROETHENE	5	1	U	1	U	1	U	1	U	1	U
TOLUENE	1,000	**0.36**	**J**	**0.55**	**J**	**0.93**	**J**	1	U	**0.57**	**J**
TRANS-1,2-DICHLOROETHENE	100	1	U	1	U	**0.43**	**J**	**0.49**	**J**	**0.4**	**J**
TRANS-1,3-DICHLOROPROPENE	NA	1	U	1	U	1	U	1	U	1	U
TRICHLOROETHENE	5	**8.5**		**3.7**		**0.91**	**J**	**160**		**2.2**	
TRICHLOROFLUOROMETHANE	NA	1	U	1	U	1	U	1	U	1	U
VINYL ACETATE	NA	2	U	2	U	2	U	2	U	2	U
VINYL CHLORIDE	2	**8.9**		**11**		**17**		**1.3**		**9.2**	

Notes
Values reported in ug/L
Detections are shown in bold font.
MCL exceedances are shown in shaded cells
NA = Not Applicable. No established MCL.

Laboratory Data Qualifiers
(stand to the left of dash, or alone. e.g. "U-D", or "N")
J. Estimated concentration.
U. Parameter not detected above method detection limit.

Appendix C

Public Announcements for Five Year Review

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PUBLIC NOTICE

Five-Year Review of Environmental Restoration
Beaver Dam Road Landfill
Beltsville Agricultural Research Center
Beltsville, MD 20705

The Beltsville (MD) Agricultural Research Center (BARC), a part of the U.S. Department of Agriculture's Agricultural Research Service, is beginning a five-year review of its environmental restoration of the Beaver Dam Road Land Fill (BDRLF). This location is about a 14-acre area of concern that is part of BARC' National Priorities Listing (Superfund) by the U.S. Environmental Protection Agency.

From the early 1940s through the 1980s, the BDRLF was used for disposal of nonhazardous materials such as rubble from masonry construction debris, tree clippings, wood, and broken asphalt from BARC operations. A Remedial Investigation also identified a plume of groundwater contaminated with trichloroethylene (TCE) up to a maximum concentration of 1,100 parts per billion (ppb). The plume impacts an area of about two-thirds of an acre to the southeast of the BDRLF. The Safe Drinking Water Act calls for a maximum contaminant level for TCE of 5 ppb; which is the cleanup goal for the site, although there are no drinking water wells in the area. To meet this goal, a remedy that included installation of a passive groundwater treatment system with a permeable reactive barrier (PRB) or "biowall" that captures and remediates TCE was selected and implemented. The biowall is currently in place and is undergoing performance monitoring.

The five-year review will include an examination of the BDRLF's Record of Decision, a review of site conditions and the effectiveness of the biowall. It is being conducted between February 1, 2018 and February 28, 2018.

All published data on the BDRLF and other BARC NPL/Superfund areas of concern are available for inspection at:

Information Repository
Building 003, Room 313
10300 Baltimore Avenue
Beltsville Agricultural Research Center
Beltsville, MD 20705

Open: Monday through Friday: 8:30 am to 4:30 pm
Facility Contacts:
Dana Jackson, Senior Remedial Project Manager
Phone: (301) 501-6025, dana.jackson@ars.usda.gov
Clyde Lathon - Safety Occupational Health and Environmental Manager
Phone: (301) 504-6262, clyde.lathon@ars.usda.gov

Comments and questions about the review may be directed to or for more information about BARC's listing as a National Priorities Site/Superfund Site, contact: Kim Kaplan, ARS Office of Communications, Room 1-2253, 5601 Sunnyside Ave. Beltsville, MD 20705; (301) 504-1637, Kim.Kaplan@ars.usda.gov.

00008180 1t 02/08/18

NEPA/S106 PUBLIC NOTICE

Cellco Partnership and its controlled affiliates doing business as Verizon Wireless is proposing to install and replace existing telecommunications equipment on the 94' tall rooftop of a 111' tall building in the vicinity of 36 Field House Drive, College Park, Prince George's County, MD, 20740. The proposed equipment will extend to a maximum height of 99' tall. Public comments regarding potential effects from this site on historic properties may be submitted within 30-days from the date of this publication to Virginia Janssen at Dynamic Environmental Associates, Inc., 3850 Lake Street, Suite C, Macon, GA 31204, (877) 968-4787, Sec106@DynamicEnvironmental.com. Re: 21707023.
00008159 1t 02/08/18

PUBLIC HEARING

COUNTY EXECUTIVE HEARING

The County Executive

of

Prince George's County, Maryland

NOTICE OF PUBLIC HEARING
ON
PROPOSED FISCAL YEAR 2019 BUDGET

The County Executive of Prince George's County, Maryland hereby gives notice of his intent to hold a public hearing to receive citizen testimony on proposed budgetary policies and programs, as required by Article 8, Section 804 of the County Charter.

The public hearing on this proposal will be held on:

TUESDAY, FEBRUARY 13, 2018
7:00 P.M.
LAUREL HIGH SCHOOL
8000 CHERRY LANE
LAUREL, MARYLAND 20707

The County Executive encourages the involvement and participation of individuals with disabilities in its programs, services and activities. Please let us know how we can best meet your needs as we will comply with the Americans with Disabilities Act in making "reasonable accommodations" to promote and encourage your participation.

Persons wishing to testify are requested to telephone the County Government (Telephone 301-952-4547, TDD (301) 985-3894) from 8:30 A.M. to 4:00 P.M., Monday through Friday for placement on the advance speakers list. You can also go online and register at www.princegeorgescountymd.gov. Time limitations of three minutes for all speakers will be imposed. There may be only one speaker per organization. Written testimony will be accepted in lieu of, or in addition to, oral comments.

BY ORDER OF THE
PRINCE GEORGE'S COUNTY EXECUTIVE

RUSHERN L. BAKER, III

County Executive
00008092 2t 02/08/18

AUCTIONS

LEGAL NOTICE

Pursuant to Article 16, Subtitle 2 of the Commercial Law Article of the Maryland Annotated Code, Equity LifeStyle Properties, Fernwood Mobile Home Park, exercises its right to establish and foreclose upon a landlord's lien on the following mobile homes, located within Fernwood Mobile Home Park, through public auction on **March 2, 2018** beginning at 10:00, a.m. at the location of each mobile home in the order listed below starting at 1909 Elmwood Park Street. Questions should be directed to the community office at 1901 Fernwood Drive, Capitol Heights, MD 20743. Equity LifeStyle Properties reserves the right to cancel a sale at any time for any reason.

Terms of Sale: Money Order/Certified Funds Only. Must be community approved. Pick up terms and application at Community Office before auction date.

