Revised Phase II Comprehensive Site Assessment

Cape Cod Gateway Airport
Hyannis, Massachusetts

RTN 4-26347

January 2022

Prepared for:
Cape Cod Gateway Airport
480 Barnstable Road Hyannis,
MA 02840

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1.0 INTRODUCTION

The Horsley Witten Group, Inc. (HW) has been retained by the Cape Cod Gateway Airport (the "Airport") to prepare this revised Phase II Comprehensive Site Assessment (Phase II) for its property located at 480 Barnstable Road, Hyannis, Massachusetts (Figure 1). The Phase II focuses on the release of Per- and Poly-Fluoroalkyl Substances (PFAS) in soil and groundwater and 1,4-dioxane in groundwater. For the purpose of this report, the term PFAS is defined as the laboraoty's analyte list as of the date of this Phase II. In general, the laboratories are reporting between 21 and 34 diffferent PFAS analtes. The Massachusetts Department of Environemtnal Protection (MassDEP) curently regulates six of these PFAS analytes.

On November 9, 2021, HW submitted a Notice of Delay in Compliance with Response Action Deadlines relating to the Phase III Remedial Action Plan for PFAS and 1,4-dioxane in soil and/or groundwater. The original deadline to submit this report was November 10, 2021. The delay was related to the following reasons as outlined below:

- On August 24, 2021, the Airport received a Notice of Audit Findings and Notice of Non-Compliance (Enforcement Document Number 00011495) that identified additional information that MassDEP required as part of the comprehensive audit of the Final Phase II Comprehensive Site Assessment submitted on March 12, 2021 (the "2021 Phase II").
- During subsequent discussions with MassDEP including two remote meetings held on August 30, 2021, and October 1, 2021, the Airport indicated that the Phase III Remedial Action Plan (Phase III Report) could not be completed until there was agreement regarding the source of the 1,4-dioxane groundwater plume and the extent of the Airports PFAS plumes documented in the 2021 Phase II. The Airport indicated that a comprehensive response to Notice of Audit Findings and Notice of Non-Compliance (the "Notice of Audit Findings Response") would be submitted to the MassDEP on November 10, 2021. The response provided additional documentation that the source of the 1,4-dioxane plume is related to unknown off-site source and that the Airports PFAS plume has not yet impacted the Maher Well Field. The response also included a new timeline for submittal of a revised Phase II and Phase III Report as follows:
    - Submission of the response to the Notice of Audit Findings: **November 10, 2021**
    - Receipt of comments/question from MassDEP: **December 10, 2021**
    - Submission of a revised Phase II Report: **January 28, 2022**
    - Submission of the Phase III Report: **April 1, 2022**

HW did not receive any questions or comments from MassDEP regarding the Notice of Audit Findings Response as of the date of this Phase II (January 28, 2022). A copy of the Notice of Audit Findings Response is included in Appendix A. It should also be noted that the supplemental information requested by MassDEP has not changed the findings of the 2021 Phase II.

2.0 EXECUTIVE SUMMARY

For the purpose of this report, the term "Airport" specifically refers to the Cape Cod Gateway Airport property located at 480 Barnstable Road, as set forth above, and the term "Disposal Site" refers to the area impacted by the release of oil and/or hazardous material (OHM) subject to Release Tracking Number (RTN) 4-26347. A Site Locus Map and the Disposal Site Map are provided as Figures 1 and 2

HW has prepared this Phase II in accordance with the Massachusetts Contingency Plan 310 CMR 40.0000 (MCP). The Phase II has also been prepared consistent with the Final Public Involvement Plan (the "Final PIP") for the Airport dated September 16, 2019. Consistent with the Final PIP, all persons identified on Table 1, Community Notification List, have been notified on the availability of this Phase II. The Airport previously provided a 21-day review period to allow for comments from the public. Public comments were only received by Mr. Tom Cambareri on behalf of the Town of Barnstable Department of Public Works. Where appropriate, Mr. Cambareri's comments were incorporated into this 2021 Phase II and have also been incorporated into this Phase II. A copy of Mr. Cambareri's comments are included in Appendix B.

The Phase II is based on the collection and laboratory analysis of the following samples collected between 2015 and 2021:

- 125 soil samples for laboratory analysis of PFAS;
- Three surface water samples for laboratory analysis of PFAS;
- 158 groundwater samples for laboratory analysis of PFAS;
- 45 groundwater samples for laboratory analysis of 1,4-dioxane;
- Eight fire truck spray water samples;
- Six soil and two building material samples for synthetic precipitation leaching procedure (SPLP) analysis;
- 13 groundwater and one surface water samples for Stable Isotope Analysis; and,
- 1 aqueous film-forming foam ("AFFF") sample.

