Prepared for
Nevada Environmental Response Trust
Henderson, Nevada

Prepared by
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December 8, 2017

ANNUAL REMEDIAL PERFORMANCE REPORT FOR CHROMIUM AND PERCHLORATE

NEVADA ENVIRONMENTAL RESPONSE TRUST SITE HENDERSON, NEVADA

RAMBOLL ENVIRON

Annual Remedial Performance Report for Chromium and Perchlorate

Nevada Environmental Response Trust Site (Former Tronox LLC Site) Henderson, Nevada

Nevada Environmental Response Trust (NERT) Representative Certification
I certify that this document and all attachments submitted to the Division were prepared at the request of, or under the direction or supervision of NERT. Based on my own involvement and/or my inquiry of the person or persons who manage the system(s) or those directly responsible for gathering the information or preparing the document, or the immediate supervisor of such person(s), the information submitted and provided herein is, to the best of my knowledge and belief, true, accurate, and complete in all material respects.

Office of the Nevada Environmental Response Trust

Le Petomane XXVII, Inc., not individually, but solely in its representative capacity as the Nevada Environmental Response Trust Trustee

Signature: ______________________, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Name: Jay A. Steinberg, not individually, but solely in his representative capacity as President of the Nevada Environmental Response Trust Trustee

Title: Solely as President and not individually

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Date: 12/6/17

Annual Remedial Performance Report for Chromium and Perchlorate

Nevada Environmental Response Trust Site
(Former Tronox LLC Site)
Henderson, Nevada

Responsible Certified Environmental Manager (CEM) for this project

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and, to the best of my knowledge, comply with all applicable federal, state and local statutes, regulations and ordinances.

___________________________________   _____12/08/17_______________________

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Annual Remedial Performance Report for
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Date	**December 8, 2017**
Prepared by	**Ramboll Environ**
Description	**Annual Remedial Performance Memorandum For Chromium and Perchlorate**

Project No **21-41400A**

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ACRONYMS AND ABBREVIATIONS

ARP	Athens Road Piezometer
AMPAC/Endeavour	American Pacific Corporation/Endeavour LLC
AWF	Athens Road Well Field
bgs	below ground surface
BMI	Black Mountain Industrial
BMP	Best Management Practice
BRC	Basic Remediation Company LLC
BTU	British thermal unit
CD	compact disc
CEM	Certified Environmental Manager
CO_2	carbon dioxide
COH	City of Henderson
COPC	chemical of potential concern
DO	dissolved oxygen
DVSR	Data Validation Summary Report
EDD	Electronic Data Deliverable
Envirogen	Envirogen Technologies, Inc.
ENVIRON	ENVIRON International Corporation
FBR	fluidized bed reactor
gpm	gallons per minute
GWETS	groundwater extraction and treatment system
GWTP	Groundwater Treatment Plant
HAP	hazardous air pollutants
IWF	Interceptor Well Field
IX	ion exchange
lbs	pounds
lbs/day	pounds per day
MCL	maximum contaminant level
mg/L	milligrams per liter
MWh	Megawatt Hours
NDEP	Nevada Division of Environmental Protection

NERT	Nevada Environmental Response Trust
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
ORP	oxidation reduction potential
OSSM	Olin/Stauffer/Syngenta/Montrose
OU	Operable Unit
PM	particulate matter
Qal	Quaternary alluvium
Ramboll Environ	Ramboll Environ US Corporation
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
SEFA	Spreadsheets for Environmental Footprint Analysis
Site	Nevada Environmental Response Trust Site
SNWA	Southern Nevada Water Authority
SO_x	sulfur oxides
SQL	sample quantitation limit
SWF	Seep Well Field
TDS	total dissolved solids
Tetra Tech	Tetra Tech, Inc.
TIMET	Titanium Metals Corporation
Tronox	Tronox LLC
Trust	Nevada Environmental Response Trust
µg/L	micrograms per liter
UMCf	Upper Muddy Creek Formation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	volatile organic compound
WBZ	water-bearing zone
WRF	Water Reclamation Facility

1. INTRODUCTION

Ramboll Environ US Corporation (Ramboll Environ) submits this remedial performance report to the Nevada Division of Environmental Protection (NDEP) on behalf of the Nevada Environmental Response Trust (the Trust or NERT) for the Nevada Environmental Response Trust Site (the Site). The Site is located within the Black Mountain Industrial (BMI) Complex in unincorporated Clark County and is surrounded by the city of Henderson, Nevada.

A revised groundwater monitoring program for the Site was presented in the 2016 Groundwater Monitoring Optimization Plan (Ramboll Environ 2016b), which was approved by NDEP on June 24, 2016. The plan proposed replacing the semi-annual remedial performance reports with semi-annual performance memoranda, containing streamlined data transmittals and summaries of remedial performance with respect to the performance metrics.[1] The first such streamlined semi-annual performance memorandum was submitted in April 2017. Similar to past annual reports, this report expands upon the information included in the semi-annual performance memorandum and contains additional text, tables, and figures documenting groundwater conditions at the Site and downgradient of the Site, the status of remediation efforts, and a detailed performance evaluation of the GWETS.

Sections 3 through 7 of this report present evaluations of groundwater conditions and concentration trends. These evaluations are aided by the presentation of a potentiometric surface map and isoconcentration maps for chromium, perchlorate, chloroform, and total dissolved solids (TDS). Similar to previous annual reports, concentration trends are discussed at various well lines within the plume, beginning in the southern portion of the plume and progressing downgradient to the north towards Las Vegas Wash. As requested by NDEP in the December 6, 2016 comment letter on the previous Annual Report (NDEP 2016), this report incorporates statistical analyses of the trends observed at these well lines. The well lines for which trends were evaluated were selected based on the locations of available data, and are generally similar to the well lines evaluated in previous Annual Reports, as discussed in more detail in Sections 4 through 7.

Section 8 presents an evaluation of GWETS performance with respect to the performance metrics. The performance evaluation presented is generally similar to evaluations presented in prior reports, with the exception of the evaluation of estimated mass flux, which has been expanded in response to NDEP's request in the December 6, 2016 comment letter on the previous Annual Report (NDEP 2016). NDEP requested that additional transects be evaluated to estimate horizontal flux, and that vertical flux also be evaluated, for both perchlorate and chromium. The additional mass flux transects requested by NDEP differ slightly from the well lines discussed in Sections 4 through 7, but are generally in the same vicinity.

[1] Performance metrics were developed as part of the 2013 GWETS Optimization Work Plan (ENVIRON 2013c), approved by NDEP on December 3, 2013 (NDEP 2013). These performance metrics differ from the metrics being utilized as part of NERT's monthly GWETS operations reporting, which were developed by Tetra Tech and included in their Enhanced Operational Metrics Proposal dated August 20, 2014 (Tetra Tech 2014).

For the purposes of the ongoing Remedial Investigation and Feasibility Study (RI/FS), two investigation areas were defined in 2014: the NERT On-Site Study Area (equivalent to the NERT Site boundary) and the NERT Off-Site Study Area.[2] Two additional study areas have also been defined: the Downgradient Study Area (investigations beginning in 2016) and the Eastside Study Area (investigations to begin in late 2017). At the direction of NDEP, the Trust will revise and expand the current performance metrics reported in the semi-annual performance memoranda and annual performance reports to incorporate all of these study areas. A technical memorandum describing an updated framework for estimating contaminant mass and evaluating remedial performance metrics was submitted on October 5, 2017, and approved by NDEP on October 19, 2017. The framework will be used to evaluate remedial performance once sufficient data are available from the Downgradient Study Area investigation, the Phase 2 RI, and the Phase 3 RI (Eastside Study Area investigation) according to the schedule outlined in the memorandum and discussed in Section 9. It is anticipated that these metrics and related reporting will again be revised as the Trust develops and implements a final remedy in the early 2020s.

1.1 Purpose

This report describes the performance of the groundwater extraction and treatment system (GWETS)[3] in removing and treating groundwater contaminated with perchlorate and hexavalent chromium. The primary infrastructure of the GWETS was completed by Kerr-McGee Chemical Corporation in the early 2000s in accordance with an Order issued by NDEP. The GWETS currently serves as an interim measure designed to capture the highest concentrations of perchlorate and hexavalent chromium. This report, covering the period July 2016 through June 2017, presents data collected during this period while providing discussion of groundwater conditions in the vicinity of the Site and GWETS performance relative to the established performance metrics.

1.2 Organization

This report is provided in both hard copy and electronic forms. Where electronic files are referenced or information is stated as provided on compact disc (CD), this information is contained on the CD attached to the hard copy report.

This report is organized as follows:

- **Section 1** presents the purpose and organization of the report.
- **Section 2** provides a summary of GWETS operations during the reporting period.
- **Section 3** presents area groundwater conditions during the reporting period.
- **Section 4** provides a summary of the chromium removal and extent during the reporting period.

[2] The NERT Off-Site Study Area was formerly defined in the RI/FS Work Plan (ENVIRON 2014) as the Downgradient Plume Area, and has been referred to in prior performance evaluations as the Off-Site NERT RI Study Area.

[3] Herein "GWETS" will be used to refer to the entirety of all systems and components of the groundwater extraction and treatment systems owned by the Trust, both on-site and off-site, including extraction well fields, treatment facilities, and groundwater conveyance systems.

- **Section 5** provides a summary of the perchlorate removal and extent during the reporting period.
- **Section 6** provides a summary of the extent of chloroform and other volatile organic compounds (VOCs) during the reporting period.
- **Section 7** presents a discussion on other measured parameters, including TDS, chlorate, and nitrate.
- **Section 8** provides an evaluation of GWETS performance relative to the established performance metrics.
- **Section 9** provides an update on ongoing and proposed future activities related to the GWETS and groundwater monitoring program.
- **Section 10** lists citations for key documents referenced in this memorandum.
- **The Electronic Map** (on the CD) is a Google Earth compatible file showing the locations of all former and current wells in the vicinity.
- **Appendix A** contains Table A-1, which has five quarters of analytical and groundwater elevation data, including data from the Phase 1 RI supplementary sampling events conducted in second and third quarter 2016 (Phase 1 RI supplementary sampling). Table A-2 contains VOC analytical data from the second quarter annual sampling event and the third quarter 2016 Phase 1 RI supplementary sampling. Table A-3 includes groundwater field parameters (e.g., dissolved oxygen [DO], oxygen reduction potential [ORP], temperature, pH, conductivity) collected as part of the groundwater sampling events conducted between November 2016 and June 2017. Table A-4 contains supplemental second quarter 2017 analytical and groundwater elevation data collected by American Pacific Corporation/Endeavour LLC (AMPAC/Endeavour), Olin/Stauffer/Syngenta/Montrose (OSSM), Titanium Metals Corporation (TIMET), and Southern Nevada Water Authority (SNWA), which was used in the preparation of this report. Table A-4 also includes additional 2016 data received from AECOM and 2014-2015 data from Basic Remediation Company LLC (BRC).
- **Appendix B** (on the CD) contains well data sheets for monitoring and extraction wells, which show groundwater elevations, perchlorate concentrations, and chromium concentrations over time for each well, in addition to well construction details and the location of the Upper Muddy Creek Formation (UMCf) contact. In addition, extraction wells' pumping rates, specific capacities, and estimated mass removals of perchlorate and chromium over time are shown.
- **Appendix C** contains statistical trends for water levels and analytical data at well locations in the groundwater monitoring program.
- **Appendix D** (on the CD) contains the field records from the first and second quarter 2017 groundwater monitoring program events.
- **Appendix E** (on the CD) contains the Data Validation Summary Report (DVSR).
- **Appendix F** (on the CD) contains the Electronic Data Deliverable (EDD), which includes an Access© compatible data file containing analytical results, an Access© compatible data file containing water level monitoring data, and analytical lab reports for the first and second quarter 2017 groundwater monitoring program events.

- **Appendix G** (on the CD) contains an inventory of energy and materials used, wastes generated, and activities and services conducted at the Site for the purpose of an environmental footprint analysis for July 2017 through June 2017 conducted using the United States Environmental Protection Agency (USEPA) Spreadsheets for Environmental Footprint Analysis (SEFA).

2. MONITORING AND OPERATIONS SUMMARY

This section provides a summary of groundwater monitoring and GWETS operations during the period of performance from July 2016 through June 2017 (the reporting period).

2.1 Groundwater Monitoring Program Summary

Detailed information regarding the Site's groundwater monitoring program (including the scope of sampling events, key roles and responsibilities, and data collection procedures) are described in the Remedial Performance Groundwater Sampling and Analysis Plan (Ramboll Environ 2017a), which was approved by NDEP on April 7, 2017. Figure 1 shows the locations of all monitoring wells included in the previous and current revised monitoring programs. The electronic map, included on CD, shows the locations of all former and current wells in the vicinity.

2.2 Groundwater Extraction

The GWETS utilizes three groundwater capture well fields, as shown on Figure 1: the Interceptor Well Field (IWF); the Athens Road Well Field (AWF); and the Seep Well Field (SWF). The IWF coupled with the on-site bentonite-slurry groundwater barrier wall (the "barrier wall") provides capture of the highest concentrations of perchlorate and chromium and significantly reduces the amount of perchlorate and chromium in downgradient groundwater. The off-site AWF, located approximately 8,200 feet downgradient of the IWF, captures significantly lower concentrations of both perchlorate and chromium, but operates at higher extraction rates than the IWF, resulting in significant contributions to overall perchlorate mass removal from the environment and mitigation of perchlorate migration in groundwater. The SWF, located in close proximity to Las Vegas Wash, operates at the highest extraction rate of the three well fields, but captures groundwater containing significantly lower perchlorate concentrations.

The AP Area Soil Flushing Treatability Study, located approximately 300 feet south of the IWF just west of AP-5, was implemented in 2016. Initial soil flushing and extraction well testing was conducted in October 2016, with continuous operation in Plot 1 beginning in November 2016. Flushing and extraction in Plot 2 began in July 2017. Average extraction rates, concentrations, and total mass removal from the AP Area are reported in the GWETS operation monthly reports submitted to NDEP (Envirogen 2016b, 2017a-g).

Average discharge rates for the IWF, AWF, SWF, and AP Area during the reporting period and from the previous four years are shown in Table 1, Table 2, Table 3, and Table 4, respectively. Monthly extraction rates during the reporting period for individual IWF, AWF, SWF, and AP Area wells are presented in Table 5.

During the reporting period, the combined discharge rate of the IWF averaged 62.4 gallons per minute (gpm), which is generally consistent with the prior reporting period. As seen in Table 5, average monthly IWF extraction rates generally ranged from 58.6 to 65.8 gpm during the reporting period, with the exception of July 2016 when total average extraction was 53.8 gpm. This decrease was due primarily to IWF aquifer tests conducted in July, resulting in temporary well shutdowns that decreased the total average extraction.

Total combined discharge at the AWF averaged 355.6 gpm during the reporting period, which is an increase of approximately 86 gpm compared to the prior reporting period. AWF flow rates increased from 292.8 gpm in July 2016 to 431.6 gpm in June 2017 as a result of recent infrastructure upgrades at the AWF and Lift Station 3 in support of well field optimization efforts, which allowed total extraction rates to increase. The upgrades at Lift Station 3 were performed in October 2016, resulting in decreased average flows at the AWF in October while the well field was temporarily shut down for equipment installation. Flow rates at the AWF were also somewhat lower in March, April, and May 2017 due to pump downtime and associated repairs.

Total combined discharge at the SWF averaged 584.6 gpm during the reporting period, which is an average increase of approximately 51 gpm over the prior reporting period. However, the SWF also experienced lower total extraction rates in October and December 2016 as a result of temporary shutdowns associated with Lift Station 1 infrastructure improvements. The improvements were associated with construction of the IX treatment system designed to treat a portion of groundwater captured by the SWF, which began operating in February 2017. Following these infrastructure improvements, extraction at PC-120 and PC-121 was re-initiated resulting in an overall increase in average extraction at the SWF. While wells PC-120 and PC-121 have relatively low concentrations of perchlorate when compared to neighboring wells in the SWF (see Section 5.2.6), the Trust has determined that the additional extraction is important to minimize perchlorate loading to Las Vegas Wash.

Total combined discharge from the AP Area extraction wells averaged 2.9 gpm during the reporting period. Extraction wells in Plot 1 had an average combined discharge of 1.5 gpm in November 2016 when they began operating continuously, which increased to 6.0 gpm by June 2017. Extraction wells in Plot 2 were activated in July 2017, after the reporting period.

2.3 Groundwater Treatment System

Treatment of chromium-contaminated groundwater extracted at the IWF and the AP Area occurs via the on-site Groundwater Treatment Plant (GWTP),[4] which chemically reduces hexavalent chromium and removes total chromium via chemical precipitation. Treatment of perchlorate-contaminated groundwater extracted at the IWF, AWF, SWF, or AP Area occurs via either 1) the on-site fluidized bed reactors (FBRs), which biologically remove perchlorate as well as chlorate, nitrate, and trace concentrations of residual chromium, or 2) an ion exchange (IX) treatment system. For approximately the first half of the reporting period (July 2016 to early February 2017), all extracted groundwater was treated by the FBRs. The IX treatment system was brought online on February 9, 2017 to treat perchlorate in groundwater extracted from a portion of the SWF in order to allow for greater treatment capacity in the FBRs and to ease water level management in GW-11 (Envirogen 2016a).

The FBR and IX systems discharge treated water to Las Vegas Wash from a combined effluent pipe that discharges to a side channel of Las Vegas Wash located immediately west of the Pabco Road erosion control structure under authority of National Pollutant

[4] By convention, the "GWTP" consists of only the on-site hexavalent chromium treatment plant. The name pre-dates the installation of any of the perchlorate treatment systems and related components.

Discharge Elimination System (NPDES) Permit NV0023060. A simplified process flow diagram is presented on Figure 2.[5] The GW-11 Pond was infrequently used for equalization purposes during the reporting period to temper variations in perchlorate concentrations prior to treatment by the FBRs. During the reporting period, the equalization tanks were largely used for this purpose. The performance of the GWETS system, including well field extraction rates, operational metrics for the various treatment systems, and information regarding GW-11 and the AP Area extraction system, is reported to NDEP monthly as part of the GWETS Enhanced Operational Metrics.

[5] The average total extraction rates reported in Table 5 differ from the average total effluent of the GWETS as shown in Figure 2. The discrepancy is the result of flow into and out of GW-11, evaporation from GW-11, and additions of stabilized Lake Mead water, which are used for maintenance operations. Perchlorate removal calculations are based on the extraction rates at each individual extraction well for the IWF, AWF, SWF, and AP Area.

3. AREA GROUNDWATER CONDITIONS

The NDEP has defined three water-bearing zones (WBZs) of interest in the vicinity of the Site, including the Shallow, Middle, and Deep WBZ. The Shallow WBZ, which extends to approximately 90 feet below ground surface (bgs), is unconfined to partially confined, and is considered the water table aquifer. Unless otherwise stated, discussions of groundwater in this report refer to the Shallow WBZ, which contains the saturated portions of the Quaternary alluvium (Qal) and the uppermost portion of the UMCf.

Plate 1, a potentiometric surface map for the Site and surrounding area, is based on groundwater elevation measurements collected by the Trust, AMPAC/Endeavour, OSSM, SNWA, and TIMET. The potentiometric surface map for the Shallow WBZ was created by interpolating measured water levels at shallow zone wells onto a grid using KT3D_H20[6] (v3.0) and then contouring the gridded data using ArcGIS Spatial Analyst. KT3D_H20 is a software program specifically designed for interpolating water level data using kriging, which combines information about sources and sinks with water levels measured at wells.[7] The major sources and sinks of water that were incorporated into the interpolation using KT3D_H20 were: all three Trust-owned extraction well fields, OSSM extraction wells and injection trenches, TIMET extraction and injection wells, AMPAC/Endeavour extraction wells, and the City of Henderson (COH) Bird Viewing Ponds.

Groundwater flow direction at the Site is generally north to northwesterly, whereas north of the Site, the direction changes to north-northeast. This generally uniform flow pattern may be modified locally by subsurface alluvial channels cut into the underlying UMCf; the NERT and TIMET barrier walls; localized areas of recharge from on-site storm water retention basins; off-site recharge from the COH Bird Viewing Ponds; groundwater extraction from the IWF, AWF, and SWF; and nearby groundwater extraction conducted by OSSM, TIMET, and AMPAC/Endeavour. During the reporting period, shallow groundwater was generally encountered in on-site wells between 20 and 80 feet bgs and is generally deepest in the southern portion of the Site. North of the Site, shallow groundwater was generally encountered between 2 and 36 feet bgs, becoming shallower as it approaches Las Vegas Wash.

As shown on Plate 1, areas of unsaturated alluvium are present within the AWF and in the area north of Sunset Road and Boulder Highway. An additional unsaturated zone is present in the vicinity of the IWF. Deeper shallow WBZ and middle WBZ data collected

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[6] Karanovic, M., Tonkin, M., and Wilson, D. 2009. KT3D_H2O: A Program for Kriging Water Level Data Using Hydrologic Drift Terms. Ground Water, Vol. 47, N0. 4:580-586.

[7] One limitation of KT3D_H2O is that it cannot represent a barrier to groundwater flow, such as the barrier wall downgradient of the IWF. In the vicinity of the IWF, the barrier wall has a significant effect on the potentiometric surface, so instead of KT3D_H2O a different approach was used to generate contours for the inset map showing the IWF. The potentiometric surface near the IWF was estimated by fitting the trend in water levels using an analytical element model and then kriging the well measurements after removing the trend. The simple analytic element model included the extraction wells at the IWF and the barrier wall, and was developed using the TimML software v3.4 (a multiaquifer analytical element model). This approach is essentially equivalent to the KT3D approach, but allows the inclusion of the barrier wall. The final potentiometric surface was calculated as the sum of the trend obtained from the analytical element model and the output from kriging of the detrended data. The resulting grid of interpolated water levels was contoured using ArcGIS Spatial Analyst in the same way as for the other areas.

as part of the Phase 2 RI are expected to provide information necessary to delineate this area of unsaturated alluvium, at which point it will be included on the report plates.

Plates 2, 3, and 4 show the May 2017 water levels in the IWF, AWF, and SWF pumping wells, respectively, in addition to water levels in adjacent monitoring wells. Plate 2 shows the series of narrow, shallow alluvial channels separated by UMCf ridges along the IWF, some of which are above the current groundwater level. Plate 3 shows the Qal overlying the UMCf ridge along the AWF continues to be partially dewatered. Plate 4 shows that the alluvial channel in the vicinity of the SWF is much less incised into the underlying UMCf than at the AWF; the configuration of the alluvial channel is a broad shallow feature about 800 feet wide and averaging about 45 feet thick. In May 2001, before pumping began, the groundwater level within the SWF area was shallow and would intersect the surface each winter forming a seep. Groundwater elevations in this area still remain relatively shallow.

Investigations of the Middle WBZ at the Site and surrounding sites indicate, with a few exceptions, a vertical upward gradient between the Middle and Shallow Zones that generally increases with depth. In the area immediately downgradient of the IWF, vertical head differences between Middle and Shallow Zone wells ranged from 5 to 26 feet during the reporting period, with calculated vertical gradients ranging between 0.05 and 0.2 ft/ft in the upward direction. Upward vertical gradients were generally more prominent near the western and central portions of the barrier wall. At the AWF, two wells were installed as part of the Phase 1 RI that are screened deeper within the shallow WBZ, PC-134D and PC-137D, to depths of 90 feet. During the reporting period, the vertical head differences measured between PC-134D and PC-137D and corresponding wells screened within the Qal were 4.1 and 3.8 feet, respectively, with upward vertical gradients of 0.09 and 0.07 ft/ft. Vertical gradients have not been evaluated near the SWF due to an absence of wells screened below the Qal.

4. CHROMIUM

4.1 Chromium Removal

During the reporting period, a total of approximately 2,500 pounds of total chromium were captured and removed from groundwater, as shown in Table 6.[8] This is a 4.9% decrease compared to the 2,630 pounds of chromium removed between July 2015 and June 2016. This decrease in removal is due primarily to lower average chromium concentrations in groundwater at the IWF and AWF, as discussed in Section 8.2.1.

Total and hexavalent chromium concentrations in the FBR effluent during the reporting period are presented in Table 7. Effluent hexavalent chromium concentrations were between <0.000066 milligrams per liter (mg/L) and 0.0007 J mg/L during the reporting period – well below the NPDES effluent discharge limitation of 0.01 mg/L (daily maximum). Total chromium was reported in effluent samples at concentrations ranging from <0.0025 to 0.041 mg/L – also below the NPDES effluent discharge limitation of 0.1 mg/L (daily maximum).

4.2 Chromium Concentration Trends

Plate 5 presents an isoconcentration map of the chromium plume from its on-site source northward to Las Vegas Wash. The mapped area has been substantially expanded as part of this report to include the Downgradient Study Area and the Eastside Study Area (which is comprised of the Eastside Sub-Area and Northeast Sub-Area).[9] The data used to develop the chromium isoconcentration contours includes second quarter 2017 shallow groundwater data collected by the Trust, OSSM, SNWA, and TIMET, in addition to second quarter 2016 shallow groundwater data collected by AECOM and 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4.