1.) 1909 Elmwood Park Street MD 20743, 1974, HILL, MH, VIN# 02111510H
2.) 9512 Eugenia Park Street MD 20743, 1998, REDMAN HOMES, REDMAN, VIN# 12231977

00008182 3T 03/01/18

MECHANICS LIEN

NOTICE OF SALE

National Lien & Recovery will sell at public auction the following vehicles under & by virtue of section 16-202 & 16-207 of the Maryland Statutes for repairs, storage & other lawful charges. Sale to be held at 5411 Berwyn Road #202B, College Park, MD 20740 at 10:00 am on February 14, 2018. Purchaser of vehicle must have it inspected as provided in Transportation Section 23-107 of the Annotated Code of Maryland. The following may be inspected during business hours.

Lot # 16815, '89 PETERBILT 357 Vin # 1XPALA0X5KN276256 Minimum Bid $ 10475.78 WITTE'S TRUCK AND TRACTOR 6417 DAVIS ROAD MOUNT AIRY MD
Lot # 16869, '07 LANDROVER RANGE ROVER Vin # SALSK25457A987802 Minimum Bid $ 2770.00 SHAFIG INVESTMENT LLC/ ACTON LANE SELF STORAGE WALDORF MD
Lot # 16878, '03 FORD F250 XLT SUPER DUTY Vin # 1FTNW21L73EC15133 Minimum Bid $ 8227.11 T.L.C. AUTOMOTIVE SERVICES 319 S. CATON AVE BALTIMORE MD
Lot # 16879, '12 CHRYSLER 200 LX Vin # 1C3CCBAG5CN240622 Minimum Bid $ 15193.06 SERVICE FIRST COLLISION REPAIR 107 COUNTRY DAY ROAD CHESTER MD
Lot # 16881, '13 CHEVROLET IMPALA LT Vin # 2G1WG5E31D1120723 Minimum Bid $ 2842.88 CRISWELL CHEVROLET INC 503 QUINCE ORCHARD RD GAITHERSBURG MD
Lot # 16882, '01 NISSAN PATHFINDER Vin # JN8DR09Y21W596957 Minimum Bid $ 2180.12 DARCARS NISSAN OF COLLEGE PARK 9330 BALTIMORE AVE COLLEGE PARK MD
Lot # 16884, '04 ACURA MDX Vin # 2HNYD18694H500840 Minimum Bid $ 4277.62 T.L.C. AUTOMOTIVE SERVICES 319 S. CATON AVE BALTIMORE MD
Lot # 16885, '06 SUZUKI AN650 Vin # JS1CP51A962101493 Minimum Bid $ 6989.34 GUNPOWDER SERVICE CENTER 12120 PULASKI HWY JOPPA MD

TERMS OF SALE: CASH OR CASHIER CHECK + 10% BUYER PREMIUM. MINIMUM BID POSTED. LIENOR RESERVES RIGHT TO BID. ANY PARTIES CLAIMING INTEREST IN THE ABOVE MAY CONTACT NATIONAL LIEN & RECOVERY AT 1-800-841-5436. FAX 301-345-1892.
00008153 2t 02/08/18

JUDICIAL PROBATE

IN THE ORPHANS' COURT FOR
(OR)
BEFORE THE REGISTER OF WILLS FOR
PRINCE GEORGE'S COUNTY, MARYLAND

IN THE ESTATE OF: ESTATE 108700
LAWRENCE D. FIGGS

NOTICE OF JUDICIAL PROBATE

To all Persons Interested in the above estate:

You are hereby notified that a petition has been filed by

THOMAS J. KOKOLIS

for judicial probate for the appointment of a personal representative. A hearing will be held at 14735 MAIN STREET, ROOM D4010, UPPER MARLBORO, MD 20773 on MARCH 14, 2018 at 9:30 A.M.

This hearing may be transferred or postponed to a subsequent time. Further information may be obtained by reviewing the estate file in the Office of the Register of Wills.

Cereta A. Lee
Register of Wills

00008165 2t 02/15/18

LEGALS

NOTICE OF APPOINTMENT
NOTICE TO CREDITORS
NOTICE TO UNKNOWN HEIRS

TO ALL PERSONS INTERESTED
IN THE ESTATE OF
CAESAR A LEWIS

Notice is given that Ruth V Jones, whose address is 4018 Bridle Ridge Road, Upper Marlboro, MD 20773, was on January 12, 2018 appointed Personal Representative of the estate of Caesar A Lewis, who died on October 13, 2017 without a will.

Further information can be obtained by reviewing the estate file in the office of the Register of Wills or by contacting the personal representative or the attorney.

All persons having any objection to the appointment (or to the probate of the decedent's will) shall file their objections with the Register of Wills on or before the 12th day of July, 2018.

Any person having a claim against the decedent must present the claim to the undersigned personal representative or file it with the Register of Wills with a copy to the undersigned, on or before the earlier of the following dates:

(1) Six months from the date of the decedent's death, except if the decedent died before October 1, 1992, nine months from the date of the decedent's death; or

(2) Two months after the personal representative mails or otherwise delivers to the creditor a copy of this published notice or other written notice, notifying the creditor that the claim will be barred unless the creditor presents the claims within two months from the mailing or other delivery of the notice.

A claim not presented or filed on or before that date, or any extension provided by law, is unenforceable thereafter. Claim forms may be obtained from the Register of Wills.

RUTH V JONES
Personal Representative

CERETA A. LEE
REGISTER OF WILLS FOR
PRINCE GEORGE'S COUNTY
P.O. BOX 1729
UPPER MARLBORO, MD 20773-1729

Estate No. 108875

129535 (2-1,2-8,2-15)

NOTICE

Edward S. Cohn
Stephen N. Goldberg
Richard E. Solomon
Richard J. Rogers
Michael McKeefery
Christianna Kersey
600 Baltimore Avenue, Suite 208
Towson, MD 21204
Substitute Trustees,
Plaintiffs

v.

Cynthia King

AND

Paul King

14615 Crescent Drive
Upper Marlboro, MD 20772

Defendants

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-07510

Notice is hereby given this 24th day of January, 2018, by the Circuit Court for Prince George's County, that the sale of the property mentioned in these proceedings, made and reported, will be ratified and confirmed, unless cause to the contrary thereof be shown on or before the 26th day of February, 2018, provided a copy of this notice be published in a newspaper of general circulation in Prince George's County, once in each of three successive weeks before the 26th day of February, 2018.

The Report of Sale states the amount of the foreclosure sale price to be $124,000.00. The property sold herein is known as 14615 Crescent Drive, Upper Marlboro, MD 20772.

SYDNEY J. HARRISON
Clerk of the Circuit Court
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129517 (2-1,2-8,2-15)

NOTICE

Carrie M. Ward, et al.
6003 Executive Blvd., Suite 101
Rockville, MD 20852

Substitute Trustees,
Plaintiffs

vs.

XAVIER EASTERLING
CONSTANCE HOWARD
9941 Boise Road
Laurel, MD 20708
Defendant(s)

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-21426

Notice is hereby given this 19th day of January, 2018, by the Circuit Court for Prince George's County, Maryland, that the sale of the property mentioned in these proceedings and described as 9941 Boise Road, Laurel, MD 20708, made and reported by the Substitute Trustee, will be RATIFIED AND CONFIRMED, unless cause to the contrary thereof be shown on or before the 19th day of February, 2018, provided a copy of this NOTICE be inserted in some weekly newspaper printed in said County, once in each of three successive weeks before the 19th day of February, 2018.

