CYCLE TEST REPORT - FINAL

Peace River Facility Partially Treated Surface Water ASR Pilot Study

Prepared for

Peace River Manasota Regional Water Supply Authority

August 2018

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Acronyms and Abbreviations

AO	Administrative Order
ASR	Aquifer Storage and Recovery
Authority	Peace River Manasota Regional Water Supply Authority
BG	Billion Gallons
bls	Below Land Surface
BMDL	Below Method Detection Level
CFU	Colony Forming Units
CT1	Cycle Test 1
CT2	Cycle Test 2
DO	Dissolved Oxygen
DWS	Drinking Water Standard
FDEP	Florida Department of Environmental Protection
gpm	Gallons per minute
gpm/ft	Gallons per minute per foot of drawdown (or rise)
HDPE	High Density Polyethylene
IAS	Intermediate Aquifer System
MCL	Maximum Contaminant Level
MG	Million Gallons
mg/L	Milligrams per liter
mgd	Million gallons per day
NGVD	National Geodetic Vertical Datum
PCU	Platinum Cobalt Units
POR	Period of Record
PRF	Peace River Facility
PTSW	Partially Treated Surface Water
Q	Pumping rate (gpm)
Q/s	Specific capacity (gpm/foot of drawdown)
S	Drawdown (feet)
SCADA	Supervisory Control and Data Acquisition (refers to the functional system)
SI	Specific Injectivity (gpm/foot of water level increase)
SWFWMD	Southwest Florida Water Management District
TDS	Total Dissolved Solids
TNTC	Too Numerous to Count
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UFA	Upper Floridan Aquifer
UFAS	Upper Floridan Aquifer System
UIC	Underground Injection Control
USGS	United States Geological Survey
WF1	ASR Wellfield No. 1
WF2	ASR Wellfield No. 2
WQCE	Water Quality Criteria Exemption
WUP	Water Use Permit
µg/L	Micrograms per liter
ZOD	Zone of Discharge

Professional Geologist

The evaluation and interpretations in the *Peace River Facility Partially Treated Surface Water ASR Pilot Study – Cycle Test Report, dated August 2018,* on behalf of the Peace River Manasota Regional Water Supply Authority were prepared by or reviewed by a Licensed Professional Geologist in the State of Florida.

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Executive Summary

The Peace River Manasota Regional Water Supply Authority (Authority) operates a potable water Aquifer Storage and Recovery (ASR) system which includes ASR Wellfield No. 1 (WF1) and ASR Wellfield No. 2 (WF2) at the Peace River Regional Water Supply Facility (PRF). The Authority is committed to exploring project options which bolster regional water supply system resiliency by increasing water supply capacity, improving water quality, adding supply diversity, increasing system storage for drought tolerance or reducing operational costs. Sometimes projects are identified which can meet several of these objectives at the same time. Implementing partially treated surface water (PTSW) instead of fully treated potable water as a recharge water source for the ASR system provides for additional storage capability, has expected water quality benefits, and offers a significant decrease in overall delivery costs. Rather than the current ASR operating practice of treating stored river water to potable standards twice before distributing treated water to the public (once on injection/recharge to ASR and again after recovery from ASR), the Authority would only need to treat raw water once through the PRF. Also, ASR injection is currently limited by treatment capacity, and compulsory maintenance can take treatment trains out of operation which can constrain ASR recharge potential. So, the Authority could also more opportunistically inject water when it is available from the river since the water would not need to be routed through the PRF first.

The concept of using PTSW at this location was first evaluated in a desk top study (*Partially Treated Surface Water ASR Desktop Study*, CH2M and ASRus, March 2016). Based on the findings of that study, a modification to the permit was requested and approved by the Florida Department of Environmental Protection (FDEP) to allow pilot testing at two of the twelve ASR wells in WF2 using PTSW. PTSW is surface water from the Peace River that is stored in the Authority's reservoir system and filtered prior to recharge into the ASR wells. The objectives of the pilot test included evaluating how water quality aspects associated with PTSW differ from those associated with potable water ASR and observation of overall well performance with respect to production and recharge capacities.

Two cycles, each consisting of a period of recharge, storage, and recovery, were completed at ASR wells S-4 and S-20 as part of the pilot testing. Cycle Test 1 (CT1) began in February 2017 and included recharging ASR wells S-4 and S-20 with a total of 59 million gallons (MG) of PTSW and storing the water for approximately two weeks. A total of 25 MG was subsequently recovered from these two wells before seasonally dry conditions warranted recovery operation from the other wells in the same wellfield. Although the two pilot wells continued recovery for nearly 2 months along with the remainder of wells in the wellfield, and theoretically withdrew far more water than the volume of PTSW that had originally been injected, during this later period they only represented a small fraction of the total withdrawal from the wellfield.

Cycle Test 2 (CT2) began in July 2017, recharging a total of 178 MG of PTSW, storing the water for approximately one month in November 2017 and then recovering approximately 57 MG from the same ASR wells during December 2017 and early January 2018. During the entirety of CT2 recharge, S-4 and S-20 recharged PTSW while the rest of the WF2 wells were recharging potable water. All WF2 wells ceased recharge and were in storage mode at the same duration. Unlike CT1, no other wells in the same wellfield were in recovery mode during the entirety of CT2 recovery. During the pilot test, water quality data was collected from the extensive monitoring well network surrounding WF2.

Data from the monitor wells showed clear indications of arrival of the PTSW from water quality indicators such as color, total organic carbon, and total coliform, each present at relatively high concentrations in PTSW compared to native ground water or potable water. One of the primary water quality concerns of PTSW ASR is the fate of total coliform (which is ubiquitous in surface water) once recharged into the aquifer. Data showed that while total coliform counts were observed at high levels as far away as monitor well M-15 (located approximately 1,100 feet downgradient of S-20), they decline rapidly after the PTSW recharge period is ceased. The "die-off" or "inactivation" period to reach the regulatory groundwater standard of 4 colony forming units (CFU) per 100 milliliters (mL) from a too-numerous-to-count CFU/100mL was between three and four weeks based on the data collected from the monitor wells.

Arsenic concentrations were also monitored to evaluate potential impacts (positive or negative) from the use of PTSW. Arsenic concentrations increased in some of the monitor wells near the end of CT2 recharge, including monitor well M-15, a compliance well listed in the Authority's Water Quality Criteria Exemption (WQCE) for arsenic associated with the ASR permit. However, the increase in arsenic concentration coincided with an overall increase in the total storage volume at WF2 (the highest since operations began at this site 18 years ago) as well as the largest recovery event since potable water was completely recovered from the ground in 2006 due to drought conditions. So, the increases in arsenic could be attributed to PTSW, or the higher potable water storage volumes (with the assumption that the large volume of stored water is resulting in geochemical changes further from the center of the wellfield than previously seen), or a combination of these events.

Arsenic concentrations at M-15, though above the regulatory limit of 10 micrograms per liter (µg/L), are relatively low at around 16 µg/L and appear to have stabilized. It is believed that these higher concentrations will decrease as the geochemical environment stabilizes in the aquifer as demonstrated at other monitor wells during past ASR operations. Since M-15 is 1,100 feet from the nearest property boundary to the southeast and over two miles from the property boundary to the southwest (the direction of groundwater flow), and other ASR compliance wells have remained below 10 µg/L, the mobilization of arsenic continues to be effectively managed at this system. Continued increases in ASR storage volumes and the conversion to PTSW will need to be closely monitored to assure arsenic mobilization from ASR operations continues to remain within boundaries of property owned or controlled by the Authority.

Dissolved arsenic and phosphorus exhibit similar geochemical speciation and behavior in many types of water-rock reactions, including sorption onto iron oxide solids. Unlike arsenic, phosphorus showed attenuation during CT2. Phosphorus declined from concentrations greater than 0.2 mg/L to below the detection limit (0.008 mg/L) during late storage and recovery. Because phosphorus was present at concentrations 10 to 15 times greater than arsenic, it is believed that phosphorus preferentially sorbed onto iron oxide solids.

The PTSW was filtered with either 50-micron mesh bags, 100-micron mesh bags, or a stainless-steel basket with 1/8" openings at various times during the test. The performance of S-4 and S-20 showed some decline during recharge events with S-4 showing more decline than S-20. However, recovery of PTSW after Cycle 1 and Cycle 2 showed that the wells could restore lost capacity. While only the stainless-steel basket was used for filtration late in the test, a back-flush protocol was implemented during PTSW recharge that involved periodically stopping recharge activities and pumping the wells (recovery) briefly to remove any solids that had potentially accumulated. The effort was successful in maintaining capacity in the wells, and no significant plugging of the wells was observed which would prevent implementation of PTSW. The calculated specific injectivity (SI) for S-4 during PTSW was similar to SI values observed historically. The SI for S-20 during PTSW recharge was within range of historic SI values observed at this well.

As stated in the *Partially Treated Surface Water ASR Desktop Study* (CH2M and ASRus, March 2016), full conversion of WF2 to a PTSW ASR system was estimated to have a capital cost of approximately $7.5M assuming construction of a 20 mgd PTSW Pump Station to supply at least 1 mgd of PTSW to the existing 12 WF2 wells and to accommodate future expansion of the wellfield. As an added benefit, the new pump station would also supplement and back up the aging Reservoir Pump Station feeding the PRF.

The operational cost difference between PTSW and Potable water ASR would likely range from $500,000 - $1 million per year depending on annual recharge needs. However, these savings must be offset by initial investment needs and continuing O&M on the new equipment. Considering the capital cost of a new pump station, debt service on a loan of $7.5M for this construction, new pump station maintenance costs, and reduced ASR operational costs, we estimate direct savings of PTSW ASR would likely be approximately $334,000 per year.

The Authority has a significant investment in the current ASR system, not just in the capital cost of the infrastructure and the cost of the water currently in storage, but also the considerable resources spent collecting years of data that have led to a regulatory solution enabling the ASR system to receive an operation permit. Conversion of the potable system to a PTSW system would maximize the use of this valuable resource, allowing the Authority to see a greater return on this investment.

With PTSW ASR implementation, the Authority can realize measurable benefits both with ASR system recharge quantities and ASR system recovery volumes. The Authority has a Total Dissolved Solids (TDS) Yield prediction model to estimate the volume of water that can be recovered from their ASR Wellfields under normal operating conditions before the TDS concentration of the recovery stream becomes too great for the water being conveyed to the Peace River Facility to be treated to the secondary drinking water standard of 500 mg/L. Because the Peace River Facility adds approximately 75 mg/L TDS to the treatment stream to provide high quality finished water, PTSW has a lower TDS concentration than potable water. Therefore, PTSW has a greater recovery volume potential. Utilizing this TDS Yield model to predict the additional volume from converting WF2 or both wellfields to PTSW ASR, the additional recovery volumes are estimated to be between 332 MG and 627 MG, respectively. This translates to a 10% to 19% increase in potential yield of PTSW instead of potable water.

Conclusions of the PTSW pilot testing suggest that water quality issues can likely be managed through a regulatory relief mechanism such as a zone of discharge (ZOD) that will allow for temporary exceedances of total coliform, arsenic, and some secondary drinking water standards on property owned or controlled by the Authority. Initial discussions with FDEP regarding the permitting of this facility have indicated that a ZOD would be the preferred mechanism rather than the currently issued WQCE issued for arsenic, and it would be like the WQCE in that primary and secondary drinking water standards would need to be maintained at the Authority's property boundary. If full scale PTSW ASR is implemented, it should be done so in a measured approach with appropriate monitoring and management strategies in place to insure compliance with the ZOD order. These strategies will likely include one or more of the following

- Construction of additional monitoring wells,
- Disinfection of the PTSW prior to recharge,
- Replacement of ASR wells located nearest current property boundaries by new ASR production wells located further from the property boundaries,
- The addition of ASR wells (ASR expansion)
- Authority purchase or control of additional property,
- Limits on total water in storage and/or development of alternative wellfield management (recharge and recovery) strategies.

SECTION 1

Background

The Peace River Manasota Regional Water Supply Authority (Authority) was created to meet the growing public water supply requirements for Charlotte, DeSoto, Manatee, and Sarasota Counties. The Peace River Facility (PRF) is located in southwest DeSoto County, Florida and is owned and operated by the Authority. The Authority is an independent, nonprofit, wholesale distributor of potable water serving Charlotte, DeSoto, and Sarasota Counties, and the City of North Port, and has the future plans to provide service to Manatee County. The PRF is a conventional alum coagulation surface water treatment facility. Raw water supply needs are met entirely by withdrawals from the Peace River. The Peace River flow is highly seasonal and permit restrictions are in place to protect downstream ecology typically preventing river withdrawals during the dry season. Therefore, seasonal system storage is a critical component of the PRF. The Aquifer Storage and Recovery (ASR) system and the two off-stream surface reservoirs at the PRF are key components of the surface water treatment, storage, and transmission system. The Authority has successfully developed a reliable and drought tolerant water supply through the combined use of ASR to store water below ground and off-stream surface water reservoirs. **Figure 1-1** presents the map showing the location of the PRF.

The Authority operates a potable water ASR system referred to as ASR Wellfield No. 1 (WF1) and ASR Wellfield No. 2 (WF2). **Figure 1-2** presents a site map showing the PRF, the two off-stream reservoirs, and both ASR wellfields. WF1 consist of eight Suwannee Zone ASR wells and a single Tampa Zone ASR well located on the PRF property (**Figure 1-3**). WF1 has been in operation since the mid-1980s. A test ASR well completed into the Avon Park High Permeability Zone is also located within WF1, but has not been used extensively to date. Each well has the capacity to inject or recover approximately 1 million gallons per day (mgd). **Figure 1-4** is a cross section showing the construction details of the ASR wells in WF1. WF2 was constructed in 2002 and consists of 12 Suwannee Zone ASR wells located immediately south of the Authority's Reservoir No. 1 and approximately 1 mile southwest of the PRF (**Figure 1-5**). Each well has a nominal capacity of approximately 1 mgd. **Figure 1-6** is a cross-section of the ASR wells and shows well construction details and the hydrogeologic intervals intercepted by each well.

Permitting of ASR wells is under the oversight of the Florida Department of Environmental Protection's (FDEP) Underground Injection Control (UIC) Program. A Class V Operation Permit was issued to the Authority on April 24, 2013, for operation of the two wellfields under a single permit (FDEP Permit No. 0136595-014-UO5Q). The two wellfields are now operated as one ASR system. In conjunction with the Operation Permit, a water quality criteria exemption (WQCE) was also issued that waived the arsenic standard in the ASR zone within property under the control of the Authority. The WQCE was issued based on the extensive dataset collected at the PRF monitoring wells which showed elevated arsenic concentrations did not extend far from the ASR wells, arsenic concentrations decreased over time. and groundwater exceedances of the arsenic standard did not extend beyond the property under control of the Authority. The two wellfields are now operated as one ASR system. A copy of the Class V Operation Permit is included in **Appendix A**.

The potable water ASR system, as currently permitted and operated, requires that the stored water be fully treated to drinking water standards prior to recharge into the aquifer. Stored water is then recovered back to the off-stream reservoir system where it mixes with raw water to eventually be treated for a second time at the treatment facilities. This second round of treatment is done out of an abundance-of-caution to insure a high level of public protection from any arsenic which may have become mobilized during ASR storage. The alum coagulation process is highly effective at arsenic removal, but it does come at the economic cost of dual treatment. There are also unavoidable secondary water quality impacts from dual treatment; each time water passes through the treatment process, the total dissolved solids (TDS) increases by about 75 milligrams per liter (mg/L), mostly from sulfate but also some chloride and sodium. So, the dual treatment scheme adds up to 150 mg/L of TDS to the water. This is in addition to any naturally occurring sulfate and calcium found in the aquifer which tends to mix with the ASR water during storage. TDS is a secondary drinking water parameter, meaning it is not considered a primary health threat but of aesthetic concern with a maximum contaminant level (MCL) of 500 mg/L. Generally, raw water in the reservoir system has a TDS of about 250 mg/L and so the average finished water TDS varies between 275 mg/L and 325 mg/L, well below the MCL, but during dry years when there is significant ASR recovery, compliance with the TDS MCL can be challenging. So, storing potable water in the ASR system is economically less favorable and has other associated challenges as compared with storing raw surface water in the off-stream reservoirs from which it only requires treatment once prior to delivery to customers.

The Authority has a Total Dissolved Solids (TDS) Yield prediction model to estimate the volume of water that can be recovered from their ASR Wellfields under normal operating conditions before the TDS concentration of the recovery stream becomes too great for the water being conveyed to the Peace River Facility to be treated to the secondary drinking water standard of 500 mg/L. This model was run for a potential scenario of converting the Authority's ASR System partially (WF2 only) or fully (WF1 and WF2) to PTSW ASR, and the increase in potential annual average recovery flowrate achievable per year is approximately 0.9 – 1.7 MGD, or 10% to 19% yield increase, respectively. The summary of this exercise is located in **Appendix A.**

Replacement of potable water with Partially Treated Surface Water (PTSW) for the Authority's ASR recharge program at WF2 would provide cost savings, improve efficiency, increase reliability and would enhance resource recovery benefits. The following sections provide an overview of the permitting, potential measurable benefits, proposed implementation plan, and budgetary level costs related to the conversion of WF2 to a PTSW ASR system.

A desktop study was prepared to evaluate PTSW ASR (*Partially Treated Surface Water ASR Desktop Study*, CH2M and ASRus, March 2016). Based on a recommendation in that study to pilot test the PTSW ASR concept at WF2, the Authority submitted a request for a modification of the ASR permit to allow limited testing of PTSW ASR to evaluate water quality and operational considerations. The permit major modification (136595-016-017-UO/M5) was issued by the FDEP December 14, 2016 and expired on April 23, 2018 (timely renewal of the Authority's ASR Operating permit was applied for in February 2018). **Appendix B** provides the FDEP permit modification to allow PTSW ASR pilot testing.

To successfully permit the ASR system to PTSW, a demonstration was necessary to show that regulatory water quality requirements could be met at the boundary of property owned or controlled by the Authority. This included demonstration that coliform bacteria (which is present in all Florida surface waters bodies) would be deactivated once in the aquifer, and that the groundwater standard for total coliform of 4 colony forming units per 100 milliliters (CFU/100 mL) could be met on Authority controlled property. Coliform samples taken from Reservoir 1 were too numerous to count CFU/100 mL. Water quality data collected during this pilot study showed that once recharge of PTSW ceased, the coliform bacteria was below the groundwater standard within 3 to 4 weeks.

To provide the data necessary to support PTSW ASR, a pilot test was designed using two production wells at WF2; S-4 and S-20. PTSW for recharge would be supplied directly from Reservoir No. 1. Cycle Testing began in February of 2017 and was completed in January of 2018. The following sections of the report detail the Cycle Test design, water quality results, well performance, and recommendations and considerations for future development of the PTSW ASR concept onsite.

FIGURE 1-1 Project Location Map

WBG062512214751TPA F2-1 Project Location Map.ai

FIGURE 1-2
Site Map of ASR System (WF1 and WF2)

WBG062512214751TPA F2-6 Site Map of ASR System-rev1.ai

Image: © Google Earth Pro
Data: CH2M HILL

Imagery Date: 1/19/2012

FIGURE 1-3
Wellfield 1 Site Plan

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WBG082512214761TPA F2-2 WF1 Site Plan-rev3.ai

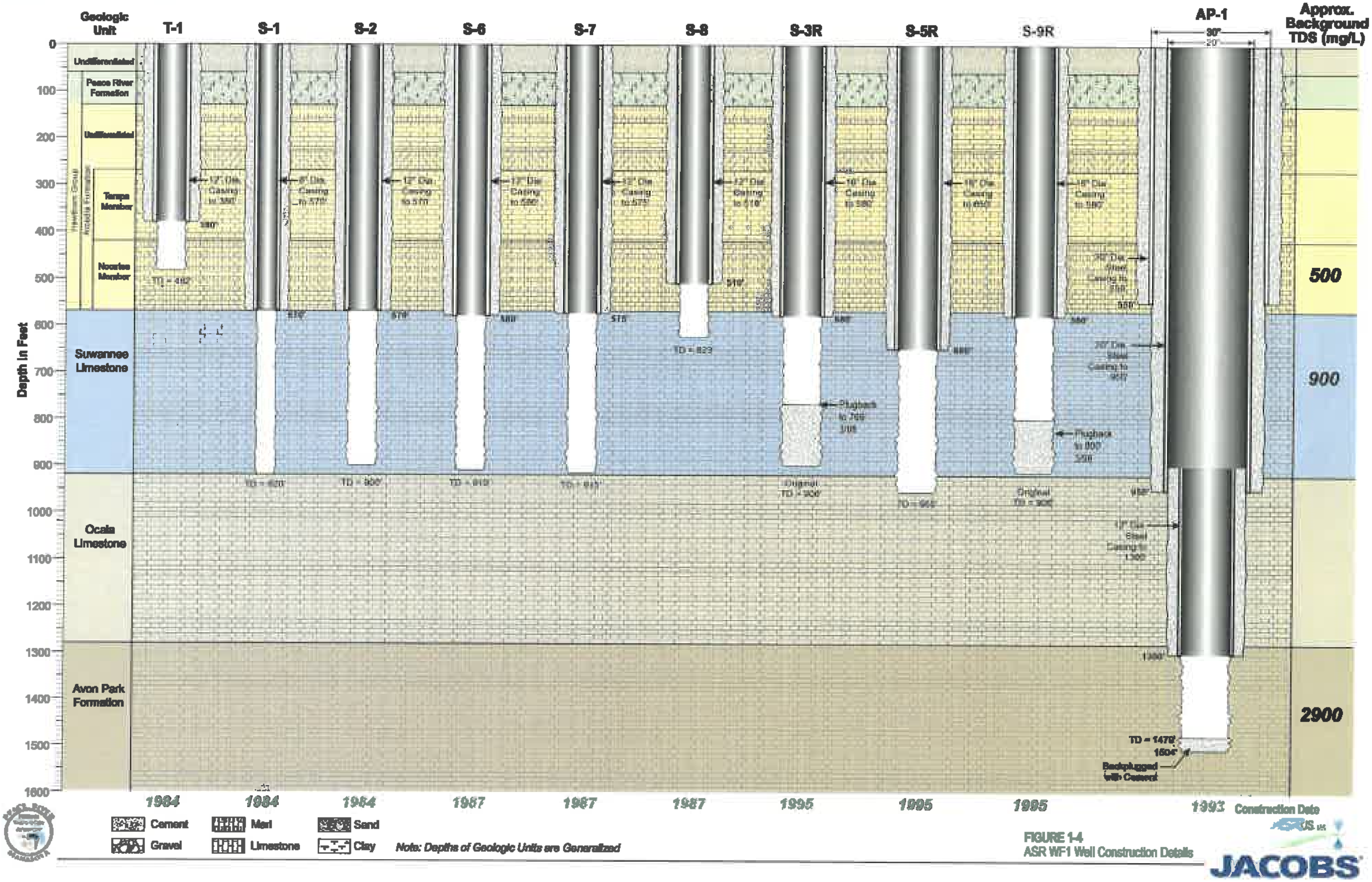


FIGURE 1-4
ASR WF1 Well Construction Details

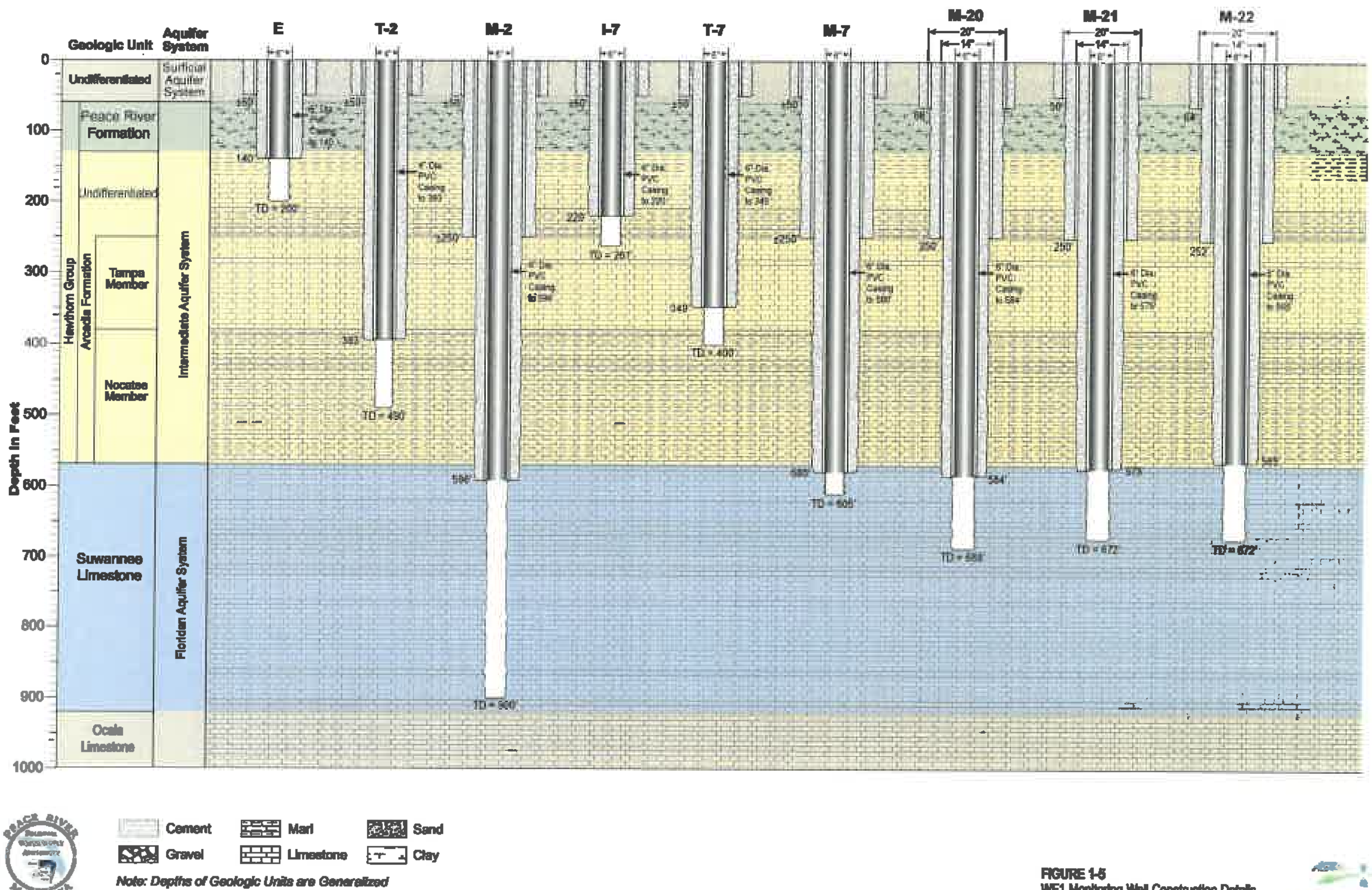
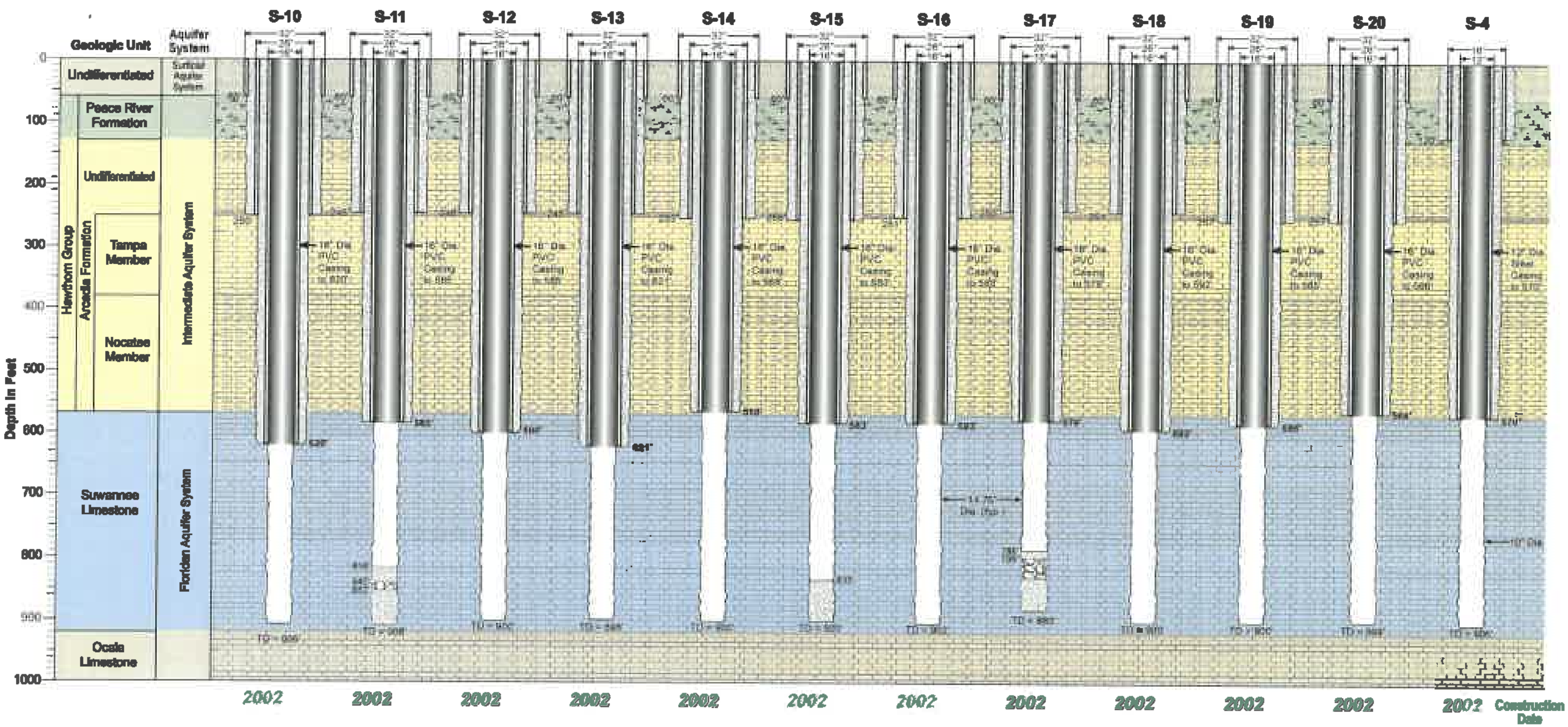


FIGURE 1-5
WF1 Monitoring Well Construction Details

FIGURE 1-6
Wellfield 2 Site Plan

WBG002512214751TPA F2-4 WF2 Site Plan-rev1.ai



Cement
Gravel
Marl
Limestone
Sand
Clay

Note: Depths of Geologic Units are Generalized

FIGURE 1-7
ASR WF2 Well Construction Details

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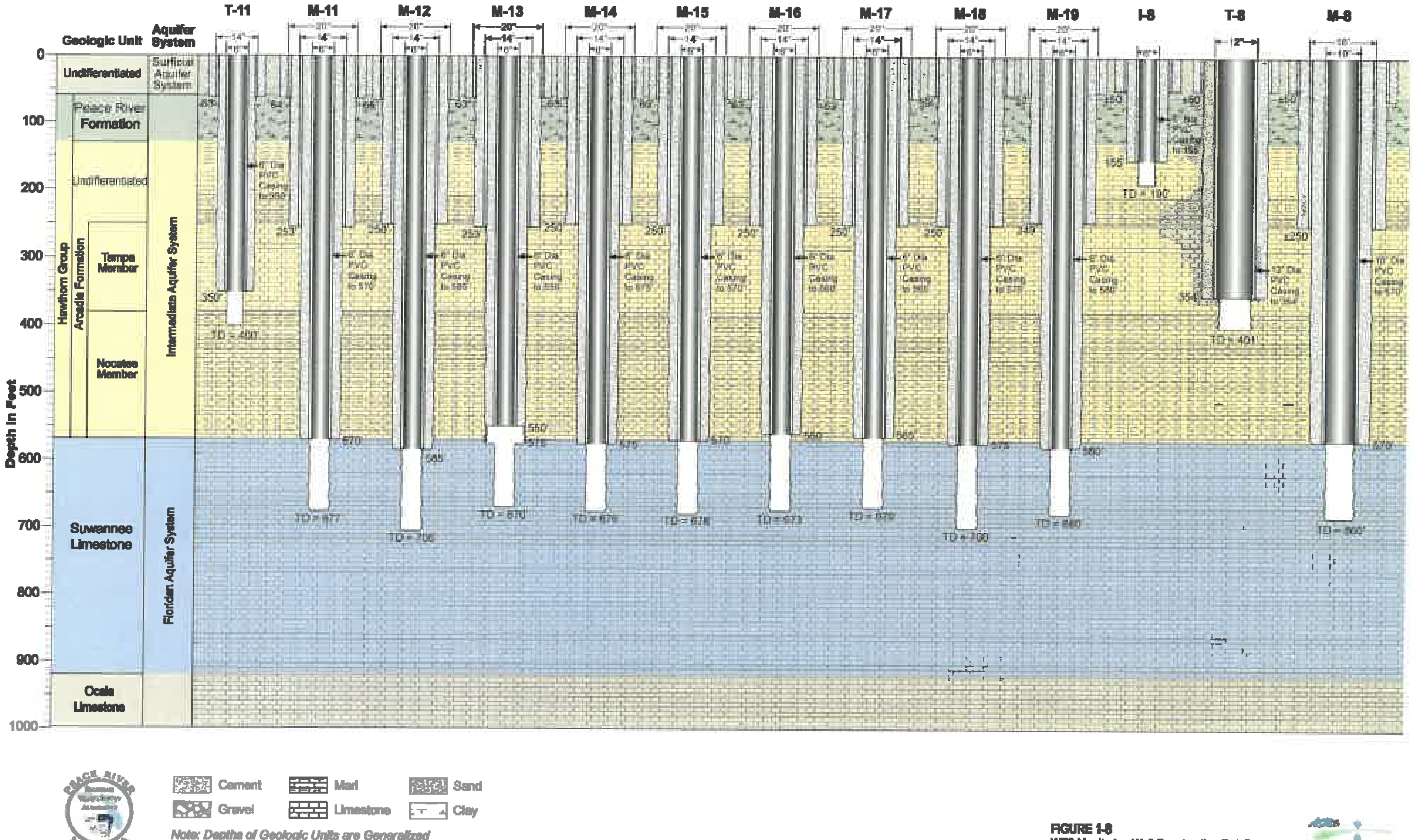

FIGURE 1-8
WF2 Monitoring Well Construction Details

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SECTION 2

Pilot Test Design

2.1 Pilot Test Overview

The objective of the PTSW ASR pilot testing was to conduct small scale cycle tests using recharge volumes large enough to arrive in the monitor wells but not so large that it potentially left the property under the control of the Authority. The pilot test was implemented at WF2 using wells S-4 and S-20. surface water stored in Reservoir No. 1 was pumped through a filtration unit and recharged into the wells, then later recovered back to the reservoir system. ASR Wells S-4 and S-20 were chosen as the pilot test wells for the following reasons:

- They are closest to Reservoir No. 1 requiring the least amount of temporary piping.
- They are some of the furthest wells from the property boundary, maximizing the buffer and the maximum possible distance to assess water quality prior to leaving Authority-controlled property.
- The clustering of monitor wells near S-4 and S-20 provides a comprehensive monitoring network to evaluate water quality at different distances (travel times) from the ASR production wells.
- S-20 has a relatively high specific injectivity and S-4 has a relatively moderate specific injectivity that is representative of most of the other ASR wells in WF2. This will allow for the comparison of well performance regarding the effect of PTSW on a well whose capacity is more dependent on matrix primary porosity (S-4) with one exhibiting a more secondary porosity (fractured) flow profile (S-20).

Pilot testing was conducted in conjunction with the Authority's normal potable water ASR system operations as this storage is an integral part of the Authority's water system reliability strategy and could not be placed on hold for the extended period of time necessary to complete the PTSW pilot testing.

2.2 Cycle Test Program

A cycle test program was proposed in the permit modification request to implement PTSW pilot testing that consisted of up to three cycles at progressively increasing volumes. The target recharge volume proposed for the first cycle (CT1) was relatively low (50 MGD) to allow for evaluation of water quality changes at monitor wells near the point of recharge before the PTSW left the property under control of the Authority. After the first cycle was completed, the project team decided to only conduct two cycles and increase the recharge volume and storage duration between recharge and recovery for the second cycle test (CT2) to more closely simulate a typical recharge cycle. The proposed cycle test program is provided in the FDEP major modification located in **Appendix B**. The following section shares details on the PTSW testing setup and associated equipment. Section 3 then will present operational specifications for each of the two respective cycles.

2.3 Description of Temporary Facilities

Temporary piping and pumping equipment was installed at S-4 and S-20 so that the wells could be recharged directly from Reservoir No. 1 during the pilot test program. A single electrically-driven centrifugal pump, mechanical filtration, and piping system was rented from Xylem Dewatering Solutions, Inc. to temporarily supply PTSW to S-4 and S-20 during the demonstration period. The pump was powered using electricity fed from one of the Authority's nearby control panels and operated locally with an adjustable frequency drive. The pump intake consisted of a capped HDPE tee located about 75 feet from the Reservoir 1 bank that was perforated with numerous 0.25" diameter holes on its underside which served to mitigate the intake of aquatic macro organisms. The unique design trapped an air bubble in the assembly so as to provide positive buoyancy and keep it afloat so that water was withdrawn from the top of the 20 feet deep water column. The pump intake was located on the south side of Reservoir No. 1 near S-4 and S-20 to minimize the distance of temporary piping to the wells.

A pressurized filtration system consisting of 4 parallel filter pods was installed downstream of the pump to remove particulates and total suspended solids (TSS). Each filter pod contained six (6) stainless-steel filter baskets with 1/8" diameter openings. This allowed for the use of 100-micron and 50-micron mesh filter bags in each filter basket without the risk of losing a mesh bag into the ASR wells. During operation, pressure data upstream and downstream of each filter pod was observed to determine the replacement schedule for the mesh filter bags. A pump operation indicator was added to SCADA programming to remotely alert operators located in the PRF control room of a pump failure.

The temporary recharge piping was installed from the mechanical filter housings to existing permanent pipe assemblies located at S-4 and S-20 which facilitated use of the existing flow meters. In case S-4 and S-20 needed to be purged during recharge periods, isolation valves were installed on the recharge piping to allow purged water to be discharged to ground in topographically low areas near each well. The existing ASR Well System piping was used during recovery to convey recovered water back to the reservoir system. **Figure 2-1** shows a diagram of the equipment for this pilot testing. **Figures 2-2 through 2-7** show the equipment installed in the field.

Water level, flow rate and pressure data was remotely collected from S-4 and S-20 through the SCADA system during recharge, storage and recovery throughout the cycle tests.

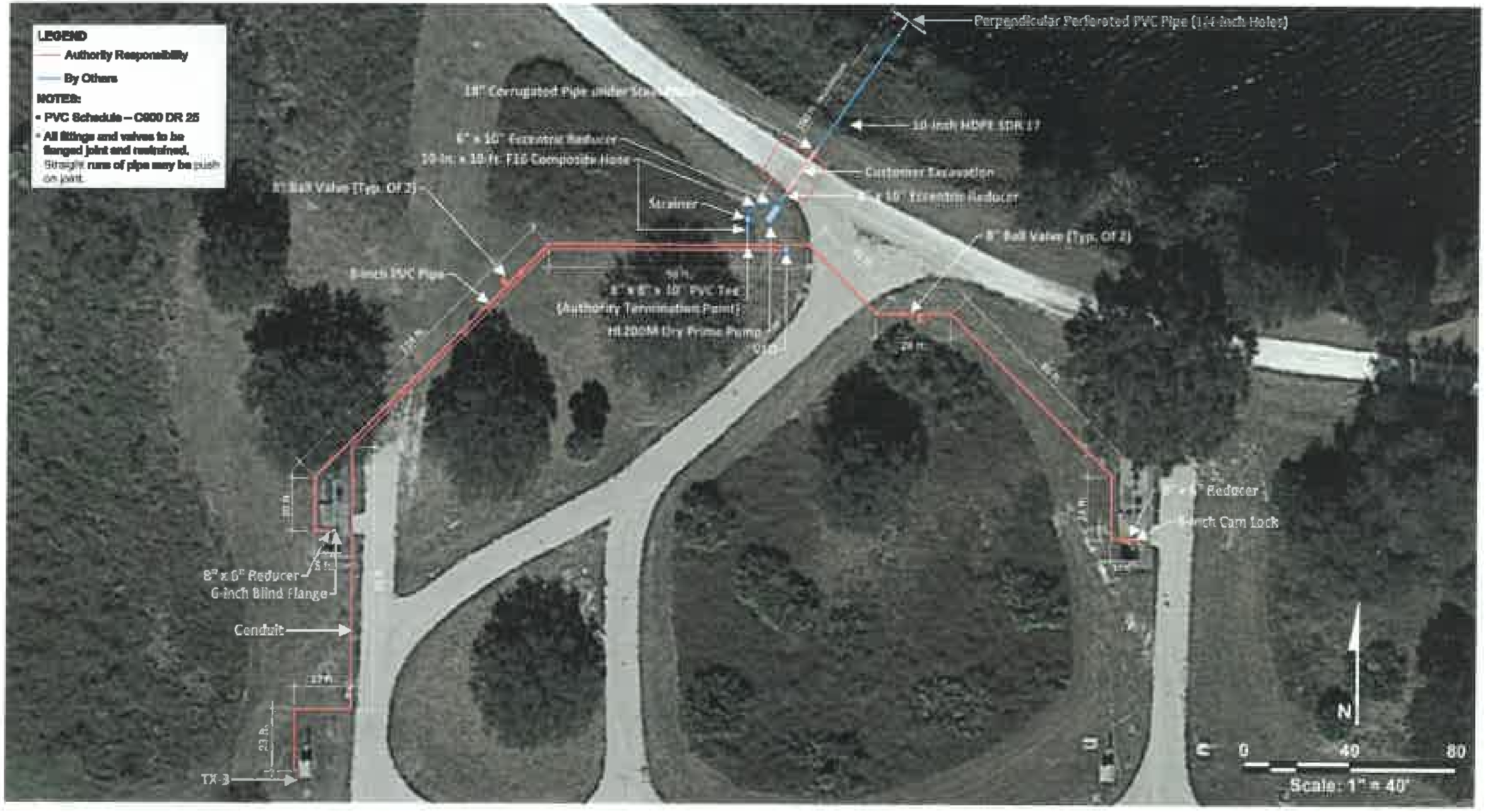

Figure 2-1
PTSW Pilot Study Study Equipment Diagram
Peace River Partially Treated Surface Water ASR Pilot Test - Cycle Test Report

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Figure 2-2. Intake Tee Prior to Equipment Startup

Figure 2-3. Centrifugal Pump

Figure 2-4. Variable Frequency Drive

Figure 2-5. Mechanical Filtration System

Figure 2-6. Piping to ASR Well with Gate Valve for Purging

Figure 2-7. Piping to ASR Well

SECTION 3

Well Performance Data Evaluation

3.1 Test Well Recharge and Recovery Summary

Cycle Test 1

Cycle test 1 (CT1) began on February 9, 2017, with the recharge of PTSW at ASR wells S-4 and S-20. The recharge phase of CT1 continued until March 9, 2017. Recharge consisted of the injection of 59.4 million gallons (MG) of PTSW at ASR wells S-4 and S-20. The other ten ASR production wells within WF2 (S-10 through S-19) were not in operation during the CT1 recharge phase.

Following the recharge phase of CT1, S-4 and S-20 remained in storage until March 27, 2017, when the recovery phase of CT1 was initiated. S-4 and S-20 began the recovery phase of CT1 exclusive of the other WF2 ASR wells from March 27 to April 9, 2017, recovering a total of 25.1 MG during that time, approximately 42 percent of the total PTSW injected during the CT1 recharge phase.

On April 10, 2017, the remaining WF2 ASR wells began recovery as part of the normal seasonal ASR operation at the PRF. This increased the WF2 recovery rate from an average of 1.8 mgd (S-4 and S-20) to a maximum of 14.4 mgd during CT1. Recovery was ceased on June 5, 2017 at S-4 and S-20 but continued at five (5) of the WF2 ASR wells (S-11, S-14, S-15, S-16, S-18) until June 15, 2017. A total volume of 801.2 MG was recovered from WF2 from the start of PTSW CT1 to June 15, 2017 when recovery ceased at all the WF2 ASR wells. This recovery volume is the highest observed since all the potable water was recovered from the WF2 aquifer system in 2006 and 2008 due to drought conditions. **Table 3-1** and **Figures 3-1, 3-2,** and **3-3** provide a summary of the operational recharge, storage, and recovery of CT1.