The following sections describe chromium concentration trends at various well lines within the chromium plume, beginning with the southern-most well line and progressing downgradient to the north towards Las Vegas Wash. The west-east well lines evaluated in this section are generally consistent with those evaluated in prior reports and include the following (as shown on Figure 1):

- **The IWF**, comprised of the 30 IWF extraction wells;
- **Downgradient of the Barrier Wall**, comprised of shallow monitoring wells located immediately north (downgradient) of the barrier wall for which data were available during the reporting period; and
- **The AWF**, comprised of the eight AWF extraction wells (ART-1/1A, ART-2/2A, ART-3/3A, ART-4/4A, ART-7A/7B, ART-8/8A, ART-9, and PC-150) and shallow monitoring wells located along the AWF for which data were available during the reporting period.

[8] Chromium mass removal, reported herein, was calculated using a methodology which has been approved by NDEP (Tetra Tech 2015).

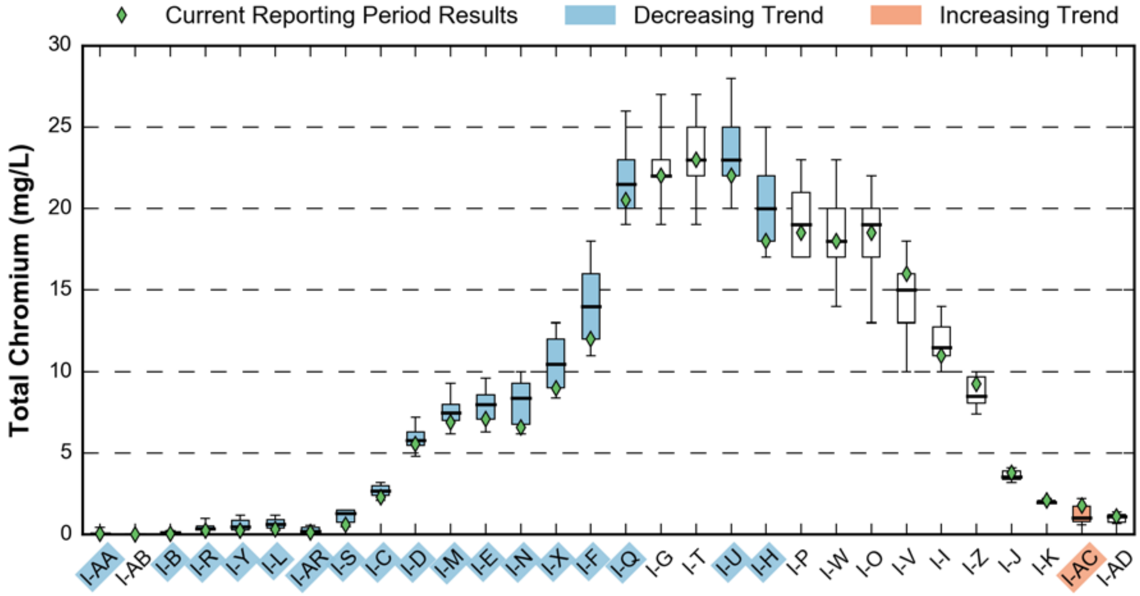
[9] The presence of total and hexavalent chromium within the Eastside Sub-Area will be investigated and remediated by BRC, if necessary, pursuant to the terms of the Settlement Agreement and Administrative Order on Consent, BMI Common Areas, Phase 3, with NDEP in 2006 (AOC3). As part of the Phase 3 RI Work Plan, chromium and hexavalent chromium have been included in the analyte list for the Northeast Sub-Area for consistency with investigation of the Downgradient Study Area.

Chromium concentration trends at additional well lines downgradient of the AWF were not evaluated because total chromium concentrations downgradient of the AWF are typically less than the federal maximum contaminant level (MCL) of 100 micrograms per liter (µg/L) for total chromium, which the State of Nevada has adopted. Chromium concentration trends were also not evaluated at the AP Area extraction wells, as these wells did not begin operating until November 2016 and therefore limited data are available.

As requested by NDEP in the December 6, 2016 comment letter on the previous Annual Report (NDEP 2016), this report incorporates statistical analyses of well line concentration trends. The box plots incorporated within the text below, as well as the statistical information for each well in Appendix C, are designed to help distinguish between long-term concentration trends and seasonal/short-term variations. The box plots use color to depict statistically significant (95% confidence) concentration trends, as established using the Mann-Kendall test on the last four years of available data (July 2013 to June 2017). The Mann-Kendall test was selected because it is non-parametric and therefore more generally applicable than regression analysis. Appendix C includes linear regression analysis (calculation of residual normality and linear slopes), Mann-Kendall testing, calculation of the non-parametric Theil-Sen slope, and calculation of an autocorrelation function for each well in the sampling program with sufficient chromium data (as well as perchlorate and groundwater elevation data).

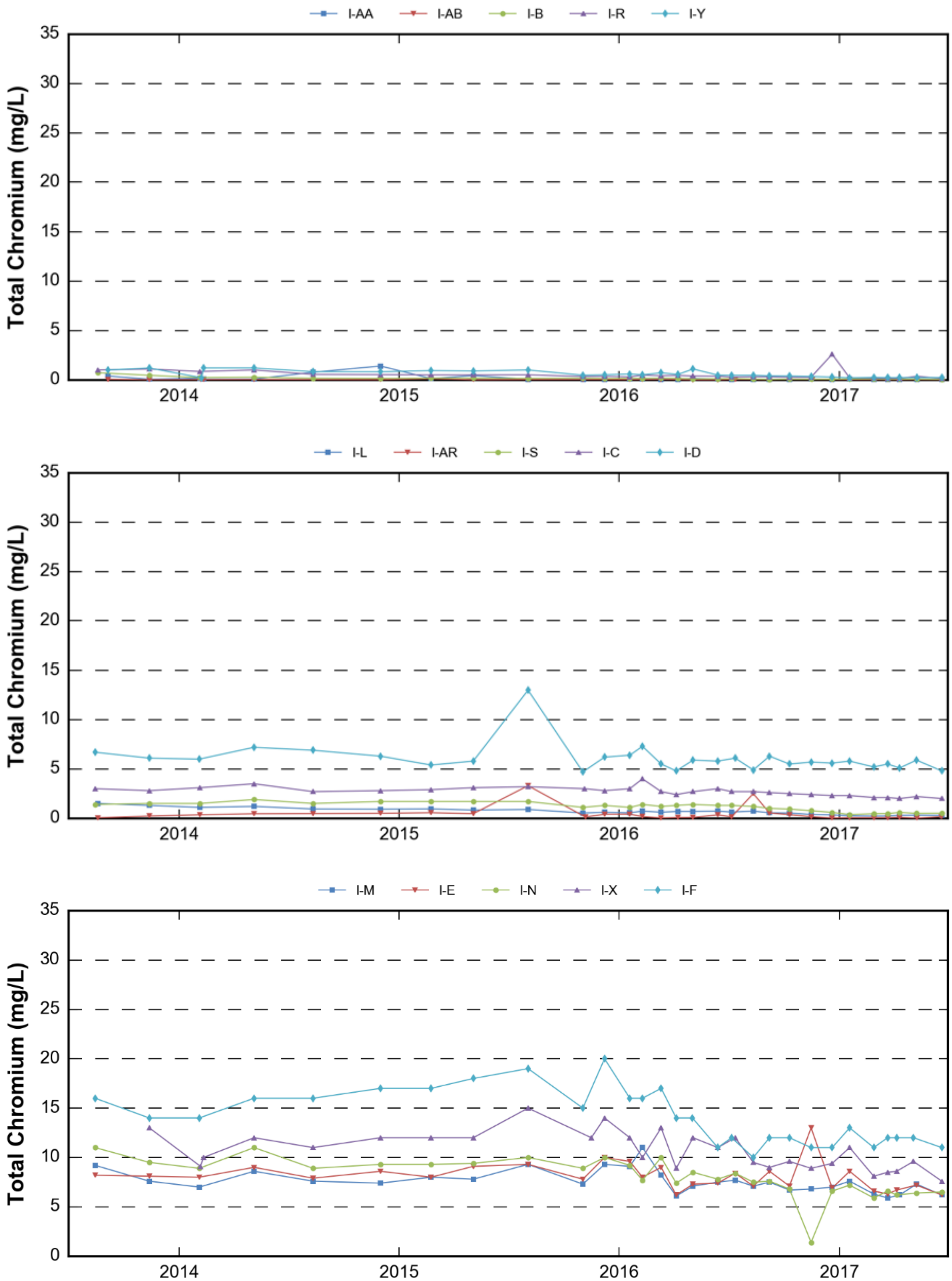
4.2.1 Interceptor Well Field

The box plots and time series plots below present chromium data over the last four years at the IWF extraction wells in geographical order from west to east. As shown in the box plots, chromium concentrations are highest and most variable in the central and eastern portions of the IWF. The statistical analysis indicates that concentrations in a majority of the IWF wells (17 wells) have decreased over the last four years, with the exception of concentrations in one extraction well (I-AC) where concentrations have increased. I-AC is located on the eastern edge of the well field in an area with groundwater concentrations less than 5 mg/L of total chromium, and is within the IWF and AWF capture zones. Statistically significant trends were not identified in the other 12 extraction wells.

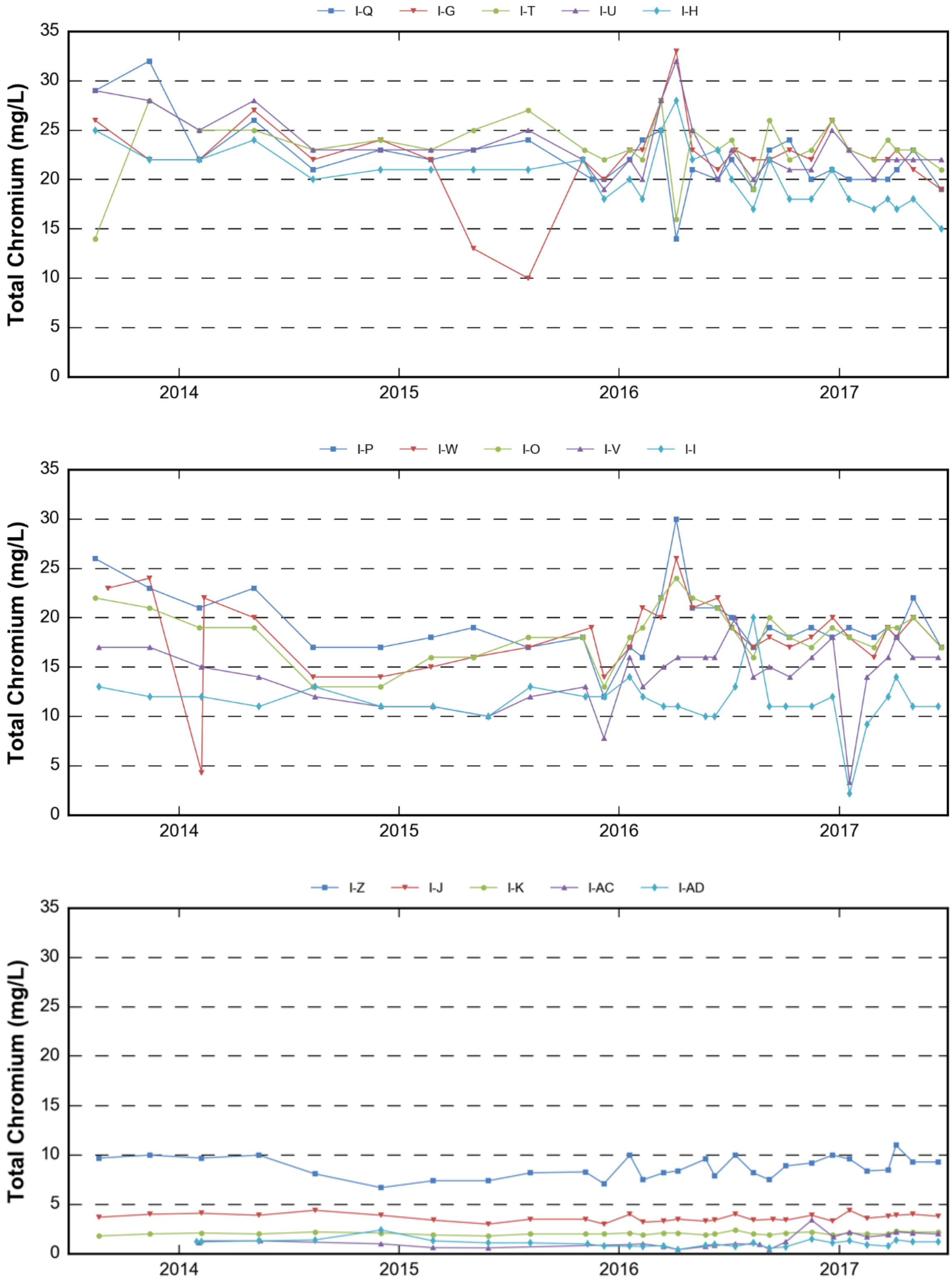


Box Plots: IWF Chromium Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

As shown on the time series plots presented below, concentrations during the reporting period appear consistent with these identified trends, with the exception of concentrations in wells I-E and I-N in November 2016 and I-V and I-I in January 2017. A review of hexavalent chromium data for these wells during these timeframes found that hexavalent chromium concentrations were consistent with the total chromium data collected during the remainder of the reporting period; therefore, the total chromium results for these wells during these timeframes are believed to be anomalous and not indicative of chromium concentration trends.



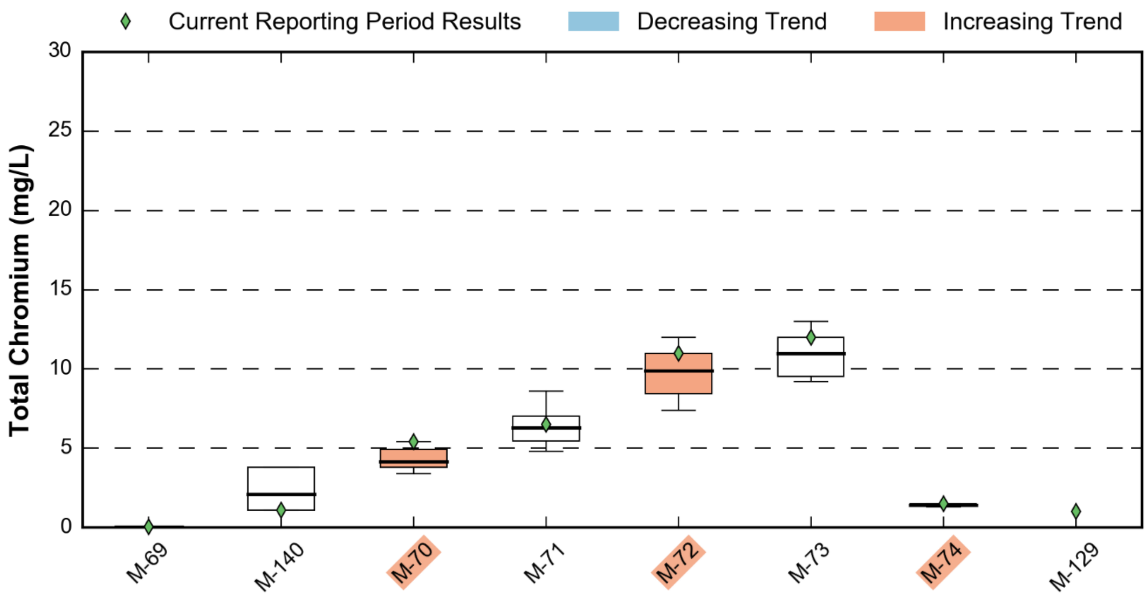
Time Series Plots: IWF Chromium Concentrations. These charts depict chromium concentration data collected in IWF wells during the last four years, presented in geographical order from west to east.



Time Series Plots: IWF Chromium Concentrations. These charts depict chromium concentration data collected in IWF wells during the last four years, presented in geographic order from west to east.

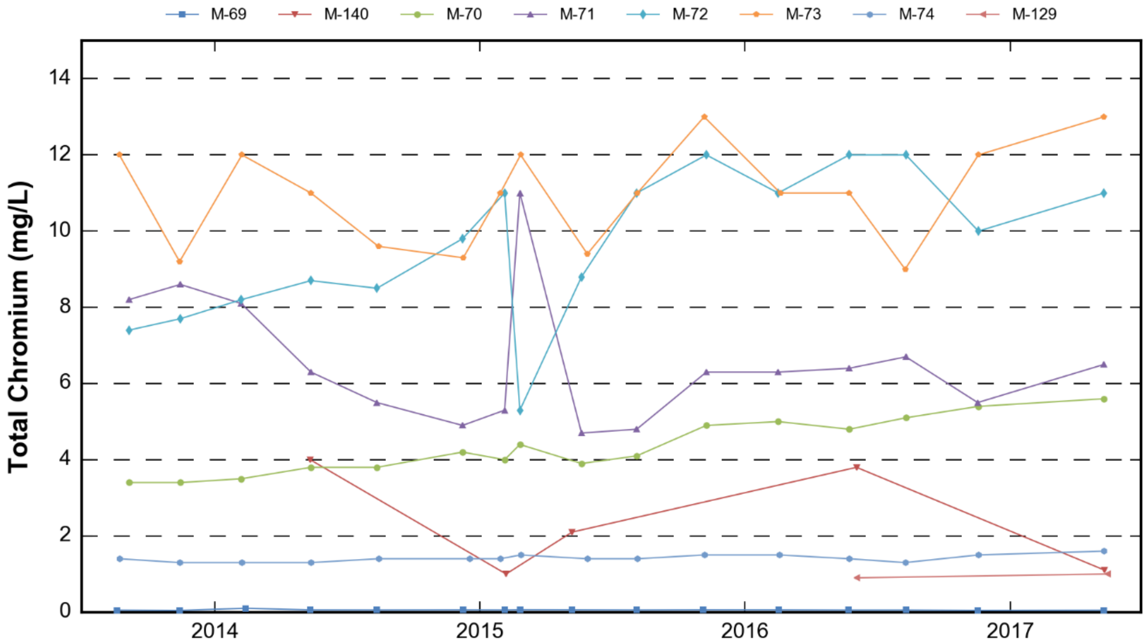
4.2.2 Downgradient of the Barrier Wall

The box plots and time series plots below present chromium data over the last four years at shallow monitoring wells located immediately downgradient of the barrier wall. Similar to the IWF, chromium concentrations are highest in the central and eastern portions of the well line. The statistical analysis indicates that chromium concentrations increased in M-70, M-72, and M-74 over the last four years; statistically significant trends were not identified in the other monitoring wells.



Box Plots: Chromium Concentrations Downgradient of the Barrier Wall. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the “whiskers” represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend). For wells with fewer than 4 data points available, box plots are not shown; instead, only the median value during the reporting period is plotted.

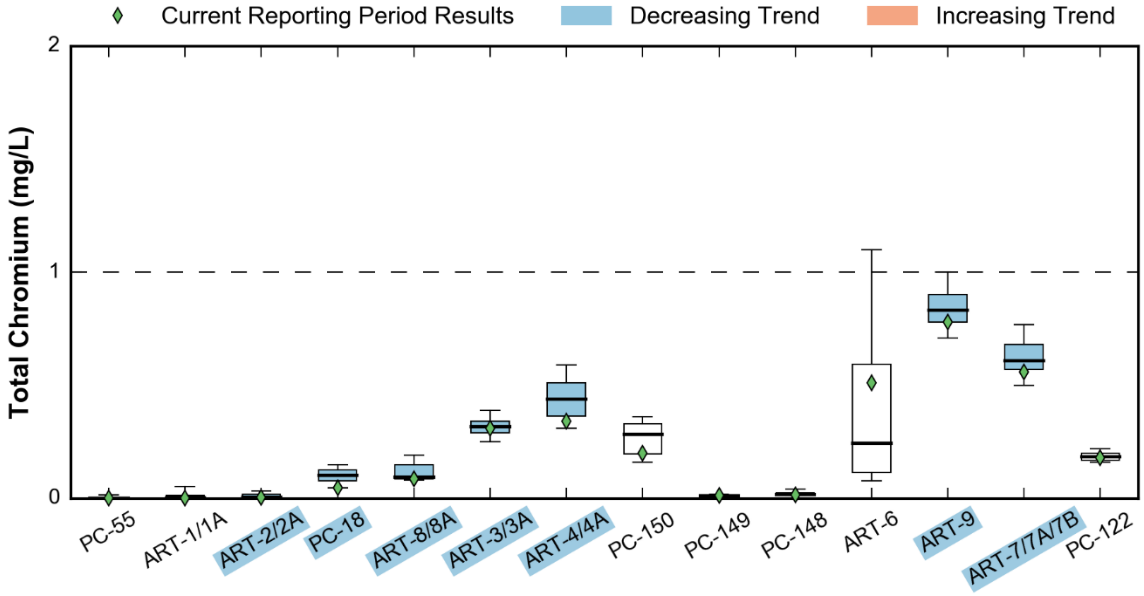
Chromium concentrations during the reporting period (as shown on the time series plots below) appear consistent with these identified trends. Chromium concentrations in these wells have increased since November 2010, following the shutdown of the recharge trenches in September 2010. This suggests that the former recharge trenches either diluted chromium concentrations in groundwater at these wells, prevented lateral migration through or around the barrier wall, or mitigated the upward migration of chromium from the UMCf. An evaluation of the integrity and effectiveness of the barrier wall, as outlined in the NDEP-approved Barrier Wall Integrity Field Evaluation Work Plan (Ramboll Environ 2017b), is scheduled to take place in 2018.



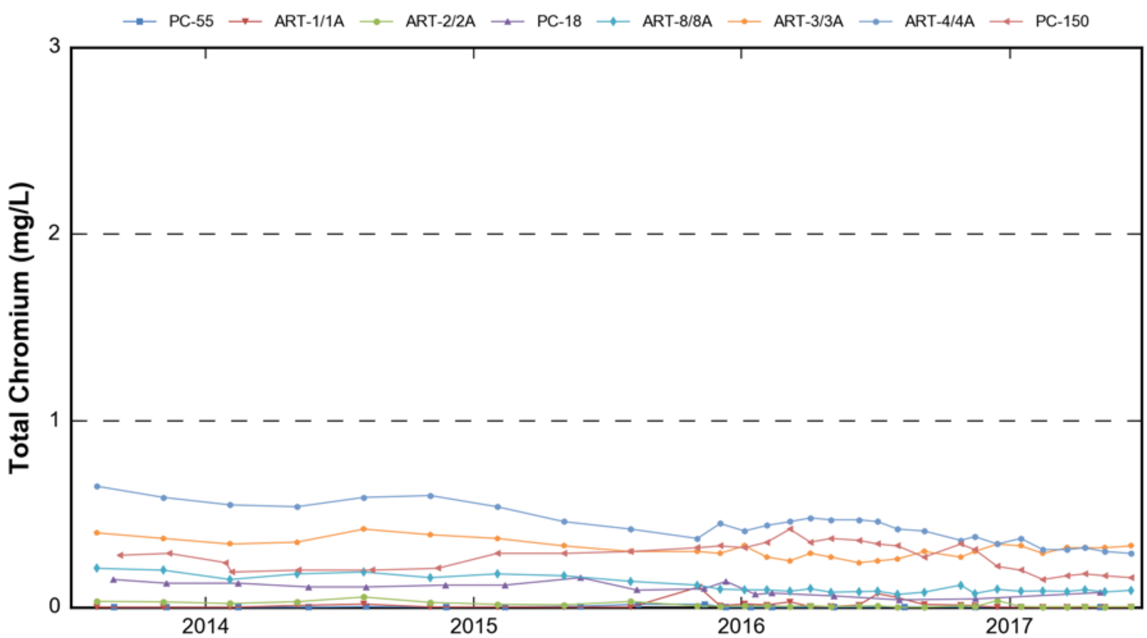
Time Series Plots: Chromium Concentrations Downgradient of the Barrier Wall. This chart depicts chromium concentration data collected immediately downgradient of the barrier wall during the last four years.