As documented in "*Interim Guidance on Sampling and Analysis for PFAS at Disposal Sites Regulated Under the Massachusetts Contingency Plan", a fact sheet* prepared by the MassDEP and dated October 21, 2020, the following six PFAS analytes are currently regulated in Massachusetts:

- Perfluorodecanoic Acid (PFDA);

- Perfluoroheptanoic Acid (PFHpA);
- Perfluorohexanesulfonic Acid (PFHxS);
- Perfluorooctanoic Acid (PFOA);
- Perfluorooctanesulfonic Acid (PFOS); and,
- Perfluorononanoic Acid (PFNA)

Although MassDEP is currently regulating the six PFAS analytes described above, it does recommend that the 14 analytes included in EPA Method 537.1.1 be evaluated to determine if other PFAS analytes may be present in a release. MassDEP has not provided toxicity information sufficient for the purposes of conducting a MCP risk assessment beyond the six PFAS analytes documented above (refer to the Technical Support Document titled "*Per-and Polyfluoroalkyl Substances (PFAS): An Updated Subgroup Approach to Groundwater and Drinking Water Values*" prepared by the MassDEP and dated December 26, 2019).

The Airport has gone beyond the recommended list of 14 PFAS analytes included in EPA 537.1.1 and instead is currently evaluating the PFAS release using approximately 21 to 34 PFAS-analytes that are reported by the laboratory. The sum of all 21 to 34 compounds is used to determine "Total PFAS" present in soil, groundwater, and surface water. The term "Total PFAS" does not include the over 4,000 other PFAS analytes that are not reported in the current analytical testing method. This term is also different from the "Sum of Six" which is the sum of the MassDEP six regulated PFAS analytes (PFDA, PFHpA, PFHxS, PFOA, PFOS, and PFNA).

Based on interviews with Airport staff (Mr. Art Jenner and Bob Holzman) who have worked at the Airport since the 1980s, AFFF was only intentionally sprayed at the Airport during tri-annual drills (1991, 1994, 1997, 2000, 2003, 2006, 2009, and 2012), during an Airport Emergency (1981 and 2016 aircraft crash), and once per year between 2004 and 2015 as part of the Federal Aviation Administration ("FAA") annual foam testing requirement (14 CRF 139). With the exception of the 1991 tri-annual drill, all drills have been conducted at the unpaved Deployment Area (Figure 2) located adjacent to the East Ramp at the Airport. With the exception of the events detailed above, the two Airport staff indicated that foam testing was not completed prior to 1991 due to cost, limited availability, and lack of an FAA requirement mandating foam usage.

Historical Airport purchase records indicate that a fluorotelomer-based AFFF (Chem-Guard 3% mil spec) has been purchased by the Airport since 2000, and interviews with Airport staff indicated that this type of foam was also purchased as early as the 1980s. According to the Interstate Technology Regulatory Council (ITRC), fluorotelomer-based AFFF has been available since the 1970's. As indicated above, fluorotelomer-based AFFF contains multiple PFAS analytes including the MassDEP Sum of Six and substantially higher levels of 6:2 FTS when compared to other PFAS analytes.

In addition to the tests and training usage with AFFF, daily (approximately 5 gallons) and monthly (100 gallons) testing of the fire apparatus is conducted with just water. The test is conducted to verify that the fire apparatus pumps are operational. No foam is intentionally sprayed during these tests. The spray water from the fire trucks were tested for PFAS in 2019 to verify that the valve mechanism that segregates the AFFF tank from the water tank was working properly. The analytical results indicated that AFFF was being mixed with the water unintentionally (no visible foam generation) from the internal AFFF holding tanks, and the resulting spray water had a concentration of PFAS above the MassDEP Sum of Six Method 1 GW-1 standard (Table 2).

It was determined that the valve that segregates the AFFF was faulty and was the cause of the unintentional mixing. The faulty valve was replaced, and a maintenance schedule has been initiated to prevent the unintentional mixing. Subsequent testing of the spray water indicates that PFAS levels are less than the current Method 1 GW-1 standard, although PFAS is still detected (Table 2). The combination of tri-annual drills, the annual AFFF testing, and, to a lesser extent, the daily and monthly spraying of water have contributed to the AFFF related PFAS impacts in the Deployment Area. The Airport stopped using AFFF in the tri-annual training drills in 2015 and purchased an ecological cart in 2016 to stop spraying AFFF as part of the annual FAA testing requirement.