Table 3-1. Cycle Test 1 Operational Summary
Peace River PTSW Pilot Study

CT1 Operational Status	Date Range	Number of Days	Avg. S-4 Flow Rate (mgd)	Avg. S-20 Flow Rate (mgd)	Avg. WF2 Flow Rate Excluding S-4 & S-20 (mgd)	Avg. Total WF2 Flow Rate (mgd)	PTSW Rate / Total Rate
CT1 Recharge	2/09/17 – 3/09/17	29	0.71	1.34	-	2.05	100%
CT1 Storage	3/10/17 – 3/26/17	17	-	-	-	-	-
CT1 Recovery	3/27/17 – 4/09/17	14	-0.64	-1.15	-	-1.79	100%
CT1 & WF2 Recovery	4/10/17 – 6/05/17	57	-0.65	-1.12	-10.71	-12.48	14%
WF2 Recovery	6/06/17 – 6/15/17	10	-	-	-6.44	-6.44	0%

Avg. = Average

- = 0.00

Pulled 800 MG out of the system

Figure 3-1. Cycle Test 1 Well Daily Flow Rates Compared to Rest of Wellfield

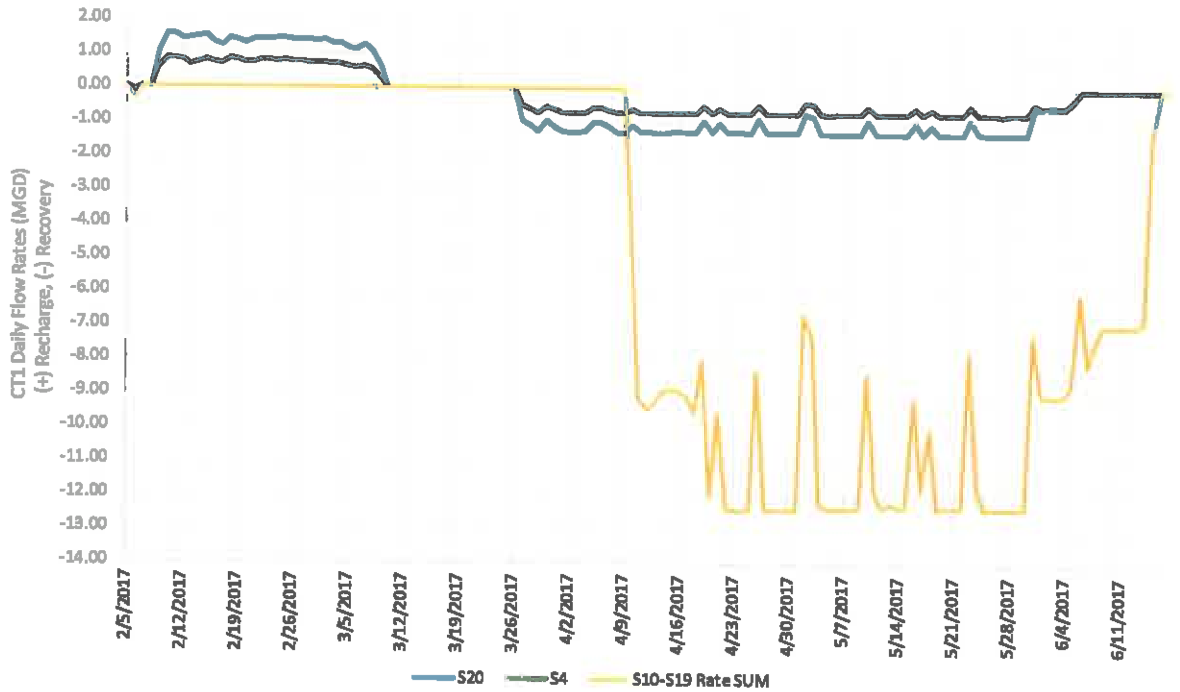


Figure 3-2. Cycle Test 1 Well Flow Percent Contribution Compared to Rest of Wellfield

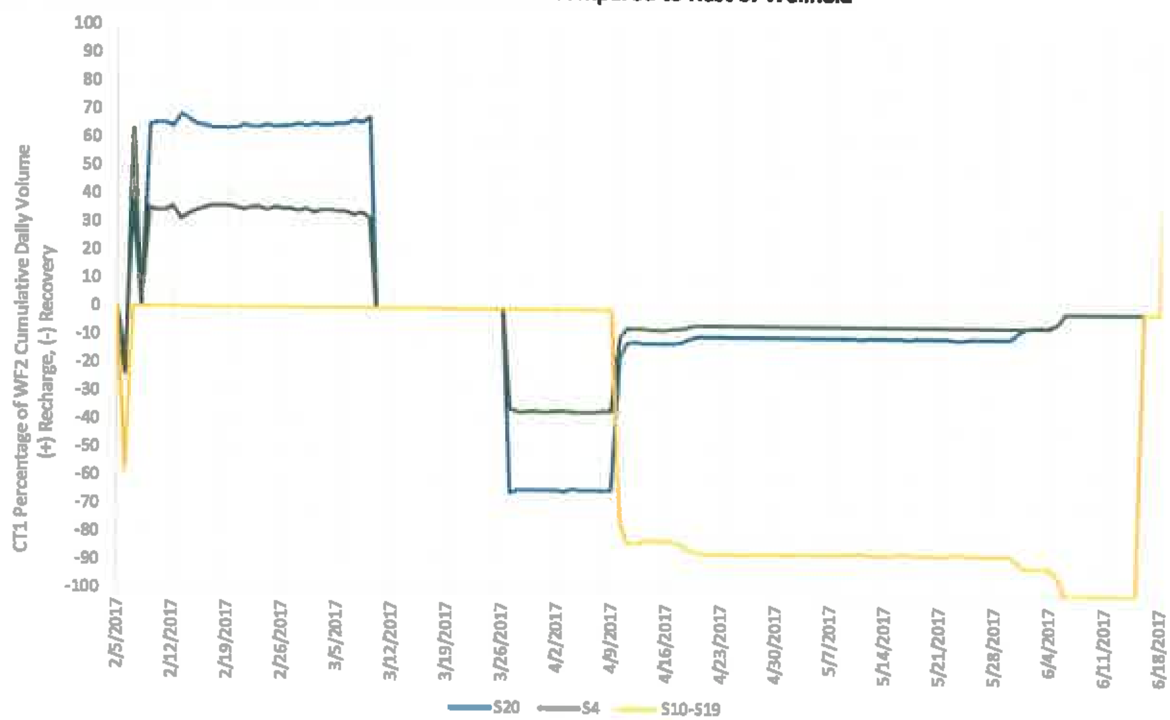
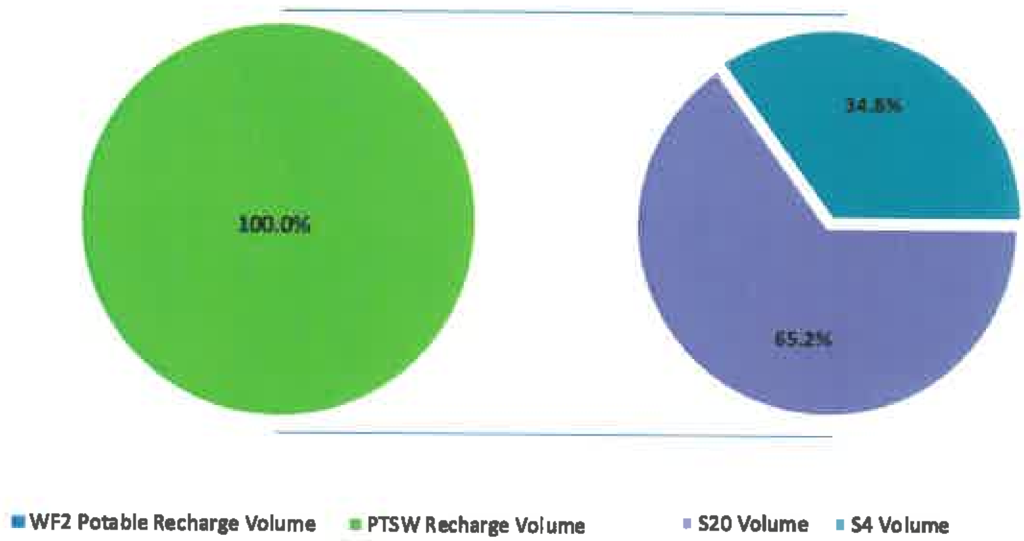


Figure 3-3. Cycle Test 1 Recharge Storage Volume Percentages (Total CT1 Recharge Volume = 59.4 MG)



*Note: There was no potable water recharge during PTSW CT1 Recharge

Cycle Test 2

Recharge of potable water began on June 19, 2017 at ASR wells S-10 through S-19. A volume of 102.7 MG of potable water was recharged prior to beginning PTSW CT2. PTSW CT2 recharge began at S-4 and S-20 on July 6, 2017. PTSW CT2 recharge at S-4 and S-20, and recharge of potable water with ASR wells S-10 through S-19 continued until November 1, 2017; however, PTSW injection was interrupted sporadically due to mechanical issues with the PTSW supply pump. The PTSW supply pump was not in operation between the dates of July 14 through July 17, July 18 through July 24, and July 28 through August 2, 2017. Additionally, recharge was temporarily suspended at S-4 and S-20 from September 7 through 17, 2017 due to Hurricane Irma events. During this time, S-10 through S-19 recharge was also temporarily suspended for a shorter time period between September 10 and September 12, 2017, but recovery occurred on September 14, 2017 for routine sampling. CT2 recharge using PTSW in S-4 and S-20 continued until November 1, 2017, and recharge of potable water in the remaining WF2 ASR wells continued until October 31, 2017. A total of 783 MG of potable water and 178.3 MG of PTSW were recharged during the PTSW CT2 recharge phase.

CT2 storage for all ASR wells in WF2 was initiated November 1, 2017 and continued until December 5, 2017 when recovery exclusively at S-4 and S-20 was initiated. The recovery of 55.9 MG occurred uninterrupted between December 5, 2017, and January 2, 2018. **Table 3-2** and **Figures 3-4, 3-5, and 3-6** provide a summary of the operational recharge, storage, and recovery of CT2.

Table 3-2. Cycle Test 2 Operational Summary
Peace River PTSW Pilot Study

CT2 Operational Status	Date Range	Number of Days	Avg. S-4 Flow Rate (mgd)	Avg. S-20 Flow Rate (mgd)	Avg. WF2 Flow Rate Excluding S-4 & S-20 (mgd)	Avg. Total WF2 Flow Rate (mgd)	PTSW Rate / Total Rate
WF2 Recharge	6/19/17 – 7/05/17	17	-	-	6.04	6.04	0%
CT2 & WF2 Recharge	7/06/17 – 9/06/17	63	0.37*	1.04*	7.65	9.06	16%
WF2 Recharge	9/07/17 – 9/09/17	3	-	-	4.76	4.76	0%
Recharge Interrupted	9/10/17 – 9/12/17	3	-	-	-	-	-
WF2 Recharge Only	9/13/17 – 9/17/17	5	-	-	1.89	1.89	0%
CT2 & WF2 Recharge	9/18/17 – 10/31/17	44	0.67	1.58	6.50	8.52	26%
CT2 Recharge	11/01/17	1	0.13	0.49	-	0.62	100%
CT2 Storage	11/02/17 – 12/04/17	33	-	-	-	-	-
CT2 Recovery	12/05/17 – 1/02/18	29	-0.66	-1.31	-	-1.97	100%

* = S-4 and S-20 Recharge interrupted multiple times due to PTSW supply pump malfunction. Averages include days with zero flow.

Avg. = Average

- = 0.00

Figure 3-4. Cycle Test 2 Well Daily Flow Rates Compared to Rest of Wellfield

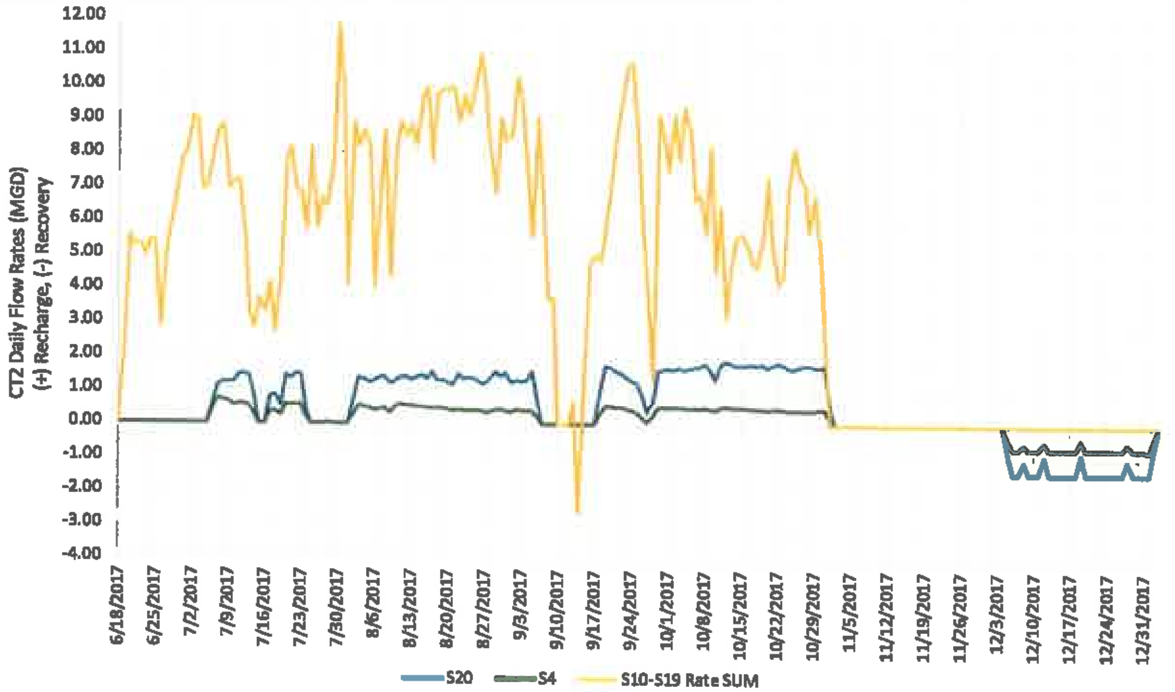
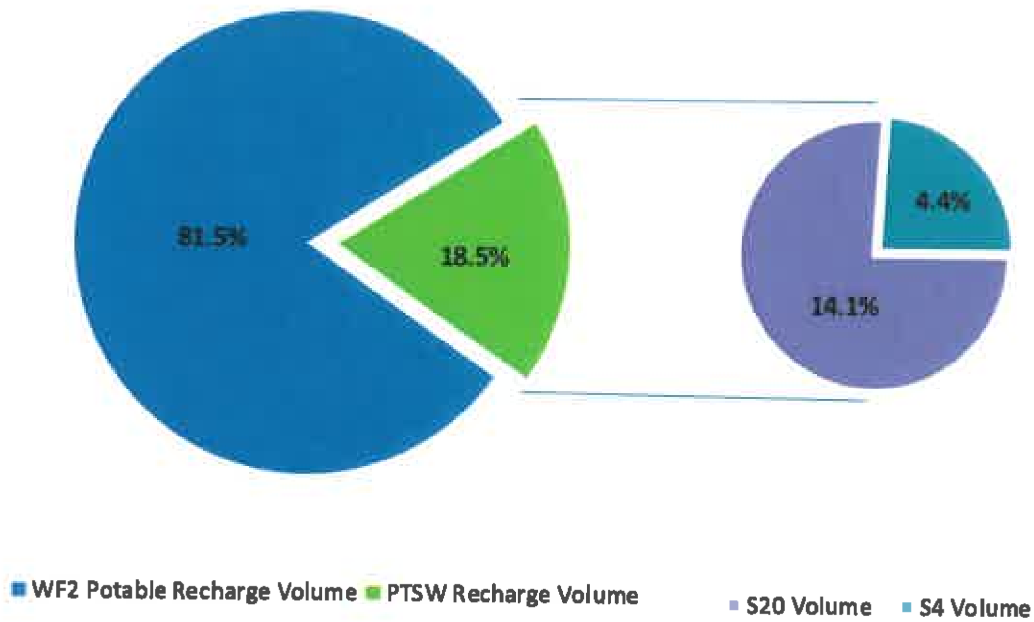


Figure 3-5. Cycle Test 2 Well Flow Percent Contribution Compared to Rest of Wellfield

Figure 3-6. Cycle Test 2 Recharge Storage Volume Percentages (Total CT2 Recharge Volume = 961.3 MG)



3.2 Well Performance Evaluation

Reservoir water quality is good but does contain more particulate matter than potable water, therefore, the project team felt it important to evaluate if the use of reservoir water for ASR would result in significant declines in well performance at the ASR wells. Well performance for the purposes of this report refers to the injection and recovery capacity of the ASR well. To evaluate well performance, the flow and pressure of the wells were recorded, and the specific injectivity (recharge) or specific capacity (recovery) was calculated as the flow rate in gpm per unit of water level change in feet.

Water from the reservoir was pumped through a filter pod system and then to S-4 and S-20. During most of the testing, the filter pods were fitted with 100-micron filter bags apart from a short period during CT1 where 50-micron bags were used, and at the end of CT2 when the filter bags were removed and the only filtration was with the 1/8-inch diameter holes in the filter pods' integral stainless-steel baskets.

Flow and pressure were measured downstream of the filter pods, and the pump was operated at a constant speed. However, since the pump delivered a continuous amount of energy, as the filters became plugged, they created a localized pressure loss, and the resulting flow to each ASR well decreased. This translated to decreases in flow and available pressure at the wells between filter bag changes that had little-to-nothing to do with daily well performance but was attributable to constraints in the feed/filtration system design. With pressure and flow data collected at the wellhead, "noise" in the specific injectivity data from feed system performance is largely avoided. In the sections below, well performance of S-4 and S-20 is documented during PTSW CT1 and CT2.

Cycle Test 1

During CT1 recharge, only S-4 and S-20 were recharging PTSW, and the rest of the wellfield was offline. This allowed for a good comparison of the effects of PTSW water quality and filtration on the ASR well behavior without pumping influence from other wells. **Figure 3-7** is a graph of the flow, pressure, and specific injectivity (SI) of S-4. Vertical lines in the graph indicate the times that the filter bags were replaced. SI of S-4 at the beginning of the test was approximately 11 gpm/ft and declined to approximately 6 gpm/ft, near the end of the test. For the recharge event to reach a stable SI, the aquifer must reach a stable piezometric head contour surrounding the well in response to the recharge rate. Therefore, a gradually decreasing trend in SI during CT1 recharge is observed. However, the magnitude of SI decline was within the range of SI that has been observed at the same well over the period of record with the use of potable water for recharge (see **Figure 3-11**). The SI was also observed to be reaching what appeared to be a stable lower limit by the end of the period, indicating that minimal or no plugging was occurring from TSS that may have passed through the mesh filter bags.

During CT1 at both S-4 and S-20, filters with a 100-micron mesh size were used from February 9 to February 21, 2017 and from February 27 to March 9, 2017. The 50-micron mesh size filter bags were used from February 21 to February 26, 2017. During CT1 recharge, 100-micron mesh size filter bags were changed at an average interval of three (3) days while 50-micron filters (not used during the same time periods) were changed at an average interval of 2 days. No significant difference in the rate of SI decrease is observed when comparing the time periods when 100-micron mesh size and 50-micron mesh size filter bags were used, which further confirms that minimal or no plugging was occurring from TSS that may have passed through the mesh filter bags. Additionally, the frequency of the needed filter changes would suggest that a significant amount of particulate matter was removed from the PTSW water before recharge.

Figures 3-8 shows the flow, pressure, and SI at S-20 during CT1 recharge. Since both wells were fed from the same feed pump and mechanical strainer pod array, as noted for S-4 previously, the vertical lines show times associated with each filter bag change. Between filter bag changes, there were instantaneous spikes in flow and pressure at S-4 and S-20 at approximately 9 a.m. on days when M-14 was purged for sampling. Because of the hydraulic connectivity observed between M-14 and the pilot study wells (as discussed in Section 4.6 below), head conditions in the storage zone decreased at S-4 and S-20 when M-14 was purged for sampling during PTSW recharge mode. As the pump was operated at a constant speed, the combined flow into S-4 and S-20 increased by approximately 150 gpm during the M-14 sampling period; however, the flow into each well changed in accordance with the specific injectivity behaviors of each well. The flow in S-4 during M-14 sampling decreased approximately 50 gpm to hold a constant specific injectivity while the flow in S-20 increased by approximately 200 gpm resulting in a greater instantaneous specific injectivity. This behavior during M-14 sampling agrees with historic performance of S-4 (an average capacity well) and S-20 (a high-capacity well) as shown in **Figures 3-11 and 3-12** below.

Like S-4, an initial decreasing trend in SI is observed during the recharge event to establish stable aquifer head and well SI conditions. The SI at the beginning of recharge was approximately 18 gpm/ft, decreasing to 12 gpm/ft by the end of the CT1 recharge phase but it appeared to have reached a stable lower limit. However, the degree of SI decline observed does not appear to be caused by well plugging and is not anticipated to significantly impact the ability to implement PTSW ASR.

Figure 3-7A. S-4 Cycle Test 1 Recharge Physical Parameters

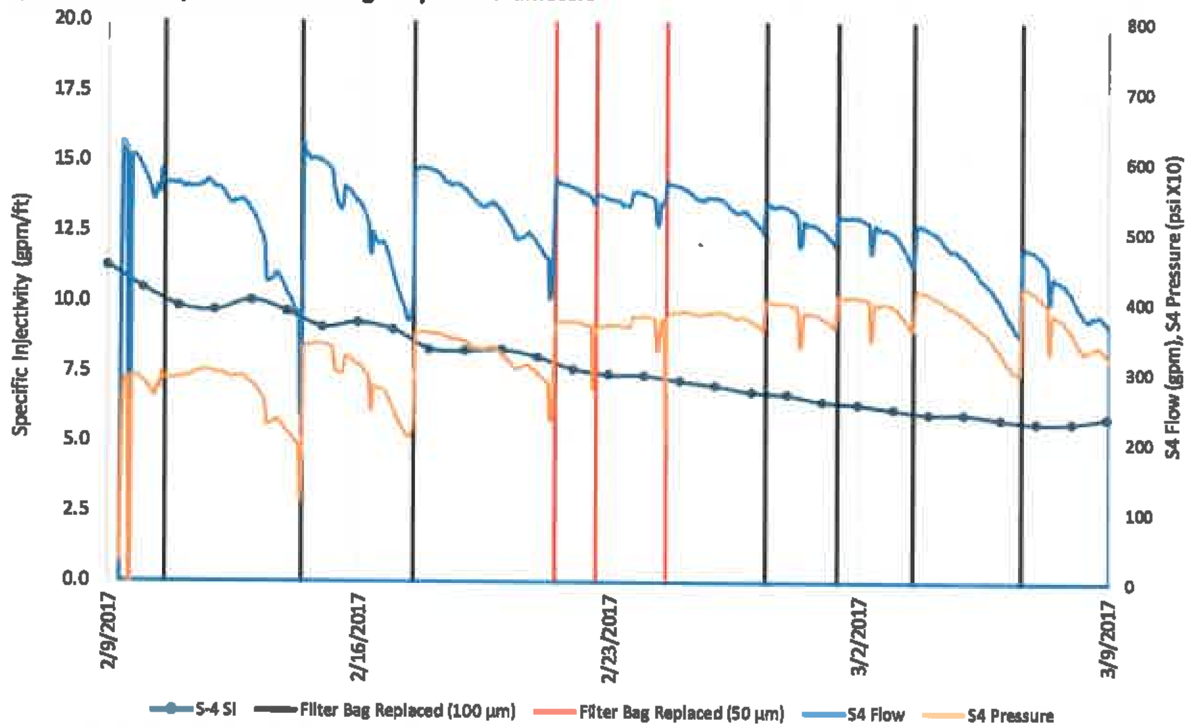


Figure 3-7B. S-4 Cycle Test 1 Recovery Physical Parameters

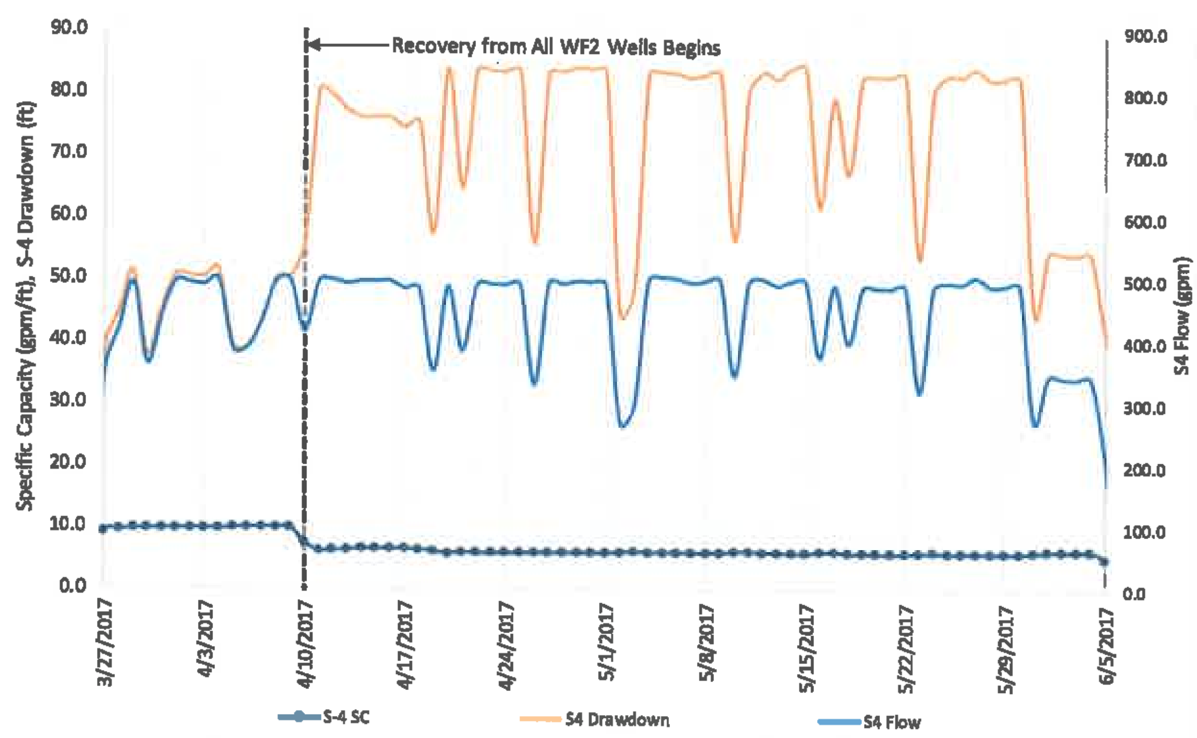


Figure 3-8A. S-20 Cycle Test 1 Recharge Physical Parameters

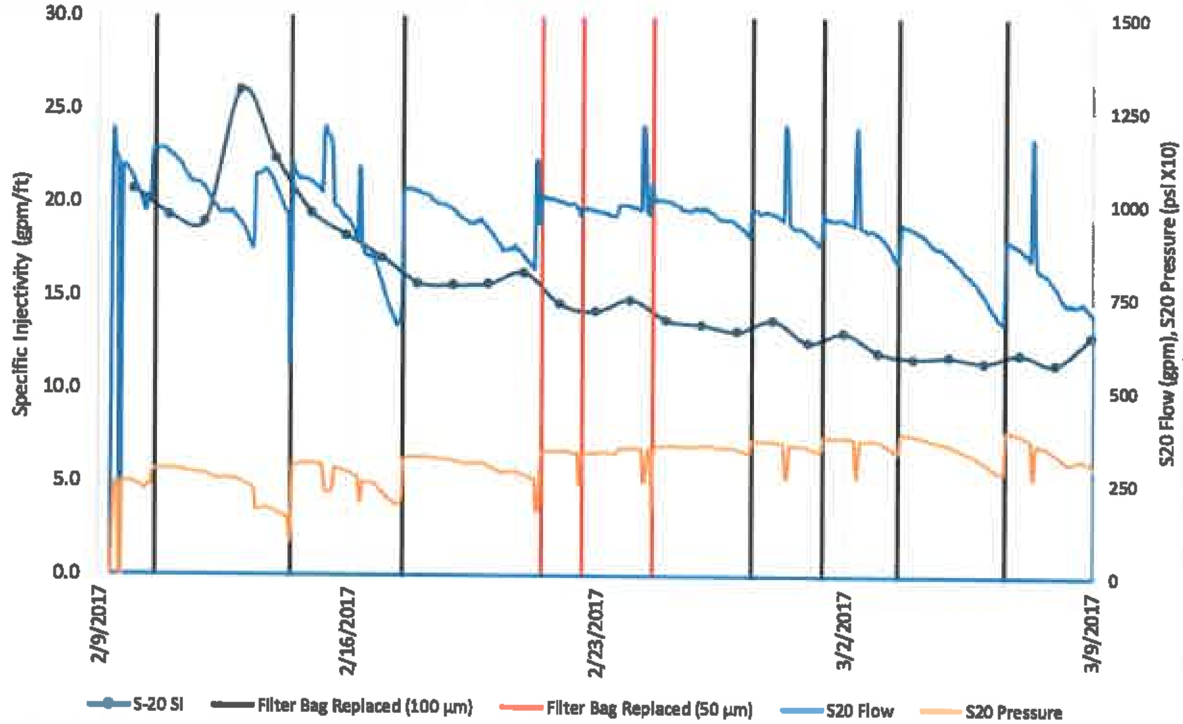
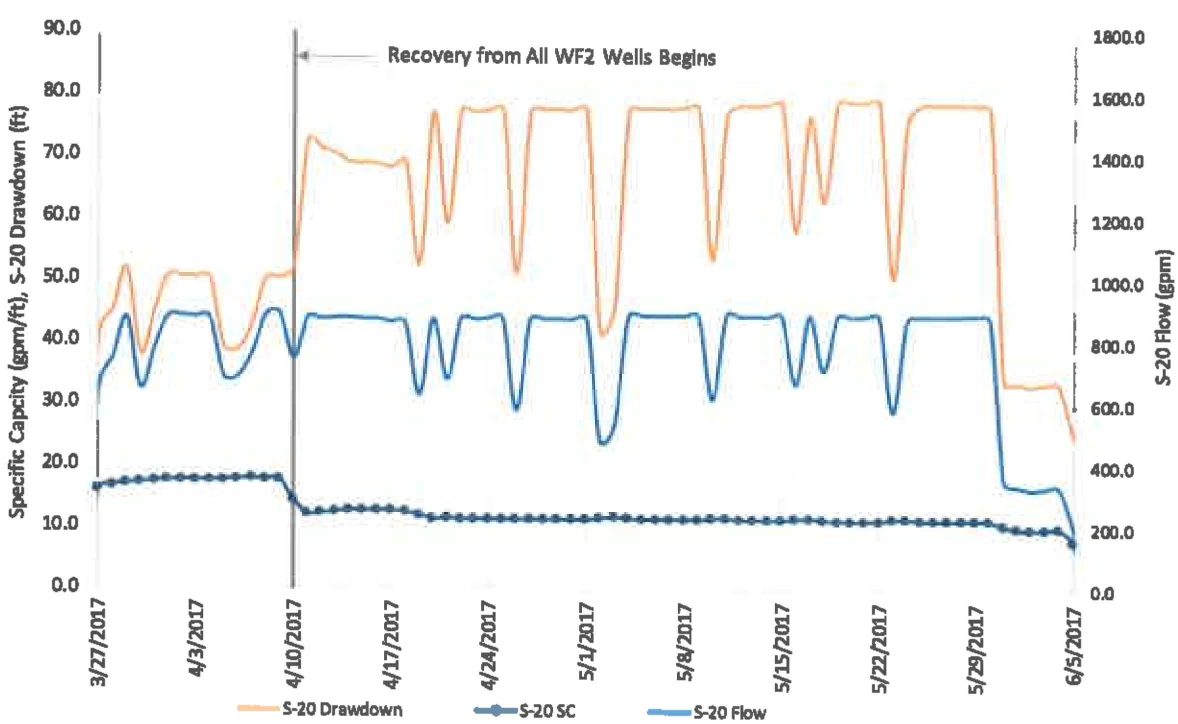


Figure 3-8B. S-20 Cycle Test 1 Recovery Physical Parameters



Cycle Test 2

As shown in **Figure 3-9**, **Figure 3-10**, and **Table 3-2** above, the CT2 recharge phase occurred during a time period of approximately four months from July 6 through November 1, 2017. The CT2 recharge phase incorporated a higher number of operational changes when compared to the CT1 recharge phase. These include potable water recharge at all other WF2 wells during PTSW recharge at S-4 and S-20, time periods when WF2 wells were recharging potable water without contributions from S-4 and S-20, multiple instances of PTSW intake pump failures leading pauses of PTSW recharge, the removal of the mesh filter bags beginning on September 28, 2017, and the purging of wells S-4 and S-20 to improve SC and SI. Observed trends in the SI of S-4 and S-20 during this time period, while affected by multiple factors, showed an overall neutral to increasing trend. Close examination of the data shows that changes in SI are impacted mostly by changes in wellfield recharge rate. As the WF2 flow rate increases, the head conditions (i.e., water levels) in the aquifer increase resulting in a perceived decrease in SI. Conversely, when the WF2 recharge rate decreases, the head conditions in the aquifer decrease and SI appears to improve.

Near the end of the CT2 recharge event, the mesh bags were removed from the filter pods resulting in filtration with only the 1/8-inch perforations in the stainless-steel baskets. This was done to test the plugging potential of the wells with a coarser level of filtration and to avoid feed system performance concerns. Data suggest no significant decline in SI during this period; however, the WF2 flow rate is decreasing during this period potentially masking some of the declines from plugging. Regardless, a rapid decline in SI was not observed when the filter bags were removed, and the subsequent recovery period did not indicate a significant decline in specific capacity (**Figures 3-9** and **Figure 3-10**).

Figure 3-9A. S-4 Cycle Test 2 Recharge Physical Parameters

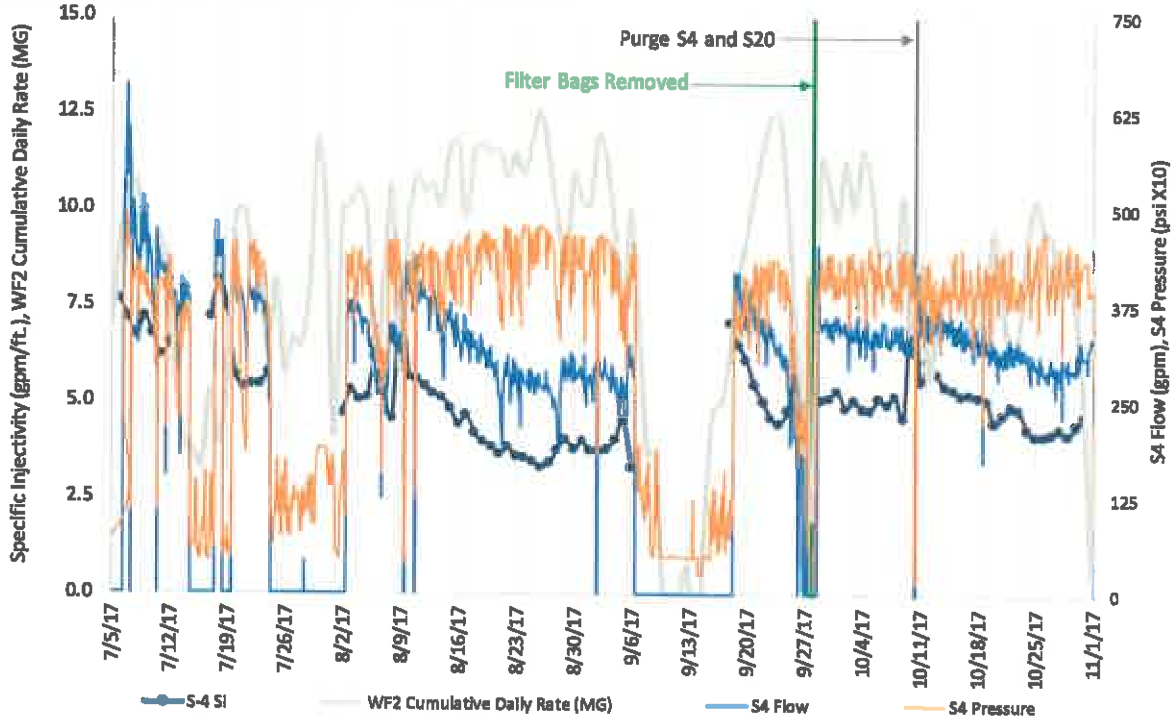


Figure 3-9B. S-4 Cycle Test 2 Recovery Physical Parameters

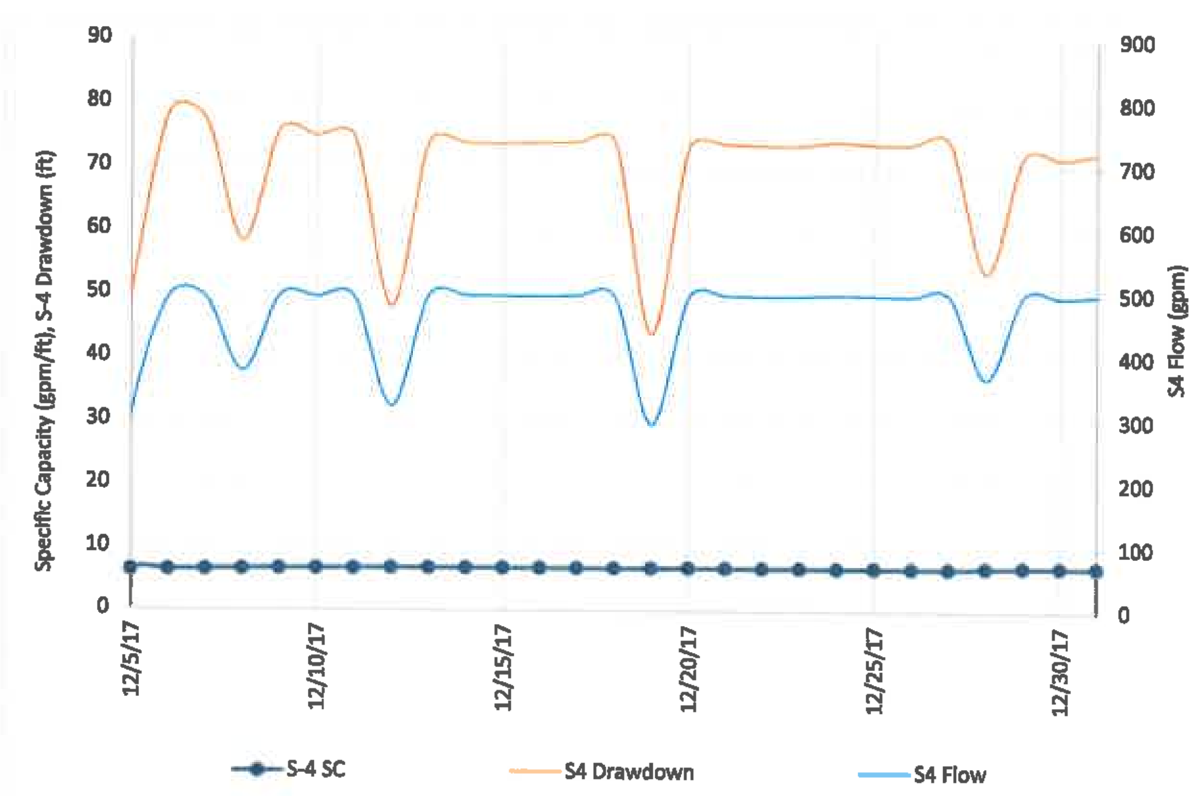


Figure 3-10A. S-20 Cycle Test 2 Recharge Physical Parameters

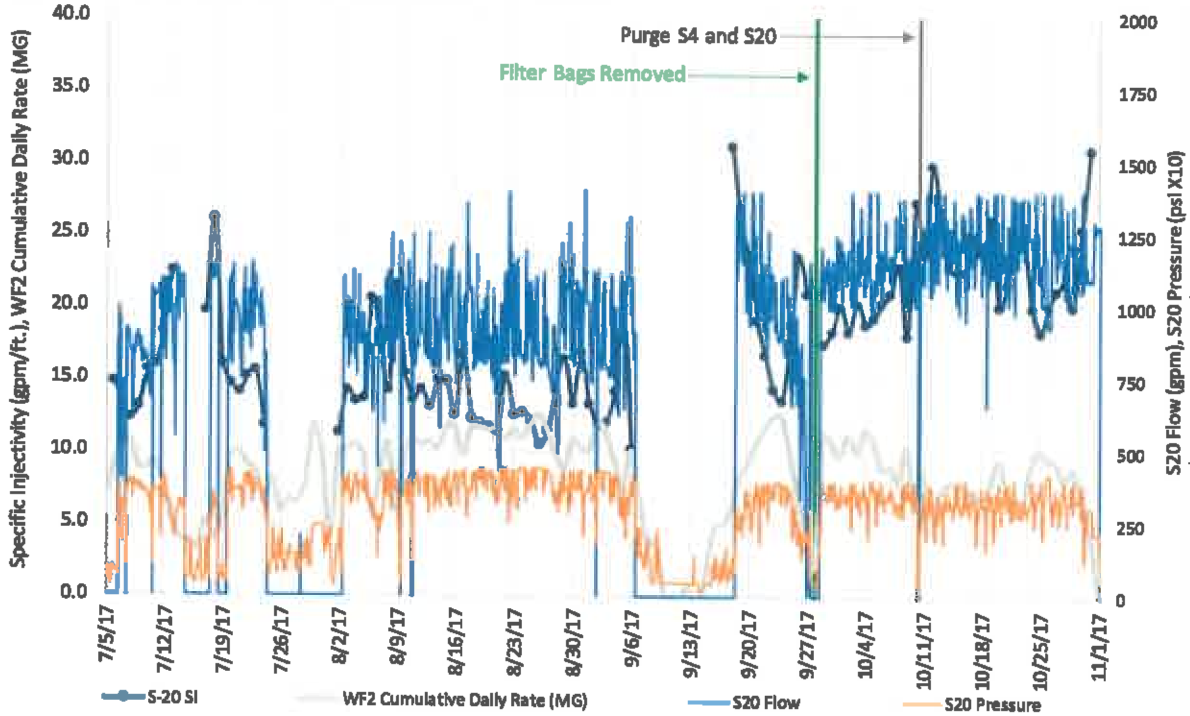
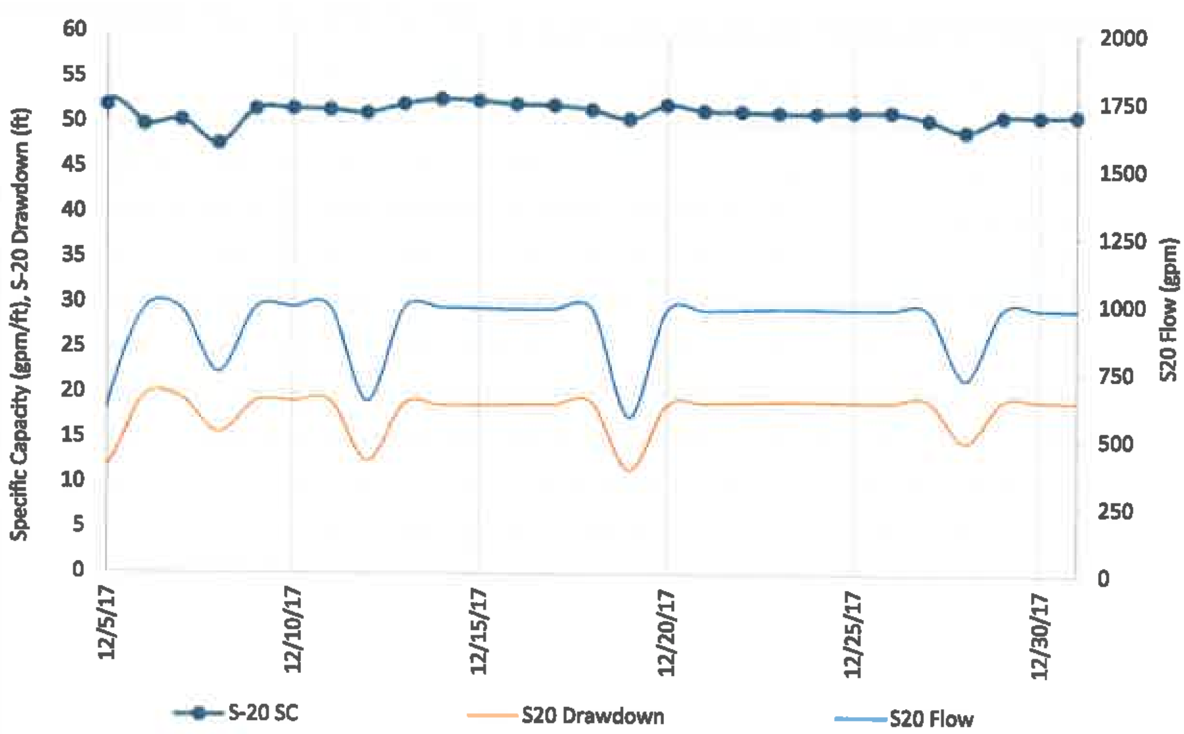


Figure 3-10B. S-20 Cycle Test 2 Recovery Physical Parameters



Cycle Testing Well Performance Summary

Over the PTSW recharge periods, the range of SI values observed at S-4 and S-20 were within the range of SI recorded at these wells over the period of record as shown in Figure 3-11 and Figure 3-12.