4.2.3 Athens Road Well Field

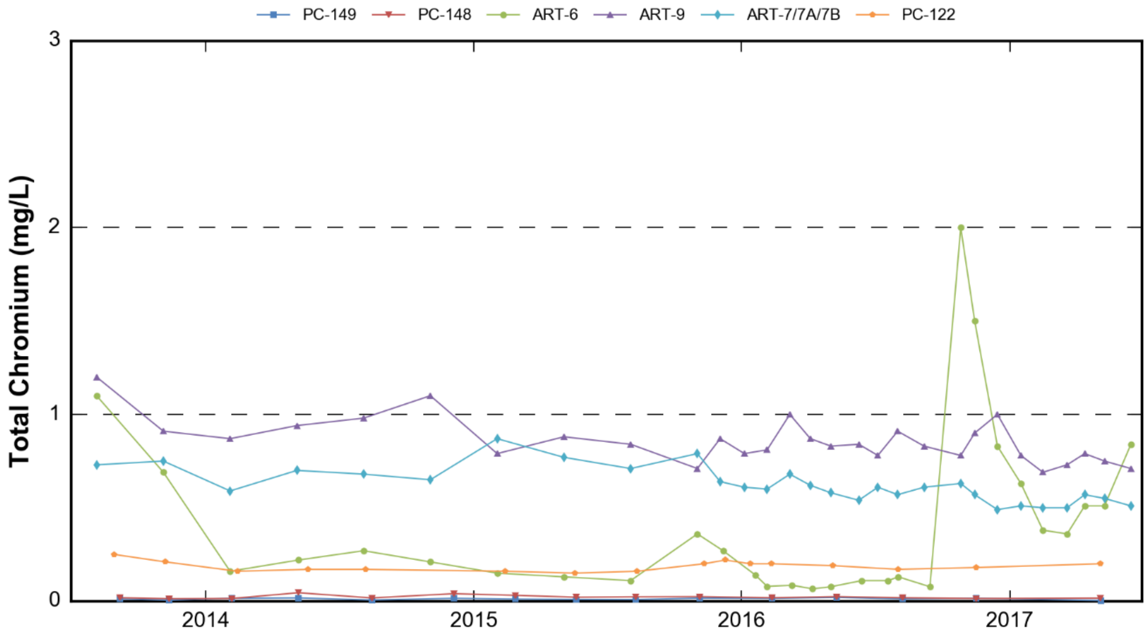
The charts below show concentrations of total chromium from the last four years in groundwater within the eight AWF pumping wells (ART-1/1A, ART-2/2A, ART-3/3A, ART-4/4A, ART-7A/7B, ART-8/8A, ART-9, and PC-150) and several shallow monitoring wells located along the AWF. Chromium concentrations in the western sub-channel (represented by wells west of PC-149) are lower relative to those in the eastern sub-channel (represented by wells east of PC-148). The statistical analysis indicates that chromium concentrations in 7 of the wells decreased over the last four years, 6 of which are extraction wells. Statistically significant trends were not identified in the other 7 wells. Concentrations in ART-6 exhibit higher variability over the last four years compared to other nearby wells. During the reporting period, chromium concentrations were generally consistent with these identified trends, as shown on the time series plots below.



Box Plots: AWF Chromium Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).



Time Series Plots: Western AWF Chromium Concentrations. This chart depicts chromium concentration data collected at the western half of the AWF over the last 4 years.



Time Series Plots: Eastern AWF Chromium Concentrations. This chart depicts chromium concentration data collected at the eastern half of the AWF over the last 4 years.

4.2.4 Seep Well Field

Total chromium concentrations in groundwater samples collected from the wells in the SWF were generally non-detect during the reporting period. For the purpose of the statistical trend analysis presented in Appendix C, half of the detection limit was substituted for non-detected results. Statistical analysis of chromium concentrations in the SWF extraction wells (PC-99R2/R3, PC-115R, PC-116R, PC-117, PC-118, PC-119, PC-120, PC-121, and PC-133) indicates that no statistically significant trends were identified.

5. PERCHLORATE

5.1 Perchlorate Removal

During the reporting period, a total of approximately 389,900 pounds of perchlorate were captured and removed from groundwater by the GWETS, as shown in Table 8.[10] This is a 4.4% decrease compared to the 407,900 pounds removed between July 2015 and June 2016.[11] The Trust increased the extraction rates of the AWF and SWF during the reporting period, as described in Section 2.2, and current conditions at the AWF appear to represent maximum sustainable extraction rates. However, the amount of perchlorate removed by the GWETS decreased compared to the prior reporting period due to lower average perchlorate concentrations in groundwater at the IWF and AWF, as further discussed in Section 8.2.1.

Perchlorate concentrations in the combined FBR and IX effluent during the reporting period are presented in Table 9. Perchlorate was not detected at concentrations exceeding the laboratory sample quantitation limit (SQL) (0.0025 mg/L or 0.0010 mg/L) in effluent discharged to Las Vegas Wash during the reporting period.[12]

5.2 Perchlorate Concentration Trends

Plate 6 shows the contoured perchlorate plume from the south end of the Site to Las Vegas Wash. The mapped area has been substantially expanded as part of this report to include the Downgradient Study Area and the Eastside Study Area (which is comprised of the Eastside Sub-Area and Northeast Sub-Area). The data used to develop the perchlorate isoconcentration contours includes second quarter 2017 shallow groundwater data collected by the Trust, AMPAC/Endeavour, OSSM, SNWA, and TIMET, in addition to second quarter 2016 shallow groundwater data collected by AECOM and 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4.

The following sections describe perchlorate concentration trends at various well lines within the perchlorate plume, beginning with the southern-most well line and progressing downgradient to the north towards Las Vegas Wash. The west-east well lines evaluated in this section are generally consistent with those evaluated in prior reports and include the following (as shown on Figure 1):

- **The IWF**, comprised of the 30 IWF extraction wells;

[10] Perchlorate mass removal, reported herein, was calculated using a methodology which has been approved by NDEP (Tetra Tech 2015) and used for mass removal calculations since January 2015.

[11] Mass removals may differ from previously presented values, as mass removals have been revised in Table 8 based on recent updates to the flow data to correct minor inaccuracies.

[12] Perchlorate was detected in the seven-day composite sample for the week ending on August 6, 2016 at a concentration of 0.039 mg/L. This detected concentration is believed to be the result of cross-contamination during the compositing of daily effluent samples collected between July 31 and August 6, 2016. When the individual daily samples and a new composite sample were analyzed, perchlorate was not detected; therefore, the original result was determined to be erroneous. A similar event occurred for the seven-day composite sample for the week ending on February 11, 2017 when perchlorate was detected at a concentration of 0.034 mg/L. The individual daily samples and a new composite sample for the week were analyzed, and perchlorate was not detected; therefore, the original result was determined to be erroneous.

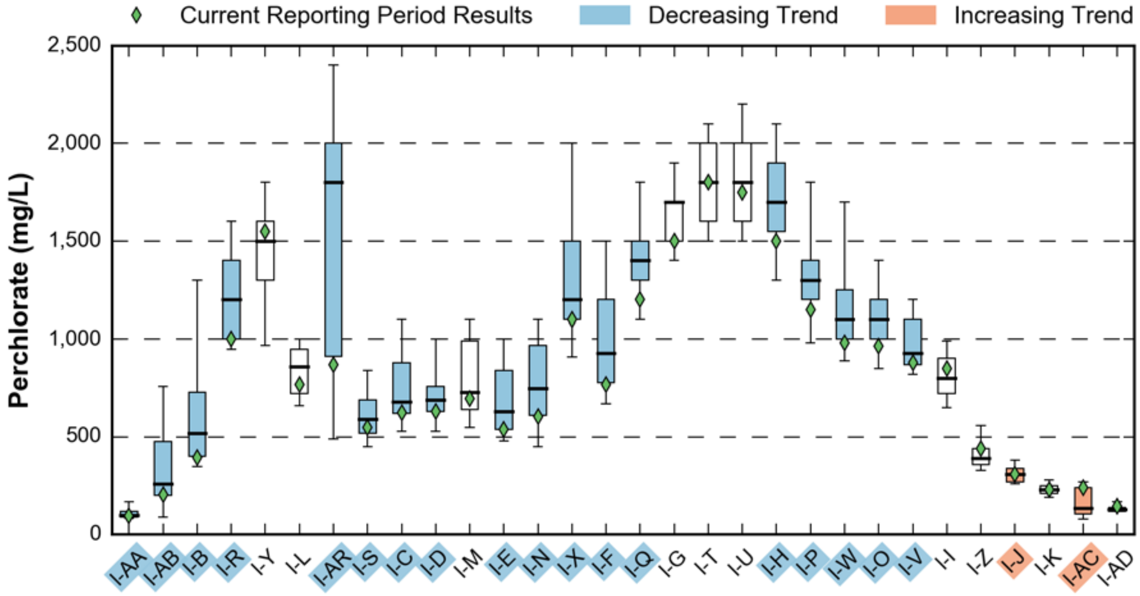
- **Downgradient of the Barrier Wall**, comprised of shallow monitoring wells located immediately north (downgradient) of the barrier wall for which data were available during the reporting period;
- **The AWF**, comprised of the eight AWF extraction wells (ART-1/1A, ART-2/2A, ART-3/3A, ART-4/4A, ART-7A/7B, ART-8/8A, ART-9, and PC-150) and shallow monitoring wells located along the AWF for which data were available during the reporting period;
- **The Athens Road Piezometer (ARP) Well Line,** comprised of shallow monitoring wells located approximately 250 feet north of the AWF;
- **The COH Water Reclamation Facility (WRF) Well Line,** comprised of shallow monitoring wells located east of the COH Bird Viewing Ponds and approximately 2,200 feet north of the AWF;
- **The Lower Ponds Well Line,** comprised of shallow monitoring wells located approximately 4,400 feet north of the AWF and 2,200 feet north of the COH WRF Well Line; and
- **The SWF,** comprised of the 10 SWF extraction wells, two of which (PC-99R2 and PC-99R3) are connected and operate as one combined well.

Perchlorate concentration trends at well lines downgradient of the AWF are evaluated in this section because perchlorate concentrations in groundwater exist above NDEP's provisional action level of 18 µg/L between the AWF and Las Vegas Wash. Perchlorate concentration trends at the AP Area extraction wells were not evaluated, as these wells did not begin operating until November 2016 and therefore limited data are available.

As requested by NDEP in the December 6, 2016 comment letter on the previous Annual Report (NDEP 2016), this report incorporates statistical analyses of well line concentration trends, as described in Section 4.2.

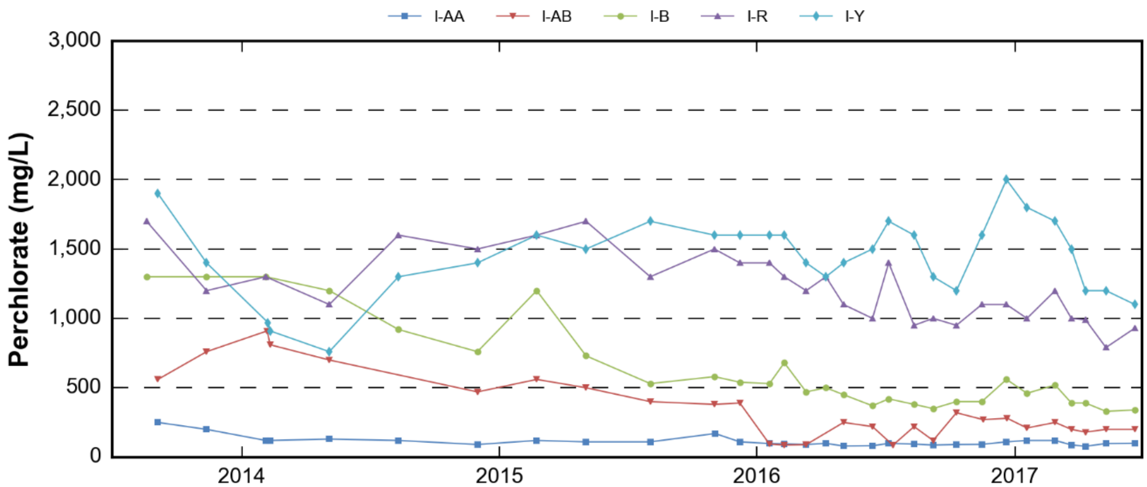
5.2.1 Interceptor Well Field

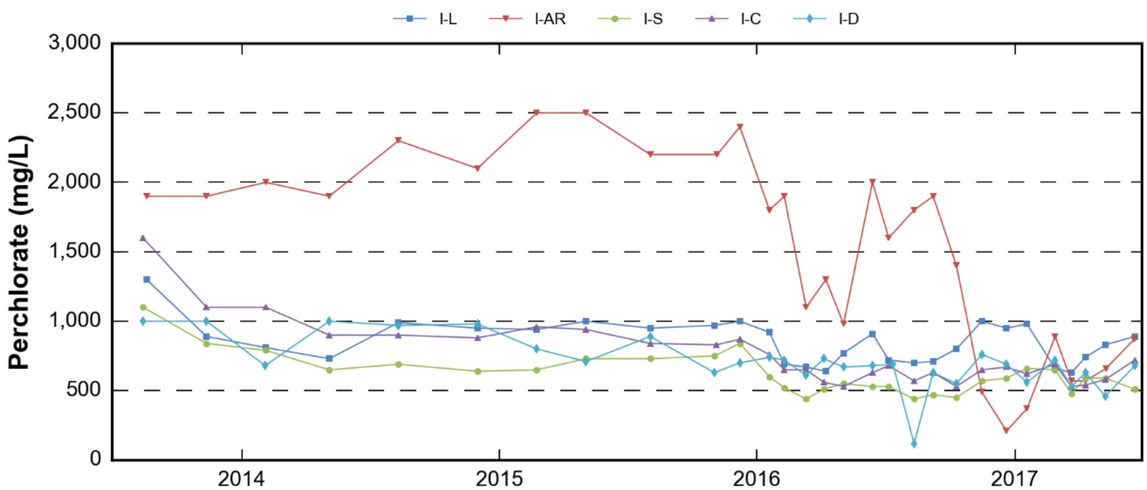
The box plots and time series plots below present perchlorate data over the last four years at the IWF extraction wells in geographical order from west to east. As shown in the box plots, the highest concentrations are located in the western and central portions of the well line. The statistical analysis indicates that concentrations in groundwater in a majority of the IWF wells (18 wells) have decreased over the last four years, with the exception of concentrations in groundwater at two extraction wells (I-J and I-AC) where concentrations have increased. I-J and I-AC are located along the eastern edge of the well field in an area with groundwater concentrations less than 500 mg/L of perchlorate, and are within the IWF and AWF capture zones. Statistically significant trends were not identified in the other 10 extraction wells.

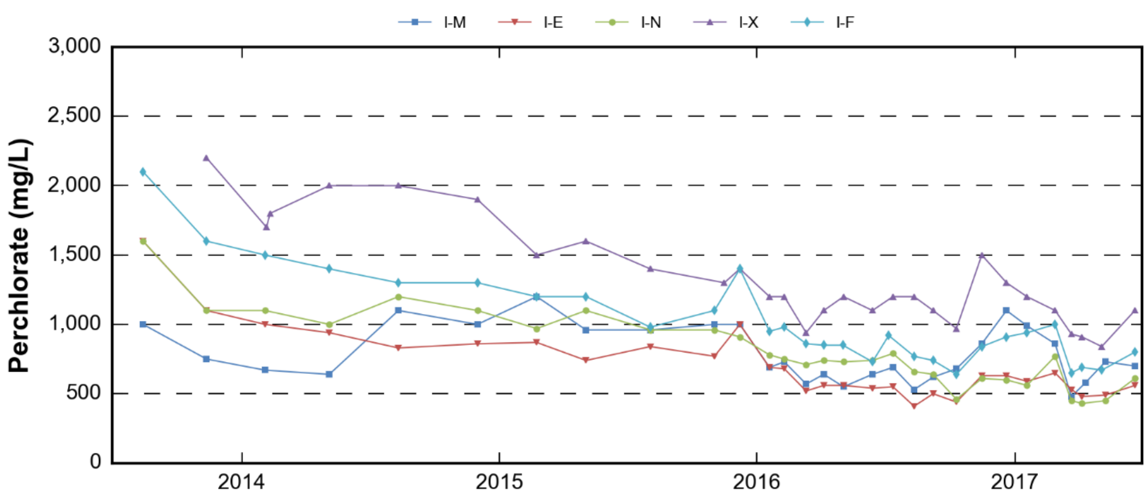


Box Plots: IWF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

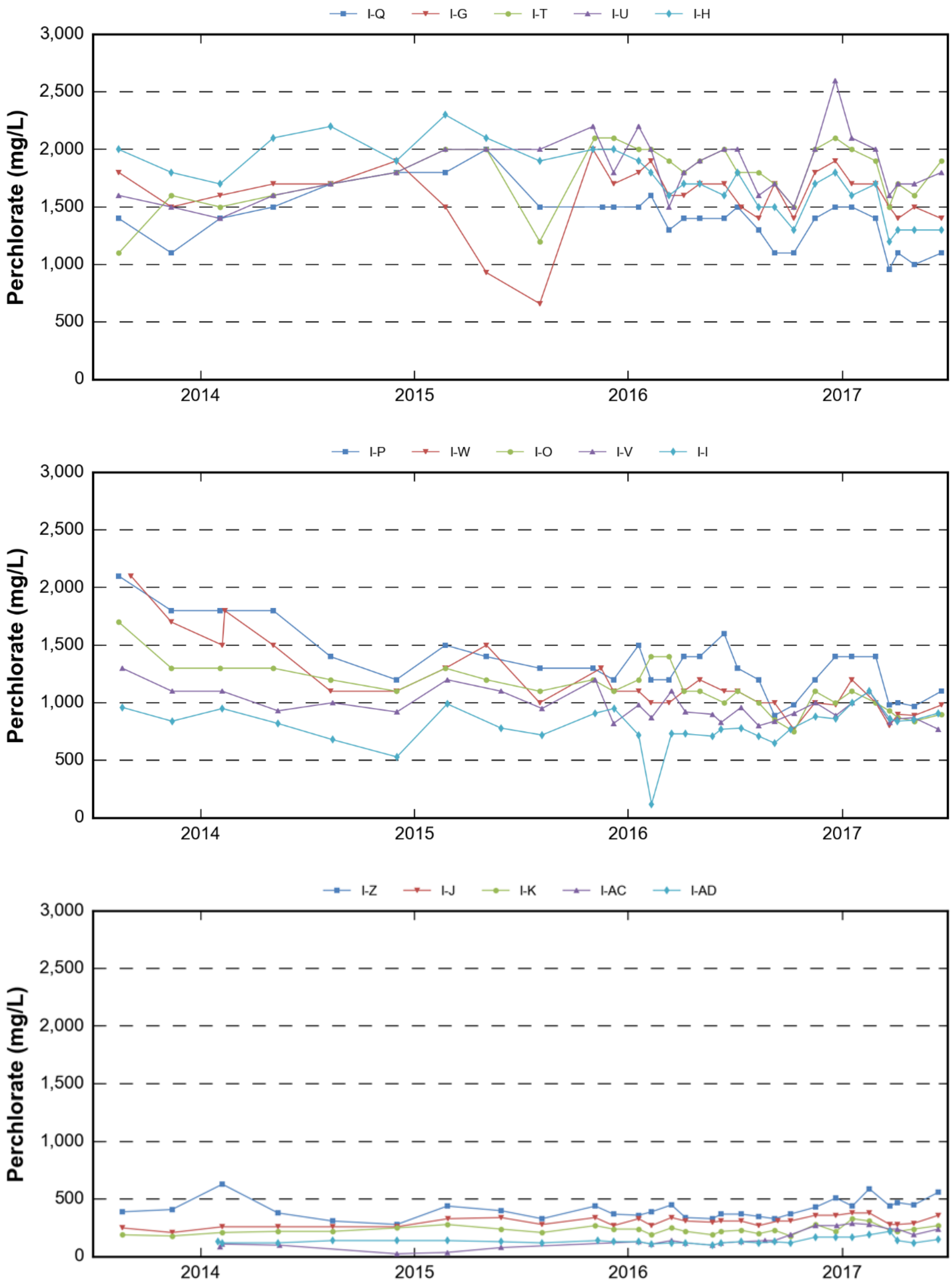
Concentrations measured during the reporting period, as shown on the time-series plots below, appear consistent with the identified statistical trends discussed above, with the exception of concentrations in well I-AR. I-AR exhibited historically low concentrations from November 2016 through the end of the reporting period. I-AR is located near the AP Area flushing and extraction wells, which began operating continuously in November 2016.







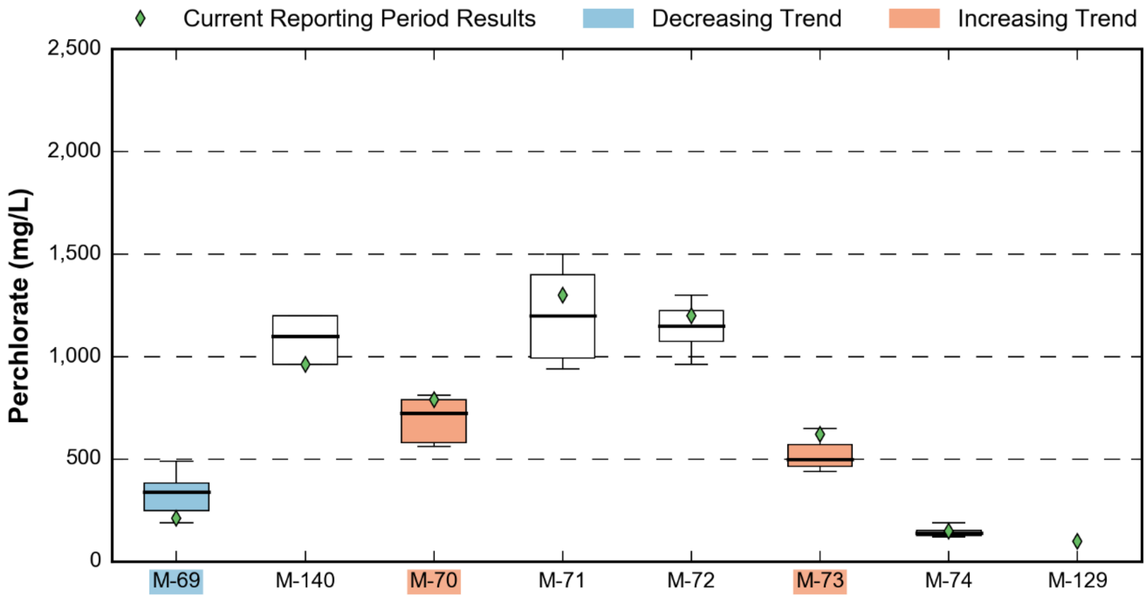
Time Series Plots: IWF Perchlorate Concentrations. These charts depict perchlorate concentration data collected in IWF wells during the last four years, presented in geographical order from west to east.



Time Series Plots: IWF Perchlorate Concentrations. These charts depict perchlorate concentration data collected in IWF wells during the last four years, presented in geographical order from west to east.

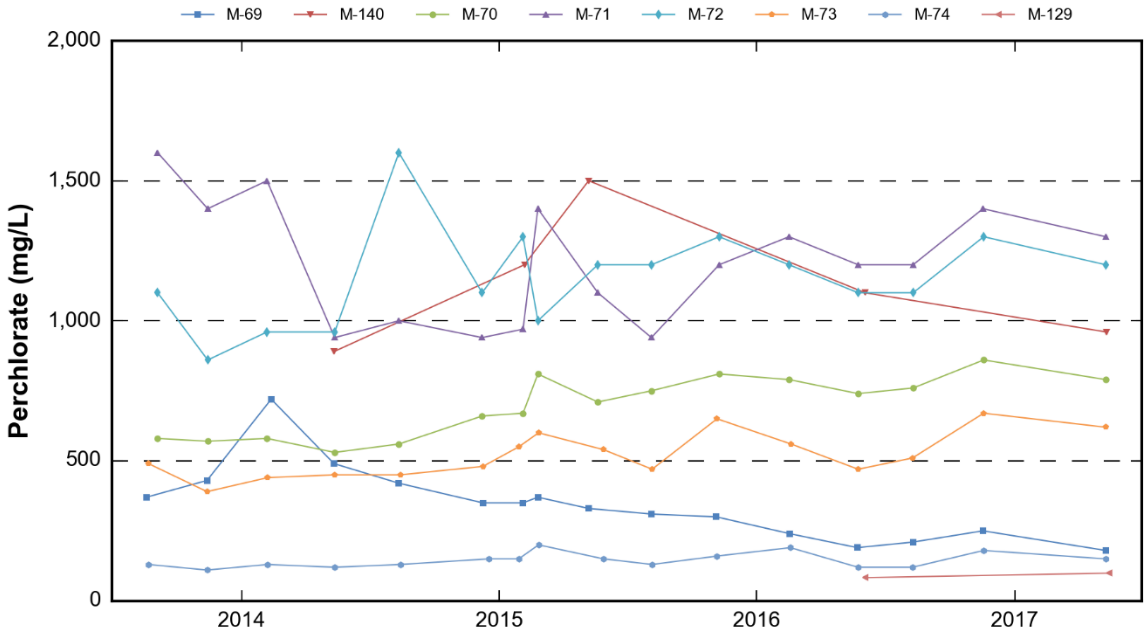
5.2.2 Downgradient of Barrier Wall

As shown below, the statistical analysis indicates that perchlorate concentrations in wells located between the barrier wall and former recharge trenches have increased in M-70 and M-73, and decreased in M-69. Perchlorate concentrations in groundwater in this area are below 1,500 mg/L and located within the capture zone of the AWF. Statistically significant trends were not identified at the other monitoring wells. Similar to the IWF, the highest concentrations are located in the central and eastern portions of the well line.



Box Plots: Perchlorate Concentrations Downgradient of the Barrier Wall. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend). For wells with fewer than 4 data points available, box plots are not shown; instead, only the median value during the reporting period is plotted.