The report states the purchase price at the Foreclosure sale to be $197,200.00.

SYDNEY J. HARRISON
Clerk, Circuit Court for
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129437 (2-1,2-8,2-15)

NOTICE

Carrie M. Ward, et al.
6003 Executive Blvd., Suite 101
Rockville, MD 20852

Substitute Trustees,
Plaintiffs

vs.

CATHERINE E. HOLLY
WALTER L. HOLLY
4906 Vienna Drive
IRTA 4906 Bienna Drive
Clinton, MD 20735
Defendant(s)

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 16-24818

Notice is hereby given this 18th day of January, 2018, by the Circuit Court for Prince George's County, Maryland, that the sale of the property mentioned in these proceedings and described as 4906 Vienna Drive, IRTA 4906 Bienna Drive, Clinton, MD 20735, made and reported by the Substitute Trustee, will be RATIFIED AND CONFIRMED, unless cause to the contrary thereof be shown on or before the 19th day of February, 2018, provided a copy of this NOTICE be inserted in some weekly newspaper printed in said County, once in each of three successive weeks before the 19th day of February, 2018.

The report states the purchase price at the Foreclosure sale to be $179,000.00.

SYDNEY J. HARRISON
Clerk, Circuit Court for
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129428 (1-25,2-1,2-8)

Janelle Ryan-Colbert
9450 Marlboro Pike Suite 5
Upper Marlboro, MD 20772
301-576-6200

NOTICE OF APPOINTMENT
NOTICE TO CREDITORS
NOTICE TO UNKNOWN HEIRS

TO ALL PERSONS INTERESTED
IN THE ESTATE OF
JAMES KENNETH KELLY

Notice is given that Regina Clay, whose address is 7525 Buchanan Street, Landover Hills, MD 20784, was on January 22, 2018 appointed Personal Representative of the estate of James Kenneth Kelly who died on September 17, 2017 with a will.

Further information can be obtained by reviewing the estate file in the office of the Register of Wills or by contacting the personal representative or the attorney.

All persons having any objection to the appointment (or to the probate of the decedent's will) shall file their objections with the Register of Wills on or before the 22nd day of July, 2018.

Any person having a claim against the decedent must present the claim to the undersigned personal representative or file it with the Register of Wills with a copy to the undersigned on or before the earlier of the following dates:

(1) Six months from the date of the decedent's death, except if the decedent died before October 1, 1992, nine months from the date of the decedent's death; or

(2) Two months after the personal representative mails or otherwise delivers to the creditor a copy of this published notice or other written notice, notifying the creditor that the claim will be barred unless the creditor presents the claims within two months from the mailing or other delivery of the notice.

A claim not presented or filed on or before that date, or any extension provided by law, is unenforceable thereafter. Claim forms may be obtained from the Register of Wills.

REGINA CLAY
Personal Representative

CERETA A. LEE
REGISTER OF WILLS FOR
PRINCE GEORGE'S COUNTY
P.O. BOX 1729
UPPER MARLBORO, MD 20773-1729
Estate No. 107927

129531 (2-1,2-8,2-15)

NOTICE

Carrie M. Ward, et al.
6003 Executive Blvd., Suite 101
Rockville, MD 20852

Substitute Trustees,
Plaintiffs

vs.

ROBERT GOLSBY
4907 Grid Street
Bowie, MD 20720
Defendant(s)

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-18700

Notice is hereby given this 18th day of January, 2018, by the Circuit Court for Prince George's County, Maryland, that the sale of the property mentioned in these proceedings and described as 4907 Grid Street, Bowie, MD 20720, made and reported by the Substitute Trustee, will be RATIFIED AND CONFIRMED, unless cause to the contrary thereof be shown on or before the 19th day of February, 2018, provided a copy of this NOTICE be inserted in some weekly newspaper printed in said County, once in each of three successive weeks before the 19th day of February, 2018.

The report states the purchase price at the Foreclosure sale to be $275,000.00.

SYDNEY J. HARRISON
Clerk, Circuit Court for
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129421 (1-25,2-1,2-8)

LEGALS

NOTICE

Carrie M. Ward, et al.
6003 Executive Blvd., Suite 101
Rockville, MD 20852

Substitute Trustees,
Plaintiffs

vs.

CARMEN SUBRYAN
11400 Pitsea Drive
Beltsville, MD 20705
Defendant(s)

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-20071

Notice is hereby given this 18th day of January, 2018, by the Circuit Court for Prince George's County, Maryland, that the sale of the property mentioned in these proceedings and described as 11400 Pitsea Drive, Beltsville, MD 20705, made and reported by the Substitute Trustee, will be RATIFIED AND CONFIRMED, unless cause to the contrary thereof be shown on or before the 19th day of February, 2018, provided a copy of this NOTICE be inserted in some weekly newspaper printed in said County, once in each of three successive weeks before the 19th day of February, 2018.

The report states the purchase price at the Foreclosure sale to be $237,000.00.

SYDNEY J. HARRISON
Clerk, Circuit Court for
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129420 (1-25,2-1,2-8)

ORDER OF PUBLICATION

FNA Maryland, LLC
C/o Benjamin M. Decker, Esquire
2806 Reynolda Rd., #208
Winston-Salem, NC 27106

Plaintiff

vs.

511 ASHLEAF LLC
RAMONA YOUNG
DERRICK YOUNG
Prince George's County, Maryland

AND

Heirs, devisees, personal representatives, and executors, administrators, grantees, assigns or successors in right, title or interest and any and all persons having or claiming to have any interest in the property and premises situate, described as:

Prince George's County, described as follows: Tax Account No 5539903, SEAT PLEASANT 18TH ELECTION DISTRICT; 5,500 SQ FT JOSEPHS MANOR LOT 22 BLK A ASSMT $45,100 LIB 35043 FL 213; ADDRESS 513 ASHLEAF AVE CAPITOL HEIGHTS 20743.

Defendants

In the Circuit Court for Prince George's County, Maryland
Civil Division
Civil Action No. CAE 17-39058

The object of this proceeding is to secure the foreclosure of all rights of redemption in the following property situate, lying and being in Prince George's County, Maryland, sold by the Collector of Taxes for Prince George's County and the State of Maryland to the Plaintiff in this proceeding:

Prince George's County, described as follows: Tax Account No 5539903, SEAT PLEASANT 18TH ELECTION DISTRICT; 5,500 SQ FT JOSEPHS MANOR LOT 22 BLK A ASSMT $45,100 LIB 35043 FL 213; ADDRESS 513 ASHLEAF AVE CAPITOL HEIGHTS 20743.

The Complaint states, among other things, that the amounts necessary for redemption have not been paid.