Figure 3-11. S-4 Historical Specific Injectivity and Specific Capacity Data

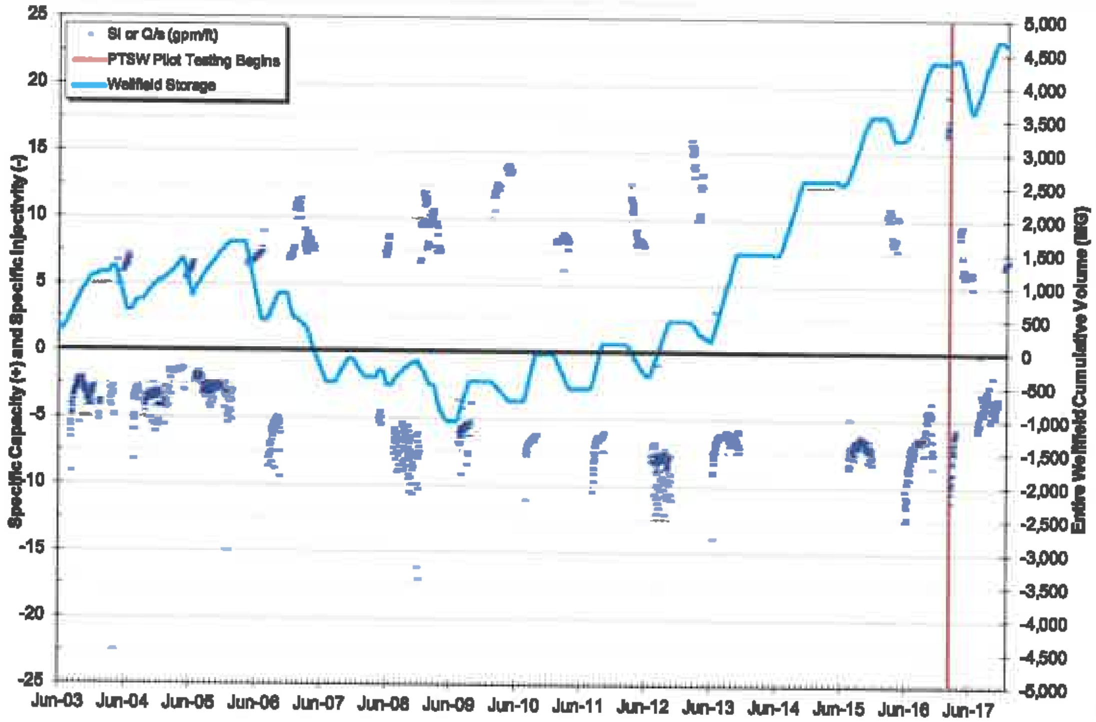
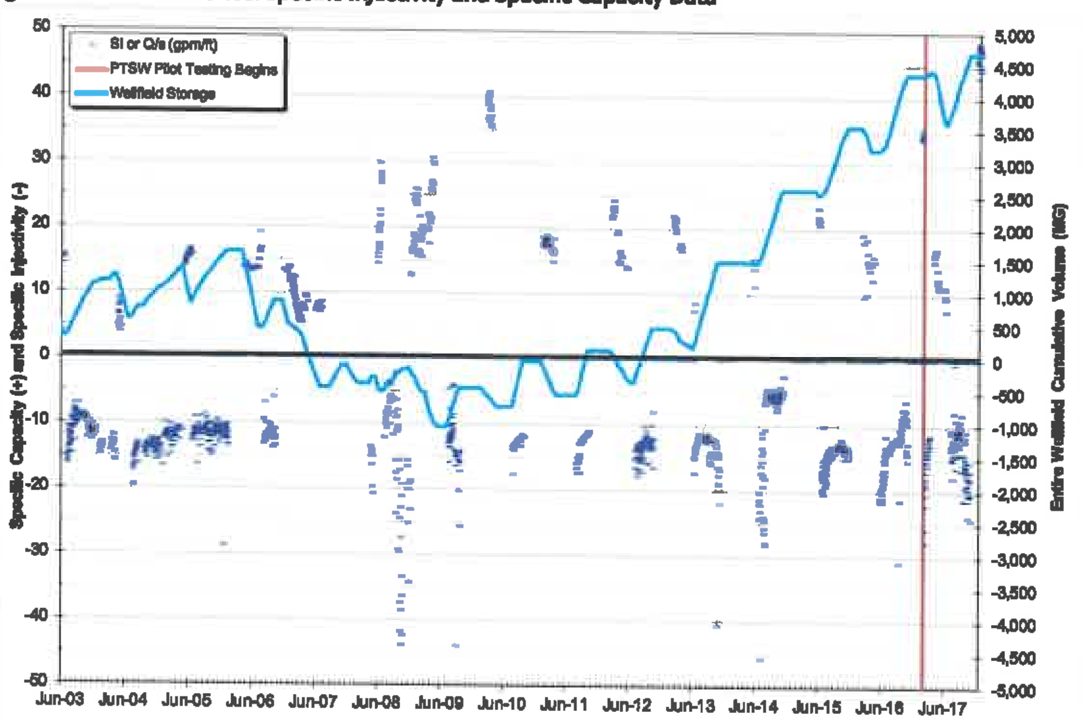


Figure 3-12. S-20 Historical Specific Injectivity and Specific Capacity Data



The following observations on SI and SC are drawn from the data collected during CT1 and CT 2 PTSW recharge and recovery:

- The SI at S-4 ranged from 3 gpm/ft to 11 gpm/ft and S-20 ranged from 10 gpm/ft to 30 gpm/ft, both within the range of SI observed over the historic period of record for this well.
- The SC at S-4 ranged from 5 gpm/ft to 10 gpm/ft during recovery of PTSW during Cycle 1 and Cycle 2. This is also within the historic range of S-4's SC observed over the period of record.
- The SC at S-20 ranged from 7 gpm/ft to 15 gpm/ft during Cycle 1 while the rest of the wellfield was also recovering potable water; however, the SC ranged from 40 gpm/ft to 50 gpm/ft during Cycle 2 recovery, when only S-4 and S-20 were recovering PTSW. Although this is the historic high recorded SC at S-20, recovery in 2009 exceeded 40 gpm/ft when only five (5) of the other 11 ASR wells were recovering.

As the SI appeared to reach a stable 6 gpm/ft at S-4 and 12 gpm/ft at S-20 during CT1, the mesh filter bags appeared to remove substantial particulates that would likely mitigate potential well plugging. Though SI data after the mesh bags were removed did not conclusively indicate plugging, the data could have been skewed by other variables affecting the calculation of SI (e.g., changing head conditions from varying wellfield recharge rates). Based on the visual evidence of the particulate matter collected in the bags (**Figure 3-13**), one would expect that the filtration was providing a degree of benefit against potential plugging. Therefore, it is recommended that as a precaution filtration should be included in longer term implementation of PTSW.

Figure 3-13. S-20 Algae and Particulate Matter Captured in Mesh Filter Bags

SECTION 4

Water Quality Data Evaluation

4.1 Overview of Water Quality Monitoring Program

An extensive network of monitoring wells surrounds both WF1 and WF2 including sixteen wells in the ASR zone (Suwannee Limestone permeable unit) and eight wells completed in the overlying Hawthorn aquifer system. **Table 4-1** and **Table 4-2** summarize the ASR system monitoring well details for WF1 and WF2, respectively. Monitoring of the PTSW pilot test focused on monitoring wells located near WF2 since the recharge of PTSW was at S-4 and S-20 (see **Figure 1-5** for WF2 layout). In addition to the water quality parameters listed in the current operation permit, the sampling regimen was expanded to include parameters of interest in PTSW, such as total coliform, nitrogen species and total organic carbon (TOC). Several specific constituents (iron, total organic carbon, and phosphorus) present in surface water at higher concentrations than potable water or native ground water in the ASR storage zone were also added as it was believed they could be useful as indicator parameters.

To the greatest extent possible, water sampling for the PTSW testing was coordinated in conjunction with the typical sample schedule underlying the ASR operation permit. In instances where the same parameters were listed in both the PTSW and operation permit sampling schedules, two samples were collected and analyzed separately, producing two results for that analyte even though they were essentially duplicates. This was not done intentionally, but was an artifact of coordinating sampling efforts for PTSW testing and the operation permit independently. The data presented in this report is from the PTSW data set, to avoid confusion in instances where duplicate samples might have slightly different results. The operation permit sampling data set was previously provided in the monthly operating reports pursuant to permit requirements.

Two important objectives for the monitoring program were to attempt to track arrival of the PTSW at the monitor wells and determine the fate of total coliform in the aquifer (i.e., the time required for inactivation) if detected at the monitor well. It was also important to ascertain if any other primary or secondary state drinking water standards would be exceeded, and if so, the fate of these analytes as well. The list of analytes and sample frequency for the PTSW pilot test is shown in **Table 4-3**. The full FDEP permit major permit modification in which the sampling schedule is contained is provided in **Appendix B**. Sampling of the PTSW wells was conducted during recharge, storage and recovery events. The Authority also continued water quality sampling of WF2 monitoring wells per the current Class V operation permit sample schedule.

Finally, during the PTSW cycle testing, the project team periodically reviewed the analytical water quality data as it became available looking for interesting or unexpected changes. As a result, the frequency of analysis was increased at some monitor wells, and some monitor wells not listed in the permit modification schedule were also sampled if deemed helpful to characterize and track movement of PTSW. Therefore, monitoring wells M-12 and M-15 were added to the sampling regimen during the course of the program.

Table 4-1. WF1 Monitor Well Construction Details
Peace River PTSW Pilot Study

Well	Casing Diameter (Inches)	Casing Depth (feet bls)	Total Depth (feet bls)	Approximate Distance To nearest ASR well (feet)	Hydrogeologic Interval
E	6	140	200	>50 feet (S-2)	UPZ
T-2	4	393	490	1,900 (S-1)	LPZ
M-2	6	596	900	1,900 (S-1)	Suwannee Zone
I-7	6	220	261	360 (S-6)	LPZ
T-7	6	349	400	360 (S-6)	LPZ
M-7	6	580	605	360 (S-6)	Suwannee Zone
M-20	6	584	688	450 (SR-5)	Suwannee Zone
M-21	6	575	672	190 (S-7)	Suwannee Zone
M-22	6	565	572	100 (S-2)	Suwannee Zone

LPZ= lower producing zone of the Hawthorn aquifer system (a.k.a. lower Arcadia aquifer, Tampa Zone)

UPZ= upper producing zone of the Hawthorn aquifer system

Suwannee Zone = refers to the Upper Floridian aquifer permeable unit within the Suwannee Limestone formation

Table 4-2. WF2 Monitoring Well Construction Details
Peace River PTSW Pilot Study

Well	Casing Diameter (Inches)	Casing Depth (feet bls)	Total Depth (feet bls)	Approximate Distance To nearest ASR well (feet)	Hydrogeologic Interval
T11	6	350	400	340 (S-20)	LPZ
M11	6	570	677	340 (S-20)	Suwannee Zone
M12	6	585	705	400 (S-15)	Suwannee Zone
M13	6	550	670	660 (S-20)	Suwannee Zone
M14	6	575	676	170 (S-20, S-19)	Suwannee Zone
M15	6	570	678	560 (S-14)	Suwannee Zone
M16	6	560	673	400 (S-15)	Suwannee Zone
M17	6	565	670	95 (S-16)	Suwannee Zone
M18	6	575	700	250 (S-10)	Suwannee Zone
M19	6	580	680	525 (S-17)	Suwannee Zone
I-10	6	260	320	6,400	LPZ
M-6	6	579	640	7,900	Suwannee Zone
I-8	6	155	190	860 (S-20)	UPZ
T-8	12	354	401	860 (S-20)	LPZ
M-8	10	570	860	900 (S-20)	Suwannee Zone

LPZ= lower producing zone of the Hawthorn aquifer system (a.k.a. lower Arcadia aquifer, Tampa Zone)

UPZ= upper producing zone of the Hawthorn aquifer system

Suwannee Zone = refers to the Upper Floridian aquifer permeable unit within the Suwannee Limestone Formation

Table 4-3. PTSW Pilot Study Monitoring Plan
Peace River PTSW Pilot Study

Parameter	Units	Recording Frequency	Frequency of Analysis			
			Recharge (reservoir)	*Recovery (S-4, S-20)*	*M-11, M-14, M-16, M-17, M-18, T-11*	*M-8, M-13, T-8*
Flow Rate, max.	gpm	daily	D/M	D/M		
Flow Rate, min.	gpm	daily	D/M	D/M		
Flow Rate, avg.	gpm	daily	D/M	D/M		
Total Volume Recharged	Mg	daily	D/M			
Total Volume Recovered	Mg	daily		D/M		
Injection Pressure, max.	Psi	continuous	D/M			
Injection Pressure, min.	Psi	continuous	D/M			
Injection Pressure, avg.	Psi	continuous	D/M			
Water Level, max.	feet (NGVD)	continuous		D/M	D/M	D/M
Water Level, avg.	feet (NGVD)	continuous		D/M	D/M	D/M
Water Level, min.	feet (NGVD)	continuous		D/M	D/M	D/M
pH +	std. Units		W[a]	W[b]	W	M
Specific Conductivity +	µmhos/cm		W[a]	W[b]	W	M
Temperature +	°C		W[a]	W[b]	W	M
Dissolved Oxygen +	mg/L		W[a]	W[b]	W	M
Turbidity +	NTU		W[a]	W[b]	W	M
Oxidation-Reduction Potential +	mV		W[a]	W[b]	W	M
Total Dissolved Solids	mg/L		W[a]	W[b]	W	M
Chloride	mg/L		W[a]	W[b]	W	M
Sulfate	mg/L		W[a]	W[b]	W	M
Arsenic	µg/L		W[a]	W[b]	W	M
Total Suspended Solids	mg/L		W[a]	W[b]	W	M
Nitrate (as N)	mg/L		W[a]	W[b]	W	M
TKN	mg/L		W[a]	W[b]	W	M
Ammonia	mg/L		W[a]	W[b]	W	M
TOC	mg/L		W[a]	W[b]	W	M
Color	Units		W[a]	W[b]	W	M
Aluminum	µg/L		W[a]	W[b]	W	M
Total Coliform	CFU/100 mL		W[a]	W[b]	W	M
Escherichia coli	CFU/100 mL		W[a]	W[b]	W	M
Primary and Secondary stds.	mg/L		B		-	-
Iron[c]	mg/L		W[a]	W[b]	W	M
Phosphorus[d]	mg/L		W[a]	W[b]	W	M

Notes:

No sampling of ASR wells during storage
W - weekly; D/M - daily and monthly;
a - during recharge only
b - during recovery only

c - sampling started 9/15/18
d – sampling started 10/24/18
+ - field samples
B - Background sample prior to cycle 1 recharge

4.2 Reservoir Water Quality

Water quality from Reservoir No. 1 was analyzed during recharge of PTSW cycle testing according to the schedule in the PTSW permit modification. An extensive data set of water quality was also available from routine analysis performed by the Authority during normal operations before PTSW began. This data was provided in the permit modification request and is again provided in this document in **Appendix C**. In addition to that background data, a comprehensive water quality analysis was conducted June 28, 2016, which included primary and secondary state and federal drinking water standards (DWS).

Water quality from the reservoir is very good, with total coliform, aluminum, color, and odor the only parameters above their respective DWS or groundwater standard. Total coliform is ubiquitous in surface water and levels in the reservoir during PTSW were generally above the laboratory method limit listed as >2420 CFU/100 mL, i.e., total coliform counts in the sample are greater than 2420 CFU/100 mL and too numerous to count (TNTC). Aluminum concentrations in reservoir samples ranged between 176 µg/L and 397 µg/L (2015-2016 samples), with most values exceeding the 200 µg/L secondary DWS. The aluminum presence in the reservoir is due to aluminum concentrations from Peace River which typically range from 100 µg/L to 200 µg/L as well as backwashing from the PRF's filter systems which remove the dissociated aluminum from alum that is dosed into the treatment scheme for flocculation of smaller suspended solids. TOC was not measured in reservoir samples, but the color parameter (in platinum cobalt units, PCU) serve as a proxy for TOC. Color values are high but typical of Florida rivers, ranging between 50 PCU and 101 PCU (2015-2016 samples), exceeding the 50 PCU secondary DWS. TOC concentrations were measured during cycle testing and will be discussed in **Section 4.3.** Iron in recharge water is an important control on arsenic concentrations during cycle testing as detailed in **Appendix E.** Iron concentrations in reservoir samples vary between wet and dry seasons. Wet season iron concentrations are lower, generally ranging between 59 µg/L and 88 µg/L; dry season iron concentrations are higher, generally ranging between 106 µg/L and 163 µg/L. Sulfate concentrations in reservoir samples are relatively consistent (2015-2016 samples), ranging between 58 mg/L and 71 mg/L. Phosphorus concentrations were measured at 0.225 mg/L and 0.155 mg/L during CT2.

Water quality graphs of the PTSW cycle testing are organized by parameter showing results from each well and are included in **Appendix D.** In each of the graphs, the reservoir trend for the same parameter is reflected to create a framework whereby convergence of monitoring well water quality towards reservoir water quality signifies arrival of PTSW. The water quality evaluation focuses on these differences between the PTSW and groundwater at the monitor wells. The following sections detail the PTSW monitoring well water quality results during cycle testing. An addendum that discusses geochemical controls on iron, arsenic, and phosphorus is attached as **Appendix E.**

4.3 Contextual Discussion on Tracers of PTSW

The PTSW from Reservoir No. 1 used for this test is high quality for a surface water, shows fairly low turbidity values, and its high color tends to thwart light transmittance which inhibits algal growth. Most primary and secondary drinking water standards are met, or are regulated with a zone of discharge (ZOD) issued with the testing permit. However, there are some notable differences when PTSW and native groundwater are compared. For example, total coliforms are present in the PTSW, but are absent in native groundwater and potable water sources.

The regulatory groundwater standard for total coliforms is 4 CFU/100mL. Because total coliform levels are significantly higher in the PTSW, it was important to demonstrate whether total coliforms persist in the aquifer after recharge of PTSW, or if not, estimate the rate of total coliform inactivation. PTSW cycle testing data showed that total coliforms arrived at the monitor wells at relatively high concentrations during recharge. This high concentration could have been a result of many sources of coliforms. One possibility is water birds such as Anhingas that were frequently observed to be using the floating intake tee as a perch location during CT1 as shown in **Figure 4-1.**

Figure 4-1. HDPE Intake Tee as a Bird Perch during CT1

Total coliforms are quantified in the groundwater monitoring program in terms of most probable number (MPN) of colony forming units with the laboratory maximum level at >2420 CFU/100 mL, or too numerous to count (TNTC).

Quantification of coliform inactivation rates is performed using bench-top studies conducted in native groundwater, or in the field using sequential sampling of inoculated flow-through mesocosms or diffusion samplers. In these experiments, coliform-inoculated samplers are sampled over time so that the declining number of coliform cells can be counted over known time steps, and an inactivation rate is quantified. Coliform inactivation using groundwater samples obtained in monitor wells over time is useful for field verification of experimental results. However, it is difficult to calculate inactivation rates from these data because weekly sampling frequency may not be sufficient to define the inactivation rate curve. Field data collections are still important though because coliform monitoring during cycle testing will ultimately show a condition of zero coliforms at some point during storage. Coliforms generally cannot survive the dark pressurized environment of the upper Floridan Aquifer in the presence of native aquifer microbe communities. Because so few ASR systems have had a robust coliform monitoring program, and because geochemical conditions differ regionally in the upper Floridan Aquifer, coliform inactivation rates and controlling conditions are not yet well-established. Total coliform samples from monitor wells at the Kissimmee River ASR system (also using partially treated surface water during a 6-month recharge) showed coliform levels below 4 CFU/100 mL approximately two months after the initiation of storage (Mirecki et al., 2013). However, the geochemical environment at the upper Floridan Aquifer at the Kissimmee River ASR system differs from that at Peace River ASR system.

Besides total coliforms, other possible indicator tracers of PTSW are described below. Differentiation of the PTSW water from potable water was necessary since the other ten wells in WF2 were recharged with potable water during PTSW cycle testing. The list below identifies those parameters considered as tracers of PTSW along with discussion on their value for this task:

- TDS and Chloride - TDS and chloride are higher in the pre-test groundwater compared to potable water or PTSW. However, the range of TDS and chloride concentrations between the potable water and PTSW are not markedly different enough to be useful. Therefore, changes during CT2 when both PTSW and potable water were recharged could not be differentiated by TDS and chloride concentrations.
- Sulfate – Pre-test groundwater sulfate concentrations are higher than potable water and PTSW. However, the sulfate concentration in potable water (typically 100-150 mg/L during recharge months) is higher than PTSW (between 50-90 mg/L). Sulfate was a good indicator of PTSW arrival as decreases in concentrations were observed at wells where other PTSW indicator parameters (e.g., total coliform) were also observed. Sulfate is also a conservative parameter that should not be appreciably affected by any expected precipitation, adsorption or biological uptake reactions. Since both potable and PTSW sulfate concentrations are lower than native ground water, the observed decreases in sulfate during CT2 may be partially attributed to the influence from potable recharge because potable ASR operations at WF2 coincided with PTSW recharge at S-4 and S-20.
- Total Suspended Solids and Turbidity – Suspended solids and turbidity in pre-test groundwater is very low, with turbidity generally below 1 NTU and suspended solids less than 1 mg/L. Turbidity of the reservoir water is much higher ranging from 5-20 NTUs and suspended solids ranged from 5-25 mg/L. Since turbidity and suspended solids are also very low in potable water, this difference appeared to make turbidity and suspended solids good tracers for the PTSW, however there were some disparities observed. Turbidity and suspended solids increased in wells where other indicator parameters increased; however, turbidity and suspended solids were significantly higher than the reservoir water in some of the wells (e.g., M-12 and M-11). This increase in suspended solids at M-11 and M-12 would suggest very early arrival of the PTSW (the first sample after recharge began) where other indicators (including total coliform) did not indicate the same at these wells. Since suspended solids can be generated in wells from pumping the well (e.g., purging for sampling) TSS was not a conclusive indicator. Yet suspended solids and turbidity quickly returned to background in M-12 and M-11 once PTSW recharge ceased, suggesting that the increased suspended solids and turbidity at these wells had some link to the PTSW recharge activity though not completely understood.
- Color – Color values in surface water are significantly higher than in both potable water and pre-test groundwater making it a good qualitative tracer of PTSW. Color values are analyzed by spectrophotometry and are quantified by comparison to platinum cobalt standards. Color can be reported as true color or apparent color. Analyses reported as apparent color mean that turbidity is not removed from the sample and therefore may contribute to the color of the sample. Color is a good qualitative tracer of PTSW. However, because color is a relative value (not a concentration), use of color as a tracer is qualitative.
- Total Organic Carbon – TOC was found to be a useful tracer of PTSW as it is detected at relatively high concentrations compared to potable water and pre-test groundwater. TOC concentrations in reservoir samples ranged between 10 mg/L and 20 mg/L during recharge events.

Being able to establish whether the decrease in total coliforms observed in the monitor wells after recharge ceased was due to inactivation or movement of PTSW out of the monitoring well area of influence was an important aspect of the water quality evaluation. TOC concentrations served well as a tracer, indicating the arrival of PTSW at the monitor wells. After PTSW arrived at each monitoring well, total coliforms continue to travel with PTSW as long as recharge continues. Static conditions of storage are the most appropriate portion of a cycle test to evaluate declining total coliform values.

4.4 Cycle Test Water Quality – Microbiological Results

Total coliform values measured in ASR and monitoring well samples during CT1 and CT2 are shown in **Figure 4-2 (at the end of this section)**. Also shown is the cumulative volume of PSTW and potable water stored during these cycle tests. Graphical depiction of PTSW total coliforms, PTSW storage volume, and WF2 potable water storage volume data illustrates water-quality changes that occur during each phase of the cycle test. During CT1 recharge, total coliforms were detected at M-14 and ASR well S-19. PTSW water, characterized by high color values (70 PCU) and total organic carbon concentrations (11.5 mg/L) arrived at M-14 within hours of initiation of recharge. Rapid breakthrough of PTSW suggests a hydraulic connection between the monitoring well M-14 and ASR wells S-20 and/or S-4. After recharge ceased, total coliform abundance declined significantly from TNTC (> 2420 CFU/100mL) to 19 CFU/100mL during the two-week storage period. It is likely that the decline in total coliform values probably results from transport through the storage zone combined with coliform inactivation.

CT2 recharge phase was longer (approximately 3.5 months with interruptions), so that total coliforms were detected at several downgradient monitoring wells primarily in the southwestern direction. Monitoring wells M-14, M-12, and M-15 showed the high concentrations of total coliforms, with maximum values at TNTC. Total coliforms also were detected in high concentrations at Suwannee Limestone permeable zone well M-11. Again, the cycle testing data suggested that total coliforms persisted in the aquifer as long as recharge of PTSW continued and declined once recharge ceased.

Figure 4-3 (at the end of this section) shows the concentrations of total coliforms and TOC in monitoring well M-12 and PTSW during CT2. The arrival of PTSW at M-12 was indicated by the simultaneous increase in TOC and total coliforms, which occurs 38 days after recharge commenced. After approximately 55 MG of recharge of PTSW (approximately 6 weeks), concentrations of TOC and total coliforms at M-12 reached the same levels observed at the reservoir, suggesting that 100 percent of the water at monitoring well M-12 consisted of PTSW. This trend was consistent through the remainder of the recharge period. Recharge ceased (at both PTSW and WF2 potable recharge) on October 31, 2017. Total coliform values declined significantly after recharge ceased, reaching non-detect in approximately 3 weeks and remaining below 4 CFU/100 mL through the remainder of storage and recovery phases of CT2.

TOC and total coliform concentrations also declined within a few days after storage is initiated. The geochemical controls on TOC concentrations differ from those of total coliforms. TOC concentrations decreased presumably by either dilution of PTSW by groundwater, or uptake of the carbon by natural processes such as microbe-mediated redox reactions or sorption. Total coliforms are inactivated because these cells cannot survive the aquifer environment. Factors that control total coliform inactivation include aquifer redox environment, groundwater salinity, and the presence of native microorganisms in the upper Floridan aquifer, for example.

The pathogen *Escherichia coli* (E. coli) also was measured during cycle testing. *E. coli* is a coliform bacterium in the environment originating from the intestines of humans and other animals. *E. coli* concentrations from the PTSW were very low with detection (>1 CFU/100 mL) in only 8 of the 28 samples, with the highest concentration recorded at 6 CFU/100 mL (CT2 recharge) *E. coli* concentrations were low and often at below detection (< 4 CFU/100 mL) at the monitor wells where PTSW also was detected. The highest *E. coli* measurement value was 12 CFU/100 mL in M-12 (first sample event in CT2 storage). As observed with total coliform data, once PTSW recharge ceased, *E. coli* values declined significantly in the aquifer.

4.5 Cycle Test Water Quality – Metals and Color Results

Arsenic is naturally present in pyrite minerals in the formation. Pyrite is oxidized by dissolved oxygen in recharge water and has been well documented at the PRF ASR system and other ASR systems in Florida. (Pichler et al., 2011; Mirecki et al., 2013). Dissolved oxygen concentrations measured in recharge water at S-4 and S-20 generally range between 1 mg/L and 3 mg/L. Although these concentrations are below saturation, they are still sufficient to induce pyrite oxidation and arsenic mobilization during cycle testing. Arsenic was monitored during the pilot tests to evaluate any changes that result from recharge of PTSW. **Figure 4-4** (at the end of this section) shows arsenic concentrations in ASR and monitoring wells from the PTSW cycle tests. Arsenic was detected in most M-series wells but were highest at M-11, M-12, M-14, M15, and M-16. However, not all of these increases may be necessarily attributed to PTSW cycle testing. WF2 potable water storage volumes had been increasing each year since 2013. Arsenic detections had already begun to increase at M-15, M-18, M-19 before PTSW testing and was believed to be the result of the expanding underground bubble of stored potable water. A more detailed discussion of geochemical controls on iron and arsenic is presented in **Appendix E** and graphs of historic arsenic data at each of the M-series wells associated with WF2 is updated through 2017 and presented in **Appendix F.**

Elevated arsenic concentrations were observed at M-11, M-12, and M-16 starting in 2017, which suggests a possible relationship to PTSW testing. However, PTSW potable water recovery from WF2 between PTSW CT1 and CT2 was the highest potable water recovery volume observed since all potable water was recovered from the WF2 aquifer system in 2006 and 2008. Moreover, PTSW CT2 coincided with the potable water storage reaching the highest volumes at WF2 since operations began. The large volume recovery event and largest storage volume may be a contributing factor to the cause of the higher arsenic concentrations observed at the monitor wells. Arrival of PTSW was observed at M-11 and M-12, but not at M-16 yet arsenic responses during CT2 storage and subsequent recovery is similar to M-11 and M-12, suggesting that the increases may be related to the increase in WF2 storage volume.

Overall, arsenic concentrations have remained relatively low at the monitoring wells; however, M-11, M-12, M-14, M-15, and M-16 exceeded 10 µg/L. Of these, only M-15 is a compliance well listed in the current water quality criteria exemption (WQCE) issued to the Authority for arsenic. Arsenic concentrations at M-15 are relatively low, with the highest concentration recorded at 21 µg/L after CT2 recovery as the wellfield has been in storage mode (**Figure 4-4**). Increased monitoring at this well has begun (twice per week) until arsenic concentrations are consistently under 10 µg/L, at which point weekly sampling at this well will resume. Arsenic concentrations at M-15 have shown a stable trend around 16 µg/L from February 2018 through March 2018.

Dissolved arsenic and phosphorus often behave similarly when considering the types of reactions between water and minerals. Arsenic is just below phosphorus on the periodic table of elements, so aqueous speciation and reactions are quite similar. Phosphorus would originate from two sources: 1) from PTSW during recharge; and/or 2) release of sorbed phosphorus if iron oxide solids become unstable and dissolve under reducing conditions. It is likely that both sources contribute to phosphorus in the aquifer during CT2. Total phosphorus concentrations measured in reservoir samples were 0.251 mg/L and 0.155 mg/L, similar to the range of concentrations measured in proximal monitor well samples during recharge. Total phosphorus concentrations vary during storage, possibly reflecting increases that result from iron oxide dissolution and release of sorbed phosphorus. However, unlike arsenic, total phosphorus concentrations decline during late storage and recovery. Because iron oxide solids are stable in the aquifer during these phases of cycle test 2, it is possible that arsenic and phosphorus compete for binding sites on iron oxide solids. Because phosphorus concentrations are significantly greater, phosphorus could become sorbed preferentially compared to arsenic.

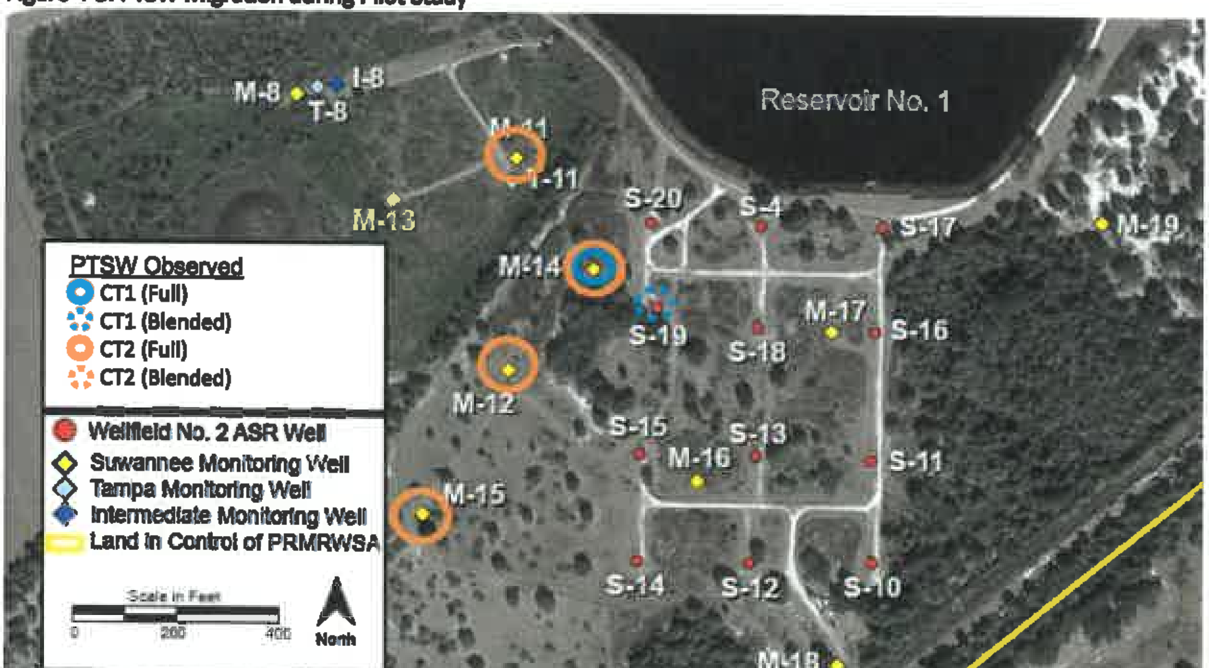
Secondary drinking water standards of interest include color and aluminum, both of which are above their respective standard in the PTSW. Both color and aluminum naturally attenuate at the monitor wells during storage as observed during CT2. Graphs of color and aluminum data collected during PTSW cycle testing are provided in **Appendix D**.

4.6 Cycle Test Results – Water Movement

Analysis of the water quality data provided some insight to the directional flow paths at WF2. **Figure 4-5** shows a map of the monitoring wells that observed full or blended PTSW arrival during CT1 recharge and CT2 recharge. Arrival of PTSW during CT1 was observed at M-14 within hours of initiating recharge suggesting a direct conduit system to this well from S-20 and/or S-4. Some PTSW arrival was noted at S-19; however only a small percentage of PTSW was observed based on the TOC and total coliform concentrations. During CT1 only PTSW was recharged, using S-4 and S-20. A total of 59 MG was recharged and the other WF2 wells were not in operation.

During CT2 a larger volume of PTSW was recharged compared to CT1, totaling 178 MG. During this cycle, arrival of PTSW was first seen at M-14, followed by M-12, M-15, and M-11, each exhibiting TOC and total coliform concentrations that suggest 100-percent of PTSW at the monitor well. The exact time of arrival at M-15 was uncertain since sampling for PTSW parameters at this well did not begin until it was observed that PTSW had arrived at M-12, the next closest monitor well in the direction of M-15. The relatively fast arrival of PTSW at M-12 and M-15, and the fact that other wells at an equidistance (e.g., M-13) from S-20 and S-4 did not show indications of PTSW, suggests a preferential flow path from S-4 and S-20 in the direction of M-14, M-12, and M-15. This directional flow may have been influenced by potable recharge activities that occurred simultaneously at the other WF2 ASR wells during PTSW recharge, which may have prevented movement of PTSW to the east or southeast directions. Mixing of potable water with PTSW would have been expected at M-12 and M-15, yet despite the 4:1 volume of potable to PTSW recharged during CT2, the monitor wells exhibited water quality suggesting 100-percent PTSW. This may have been a result of the higher flow rate at S-20 (**Figure 3-4 above**) compared to the other wells. The average flow rate at S-20 was 1.4 MGD compared to 0.5 MGD to 0.75 MGD at the other WF2 wells. This disparity in the flow rate may have contributed to the dominate flow of PTSW along a conduit system (i.e., fractures or solution channels within the aquifer) that potentially exist in the direction of M-14, M-12, and M-15.

Figure 4-5. PTSW Migration during Pilot Study



4.7 Summary Water Quality Data

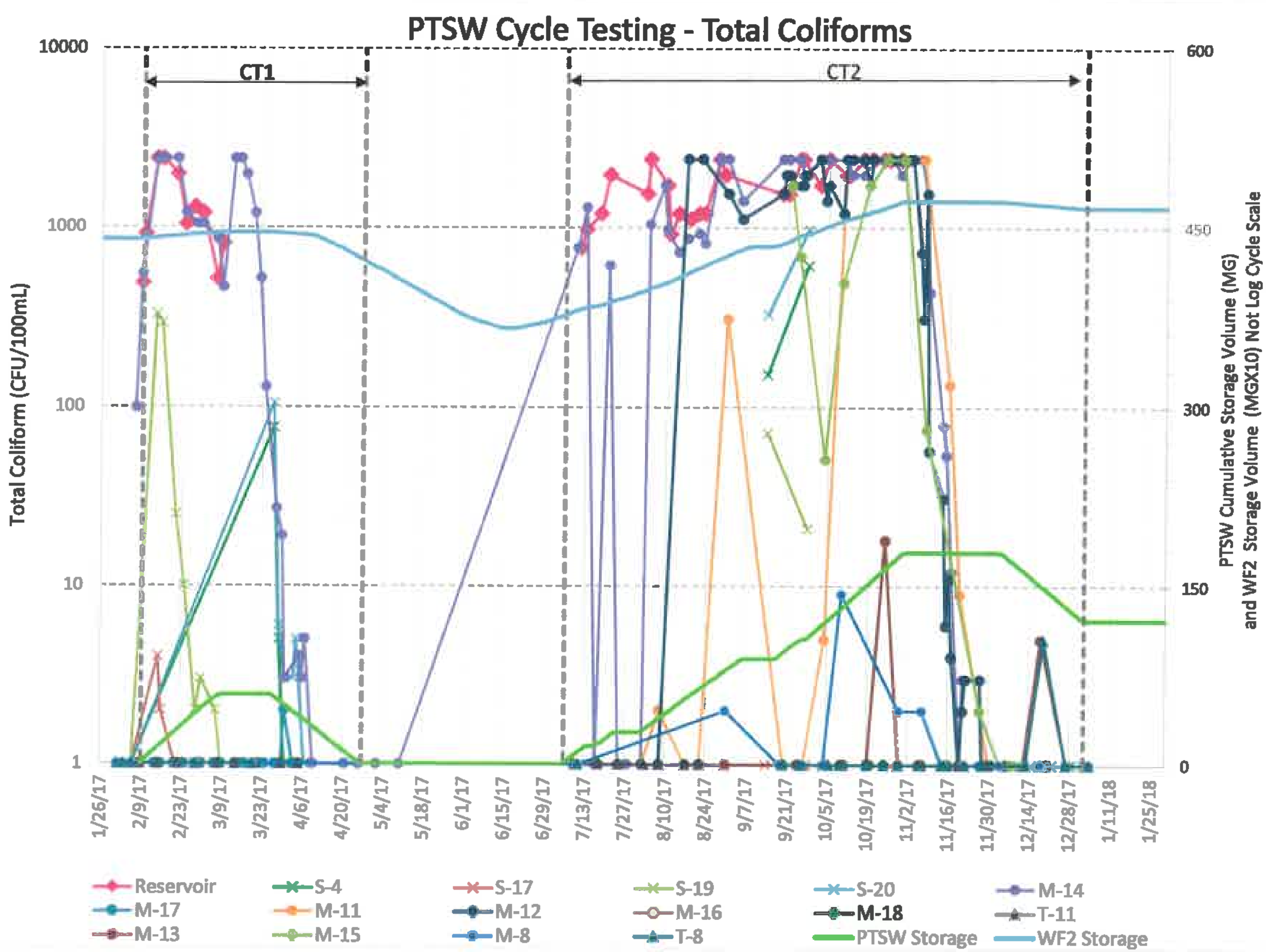
The primary objective of the water quality sampling plan for the PTSW pilot test was to demonstrate arrival of PTSW at the monitoring wells, to provide an estimation of total coliforms inactivation in the aquifer, and to evaluate whether any other water quality concerns arose from the use of PTSW for ASR. A total of ten Suwannee Limestone monitor wells and four Hawthorn Aquifer System monitor wells are within and around WF2. During PTSW cycle testing, sampling was conducted on a weekly schedule at select wells and included an expanded list of parameters beyond the parameters required in the operation permit. The expanded list of parameters included constituents that were important in the monitoring of PTSW and included total: coliforms, color, and TOC along with other constituents.

During CT1, arrival of PTSW was observed at M-14 within hours of beginning recharge at S-4 and S-20, suggesting existence of a fracture feature promoting flow between the injection site(s) and the monitoring well. Approximately 59 MG was recharged during CT1 and no significant indication of PTSW arrival was noted at any of the other monitor wells. However, minor influence was observed at neighboring ASR well S-19. During CT2 PTSW indicators such as TOC and total coliform were observed at M-11, M-12, M-14 and M-15 at levels suggesting that the monitor wells were influenced with 100 percent of PTSW. After M-14, arrival of PTSW was observed at M-12 after approximately 55 MG of PTSW recharge, or approximately 6 weeks. Arrival was observed at M-15 followed by M-11, suggesting a dominant flow path of PTSW in the southwest direction from S-20.

Total coliforms were observed at S-19 at concentrations greater than 300 CFU/100 mL and at M-14 in concentrations TNTC during recharge of CT1. Total coliforms were observed at the monitor wells M-11, M-12, M-14, and M-15 in concentrations TNTC during recharge of CT2. A decline in total coliform was observed during both CT1 and CT2 after recharge of PTSW ceased. The decline of total coliform values to below 4 CFU/100 mL occurred between 3 weeks and 4 weeks after cessation of recharge.

Arsenic concentrations increased in some of the monitor wells including M-15, a compliance well listed in the WQCE. Arsenic concentration increases occurred as a result of recharge of potable water and PTSW. Arsenic concentrations increased near the end of CT2, however, potable water recharge was transpiring at the same time. Along with the large recovery event, storage volumes at WF2 had reached the highest volumes on record coinciding with the end of PTSW recharge, making it difficult to determine if the increases in arsenic were from PTSW or just the continuation of potable water ASR operations. Regardless, concentrations observed at M-15 were relatively low and have shown a stabilizing trend and are not increasing.

Phosphorus attenuation occurred during CT2. Monitor well concentrations decreased from approximately 0.2 mg/L during recharge, to below the minimum detection limit (0.008 mg/L) during late storage and recovery. It is possible that phosphorus and arsenic compete for sorption sites on iron oxide solids in the aquifer. Phosphorus appears at significantly higher concentrations, so it sorbs preferentially compared to arsenic.