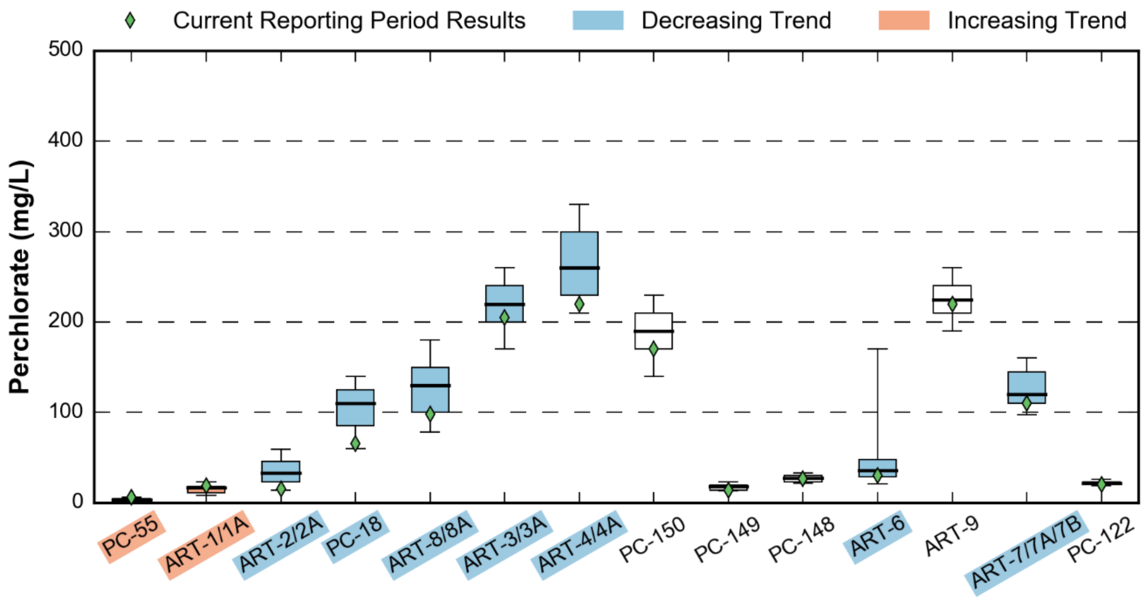
Perchlorate concentrations during the reporting period (as shown on the time series plots) appear consistent with these identified trends. Perchlorate concentrations in these wells have generally increased since November 2010, following the shutdown of the recharge trenches in September 2010. This suggests that the former recharge trenches either diluted perchlorate concentrations in groundwater at these wells, prevented lateral migration through or around the barrier wall, or mitigated the upward migration of perchlorate from the UMCf. As described in Section 4.2.2, an evaluation of barrier wall effectiveness is scheduled to take place in 2018.



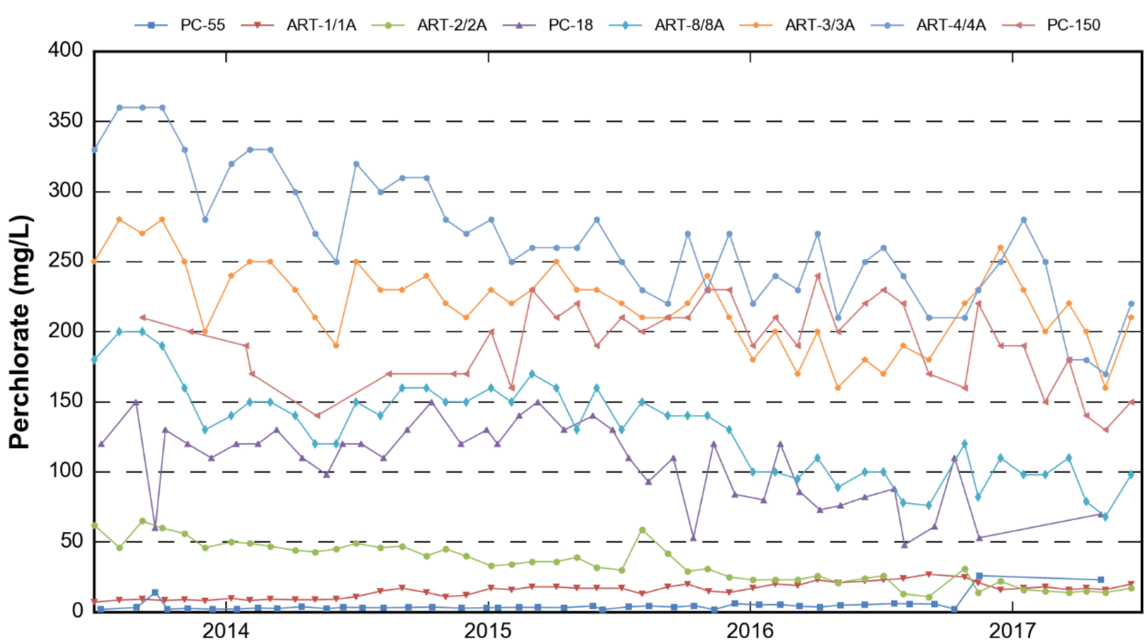
Time Series Plots: Perchlorate Concentrations Downgradient of the Barrier Wall. This chart depicts perchlorate concentration data collected immediately downgradient of the barrier wall over the last four years.

5.2.3 Athens Road Well Field

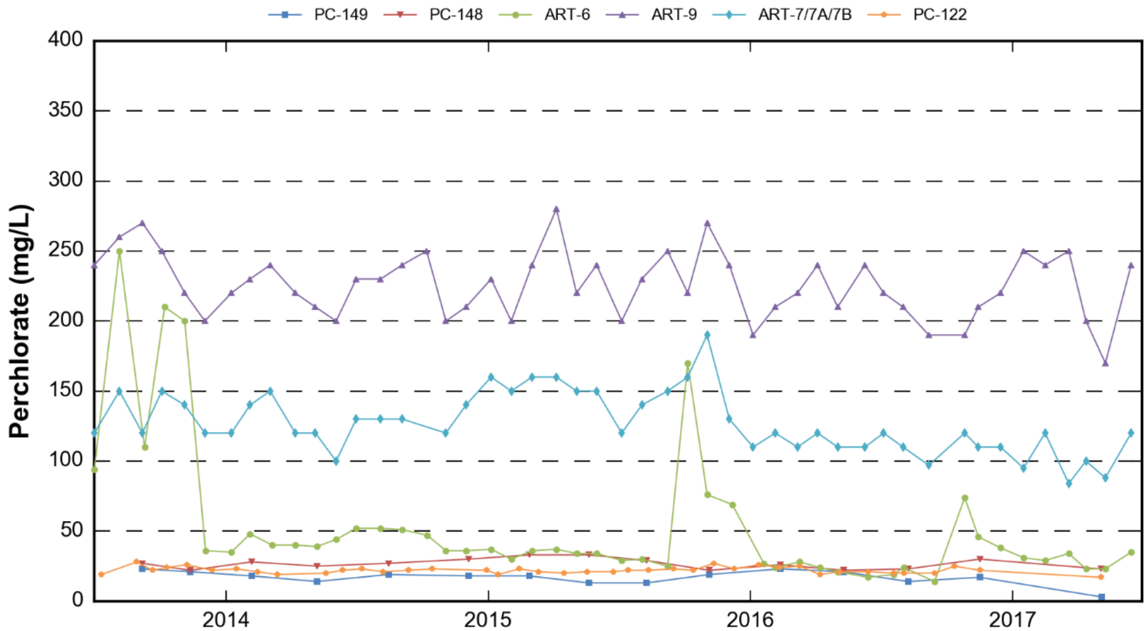
Perchlorate concentrations in the AWF's eight pumping well pairs and several shallow monitoring wells located along the AWF are shown in the charts below. Perchlorate concentrations in the western sub-channel (represented by wells west of PC-149) are higher relative to those in the eastern sub-channel (represented by wells east of PC-148). The statistical analysis indicates that perchlorate concentrations decreased in 7 wells, but increased in two wells (PC-55 and ART-1) located at the west end of the well line. As shown in the plume map on Plate 6, the wells on the western edge of the AWF are impacted by the perchlorate plume originating from the former AMPAC/Endeavour site. Statistically significant trends were not identified for the other wells. Concentrations in ART-6 exhibit higher variability over the last four years compared to other nearby wells. During the reporting period, perchlorate concentrations were generally consistent with these identified trends, as shown on the time series plots below.



Box Plots: AWF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).



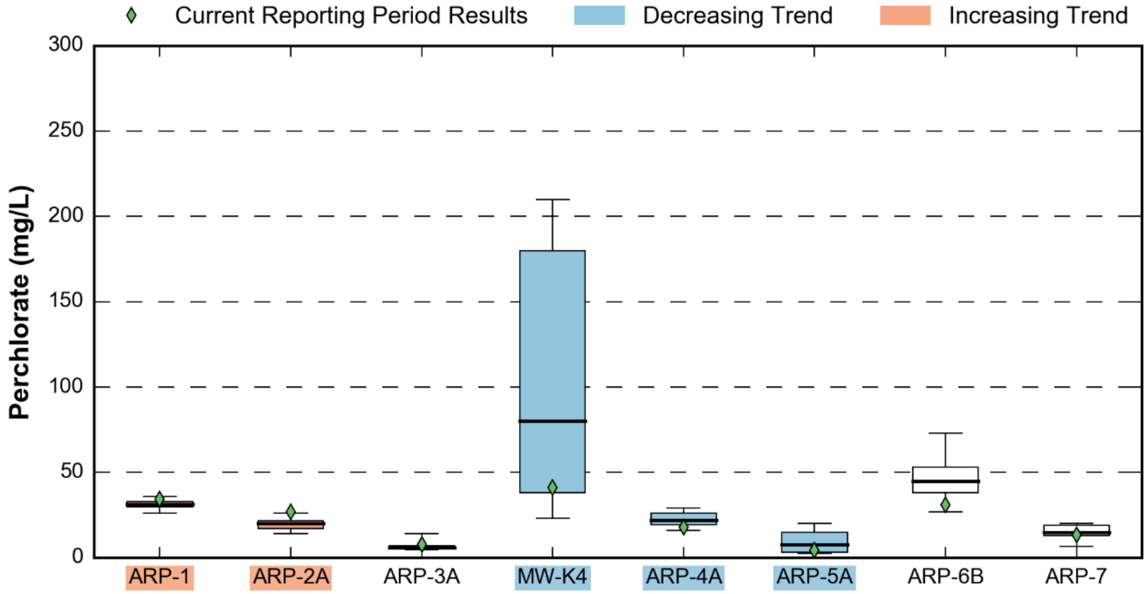
Time Series Plots: Western AWF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the western half of the AWF over the last four years.



Time Series Plots: Eastern AWF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the eastern half of the AWF over the last four years.

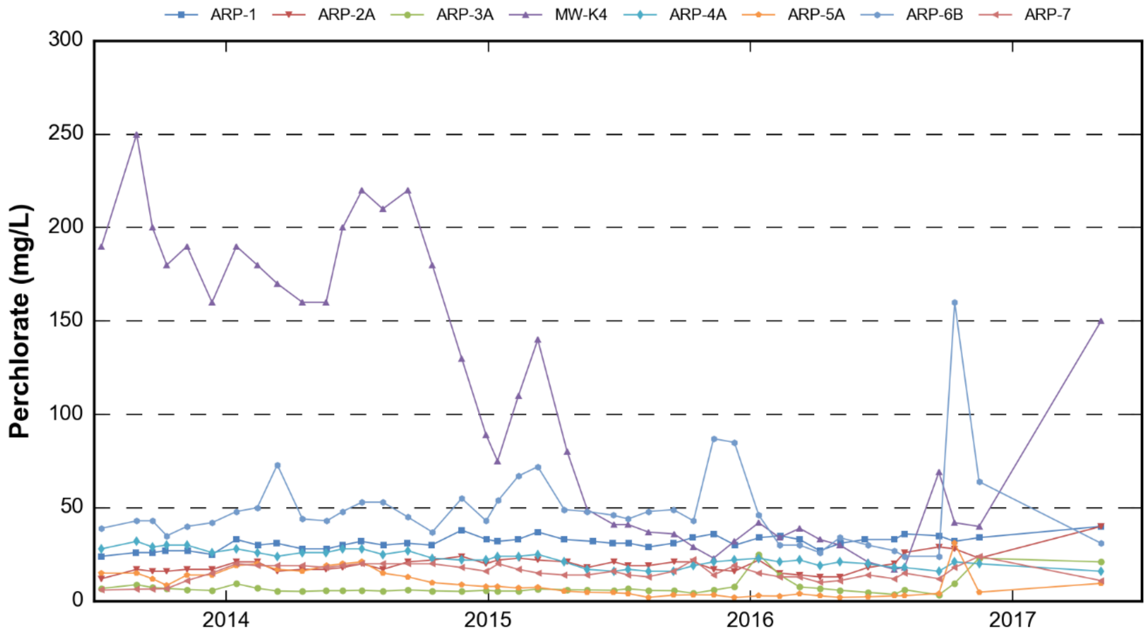
5.2.4 Athens Road Piezometer Well Line

Concentrations of perchlorate within the ARP Well Line were consistently less than 100 mg/L during the last four years, as shown on the box plots below, with the exception of concentrations at well MW-K4, indicating that the AWF has been effective in capturing perchlorate contaminated groundwater in these sections of the plume. The statistical analysis indicates that perchlorate concentrations in the central portion of the well line (MW-K4, ARP-4A, ARP-5A) have decreased over the last four years, while concentrations on the western end of the well line (ARP-1, ARP-2A) have increased. As shown in the plume map on Plate 6, the wells on the western edge of the ARP well line are impacted by the perchlorate plume originating from the former AMPAC/Endeavour site. Statistically significant trends were not identified in the other wells.



Box Plots: ARP Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

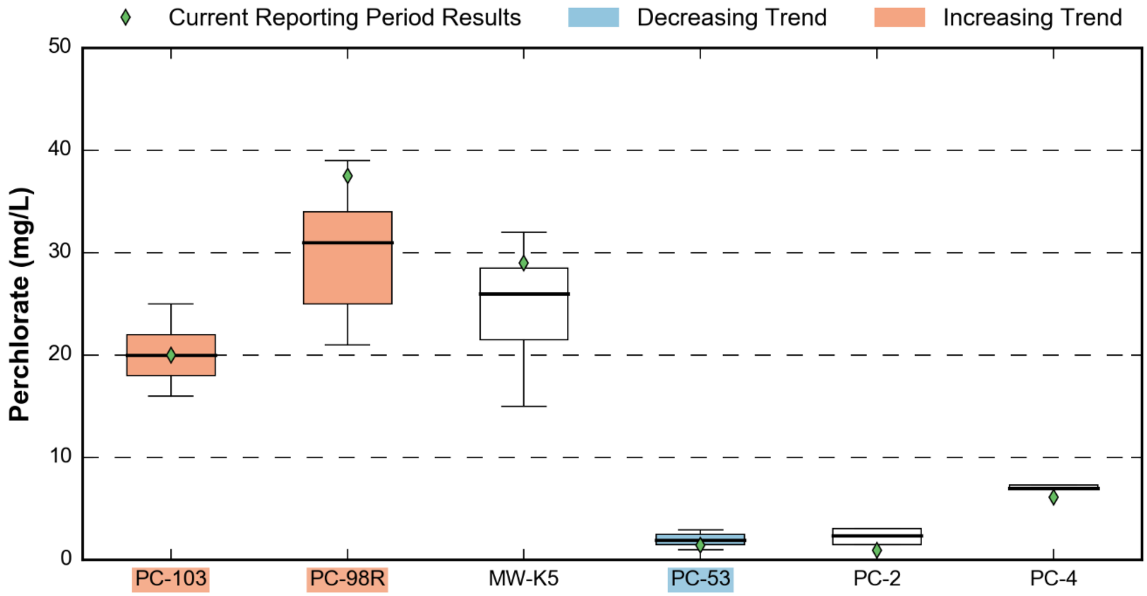
During the reporting period, perchlorate concentrations were generally consistent with the identified trends, as shown on the time series plots below. ARP-6B and MW-K4 continued to show relatively high and variable concentrations relative to other nearby wells. Analysis first presented in Appendix E of the 2011-2012 Annual Performance Report indicated that there could be a gap in the capture zone that may be responsible for the relatively high and variable concentrations in MW-K4 (ENVIRON 2012). PC-150 was activated in November 2014, and perchlorate concentrations generally decreased following activation. However, MW-K4 exhibited elevated concentrations during second quarter 2017. The variable perchlorate concentrations in groundwater at MW-K4 may be influenced by perchlorate mass present in the UMCf and upward flow caused by the natural vertical gradient, as discussed in the Phase 1 Remedial Investigation Data Evaluation Technical Memorandum (Ramboll Environ 2016c). The cause of these concentration trends will be further evaluated as part of the AWF Capture Evaluation and Matrix Diffusion Study Work Plan, which was submitted in September 2017 and approved by NDEP on October 3, 2017 (Ramboll Environ 2017c).



Time Series Plots: ARP Perchlorate Concentrations. This chart depicts perchlorate concentration data collected from the ARP wells over the last four years.

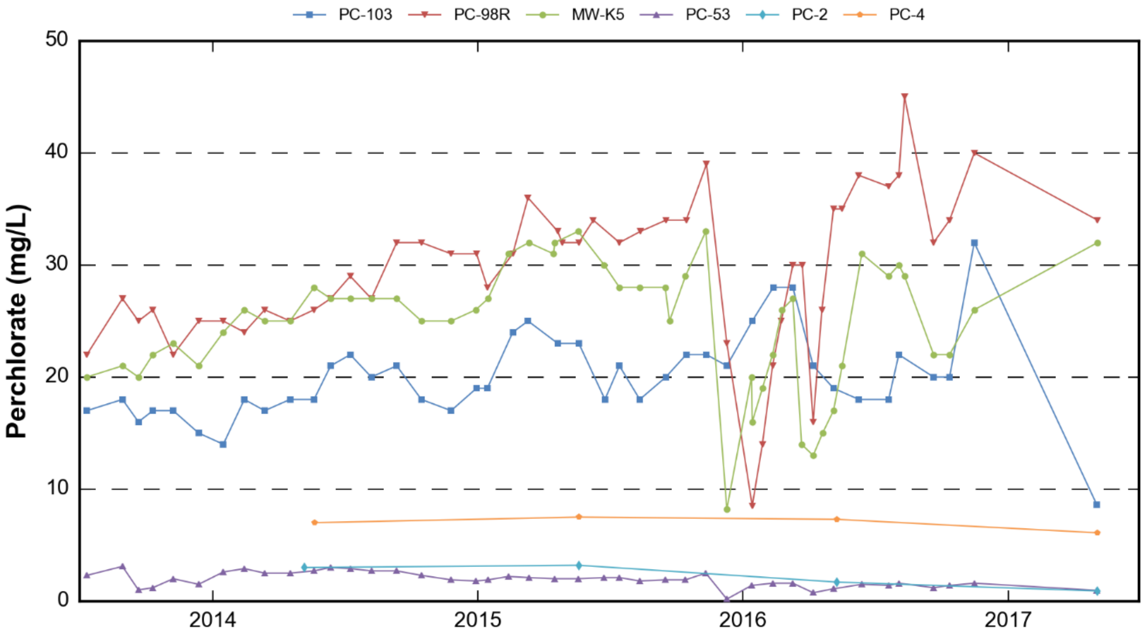
5.2.5 City of Henderson Water Reclamation Facility Well Line

Perchlorate concentrations in the COH WRF Well Line are shown in the charts below. Wells PC-103 and PC-98R, located on the western edge of the COH WRF Well Line, have both shown statistically significant increases in concentration over the last four years, while concentrations in PC-53 have decreased. Statistically significant trends were not identified at the other wells. As shown on Plate 6, the increasing perchlorate concentrations in PC-103 and PC-98R are likely due to contaminant contributions from the adjacent AMPAC/Endeavour perchlorate plume.



Box Plots: COH WRF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

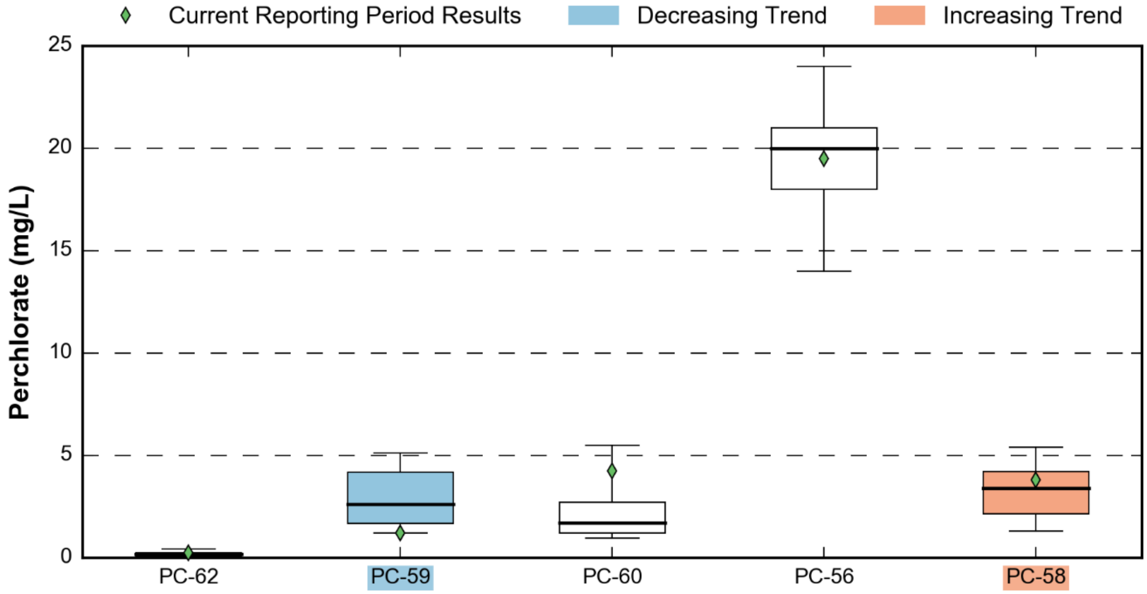
As shown on the time series plots, concentrations measured during the reporting period were generally consistent with these identified trends, with the exception of concentrations in PC-103 which were relatively low in second quarter 2017. During the previous reporting period, sharp decreases in perchlorate concentrations were observed in wells MW-K5 and PC-98R in December 2015 and April 2016, which correspond to sudden increases in measured groundwater elevations in these wells. These trends may be the result of operation of the COH Bird Viewing Ponds, potential influence from the Groundwater Bioremediation Treatability Study that occurred upgradient of the COH WRF well line, or a combination of both. Concentrations in both of these wells appeared more stable during the reporting period.



Time Series Plots: COH WRF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the COH WRF well line over the last four years.

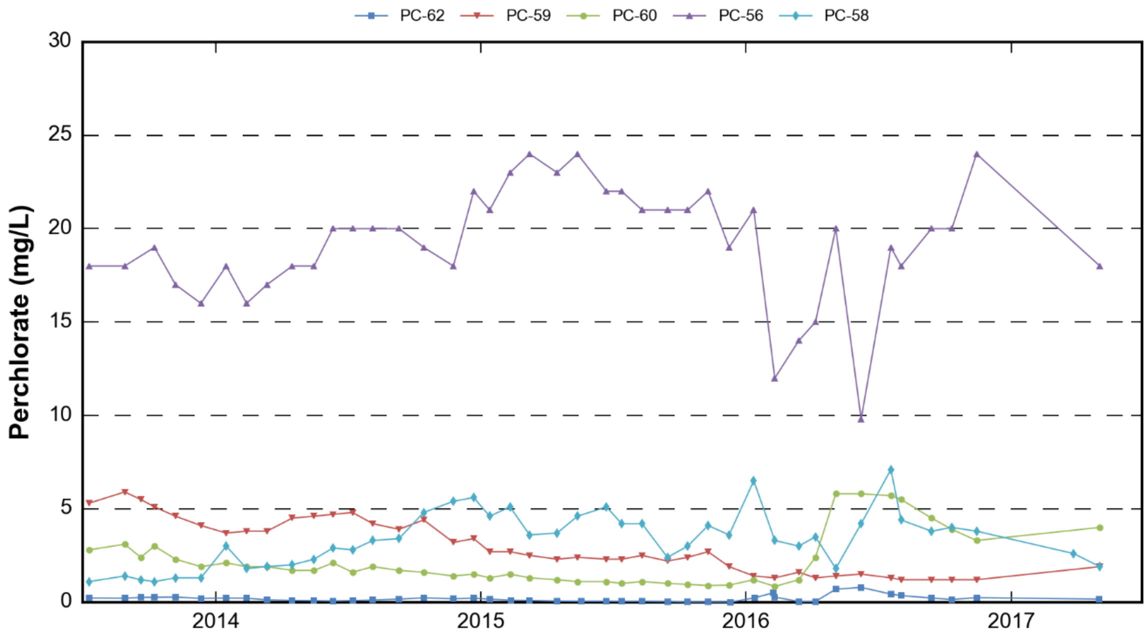
5.2.6 Lower Ponds Well Line

As shown below, the highest concentrations in the Lower Ponds Well Line are in well PC-56. Perchlorate concentrations in well PC-56 have historically been higher and more variable than in other wells along the Lower Ponds Well Line, and may be related to the well's location with respect to the paleochannels as shown on Plate 6.



Box Plots: Lower Ponds Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

Concentrations measured during the reporting period are generally consistent with the above identified trends, as shown in the time series plots below. During the previous reporting period, PC-56 exhibited sudden decreases in concentration in February and June 2016. As discussed in the previous Annual Report (Ramboll Environ 2016e), these low concentrations could be due to a zone of clean water traveling down the alluvial channel originating from either the Groundwater Bioremediation Treatability Study injection site or the COH Bird Viewing Ponds. Concentrations at PC-56 during the reporting period appeared relatively stable.