It is thereupon this 22nd day of January, 2018, by the Circuit Court for Prince George's County, Maryland, ORDERED, That notice be given by the insertion of a copy of this Order in some newspaper having a general circulation in Prince George's County, Maryland, once a week for 3 successive weeks, on or before the 16th day of February, 2018, warning all persons interested in the property to appear in this Court by the 27th day of March, 2018, and redeem the property herein described and answer the complaint or thereafter a final judgment will be entered foreclosing all rights of redemption in the property, and vesting in the plaintiff a title, free and clear of all encumbrances.

SYDNEY J. HARRISON
Clerk of the Circuit Court for
Prince George's County, Maryland

True Copy—Test:
Sydney J. Harrison, Clerk
129493 (2-1,2-8,2-15)

NOTICE

Laura H.G. O'Sullivan, et al.,
Substitute Trustees
Plaintiffs

vs.

Cynthia Wood Russell
Defendant

IN THE CIRCUIT COURT FOR PRINCE GEORGE'S COUNTY, MARYLAND

CIVIL NO. CAEF 17-26208

ORDERED, this 22nd day of January, 2018 by the Circuit Court of PRINCE GEORGE'S COUNTY, Maryland, that the sale of the property at 6831 Milltown Court, District Heights, Maryland 20747 mentioned in these proceedings, made and reported by Laura H.G. O'Sullivan, et al., Substitute Trustees, be ratified and confirmed, unless cause to the contrary thereof be shown on or before the 22nd day of February, 2018 next, provided a copy of this notice be inserted in some newspaper published in said County once in each of three successive weeks before the 22nd day of February, 2018, next.

The report states the amount of sale to be $105,000.00.

SYDNEY J. HARRISON
Clerk of the Circuit Court
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk

129497 (2-1,2-8,2-15)

ORDER OF PUBLICATION

FNA Maryland, LLC
C/o Benjamin M. Decker, Esquire
2806 Reynolda Rd., #208
Winston-Salem, NC 27106

Plaintiff

vs.

JONATHAN M BALLARD
Prince George's County, Maryland

AND

Heirs, devisees, personal representatives, and executors, administrators, grantees, assigns or successors in right, title or interest and any and all persons having or claiming to have any interest in the property and premises situate, described as:

Prince George's County, described as follows: Tax Account No 0481432, SPAULDING 6TH ELECTION DISTRICT; 46.167 SQ FT & IMPS LITTLE WASHINGTON LOT 17 ASSMT $136,234 LIB 36001 FL 078; ADDRESS 8918 SOUTH CHERRY LN UPPER MARLBORO 20774.

Defendants

In the Circuit Court for Prince George's County, Maryland
Civil Division
Civil Action No. CAE 17-39059

The object of this proceeding is to secure the foreclosure of all rights of redemption in the following property situate, lying and being in Prince George's County, Maryland, sold by the Collector of Taxes for Prince George's County and the State of Maryland to the Plaintiff in this proceeding:

Prince George's County, described as follows: Tax Account No 0481432, SPAULDING 6TH ELECTION DISTRICT; 46.167 SQ FT & IMPS LITTLE WASHINGTON LOT 17 ASSMT $136,234 LIB 36001 FL 078; ADDRESS 8918 SOUTH CHERRY LN UPPER MARLBORO 20774.

The Complaint states, among other things, that the amounts necessary for redemption have not been paid.

It is thereupon this 22nd day of January, 2018, by the Circuit Court for Prince George's County, Maryland, ORDERED, That notice be given by the insertion of a copy of this Order in some newspaper having a general circulation in Prince George's County, Maryland, once a week for 3 successive weeks, on or before the 16th day of February, 2018, warning all persons interested in the property to appear in this Court by the 27th day of March, 2018, and redeem the property herein described and answer the complaint or thereafter a final judgment will be entered foreclosing all rights of redemption in the property, and vesting in the plaintiff a title, free and clear of all encumbrances.

SYDNEY J. HARRISON
Clerk of the Circuit Court for
Prince George's County, Maryland

True Copy—Test:
Sydney J. Harrison, Clerk
129494 (2-1,2-8,2-15)

LEGALS

NOTICE

IN THE MATTER OF:
Sheila Jeannette Escobar

FOR THE CHANGE OF
NAME TO:
Sheila Jeannette Lopez Escobar

In the Circuit Court for Prince George's County, Maryland

Case No. CAE 18-01860

A petition has been filed to change the name of (Minor Child(ren)) Sheila Jeannette Escobar to Sheila Jeannette Lopez Escobar.

The latest day by which an objection to the petition may be filed is February 26, 2018.

Sydney J. Harrison
Clerk of the Circuit Court for
Prince George's County, Maryland
129599 (2-8)

NOTICE

IN THE MATTER OF:
Rey LaMarr Gillespie Jr.
Annette Cuffee

FOR THE CHANGE OF
NAME TO:
Ray Sharif
Annette Sharif

In the Circuit Court for Prince George's County, Maryland

Case No. CAE 18-02009

A petition has been filed to change the name of Rey LaMarr Gillespie Jr. to Ray Sharif and Annette Cuffee to Annette Sharif.

The latest day by which an objection to the petition may be filed is February 26, 2018.

Sydney J. Harrison
Clerk of the Circuit Court for
Prince George's County, Maryland
129600 (2-8)

LEGALS

NOTICE

Edward S. Cohn
Stephen N. Goldberg
Richard E. Solomon
Richard J. Rogers
Michael McKeefery
Christianna Kersey
600 Baltimore Avenue, Suite 208
Towson, MD 21204
Substitute Trustees,
Plaintiffs

v.

Shirley A. Ripley
8495 Greenbelt Road, Unit 102
Greenbelt, MD 20770
Defendant

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-31803

Notice is hereby given this 11th day of January, 2018, by the Circuit Court for Prince George's County, that the sale of the property mentioned in these proceedings, made and reported, will be ratified and confirmed, unless cause to the contrary thereof be shown on or before the 12th day of February, 2018, provided a copy of this notice be published in a newspaper of general circulation in Prince George's County, once in each of three successive weeks before the 12th day of February, 2018.

The Report of Sale states the amount of the foreclosure sale price to be $72,200.00. The property sold herein is known as 8495 Greenbelt Road, Unit 102, Greenbelt, MD 20770.

SYDNEY J. HARRISON
Clerk of the Circuit Court
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129330 (1-25,2-1,2-8)

NOTICE

Edward S. Cohn
Stephen N. Goldberg
Richard E. Solomon
Richard J. Rogers
Michael McKeefery
Christianna Kersey
600 Baltimore Avenue, Suite 208
Towson, MD 21204
Substitute Trustees,
Plaintiffs

v.

Luis A. Rios
12105 Tawny Lane
Bowie, MD 20715
Defendant

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-26157

Notice is hereby given this 18th day of January, 2018, by the Circuit Court for Prince George's County, that the sale of the property mentioned in these proceedings, made and reported, will be ratified and confirmed, unless cause to the contrary thereof be shown on or before the 19th day of February, 2018, provided a copy of this notice be published in a newspaper of general circulation in Prince George's County, once in each of three successive weeks before the 19th day of February, 2018.