PTSW Cycle Testing - Total Coliforms
CT1
CT2
Total Coliform (CFU/100mL)
10000
1000
100
10
1
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10) Not Log Cycle Scale
600
450
300
150
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

FIGURE 4-2

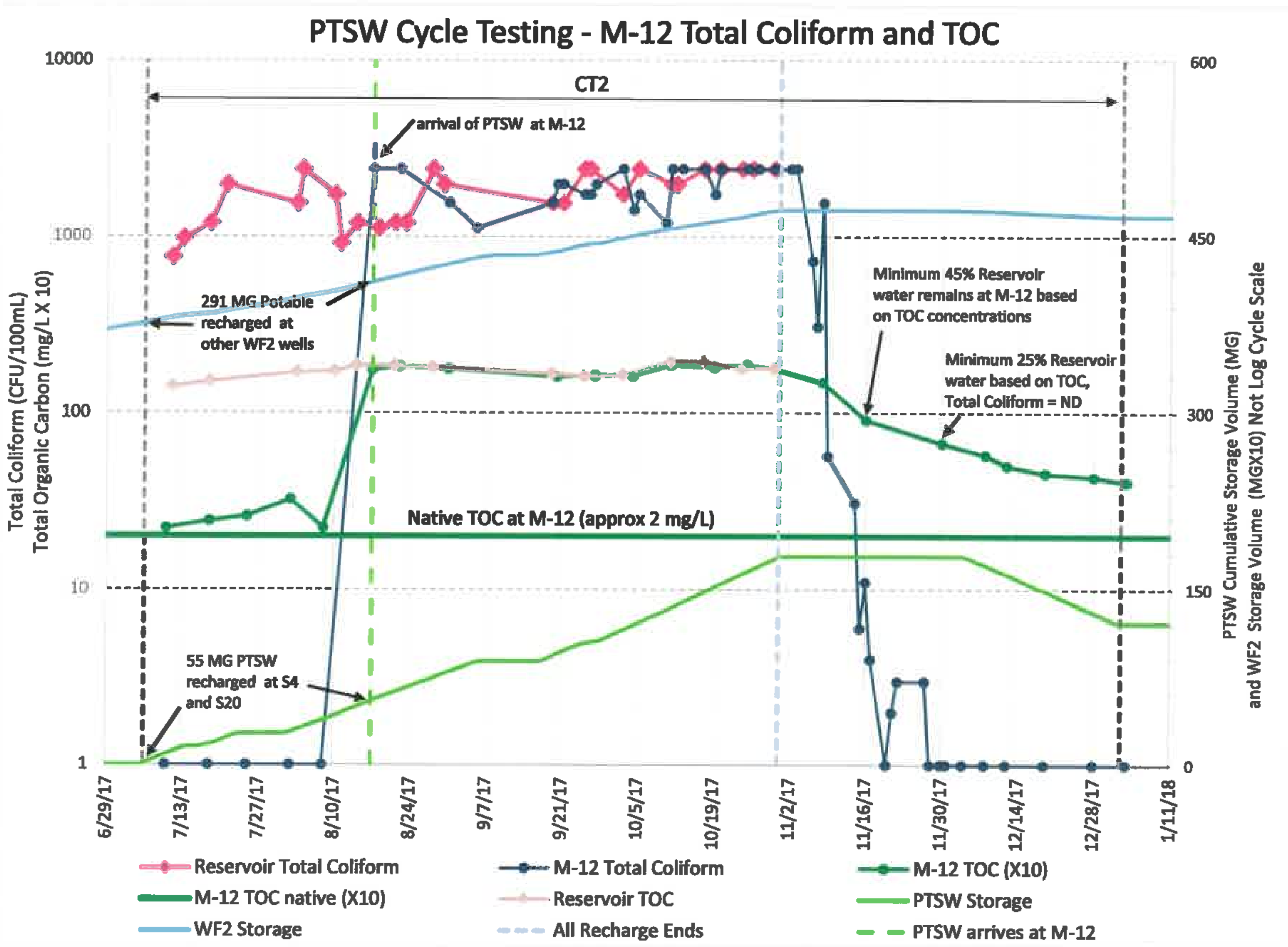

PTSW Cycle Testing - M-12 Total Coliform and TOC
CT2
arrival of PTSW at M-12
291 MG Potable recharged at other WF2 wells
Minimum 45% Reservoir water remains at M-12 based on TOC concentrations
Minimum 25% Reservoir water based on TOC, Total Coliform = ND
Native TOC at M-12 (approx 2 mg/L)
55 MG PTSW recharged at S4 and S20
Total Coliform (CFU/100mL)
Total Organic Carbon (mg/L X 10)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10) Not Log Cycle Scale
10000
1000
100
10
1
600
450
300
150
0
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
Reservoir Total Coliform
M-12 Total Coliform
M-12 TOC (X10)
M-12 TOC native (X10)
Reservoir TOC
PTSW Storage
WF2 Storage
All Recharge Ends
PTSW arrives at M-12

FIGURE 4-3

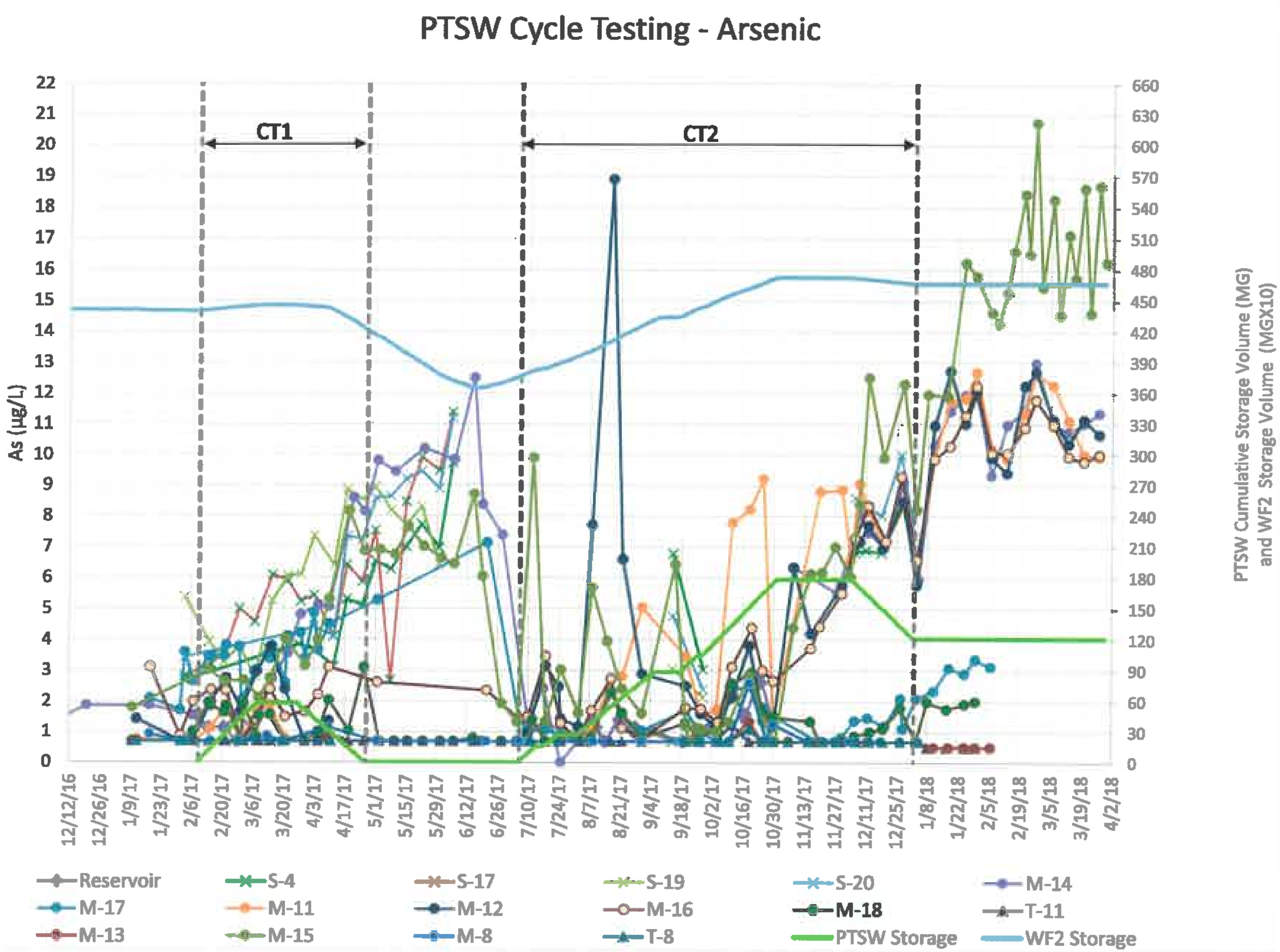

PTSW Cycle Testing - Arsenic
As (µg/L)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
CT1
CT2
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
0 30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480 510 540 570 600 630 660
12/12/16 12/26/16 1/9/17 1/23/17 2/6/17 2/20/17 3/6/17 3/20/17 4/3/17 4/17/17 5/1/17 5/15/17 5/29/17 6/12/17 6/26/17 7/10/17 7/24/17 8/7/17 8/21/17 9/4/17 9/18/17 10/2/17 10/16/17 10/30/17 11/13/17 11/27/17 12/11/17 12/25/17 1/8/18 1/22/18 2/5/18 2/19/18 3/5/18 3/19/18 4/2/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

FIGURE 4-4

SECTION 5

Conceptual Design and Operation Considerations for Full-Scale Implementation

Full-scale PTSW ASR system implementation would conceptually recharge water directly from the Authority's Reservoir No. 1 to WF2, and in the future possibly WF1. The PTSW pump station would be nominally sized for 20 million gallons per day (mgd). This capacity would provide at least 1 mgd to each of WF2's 12 existing wells and provide room for future expansion of the wellfield. The new pump station would be constructed near the existing Reservoir Pump Station to take advantage of the concentration of critical piping and electrical feeds in this area. This PTSW pumping component could be incorporated into a new, larger reservoir water pump station complex serving to supplement or backup the existing 40-year-old pump station building and wet well system that conveys stored surface water to the Peace River Facility. The new pumps should use variable frequency drives (VFDs) for efficiency and would allow the pump station to run over a much wider operational band to efficiently serve double duty: up to 70 psi for feeding PTSW and 30 psi when feeding the treatment plant.

At the intake of the new pump station, a screen system with approximately 1/8" openings would be constructed. To discourage migration of aquatic organisms or debris into the pump intake, the screening system would be equipped with airburst cleaning. To reduce the amount of coliform and algae in the intake flow stream, the screening system should be installed in the middle depth of the reservoir and could also have slide rails to pull it out of the water for maintenance. Observations from the PTSW pilot study indicated that a screen opening of 1/8" would be beneficial to help protect the wells in the short term in the event that a secondary finer screening system should be offline.

Downstream of the pumps, an automatic backwashing sand strainer system with bypass option could be installed on the piping system to WF2 to remove large solids and TSS to minimize the potential for well plugging. An aerial diagram of this pump station utilizing a pressurized strainer system downstream of the pump station is shown in **Figure 5-1**. The strainer assembly would need to be sized to consider the flow rate and frequency of backwashing. Water to be used for backwashing the strainers could come from a new tank that stores a specified amount of PTSW. The filter backwash would be conveyed back to the reservoir downstream of the pump station in the reservoir's current flow path, or the backwash could be diverted to a settling pond, and the decant from the pond could be placed downstream of the pump station in the reservoir's current flow path.

PTSW would be conveyed to WF2 via the existing 36" dedicated pipeline which currently serves the wellfield. This line is cleared as a potable water line now and originates at the PRF, but the portion of the pipe which would no longer be used could be capped and abandoned in place and possibly to be repurposed at some point. Alternatively, a double check valve assembly could be installed for backflow prevention on the unused portion of the pipe so that potable water could still recharge all of WF2. If there is a need to supply potable water to some of the WF2 wells, a new metered interconnect could be installed from any of the three large regional potable water transmission mains which run along the RV Griffin Reserve southerly boundary and approach within about 100 yards of WF2 – these pipelines all carry water typically in excess of 70 psi service pressure.

This pump station would conceptually be remotely operated and controlled by integrating it with the existing supervisory control and data acquisition (SCADA) system at the PRF along with the existing Reservoir Pump Station. Wet well level controls will be in place to ensure that the new pumps do not cavitate and that the reservoir is not drawn down below the minimum operating level. Conceptually, four (4) duty pumps would be operated in parallel with one standby pump for redundancy. For recovery, the ASR wells would essentially be operated as they are now, recovering water back to the off-stream reservoir system.

As stated in the *Partially Treated Surface Water ASR Desktop Study* (CH2M and ASRus, March 2016), full conversion of WF2 to a PTSW ASR system is estimated at approximately $7.5M assuming construction of a 20 mgd PTSW Pump Station. Considering the capital cost of a new pump station, debt service on a loan for this construction, new pump station maintenance costs, and reduced ASR operational costs, estimated direct savings of PTSW ASR is approximately $334,000 per year. This direct savings assumes an annual recharge of 1.2 billion gallons (BG) with a recovery efficiency of 0.8, a loan period of 20 years, and an annual interest rate of 3 percent.

In addition to the new PTSW Pump Station, wellfield-specific improvements may need to be made depending on permit requirements, comprehensive design, and initial findings of full-scale operation of PTSW ASR. These ideas and the associated conceptual cost estimated are discussed in Section 6.

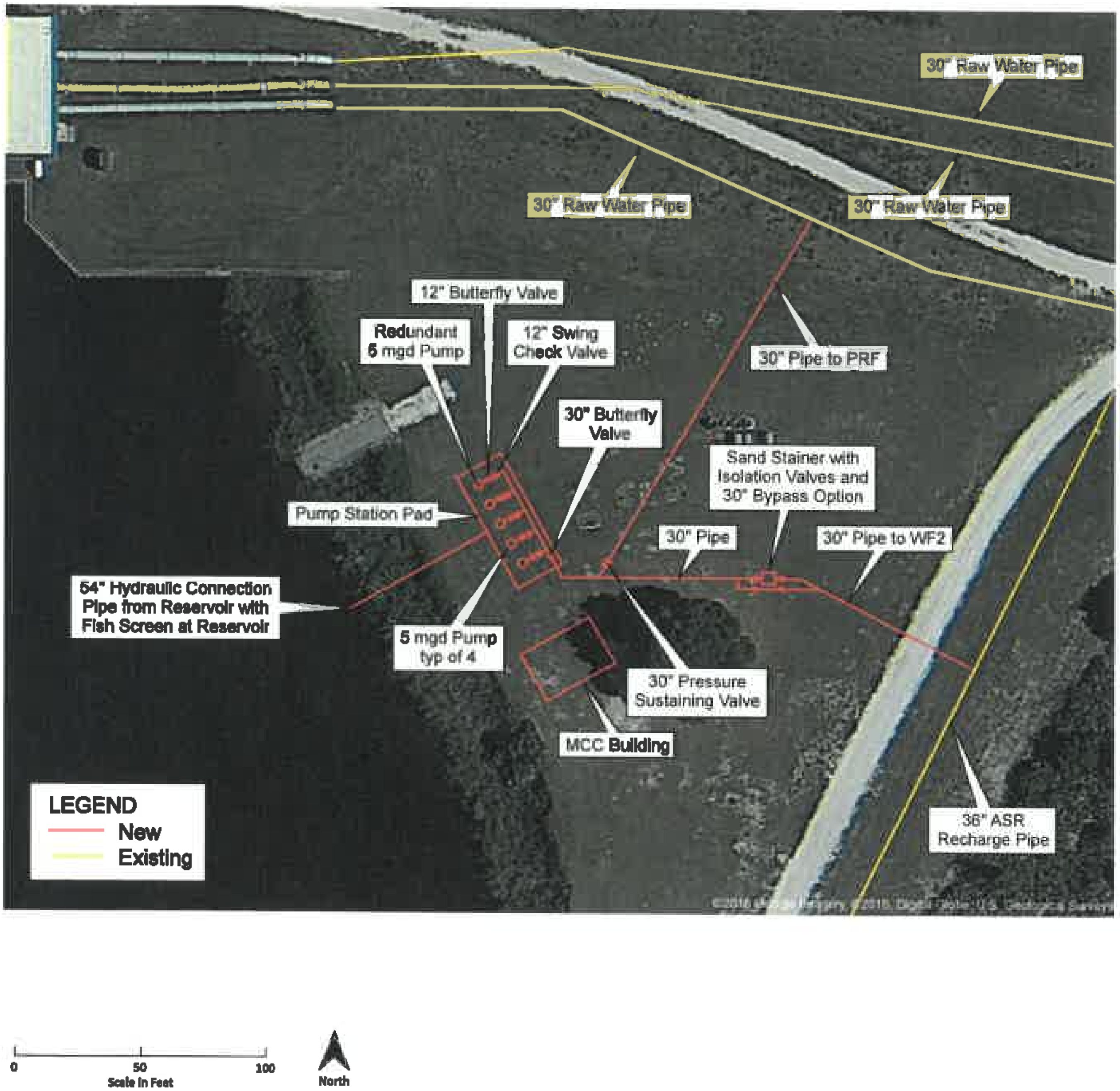


FIGURE 5-1
Pump Station Concept to Supply Water from Reservoir No. 1
Peace River Partially Treated Surface Water ASR Pilot Test - Cycle Test Report

SECTION 6

Summary and Recommendations

This section presents a summary of the PTSW pilot testing and recommendations for future implementation of PTSW ASR at the PRF.

6.1 Pilot Cycle Test Summary

Pilot testing of PTSW included two cycle tests conducted between February 2017 and January 2018, using two wells in WF2, S-4 and S-20. During CT1 a total of 59 MG of PTSW was recharged. Following a two-week storage period, all of the PTSW was recovered. CT2 consisted of 178 MG of recharge, a one-month storage period, and recovery of 57 MG from S-4 and S-20. Recharge capacity of the wells was not significantly impacted by injection of PTSW, and recovery efforts helped restore lost capacity. The intake screen was valuable for keeping large aquatic organisms out of the pump, helping protect the temporary PTSW system in place and avoid particulates large enough to contribute to well plugging concerns. The filtration system seemed effective at removing clumps of algae floating in the reservoir. Changing of the filter bags on a routine basis was necessary as they became blinded within approximately 2-3 days. Near the end of the CT2 recharge, the mesh filter bags were left out leaving only filtration through a stainless steel basket with 1/8" openings. This coarser filtration appeared to have some short-term impact on S-4, but the well capacity was able to be restored through intermittent short-term well development as well as a sufficient recovery period.

Arrival of PTSW was observed at select monitor wells primarily in the southwest direction indicating a preferential flow path. At monitor wells M-14, M-11, M-12, and M-15 water quality analysis suggested 100-percent of PTSW arrival at these wells during CT2. Total coliform was present at high concentrations, however, once recharge of PTSW ceased, total coliform inactivation was observed with total coliform counts reaching less than 4 CFU/100 mL after approximately 3 to 4 weeks. Arsenic concentration increased at some of the monitor wells including M-15, near the end of CT2 recharge. It was uncertain however, if these increases were a result of PTSW or the increase in WF2 overall storage volumes.

6.2 Recommendations

For full-scale PTSW implementation, a ZOD or other regulatory relief mechanism will be needed to allow exceedances of some drinking water standards to naturally attenuate before leaving property under the control of the Authority.

Implementation of PTSW appears to be feasible after the PTSW pilot study, however, there may be long-term issues of concern which are not immediately apparent. Should the Authority choose to implement PTSW as a source water for WF2, the following are some mitigation strategies for consideration if water quality standards are not met at compliance wells:

- Stop recharge at ASR wells that are closer to the monitoring wells with exceedances.
- Add additional monitor wells within the PTSW flow path on Authority controlled land (e.g. to the West-Southwest of WF2). The budgetary cost for a 6" Suwannee Zone monitoring well is approximately $450k with an anticipated accuracy range of -30% to +50%. This includes costs associated with well and wellhead assembly permitting, design, bidding, consultant services during construction, contractor construction, and completion report.

- Expand the ASR Wellfield to the west and discontinue or minimize use of ASR wells closer to property boundaries. The budgetary cost for a 20" Suwannee Zone ASR well is approximately $1.6M with an anticipated accuracy range of -30% to +50%. This includes costs associated with well and wellhead assembly permitting, design, bidding, consultant services during construction, contractor construction, and completion report. This cost does not consider the piping required to feed the ASR well from the existing WF2 piping. The cost for abandonment of an existing ASR well, if warranted, is assumed to be $100k with an accuracy range of -30% to +50%. However, depending on their location, it is worth noting that some older ASR wells might be suitably converted to useful monitoring wells.
- Purchase or lease the parcel between WF2 and King's Highway (east of M-18) and add a new property boundary Suwannee Zone Monitoring Well.
- Implement an Ordinance for Institutional Control under a conservative estimate of the PTSW storage bubble.
- Add in-line disinfection to the PTSW conveyance system to preemptively treat coliform and algae as needed. The budgetary cost for an in-line disinfection system is approximately $400k with an anticipated accuracy range of -30% to +50%. This cost includes costs associated with permitting, design, bidding, consultant services during construction, and contractor construction for a bulk chlorine storage tank, chemical feed pumping and metering system, containment pad, and chemical piping.
- If additional pilot testing using PTSW is initiated, parameters for better characterization of aquifer redox environment during cycle testing should be collected, in addition to those constituents required by permit.
- A longer storage period (more than one month) would be helpful to characterize equilibrated geochemical conditions in the aquifer.

6.2.1 Long Term Operational Considerations

After PTSW full-scale startup and success with the implementation of any listed mitigation strategies listed above, as needed, the Authority should consider the following items to capitalize on the benefits of using PTSW as source water in lieu of potable water:

1. WF1 conversion

Adding PTSW as a source water to WF1 would be of minimal additional cost. It is assumed that the new PTSW Pump Station could recharge WF1 through the 36" ASR Recharge Pipe shown in Figure 5-1. Recovery of water from WF1 wells can be performed in the same manner as currently recovered. This assumption does not include consideration of additional flow beyond 20 mgd to supply these wells. Should WF1 be considered to add PTSW as a source water, it is possible that T-1 would need to either remain a potable water ASR well, be abandoned, or be repurposed as a monitor well. Although the Nocatee member has demonstrated good confinement between the Suwannee Limestone aquifer system (which is the production zone for all other ASR wells) and the Tampa Member (which is the production zone for T-1), the Tampa Member is within the Intermediate Aquifer which is a shallower, fresher aquifer, and, therefore, has greater potential for competing use.

2. SWFWMD consideration for groundwater credits

Recharging an excess amount of PTSW could help benefit the Southwest Water Management District's (SWFWMD's) Southern Water Use Caution Area Recovery Plan. Recharging an excess amount of PTSW could increase the piezometric head in the Upper Floridan Aquifer over a wide surface area, which has regional net positive benefit implications. As such, the Authority could pursue groundwater credits (net positive benefits) for groundwater withdrawals elsewhere of a smaller portion of water than is recharged.

3. Avon Park aquifer recharge

Another consideration to improve reliability particularly at WF2 is inclusion of a vertically layered aquifer recharge concept. Due to the close spacing of wells in WF2, they can exhibit significant upconing (movement of more saline water from below the ASR storage zone) during pumping events. Installing a PTSW aquifer recharge well in the permeable zone below the ASR zone (Avon Park high permeability zone) would displace the brackish native water and provide a protective fresh water barrier beneath the wellfield. This is expected to reduce the increases in salinity observed during recovery and allow for a greater recovery efficiency from the wells. Aquifer recharge may be considered an alternative water supply benefit by maintaining water levels in the Upper Floridan aquifer which is heavily utilized by agriculture in the region. This concept may qualify for SWFWMD funding and could provide the Authority with groundwater withdrawal credits based on a percentage of the water invested as a regional benefit.

Figure 6-1 shows a diagram of a conceptual recharge well along with a typical WF2 ASR well. The well would be similar to the existing Avon Park well at the PRF, however, to provide maximum effectiveness a new well would be located within WF2. The budgetary cost for a 24" Avon Park Recharge Well is approximately $2.1M with an anticipated accuracy range of -30% to +50%. This includes costs associated with permitting, design, bidding, consultant services during construction, contractor construction, and completion report of an Avon Park well and associated ASR wellhead assembly. This cost does not consider the piping required to feed the Recharge Well from the existing WF2 piping; however, it is assumed to be minimal since the well could potentially be recharged with the same PTSW infrastructure that would serve WF2.

6.2.2 Full Scale Facility Improvements

The recommended full-scale facility improvements include:

- A new pump station that will convey at least 20 mgd of PTSW from Reservoir No. 1 to WF2. This will provide at least 1 mgd to each of WF2's 12 existing wells and provide room for future expansion of the wellfield.
- The pump station will also serve as a supplement or backup to the existing raw water pump station serving the treatment facilities.
- The new pump station will be constructed adjacent (within 100 yards) to the existing Reservoir Pump Station.
- An intake screen with 1/8" openings will be installed at the intake of the pump station with airburst cleaning.
- An automatic backwashing sand strainer assembly with bypass option could be installed on the downstream end of the pump station on the leg of pipe which feeds WF2 to remove large solids and TSS to minimize the potential for well plugging. Otherwise, a secondary passive screen upstream of the pumps with 100-micron screening could serve the same purpose.
- The sand strainer backwash will be piped back to Reservoir No. 1 with considerations to minimize immediate recycle of the backwash material to the pump station.
- PTSW will be conveyed by the new pump station to WF2 via tying into the existing 36" dedicated pipeline which currently serves the wellfield.
- This new pump station will also tie into the existing piping system from the existing Reservoir Pump Station to the PRF to provide redundancy for the existing pump station.
- The new pump station will be equipped with four (4) duty pumps and one (1) standby pump operating on VFDs to allow the pump station to run over a wide range of flows.

- The new pump station will be remotely operated and controlled by integrating it with the existing SCADA at the PRF along with the existing Reservoir Pump Station.
- The strainer assembly will have upstream and downstream pressure gauges readable at the PRF for backwashing.

The budgetary cost for this pump station is approximately $7.5M with an anticipated accuracy range of -30% to +50%. This includes costs associated with permitting, design, bidding, consultant services during construction, and contractor construction.

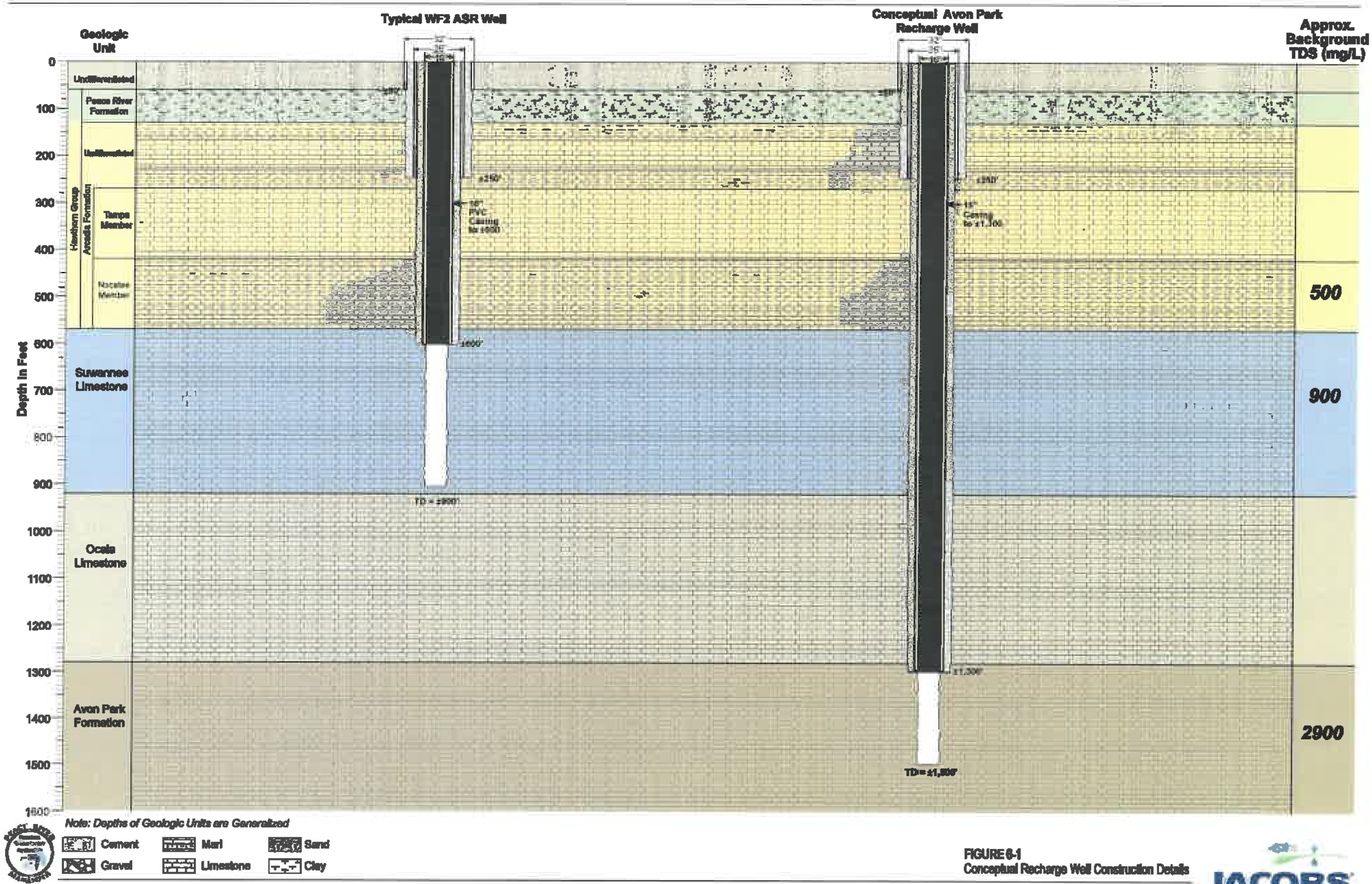


FIGURE 6-1
Conceptual Recharge Well Construction Details

JACOBS

SECTION 7

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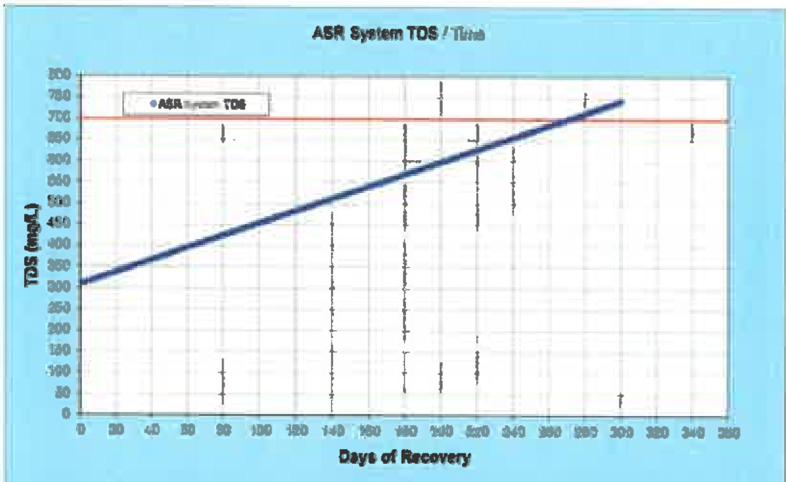
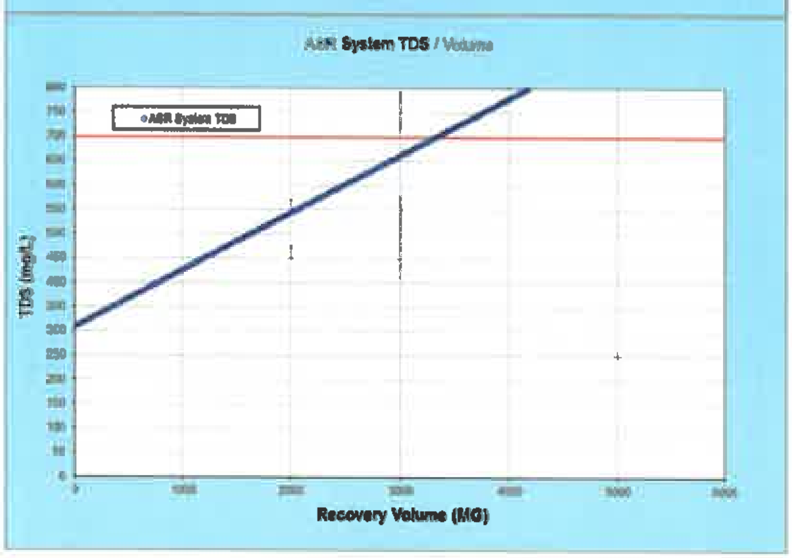
Appendix A
TDS Yield Model Scenario Summary

TDS Yield Model Scenario Runs for Potable Water ASR and PTSW ASR Yield Comparison

The Authority has a Total Dissolved Solids (TDS) Yield prediction model to estimate the volume of water that can be recovered from their ASR Wellfields under normal operating conditions before the TDS concentration of the recovery stream becomes too great for the water being conveyed to the Peace River Facility to be treated to the secondary drinking water standard of 500 mg/L. The Authority has indicated that an ASR System TDS concentration threshold of 700 mg/L is satisfactory to ensure the blended water stream of surface water and ASR water to the Peace River Facility ensures that the TDS secondary drinking water standard (500 mg/L) is met. In 2017, the average TDS concentration of potable water recharge was 278 mg/L. At the end of 2017, Wellfield 1 had a storage balance of 1.4 billion gallons (BG), and Wellfield 2 had a storage balance of 4.7 BG. Using this information and historical data gathered from individual well TDS concentration trends as water is recovered, a recovery volume of 3,321 million gallons (MG) at a TDS concentration of 700 mg/L is predicted. Should this potable water recovery need to occur over the course of a year, the annual average daily flow (AADF) recovery flow rate would be 9.1 million gallons per day (MGD).

Potable Water Yield:

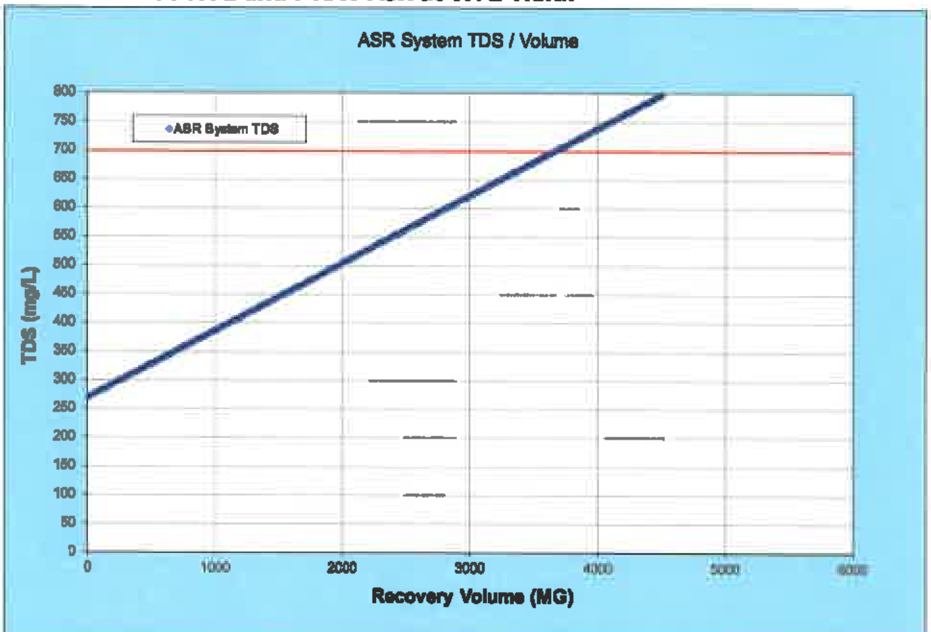


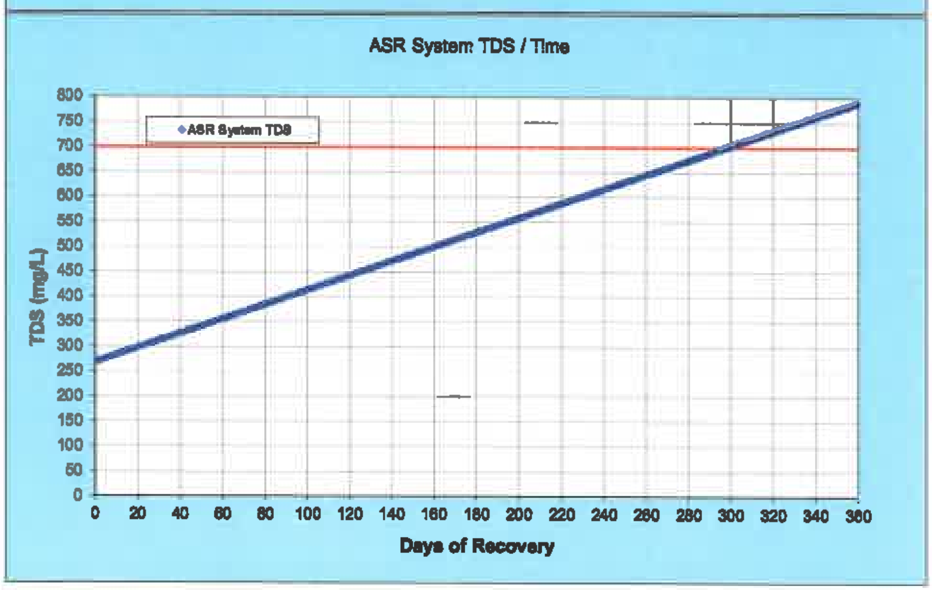


Scenario with Potable ASR at WF1 and PTSW ASR at WF2

As the Peace River surface water is treated through the Peace River facility, about 75 mg/L TDS is added. For comparison, the theoretical potential recovery volume of utilizing potable water at WF1 and PTSW at WF2, the recharge TDS can be lowered in the TDS Yield Model. Assuming a lower recharge TDS concentration of 203 mg/L for surface water, the TDS Yield Model predicts that a volume of 3,653 MG can be recovered. This yield is a 10 percent increase over the yield predicted from the use of only potable water as a source water. This assumes the same ASR wellfield storage volumes and ASR wellfield operation as the above potable water recharge scenario, but this also assumes that all stored potable water in WF2 is converted to PTSW. Because of the lower recharge TDS, an additional 332 MG of potential recoverable water is predicted. Should this PTSW recovery need to occur over the course of a year, the annual average recovery flow rate would be 10.0 MGD. Therefore, up to an additional 0.9 MGD AADF is estimated to be recoverable if PTSW is used as a source water for the Authority's ASR system.

Potable ASR at WF1 and PTSW ASR at WF2 Yield:

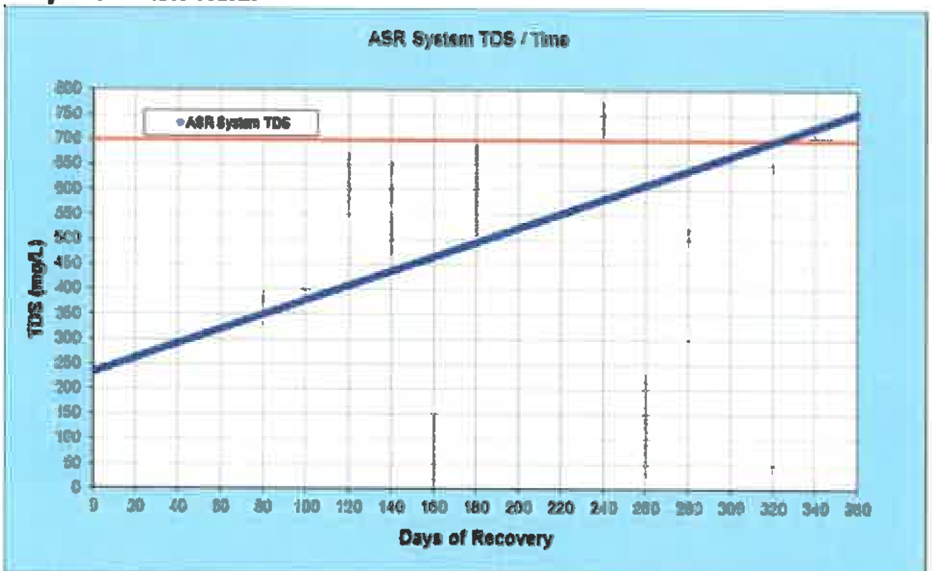


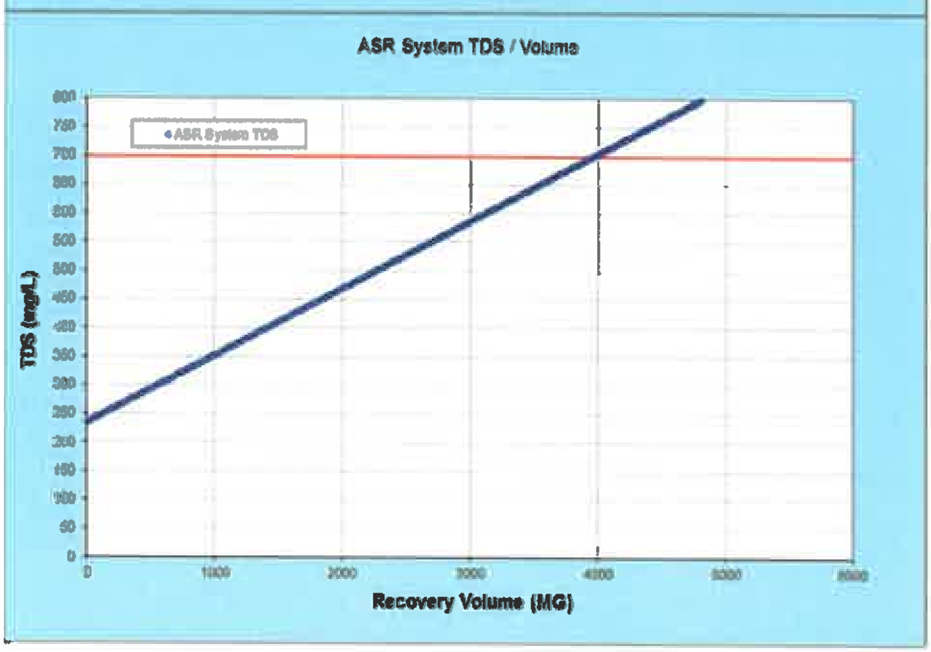


Scenario with PTSW ASR at WF1 and WF2

As the Peace River surface water is treated through the Peace River facility, about 75 mg/L TDS is added. For comparison of theoretical potential recovery volumes of potable water and PTSW, the recharge TDS can be lowered in the TDS Yield Model. Assuming a lower recharge TDS concentration of 203 mg/L for surface water, the TDS Yield Model predicts that a volume of 3,948 MG can be recovered. This yield is a 19 percent increase over the yield predicted from the use of only potable water as a source water. This assumes the same ASR wellfield storage volumes and ASR wellfield operation as the above potable water recharge scenario, but this also assumes that all stored potable water is converted to PTSW. Because of the lower recharge TDS, an additional 627 MG of potential recoverable water is predicted. Should this PTSW recovery need to occur over the course of a year, the annual average recovery flow rate would be 10.8 MGD. Therefore, up to an additional 1.7 MGD AADF is estimated to be recoverable if PTSW is used as a source water for the Authority's ASR system.

Only PTSW ASR Yield:





Appendix B
FDEP Underground Injection Control Permit Modification

Rec via E-MAIL
12-14-2016

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Rick Scott
Governor

Carlos Lopez-Cantera
Lt. Governor

Jonathan P. Steverson
Secretary

SENT VIA ELECTRONIC MAIL

In the Matter of an Application for Permit by:

14 December 2016

Mr. Patrick J. Lehman, P.E., Executive Director
Peace River Regional Water Supply Authority
9415 Town Center Parkway
Lakewood Ranch, FL 34202
PLehman@RegionalWater.org

Desoto County UIC
FDEP File No: 136595-016-017-UO/M5
WACS ID Number: 40593
Class V ASR Injection Well System
Operation Permit

NOTICE OF PERMIT

Enclosed is Permit Number 136595-016-017-UO/M5 to modify a non-hazardous Class V injection well operation permit to allow cycle tests of aquifer storage and recovery (ASR) wells S-4 and S-20 at wellfield No. 2. ASR wells S-4 and S-20 will receive partially treated surface water. Recharge of the remaining nineteen ASR wells with potable water from the Peace River Water Treatment Plant (WTP), 8998 SW County Road 769, Arcadia, DeSoto County will continue at Wellfields No. 1 & 2. ASR wells S-4 and S-20 will be recharged with 2 to 4 million gallons per day each.

Any party to this Order (permit) has the right to seek judicial review of the permit pursuant to Section 120.68, Florida Statutes, by the filing of a Notice of Appeal pursuant to Rules 9.110 and 9.190, Florida Rules of Appellate Procedure, with the Clerk of the Department in the Office of General Counsel, 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida 32399-3000, agency_clerk@dep.state.fl.us; and by filing a copy of the Notice of appeal accompanied by the applicable filing fees with the appropriate District Court of Appeal. The Notice of Appeal must be filed within 30 days from the date this Notice is filed with the Clerk of the Department.

Executed in Leon County, Florida.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL PROTECTION

Joseph Haberfeld

Joseph Haberfeld, P.G.
Environmental Administrator
Aquifer Protection Program
Division of Water Resource Management

PERMITTEE: Mr. Patrick Lehman, Executive Director
Peace River Water Treatment Plant
Class V, ASR Injection Well System

WACS ID No.: 40593
Permit ID No.: 136595-016-017-UO/M5
Date: December 14, 2016

CERTIFICATE OF SERVICE

The undersigned designated clerk hereby certifies that this NOTICE OF PERMIT and all copies were mailed before the close of business on Wednesday, December 14, 2016, to the listed persons.

FILING AND ACKNOWLEDGMENT

FILED, on this date, pursuant to Section.120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged

Mary Genung
Clerk

December 14,2016
Date

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FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Lt. Governor

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Secretary

Underground Injection Control
Class V, Group 7, Aquifer Storage and Recovery (ASR) Well System
Operation Permit Major Modification

December 14, 2016

Permittee:
Peace River Regional Water Supply Authority

Responsible Official:
Mr. Patrick J. Lehman, P.E., Executive Director
9415 Town Center Parkway
Lakewood Ranch, FL 34202
PLehman@RegionalWater.org

Facility:
Peace River Water Treatment Plant
8998 Southwest County Road 769
Arcadia, Florida 34269

Permit/Certification:

Permit Number:	136595-016-017-UO/M5
WACS ID:	40593
Date of Issuance:	December 14, 2016
Date of Expiration:	April 23, 2018
Permit Processor:	Neil I. Campbell

Section/Township/Range S16 / T39S / R23E

Location:

County:	Desoto
Latitude:	27° 05' 06" N
Longitude:	82° 01' 08" W

RE: Major Modification to FDEP Permit 136595-016-017-UO/M5 under 136595-016-017-UO/M5 to allow cycle tests of aquifer storage and recovery (ASR) wells S-4 and S-20 at wellfield No. 2.

This permit is issued under the provisions of Chapter 403, Florida Statutes (F.S.), and the rules adopted thereunder. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the Department and made a part hereof and specifically described as follows.

To modify a non-hazardous Class V injection well operation permit to allow cycle tests of aquifer storage and recovery (ASR) wells S-4 and S-20 at wellfield No. 2. ASR wells S-4 and S-20 will receive partially treated surface water. Recharge of the remaining nineteen ASR wells with potable water from the Peace River Water Treatment Plant (WTP), 8998 SW County Road 769, Arcadia, DeSoto County will continue at Wellfields No. 1 & 2. ASR wells S-4 and S-20 will be recharged with 2 to 4 million gallons per day each.

IN ACCORDANCE WITH: The Application to Modify the current Operating Permit DEP Form No. 62-528.900(1) received, August 16, 2016, response to the Department's request for additional information, received September 8, 2016, and supporting information submitted to this agency.

LOCATION: Peace River Water Treatment Plant, 8998 Southwest County Road 769, Arcadia, Florida 34269, in the county of Desoto.

Based on the information provided to the Department, per the request of the Peace River Regional Water Supply Authority, the Department hereby approves the above major modification to FDEP Permit Number 136595-014-UO/5Q under FDEP Permit Modification Number 136595-016-017-UO/M5. Testing of partially treated surface water (PTSW) as a source water for storage in two of ASR Wellfield No. 2 (WF2) wells, S-20 and S-4, may begin upon receipt of this modification. The permit's operational specific conditions I. through III. are changed as specified below:

Page 3 – Adds the Avon Park Monitor well, AP-1, 12-inch casing set to 1300 feet below land surface (bls), open hole to 1479 feet bls.