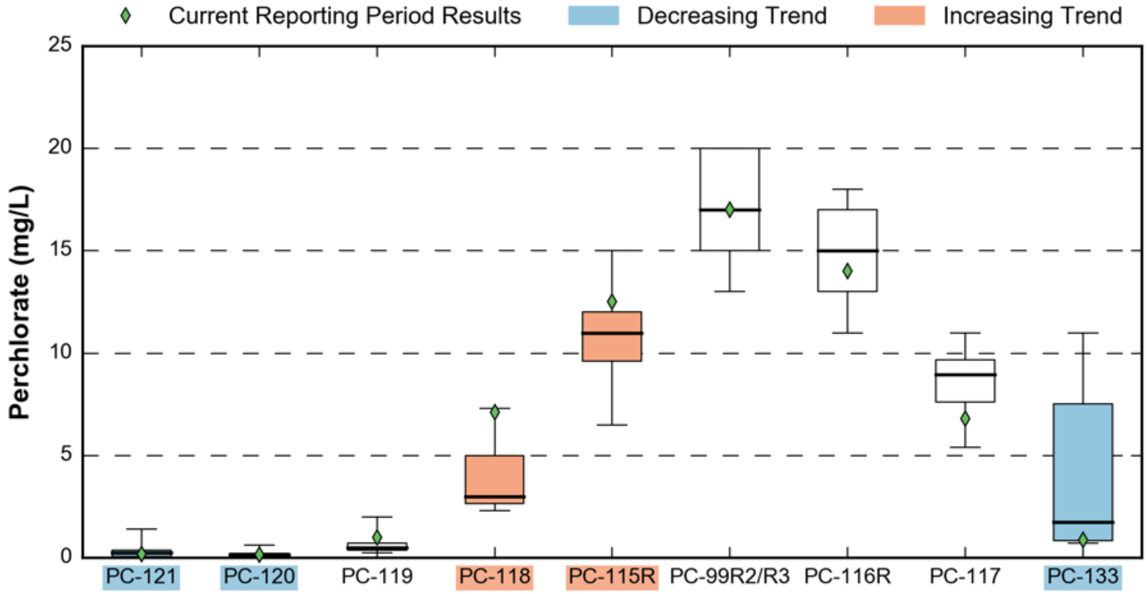


Time Series Plots: Lower Ponds Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the Lower Ponds well line over the last four years.

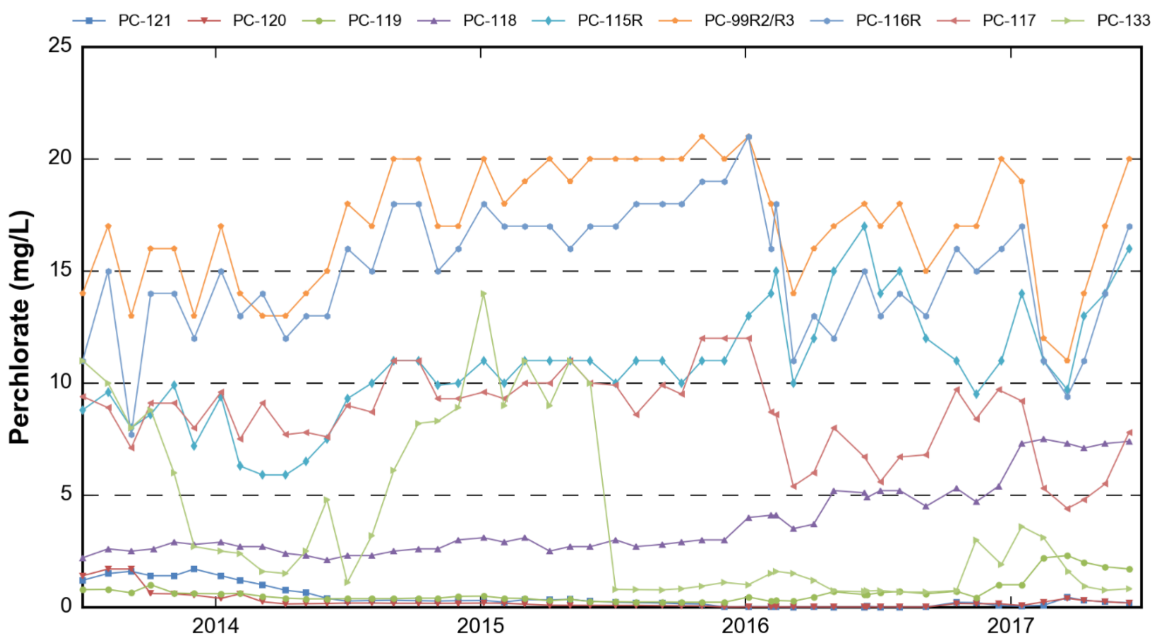
5.2.7 Seep Well Field

The SWF is located approximately 1 mile downgradient (north) of the AWF and is the last point of extraction and contaminant removal before groundwater intersects Las Vegas Wash. While the SWF wells contribute approximately 60% of the total volume of treated water, the relatively low perchlorate concentrations in these wells means that changes in their concentration do not have a large impact on the overall quantity of perchlorate removed from the environment.

As shown in the box plots below, the highest concentrations of perchlorate are located in the central portion of the well line near PC-99R2/R3. The statistical analysis indicates that concentrations in groundwater on the west end of the SWF (PC-120 and PC-121) and the east end of the SWF (PC-133) have decreased over the last four years. Groundwater data from well PC-133 has shown relatively high variability compared to other extraction wells in the SWF, with concentrations ranging from <1 mg/L to 14 mg/L over the last four years (see time series trend graph). The reason for this historical concentration fluctuation is unclear, but perchlorate concentrations were relatively stable in PC-133 during the reporting period. Wells PC-118 and PC-115R, located near the center of the well field, have both shown statistically significant increases in perchlorate concentration over the last four years. The source of the increase is unknown, although chlorate and nitrate concentrations have also increased in this portion of the well field over the same period, as discussed in Sections 7.2.2 and 7.3.2. This trend will continue to be evaluated in future remedial performance reports. Statistically significant trends were not identified in the other extraction wells.



Box Plots: SWF Perchlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).



Time Series Plots: SWF Perchlorate Concentrations. This chart depicts perchlorate concentration data collected in the SWF over the last four years.

6. CHLOROFORM AND OTHER VOLATILE ORGANIC COMPOUNDS

6.1 Volatile Organic Compounds

Chloroform and other VOCs were added to the groundwater monitoring program as part of the 2016 Groundwater Monitoring Optimization Plan after initial evaluations of RI data suggested that these chemicals were present at detectable levels throughout the Site and the NERT Off-Site Study Area (Ramboll Environ 2016c). Comprehensive VOC sampling was conducted as part of the annual (second-quarter) sampling event in May 2017 and will be conducted on an annual basis moving forward. Additional VOC sampling was also conducted in third quarter 2016 as part of the Phase 1 RI supplementary sampling event. The VOC results from these sampling events are presented in Table A-2.

Chloroform was the most widely detected VOC and the only VOC defined as a chemical of potential concern (COPC) within the NERT Off-Site Study Area as part of the Remedial Investigation (RI), and is therefore the focus of the remainder of this section. Of the 62 VOCs analyzed, 23 were detected in addition to chloroform as follows:

- 1,2,3-Trichloropropane was detected in groundwater at 125 wells, with concentrations ranging from 0.0025 µg/L to 0.44 µg/L. The BCL of 0.0026 µg/L was exceeded in groundwater at 123 of these locations. The distribution of 1,2,3-Trichloropropane is generally similar to, but less extensive than, the distribution of chloroform.
- 1,4-Dioxane was detected in groundwater at 86 wells, with concentrations ranging from 0.5 µg/L to 12 µg/L. The BCL of 0.779 µg/L was exceeded in groundwater at 49 of these locations, most of which were distributed downgradient of the Site's Unit Buildings, near OSSM's VOC extraction and treatment system (located to the west of the northwest site boundary), or downgradient of the Site within Parcel A and B.
- Trichloroethene, 1,1-Dichloroethane, Tetrachloroethene, Carbon Tetrachloride, 1,4-Dichlorobenzene, and 1,2-Dichlorobenzene were detected in groundwater at 42 to 61 locations, but had fewer than 10 locations where applicable BCLs or MCLs were exceeded.
- Methylene Chloride, 1,2,4-Trichlorobenzene, and Chlorobenzene were detected in groundwater at approximately 26 to 31 locations, but had fewer than 10 locations where applicable BCLs or MCLs were exceeded in groundwater.
- 1,2,3-Trichlorobenzene, 1,2-Dichloroethane, 1,1-Dichloroethene, Benzene, and Hexachlorobutadiene were detected in groundwater at fewer than 20 locations, and had fewer than 10 locations where applicable BCLs or MCLs were exceeded in groundwater.
- 1,3-Dichlorobenzene, toluene, bromodichloromethane, bromoform, 1,3-dichloropropane, 2-butanone, and trichlorofluoromethane were detected in groundwater at 28 or fewer wells. However, none of these detections exceeded MCL or BCL groundwater screening levels.

6.2 Chloroform Concentration Trends

Plate 7 shows the contoured chloroform plume from the south end of the Site to Las Vegas Wash. The mapped area includes the Downgradient Study Area and the Eastside Study Area (which is comprised of the Eastside Sub-Area and Northeast Sub-Area).[13] The data used to develop the chloroform isoconcentration contours includes second quarter 2017 shallow groundwater data collected by the Trust, OSSM, and TIMET, in addition to 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4. Additional groundwater data collected during 2008/2009 within the Eastside Study Area was also included in the plume interpretation, but is not presented on Plate 7.

The following sections describe chloroform concentration trends at various well lines within the chloroform plume, beginning with the southern-most well line and progressing downgradient to the north towards Las Vegas Wash. The west-east well lines evaluated in this section are generally similar to those evaluated for perchlorate, with the exception of the extraction well fields. VOCs were not collected from extraction wells due to the potential for volatilization of organics when sampled from an extraction well; as such, chloroform concentrations were not evaluated at the extraction well fields. Chloroform concentrations were instead evaluated at alternative well lines comprised of shallow monitoring wells located upgradient of the extraction well fields. The well lines evaluated in this section include the following (as shown on Figure 1):

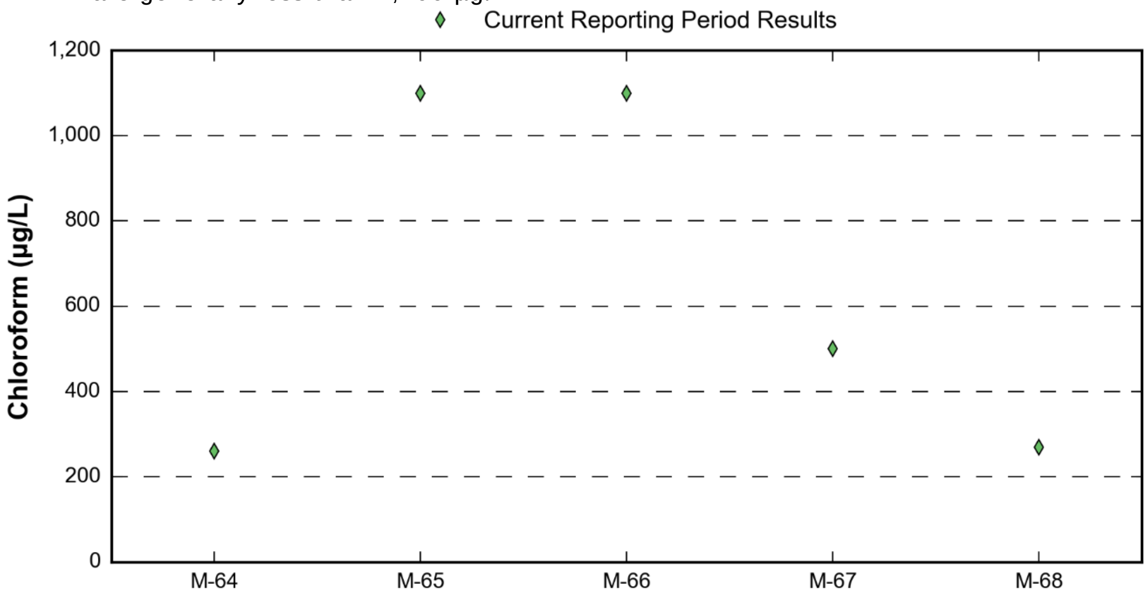
- **Upgradient of the IWF**, comprised of shallow monitoring wells located approximately 100 feet south (upgradient) of the IWF for which data were available during the reporting period;
- **Downgradient of the Barrier Wall**, comprised of shallow monitoring wells located immediately north (downgradient) of the barrier wall for which data were available during the reporting period;
- **Sunset Road Well Line,** comprised of shallow monitoring wells located along Sunset Road, approximately 1,400 feet upgradient of the AWF;
- **The ARP Well Line,** comprised of shallow monitoring wells located approximately 250 feet north of the AWF;
- **The COH WRF Well Line,** comprised of shallow monitoring wells located east of the COH Bird Viewing Ponds and approximately 2,200 feet north of the AWF;
- **The Lower Ponds Well Line,** comprised of shallow monitoring wells located approximately 4,400 feet north of the AWF and 2,200 feet north of the COH WRF Well Line.

These well lines were selected in order to evaluate chloroform concentrations between the Site and Las Vegas Wash during this initial comprehensive round of sampling. The data visualizations presented in this section are limited by the fact that only one comprehensive sampling event has been conducted to date. Box plots and time series plots will be incorporated into future Annual Reports as more data are collected.

[13] The presence of chloroform and other VOCs within the Eastside Sub-Area will be investigated and remediated by BRC, if necessary, pursuant to the terms of the 2006 AOC.

6.2.1 Upgradient of the Interceptor Well Field

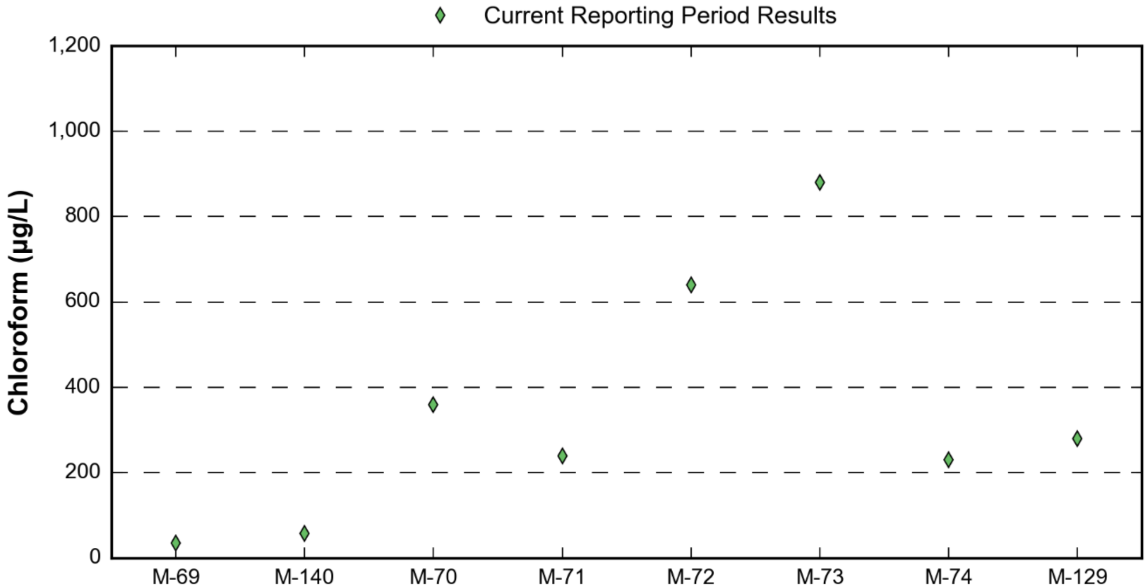
The wells plotted below are located approximately 100 feet south (upgradient) of the IWF. As shown below and on Plate 7, in this initial round of sampling it appears chloroform concentrations are higher near the center of the IWF and lower towards the edges of the well field. Chloroform concentrations immediately upgradient of the IWF are generally less than 1,200 µg/L.



Scatter Plot: Chloroform Concentrations Upgradient of the IWF. This chart depicts chloroform concentration data collected upgradient of the IWF during the second quarter 2017 sampling event.

6.2.2 Downgradient of the Barrier Wall

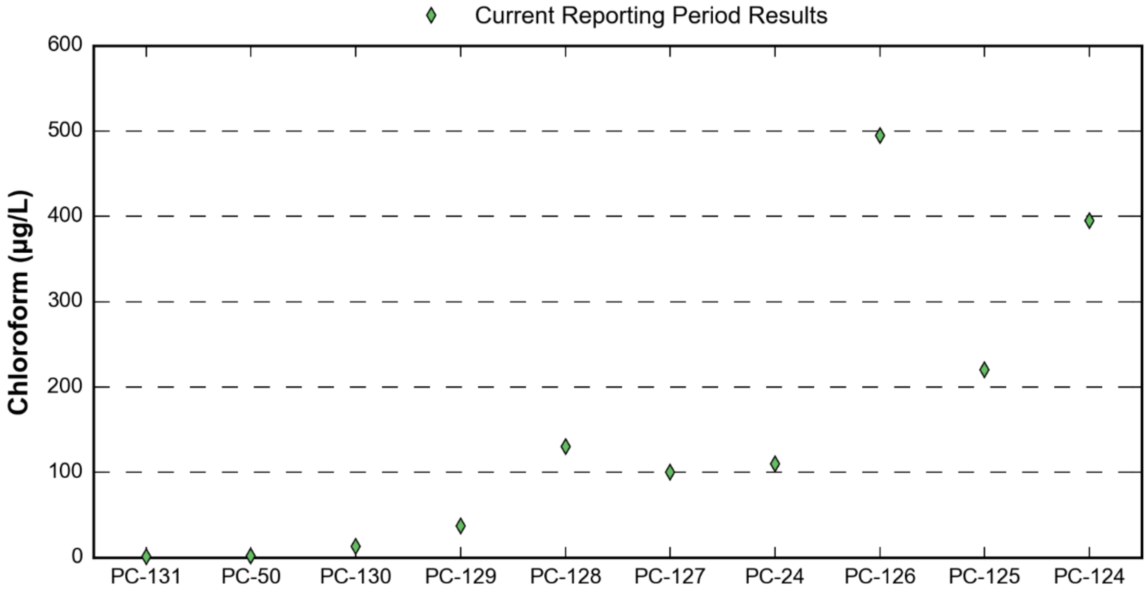
As shown below and on Plate 7, chloroform concentrations in wells located between the barrier wall and former recharge trenches are generally less than 1,000 µg/L and somewhat lower than those upgradient of the barrier wall. The highest concentrations were observed in the eastern central portion of the well line.



Scatter Plot: Chloroform Concentrations Downgradient of the Barrier Wall. This chart depicts chloroform concentration data collected downgradient of the barrier wall during the second quarter 2017 sampling event.

6.2.3 Sunset Road Well Line

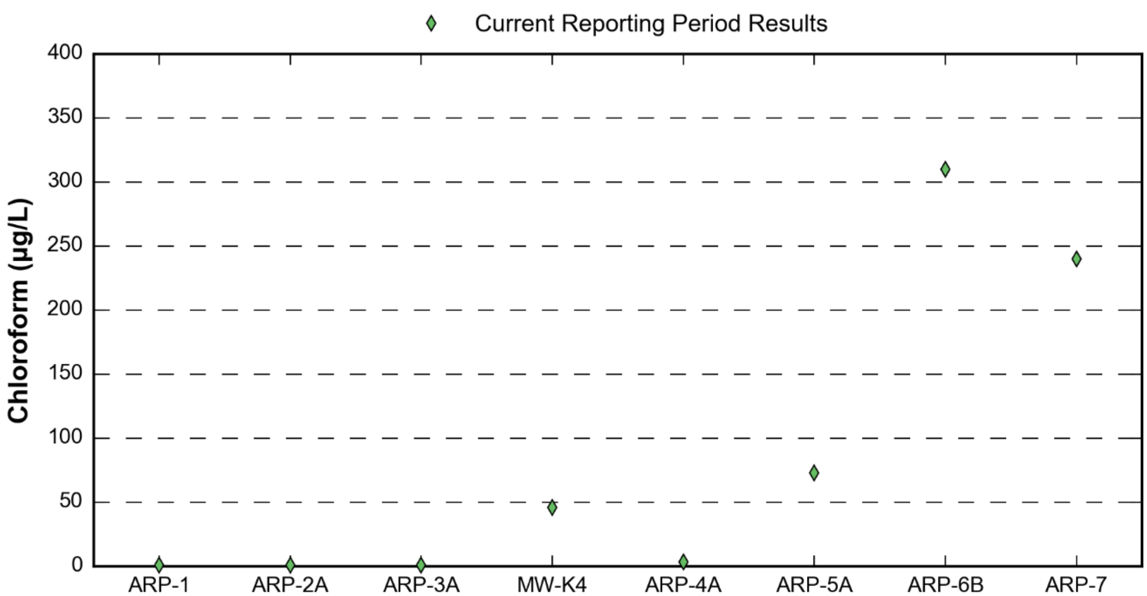
As shown below, chloroform concentrations are generally lower along the Sunset Road Well Line than within the NERT site, with higher chloroform concentrations measured in groundwater from wells located on the east side of the well line. As shown on Plate 7, the chloroform plume likely extends further east of the Sunset Road Well Line; however, shallow groundwater data is currently not available in this area.



Scatter Plot: Chloroform Concentrations on Sunset Road. This chart depicts chloroform concentration data collected along Sunset Road during the second quarter 2017 sampling event.

6.2.4 Athens Road Piezometer Well Line

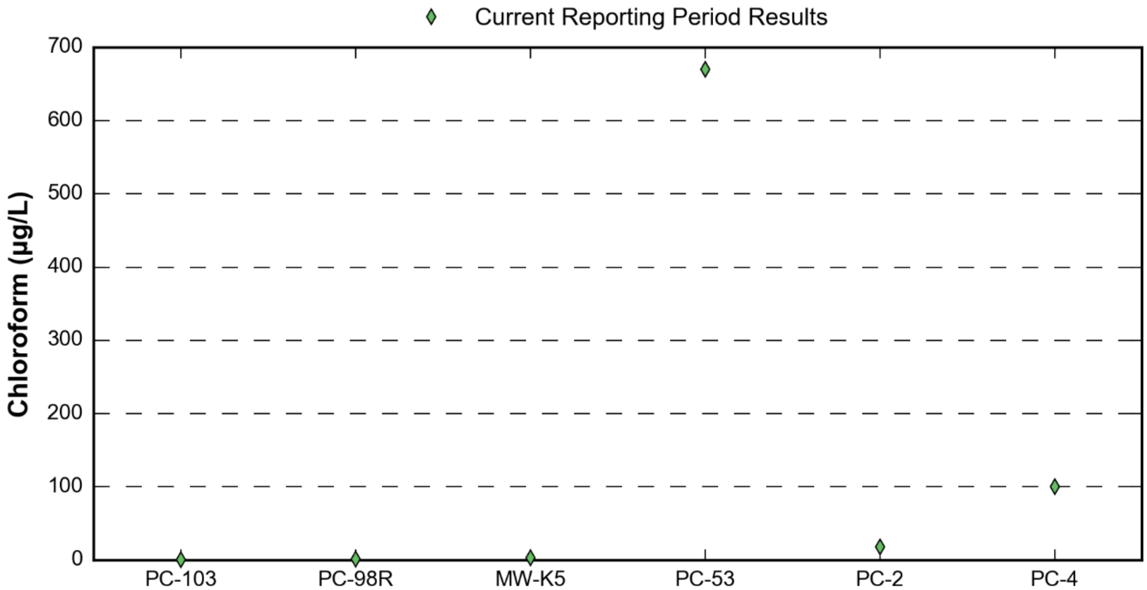
Chloroform concentrations across the ARP Well Line are presented below. Concentrations were less than 350 µg/L along this well line during the reporting period, with the highest concentrations observed on the east side of the well line.



Scatter Plot: Chloroform Concentrations at the Athens Road Piezometers. This chart depicts chloroform concentration data collected from the Athens Road Piezometers during the second quarter 2017 sampling event.

6.2.5 City of Henderson Water Reclamation Facility Well Line

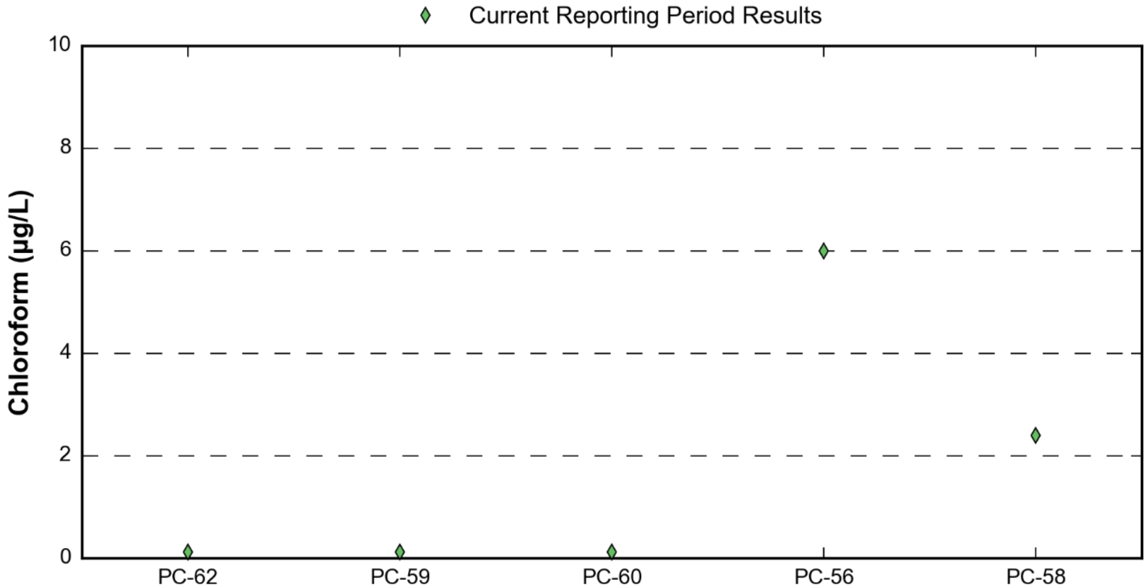
Chloroform concentration across the COH WRF Well Line were less than 100 µg/L during the reporting period with the exception of PC-53. Future monitoring events will help determine if PC-53 is anomalous or accurately reflects current groundwater conditions.