The Report of Sale states the amount of the foreclosure sale price to be $209,500.00. The property sold herein is known as 12105 Tawny Lane, Bowie, MD 20715.

SYDNEY J. HARRISON
Clerk of the Circuit Court
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129419 (1-25,2-1,2-8)

LEGALS

FIVE-YEAR REVIEW OF ENVIRONMENTAL RESTORATION
BEAVER DAM ROAD LANDFILL
BELTSVILLE AGRICULTURAL RESEARCH CENTER
BELTSVILLE, MD 20705

The Beltsville (MD) Agricultural Research Center (BARC), a part of the U.S. Department of Agriculture's Agricultural Research Service, is beginning a five-year review of its environmental restoration of the Beaver Dam Road Land Fill (BDRLF). This location is about a 14-acre area of concern that is part of BARC' National Priorities Listing (Superfund) by the U.S. Environmental Protection Agency.

From the early 1940s through the 1980s, the BDRLF was used for disposal of nonhazardous materials such as rubble from masonry construction debris, tree clippings, wood, and broken asphalt from BARC operations. A Remedial Investigation also identified a plume of groundwater contaminated with trichloroethylene (TCE) up to a maximum concentration of 1,100 parts per billion (ppb). The plume impacts an area of about two-thirds of an acre to the southeast of the BDRLF. The Safe Drinking Water Act calls for a maximum contaminant level for TCE of 5 ppb; which is the cleanup goal for the site, although there are no drinking water wells in the area. To meet this goal, a remedy that included installation of a passive groundwater treatment system with a permeable reactive barrier (PRB) or "biowall" that captures and remediates TCE was selected and implemented. The biowall is currently in place and is undergoing performance monitoring.

The five-year review will include an examination of the BDRLF's Record of Decision, a review of site conditions and the effectiveness of the biowall. It is being conducted between February 1, 2018 and February 28, 2018.

All published data on the BDRLF and other BARC NPL/Superfund areas of concern are available for inspection at:

Information Repository
Building 003, Room 313
10300 Baltimore Avenue
Beltsville Agricultural Research Center
Beltsville, MD 20705

Open: Monday through Friday: 8:30 am to 4:30 pm
Facility Contacts:
Dana Jackson, Senior Remedial Project Manager
Phone: (301) 501-6025, dana.jackson@ars.usda.gov
Clyde Lathon - Safety Occupational Health and Environmental Manager
Phone: (301) 504-6262, clyde.lathon@ars.usda.gov

Comments and questions about the review may be directed to or for more information about BARC's listing as a National Priorities Site/Superfund Site, contact: Kim Kaplan, ARS Office of Communications, Room 1-2253, 5601 Sunnyside Ave. Beltsville, MD 20705; (301) 504-1637, Kim.Kaplan@ars.usda.gov.

129608 (2-8)

NOTICE

Edward S. Cohn
Stephen N. Goldberg
Richard E. Solomon
Richard J. Rogers
Michael McKeefery
Christianna Kersey
600 Baltimore Avenue, Suite 208
Towson, MD 21204
Substitute Trustees,
Plaintiffs

v.

Ronald A. Johnson
12213 Pheasant Run Drive
Laurel, MD 20708
Defendant

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-29253

Notice is hereby given this 29th day of January, 2018, by the Circuit Court for Prince George's County, that the sale of the property mentioned in these proceedings, made and reported, will be ratified and confirmed, unless cause to the contrary thereof be shown on or before the 1st day of March, 2018, provided a copy of this notice be published in a newspaper of general circulation in Prince George's County, once in each of three successive weeks before the 1st day of March, 2018.

The Report of Sale states the amount of the foreclosure sale price to be $181,122.00. The property sold herein is known as 12213 Pheasant Run Drive, Laurel, MD 20708.

SYDNEY J. HARRISON
Clerk of the Circuit Court
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129559 (2-8,2-15,2-22)

NOTICE

Edward S. Cohn
Stephen N. Goldberg
Richard E. Solomon
Richard J. Rogers
Michael McKeefery
Christianna Kersey
600 Baltimore Avenue, Suite 208
Towson, MD 21204
Substitute Trustees,
Plaintiffs

v.

Timothy L. Capino
12006 Towanda Lane
Bowie, MD 20715
Defendant

In the Circuit Court for Prince George's County, Maryland
Case No. CAEF 17-12545

Notice is hereby given this 29th day of January, 2018, by the Circuit Court for Prince George's County, that the sale of the property mentioned in these proceedings, made and reported, will be ratified and confirmed, unless cause to the contrary thereof be shown on or before the 1st day of March, 2018, provided a copy of this notice be published in a newspaper of general circulation in Prince George's County, once in each of three successive weeks before the 1st day of March, 2018.

The Report of Sale states the amount of the foreclosure sale price to be $294,175.00. The property sold herein is known as 12006 Towanda Lane, Bowie, MD 20715.

SYDNEY J. HARRISON
Clerk of the Circuit Court
Prince George's County, MD
True Copy—Test:
Sydney J. Harrison, Clerk
129560 (2-8,2-15,2-22)

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Appendix D

Interview Forms

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Five Year Review Stakeholder Interview Form
For Environmental Restoration at Beltsville Agricultural Research Center
Beltsville, MD 20705

NAME: _David Johnson____________________
ORGANIZATION: _BARC-ARS____________________
POSITION _Security Officer___

INTERACTIONS WITH BDRLF:

GOES ONSITE	~~**YES**~~	**NO**	**IF YES, WHAT**:_________________
ACTIVITIES OFFSITE	~~**YES**~~	**NO**	**IF YES, WHAT**:_________________

OBSRVATIONS

ACCESS AND SITE CONTROLS:	Familiar with fencing, but only limited knowledge about purpose and scope.
SITE MAINTENANCE:	Site appears to be maintained.
PROBLMS/CONCERNS	No observed problems or concerns.

OTHER ISSUES THAT COULD AFFECT PROTECTIVENESS

No known issues or observations that would be associated with the remedy's protectiveness. He observed no signs of dumping or trespass in the area of the former landfill or area of the remedy.

INTERVIEW NOTES

Does want additional information regarding purpose and responsibility for maintenance of fencing and gate controls. If the controls are for Security or Environmental they will have different levels of responsibility.

Primary questions to be answered in FYR:

- *Successes/problems in the implementation of access and ICs*
- *Successes/problems with the construction of the remedy and/or O&M*
- *Unusual situations or problems at the site*

INTERVIEW DATE: **11/28/2017**
INTERVIEWER: **JASON LORENZETTI**

Five Year Review Stakeholder Interview Form
For Environmental Restoration at Beltsville Agricultural Research Center
Beltsville, MD 20705

NAME: Mike Dudley_____
ORGANIZATION: USDA Wildlife Management___
POSITION: Biological Science technician "Wildlife" _____

INTERACTIONS WITH BDRLF:

GOES ONSITE **YES** ~~**NO**~~ **IF YES, WHAT:** INSPECTION of hunting areas, less than 1/Year

ACTIVITIES OFFSITE **YES** ~~**NO**~~ **IF YES, WHAT:** INSPECTION of hunting areas, multiple times per year (once per season).