Conditions I. Operating Requirements:

A.1 Injection of fluids other than those permitted into the ASR well will constitute a violation of this permit and shall constitute cause for permit revocation and possible enforcement action for water quality violation. Only water from the Peace River Regional Water Supply Facility, a surface water drinking water facility, may be injected, **except that partially treated surface water from Reservoir No. 1 may be injected into ASR wells S-4 and S-20.**

A.7 This ASR facility shall be operated in conformance with the criteria contained in Water Quality Criteria Exemption OGC File 12-1502. **This permit modification removes ASR wells S-4 and S-20 from the Exemption in order to cycle test those wells with partially treated surface water. All other provisions of the Exemption remain unchanged.**

A.8 **NEW: Zone of Discharge**

a. A zone of discharge under Rule 62-520.465(2)(b), F.A.C, is established for this injection project for the parameters of total coliform bacteria, aluminum, and color. The zone of discharge extends to the permittee's property boundary. *[62-520.465(2)(b)]*

b. Compliance with the zone of discharge shall be demonstrated at monitor well M-18; total coliform bacteria, aluminum, and color must be met at this compliance well. If the concentration for any standard in the natural background quality is greater than that which is listed in Rule 62-520.420(1), F.A.C., or in the case of pH is also less than the minimum, the representative natural background quality shall be the prevailing standard. *[62-520.420, 62-520.600]*

c. Should ground water monitoring during operation indicate drinking water parameters are not met at compliance well M-18, the permittee shall, upon the Department's request, submit a report addressing the results of the collected ground water monitoring data. The report shall be submitted to the Department no later than 90 days after the request and shall include a discussion of the changes in water quality for parameters exceeding maximum contaminant levels. The report shall also address the adequacy of the zone of discharge and the steps to be taken to come into compliance. *[62-520.700, 62-528.610(1)]*

Conditions III. Testing and Reporting Requirements

A.3 **NEW:** Cycle testing of ASR-4 and ASR-20 shall be in accordance with the schedule specified below:

Cycle	Recharge Rate (MGD)	Storage Duration (Days)	Recovery Rate (MGD)	Volume in Storage (MG)
1	2-4	15	1.5-2.5	50
2	2-4	15	1.5-2.5	100
3	2-4	15	1.5-2.5	150

Additional or fewer cycles, or changes in the cycle testing details above, may be authorized in writing by the Department.

[62-528.450(3)(a)]

B.5 **NEW:** Table 3 of the permittee's September 8, 2016 response to a Request for Additional Information is incorporated into this permit modification. It contains monitoring and sampling requirements specific to the cycle testing, and is reproduced as an attachment at the end of this modification. *[62-528.307(3)(d) and 528.430(2)]*

B.6 **NEW:** Monitoring well AP-1 shall be sampled semiannually for static pressure or water level, chloride, total dissolved solids, and field pH, specific conductance, and temperature (°C). *[62-528.307(2)(d) and 528.430(2)]*

This document must be attached to your permit and becomes a part of that permit. All conditions of Permit no. 0136595-014-UO/5Q not specifically modified or deleted in this document remain in effect.

Table 3. Proposed Monitoring Plan

Peace River WF2 PTSW ASR Pilot Testing

Parameter	Units	Recording Frequency	Frequency of Analysis			
			Recharge (reservoir)	*Recovery (S-4, S-20)*	*M-11, M-14, M-16, M-17, M-18, T-11*	*M-8, M-13, T-8*
Flow Rate, max.	gpm	daily	D/M	D/M		
Flow Rate, min.	gpm	daily	D/M	D/M		
Flow Rate, avg.	gpm	daily	D/M	D/M		
Total Volume Recharged	Mg	daily	D/M			
Total Volume Recovered	Mg	daily		D/M		
Injection Pressure, max.	Psi	continuous	D/M			
Injection Pressure, min.	Psi	continuous	D/M			
Injection Pressure, avg.	Psi	continuous	D/M			
Water Level, max.	feet (NGVD)	continuous		D/M	D/M	D/M
Water Level, avg.	feet (NGVD)	continuous		D/M	D/M	D/M
Water Level, min.	feet (NGVD)	continuous		D/M	D/M	D/M
pH +	std. Units		W[a]	W[b]	W	M
Specific Conductivity +	µmhos/cm		W[a]	W[b]	W	M
Temperature +	°C		W[a]	W[b]	W	M
Dissolved Oxygen +	mg/L		W[a]	W[b]	W	M
Turbidity +	NTU		W[a]	W[b]	W	M
Oxidation-Reduction Potential +	mV		W[a]	W[b]	W	M
Total Dissolved Solids	mg/L		W[a]	W[b]	W	M
Chloride	mg/L		W[a]	W[b]	W	M
Sulfate	mg/L		W[a]	W[b]	W	M
Arsenic	µg/L		W[a]	W[b]	W	M
Total Suspended Solids	mg/L		W[a]	W[b]	W	M
Nitrate (as N)	mg/L		W[a]	W[b]	W	M
TKN	mg/L		W[a]	W[b]	W	M
Ammonia	mg/L		W[a]	W[b]	W	M
TOC	mg/L		W[a]	W[b]	W	M
Color	Units		W[a]	W[b]	W	M
Aluminum	µg/L		W[a]	W[b]	W	M
Total Coliform	CFU/100 mL		W[a]	W[b]	W	M
Escherichia coli	CFU/100 mL		W[a]	W[b]	W	M
Primary and Secondary stds.	mg/L		B		-	-

Notes:

No sampling of ASR wells during storage

W - weekly; D/M - daily and monthly;

a - during recharge only

b - during recovery only

+ - field samples

B - Background sample prior to cycle 1 recharge

Appendix C
PTSW ASR Pilot Cycle Test Water Quality Graphs

Appendix C-1
Reservoir Water Quality Data (May 2012- May 2016)

Station_ID	Sample Date	Color PCU	Chlorides mg/L	Total Alkalinity mg/l CaCO3	T. Hardness mg/l CaCO3	[illegible] Hardness mg/l CaCO3	Sulfate mg/l	Total Dissolved Solids mg/l	Total Iron ug/l	Total Nitrogen mg/l	Nitrite / Nitrate mg/l	Nitrate mg/l	TKN mg/l	Ammonia mg/l	T Phosphorus mg/l	Ortho Phosphorus mg/l	Copper ug/l	Chlorophyll mg/m^3	[illegible] (1,2,7,7- [illegible])	MIB ng/l (2- [illegible] ol)	Nitrite Nitrogen (mg/L)	Aluminum (ug/L)	Zinc (ug/L)	Thallium (ug/L)	Fluoride (mg/L)	Glyphosate (ug/L)	Endothall (ug/L)
Composite of Reservoir 1 South	05/16/12	57	60	61	178	110	119.0	380	117.0	0.660	0.004 I	0.004 U	0.656	0.008 I	0.151	0.085	70.3	14.20	<2.0	15.0							
Composite of Reservoir 1 South	05/30/12	52	61	58	184	110	107.0	376	80.1 I	0.744	0.050 U	0.050 U	0.740	0.008 U	0.145	0.092	241.0	7.59	<2.0	8.3							
Composite of Reservoir 1 South	06/12/12	54	58	65	188	112	119.0	360	43.4	0.844	0.004 U	0.004 U	0.844	0.067	0.120	0.088	382.0	11.00	<2.0	<2.0	0.003 U						
Composite of Reservoir 1 South	07/12/12						121.0	400	121.00	1.050	0.004 U	0.004 U	1.050	0.008 U	0.360	0.258	27.90	39.300			0.003 U						
Composite of Reservoir 1 South	07/12/12																		<2.0	19.9							
Composite of Reservoir 1 South	07/16/12	90	55	63	172	108																					
Composite of Reservoir 1 South	07/26/12	118	52	61	166	104													<2.0	19.9							
Composite of Reservoir 1 South	07/26/12						119.0	308	184.00	1.170	0.116	0.116	1.090	0.008 U	0.432	0.311	19.50	26.800			0.003 U						
Composite of Reservoir 1 South	08/09/12						94.5	204	184.00	1.180	0.216	0.216	0.966	0.008 U	0.439	0.347	16.90	22.300			0.003 U						
Composite of Reservoir 1 South	08/09/12	128	51	63	160	105													<2.0	27.5							
Composite of Reservoir 1 South	09/12/12																		<2.0	<2.0							
Composite of Reservoir 1 South	09/12/12	121	44	60	145	92																					
Composite of Reservoir 1 South	09/12/12						91.9	260	188.00	1.120	0.123	0.123	1.000	0.072	0.309	0.228	22.60	18.500			0.003 U						
Composite of Reservoir 1 South	10/10/12																		1.1	2.0							
Composite of Reservoir 1 South	10/10/12						74.7	232	188.00	1.220	0.285	0.281	0.951	0.008 U	0.281	0.230	21.70	11.300			0.004 I						
Composite of Reservoir 1 South	11/07/12	134	42	59	137	87																					
Composite of Reservoir 1 South	11/07/12																		<1.0	<1.0							
Composite of Reservoir 1 South	11/07/12						73.9	248	203.00	1.380	0.325	0.325	1.050	0.008 U	0.326	0.230	22.50	22.900			0.003 U						
Composite of Reservoir 1 South	12/05/12																		<1.0	<1.0							
Composite of Reservoir 1 South	12/05/12						80.5	300	141.0	1.290	0.372	0.372	0.916	0.008 U	0.311	0.206	20.7	9.91			0.003 U						
Composite of Reservoir 1 South	12/06/12	115	41	63	140	90																					
Composite of Reservoir 1 South	04/02/13	106	41	63	145	95																					
Composite of Reservoir 1 South	01/02/13																		2.4	<1.0							
Composite of Reservoir 1 South	01/02/13						78.4	244	149.0	1.190	0.380	0.380	0.811	0.016 I	0.315	0.269	15.5 I	12.70			0.003 U						
Composite of Reservoir 1 South	02/12/13																		7.4	2.1							
Composite of Reservoir 1 South	02/12/13	97	46	65	167	93																					
Composite of Reservoir 1 South	02/12/13						87.4	276	136.00	1.160	0.273	0.273	0.882	0.008 U	0.328	0.228	18.50	14.900			0.008 U						
Composite of Reservoir 1 South	02/26/13	85	46	68	157	100																					
Composite of Reservoir 1 South	02/26/13																		10.4	4.0							
Composite of Reservoir 1 South	02/26/13						82.8	312	117.0	1.020	0.103	0.103	0.915	0.008 U	0.258	0.195	18.0	27.00			0.003 U						
Composite of Reservoir 1 South	03/13/13																		8.3	5.3							
Composite of Reservoir 1 South	03/13/13	76	47	70	160	104																					
Composite of Reservoir 1 South	03/13/13						59.9	260	119.0	0.945	0.197	0.155	0.748	0.008 U	0.282	0.205	17.5	11.00			0.004 I						
Composite of Reservoir 1 South	04/16/13																		5.5	4.8							
Composite of Reservoir 1 South	04/16/13	67	49	63	155	98																					
Composite of Reservoir 1 South	04/16/13						97.6	324.00	75.30 I	0.706	0.085 I	0.085 I	0.701	0.008 U	0.205	0.130	13.80 I	17.800			0.003 U						
Composite of Reservoir 1 South	05/23/13	55	51	70	158	108																					
Composite of Reservoir 1 South	05/23/13																		14.4	26.3							
Composite of Reservoir 1 South	05/23/13						61.0	308.00	75.58 I	0.792	0.004 U	0.004 U	0.792	0.008 U	0.163	0.055	12.50 I	6.170			0.003 U						
Composite of Reservoir 1 South	06/19/13																		<1.0	4.6							
Composite of Reservoir 1 South	06/19/13	64	49	59	159	102																					
Composite of Reservoir 1 South	06/19/13						89.9	256	69.9 I	0.904	0.004 U	0.004 U	0.904	0.022 I	0.132	0.088	252.0	18.60			0.003 U						
Composite of Reservoir 1 South	07/18/13																		<1.0	8.7							
Composite of Reservoir 1 South	07/18/13	96	43	54	130	88																					
Composite of Reservoir 1 South	07/18/13						78.2	252	185.0	0.182	0.182	1.070	0.891	0.008 U	0.237	0.182	41.3	12.30			0.003 U						
Composite of Reservoir 1 South	08/21/13																		1.2	10.9							
Composite of Reservoir 1 South	08/21/13	125	39	55	127	83																					
Composite of Reservoir 1 South	08/21/13						68.5	268	185.0	1.220	0.243 V	0.243	0.980	0.008 U	0.391	0.229	77.4	10.60			0.003 U						
Composite of Reservoir 1 South	09/26/13	120	36	52	130	84																					
Composite of Reservoir 1 South	09/26/13																		<1.0	2.3							
Composite of Reservoir 1 South	09/26/13						62.4	224	210.0	1.360	0.302	0.302	1.060	0.008 I	0.287	0.223	26.9	9.25			0.003 U						
Composite of Reservoir 1 South	10/23/13																		1.1	1.4							
Composite of Reservoir 1 South	10/23/13	118	33	55	126	75																					
Composite of Reservoir 1 South	10/23/13						58.9	220	280.0	1.210	0.275	0.275	0.933	0.107	0.313	0.229	20.0	10.70			0.005 U						
Composite of Reservoir 1 South	11/21/13	105	37	59	138	80																					
Composite of Reservoir 1 South	11/21/13																		<1.0	<1.0							
Composite of Reservoir 1 South	11/21/13						60.7	256.00	281.00	1.220	0.282	0.282	0.998	0.008 U	0.414	0.257	26.10	17.100			0.003 U						
Composite of Reservoir 1 South	12/17/13	86	37	64	140	88																					
Composite of Reservoir 1 South	12/17/13																		<1.0	<1.0							
Composite of Reservoir 1 South	12/17/13						68.9	244	176.0	1.190	0.306	0.304	0.881	0.040 I	0.304	0.281	22.1	8.14			0.005 I						
Composite of Reservoir 1 South	01/22/14	79	39	70	155	94																					
Composite of Reservoir 1 South	01/22/14																		1.0	1.2							
Composite of Reservoir 1 South	01/22/14						73.1	264	105.0 I	1.120	0.262	0.249	0.838	0.008 U	0.306	0.297	19.4	7.00			0.013						
Composite of Reservoir 1 South	02/19/14																		2.5	4.8							
Composite of Reservoir 1 South	02/19/14	71	40	68	170	98																					
Composite of Reservoir 1 South	02/19/14						88.6	272	87.9 I	1.160	0.268	0.263	0.836	0.008 U	0.324	0.289	16.9	12.70			0.003 I						
Composite of Reservoir 1 South	03/26/14																		3.0	5.1							
Composite of Reservoir 1 South	03/26/14	68	43	68	172	100																					
Composite of Reservoir 1 South	03/26/14						84.3	256.00	82.30 I	0.952	0.129	0.118	0.823	0.010 I	0.349	0.257	15.60 I	9.370			0.011 I						
Composite of Reservoir 1 South	04/23/14	61	44	72	182	104																					
Composite of Reservoir 1 South	04/23/14																		2.5	4.8							
Composite of Reservoir 1 South	04/23/14						87.4	316.00	77.60 I	0.904	0.021	0.018	0.883	0.024 I	0.283	0.253	13.90 I	10.400			0.003 I	284					
Composite of Reservoir 1 South	04/23/14																						4	<0.001	0.563	<5.4	<4.1
Composite of Reservoir 1 South	05/22/14						96.5	300	65.2 I	4.752	0.004 U	0.004 U	4.752	0.008 U	0.303	0.212	81.1	6.92			0.005 I	290					
Composite of Reservoir 1 South	05/22/14																		2.1	7.2							
Composite of Reservoir 1 South	05/22/14	57	46	73	192	104																					

Appendix C-1

Reservoir Water Quality Data (May 2012- May 2016)

Station_ID	Sample Date	Color PCU	Chlorides mg/L	Total Alkalinity mg/l Ca CO3	T. Hardness mg/l CaCO3	C. Hardness mg/l CaCO3	Sulfate mg/l	Total Dissolved Solids mg/l	Total Iron ug/l	Total Nitrogen mg/l	Nitrite / Nitrate mg/l	Nitrate mg/l	TKN mg/l	Ammonia mg/l	T Phosphorus mg/l	Ortho Phosphorus mg/l	Copper ug/l	Chlorophyll mg/m^3	[illegible] (1,2,7,7- [illegible] norborneol)	MIB ng/l (2- [illegible] ol)	Nitrite Nitrogen (mg/L)	Aluminum (ug/L)	Zinc (ug/L)	Thallium (ug/L)	Fluoride (mg/L)	Glyphosate (ug/L)	Endothall (ug/L)
Composite of Reservoir 1 South	05/29/14																		2.2	4.9							
Composite of Reservoir 1 South	06/02/14																		3.4	4.0							
Composite of Reservoir 1 South	06/09/14																		5.5	2.9							
Composite of Reservoir 1 South	06/16/14																		2.5	9.2							
Composite of Reservoir 1 South	06/18/14																		3.1	16.9							
Composite of Reservoir 1 South	06/18/14						94.4	204	55.3 I	0.721	0.007 I	0.007 I	0.714	0.006 U	0.200	0.194	92.2	6.47			0.005 U	251					
Composite of Reservoir 1 South	06/19/14	51	46	70	180	104																					
Composite of Reservoir 1 South	06/19/14																		1.5	12.8							
Composite of Reservoir 1 South	06/23/14																		<1.0	14.2							
Composite of Reservoir 1 South	07/01/14																		<1.0	11.2							
Composite of Reservoir 1 South	07/07/14																		<1.0	11.7							
Composite of Reservoir 1 South	07/14/14																		<1.0	6.3							
Composite of Reservoir 1 South	07/21/14																		<1.0	7.5							
Composite of Reservoir 1 South	07/24/14																		<1.0	17.3							
Composite of Reservoir 1 South	07/24/14	79	42	70	160	94																					
Composite of Reservoir 1 South	07/24/14						79.4	272.00	107.00 I	0.844	0.007 I	0.004 U	0.837	0.071	0.533	0.159	25.10	14.500			0.005 I	284					
Composite of Reservoir 1 South	07/29/14																		<1.0	24.3							
Composite of Reservoir 1 South	08/04/14																		<1.0	15.3							
Composite of Reservoir 1 South	08/11/14																		1.6	14.7							
Composite of Reservoir 1 South	08/19/14																		4.9	10.4							
Composite of Reservoir 1 South	08/25/14																		9.3	9.9							
Composite of Reservoir 1 South	08/27/14																		8.1	8.8							
Composite of Reservoir 1 South	08/28/14	81	42	64	152	90																					
Composite of Reservoir 1 South	09/04/14																		5.2	7.0							
Composite of Reservoir 1 South	09/23/14						82.8	256 Q	107 I	0.836	0.057	0.057	0.799	0.008 U	0.45	0.215	10.7 I	4.92			0.005 U	224					
Composite of Reservoir 1 South	09/25/14																		3.7	8.3							
Composite of Reservoir 1 South	09/25/14	79	39	63	142	89																					
Composite of Reservoir 1 South	09/25/14						66.3	252	133	0.957	0.076	0.072	0.881	0.008 U	0.373	0.186	16.5	18.6			0.004 I	381					
Composite of Reservoir 1 South	10/29/14	87	37	61	140	83																					
Composite of Reservoir 1 South	10/29/14																	1.3	3.6								
Composite of Reservoir 1 South	10/29/14						67.5	236.00	147.00	1.040	0.069	0.069	0.946	0.008 U	0.355	0.244	15.10 I	19.700			0.003 U	337					
Composite of Reservoir 1 South	11/20/14	93	37	62	148	83																					
Composite of Reservoir 1 South	11/20/14																		1.0	7.2							
Composite of Reservoir 1 South	11/20/14						66.2	224	163	1.15	0.196	0.196	0.953	0.01 I	0.344	0.272	17.7	11			0.003 U	393					
Composite of Reservoir 1 South	01/29/15																		2.8	2.5							
Composite of Reservoir 1 South	04/29/15	81	40	63	153	92																					
Composite of Reservoir 1 South	04/29/15						67.6	232.00	129.00	1.210	0.240	0.240	0.965	0.011 I	0.348	0.271	17.30	11.900			0.003 U	279					
Composite of Reservoir 1 South	02/25/15	86	39	63	154	87																					
Composite of Reservoir 1 South	02/25/15																		9.7	2.3							
Composite of Reservoir 1 South	02/25/15						69.8	256	116	1.03	0.122	0.122	0.904	0.03 I	0.281	0.228	17.2	17.8			0.003 U	279					
Composite of Reservoir 1 South	03/26/15	74	38	62	147	90																					
Composite of Reservoir 1 South	03/26/15																		6.8	8.4							
Composite of Reservoir 1 South	03/26/15						68.6	236	106 I	0.975	0.055	0.045	0.92	0.008 U	0.32	0.204	13.7 I	17.1			0.01 I	266					
Composite of Reservoir 1 South	04/21/15																		10.7	11.3							
Composite of Reservoir 1 South	04/22/15	68	44	68	170	90																					
Composite of Reservoir 1 South	04/21/15						70.4	236	120	1.06	0.025	0.021	1.04	0.011 I	0.264	0.208	13.7 I	21.8			0.004 I	267					
Composite of Reservoir 1 South	06/22/15	50	46	64	156	100																					
Composite of Reservoir 1 South	06/22/15																		1.6	27.7							
Composite of Reservoir 1 South	07/21/15																		3.9	12.1							
Composite of Reservoir 1 South	07/21/15	54	41	62	158	89																					
Composite of Reservoir 1 South	06/22/15						73.3	220.00	58.8 I	1.39	0.300 U	0.300 U	1.39	0.008 U	0.216	0.140	21.80	8.59			0.005 I	234					
Composite of Reservoir 1 South	07/21/15						75.3	268	83.1 I	0.939	0.004 U	0.004 U	0.939	0.031 I	0.242	0.156	15.7 I	16.9			0.004 I	332					
Composite of Reservoir 1 South	08/24/15	62	40	57	147	92																					
Composite of Reservoir 1 South	08/24/15																		6.2	5							
Composite of Reservoir 1 South	09/28/15	80	35	55	128	74																					
Composite of Reservoir 1 South	08/24/15						69.4	216	73.1 I	1.01	0.004 U	0.004 U	1.01	0.008 U	0.180	0.119	9.20 I	18.6			0.003 I	176					
Composite of Reservoir 1 South	09/28/15																		<1.0	<1.0							
Composite of Reservoir 1 South	10/21/15	86	34	53	127	80													1.4	1.4							
Composite of Reservoir 1 South	09/28/15						60.1	208	163	0.908	0.06	0.056	0.908	0.008 U	0.196	0.122	22.1	21.8			0.004 I	397					
Composite of Reservoir 1 South	11/19/15																		<1.0	<1.0							
Composite of Reservoir 1 South	11/28/15	101	35	56.	130	76																					
Composite of Reservoir 1 South	10/21/15						57.3	208	151	1.06	0.113	0.1	0.95	0.042	0.204	0.159	11.7 I	12.6			0.013	340					
Composite of Reservoir 1 South	1/20 16						59.6	224	153	1.21	0.252	0.252	0.958	0.013 I	0.226	0.175	12.3 I	6.59			0.005 U	347					
Composite of Reservoir 1 South	2/17 16						58.0	240	129	1.12	0.209	0.206	0.909	0.004 I	0.230	0.147	7.6 I	8.63			0.003 I	283					
Composite of Reservoir 1 South	3/22 16						61.3	188	129	1.10	0.159	0.159	0.940	0.008 U	0.200	0.118	14.3 I	12.80			0.003 U	307					
Composite of Reservoir 1 South	4/13 16						64.7	228	79.8 I	1.13	0.064	0.060	1.070	0.020 I	0.180	0.110	11.0 I	9.74			0.004 I	203					
Composite of Reservoir 1 South	5/17 16						66.4	216	78.5 I	0.68	0.004 U	0.004 U	0.683	0.008 U	0.152	0.111	33.4	18.60			0.005 I	303					
	AVG	84?	43	62	152	93	79	267	129	1	0.151	0.168	0.906	0.018	0.285	0.203	32.7	13	4.8	10	0.004	289	3.5	0.981	0.530	4.5	4.1
	MAX	134	61	73	195	112	121	408	237	1	0.432	1.20	1.23	0.190	0.681	0.360	424	50	37	62	0.041	441	4.7	0.981	0.607	5.4	4.1
	Drinking Water Standard MCL	15	250	-	-	-	250	500	300	-	10	10	-				1000		-	-	1	200	5	2	4	700	100

Appendix C-2

Reservoir No. 1 Primary and Secondary Water Quality Analysis

BENCHMARK
EnviroAnalytical Inc.

FDOH Certification #E84167

Peace River/Manasota R W S
8998 Sw County Road 769
Arcadia, FL 34269

Sam Stone

ANALYTICAL TEST REPORT
THESE RESULTS MEET NELAC STANDARDS

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
	TOTAL HARDNESS (CACO3)		MG/L	118		SM2340C	0.662	06/28/2016	08:45	E84167

INORGANIC ANALYSIS
62-550.310 (1)

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
1040	NITRATE NITROGEN	10	MG/L	0.020 U	U	300.0	0.020	06/23/2016	22:29	E84167
1041	NITRITE NITROGEN	1.0	MG/L	0.020 U	U	300.0	0.020	06/23/2016	22:29	E84167
1038	NITRATE+NITRITE AS N	10	MG/L	0.020 U	U	300.0	0.020	06/23/2016	22:29	E84167
1094	ASBESTOS		MFL	0.48 UQ	QU	100.2	0.48	07/07/2016	09:04	E87604
1005	ARSENIC	0.010	MG/L	0.001 I	I	SM3113B	0.00069	06/27/2016	20:44	E84167
1010	BARIUM	2	MG/L	0.011		200.7	0.002	06/28/2016	13:22	E84167
1015	CADMIUM		MG/L	0.00009 U	U	200.8	0.00009	06/30/2016	09:54	E83182
1020	CHROMIUM	0.1	MG/L	0.002 I	I	200.7	0.002	06/28/2016	13:22	E84167
1024	CYANIDE	0.2	MG/L	0.005 U	U	335.4	0.005	06/29/2016	11:49	E84167
1025	FLUORIDE	4.0	MG/L	0.451		300.0	0.030	07/01/2016	14:05	E84167
1030	LEAD		MG/L	0.00016 U	U	200.8	0.00016	06/30/2016	09:54	E83182
1035	MERCURY	2	NG/L	1.25 C1	C1	1631E	0.191	06/29/2016		E87688

INORGANIC ANALYSIS

62-550.310 (1)

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
1036	NICKEL	0.1	MG/L	0.008		200.7	0.00118	06/28/2016	13:22	E84167
1045	SELENIUM	0.05	MG/L	0.00157 U	U	SM3113B	0.00157	07/16/2016	12:06	E84167
1052	SODIUM	160	MG/L	21.4		200.7	0.034	06/28/2016	13:22	E84167
1074	ANTIMONY	0.006	MG/L	0.00226 U	U	SM3113B	0.00226	06/30/2016	16:58	E84167
1075	BERYLLIUM	0.004	MG/L	0.000076 U	U	200.7	0.000076	06/28/2016	13:22	E84167
1085	THALLIUM	0.002	MG/L	0.00169 U	U	200.9	0.00169	07/05/2016	12:12	E84167

VOLATILE ORGANICS

62-550.310 (4) (a)

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
2378	1,2,4-TRICHLOROBENZENE	70	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2380	CIS-1,2-DICHLOROETHENE	70	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2955	XYLENES	10000	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2964	METHYLENE CHLORIDE	5	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2968	O-DICHLOROBENZENE	600	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2969	PARA-DICHLOROBENZENE	75	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2976	VINYL CHLORIDE	1	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2977	1,1-DICHLOROETHENE	7	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2979	TRANS-1,2-DICHLOROETHENE	100	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2980	1,2-DICHLOROETHANE	3	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2981	1,1,1-TRICHLOROETHANE	200	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2982	CARBON TETRACHLORIDE	3	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2983	1,2-DICHLOROPROPANE	5	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2984	TRICHLOROETHENE	3	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2985	1,1,2-TRICHLOROETHANE	5	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2987	TETRACHLOROETHENE	3	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2989	MONOCHLOROBENZENE	100	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2990	BENZENE	1	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2991	TOLUENE	1000	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167

VOLATILE ORGANICS

62-550.310 (4) (a)

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
2992	ETHYLBENZENE	700	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167
2996	STYRENE	100	UG/L	0.5 U	U	524.2	0.5	06/29/2016	11:00	E84167

SYNTHETIC ORGANICS

62-550.310 (4) (b)

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
2005	ENDRIN	2.0	UG/L	0.0021 UC3	C3U	508	0.0021	06/28/2016	19:11	E87052
2010	GAMMA-BHC (LINDANE)	0.2	UG/L	0.0023 U	U	508	0.0023	06/28/2016	19:11	E87052
2015	METHOXYCHLOR	40	UG/L	0.0075 U	U	508	0.0075	06/28/2016	19:11	E87052
2020	TOXAPHENE	3.0	UG/L	0.056 U	U	508	0.056	06/28/2016	19:11	E87052
2031	DALAPON	200	UG/L	0.95 U	U	515.1	0.95	07/05/2016	16:20	E87052
2032	DIQUAT	20	UG/L	0.40 U	U	549.2	0.40	06/28/2016	19:24	E87052
2033	ENDOTHALL	100	UG/L	6.3 UC3	C3U	548.1	6.3	07/01/2016	12:44	E87052
2034	GLYPHOSATE	700	UG/L	5.0 U	U	547	5.0	07/01/2016	00:50	E87052
2035	DI(2-ETHYLHEXYL)ADIPATE	400	UG/L	0.59 U	U	525.2	0.59	07/01/2016	22:22	E87052
2036	OXAMYL	200	UG/L	0.37 U	U	531.1	0.37	06/28/2016	07:46	E87052
2037	SIMAZINE	4.0	UG/L	0.034 U	U	525.2	0.034	07/01/2016	22:22	E87052
2039	DI(2-ETHYLHEXYL)PHTHALATE	6.0	UG/L	.059 U	U	525.2	.059	07/01/2016	22:22	E87052
2040	PICLORAM	500	UG/L	0.073 U	U	515.1	0.073	07/05/2016	16:20	E87052
2041	DINOSEB	7.0	UG/L	0.14 U	U	515.1	0.14	07/05/2016	16:20	E87052
2042	HEXACHLOROCYCLOPENTADIENE	50	UG/L	0.041 U	U	525.2	0.041	07/01/2016	22:22	E87052
2046	CARBOFURAN	40	UG/L	0.25 U	U	531.1	0.25	06/28/2016	07:46	E87052
2050	ATRAZINE	3.0	UG/L	0.022 U	U	525.2	0.022	07/01/2016	22:22	E87052
2051	ALACHLOR	2	UG/L	0.032 U	U	525.2	0.032	07/01/2016	22:22	E87052
2063	2,3,7,8-TCDD		PG/L	0.684 U	U	1613B	0.684	07/18/2016		E87688
2065	HEPTACHLOR	0.4	UG/L	0.0061 U	U	508	0.0061	06/28/2016	19:11	E87052
2067	HEPTACHLOR EPOXIDE	0.2	UG/L	0.0016 U	U	508	0.0016	06/28/2016	19:11	E87052
2105	2,4-D	70	UG/L	0.035 U	U	515.1	0.035	07/05/2016	16:20	E87052
2110	2,4,5-TP (SILVEX)	50	UG/L	0.057 U	U	515.1	0.057	07/05/2016	16:20	E87052

SYNTHETIC ORGANICS

62-550.310 (4) (b)

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
2274	HEXACHLOROBENZENE	1.0	UG/L	0.040 U	U	525.2	0.040	07/01/2016	22:22	E87052
2306	BENZO(A)PYRENE	0.2	UG/L	0.028 U	U	525.2	0.028	07/01/2016	22:22	E87052
2326	PENTACHLOROPHENOL	1.0	UG/L	0.036 U	U	515.1	0.036	07/05/2016	16:20	E87052
2383	PCB	0.5	UG/L	0.044 U	U	508	0.044	06/28/2016	19:11	E87052
2931	1,2-DIBROMO-3-CHLOROPROPANE	0.20	UG/L	0.014 U	U	504.1	0.014	06/23/2016	17:00	E84167
2946	ETHYLENE DIBROMIDE	0.02	UG/L	0.01 U	U	504.1	0.01	06/23/2016	17:00	E84167
2959	CHLORDANE	2.0	UG/L	0.12 U	U	508	0.12	06/28/2016	19:11	E87052

RADIONUCLIDES

62-550.310 (6)

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
4000	GROSS ALPHA	15	PCI/L	1.5 U	U	900.0	1.5	07/01/2016	09:45	E83033
4006	URANIUM		PCI/L	0.6 U	U	908.1	0.6	07/13/2016	06:45	E83033
4006	URANIUM		UG/L	0.9 U	U	CALC	0.9	07/13/2016	06:45	E83033
4020	RADIUM-226	5	PCI/L	0.4+/-0.2		903.1	0.2	07/08/2016	09:58	E83033
4030	RADIUM-228	5	PCI/L	1.0+/-0.8		Ra-05	1.0	07/07/2016	11:16	E83033

SECONDARY CONTAMINANTS

62-550.320

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
	COLOR PH		UNITS	7.97		SM4500H+B		06/24/2016	16:29	E84167
1002	ALUMINUM	0.2	MG/L	0.386 X	X	200.7	0.023	06/28/2016	13:22	E84167
1017	CHLORIDE	250	MG/L	27.2		300.0	0.353	06/29/2016	13:23	E84167
1022	COPPER	1	MG/L	0.034		200.7	0.004	06/28/2016	13:22	E84167
1025	FLUORIDE	4.0	MG/L	0.451		300.0	0.030	07/01/2016	14:06	E84167
1028	IRON	0.3	MG/L	0.074 I	I	200.7	0.029	06/28/2016	13:22	E84167

SECONDARY CONTAMINANTS

62-550.320

REPORT NUMBER: 16061060 - 001
SYSTEM NAME: Reservoir 1 Station 4-Pri &Sec
SYSTEM ID:

PARAMETER ID	PARAMETER NAME	MCL	UNITS	ANALYSIS RESULT	QUALIFIER	ANALYTICAL METHOD	MDL	ANALYSIS DATE	ANALYSIS TIME	LAB ID
1032	MANGANESE	0.05	MG/L	0.010		200.7	0.00098	06/28/2016	13:22	E84167
1050	SILVER		MG/L	0.000029 U	U	200.8	0.000029	06/30/2016	09:54	E83182
1055	SULFATE	250	MG/L	58.9		300.0	0.339	06/29/2016	13:23	E84167
1095	ZINC	5	MG/L	0.021		200.7	0.0014	06/28/2016	13:22	E84167
1905	COLOR, APPARENT	15	PCU	80 X	X	SM2120B	2.5	06/24/2016	16:29	E84167
1920	ODOR	3	TON	4 X	X	140.1	1	06/23/2016	14:00	E84167
1925	PH		UNITS	7.87 Q	Q	SM4500H+B		06/23/2016	16:39	E84167
1930	TOTAL DISSOLVED SOLIDS	500	MG/L	228		SM2540C	7.26	06/27/2016	10:57	E84167
2905	SURFACTANTS	0.5	MG/L	0.03 U	U	SM5540C	0.03	06/23/2016	11:25	E84167

DATA QUALIFIERS THAT MAY APPLY:

I = Reported value is between the laboratory MDL and the PQL.
J = Estimated value.
J3 = Estimated value. Quality control criteria for precision or accuracy not met.
J4 = Estimated value. Sample matrix interference suspected.
Q = Sample held beyond accepted hold time.
U = Analyte analyzed but not detected at the value indicated.
V = Analyte detected in sample and method blank. Results for this analyte in associated samples may be biased high.
Standard, Duplicate, and Spike values are within control limits. Reported data are usable.

NOTES:

PQL = 4 x MDL.
MBAS calculated as LAS; molecular weight = 340.
ND = Not Detected at or above adjusted reporting limit.
X = Value exceeds MCL.

C1 = Method Deviation: Sample was received without an associated Field or Trip Blank for Low Level Mercury Analysis.
C3 = Estimated value; value may not be accurate. Spike recovery or RPD outside of criteria.
Surrogates for Method 515.1 = Estimated value; value may not be accurate. Surrogate recovery outside of criteria.

For questions or comments regarding these results, please contact us at (941)723-9986.

Results relate only to the samples.

Benchmark EnviroAnalytical, Inc.
1711 Twelfth Street East
Palmetto, FL 34221
(941) 723-9986
(941) 723-6061 fax
WWW.Benchmarkea.com

Report by 07/15/16

Client:

Peace River/ Manasota RWS
8998 SW County Road 769
Arcadia, FL 34269
(863) 491-7567
(863) 491-7569 (Fax)

Cl_2 - 3.5
Temp - 30.9
NH4 - 0.38
per HC. 07/07/16 BB

Chain of Custody Form: Reservoir 1 Primary & Secondary Analysis
Sample Type[1]: Grab
Method of Discharge: 62-302 Class 1 Treated SW to DW   Sample Matrix[2]: DW

Laboratory Submission #: 16061040

Sample ID	Sb, As, Ba, Be, Cr, Ni, Se, Na, Tl, Al, Cu, Fe, Mn, Zn ~~Hg~~	Cd, Pb, Ag (200.8)	CN	Gross α, Radium-226 & 228 Uranium	Dioxin	Asbestos	VOCs	SOC's (Pesticides and PCB's): Carabamates 531.1	Pesticides 508	EDB/DBCP 504.1	Herbicides 515.3	Semivolatiales 525.2	Glyphosate 547	Endothall 548.1	Diquat 549.2	MBAS (Foaming Agents)	Hg (1631E)	Total Hardness	Odor	Cl, SO_4, TDS, Color/pH, pH*****, NO_2 (353.2), NO_3 (353.2), NO_3NO_2 (Calc.), Fluoride	Lab ID #
	1:4 HNO_3 pH<2 ✓	1:4 HNO_3 pH<2 ✓	NaOH pH>9 ✓	1:4 HNO_3 pH<2 ✓	Plain	Plain	NaThio 1:1 HCl*	MCAA NaS_2O_3	NaS_2O_3	NaS_2O_3	NaS_2O_3	$NaSO_3$ 1:1 HCl***	NaS_2O_3	NaS_2O_3	NaS_2O_3 H_2SO_4**	Plain	Pre-preserved from sublab	1:4 H2SO4 pH<2 ☐	Plain	Plain	
	1 x 1 Quart Plastic	1 x ½ Pint Plastic	1 x 250mL Plastic	2 x 2 Quart Plastic	2 x 950mL Amber Glass	1 x 1 Qt. Plastic	3 x 40mL Glass Vials****	2 x 60mL Glass Vials	2 x 1 Liter Glass	2 x 40mL Glass Vials	2 x 1 Liter Glass	2 x 1 Liter Glass	2 x 40mL Glass Vials	2 x 250mL Amber Glass	1 x 500mL Opaque Plastic	1 x 1 Quart Plastic	2 x 40mL Glass Vials	1 x ½ Pint Plastic	1 x 250mL Amber Glass	1 x 1 Quart Plastic	
Reservoir 1 Station 4	Date: 6/23/16 Time: 1000																				1

* 07/07/16 BB

* Add 3 drops of HCl to each Vial.
** Add H_2SO_4 to sample.
*** Add ENTIRE vial of HCl to each sample bottle.
****Fill all 3 vials COMPLETELY, there can be NO AIR BUBBLES.
*****pH Received after 15 minute hold time, ok to run.

1 "Sample Type" is used to indicate whether the sample was a grab (G) or whether it was a composite (C).
2 "Sample Matrix" is used to indicate whether the sample is being discharged to drinking water (DW), groundwater (GW), surface water (SW), soil, sediment (SDMNT), or sludge (SLDG).
3 "Container Type" is used to indicate whether the container is plastic (P) or glass (G).
4 **Sample must be refrigerated or stored in wet ice after collection. The temperature during storage should be less than or equal to 6°C (42.8°F).**
Under "Preservative," list any preservatives that were added to the sample container.

Laboratory Sample Acceptability
pH<2 ✓
Temperature: 2.1°C

Instructions:
1. Each bottle has a label identifying sample ID, premeasured preservative contained in the bottle, sample type, client ID, and parameters for analysis.
2. The following information should be added to each bottle label after collection with permanent black ink: date and time of collection, sampler's name or initials, and any field number or ID.
3. All bottles not containing preservative may be rinsed with appropriate sample prior to collection.
4. The client is responsible for documentation of the sampling event. Please note special sampling events on the sample custody form.

	Collected / Relinquished By:	Date:	Time:	Received By:	Date:	Time:
1	[signature]	6/23/16	1111	[signature]	6/23/16	1111
2	Relinquished By: [signature]	6/23/16	1140	[signature]	6/23/16	1140
3	Relinquished By: [signature]	6/23/16	1400	[signature]	6/23/16	1400
4	Relinquished By:	Date:	Time:	Received By:	Date:	Time:

Peace River Regional Water Supply Authority
8998 SW County Road 769
Arcadia, FL 34269
Phone: 863-491-7567
Fax: 863-491-7569

PROJECT: Reservoir 1 Primary and Secondary Analysis

Sample Description	Date / Time	pH (std. units)	Temperature (°C)	Specific Conductivity (µmhos/cm)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	
Reservoir 1 Station 4	6/23/16 1600						
Depth(ft)							
(Surface) 1 Ft		8.01	31.9	362	7.88	4.21	
10.25 Ft		7.99	31.1	367	7.72	4.96	
20.5 Ft		7.96	31.2	364	7.68	5.63	
							Total Depth
							21.5 Ft

Notes: BENCHMARK
24.5 ft Reservoir level

Signature of collector / Date and Time: Morgan [illegible] 6/23/16

INTERLABORATORY SAMPLE TRANSMITTAL FORM

Benchmark EnviroAnalytical, Inc.
1711 12th Street East
Palmetto, FL 34221
(941) 723-9986
(941) 723-6061 fax

Office QC Check: ________
Bottle Check: ________

Date:	06/24/16		
# of Samples:	1	Total # of Bottles:	2
Method of Shipment:			
Subcontract Laboratory:	Florida Radiochemistry 5456 Hoffner Ave. #201 Orlando, FL 32812 Phone: 407-382-7733 Fax: 407-382-7744		
Page	1	of	1

Report by 07/15/16

Laboratory Submission #	Collection Date	Collection Time	Method of Discharge	Collection Method**	Preservative	Container Qty	Container Capacity	Container Type***	Parameters	Field Conductivity µs/cm
16061060-1	06/23/16	1000	62-302 Class 1 Treated SW to DW	Grab	1:4 HNO_3	2	2 Qt	P	Gross Alpha, Radium 226 & 228 Uranium	

* Sample Matrix abbreviations: Groundwater (GW), Surface Water (SW), Saline Surface Water (SSW), Fresh Surface Water (FSW), Drinking Water (DW), Sludge (Sldg), Solid (Sol), Soil (Soil), Domestic Effluent (Dom Eff), Industrial Effluent (Ind Eff).
** Sample Method abbreviations: Grab (G), Composite (C), 24 Hour Composite (24HR Comp.)
*** Container Type abbreviations: Plastic (P), Glass (G)

Relinquished By: (Benchmark)	Sign Name:	[signature]	Date:		Received By:	[signature]	Date:	6-29-16
	Print Name:	Amnah Jensen	Time:			MIKE NAUMANN	Time:	11:36
Relinquished By:	Sign Name:		Date:		Received By:		Date:	
	Print Name:		Time:				Time:	

OrderID: 341606486

EMSL ANALYTICAL, INC.

Asbestos Chain of Custody

EMSL Order Number *(Lab Use Only)*: 341606484

EMSL ANALYTICAL, INC.
5125 ADAMSON STREET,
SUITE 900
ORLANDO, FL, 32804
PHONE: 407-599-5887
FAX: 407-599-9063

Company: Benchmark EnviroAnalytical, Inc.
EMSL-Bill to: ☐ Same ☒ Different
If Bill to is Different note instructions in Comments**
Third Party Billing requires written authorization from third party

Street: 1711 12th Street East

City: Palmetto **State/Province:** FL **Zip/Postal Code:** 34221 **Country:** USA

Report To (Name): Bettina Bellfuss **Fax #:** 941-723-6061

Telephone #: 941-723-9986 **Email Address:** Bettina.Bellfuss@benchmarkea.net

Project Name/Number:

Please Provide Results: ☐ Fax ☒ Email **Purchase Order:** **U.S. State Samples Taken:** FL

Turnaround Time (TAT) Options* – Please Check

☐ 3 Hours ☐ 6 Hours ☐ 24 Hrs ☐ 48 Hrs ☐ 3 Days ☐ 4 Days ☐ 5 Days ☐ 10 Days

*For TEM Air 3 hours/6 hours, please call ahead to schedule. *There is a premium charge for 3 Hour TEM AHERA or EPA Level II TAT. You will be asked to sign an authorization form for this service. Analysis completed in accordance with EMSL's Terms and Conditions located in the Analytical Price Guide.