Scatter Plot: COH WRF Chloroform Concentrations. This chart depicts chloroform concentration data collected near the COH WRF during the second quarter 2017 sampling event.

6.2.6 Lower Ponds Well Line

Chloroform concentrations in the Lower Ponds Well Line ranged from non-detect to less than 10 µg/L during the reporting period. The highest concentration in this well line was observed in well PC-56.



Scatter Plot: Lower Ponds Chloroform Concentrations. This chart depicts chloroform concentration data collected along the Lower Ponds well line during the second quarter 2017 sampling event.

7. OTHER MEASURED PARAMETERS

This section discusses other measured parameters including TDS, chlorate, and nitrate at the IWF, AWF, and SWF. Consistent with prior reports evaluating TDS trends, the west-east well lines evaluated in this section are limited to the extraction well lines. Similarly, chlorate and nitrate evaluations are also limited to the extraction well lines.

As requested by NDEP in the December 6, 2016 comment letter on the previous Annual Report (NDEP 2016), this report incorporates statistical analyses of well line concentration trends, as described in Section 4.2.

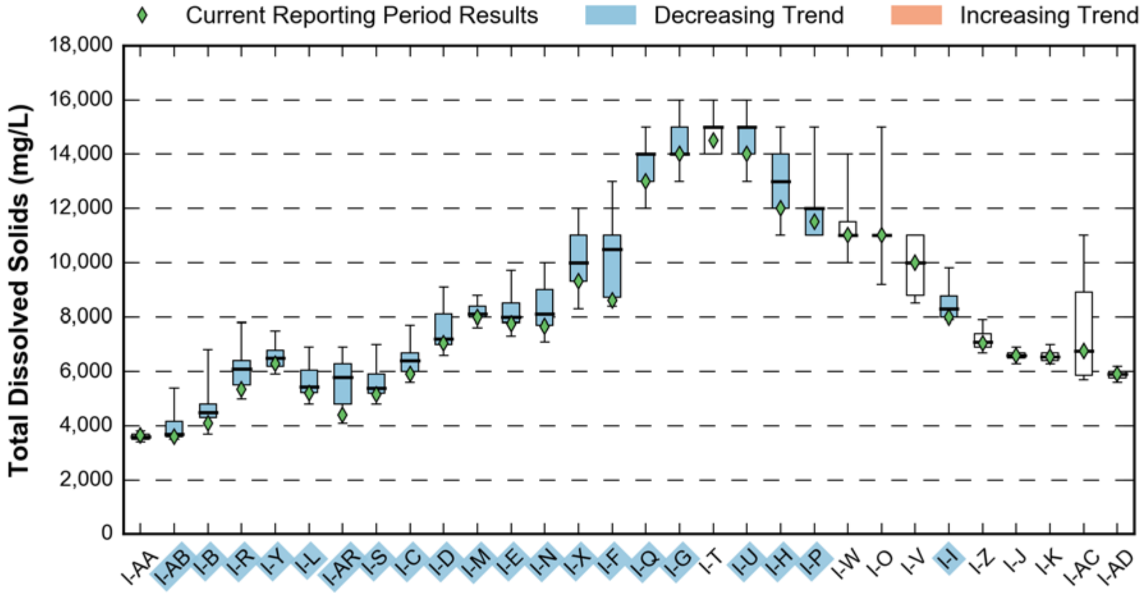
7.1 Total Dissolved Solids

Plate 8 presents the isoconcentration contours for TDS from the southern end of the Site northward to Las Vegas Wash. The mapped area has been substantially expanded as part of this report to include the Downgradient Study Area and the Eastside Study Area. The data used to develop the TDS isoconcentration contours includes second quarter 2017 shallow groundwater data collected by the Trust, OSSM, SNWA, TIMET, and AMPAC/Endeavour, in addition to second quarter 2016 shallow groundwater data collected by AECOM and 2014/2015 shallow groundwater data collected by BRC. These data are available in Table A-1 and Table A-4.

The following sections describe TDS concentration trends at the IWF, AWF, and SWF.

7.1.1 Interceptor Well Field

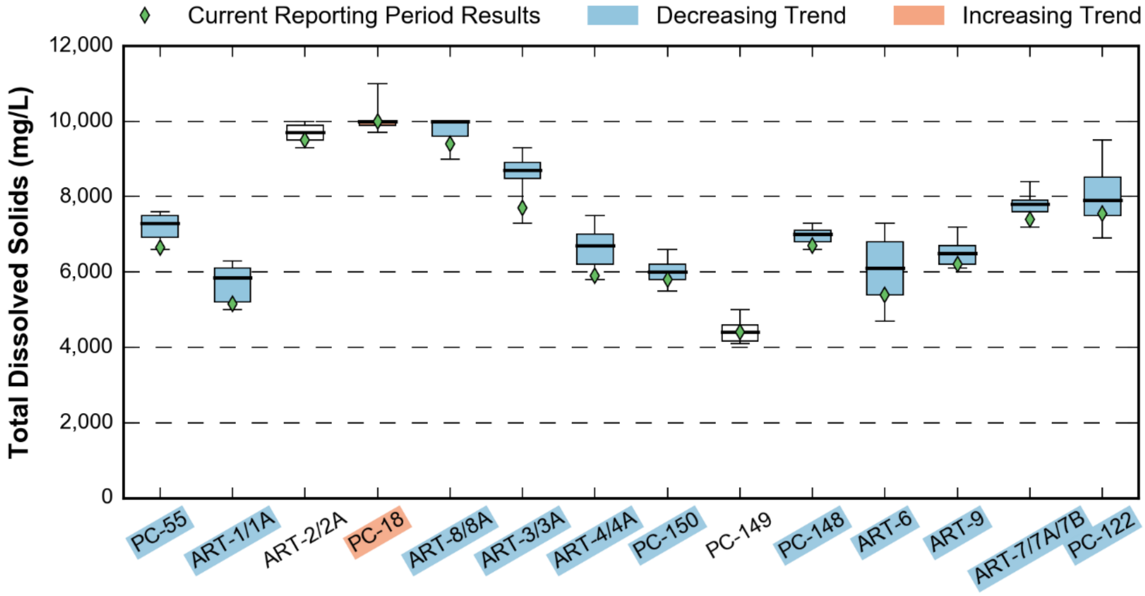
As shown in the box plot below, TDS concentrations in groundwater are higher near the center of the IWF. Statistical analysis indicates that TDS concentrations in the majority of IWF wells (20 wells) have decreased over the last four years. Statistically significant trends were not identified in data from the other extraction wells.



Box Plots: IWF TDS Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.1.2 Athens Road Well Field

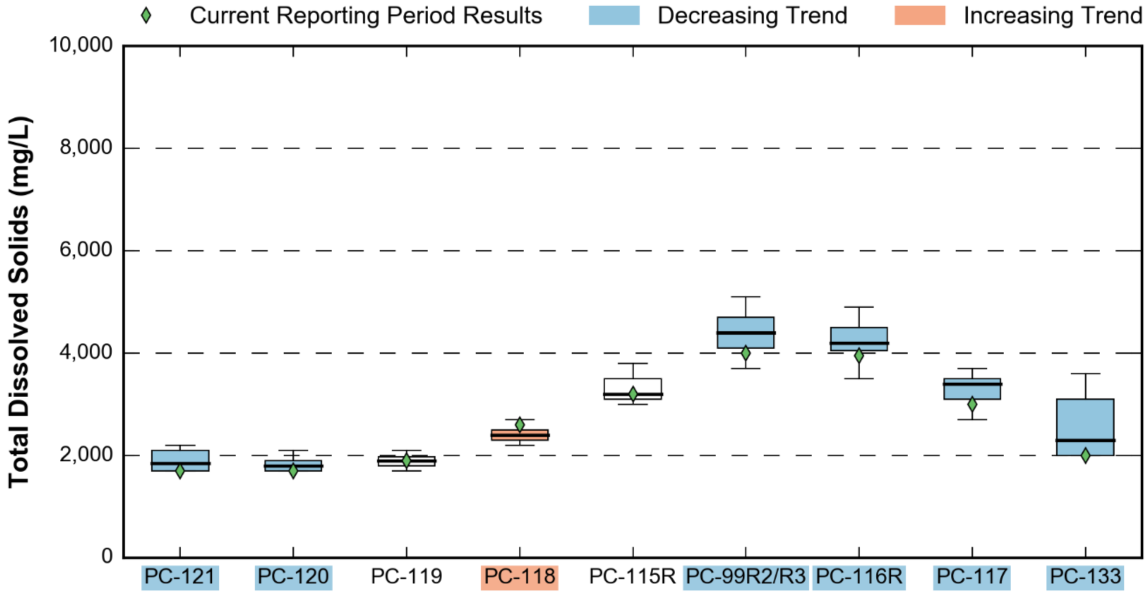
TDS concentrations in groundwater from the AWF's eight pumping well pairs are shown in the chart below, in addition to monitoring wells ART-6, PC-18, PC-55, PC-122, PC-148, and PC-149. Similar to perchlorate, TDS concentrations in the western sub-channel (represented by wells west of PC-149) are generally slightly higher relative to those in the eastern sub-channel (represented by wells east of PC-148). The statistical analysis indicates that TDS concentrations in groundwater in a majority of these well (11 wells) have decreased over the last four years, with the exception of concentrations in PC-18 which have increased. Statistically significant trends were not identified in data from the other wells.



Box Plots: AWF TDS Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.1.3 Seep Well Field

TDS concentrations in groundwater collected from the SWF are generally less than 5,000 mg/L, with the highest concentrations near the east-central portion of the well field, as shown below. The statistical analysis indicates that TDS concentrations in a majority of the SWF wells (6 wells) have decreased over the last four years, with the exception of well PC-118 where concentrations have increased. Statistically significant trends were not identified in the other extraction wells.



Box Plots: SWF TDS Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

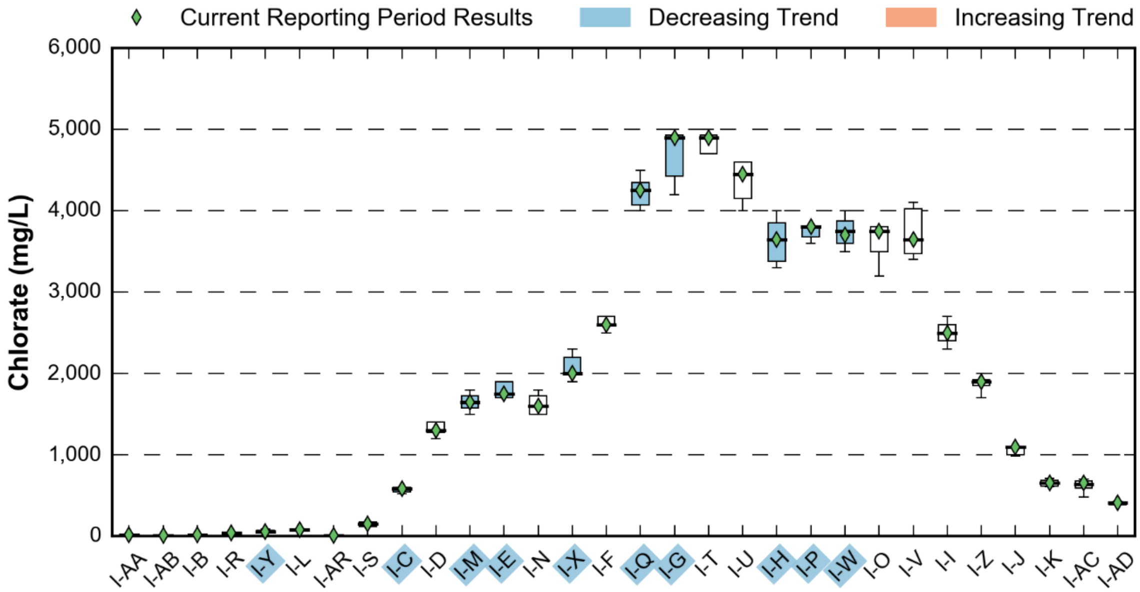
7.2 Chlorate

Chlorate monitoring was significantly expanded as part of the 2016 Groundwater Monitoring Optimization Plan to include all monitoring wells during the semi-annual (fourth quarter) and annual (second quarter) sampling events (Ramboll Environ 2016b). Chlorate was also added to the monthly sampling of extraction wells for the purpose of better understanding its impact on GWETS performance. Chlorate significantly contributes to contaminant loading at the FBRs, which also biologically remove perchlorate and nitrate.

A plume map for chlorate was generated as part of the Annual Report prior to 2012. The map is no longer routinely prepared following NDEP's comment that a chlorate isoconcentration map is not necessary because the extent of chlorate is closely aligned with the distribution of perchlorate (NDEP 2011).

7.2.1 Interceptor Well Field

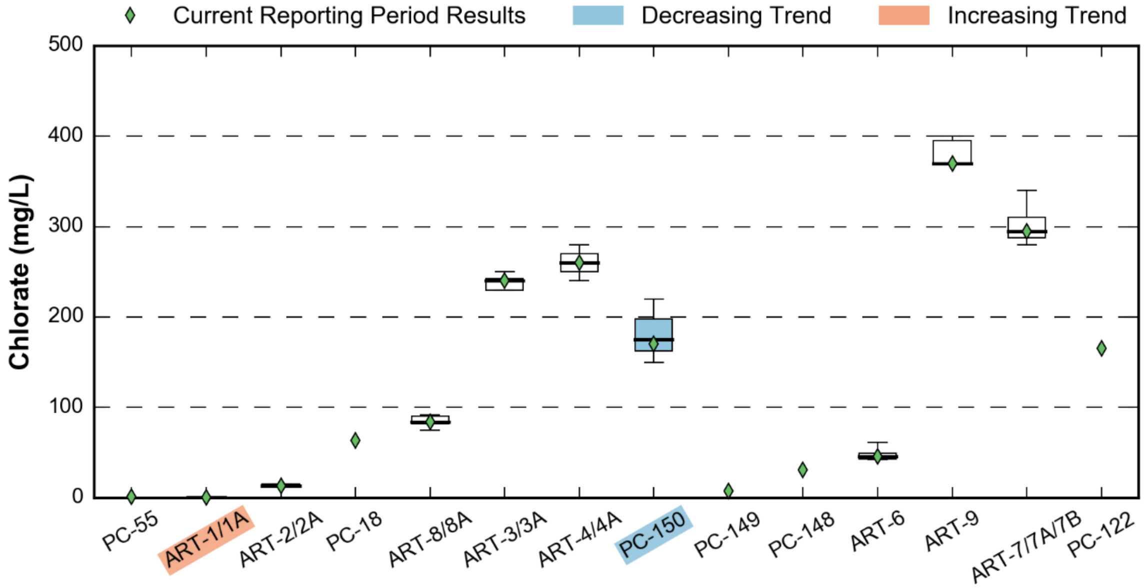
As shown in the box plot below, chlorate concentrations in groundwater are higher near the center of the IWF. The statistical analysis indicates that chlorate concentrations decreased in 10 IWF wells over the last four years. Statistically significant trends were not identified in the other extraction wells.



Box Plots: IWF Chlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.2.2 Athens Road Well Field

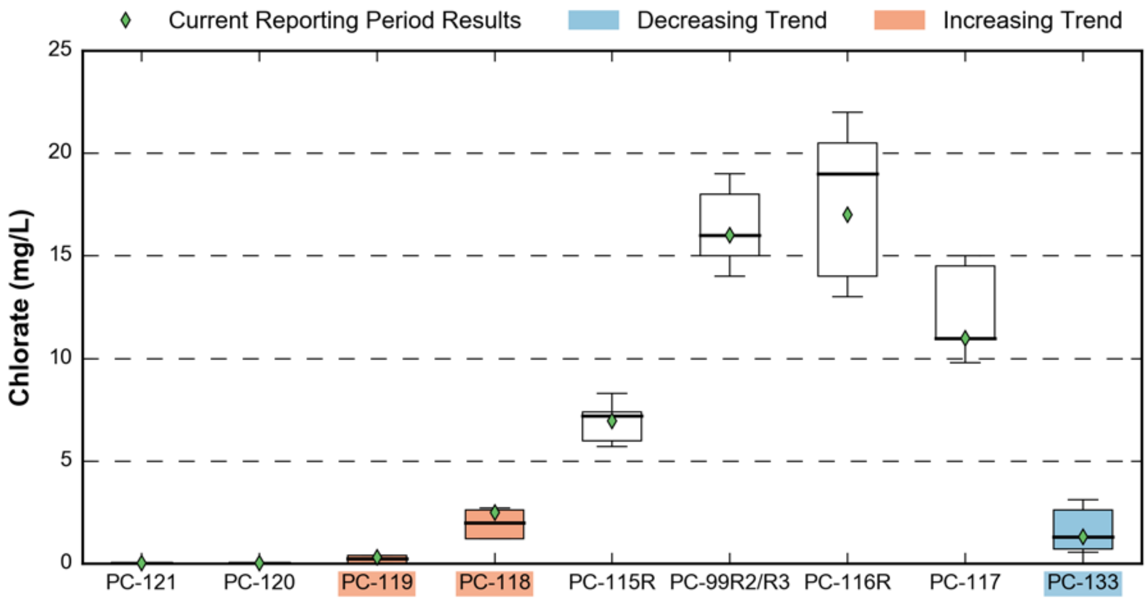
Chlorate concentrations in groundwater collected from the AWF's eight pumping well pairs are shown in the chart below, in addition to monitoring wells ART-6, PC-18, PC-55, PC-122, PC-148, and PC-149. Chlorate concentrations are generally less than 400 mg/L, and are highest in the central and eastern portions of the well field. The statistical analysis indicates that chlorate concentrations decreased in well PC-150 and increased in ART-1/1A over the last four years; however, statistically significant trends were not identified in data from the other wells.



Box Plots: AWF Chlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.2.3 Seep Well Field

Chlorate concentrations in the SWF are less than 25 mg/L, with the highest concentrations near the east-central portion of the well field. Statistical analysis indicates that chlorate concentrations in groundwater in well PC-133 have decreased, while concentrations in PC-119 and PC-118 have increased. The increasing chlorate concentrations in this area of the SWF are roughly aligned with the area of increasing perchlorate concentrations in wells PC-115R and PC-118 discussed in Section 5.2.7. Statistically significant trends were not identified in the other extraction wells.



Box Plots: SWF Chlorate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

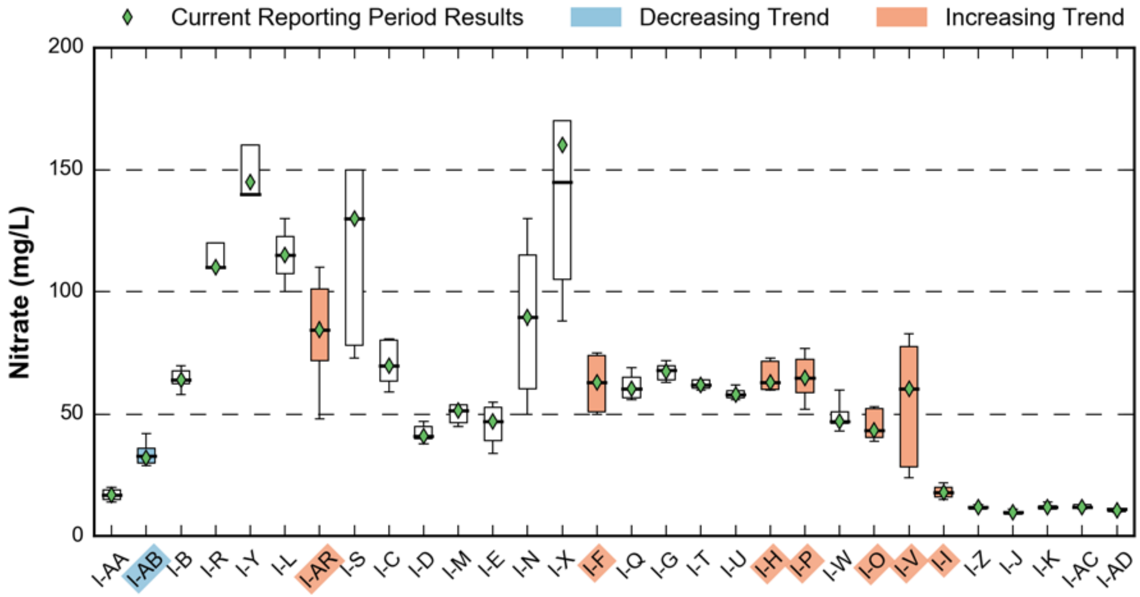
7.3 Nitrate

Nitrate monitoring was significantly expanded as part of the 2016 Groundwater Monitoring Optimization Plan to include all monitoring wells during the semi-annual (fourth quarter) and annual (second quarter) sampling events (Ramboll Environ 2016b). Nitrate was also added to the monthly sampling of extraction wells for the purpose of better understanding its impact on GWETS performance. Nitrate significantly contributes to contaminant loading at the FBRs, which also biologically remove perchlorate and chlorate.

Similar to chlorate, a plume map for nitrate was generated as part of the Annual Report prior to 2012. The map is no longer routinely prepared following NDEP's suggestion that a nitrate isoconcentration map is not necessary because the extent of nitrate is closely aligned with the distribution of perchlorate (NDEP 2011).

7.3.1 Interceptor Well Field

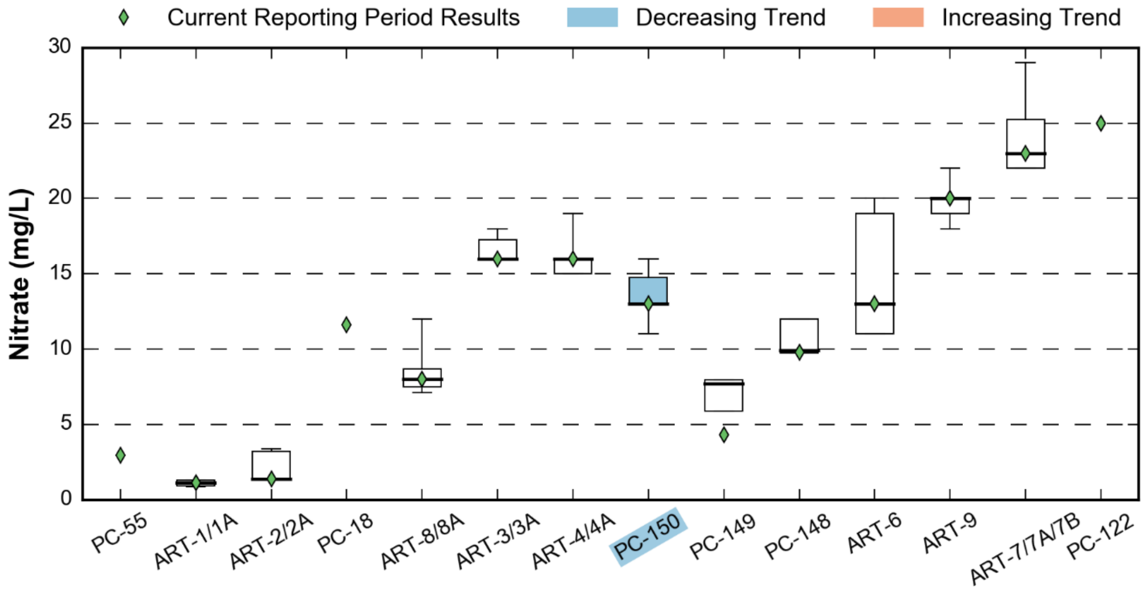
As shown in the box plot below, nitrate concentrations are higher in groundwater in the central to west-central portion of the IWF. Statistical analysis indicates that nitrate concentrations in groundwater in 7 IWF wells have increased, while concentrations in groundwater at I-AB have decreased. Statistically significant trends were not identified in the other extraction wells.