OBSRVATIONS

ACCESS AND SITE CONTROLS: Fencing prevents access, no comment on additional signage or fencing.

SITE MAINTENANCE: The site appears to be well maintained**.**

PROBLMS/CONCERNS No problems or concerns with the site.

OTHER ISSUES THAT COULD AFFECT PROTECTIVENESS

Mr. Dudley did not report any concerns that could affect protectiveness. He has not noted any hunting, trespassing, or dumping on the site.

INTERVIEW NOTES

Hunt is permitted to the sides of BDRLF, one side is for employees and the other is for public users, but no hunting is permitted on the landfill or biowall area. The hunting areas are presented on a publically available map published by BARC; and clearly show no hunting on the BDRLF site, including the remedy area. Mr. Dudley stated that he has seen no evidence of hunters accessing the site.

Primary questions to be answered in FYR:

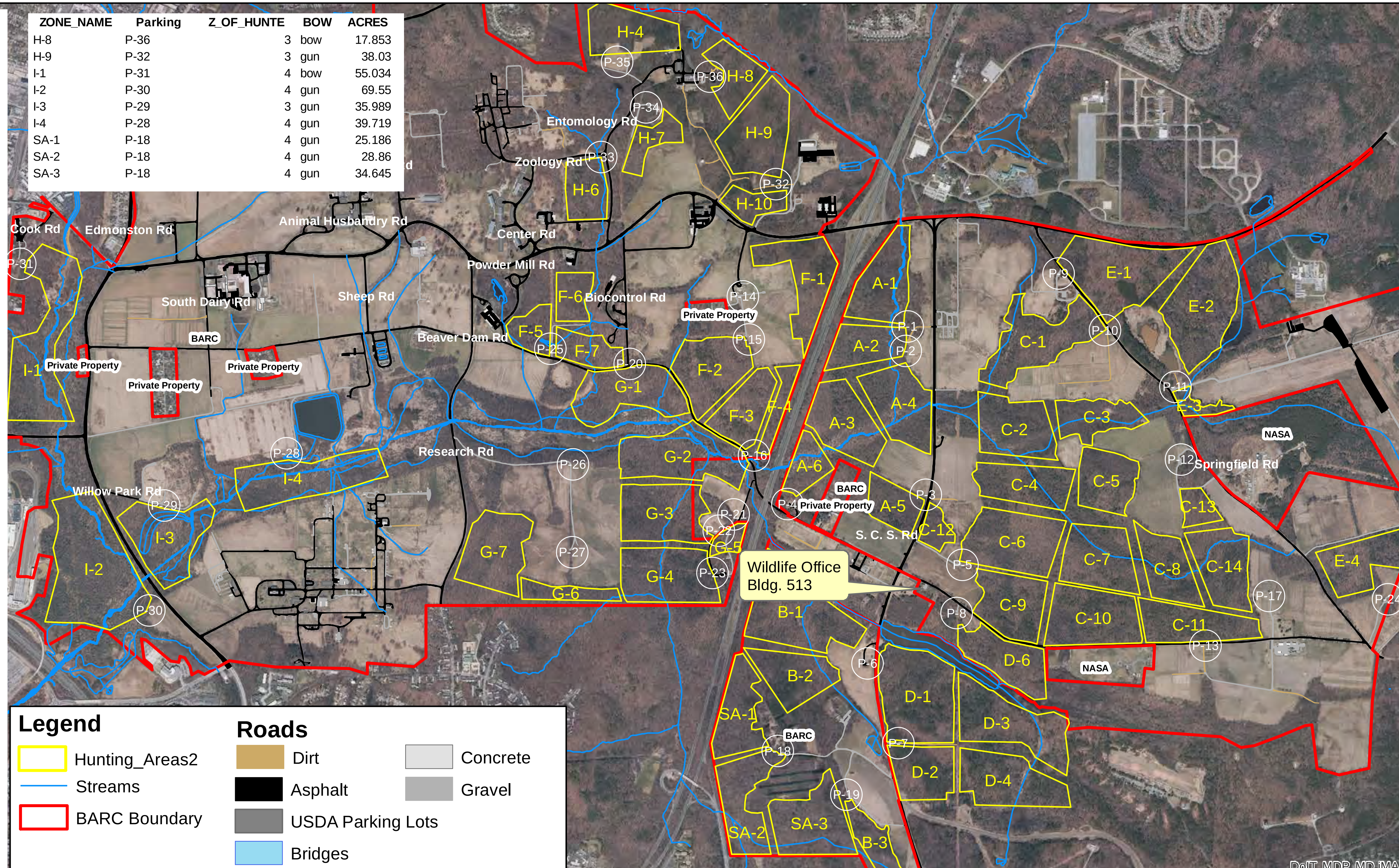
- *Successes/problems in the implementation of access and ICs*
- *Successes/problems with the construction of the remedy and/or O&M*
- *Unusual situations or problems at the site*