PCM - Air
- ☐ NIOSH 7400
- ☐ w/ OSHA 8hr. TWA

PLM - Bulk (reporting limit)
- ☐ PLM EPA 600/R-93/116 (<1%)
- ☐ PLM EPA NOB (<1%)

Point Count
- ☐ 400 (<0.25%) ☐ 1000 (<0.1%)

Point Count w/Gravimetric
- ☐ 400 (<0.25%) ☐ 1000 (<0.1%)
- ☐ NYS 198.1 (friable in NY)
- ☐ NYS 198.6 NOB (non-friable-NY)
- ☐ NIOSH 9002 (<1%)

TEM - Air
- ☐ AHERA 40 CFR, Part 763
- ☐ NIOSH 7402
- ☐ EPA Level II
- ☐ ISO 10312

TEM - Bulk
- ☐ TEM EPA NOB
- ☐ NYS NOB 198.4 (non-friable-NY)
- ☐ Chatfield SOP
- ☐ TEM Mass Analysis-EPA 600 sec. 2.5

TEM – Water: EPA 100.2
- Fibers >10µm ☐ Waste ☒ Drinking
- All Fiber Sizes ☐ Waste ☐ Drinking

TEM- Dust
- ☐ Microvac - ASTM D 5755
- ☐ Wipe - ASTM D6480
- ☐ Carpet Sonication (EPA 600/J-93/167)

Soil/Rock/Vermiculite
- ☐ PLM CARB 435 - A (0.25% sensitivity)
- ☐ PLM CARB 435 - B (0.1% sensitivity)
- ☐ TEM CARB 435 - B (0.1% sensitivity)
- ☐ TEM CARB 435 - C (0.01% sensitivity)
- ☐ EPA Protocol (Semi-Quantitative)
- ☐ EPA Protocol (Quantitative)

Other: ☐

☐ **Check For Positive Stop – Clearly Identify Homogenous Group**

Samplers Name: Client **Samplers Signature:**

Sample #	Sample Description	Volume/Area (Air) HA # (Bulk)	Date/Time Sampled
16061060	Reservoir 1 Station 4	1 Qt	6/23/16 1000
			30.1 °C

Client Sample # (s): 16061060 **Total # of Samples:** 1

Relinquished (Client): Melinda Marchant **Date:** 6/23/16 **Time:** 1545

Received (Lab): [signature] **Date:** 6-27-16 **Time:** 10:50 AM

Comments/Special Instructions: Email invoice to: Invoicing@benchmarkea.net

ENVIRONMENTAL CONSERVATION LABORATORIES CHAIN-OF-CUSTODY RECORD

Client Name: Benchmark EA	Project Number: 16061060	Requested Turnaround Times
Address: 1711 12th Street East	Project Name/Desc: Res. 1st Sta. 4	Note: Rush requests subject to acceptance by the facility
City/ST/Zip: Palmetto Fl 34221	PO # / Billing Info:	Standard
Tel: 941-722-6968 / Fax:	Reporting Contact: Bettina	Expedited
Sampler(s) Name, Affiliation (Print): Client	Billing Contact: Nathan	Due 7/15/16
Sampler(s) Signature:	Facility # (if required):	Lab Workorder: A204398

Requested Analyses: Cd, Pb, Ag (200.8)

Preservation (See Codes) (Combine as necessary): N

Item #	Sample ID (Field Identification)	Collection Date	Collection Time	Comp / Grab	Matrix (see codes)	Total # of Containers	Cd, Pb, Ag (200.8)	Sample Comments
1	16061060-1	06/23/16	1000	G	*	1	X	

Total # of Containers: 1

Sample Kit Prepared By	Date/Time	Relinquished By	Date/Time	Received By	Date/Time
		[signature]	6/24/16 1200	[signature]	6/25/16 0800
			Date/Time	Received By: S. Chesey	6/25/16 0800
			Date/Time	Received By	Date/Time

Comments: *62-302 Class 3 Treated Sed 1 to DW

Cooler #'s & Temps on Receipt: C9BHW 0.6°

Condition Upon Receipt: X Acceptable ___ Unacceptable

Matrix: GW-Groundwater SO-Soil SE-Sediment SW-Surface Water WW-Wastewater A-Air O-Other (detail in comments)

Preservation: Ice I-Ice H-HCl N-HNO3 S-H2SO4 NO-NaOH O-Other (detail in comments)

Note: All samples submitted to ENCO Labs are in accordance with the terms and conditions listed on the reverse of this form, unless prior written agreements exist.

INTERLABORATORY SAMPLE TRANSMITTAL FORM

Benchmark EnviroAnalytical, Inc.
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
Office QC Check: ________
Bottle Check: ________

16061760-001
ESU

Report by 07/15/16

Date:	06/23/16
Project Name:	Reg. 1 Sta. 4
# of Samples:	1 — Total # of Bottles: 4
Method of Shipment:	UPS – 2 Day Air
Subcontract Laboratory:	Summit Environmental 3310 Win Street Cuyahoga Falls, Ohio. 44223 (330) 253-8211
Page	1 of 1

Laboratory Submission #	Collection Date	Collection Time	Sample Matrix[1]	Collection Method[2]	Preservative	Container Qty	Container Capacity	Container Type[3]	Parameters	Comments
16061050-F	06/23/16	1000	DW	G	Plain	2	950mL	G	Dioxin	62-302 Class 5 Heated Su to Dry
16061050-E	06/23/16	1000	DW	G	Pre-Preserved	2	[illegible]	G	Low Level Mercury (1631E)	

1: "Sample Matrix" abbreviations: Groundwater (GW), Surface Water (SW), Drinking Water (DW), Sludge (Sldg), Solid (Sol), Soil (Soil), Domestic Effluent (Dom Eff), Industrial Effluent (Ind Eff)
2: "Sample Method" abbreviations: Grab (G), Composite (C)
3: "Container Type" abbreviations: Plastic (P), Glass (G)

Relinquished By: (Benchmark)	Sign Name:		Date:	06/23/16	Received By:			Date:	06/23/16
	Print Name:	Anna Jensen	Time:	1600		UPS		Time:	1600
Relinquished By:	Sign Name:		Date:		Received By:	[signature]		Date:	6-27-16
	Print Name:		Time:					Time:	1010

INTERLABORATORY SAMPLE TRANSMITTAL FORM

Benchmark EnviroAnalytical, Inc.
1711 12th Street East
Palmetto, FL 34221
(941) 723-9986
(941) 723-6061 fax
www.Benchmarkea.com
Office QC Check: ________
Bottle Check: ________

Date:		06/23/16	
# of Samples:	1	Total # of Bottles:	13
Method of Shipment:		Hand Delivery	
Subcontract Laboratory:	Test America Laboratories - Tampa 6712 Benjamin Road Suite 100 Tampa, Fl 33634 813-885-7427 ext.139 Keaton Conner: keaton.conner@testamericainc.com		
Page	1	of	1

Report by 07/15/16

Laboratory Submission #	Collection Date	Collection Time	Method of Discharge	Collection Method**	Preservative	Container Qty	Container Capacity	Container Type***	SOC's Parameters (Pesticides and PCB's)	Comments
16061060-1	06/23/16	1000	62-302 Class I Treated SW to DW	Grab	MCAA $Na_2S_2O_3$	2	60mL	G	Carabamates (531.1)	*
					$Na_2S_2O_3$	2	1 L	G	Pesticides (508)	*
					$Na_2S_2O_3$	2	1 L	G	Herbicides (515.3)	*
					$Na_2S_2O_3$, HCl	2	1 L	G	Semivolatiles (525.2) Dioxin Screen	*
					$Na_2S_2O_3$	2	40mL	G	Glyphosate (547)	*
					$Na_2S_2O_3$	2	250mL	G	Endothall (548.1)	*
					$Na_2S_2O_3$ H_2SO_4	1	500mL	P	Diquat (549.2)	*
									*Do NOT Dilute sample. Call Dale Dixon for OK first!	

* Sample Matrix Abbreviations: Groundwater (GW), Surface Water (SW), Saline Surface Water (SSW), Fresh Surface Water (FSW), Drinking Water (DW), Sludge (Sldg), Solid (Sol), Soil (Soil), Domestic Effluent (Dom Eff), Industrial Effluent (Ind Eff).
** Sample Method Abbreviations: Grab (G), Composite (C), 24 Hour Composite (24HR Comp).
*** Container Type Abbreviations: Plastic (P), Glass (G).

Relinquished By: (Benchmark)	Sign Name:	[signature]	Date:	06/24/16	Received By:	[signature]	Date:	6/24/16
	Print Name:	Annie Jepsen	Time:	830			Time:	8:21
Relinquished By:	Sign Name:	[signature]	Date:	6/24/16	Received By:	[signature]	Date:	06-25-16
	Print Name:	Kristin Southers	Time:	1800		660-126866	Time:	0708

660-126866-4

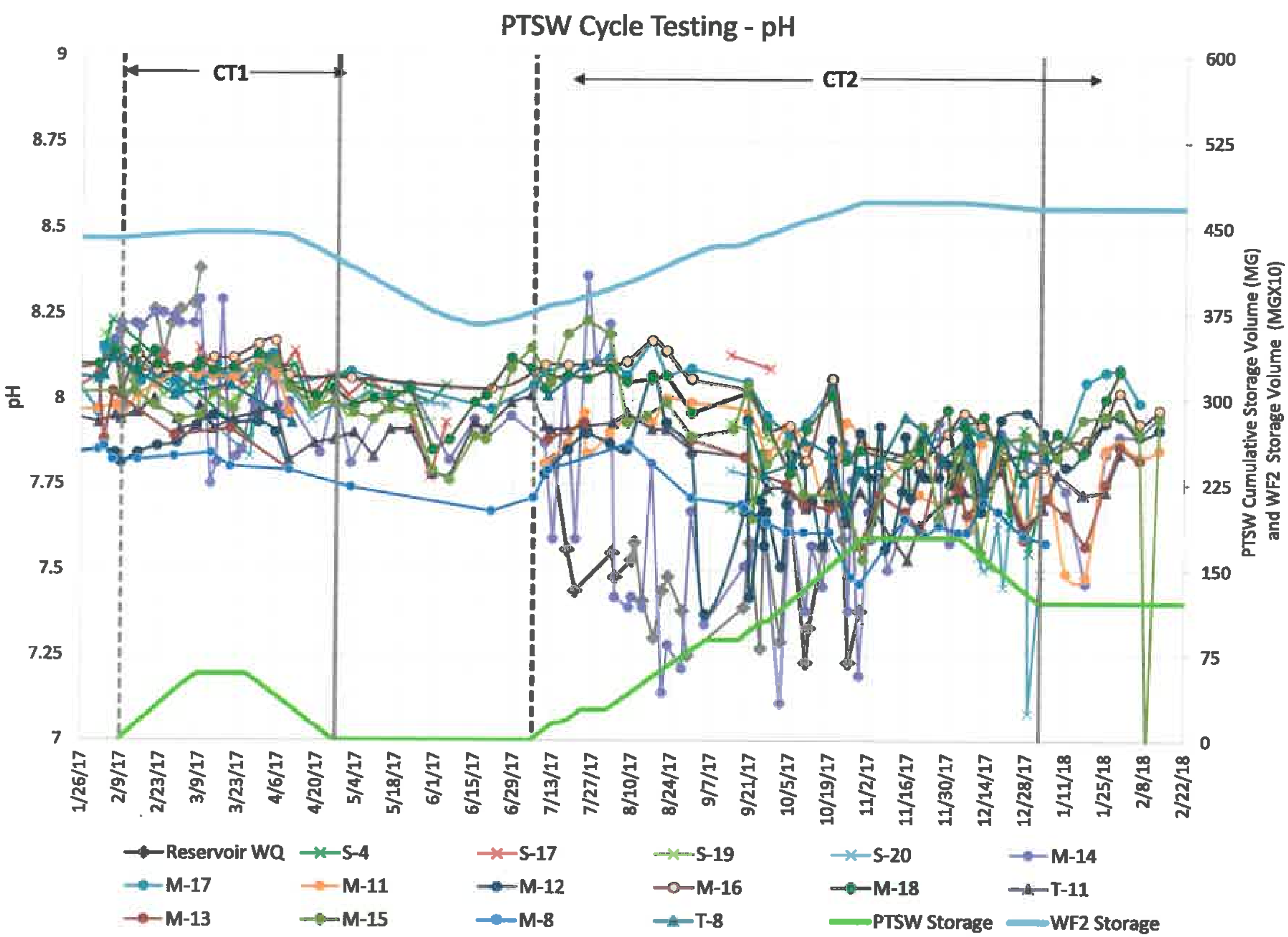
3.3/2.7/3.2/2.9 (-) 3.6/3.0/3.5/3.2 °C

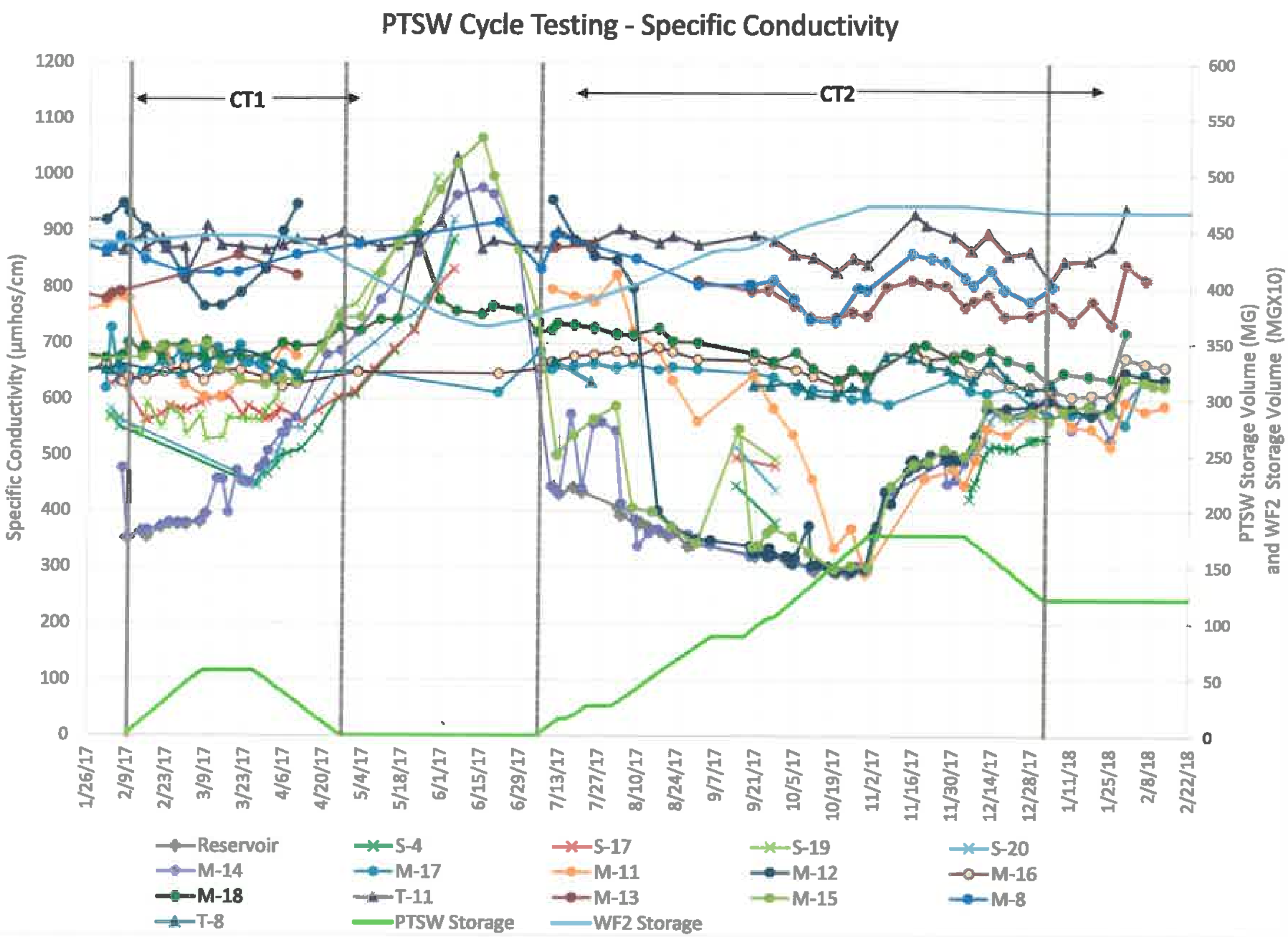
ATTACHMENT C-3
PTSW Pilot Test - PTSW Water Quality

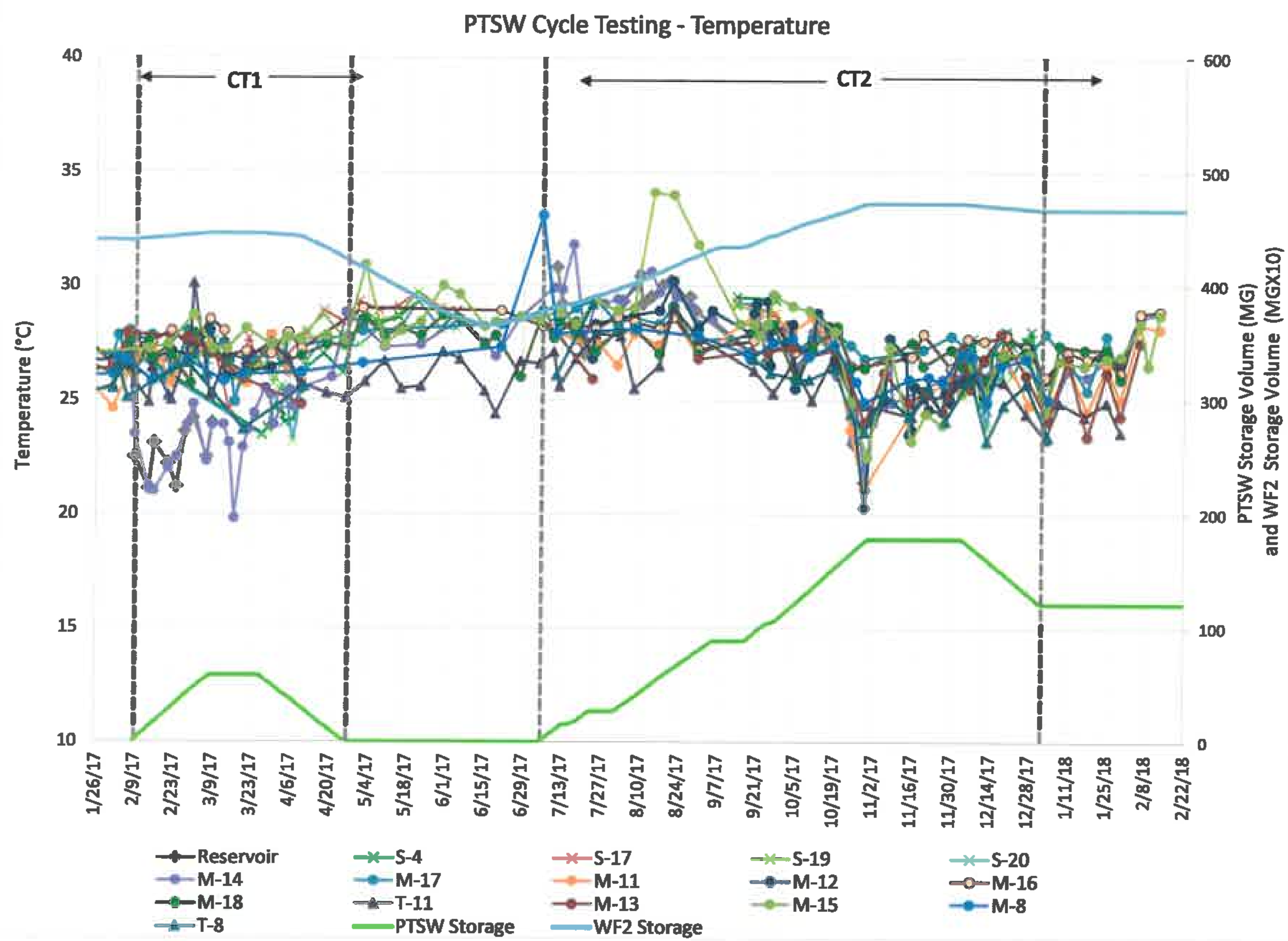
	PH	TEMP	SPECIFIC COND.	ORP	DO	TURBIDITY	Cl-	SO4	TDS	TSS	TKN	AMMONIA		COLOR	NITRATE As N		ALUMINUM	TOC	ARSENIC		TOTAL COLIFORM		E.COLI	
SAMPLE DATE	(SU)	(C°)	(µS/cm)	(mV)	(mg/L)	(NTU)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	Q	(Color Units)	(mg/L)	Q	(mg/L)	(mg/L)	(µg/L)	Q	(CFU/100mL)	Q	(CFU/100mL)	Q
2/9/2017	8.2	22.5	351	45	8.94	4.54	22.9	59.4	196	5.16	0.579	0.054		70	0.02	U	0.362	12	1.54	I	488		1	
2/10/2017	7.98																				921		3	
2/14/2017	8.05	21.1	362	245.2	9.04	4.94	24.2	62.3	220	5.11	0.813	0.028	I	70	0.02	U	0.37	11.6	1.12	I	2420	Z	1	U
2/14/2017	8.05	21.1	362	245.2	9.04	4.94															2420	Z	1	U
2/16/2017	8.21	23.1	353	-36.8	8.84	4.71		61.4													2420	Z	2	
2/21/2017	8.26	22.2	370	-150.2	8.86	3.83	25.3	65.0	204	4.89	0.676	0.055		60	0.02	U	0.466	11.2	1.12	I	1986		2	
2/24/2017	8.13	21.2	377	21.6	8.85	4.43		64.8													1046		1	
2/27/2017	8.22	23.6	376	-20.8	9.01	5.06	24.8	64.0	188	4.94	0.645	0.043		50	0.02	U	0.338	11.8	0.692	I	1300		1	U
3/2/2017	8.26	24.2	375	-106.2	8.72	5.17		64.9													1203		1	
3/7/2017	8.28	22.5	379	-121.7	8.87	4.62	25.9	67.4	192	12.2	0.702	0.1		60	0.02	U	0.341	11.1	0.897	I	517		1	U
3/9/2017	8.38	24.0	394	17.4	8.96	3.48		66.6													816		1	
7/11/2017	7.8	30.8	441	100.4	6.88	5.04	34.4	89.8	256	8.6	1.27	0.119		140	0.03		0.573	14	1.13	I	770		2	
7/11/2017	7.8	30.8	441	100.4	6.88	5.04																		
7/13/2017	7.82	29.2	430	102.9	6.91	5.79		86.3													980		1	U
7/18/2017	7.56	27.7	442	192.8	7.18	7.05	33.2	85.1	240	8.2	1.45	0.392		100	0.104		0.413	15	1.2	I	1203		1	
7/21/2017	7.44	27.0	434	20.7	7.21	7.68		84.1													1986		3	
8/3/2017	7.55	28.0	406	73.8	6.78	6.70	29.1	75.0	312	4.67	0.912	0.008	U	150	0.303		0.332	16.9	0.937	I	1553	I	1	U
8/4/2017	7.48	29.3	392	262.7	6.66	7.21		75.4													2420	Z	1	U
8/10/2017	7.53	30.4	377	124.9	7.15	8.20	28.2	73.6	280	6.67	1.13	0.008	I	180	0.337		0.329	17.2	1.15	I	1733		1	U
8/11/2017	7.58	29.2	379	222.2	6.99	6.99		71.3													921		1	U
8/14/2017	7.41	29.5	370	87.8	6.76	6.58	28.3	75.0	280	5.4	1.13	0.045		200	0.378		0.382	18.6	0.689	U	1203		1	
8/18/2017	7.3	30.0	364	189.4	6.94	6.70		70.0													1120		2	
8/21/2017	7.44	30.2	356	163.7	7.02	7.03	27.3	70.2	248	16.2	1.26	0.008	U	150	0.324		0.335	18.5	1.41	I	1203		1	U
8/23/2017	7.48	29.7	362	166.2	6.92	7.95		75.3													1203		1	U
8/28/2017	7.38	29.5	337	220.1	6.49	18.30	61.1	78.8	236	8.6	1.2	0.008	U	200	0.515		0.493	18.1	1.14		2420	Z	1	
8/30/2017	7.25	28.9	341	266.1	6.77	9.71		66.6													1986	U	1	
9/19/2017	7.39	27.0	323	14.9	7.43	7.08	25.9	65.8	244	8.8	1.19	0.008	U	150	0.445		0.47	16.6	0.689	U	1553		1	U
9/21/2017	7.58	28.7	319	-8.1	7.55	5.99		58.7													1553		1	U
9/25/2017	7.27	26.7	331	60	7.22	7.92	22.2	57.2	208	15.7	1.04	0.008	U	180	0.486		0.437	16.1	1.07	I	2420		1	U
9/26/2017	7.63	28.0	319	18.4	7.55	6.21		59.1													2420		1	
10/2/2017	7.29	28.2	314	93.9	7.3	7.24	22.5	58.5	208	7.0	0.94	0.014	I	200	0.505		0.461	16.4	1.2	I	1733		1	
10/5/2017	7.71	26.4	308	70.7	7.64	6.49		58.9													2420	Z	1	
10/11/2017	7.23	27.1	301	79.9	7.53	5.92	21.6	55.9	236	14.3	1.18	0.087		180	0.498		0.499	19.5	2.5		1986		1	
10/12/2017	7.33	28.0	294	75	7.68	6.54		57.0													1986		1	
10/17/2017	7.56	27.5	300	31.6	7.43	6.35	21.6	55.4	224	5.0	0.903	0.03	I	160	0.546		0.67	19.4	1.59	I	2420	Z	1	U
10/20/2017	7.74	26.5	291	2.8	7.62	6.40		50.1													2420		1	
10/24/2017	7.59	26.4	289	-31.6	7.54	9.31	21.1	53.8	204	24.5	0.875	0.008	U	180	0.558		0.609	17.7	2.62	I	2420		2	
10/26/2017	7.23	23.1	294	94.2	7.95	12.40		50.9													2420		1	
10/30/2017	7.38	21.4	290	175.9	8.4	7.20	21.3	53.7	212	11	1.21	0.008	U	150	0.493		0.493	17.8	1.22	I	2420	Z	6	

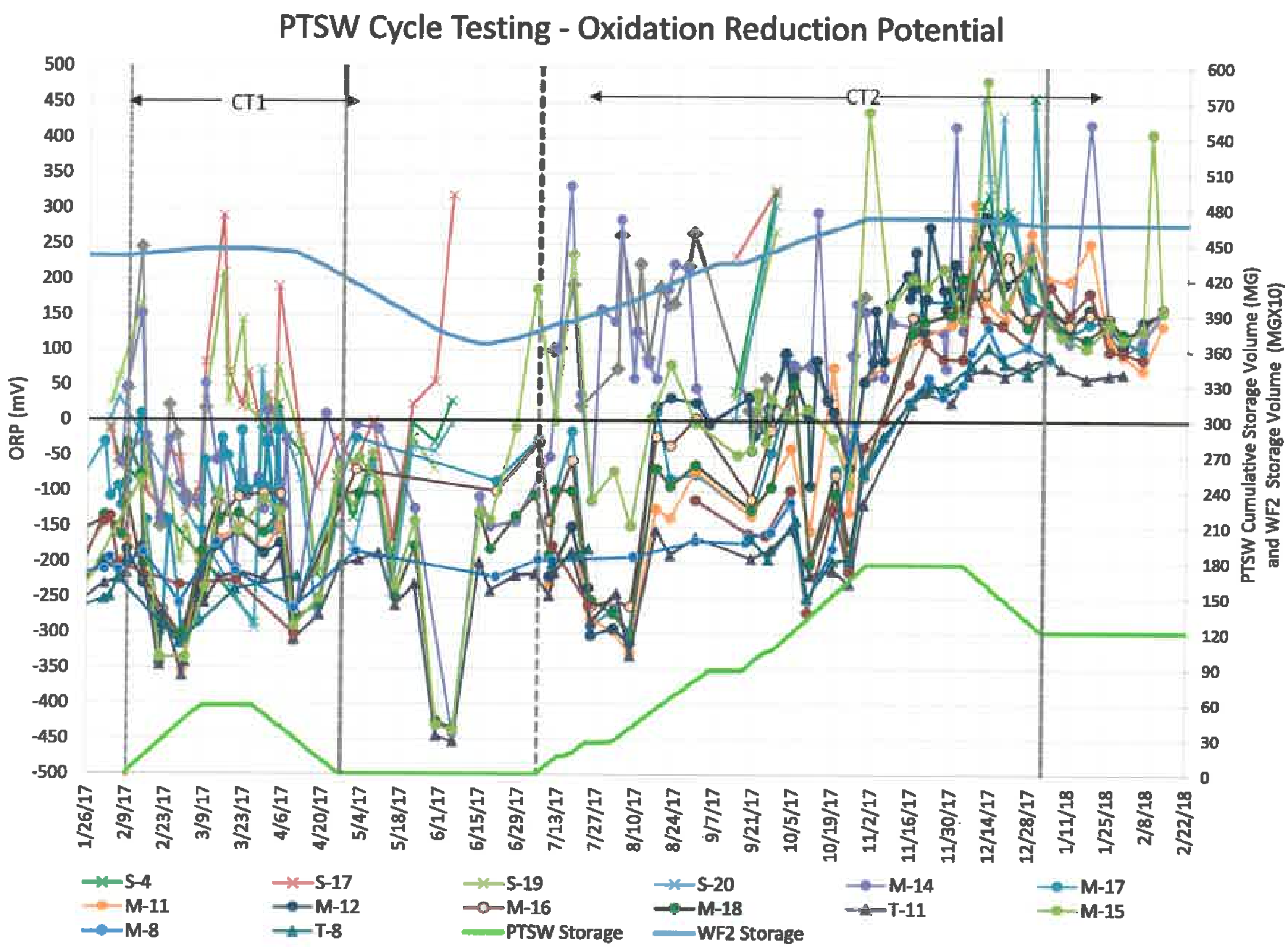
Legend:
- Z Too many colonies were present (TNTC). The numberic value represents the filtration volume
- U Analyte analyzed but not detected
- I Reported value is between the laboratory MDL and PQL

Appendix D
PTSW Water Quality Graphs

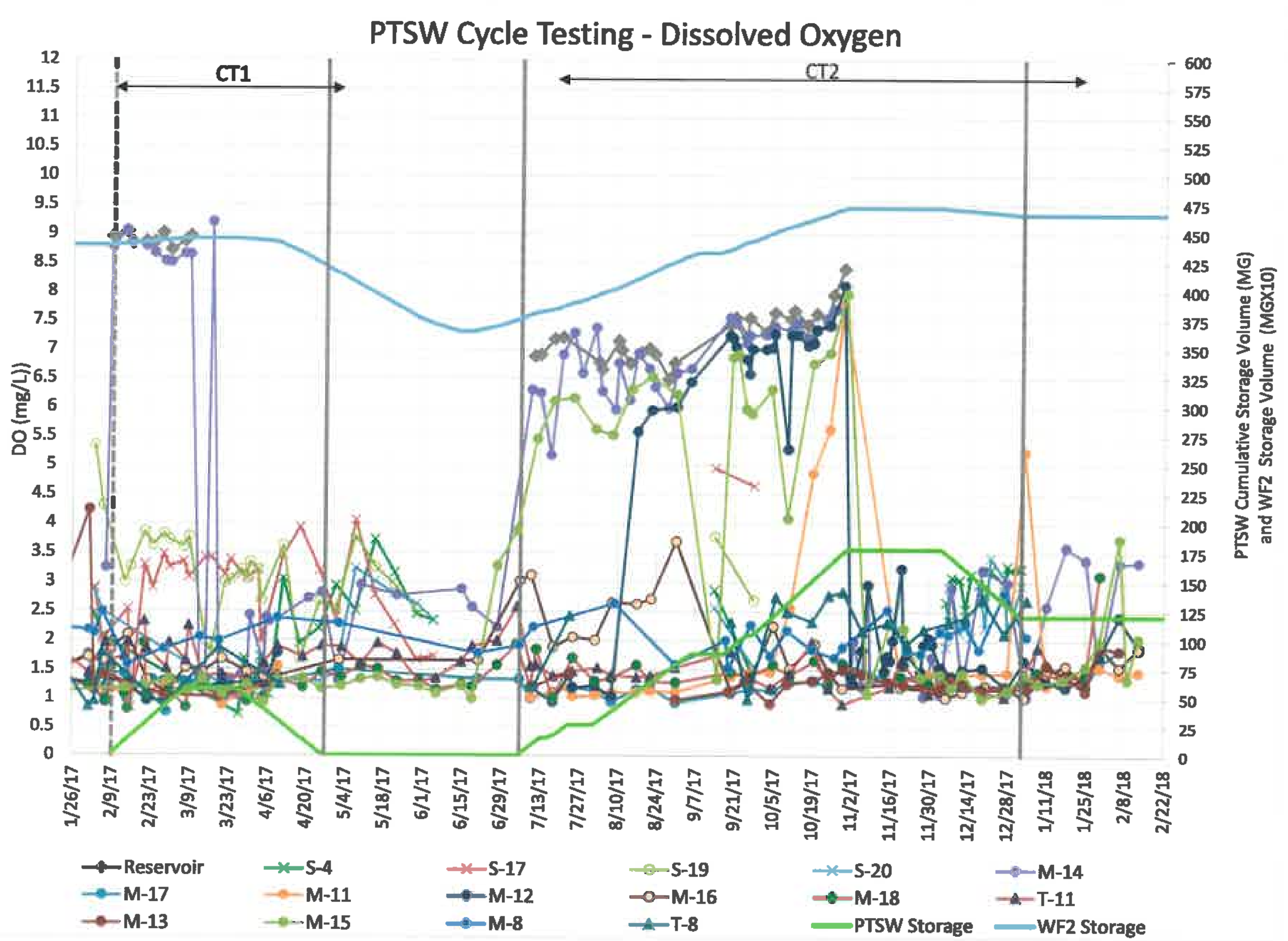

PTSW Cycle Testing - pH
CT1
CT2
pH
9
8.75
8.5
8.25
8
7.75
7.5
7.25
7
600
525
450
375
300
225
150
75
0
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
2/8/18
2/22/18
Reservoir WQ
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage


PTSW Cycle Testing - Specific Conductivity
CT1
CT2
Specific Conductivity (µmhos/cm)
PTSW Storage Volume (MG)
and WF2 Storage Volume (MGX10)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
600
550
500
450
400
350
300
250
200
150
100
50
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
2/8/18
2/22/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

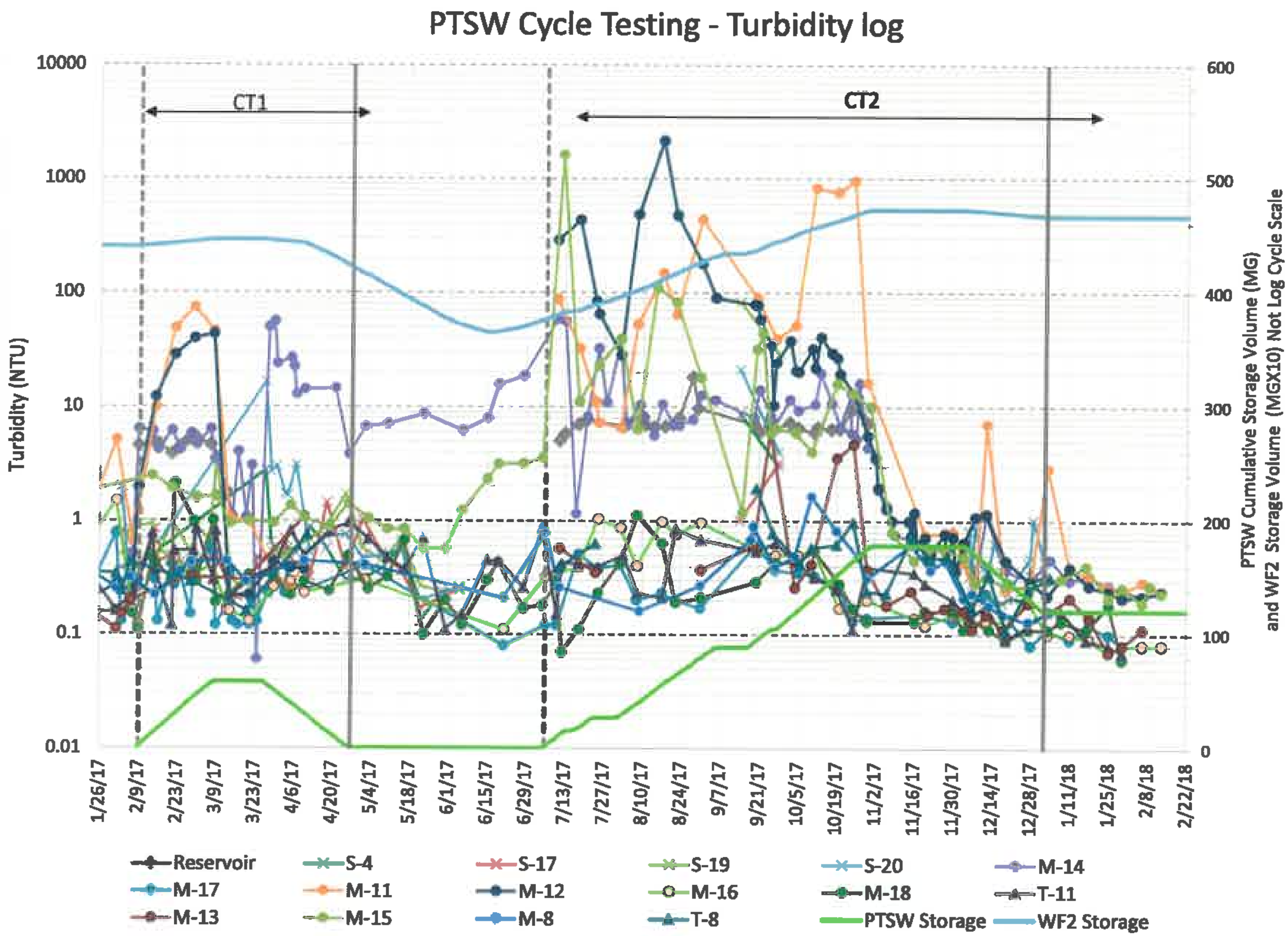

PTSW Cycle Testing - Temperature
CT1
CT2
Temperature (°C)
40
35
30
25
20
15
10
PTSW Storage Volume (MG)
and WF2 Storage Volume (MGX10)
600
500
400
300
200
100
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
2/8/18
2/22/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage



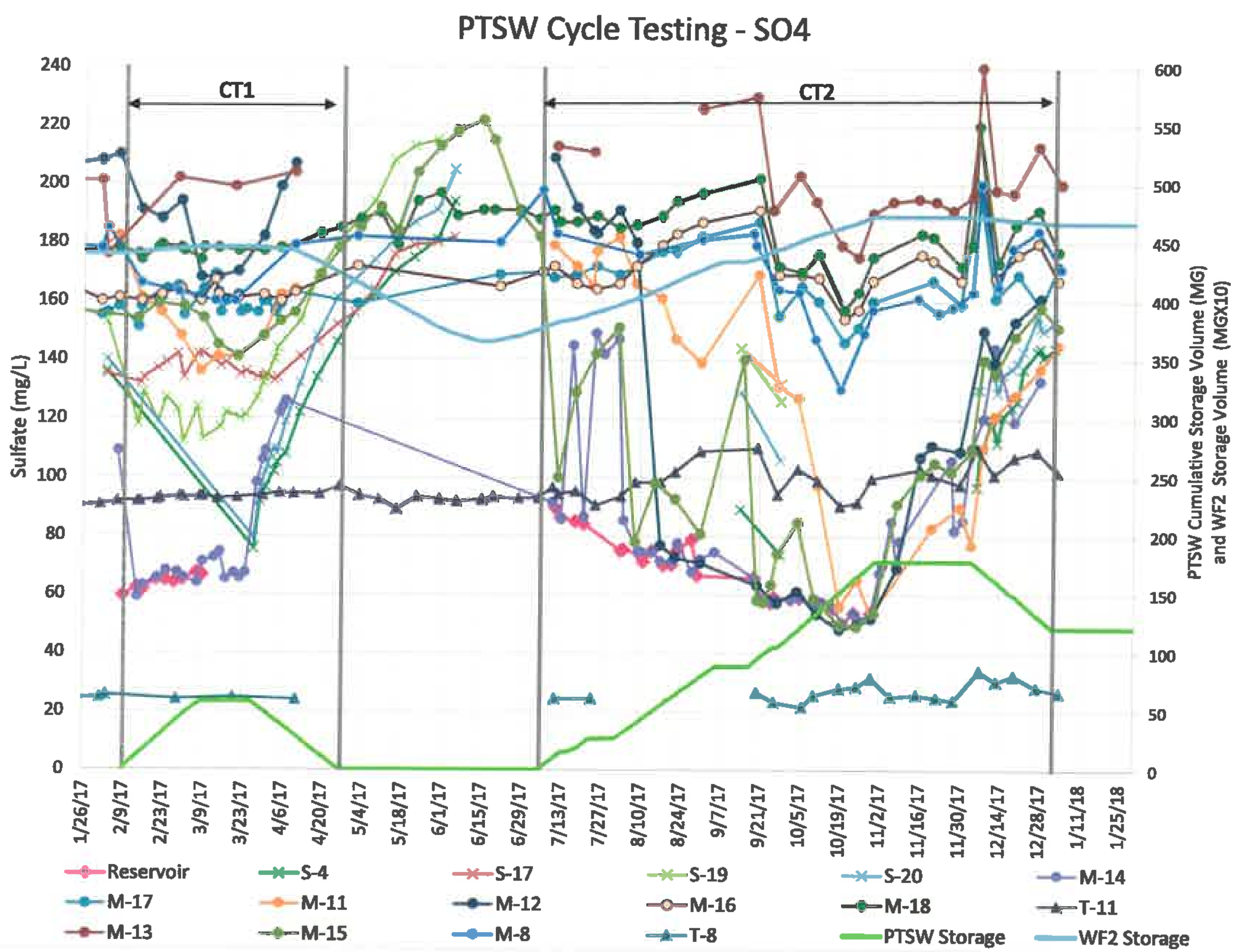
PTSW Cycle Testing - Oxidation Reduction Potential
CT1
CT2
ORP (mV)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
500
450
400
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
600
570
540
510
480
450
420
390
360
330
300
270
240
210
180
150
120
90
60
30
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
2/8/18
2/22/18
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-15
M-8
T-8
PTSW Storage
WF2 Storage