Box Plots: IWF Nitrate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.3.2 Athens Road Well Field

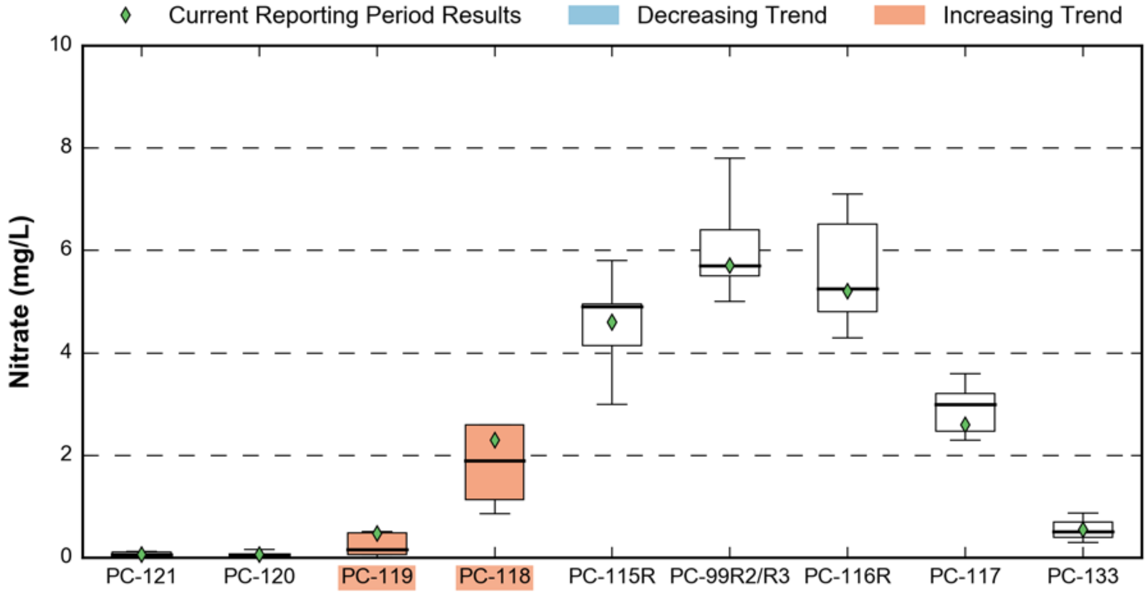
Nitrate concentrations in groundwater collected from the AWF's eight pumping well pairs are shown in the chart below, in addition to monitoring wells ART-6, PC-18, PC-55, PC-122, PC-148, and PC-149. Concentrations are generally highest in the central and eastern portions of the well line. Statistical analysis indicates that nitrate concentrations decreased in PC-150. Statistically significant trends were not identified in the other wells.



Box Plots: AWF Nitrate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25^{th}-75^{th} percentile; the "whiskers" represent data in the 5^{th}-95^{th} percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

7.3.3 Seep Well Field

Nitrate concentrations in groundwater collected from the SWF are less than 8 mg/L, with the highest concentrations near the east-central portion of the well field. The statistical analysis indicates that nitrate concentrations increased in groundwater at PC-119 and PC-118. The increasing nitrate concentrations in this area of the SWF are roughly aligned with the area of increasing chlorate concentrations in wells PC-118 and PC-119 and increasing perchlorate concentrations in wells PC-115R and PC-118. Statistically significant trends were not identified in data from the other extraction wells.



Box Plots: SWF Nitrate Concentrations. Wells are shown in geographical order from west to east. For each well location, data from July 2013 to June 2017 are displayed as follows: the thick black line represents the median value; the box represents data in the 25th-75th percentile; the "whiskers" represent data in the 5th-95th percentile. The green diamond represents the median value during the reporting period. Statistically significant concentration trends, as established using the last 4 years of available data and the Mann-Kendall Test, are depicted using color (lack of color indicates no statistically significant trend).

8. PERFORMANCE EVALUATION

This section provides an evaluation of the performance of the GWETS against a set of performance metrics developed in coordination with NDEP. The performance metrics are intended to establish a consistent framework for evaluating performance of the GWETS. At the direction of NDEP, the Trust anticipates revising and expanding the current performance metrics to incorporate additional RI study areas. A technical memorandum describing the strategy for developing these revised metrics, including a strategy for developing plume mass estimates incorporating the Downgradient Study Area and the Eastside Study Area, was submitted to NDEP on October 5, 2017 (Ramboll Environ 2017d) and approved by NDEP on October 19, 2017 (NDEP 2017). The revised metrics will be evaluated in future performance evaluations according to the implementation schedule presented in the technical memorandum.

8.1 Performance Metrics

The performance metrics are discrete measures of performance that are used to understand and adjust GWETS operations over time. The performance metrics were initially developed as part of the 2013 GWETS Optimization Work Plan (ENVIRON 2013c), approved by NDEP on December 3, 2013 (NDEP 2013b). The metrics include those identified in the October 10, 2013 letter from NDEP (NDEP 2013a) commenting on the 2012-2013 Annual Performance Report, additional data requested in the April 9, 2014 letter from NDEP (NDEP 2014) on the 2013 Semi-Annual Performance Report, and additional metrics identified by Ramboll Environ.

The current performance metrics are evaluated with respect to the NERT Site and NERT Off-Site Study Area and include the following[14]:

- Mass Removal;
- Remaining Plume Mass;
- Capture Zone Evaluation;
- Estimated Mass Flux;
- Perchlorate Mass Loading to Las Vegas Wash;
- Surface Water and Groundwater Interaction Near the SWF; and
- Environmental Footprint of the GWETS and Groundwater Monitoring Program.

As described in the abovementioned technical memorandum, expanded performance metrics will be evaluated in future performance evaluations according to the

[14] GW-11's operation as an equalization basin was evaluated as part of the performance metrics in previous performance evaluations. The evaluation of GW-11's operations has since been incorporated into the GWETS Enhanced Operational Metrics, which are evaluated as part of NERT's monthly GWETS operations reporting; therefore, GW-11's operations are no longer evaluated as part of the performance metrics. An analysis of the barrier wall's performance was also previously evaluated as part of the performance metrics in previous performance evaluations. A work plan to evaluate the integrity of the barrier wall was submitted to NDEP in September 2017 (Ramboll Environ 2017b) and approved by NDEP on October 3, 2017. Future evaluations of the barrier wall's performance will therefore be conducted as part of that effort, and will no longer be included as part of the performance metrics.

implementation schedule presented in the technical memorandum. These expanded performance metrics include the following:

- An expanded evaluation of perchlorate mass loading in Las Vegas Wash to incorporate additional sampling locations;
- An estimate of remaining perchlorate plume mass for the entire NERT RI Study Area (including the NERT Site, the NERT Off-Site Study Area, the Eastside Study Area, and the Downgradient Study Area);
- Estimated perchlorate mass flux at the Operable Unit (OU) transects across the entire NERT RI Study Area; and
- Estimated vertical mass flux of perchlorate between the alluvium and UMCf across the entire NERT RI Study Area.

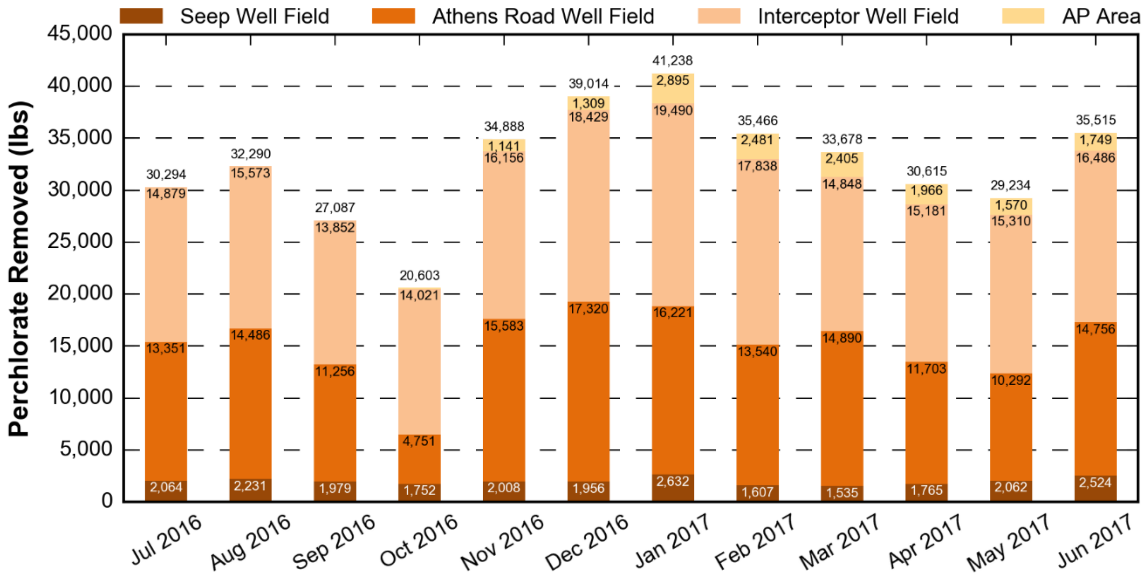
8.2 Evaluation of Performance

In this section, the performance of the GWETS is discussed in relation to the current performance metrics presented in Section 8.1.

8.2.1 Mass Removal

During the reporting period, approximately 389,900 pounds of perchlorate were captured and removed from groundwater by the GWETS, as shown in Table 8 and in the figure below. Of this total, approximately 192,100 pounds were captured by the IWF, approximately 158,100 pounds were captured by the AWF, approximately 24,100 pounds were captured by the SWF, and approximately 15,600 pounds were captured by the AP Area extraction wells.[15]

[15] Average extraction rates, concentrations, and total mass removal from the AP Area are reported in the GWETS operation monthly reports submitted to NDEP (Envirogen 2016, 2017a-f).



Perchlorate Mass Removal. This chart shows monthly perchlorate removed by the IWF, AWF, SWF, and AP Area extraction wells during the reporting period. The total amount of perchlorate removed is shown above each bar. (The AP Area extraction wells removed 79 pounds [lbs] of perchlorate in October 2016; this number is not printed on the chart, but is reflected in the total mass removal number.)

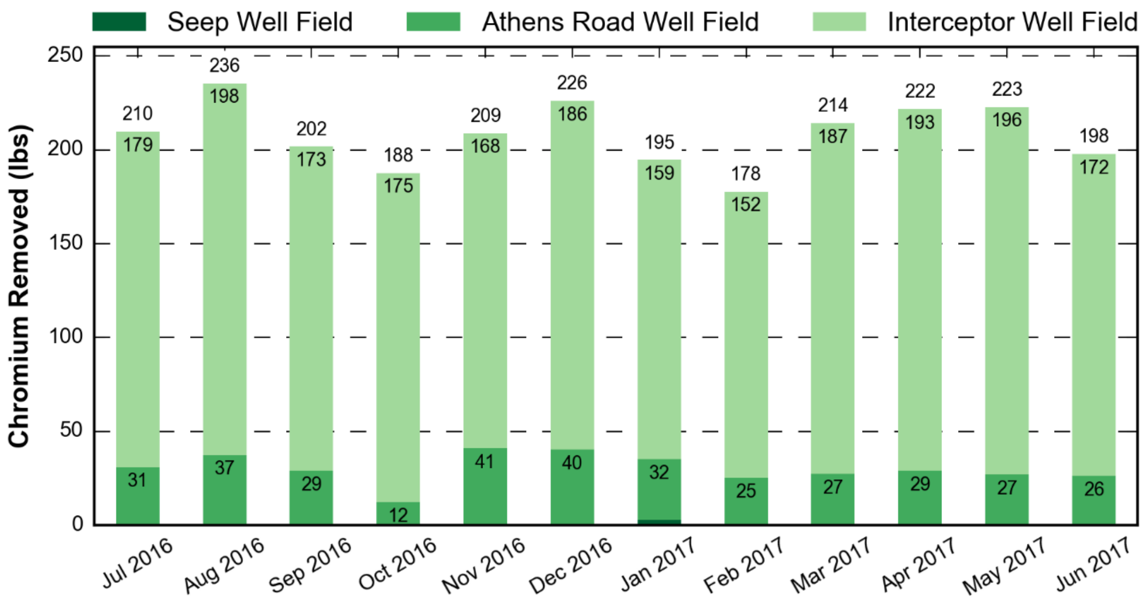
The total combined perchlorate mass removal from all extraction wells during the reporting period decreased by 4.4% compared to the 407,900 pounds removed between July 2015 and June 2016.[16] The slight decrease in removal is primarily the result of lower average perchlorate concentrations at the IWF and AWF. The average perchlorate concentrations at the IWF and AWF during the reporting period were approximately 700 mg/L and 100 mg/L, respectively; for the July 2015 through June 2016 reporting period, the average IWF and AWF concentrations were approximately 770 mg/L and 150 mg/L, respectively. Barring additional historic rain events or changes in system operation, it is expected that perchlorate concentrations and mass removals will continue to decrease consistent with the trend established prior to December 2012.[17] However, the Trust took significant actions in 2016 to improve the extraction rate of the AWF through the installation of new pumps and variable frequency drives, and AWF extraction rates increased from 292.8 gpm in July 2016 to 431.6 gpm in June 2017. The soil flushing treatability study implemented in the AP Area has also begun to contribute to mass removal near the IWF.

Approximately 2,500 pounds of total chromium were captured and removed from groundwater by the GWETS during the reporting period, as shown in Table 6 and in the figure below. This represents a 4.9% decrease compared to the approximately 2,630

[16] Mass removal values may differ from previously presented values, as mass removal calculations were revised in Table 8 based on recent updates to the flow data to correct minor inaccuracies.

[17] Starting in September 2012 there was a significant increase in the mass of perchlorate captured and removed from groundwater due to a series of storm events between August and October 2012 and subsequent infiltration, causing mobilization of perchlorate from the vadose zone. The effects of the storm events on groundwater conditions were discussed in previous remedial performance reports beginning with the 2012 Semi-Annual Remedial Performance Report (ENVIRON 2013a).

pounds of total chromium removed between July 2015 and June 2016. This slight decrease is also primarily the result of decreased average chromium concentrations observed at the IWF and AWF. The average chromium concentrations at the IWF and AWF during the reporting period were approximately 7.8 mg/L and 0.2 mg/L, respectively; for the July 2015 through June 2016 reporting period, the average IWF and AWF concentrations were approximately 8.2 mg/L and 0.3 mg/L, respectively. Of the total chromium mass removed during the reporting period, approximately 2,140 pounds were captured by the IWF and 360 pounds were captured by the AWF.



Chromium Mass Removal. This chart shows monthly total chromium removed by the IWF, AWF, and SWF during the reporting period. The total amount of chromium removed is shown above each bar.

8.2.2 Remaining Plume Mass

Mass estimates have been presented in the Annual Remedial Performance Reports since 2013. The plume mass estimates presented herein were calculated using the same methodology presented in previous performance evaluations and only include mass contained within the NERT Site boundary and the NERT Off-Site Study Area. Vertically, the current methodology includes the saturated alluvium and the saturated UMCf to a maximum depth of 50 feet below the contact with the alluvium. The current methodology does not include the vadose zone or deeper impacts within the UMCf that have been discovered during recent investigations.

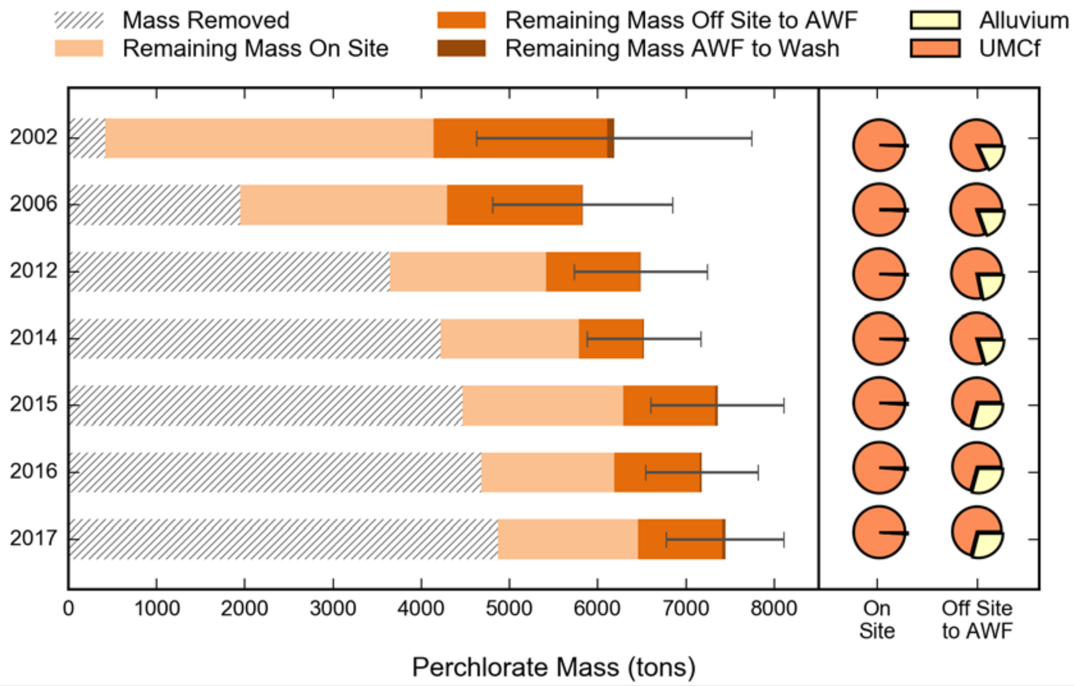
The mass is currently estimated by interpolating the groundwater concentrations of perchlorate and chromium onto a regular grid based on both the isoconcentration contours and the concentrations at well locations for each year. The grid is composed of square grid cells that all have the same area. At each grid cell, the mass is calculated by multiplying the cell area, the saturated thickness, the interpolated groundwater concentration, and the porosity. The alluvium saturated thickness is estimated as the difference between the interpolated water table elevation and the UMCf contact elevation. In order to better compare the mass estimates from year to year, mass estimates for all years are calculated using the Phase 4 model interpretation of the saturated thickness of the Qal and the Qal-UMCf contact. The UMCf thickness is assumed to be 50 feet in the on-site area, 15 feet in the area between the Site and the AWF, and 0 feet north of the AWF. The assumed depth of perchlorate contamination in the UMCf was established in 2013 based on the understanding of the plume at the time, and this assumption has continued to be used to maintain consistency from year to year. Porosities of 0.37 and 0.54 are assumed for the Qal and UMCf, respectively.

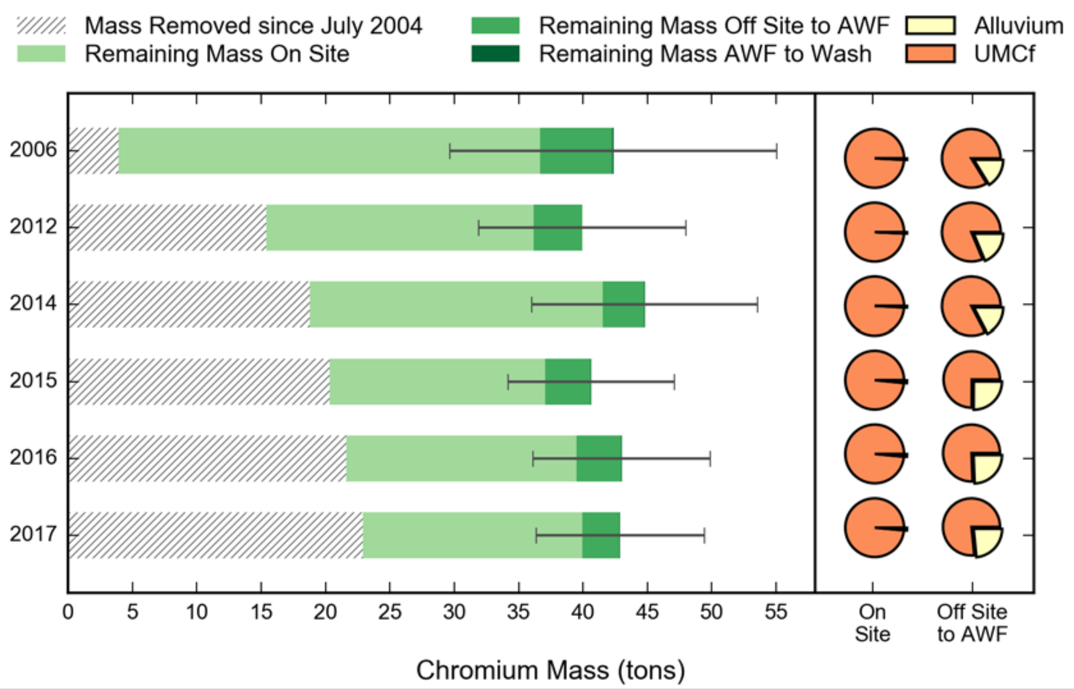
The plume masses as of second quarter 2017 are estimated to be 2,573 ± 665 tons for perchlorate and 19.98 ± 6.53 tons for chromium, as shown in Tables 10 and 11, respectively. Beginning with the 2018 Annual Remedial Performance Report, mass estimates will incorporate the entire NERT RI Study Area (including the Downgradient Study Area and the Eastside Study Area) and will be estimated using a revised methodology as described in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum (Ramboll Environ 2017d). Accordingly, future mass estimates are expected to increase substantially in subsequent evaluations.

The figures below present perchlorate and chromium plume mass estimates[18] for 2002, 2006, 2012, 2014, 2015, 2016, and 2017 with subdivisions showing estimated mass within the Site boundary, within the NERT Off-Site Study Area between the Site and the AWF, and within the NERT Off-Site Study Area between the AWF and Las Vegas Wash (the Wash). Pie charts on the right side of the figure depict the estimated fraction of mass in the Qal and the UMCf in each of these areas.[19] The figures also depict estimated cumulative mass removal over time, showing that the sum of cumulative mass removal and estimated remaining plume mass is generally consistent from year to year when the expected uncertainty is taken into account.

[18] Estimates of remaining plume mass were first presented in the 2012-2013 Annual Remedial Performance Report (ENVIRON 2013b) for years 2002, 2006, and 2012. No estimate of chromium mass for 2002 could be developed due to lack of available data. Since 2014, plume mass estimates have been calculated annually as part of the annual remedial performance reports.

[19] As described in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach memorandum (Ramboll Environ 2017d), current mass estimates were developed under the assumption that UMCf thickness is zero north of the AWF.





Remaining Plume Mass. These charts show the plume mass estimates and cumulative mass removal of perchlorate (above) and chromium (below) within the NERT Site boundary and NERT Off-Site Study Area. Future estimates will include the Downgradient Study Area and the Eastside Study Area. The error bars represent the uncertainty in the plume mass estimates. Pie charts show the proportions of mass in the alluvium and UMCf within the Site and the NERT Off-Site Study Area between the Site and the AWF.

8.2.3 Capture Zone Evaluation

Capture zones for each of the well fields were estimated in the Shallow, Middle, and Deep WBZs using forward particle tracking, calculated using MODPATH (Pollock 1994), and using a steady state version of the Phase 5 Groundwater Model[20] and second quarter 2017 pumping rates. Particles were released in the center of each model cell in model layers 1, 2 and 3 (representing the Shallow WBZ), layers 4 and 5 (representing the Middle WBZ), and layers 6 and 7 (representing the Deep WBZ). Simulated capture zones in the Shallow, Middle, and Deep WBZs are shown in Figures 3a, 3b, and 3c, respectively. This methodology is consistent with the methodology used to evaluate this metric in prior performance reports, and it is anticipated this methodology will continue to be used in future evaluations.

As shown in Figure 3a, the majority of shallow groundwater within the NERT Site boundary and NERT Off-Site Study Area is captured by the combination of the IWF, AWF, and SWF. There are two areas of shallow groundwater that are not captured by the existing system: 1) a small area between the SWF and Las Vegas Wash where perchlorate concentrations were generally less than 3 mg/L during the reporting period, and 2) an area east of the SWF where perchlorate concentrations collected from well PC-94 were approximately 12 to 22 mg/L during the reporting period. The Trust will evaluate the need to address these gaps in capture as part of the Feasibility Study.

8.2.4 Estimated Mass Flux and Well Field Capture Efficiency

As requested in NDEP's December 6, 2016 letter on the 2015-2016 Annual Performance Report, the evaluation of estimated mass flux has been expanded compared to prior performance evaluations to include additional transects for horizontal flux evaluation for both perchlorate and chromium. In addition, at NDEP's request vertical mass flux has been evaluated in the On-Site area, NERT Off-Site Study Area between the Site and AWF, and NERT Off-Site Study Area between the AWF and the Wash for both perchlorate and chromium. As described in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach memorandum, mass flux transects will ultimately be modified and extended to align with the OU boundaries. Calculation of mass flux at the extended transects will begin once data to be collected as part of the Phase 3 RI is available in mid-2018 and reported in the 2018 Annual Remedial Performance Report.

8.2.4.1 Horizontal Mass Flux

Perchlorate and chromium horizontal mass flux were evaluated at a total of 10 transects, as shown on Figure 4. The transects located just upgradient of the IWF, AWF, and SWF were established in 2014 to evaluate well field capture efficiency. At NDEP's request, an additional seven transects were established in 2016 to further evaluate horizontal mass flux. As discussed in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum (Ramboll Environ 2017d), mass flux at each transect location was calculated using groundwater velocities simulated by a

[20] A transient groundwater model (the Phase 5 model) representing groundwater conditions from 2000 to 2015 was developed by Ramboll Environ and submitted to NDEP in November 2016 (Ramboll Environ 2016f). A steady-state version of the Phase 5 model calibrated to 2015 groundwater conditions was updated with average pumping rates for second quarter 2017 to be used in the evaluations presented in this memorandum. The model grid size near the well fields was refined in the steady-state version of the Phase 5 model; however, the model layers and the layer properties remained unchanged.

steady state version of the Phase 5 groundwater model and interpolated second quarter 2017 concentrations. For each grid cell on the transect, the mass flux is calculated as the product of the interpolated concentration, simulated groundwater velocity, cell width, and saturated thickness of the alluvium and the upper 10 feet of the UMCf (Layer 2 of the model). Since the plume is representative of concentrations in the shallow WBZ, the same concentrations are used for the alluvium and the UMCf for this evaluation. Estimated horizontal mass flux for chromium and perchlorate are presented on Figure 4.