INTERVIEW DATE: **__11/22/2017__________________________**
INTERVIEWER: **__R. JASON LORENZETTI (BMT)______________**

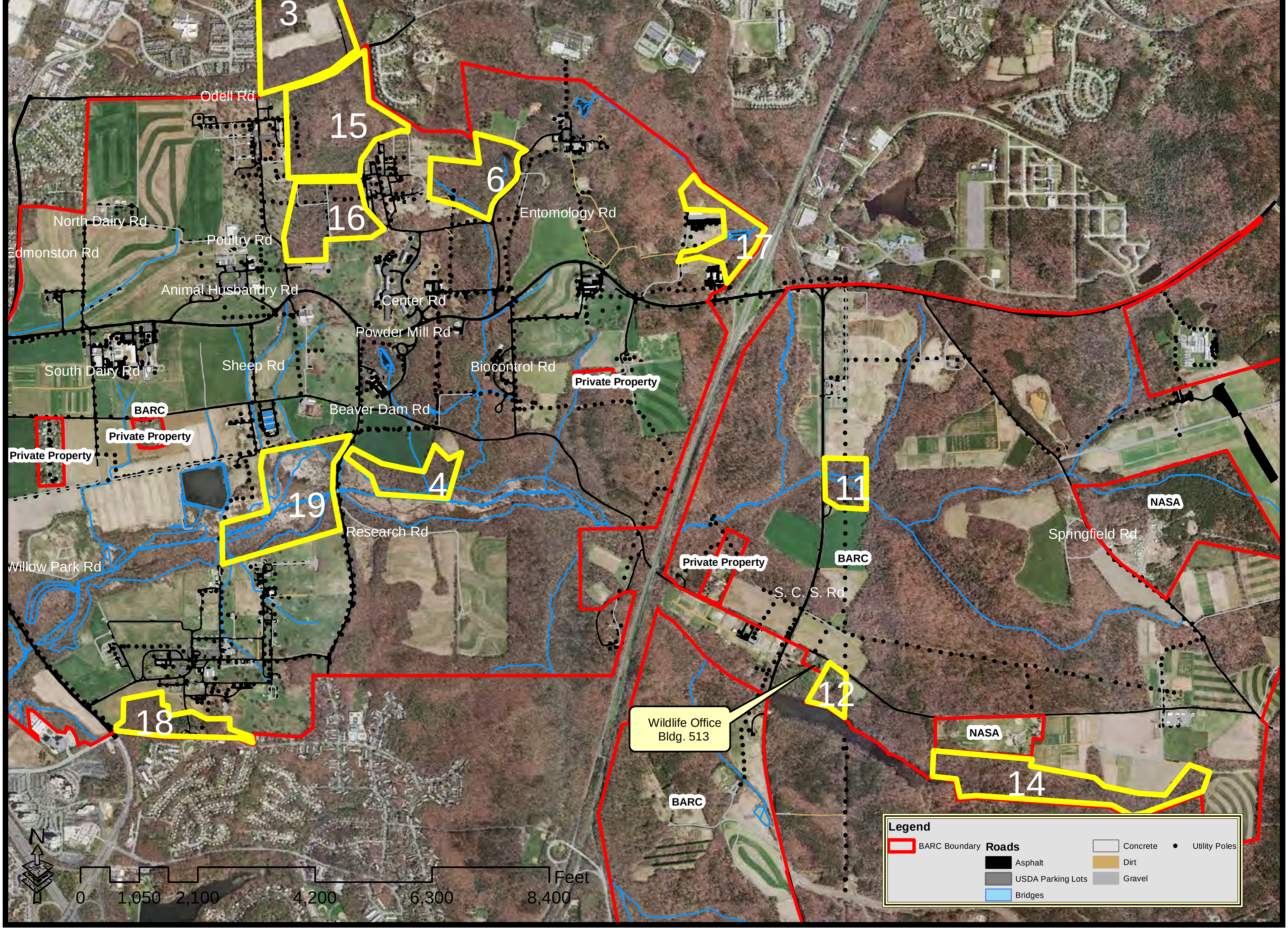
BARC Public Hunting Areas

ZONE_NAME	Parking	Z_OF_HUNTE	BOW	ACRES
A-1	P-1	3	gun	29.571
A-2	P-2	2	gun	19.913
A-3	P-4	3	gun	30.541
A-4	P-2	3	gun	30.534
A-5	P-3	2	gun	15.922
A-6	P-4	2	bow	12.977
B-1	P-6	4	gun	48.786
B-2	P-6	3	gun	24.969
B-3	P-19	2	bow	13.819
C-1	P-10	4	gun	39.004
C-10	P-5	3	gun	36.29
C-11	P-13	3	bow	28.06
C-12	P-5	2	bow	7.298
C-13	P-12	2	bow	8.087
C-14	P-17	3	gun	28.287
C-2	P-12	3	gun	30.569
C-3	P-12	2	gun	19.839
C-4	P-5	3	gun	26.229
C-5	P-12	3	gun	23.794
C-6	P-5	4	gun	38.667
C-7	P-5	3	gun	31.182
C-8	P-12	3	gun	23.499
C-9	P-5	3	gun	28.727
D-1	P-7	4	gun	47.822
D-2	P-7	2	gun	23.2
D-3	P-7	4	gun	39.979
D-4	P-7	4	gun	34.391
D-6	P-8	2	gun	26.158
E-1	P-9	4	gun	45.954
E-2	P-11	4	gun	46.295
E-3	P-11	2	bow	5.555
E-4	P-24	3	gun	27.802
F-1	P-14	3	bow	30.575
F-2	P-15	3	gun	31.026
F-3	P-16	2	gun	22.076
F-4	P-16	2	bow	8.735
F-5	P-25	2	bow	11.939
F-6	P-25	2	bow	11.913
F-7	P-25	2	bow	13.748
G-1	P-20	4	gun	34.836
G-2	P-21	4	gun	40.984
G-3	P-22	4	gun	35.098
G-4	P-23	4	gun	36.628
G-5	P-22	2	bow	5.26
G-6	P-27	2	bow	10.254
G-7	P-27	4	gun	33.134
H-10	P-32	2	bow	11.213
H-4	P-35	2	bow	27.258
H-6	P-33	2	bow	17.486
H-7	P-34	2	gun	11.976

ZONE_NAME	Parking	Z_OF_HUNTE	BOW	ACRES
H-8	P-36	3	bow	17.853
H-9	P-32	3	gun	38.03
I-1	P-31	4	bow	55.034
I-2	P-30	4	gun	69.55
I-3	P-29	3	gun	35.989
I-4	P-28	4	gun	39.719
SA-1	P-18	4	gun	25.186
SA-2	P-18	4	gun	28.86
SA-3	P-18	4	gun	34.645



BARC Employee Hunting Area



Appendix E

LUC Inspection Report

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BARC ANNUAL SITE INSPECTION

Beaverdam Road Landfill

2017

In accordance with the Land Use Control Implementation Plan (LUCIP) for the Beaverdam Road Landfill (BDRLF) the annual inspection of the site was conducted on November 21, 2017. Refer to the LUCIP for detailed requirements. Land use restrictions include the following:

- Access restrictions assessments at the site.
- No residential or industrial use at the site.
- No potable use of groundwater on the installation.
- No installation of groundwater withdrawal wells at the site.

Verification that land use restrictions are being accomplished and LUCs remain effective:

- Verify that any boundary fence in the site vicinity is intact.
- Verify that no residential housing, development activities are occurring at the site.
- Verify that no groundwater wells have been installed (except for monitoring wells installed as part of the remedy) and that no consumptive use of groundwater is occurring.
- Verify that applicable LUCs are intact, meet specifications, and/or are in good working order.
- Inspect the BDRLF cover, biowall, water management, and other features. Note deficiencies/corrective actions below:

Inspection Notes

The site inspection was performed on both the interior and exterior portions of the BDRLF in accordance with the LUC Plan for the site. The exterior of the site was examined for security and to ensure all LUC control features were intact (i.e. signage, locks, gates). ARS has proposed additional signage on the north, west, and southwest of the site.

Description and location of any intrusive activities that are apparent or observed:

There was no evidence of intrusive activities at the BDRLF.

Description and location of any deficiency or violation of the land use restrictions:

The northern chain link security gate off of Beaverdam Road is intact, but in poor condition (overgrown vegetation, rusted and bent fence posts). Stated in the Record of Decision (ROD) under Section 2.4, It states "access restrictions would include complete site enclosure enforced by fencing and signage". Although the gate and fencing along Beaverdam Road is not typically used for access to the site, ARS should consider repairing the gate and adjacent fencing, as well as improving signage on this gate. Fencing along the western boundary of the landfill has been damaged due to tree falls, and in some locations is no longer a barrier to entry. Likewise, there is a gap in the fence line to the immediate west of the Beaverdam Road gate; this gap may need to be filled in.