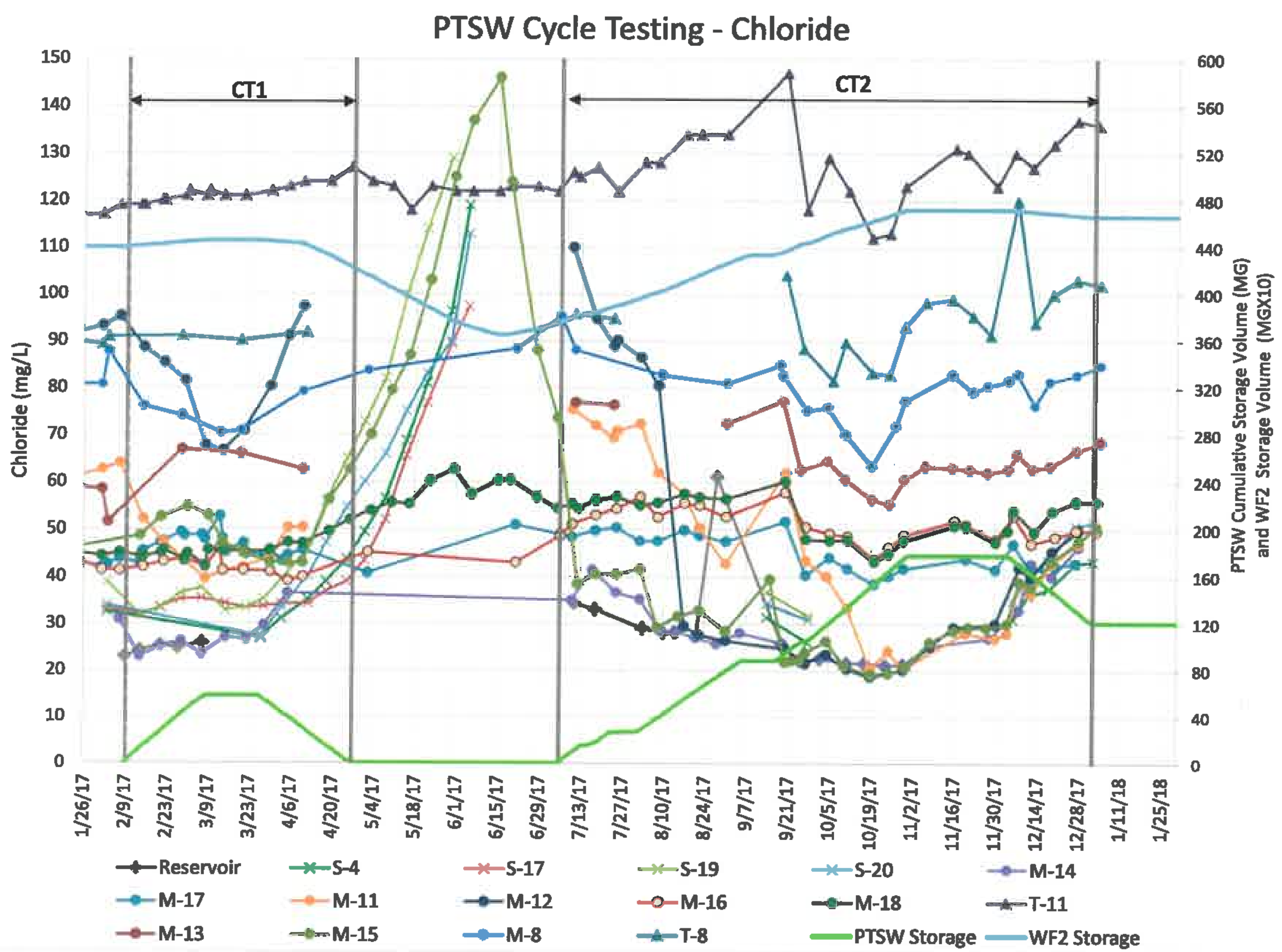


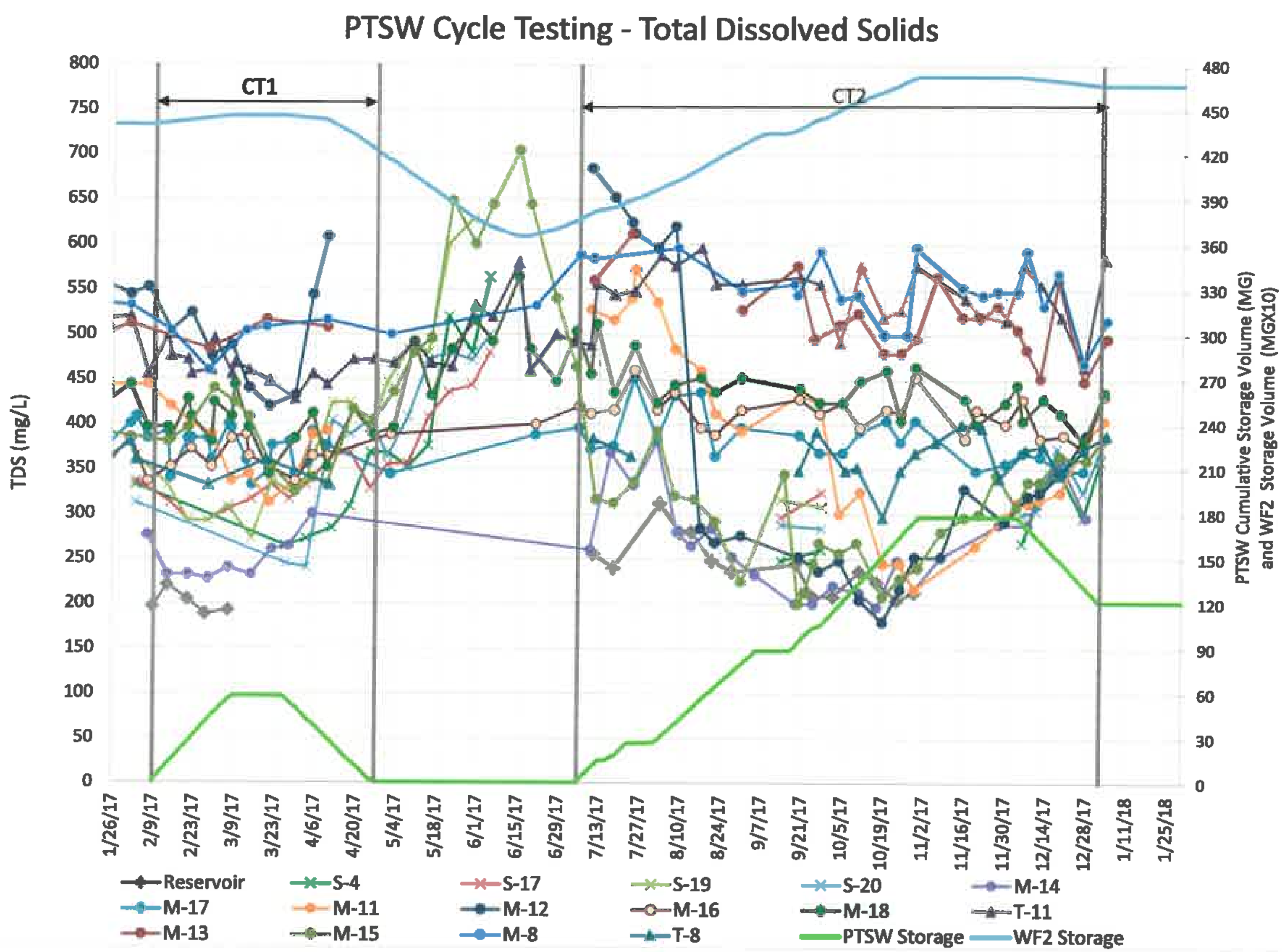
PTSW Cycle Testing - Dissolved Oxygen
CT1
CT2
DO (mg/L)
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
600
575
550
525
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
2/8/18
2/22/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

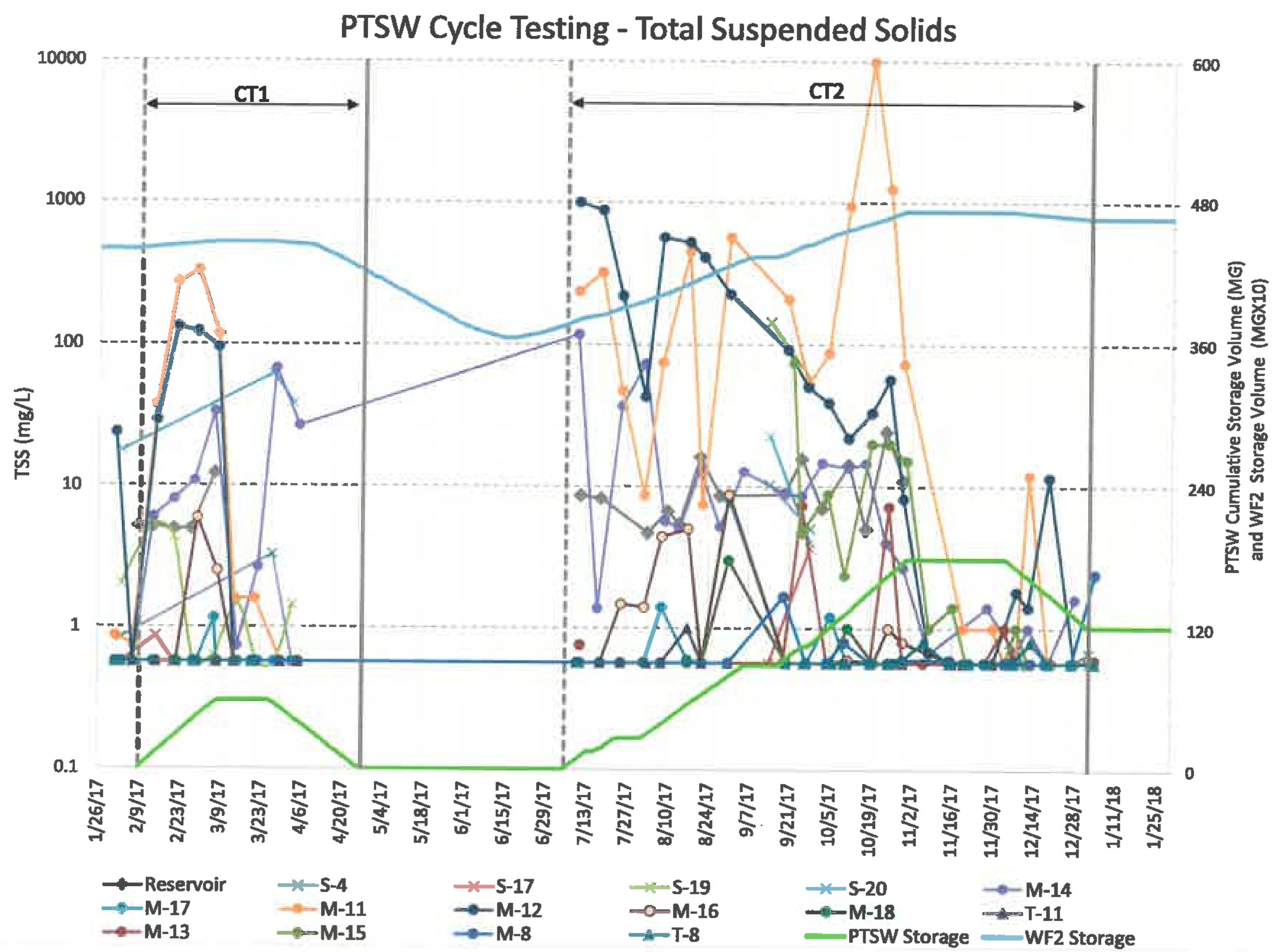


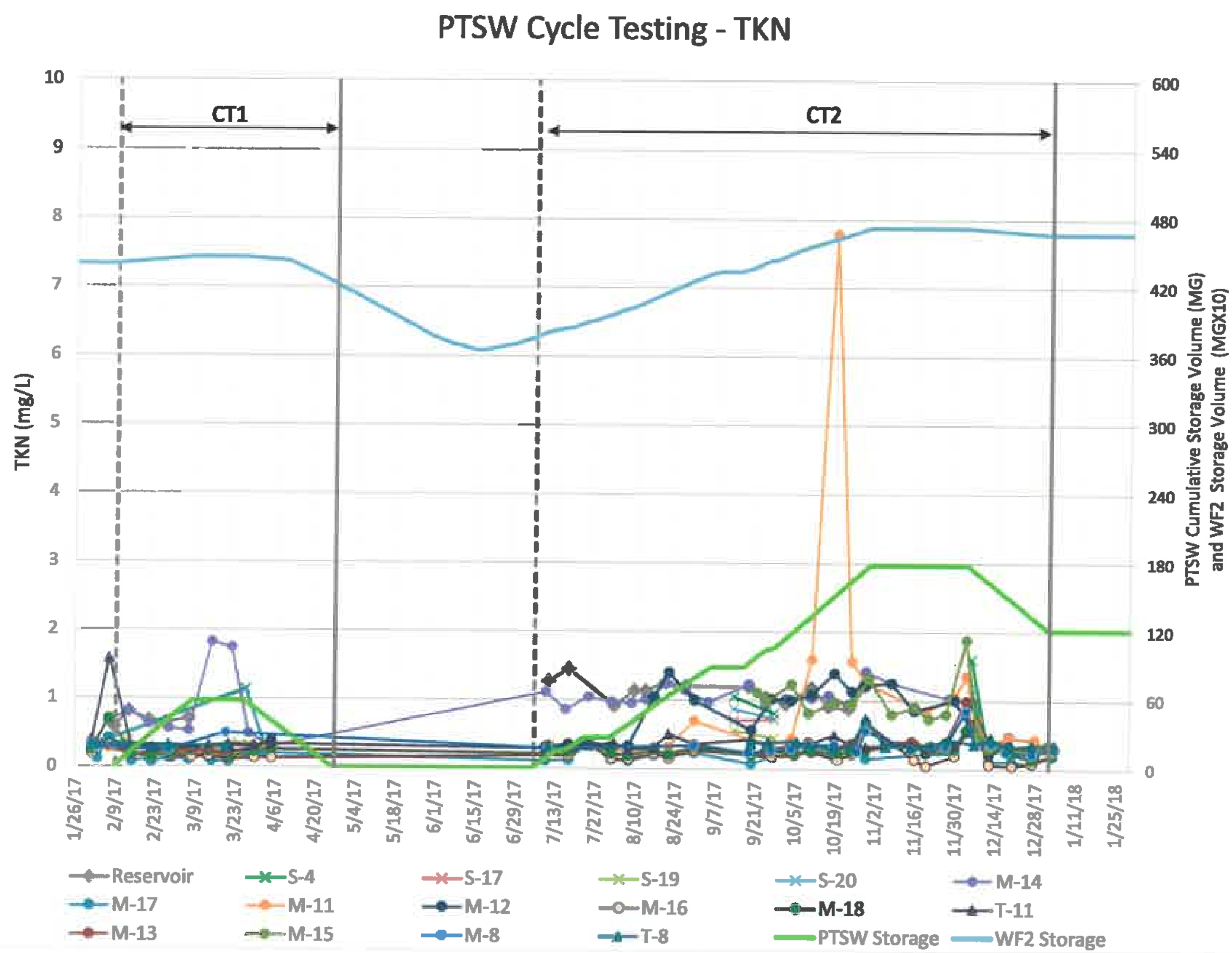
PTSW Cycle Testing - Turbidity log
CT1
CT2
Turbidity (NTU)
10000
1000
100
10
1
0.1
0.01
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10) Not Log Cycle Scale
600
500
400
300
200
100
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
2/8/18
2/22/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

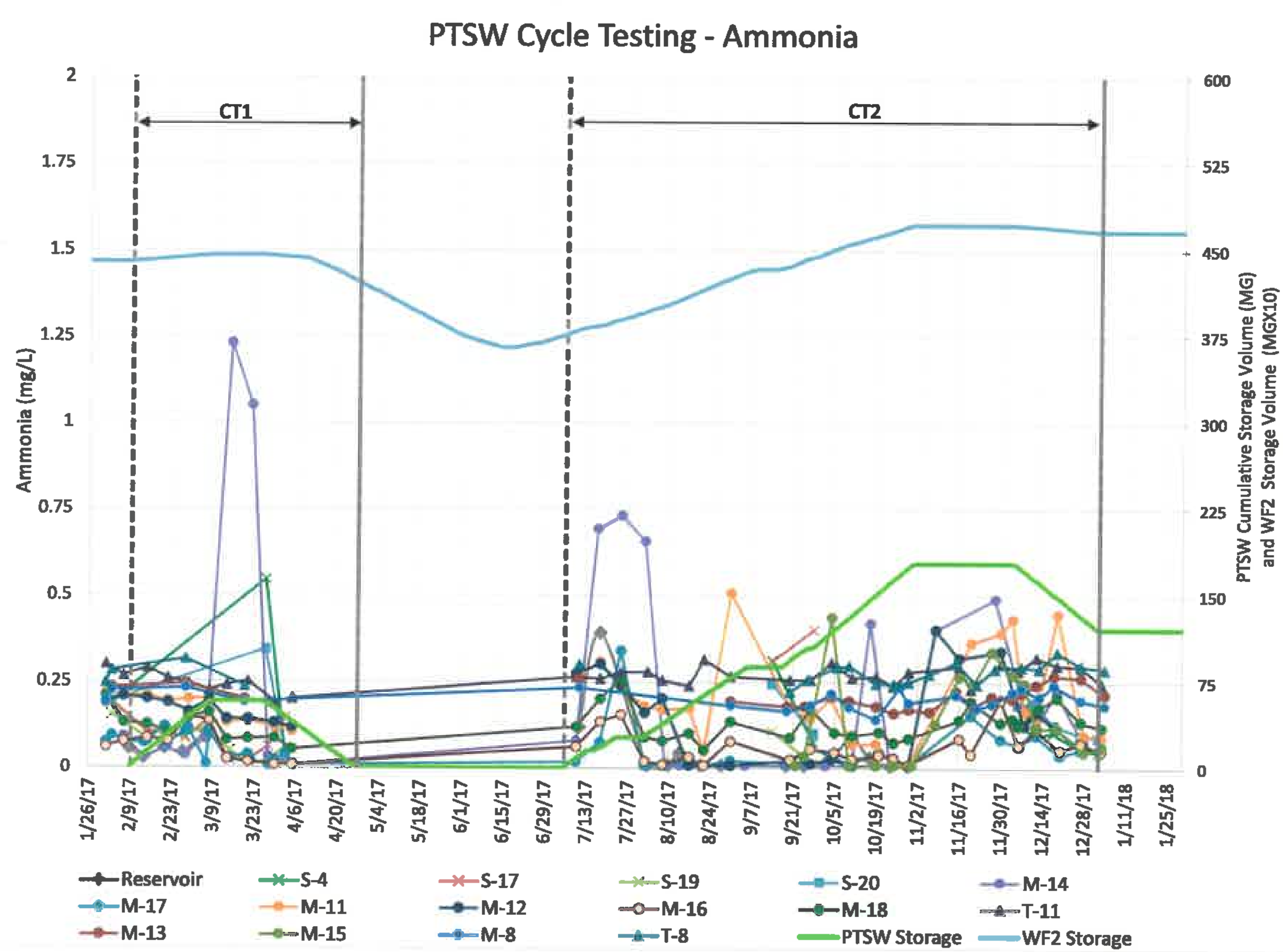

PTSW Cycle Testing - SO4
CT1
CT2
Sulfate (mg/L)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
240
220
200
180
160
140
120
100
80
60
40
20
0
600
550
500
450
400
350
300
250
200
150
100
50
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

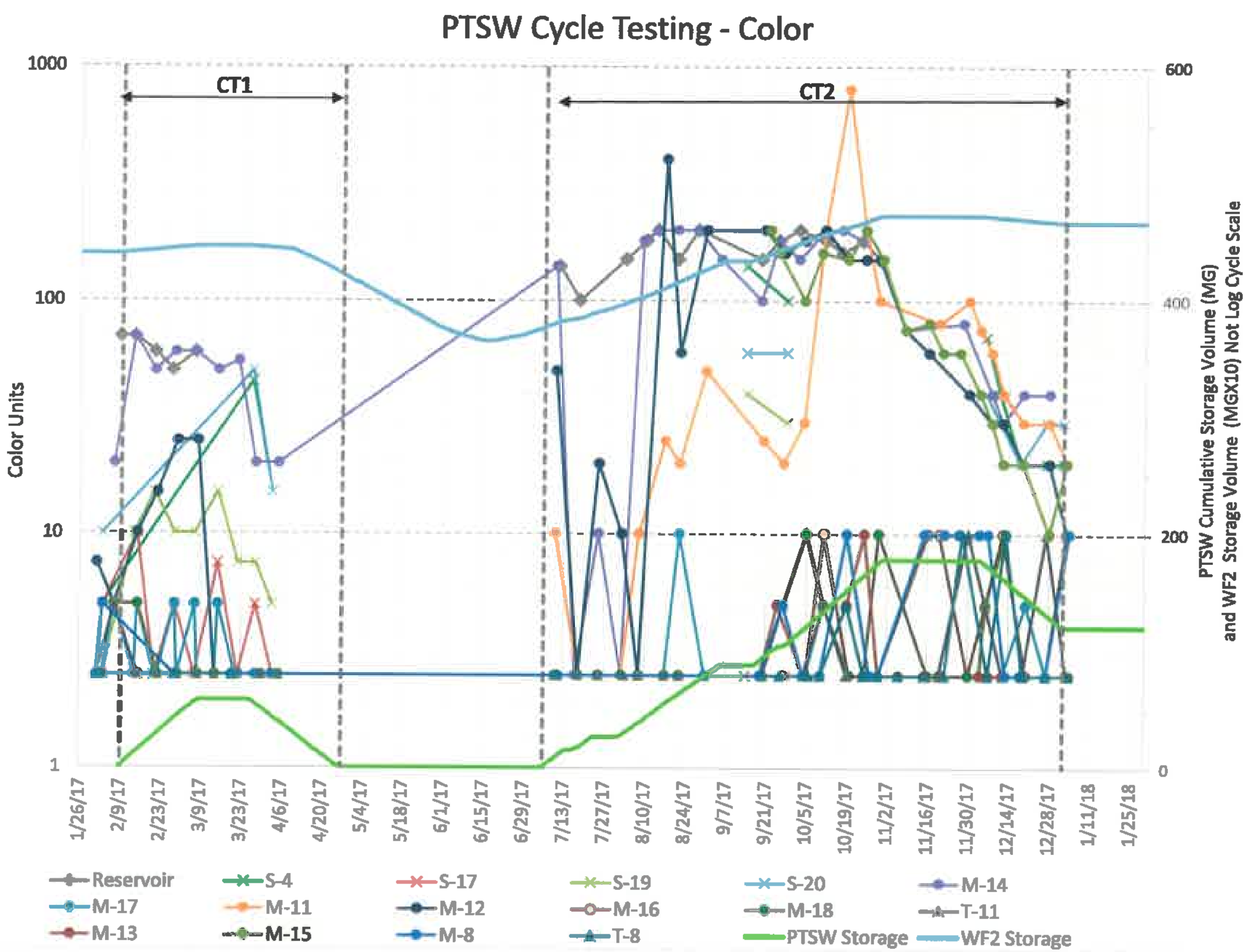

PTSW Cycle Testing - Chloride
CT1
CT2
Chloride (mg/L)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
600
560
520
480
440
400
360
320
280
240
200
160
120
80
40
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

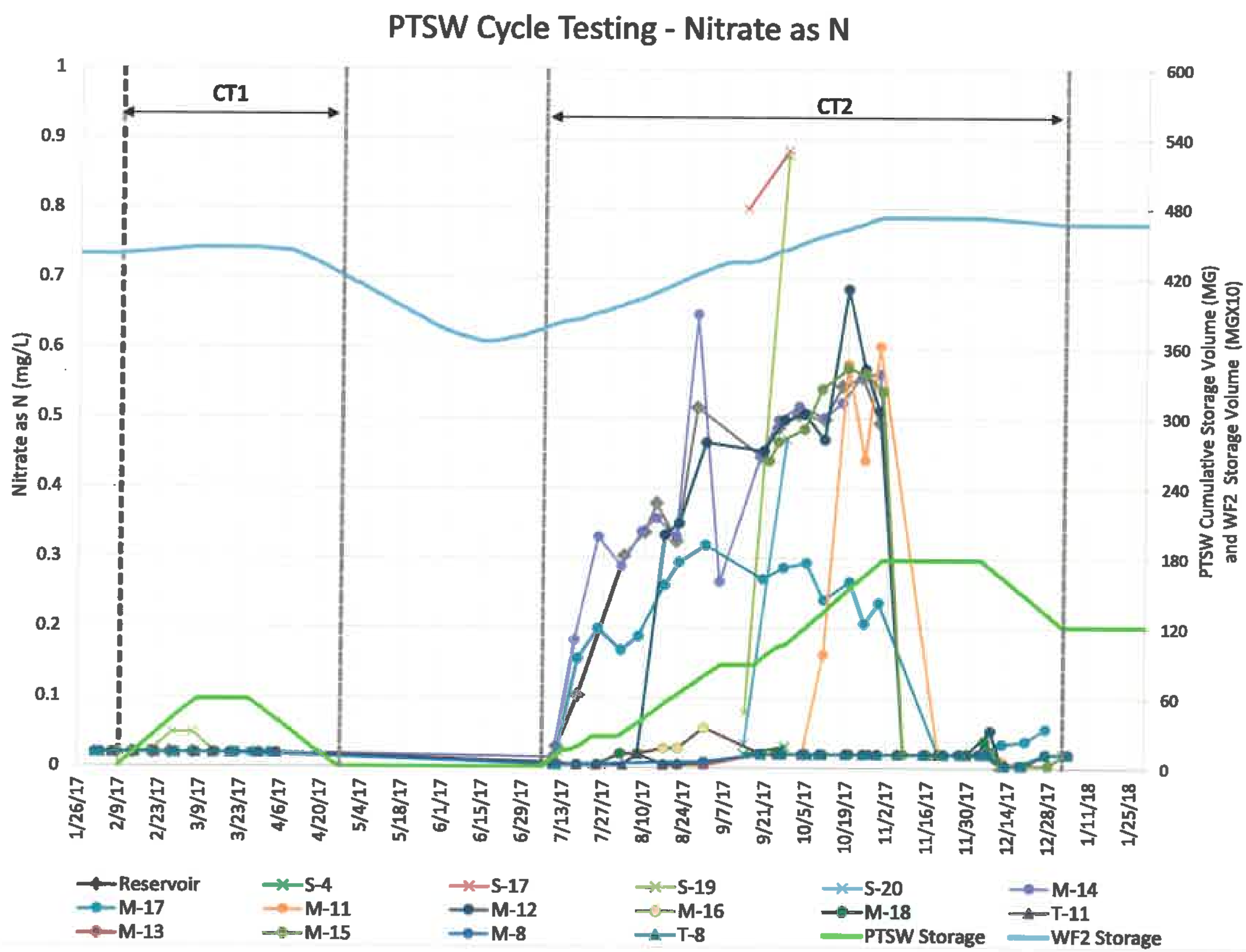

PTSW Cycle Testing - Total Dissolved Solids
CT1
CT2
TDS (mg/L)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
480
450
420
390
360
330
300
270
240
210
180
150
120
90
60
30
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

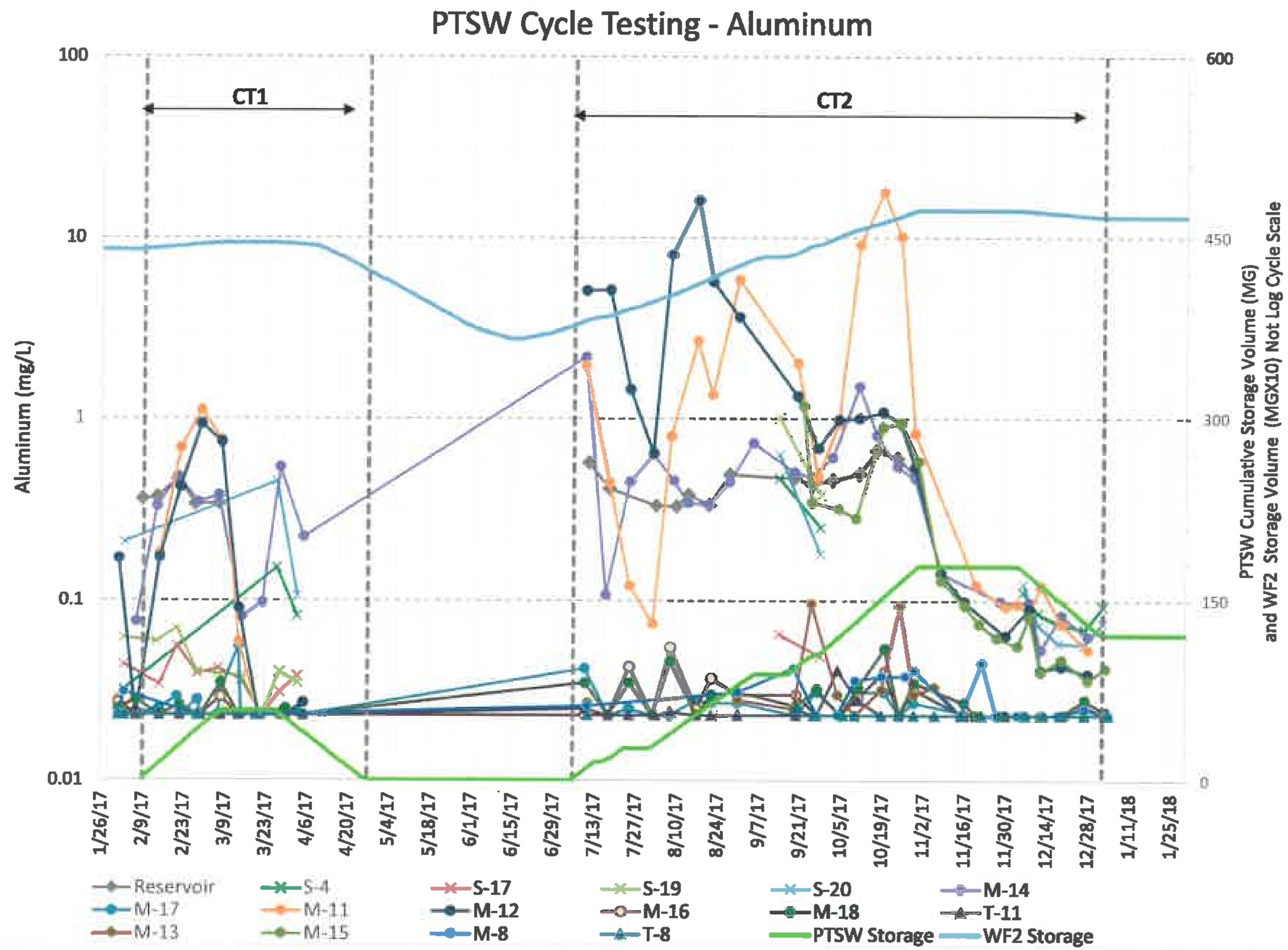

PTSW Cycle Testing - Total Suspended Solids
CT1
CT2
TSS (mg/L)
10000
1000
100
10
1
0.1
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
600
480
360
240
120
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage


PTSW Cycle Testing - TKN
CT1
CT2
TKN (mg/L)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
10
9
8
7
6
5
4
3
2
1
0
600
540
480
420
360
300
240
180
120
60
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

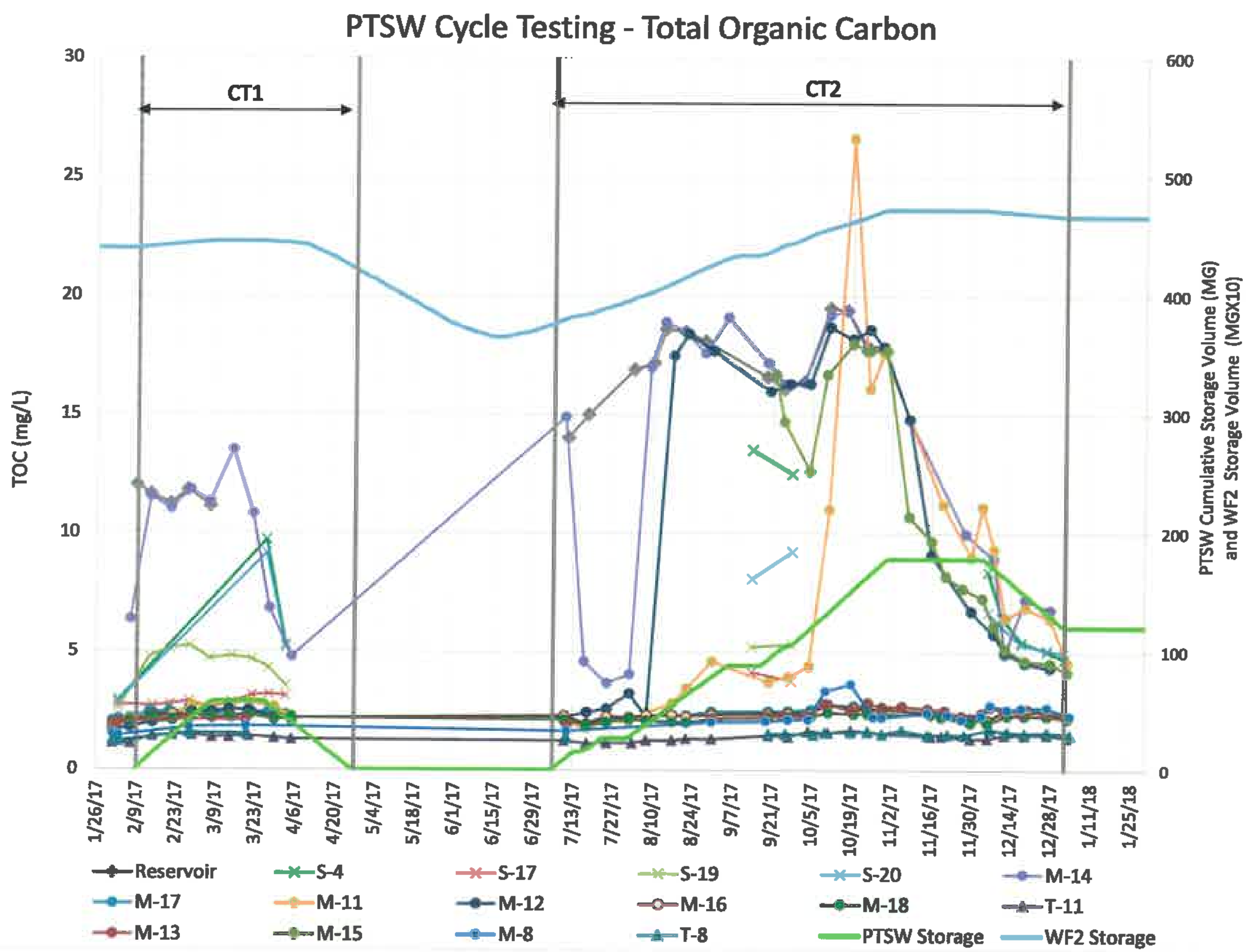

PTSW Cycle Testing - Ammonia
CT1
CT2
Ammonia (mg/L)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
600
525
450
375
300
225
150
75
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

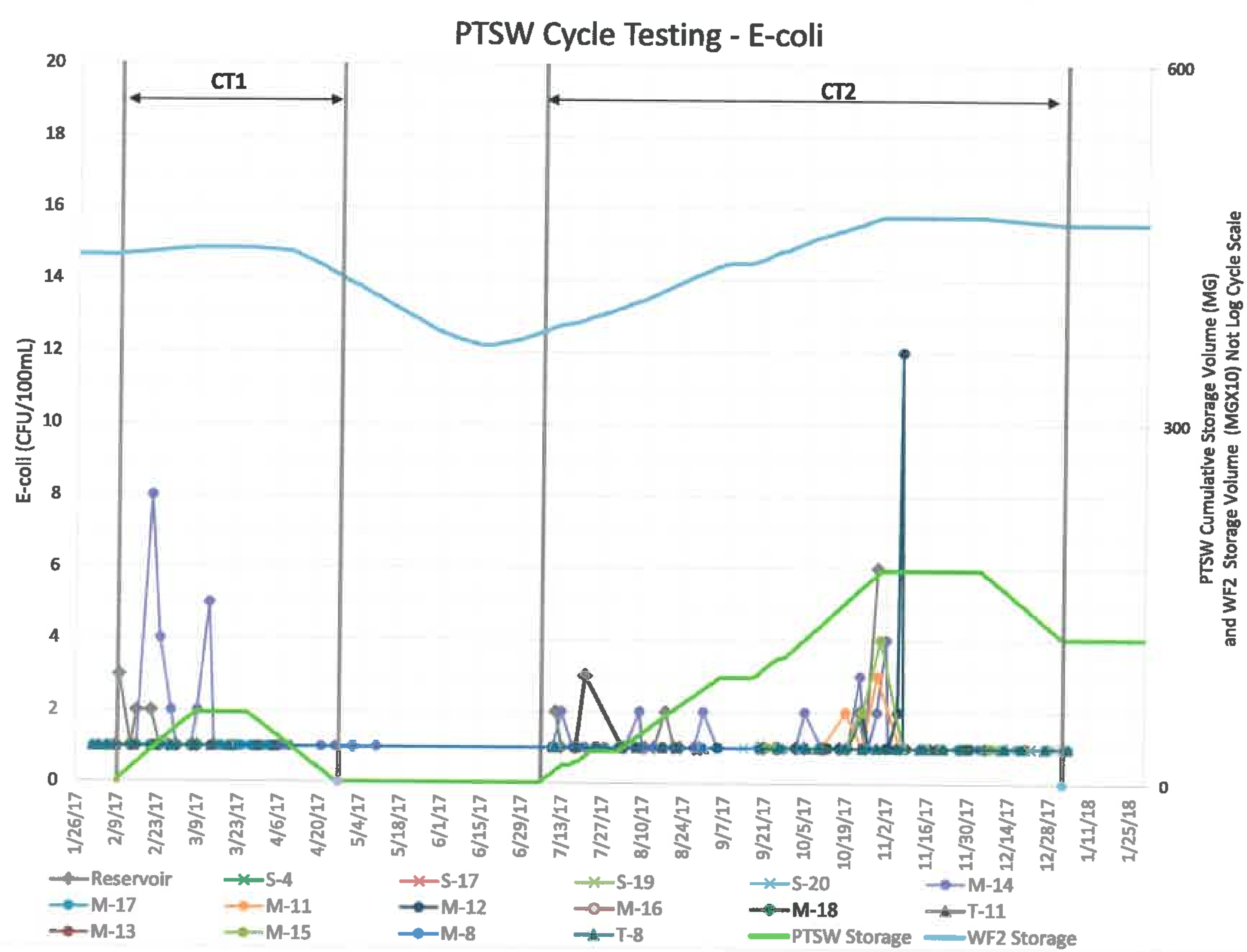

PTSW Cycle Testing - Color
Color Units
1000
100
10
1
CT1
CT2
600
400
200
0
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10) Not Log Cycle Scale
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage


PTSW Cycle Testing - Nitrate as N
CT1
CT2
Nitrate as N (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
0
60
120
180
240
300
360
420
480
540
600
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage



PTSW Cycle Testing - Aluminum
CT1
CT2
Aluminum (mg/L)
100
10
1
0.1
0.01
600
450
300
150
0
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10) Not Log Cycle Scale
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage


PTSW Cycle Testing - Total Organic Carbon
CT1
CT2
TOC (mg/L)
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10)
30
25
20
15
10
5
0
600
500
400
300
200
100
0
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage


PTSW Cycle Testing - E-coli
CT1
CT2
E-coli (CFU/100mL)
20
18
16
14
12
10
8
6
4
2
0
600
300
0
PTSW Cumulative Storage Volume (MG)
and WF2 Storage Volume (MGX10) Not Log Cycle Scale
1/26/17
2/9/17
2/23/17
3/9/17
3/23/17
4/6/17
4/20/17
5/4/17
5/18/17
6/1/17
6/15/17
6/29/17
7/13/17
7/27/17
8/10/17
8/24/17
9/7/17
9/21/17
10/5/17
10/19/17
11/2/17
11/16/17
11/30/17
12/14/17
12/28/17
1/11/18
1/25/18
Reservoir
S-4
S-17
S-19
S-20
M-14
M-17
M-11
M-12
M-16
M-18
T-11
M-13
M-15
M-8
T-8
PTSW Storage
WF2 Storage

Appendix E
Iron, Arsenic, and Phosphorus Geochemistry during Cycle Test 2

IRON, ARSENIC, AND PHOSPHORUS GEOCHEMISTRY DURING CYCLE TEST 2, WELLFIELD 2, PEACE RIVER FACILITY

1. Groundwater Geochemistry of Arsenic Mobilization and Attenuation.

Arsenic mobilization due to pyrite oxidation is common in potable water ASR systems in the Upper Floridan Aquifer of Florida, including at the Peace River Facility. Arsenic mobilization and subsequent attenuation is less commonly observed during ASR cycle tests. Arsenic mobilization during recharge, and attenuation during storage and recovery was quantified during four cycle tests at the Kissimmee River ASR system (KRASR; Mirecki et al., 2013). Lightly treated surface water (filtration and UV disinfection) was recharged into the Upper Floridan Aquifer during four successive cycle tests at the KRASR facility.

Two mechanisms of arsenic attenuation have been identified and observed at ASR systems: 1) arsenic sorption on iron oxides; and 2) arsenic coprecipitation in iron sulfides. Arsenic sorption onto iron oxide surfaces in the aquifer occurs under primarily oxidizing redox conditions. Iron oxide is stable as grain coatings and fracture coatings in the aquifer, even if dissolved oxygen is absent. Arsenic coprecipitation in iron sulfides occurs under primarily reducing redox conditions. Iron oxide solids are not stable in the presence of dissolved hydrogen sulfide, and will dissolve, releasing sorbed arsenic back into groundwater. However, if sufficient dissolved iron and hydrogen sulfide are present in the aquifer, sulfate-reducing bacteria will facilitate precipitation of iron sulfide. Arsenic is co-precipitated with the iron sulfide solid, effectively removing arsenic from groundwater.

Both attenuation reactions can be characterized by iron and arsenic concentrations in monitor well samples, primarily during the static conditions of storage. In both arsenic attenuation reactions, iron concentrations should decline (dissolved iron precipitates as either solid iron oxide or solid iron sulfide). Arsenic concentrations should also decline, due to sorption onto iron oxides, or by co-precipitation of iron sulfide. Phosphorus behaves similarly to arsenic, so these trends should apply to phosphorus as well.

2. Iron, Arsenic, and Phosphorus Concentration Trends during Cycle Test 2.

Trends in iron and arsenic concentrations during cycle test 2 are shown in a series of plots of water quality data from monitor wells **(Figure 1)**. All monitor wells show similar trends during cycle test 2.

- Iron concentrations are highly variable during recharge (0.14 mg/L to 0.48 mg/L in all monitor wells).
- Iron concentrations peak, and then decline during storage.
- Iron concentrations reach a minimum during recovery.
- Arsenic concentrations generally increase during storage and recovery.
- Phosphorus concentrations generally decrease during storage and recovery.

These trends do not confirm either mechanism (described above) of arsenic attenuation. However, there are some indications that suggest that arsenic and phosphorus attenuation can occur when surface water is recharged in the Upper Floridan Aquifer (Suwannee Limestone Permeable Zone).

a. Iron Concentration Trends

Variable iron concentrations in monitor well samples during recharge probably result from interruptions in the water supply during Hurricane Irma and from operational issues, and also due to variable iron concentrations in recharge water (as measured at S-4 and S-20). The mean iron concentration in recharge water is 0.353 +/- 0.256 mg/L (S-4 and S-20, coefficient of variation 72%, n=4).

Iron concentrations peak during the static conditions of storage, at concentrations that equal or exceed that of recharge water (see M-14, **Figure 1**). This suggests that iron is mobilized during recharge and early storage. The only geochemical mechanism that can increase groundwater iron concentrations above that of recharge water is dissolution of pre-existing iron oxide solids in the aquifer as can happen in the presence of hydrogen sulfide in reducing redox conditions, as discussed earlier.

Declining iron concentrations are observed in all proximal monitoring wells after approximately two weeks of storage. Iron concentrations decline from approximately 0.3 to 0.4 mg/L to less than 0.2 mg/L. The mean iron concentration in recovered water is 0.155 +/- 0.055 mg/L (S-4 and S-20, coefficient of variation 35%, n=8). Similar iron concentrations are shown in monitor wells during recovery. Declining iron concentrations during storage strongly suggest precipitation of an iron solid in the aquifer. Iron concentrations reach minimum values during recovery.

b. Estimating Aquifer Redox Environment

Oxidizing versus reducing conditions in the aquifer will control whether that solid is an iron oxide or iron sulfide, respectively. Iron oxide solids are stable in the presence of dissolved oxygen and the absence of dissolved hydrogen sulfide. Iron sulfide solids are stable only where there is sufficient dissolved iron and hydrogen sulfide.

Dissolved oxygen concentrations measured in monitor well samples show measurable dissolved oxygen during storage and recovery. This is surprising, as dissolved oxygen concentrations usually decline quickly (hours or days) after recharge ends. Dissolved oxygen concentrations measured in monitor well during cycle test 2 are shown in **Figure 2**.

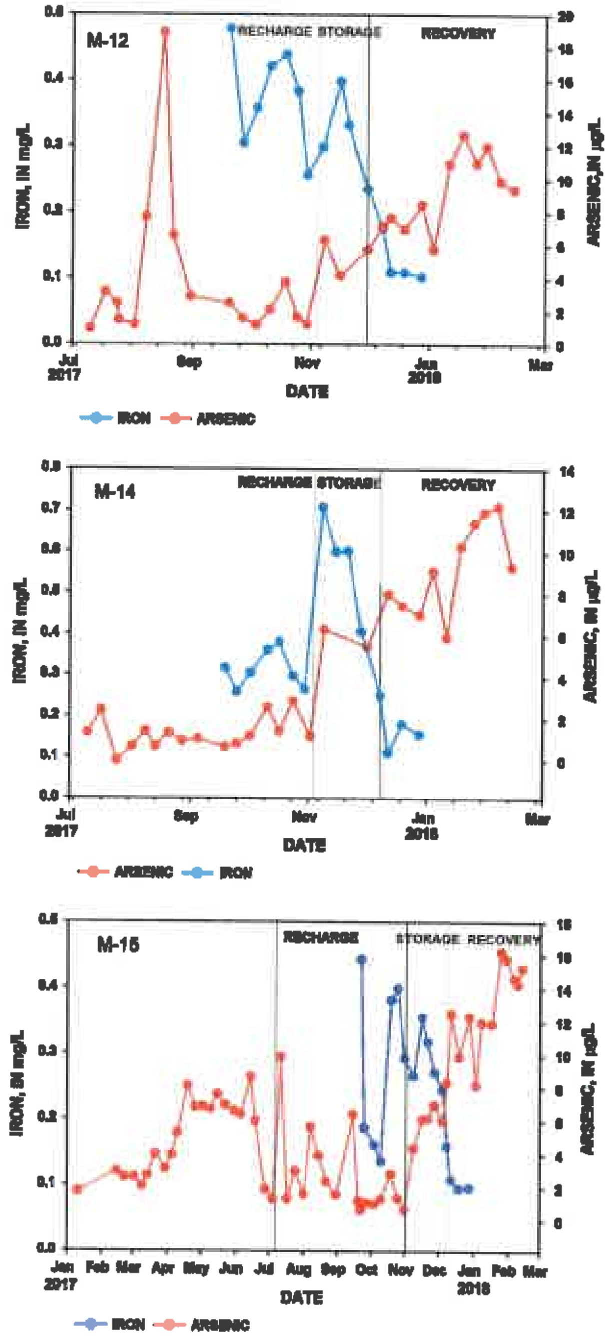


Figure 1. X-Y plots showing arsenic and iron concentrations in monitor well samples collected during cycle test 2.