The perchlorate mass flux across the transect located along Las Vegas Wash of 68 lbs/day appears to be an overestimate because it is greater than the mass loading measured in Las Vegas Wash at Northshore Road of 58.7 lbs/day (described in Section 8.2.5). As discussed in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum (Ramboll Environ 2017d), the method for calculating the mass flux will be refined in next year's annual remedial performance report. The new method will use the Phase 6 Groundwater Transport Model, which will be calibrated to give a more accurate estimate of mass flux into Las Vegas Wash. In addition, the new method will include mass flux from both advection and dispersion. The current method only includes mass flux from advection.

For the transects located immediately upgradient of the well fields, the portion of mass flux within and outside of the capture zones was estimated to further evaluate the performance of the IWF, AWF, and SWF. The captured mass flux was estimated as the well field mass removal rate, based on the monthly average pumping rates and extraction well concentrations associated with each month in second quarter 2017. The mass flux outside of the capture zone at each transect was calculated from modeled flow rates and interpolated concentrations, as described above. The capture efficiency is the percentage of mass captured versus the total mass flux (sum of captured mass and uncaptured mass). Using these approaches, mass fluxes and capture efficiencies were calculated as follows:

	Perchlorate Mass Flux			Chromium Mass Flux		
Well Field	**Mass Captured (lbs/day)**	**Mass Not Captured (lbs/day)**	**Capture Efficiency**	**Mass Captured (lbs/day)**	**Mass Not Captured (lbs/day)**	**Capture Efficiency**
IWF	516	44.9	92.0%	6.2	0.08	98.7%
AWF	404	8.2	98.0%	0.9	0.01	98.9%
SWF	70	1.7	97.7%	--	--	--

As requested in NDEP's April 9, 2014 letter on the 2013 Semi-Annual Remedial Performance Report (NDEP 2014), the capture efficiency of each well field transect was also estimated using an alternative calculation method, one based only on model-estimated groundwater flow rates and interpolated concentrations as described above. As shown in the table below, the estimated mass captured at the three well fields using the alternative method is generally consistent with the estimated mass captured using the extraction well mass removal rates (baseline method). While it is Ramboll Environ's opinion that the baseline method is likely to be most accurate, the alternative method provides a comparison to check the accuracy of the baseline method.

	Baseline Method[1]		Alternative Method	
Well Field	**Perchlorate Mass Captured (lbs/day)**	**Capture Efficiency**	**Perchlorate Mass Captured (lbs/day)**	**Capture Efficiency**
IWF	516	92.0%	515	92.0%
AWF	404	98.0%	419	98.1%
SWF	70	97.7%	57	97.2%
Well Field	**Chromium Mass Captured (lbs/day)**	**Capture Efficiency**	**Chromium Mass Captured (lbs/day)**	**Capture Efficiency**
IWF	6.2	98.7%	4.4	98.2%
AWF	0.9	98.9%	0.4	97.2%
SWF	--	--	--	--

[1] From measured flow rates and concentrations at each well during second quarter 2017.

8.2.4.2 Vertical Mass Flux

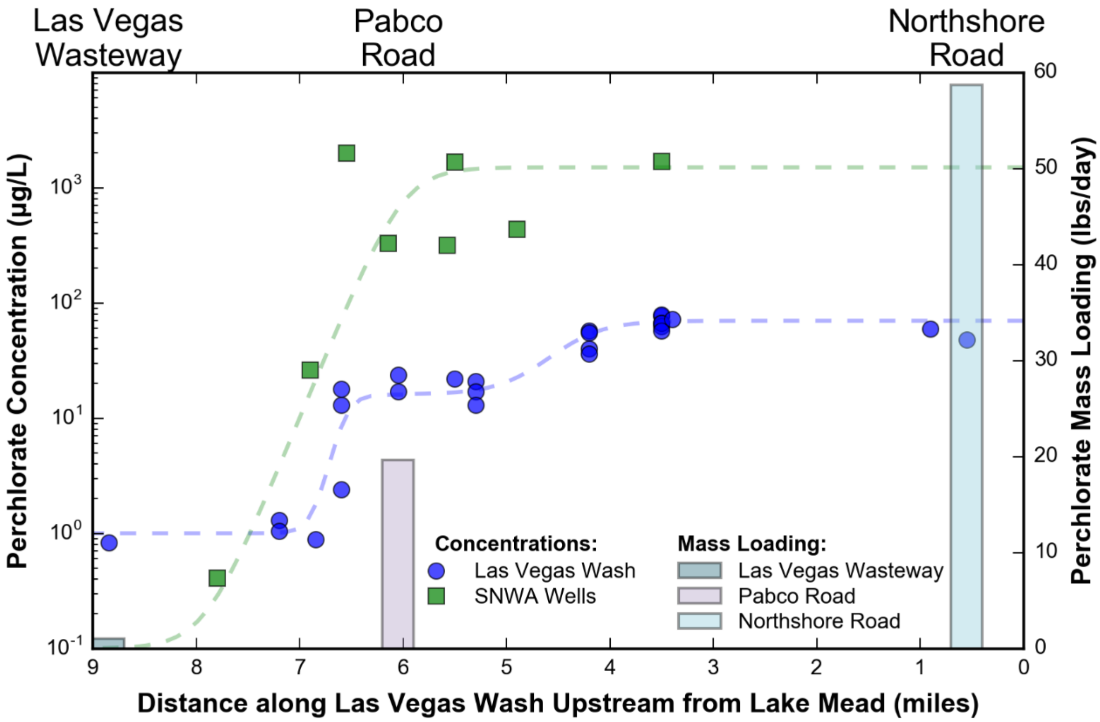
As requested in NDEP's December 6, 2016 letter on the 2015-2016 Annual Performance Report, and further discussed in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum (Ramboll Environ 2017d), vertical mass flux of perchlorate and chromium was evaluated in the On-Site area, NERT Off-Site Study Area between the Site and AWF, and NERT Off-Site Study Area between the AWF and the Wash, as shown on Figure 5. The vertical mass flux was estimated in these three areas based on the vertical groundwater flux from the groundwater flow model and the interpolated concentrations in the Shallow WBZ from second quarter 2017. The calculation of vertical mass flux is done in each grid cell of the groundwater model by multiplying the vertical groundwater flux generated from the model, the area of the model grid cell, and the interpolated concentration in the model grid cell. The total mass flux in each zone is calculated by summing the calculated mass flux from the grid cells within each zone. For these estimations, the vertical groundwater flux between model layers 1 and 2 has been used.

The NERT groundwater model continues to be refined based on additional vertical gradient data being collected as part of the ongoing RI. The next version of the model (Phase 6 Model), anticipated to be submitted in 2018, will include simulation of contaminant transport. Thus, once the Phase 6 Model is available, estimates of mass flux can be generated directly from the model, as described in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum (Ramboll Environ 2017d).

8.2.5 Perchlorate Mass Loading to Las Vegas Wash

As discussed in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum (Ramboll Environ 2017d), perchlorate mass loading in Las Vegas Wash is currently calculated at the following three locations: Las Vegas Wasteway (LW8.85), Pabco Road (LW6.05), and Northshore Road (LW0.55). These locations are shown on Figure 6. Mass loading estimates are calculated from measured perchlorate concentrations in surface water and the corresponding stream flow rate at the time of surface water sampling. Las Vegas Wash is sampled for perchlorate monthly at various locations by Envirogen Technologies, Inc. (Envirogen) and by SNWA. Stream flows are from co-located United States Geological Survey (USGS) gaging stations. As discussed in the above mentioned memorandum and later in this section, the Trust began collecting monthly surface water samples and testing for perchlorate at additional locations along Las Vegas Wash in June 2017. Data collected from these additional locations are not included in the evaluation presented herein, but will be incorporated into mass loading estimates in future performance evaluations (in accordance with the NDEP-approved above mentioned memorandum) and will be used to enhance understanding of the various sources of perchlorate loading to Las Vegas Wash.

Annual average perchlorate mass loading at Las Vegas Wasteway, Pabco Road, and Northshore Road for each year (July through June) are presented in Table 12. During the reporting period, approximately 32% of the mass loading measured at Northshore Road can generally be attributed to mass entering Las Vegas Wash between the Las Vegas Wasteway and Pabco Road stations, while approximately 67% can be attributed to mass entering the Las Vegas Wash between the Pabco Road and Northshore Road stations. The remaining 2% represents background mass loading at Las Vegas Wasteway. The figure below shows the perchlorate concentrations in Las Vegas Wash and SNWA groundwater monitoring wells along the length of Las Vegas Wash from the Las Vegas Wasteway to Lake Mead during second quarter 2017, as well as average mass loading at the three gaging stations for the reporting period.



Mass Loading to Las Vegas Wash. This chart shows perchlorate concentrations measured during second quarter 2017 in Las Vegas Wash and nearby SNWA groundwater monitoring wells along Las Vegas Wash. Average mass loading to Las Vegas Wash during the reporting period is also shown at three stream gages. The dashed lines indicate the general trend in perchlorate concentrations in Las Vegas Wash and SNWA wells.

The estimated average perchlorate mass flux to Las Vegas Wash between Las Vegas Wasteway and Pabco Road is 18.6 lbs/day during the reporting period. As discussed in Section 8.2.4, an estimated 1.7 lbs/day discharged to Las Vegas Wash from the NERT Off-Site Study Area. However, as shown on Plate 6, this mass flux is likely entering Las Vegas Wash downstream of the Pabco Road Weir, while perchlorate mass flux to Las Vegas Wash upgradient of Pabco Road is likely originating from AMPAC/Endeavour's perchlorate plume. According to AMPAC/Endeavour's recent monitoring and performance reports, AMPAC/Endeavour's average perchlorate loading to the Athens Drainage Channel[21] was 12.3 lbs/day from July to December 2016 (Endeavour 2017a, pg. 12) and 16.5 lbs/day from January to June 2017 (Endeavour 2017b, pg. 12), giving an average of 14.4 lbs/day during the reporting period. AMPAC/Endeavour additionally reported that the perchlorate loading not captured in shallow groundwater was 4 to 5 lbs/day in the second half of 2016 (Endeavour 2017a, pg. 18) and 5 to 6 lbs/day in the first half of 2017 (Endeavour 2017b, pg. 19). The Shallow Capture Zone Assessment Memorandum submitted by Geosyntec on behalf of AMPAC/Endeavour in March 2017 indicates that a portion of the uncaptured perchlorate loading in shallow groundwater may be captured by the SWF (Geosyntec 2017), as shown on Plate 6. However, the remaining uncaptured flux in shallow groundwater and uncaptured loading to the Athens Drainage Channel west of the COH Bird Viewing Ponds is likely the primary source of perchlorate mass

[21] The Athens Drainage Channel is located west of the City of Henderson Bird Viewing Ponds and discharges to Las Vegas Wash, as discussed in the Phase 4 Model Refinement report (Ramboll Environ 2016a).

loading in Las Vegas Wash upstream of the Pabco Road station. Further evaluation of the contribution of the AMPAC/Endeavour perchlorate plume to total mass loading in Las Vegas Wash will be included in future performance reports and discussed in the Trust's forthcoming RI Report.

8.2.6 Environmental Footprint

As requested by USEPA in April 2017, a quantitative analysis of the environmental footprint of the GWETS and GWM program during the current reporting period has been conducted using the USEPA's SEFA Excel workbooks. The SEFA workbooks were used to calculate environmental footprint metrics using an inventory of energy and materials used, wastes generated, and activities and services conducted for GWETS and GWM efforts. The information used for this analysis was obtained from internal documents maintained by the Trust, Envirogen, Tetra Tech, Inc. (Tetra Tech), and Ramboll Environ. As necessary to fill remaining data gaps, Ramboll Environ solicited input from Envirogen and Tetra Tech. In cases where specific information was not available, estimates have been provided based on professional judgement. The inventory format for this reporting period was updated from the previous inventory format in order to improve the accuracy of data input into SEFA workbooks, resulting in different methods used for data compilation compared with prior environmental footprint inventories. The sources of information used are further detailed in Table G-1 in Appendix G. The inventory data used as input into the SEFA workbooks are available in Tables G-2 through G-8 in Appendix G. The SEFA workbooks are also included in Appendix G (electronically on the report CD). The SEFA workbooks are comprised of three separate workbooks, which should be opened concurrently in order to view the SEFA inputs, calculations, and results. A summary of the results from the SEFA workbooks is shown in the table below.

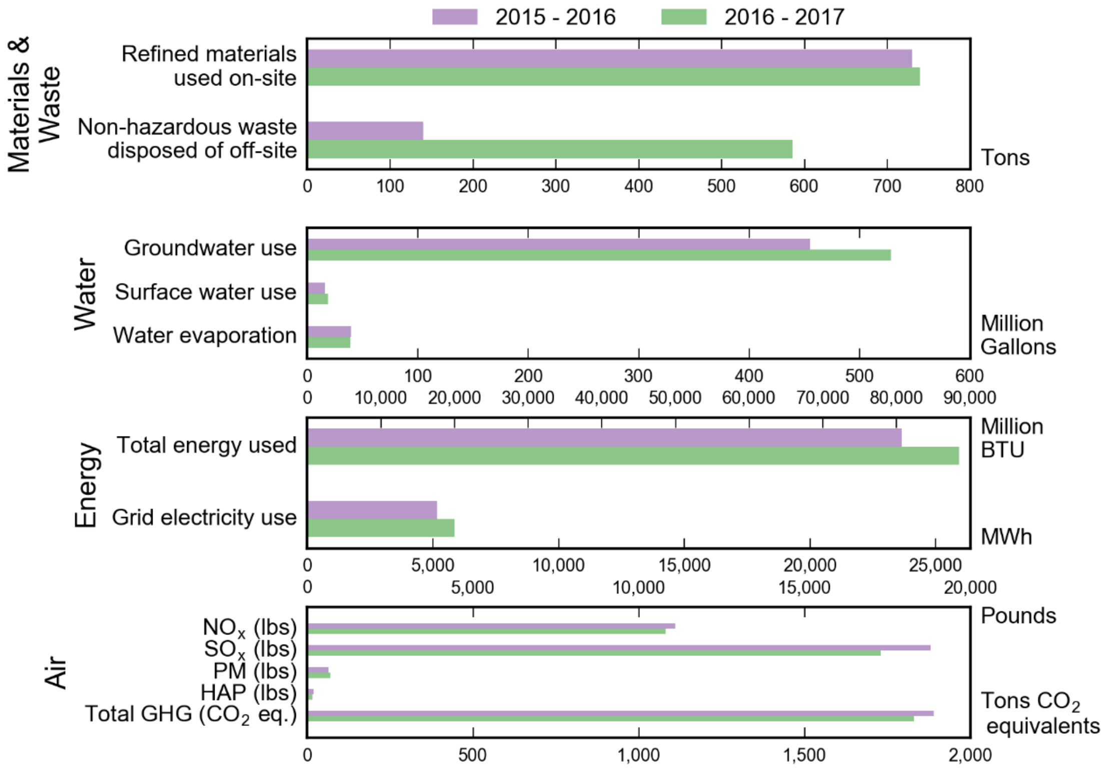
Core Element	Metric	Footprint	Units
Materials & Waste	Refined materials used on-site	739	Tons
	Non-hazardous waste disposed of off-site	586	Tons
Water	Groundwater use	528	Million Gallons
	Surface water use	19	Million Gallons
	Water evaporation	39	Million Gallons
Energy	Total energy used (on-site and off-site)	88,500	Million British Thermal Units (BTU)
	Electricity Use - Groundwater Extraction (electricity supplied by NV Energy)	1,280	Megawatt Hours (MWh)
	Electricity Use – Groundwater Treatment (hydroelectric power supplied by Colorado River Commission)	4,590	MWh
Air	Total nitrogen oxides (NO_x)emissions	10,800	lbs
	Total sulfur oxides (SO_x) emissions	17,300	lbs
	Total particulate matter (PM) emissions	702	lbs
	Total hazardous air pollutants (HAP) emissions	161	lbs
	Total greenhouse gas emissions	1,830	Tons CO_2 equivalents

Major contributors to each core element (or core element component) of the overall environmental footprint, and their relative percent contribution, are presented in the table below.

Core Element	Contributors
Materials	Groundwater treatment chemicals – **98.0%**
	IX Resin – **2.0%**
	GAC **– 0%**
Wastes	FBR Sludge – **97.9%**
	GWTP Sludge – **1.4%**
	IX Resin – **0.8%**
Water	Groundwater Use – **90.1%**
	Surface water use – **3.2%**
	Water evaporation – **6.7%**
Energy	Electricity for groundwater treatment – **58.9%**
	Electricity for groundwater extraction and conveyance **– 18.6%**
	Non-electricity energy usage **– 22.4%**
Air (Greenhouse Gas)[22]	Electricity for groundwater extraction and conveyance – **53.3%**
	Transportation (personnel, materials, equipment, waste) **– 20.4%**
	Manufacture of treatment chemicals and materials – **13.7%**
	Off-site laboratory analysis – **7.2%**
	Other off-site activities (fuel processing, waste management) – **3.7%**
	On-site equipment use (vehicles, generators, compressor) **- 1.7%**
	Electricity for groundwater treatment – **0%**

USEPA used SEFA and the environmental footprint inventory included in the 2015–2016 Annual Performance Report (Ramboll Environ 2016e) to conduct a quantitative analysis of the environmental footprint of GWETS operations and the GWM program from July 2015 through June 2016. A comparison of the environmental footprint during the current and prior reporting period is shown in the bar charts below. The environmental footprint for the current reporting period is generally consistent with the footprint from the prior year evaluated by USEPA, with the exception of slight increases in energy usage, surface water usage, and groundwater usage, and a significant increase of non-hazardous waste disposed of off-site. The increased energy usage corresponds to the increased volume of groundwater extracted, which increased at the AWF, SWF, and AP Area during the reporting period, as discussed in Section 2. The increased surface water usage is associated with AP Area flushing, which began operating continuously in November 2016. The increase in reported waste generated is due to revised waste calculation methods compared to methods used during the prior reporting period.

[22] For air emissions, only greenhouse gas emissions are evaluated by major contributor, consistent with USEPA's evaluation of the 2015-2016 environmental footprint.



Environmental Footprint Analysis. This chart compares the core elements and metrics of the environmental footprint during the current reporting period to the prior reporting period.

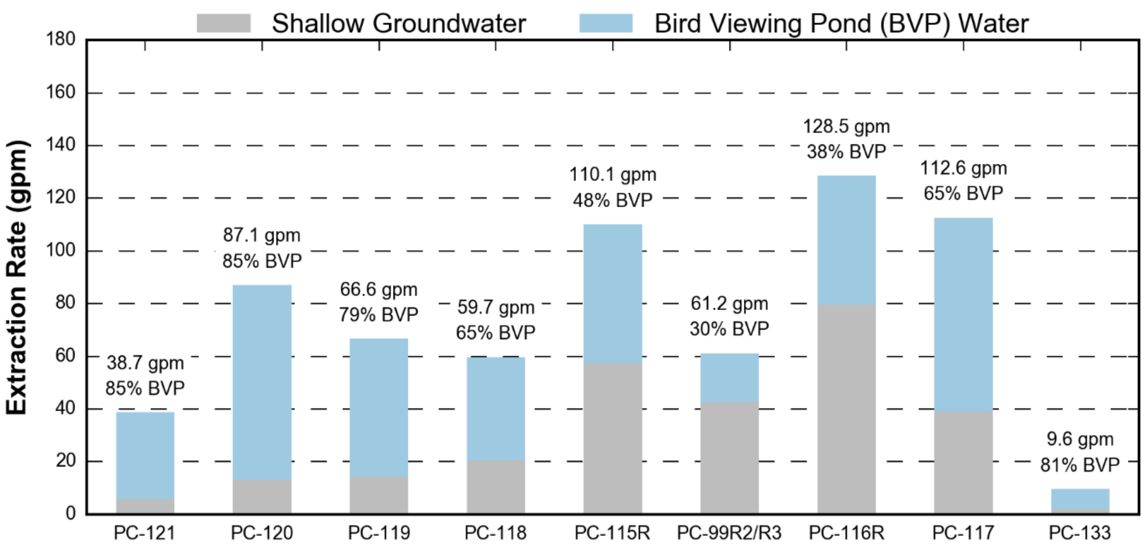
In April 2017, USEPA requested the Trust conduct a review of potential Best Management Practices (BMPs) for the GWETS and GWM Program following the ASTM Standard Guide for Greener Cleanups (E2893-16). An initial review of potential BMPs was conducted in 2017, and selected BMPs will be implemented at the Site by June 2018. The environmental footprint will be considered as a quantitative tool to assist with selection of final BMPs for implementation and to help understand the effects of the implementation of Greener Cleanup BMPs over time.

8.2.7 Surface Water and Groundwater Interaction Near the SWF

Because the SWF is located near two surface water bodies (Las Vegas Wash and the COH Bird Viewing Ponds), pumping at the SWF has the potential to induce water originating at these two surface water bodies to flow into the SWF extraction wells. Analyses presented in the Seep Well Field Flow Quantification Technical Memorandum, which was submitted to NDEP on September 9, 2016 (Ramboll Environ 2016d), evaluated the potential contributions of these sources to SWF extraction. This analysis was not a comprehensive evaluation of all potential source waters comprising SWF extraction, but rather was a focused analysis of potential surface water influences. This evaluation indicated that water extracted at the SWF is likely influenced by the COH Bird Viewing Ponds, whereas Las Vegas Wash does not appear to contribute significantly to SWF extraction.

Since the surface water from the COH Bird Viewing Ponds is comprised primarily of treated municipal wastewater effluent, minimization of this inflow would reduce the volume of clean water extracted by the SWF. However, given the presence of perchlorate in groundwater along the western flank of the SWF, reduction of extraction rates would potentially result in increased perchlorate mass flux to the Las Vegas Wash. Until final remedial decisions are made, the Trust will continue operating the SWF in its current configuration. The interactions between surface water bodies and groundwater will be an important consideration when evaluating performance of the overall long-term remedy.

A simple mixing calculation using TDS as a tracer was performed to quantify the amounts of COH Bird Viewing Pond water and upgradient shallow groundwater extracted at the SWF, the results of which are shown in the figure below. It is important to note this calculation does not consider other potential sources of contribution to SWF extraction. The calculation is based on May 2017 SWF extraction rates and May 2017 TDS concentrations in the COH Bird Viewing Ponds, upgradient shallow monitoring wells, and SWF extraction wells. This calculation suggests that wells on the western and eastern ends of the SWF are extracting primarily COH Bird Viewing Pond water, while wells in the central portion of the SWF are extracting primarily shallow groundwater.



SWF Surface Water Extraction. This chart shows the extraction rate and the estimated percentage of Bird Viewing Pond water extracted at each SWF extraction well during May 2017.

9. ONGOING AND FUTURE ACTIVITIES

The table below lists the current status of upcoming tasks related to the groundwater monitoring program.

Task	Purpose	Current Status	Planned Activities
Treatment System			
AP-5 Solids Removal and Closure	Remove solids from AP-5 in order to decommission the pond.	Tetra Tech completed solids removal activities in early 2017. Solids washing to remove perchlorate is ongoing. The AP-5 Pond Closure Plan was submitted to NDEP on November 18, 2016, and approved on January 27, 2017.	Continued treatment of water from AP-5 Process Tanks.
Performance Metrics[23]			
Mass Loading at Four Additional Las Vegas Wash Locations	Establish loading at various locations along Las Vegas Wash.	Perchlorate sampling at new USGS gaging stations began in June 2017.	The mass loading estimates will be included in the Semi-Annual Remedial Performance Technical Memorandum (April 2018).
Perchlorate Mass Estimate for NERT RI Study Area	Establish perchlorate mass estimate for the entire NERT RI Study Area, including the Downgradient Study Area and Eastside Study Area	Phase 2 data collection completed by November 2017. Phase 3 data collection to be completed between November 2017 and April 2018.	The perchlorate mass estimate will be included in the 2018 Annual Remedial Performance Report (October 2018).

[23] The implementation schedule for the future revised GWETS Performance Metrics (as discussed in Section 8.1) was presented in the RI Study Area Mass Estimate and Expanded Performance Metrics Technical Approach Technical Memorandum, which was submitted to NDEP on October 5, 2017 (Ramboll Environ 2017d) and approved by NDEP on October 19, 2017 (NDEP 2017).

Task	Purpose	Current Status	Planned Activities
Mass Flux of Perchlorate at the OU Transects and Vertical Mass Flux between Qal and UMCf	Establish the mass flux of perchlorate movement across 1) the OU transects established within the entire NERT RI Study Area and 2) between the Qal and UMCf	Phase 2 data collection completed by November 2017. Phase 3 data collection to be completed between November 2017 and April 2018.	The horizontal and vertical perchlorate mass flux will be included in the 2018 Annual Remedial Performance Report (October 2018).
Phase 6 Groundwater Model	The new model will incorporate contaminant transport, recent contaminant data, refinements to the model grid, and update the time period simulation to include 2010 to 2017.	Initial testing and data compilation for the model update is currently underway.	The majority of Phase 6 model updates will take place in 2018. The Phase 6 model update will be completed in November 2018.

10. REFERENCES

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