Other issued noticed during the inspection and to be addressed in the near future, include;

- Silt fence running the length of the biowall to the south that needs to be repaired or removed,
- Two transect wells with missing locks,
- Landfill boundary monitoring well MW-4 damaged beyond repair by ARS tractor, and
- BW10 has been out of commission since last inspection, ARS is considering reinstalling BW10.

Figure 1 shows the location of the northern fence section as well as all onsite monitoring wells and biowall wells.

Description of any proposed measures or corrective actions taken to remediate a deficiency or violation.

ARS will consider repairing the fence as well as taking out the northern gate. The gate has not been used since the implementation of the landfill.

Locks will be purchased and secured on the two transect wells.

ARS should consider abandoning MW4. MW4 has not had detections of VOCs above their respective MCLs in the past several sampling events. If required to be maintained as a landfill boundary well, MW4 will be relocated upgradient to the tree line in order to prevent future damage.

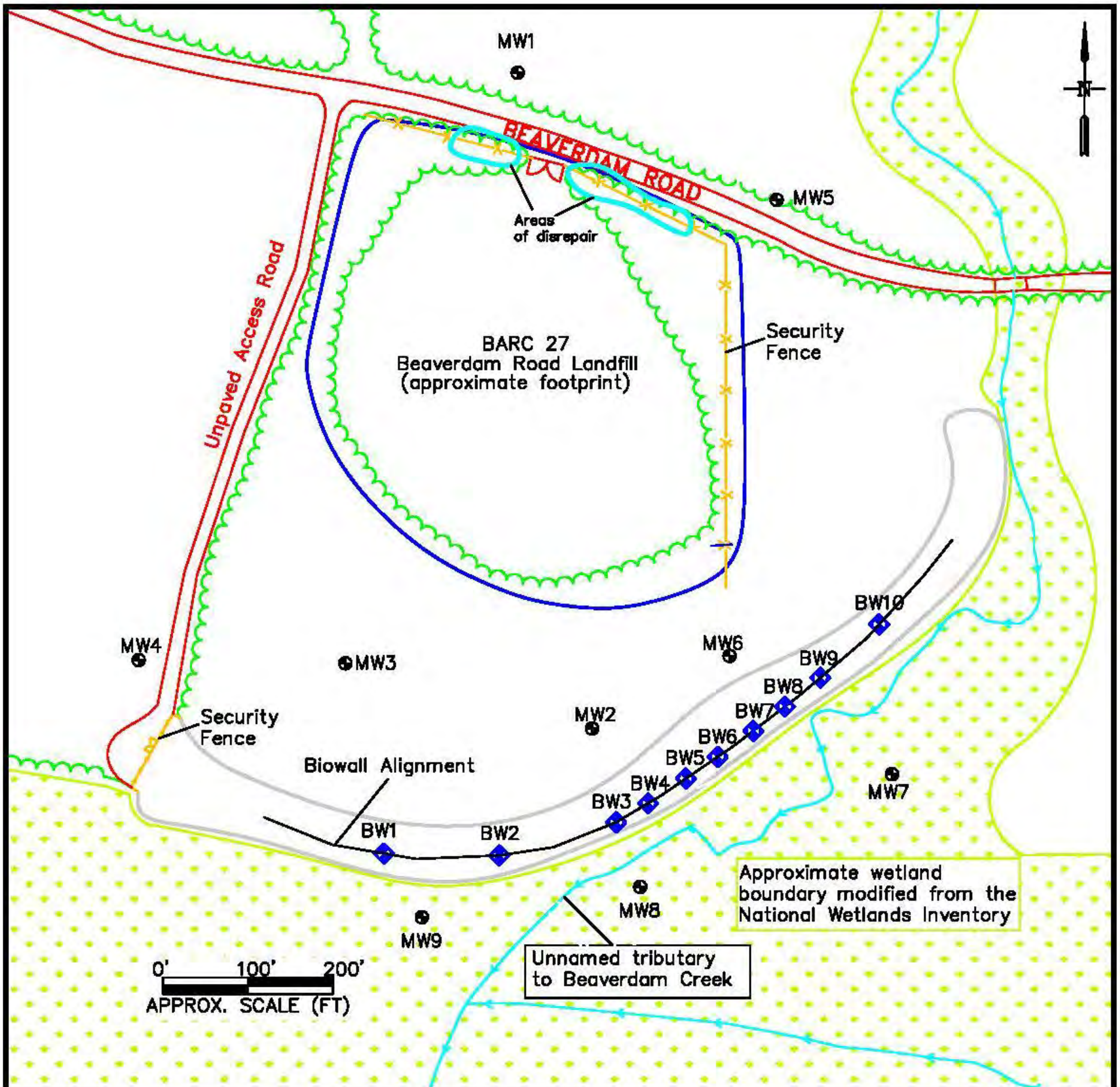

FIGURE 1

BARC 27:
Beaverdam Road Landfill
Fence Location Map

LEGEND

- Biowall Clearing Outline
- Fence
- Stream
- Biowall
- AOC Boundary
- Treeline
- Paved Road
- Existing Monitoring Well
- Biowall Monitoring Well
- Approximate Location of Fence Disrepair
- Approximate Wetland Boundary Modified from the National Wetlands Inventory

Beltsville Agricultural Research Center

BMT Designers & Planners

SEE ADMINISTRATIVE RECORD FOR SIGNED LUCIP

Certification Statement:

I, the undersigned, document that the inspection was performed as indicated above, and that the above information is true and correct to the best of my knowledge and belief. I have reviewed the provisions of the BDRLF LUCIP to verify requirements and restrictions.

Inspector: Justin Idzenga, Geologist

Signature: ________________________________ Date: ______________

Name and Title: Dana Jackson, Remedial Project Manager

Signature: _________________________________ Date:_______________

Within 30 days of the inspection, completed annual site inspection forms shall be sent to:

U.S. Environmental Protection Agency, Region 3
Attention: Mr. Jeffery Boylan
Remedial Project Manager
1650 Arch Street
Philadelphia, PA 19103

PHOTOGRAPH 01: Damaged fence on the northern edge of the Beaver Dam Road Land Fill

PHOTOGRAPH 01: Access road facing North. Landfill to the east behind heavy vegetation.

PHOTOGRAPH 03: Security Fence leading in the Biowall area.

PHOTOGRAPH 04: Damaged Monitoring well MW-4.

PHOTOGRAPH 05: Transect Wells running perpendicular to the biowall. The transect well second to the right is missing a lock.

PHOTOGRAPH 06: Biowall facing east.

PHOTOGRAPH 07: MW10 near Beaver Dam Creek tributary. MW10 is missing a lock