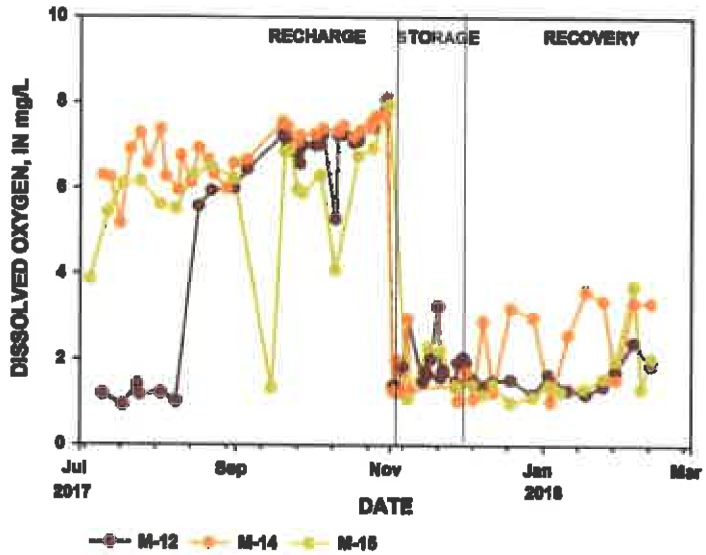


Figure 2. X-Y plot showing dissolved oxygen concentrations measured in monitor well samples during cycle test 2.

The presence of dissolved oxygen in monitor well samples during storage and recovery indicates that oxic to sub-oxic (dissolved oxygen concentrations less than 0.2 mg/L) redox conditions prevail in the aquifer during cycle test 2. Dissolved oxygen concentrations range between 1 mg/L and 4 mg/L in monitor wells during recovery. Measurable dissolved oxygen concentrations in monitor well samples during storage and recovery may have resulted from atmospheric exposure during sampling. However, even if dissolved oxygen is absent in storage and recovery samples, it is likely that iron oxide solids are stable under sub-oxic conditions. There are no data to suggest that dissolved hydrogen sulfide and precipitation of iron sulfide solids (that is, reducing conditions) exerts control on iron and arsenic in the aquifer.

c. Arsenic Concentration Trends

Arsenic concentrations generally increase in monitor well samples during recharge, which is the typical result of pyrite oxidation when oxic recharge water is introduced into an aquifer (**Figure 1**). The mean dissolved oxygen concentration of the reservoir water during recharge was 7.7 mg/L, which is sufficient to induce pyrite oxidation and arsenic mobilization at locations of proximal monitor wells.

Arsenic concentrations continue to increase in monitor well samples through storage and recovery phases of cycle test 2. The increase in arsenic concentrations is simultaneous with declining iron concentrations. So, even though declining iron suggests that iron oxide solids are precipitating during cycle test 2, attenuation resulting from sorption on the iron oxide surface is not indicated. Iron oxide is very insoluble under near-neutral pH and sub-oxic redox conditions, so precipitation would be expected to occur quickly, on the order of days. Arsenic sorption may occur more slowly. Also, arsenic and phosphorus compete for binding sites on iron oxide surfaces.

d. Total Phosphorus Concentration Trends

Dissolved arsenic and phosphorus often behave similarly when considering the types of reactions between water and minerals. Arsenic is just below phosphorus on the periodic table of elements, so aqueous speciation and reactions are similar. Trends in total phosphorus concentrations are shown in **Figure 3.**

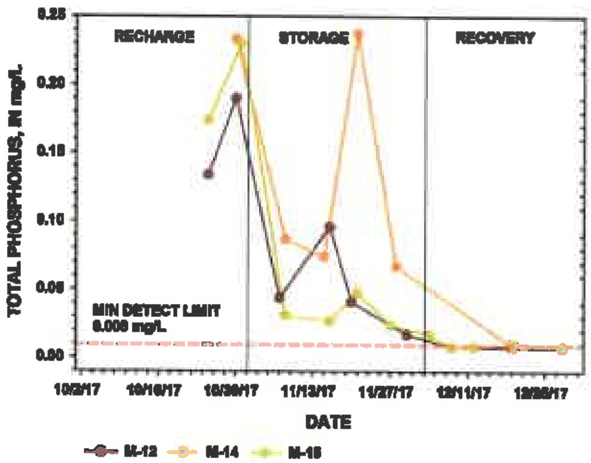


Figure 3. X-Y plot showing trends in total phosphorus concentrations measured in monitor wells.

Phosphorus would originate from two sources: 1) from partially treated surface water during recharge; and/or 2) release of sorbed phosphorus if iron oxide solids become unstable and dissolve under reducing conditions. It is likely that both sources contribute to phosphorus in the aquifer during cycle test 2. Total phosphorus concentrations measured in reservoir samples are 0.251 mg/L and 0.155 mg/L, identical to the range of concentrations measured in proximal monitor well samples during recharge. Total phosphorus concentrations vary during storage, possibly reflecting increases that result from iron oxide dissolution and release of sorbed phosphorus. However, unlike arsenic, total phosphorus concentrations decline during late storage and recovery. Because iron oxide solids are stable in the aquifer during these phases of cycle test 2, it is possible that arsenic and phosphorus compete for binding sites on iron oxide solids. Because phosphorus concentrations are far greater, phosphorus is likely sorbed preferentially compared to arsenic.

3. Conclusions and Recommendations

Cycle test 2 of the Partially Treated Surface Water Pilot Test was of relatively short duration. However, data are sufficient to identify major geochemical trends of iron, arsenic, and phosphorus in the ASR and proximal monitoring wells. Major conclusions are as follows:

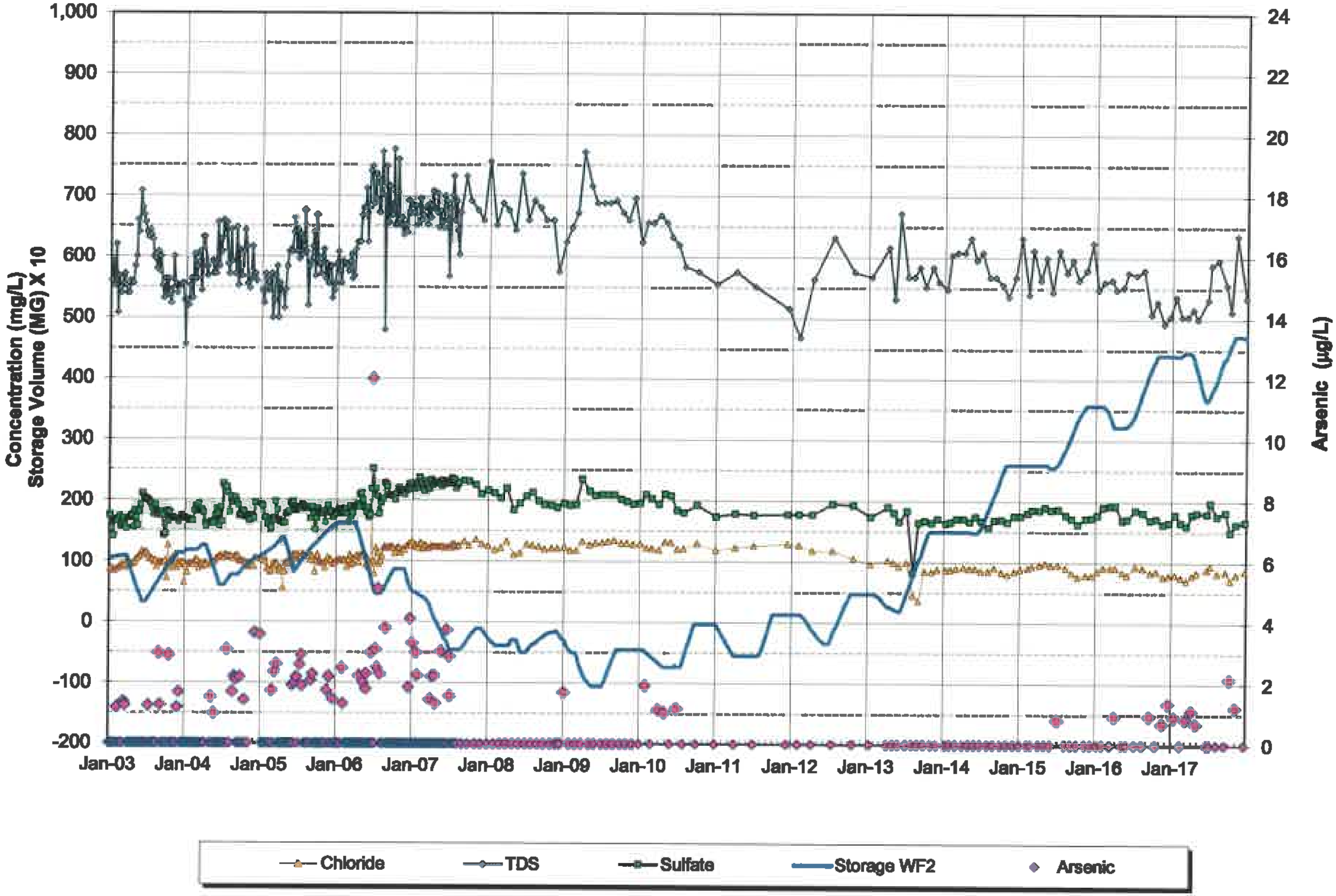
- Dissolved iron and dissolved oxygen concentrations obtained during cycle test 2 indicate a mostly oxic to sub-oxic redox condition in the storage zone throughout the test. These conditions favor iron oxide as a stable solid existing as grain and fracture coatings.
- Arsenic is mobilized during the recharge phase of cycle test 2, and concentrations increase to a maximum value of 12.3 µg/L (M-12), 12.7 µg/L (M-14), and 16.2 µg/L (M-15) through the recovery phase. Despite the presence of stable iron oxide, arsenic sorption is not clearly shown.

- Phosphorus concentrations increase during recharge in monitor well samples, then subsequently decline during late storage and recovery. The geochemical behavior of arsenic and phosphorus are similar in that both species will sorb onto binding sites on iron oxide solids. Because phosphorus occurs at much higher concentrations than arsenic, it is possible that phosphorus sorption occurs preferentially on a finite number of binding sites on the solid. Phosphorus concentrations decline from approximately 0.2 mg/L to <0.008 mg/L (the detection limit) during late storage and recovery.

Two factors would clarify controlling geochemical reactions of iron, arsenic, and phosphorus during PTSW cycle testing, and these are recommended for future testing.

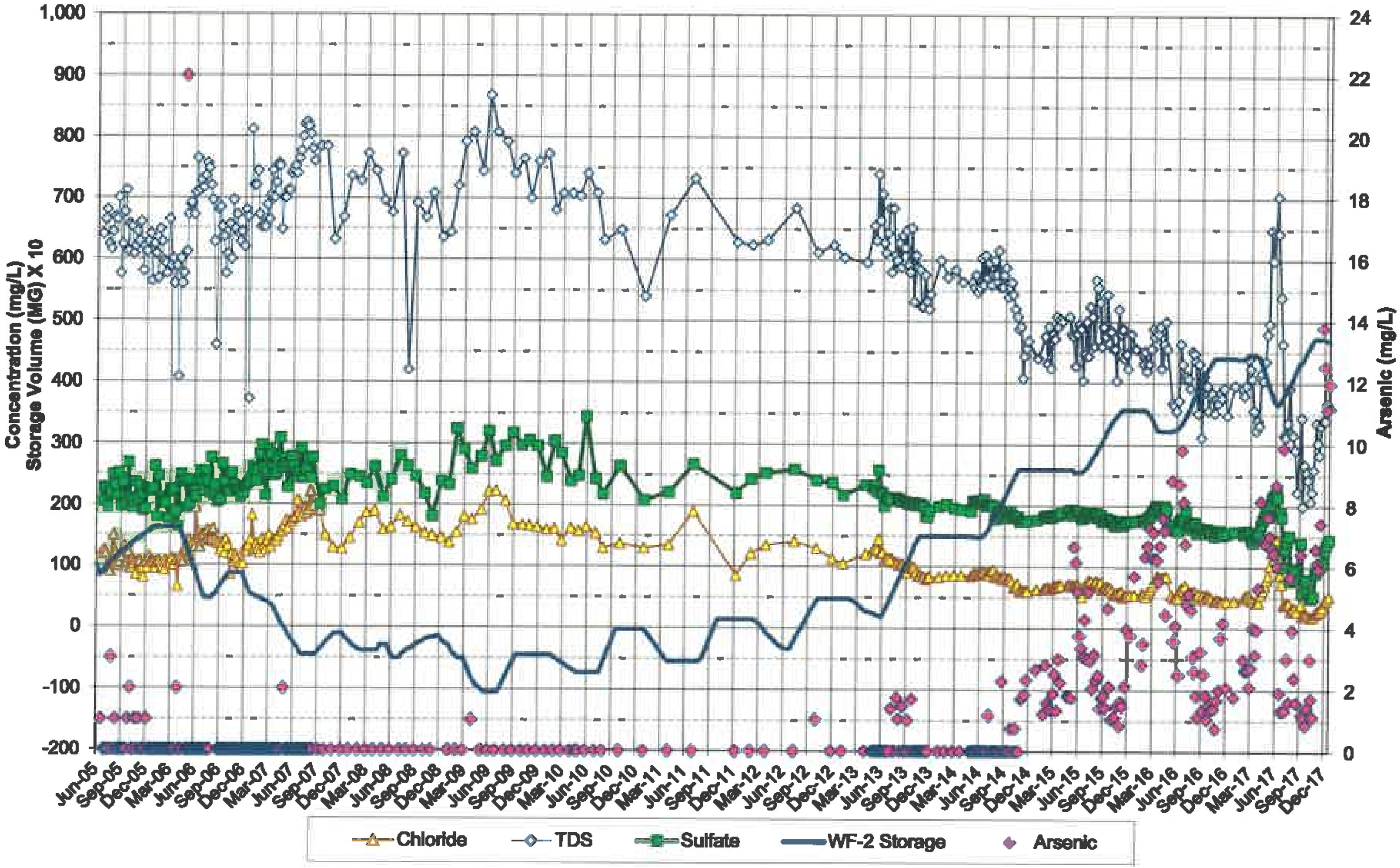
- Data for more conclusive characterization of aquifer redox environment. Dissolved oxygen measurements must not contact the atmosphere during sampling. The presence or absence of dissolved hydrogen sulfide requires confirmation. Iron, arsenic and phosphorus should be measured in every sample.
- The duration of storage should be increased, if possible. One month of storage may not be sufficient for the aquifer to equilibrate under static conditions

Appendix F
PTSW Monitor Wells Water Quality



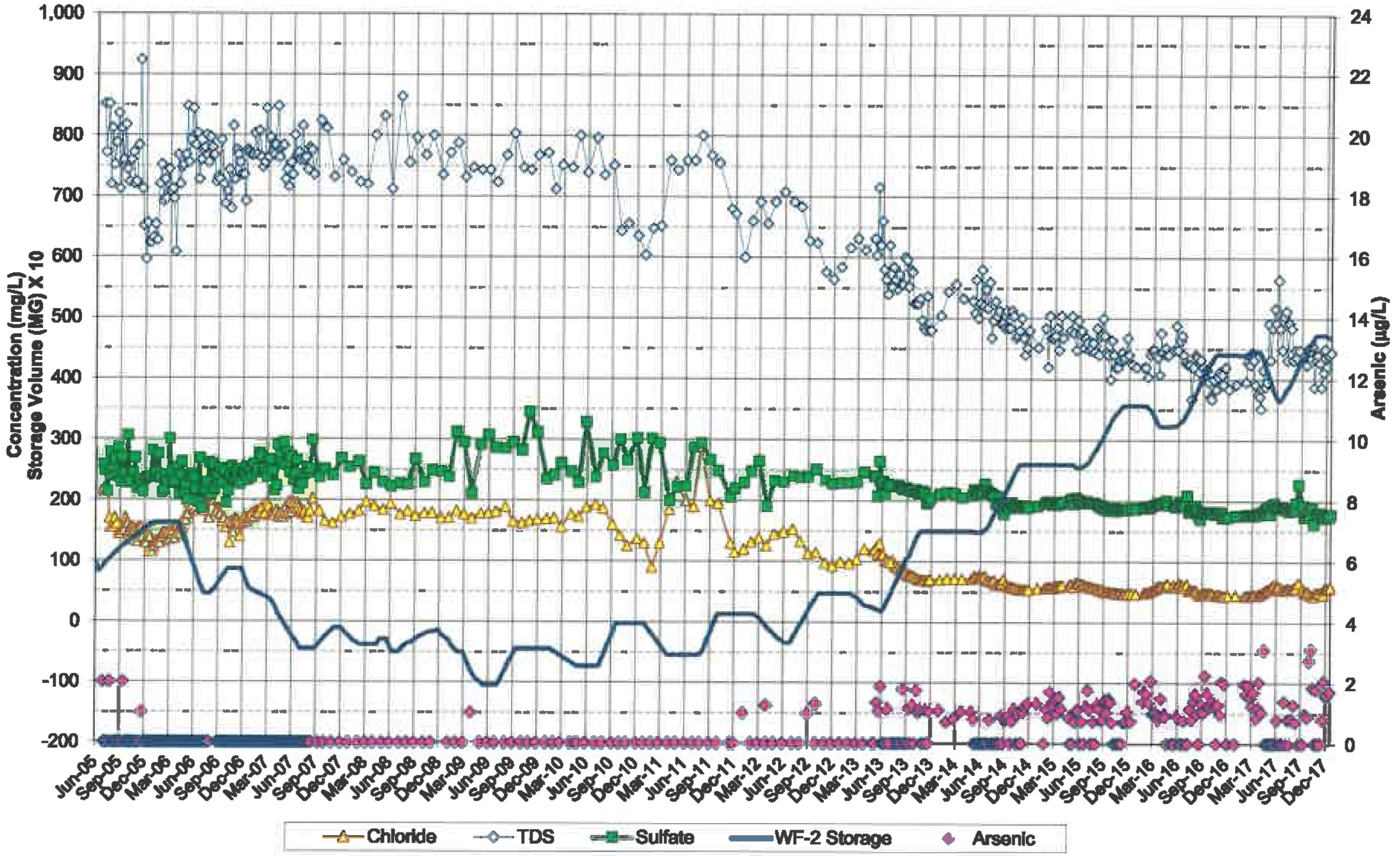
Note: Values reported at below method detection limits are shown as zero

Appendix F-1
Monitoring Well M-8 Water Quality



Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

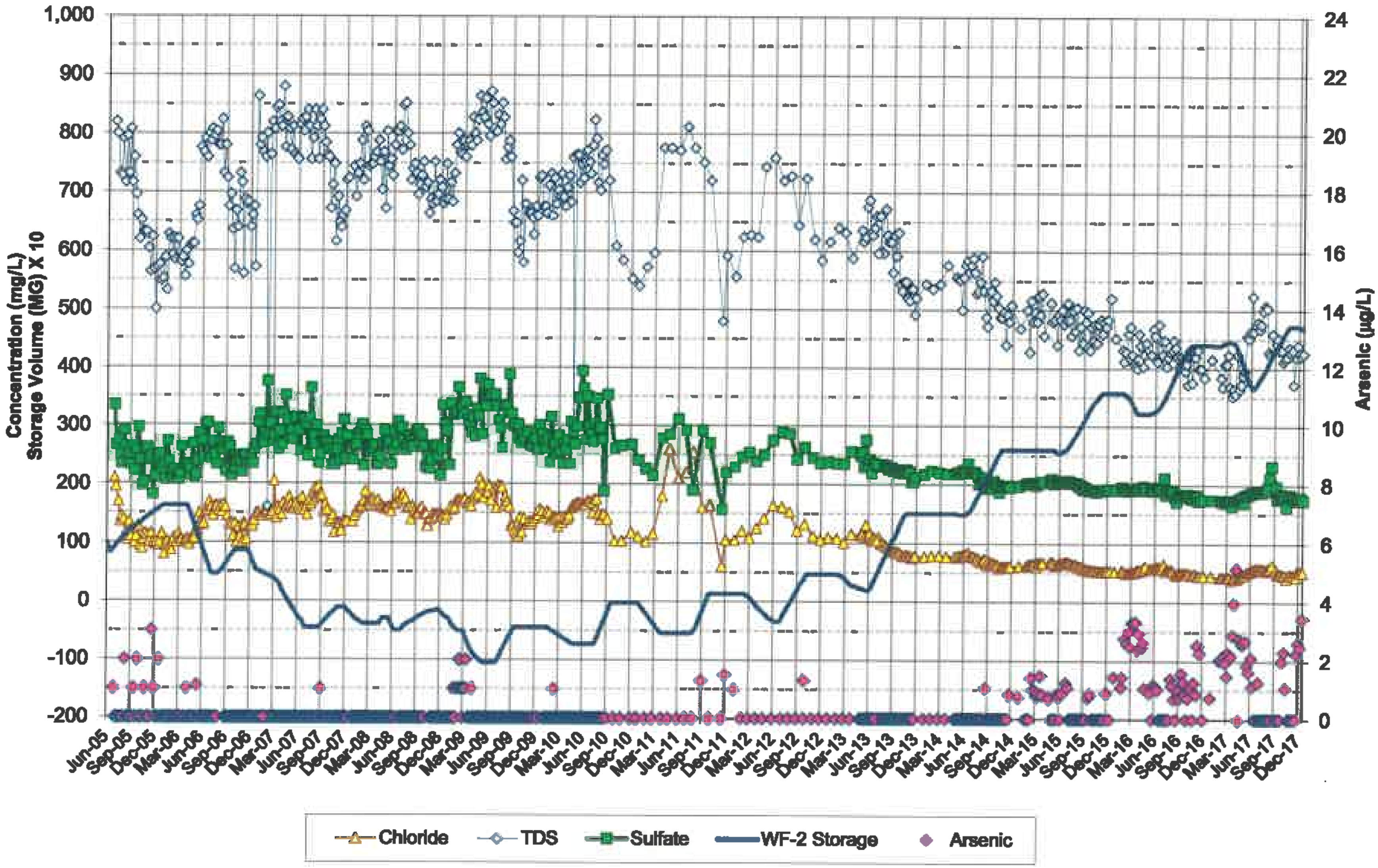
Appendix F-2
Monitoring Well M-15 Water Quality



Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

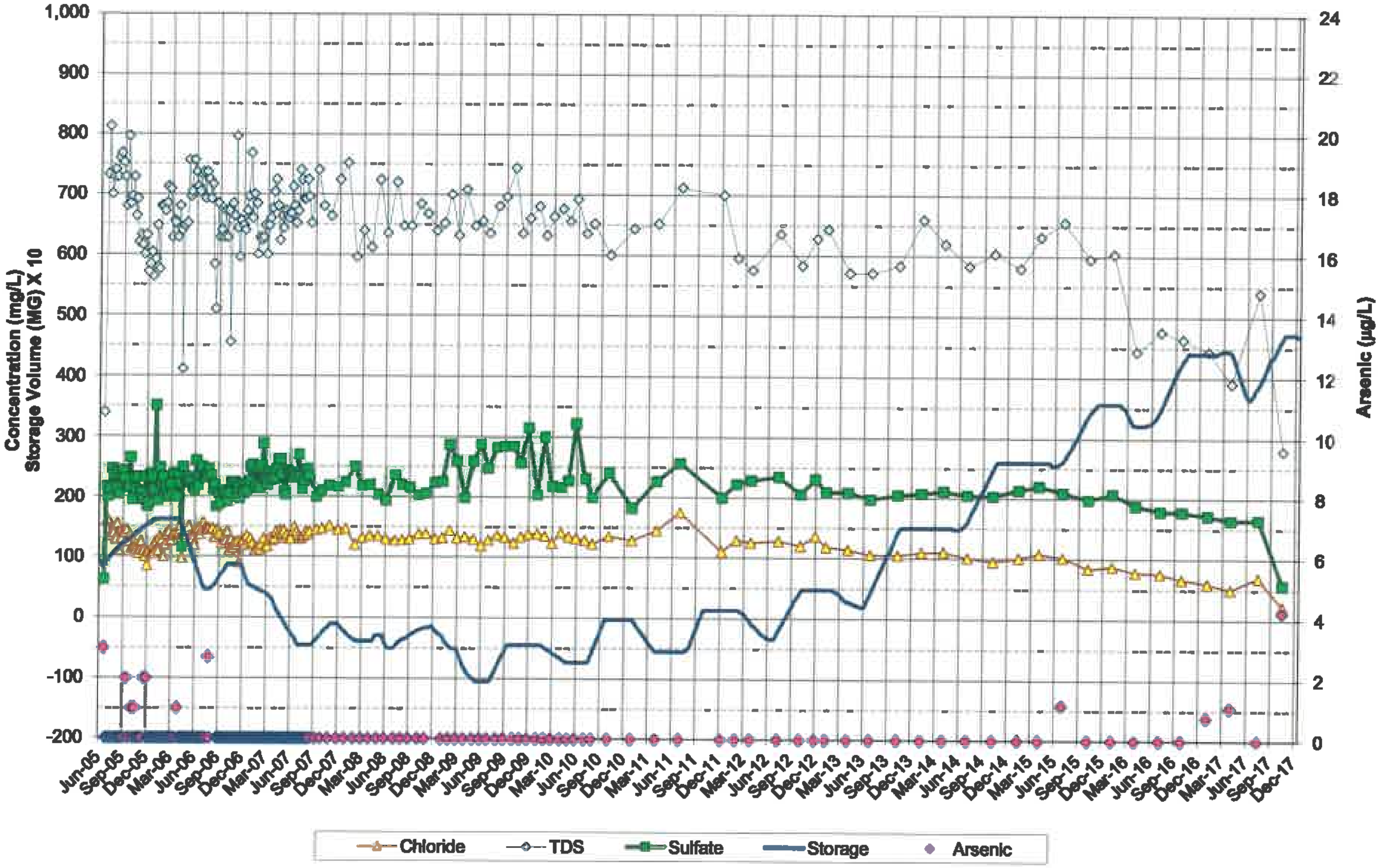
Appendix F-3

Monitoring Well M-18 Water Quality



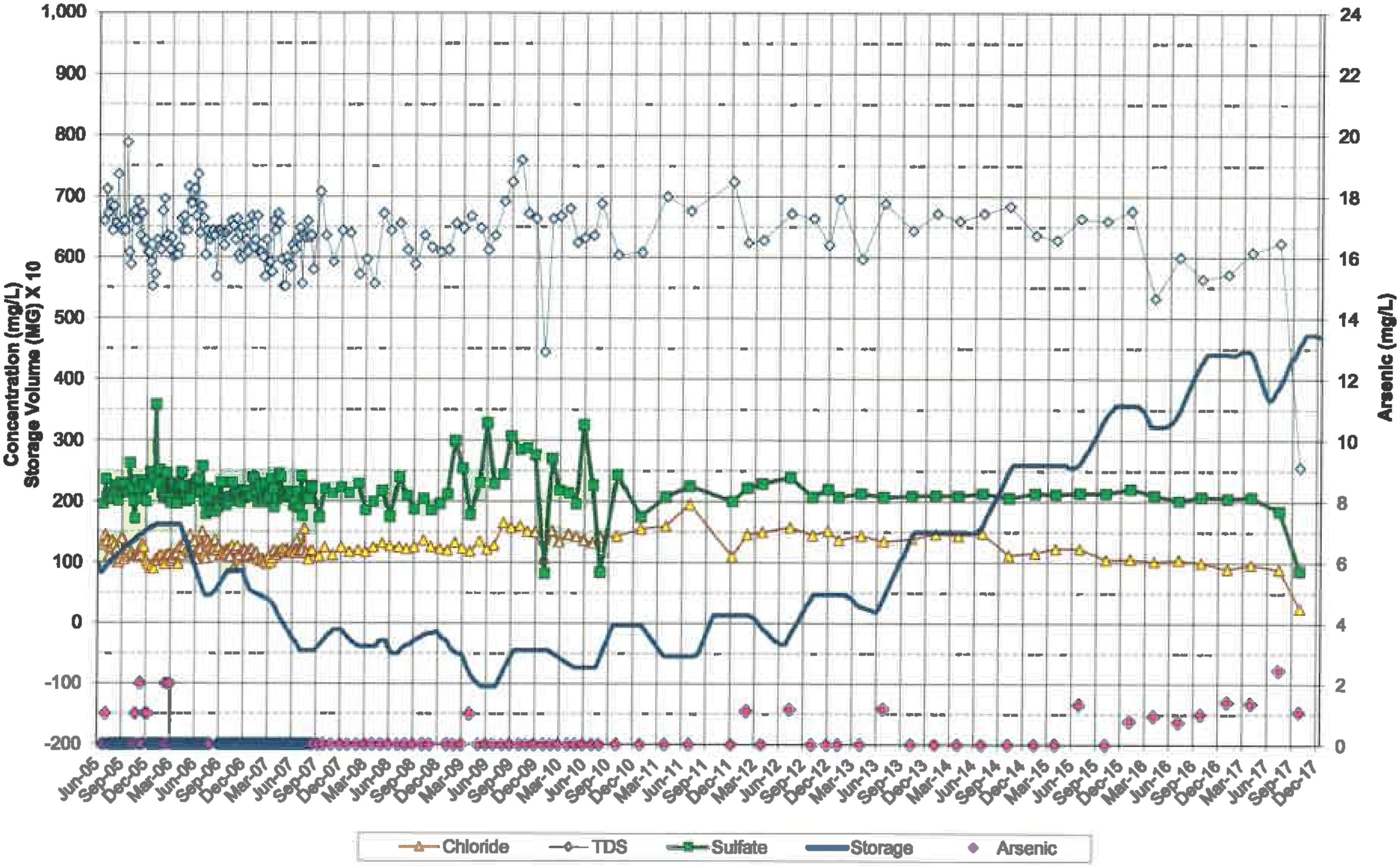
Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

Appendix F-4
Monitoring Well M-19 Water Quality



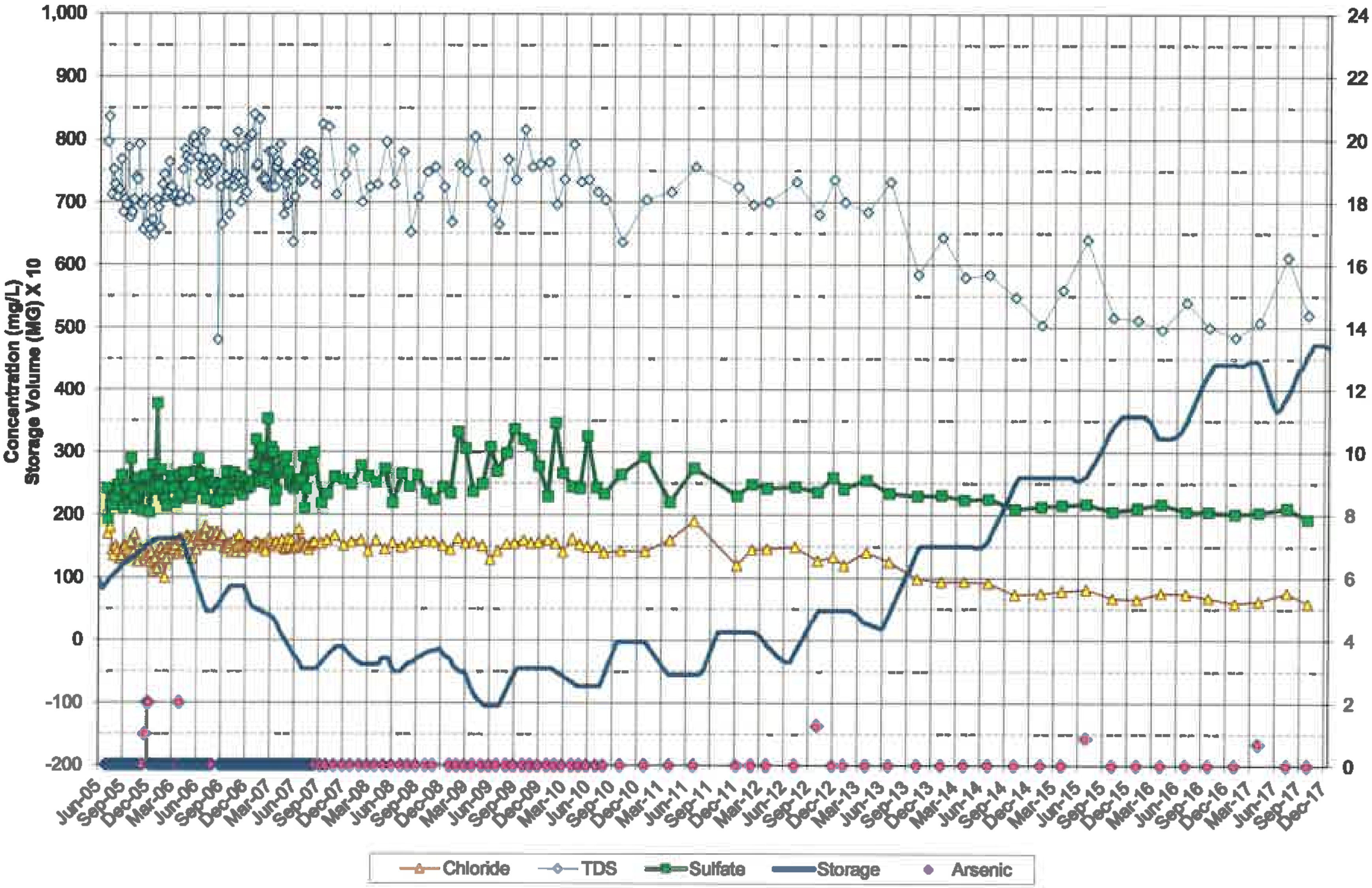
Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

Appendix F-5
Monitoring Well M-11 Water Quality



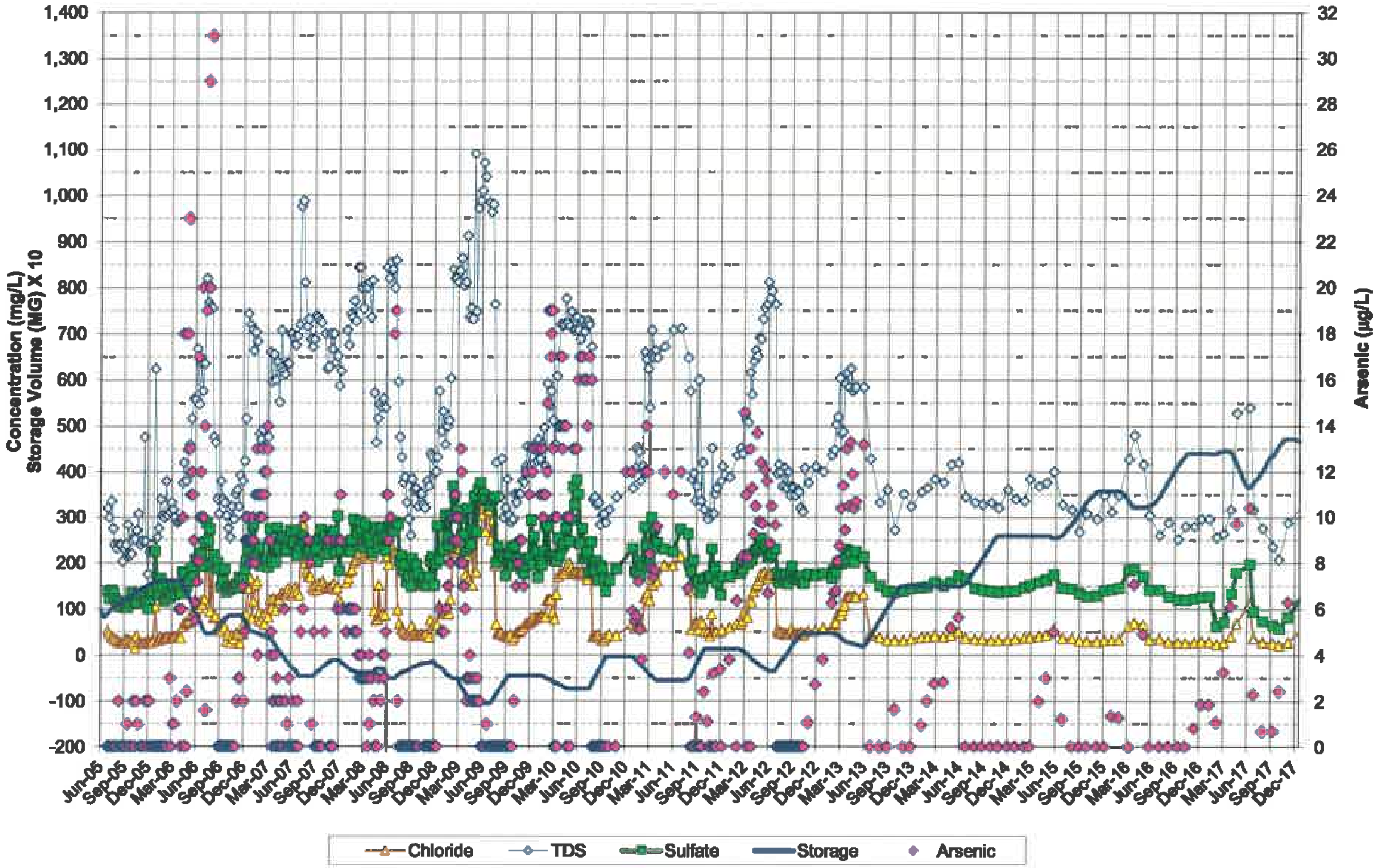
Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

Appendix F-6
Monitoring Well M-12 Water Quality



Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

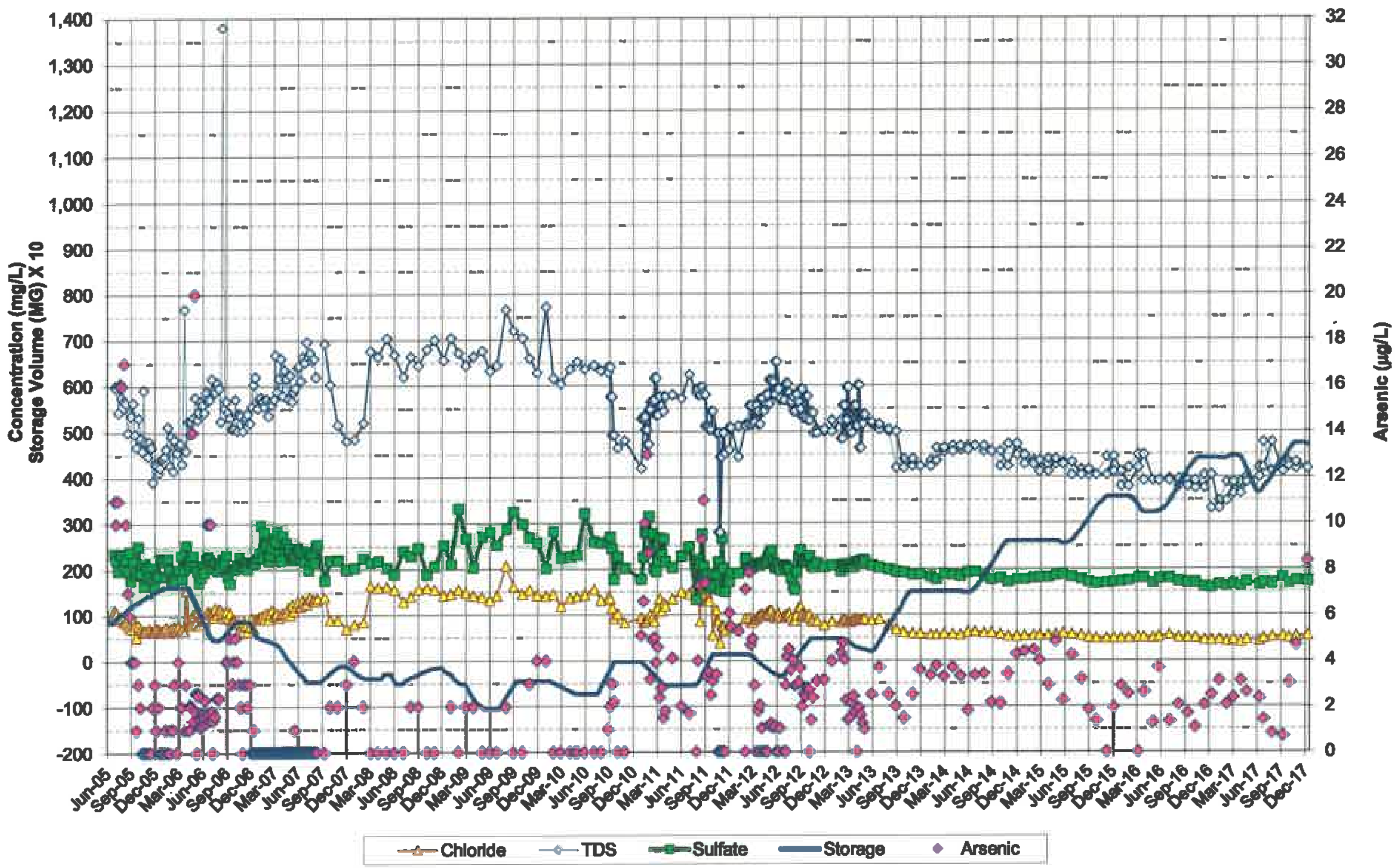
Appendix F-7
Monitoring Well M-13 Water Quality



Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

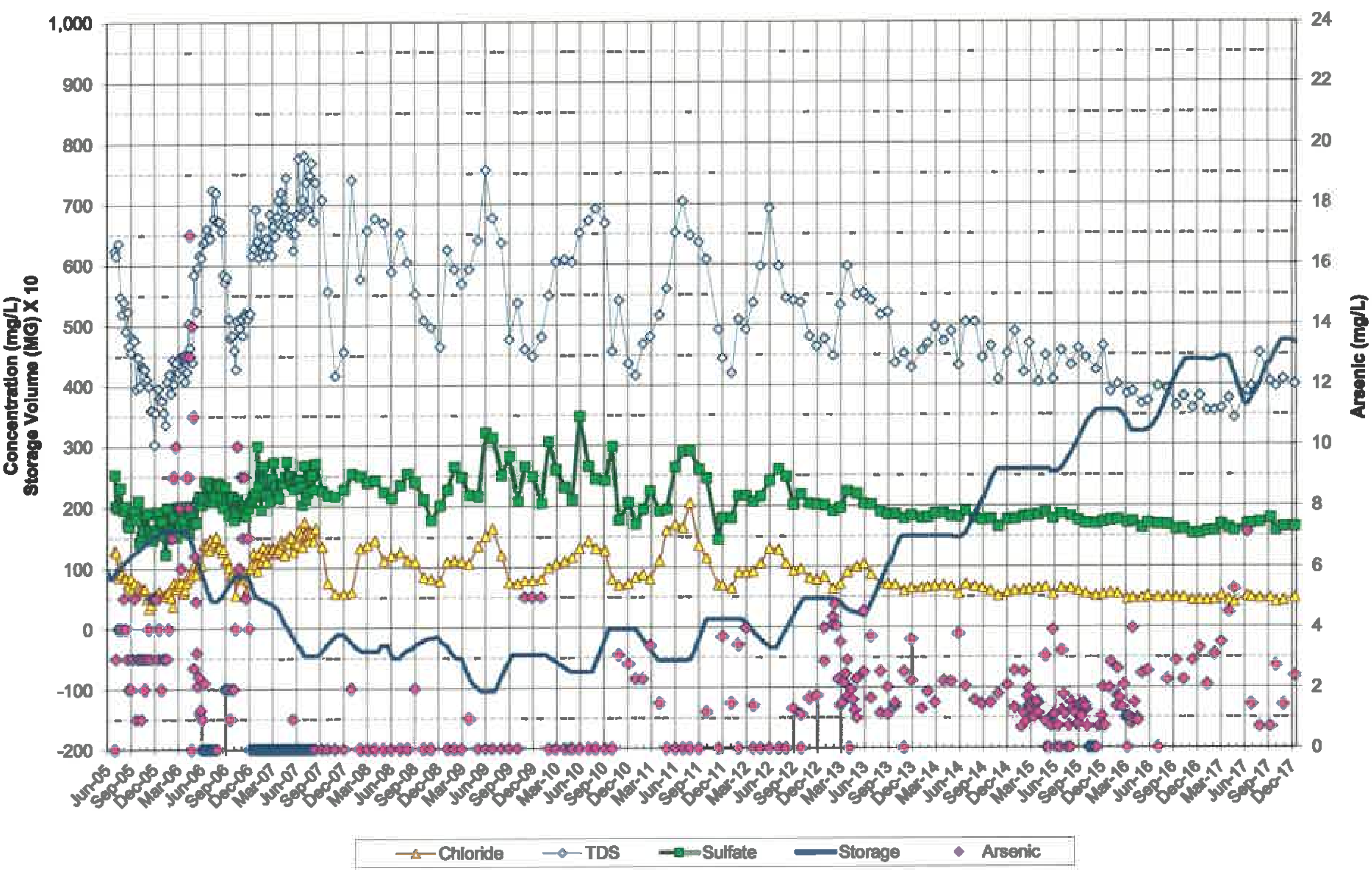
Appendix F-8

Monitoring Well M-14 Water Quality



Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

Appendix F-9
Monitoring Well M-16 Water Quality



Note: For the purpose of this graphic any readings below the laboratory method detection limit were assigned zero

Appendix F-10
Monitoring Well M-17 Water Quality