The extent of the PFAS plume in the vicinity of the Deployment Area is indicated on Figure 2. The plume location is based on analytical data, environmental forensics (to distinguish PFAS sources in co-mingled plumes), and PFAS related fate and transport mechanisms of the MassDEP Sum of Six and 6:2 FTS. based on analytical data and forensics, the Airport AFFF PFAS plume in the Deployment Area does not appear to have impacted the Maher Wells with the MassDEP Sum of Six PFAS analytes at this time. However, due to the direction of groundwater flow which is moving south/southeasterly, it is understood that the Airport's PFAS Plume is migrating downgradient toward the Maher Wells and will likely impact them in the near future.

The current Airport Rescue and Firefighting/Snow Removal Equipment (ARFF/SRE) Building was constructed in 1996, and PFAS is assumed to have been released in this area through what is presumed to be incidental spillage, drips from fire hoses that are hung to dry, and cleaning of equipment in the event of accidentally engaging the foam pump button. Interior floor drains within the ARFF/SRE building historically discharged to the adjacent grass area that was capped in the fall of 2020 to reduce infiltration of stormwater. The interior floor drains were closed in the 2000's and connected to a permitted discharge to the Barnstable Wastewater Treatment Plant.

The extent of the PFAS plume in the vicinity of the ARFF/SRE Area is indicated on Figure 2. Again, this projected plume location is based on analytical data, environmental forensics (to distinguish PFAS sources in co-mingled plumes), and PFAS related fate and transport mechanisms of the MassDEP Sum of 6 (See Section 5.0 for more information). The Airport's AFFF PFAS plume in the vicinity of the ARFF/SRE Building does not appear to have impacted the Maher Wells with the MassDEP Sum of Six PFAS analytes. However, due to the direction of groundwater flow which is moving south/southeasterly, it is understood that the Airport's PFAS Plume is migrating downgradient toward the Maher Wells and will likely impact them in the near future.

Prior to 1996, the Airport fire truck was housed in the former ARFF/SRE Building located adjacent to the former terminal along the North Ramp as indicated on Figure 2. This building was demolished in 2011. Based on interviews with two firefighting staff who have worked at the Airport since the 1980s, AFFF containers were also stored in this building. The building did have two floor drains that were closed prior to 1997 (discharge location unknown) and a third-floor drain that was traced to a catch basin that discharged to Upper Gate Pond. The former building was surrounded in its entirety by asphalt and, according to stormwater plans from 1999, storm drains in proximity to the building discharge to Upper Gate Pond. Investigation conducted in the vicinity of the former ARFFF/SRE Building did not identify any of the six regulated PFAS analytes in soil above the laboratory reporting limit (Table 3). Groundwater testing in the area did identify concentrations of the Sum of Six PFAS above the applicable Method 1 GW-1 Standard, however the impacts are not consistent with the Airports AFFF release (Table 4). The detections appear to be related to the off-Airport PFAS source(s) that are migrating onto the Airport. Additionally, testing of surface water from Upper Gate Pond did not identify any of the Sum of Six PFAS analytes above the laboratory reporting limit (Table 5).

During the assessment to delineate the nature and extent of PFAS relating to the Airport's use of fluorotelomer-based AFFF, PFAS in groundwater above the MassDEP Sum of Six Method 1 GW-1 Standard was identified entering the Airport from several upgradient locations. Forensic techniques, including data normalization and the preparation of Radar Plots for the purpose of distinguishing PFAS sources, was necessary to differentiate the Airport's PFAS source from other nearby, off-site sources. Radar plots were generated for each of the groundwater monitoring wells tested both on and off Airport property, from the fire truck spray water, and from AFFF concentrate. The data normalization used all laboratory reported PFAS and their contribution to the "Total PFAS" concentration detected in groundwater. The Radar Plots are considered a PFAS fingerprint. The PFAS fingerprint was used to determine plume migration relating to the Airport PFAS release as well as contributions from other off-site non-Airport related sources.

As indicated on Figure 2, PFAS impacted groundwater is migrating onto the Airport from hydraulically upgradient sources that are not consistent with the AFFF PFAS plume associated with Airport. Additionally, as indicated on Figure 2, the PFAS plume associated with the Airport does not appear to have reached the Maher Wells at the time of monitoring. Additional testing of soil and/or groundwater is planned as part of ongoing IRA activates to further support the Conceptual Site Model, aid with any proposed remedial design, and refine the forensic approach for source delineation.

The Airport has also contained a majority of its sources of PFAS in soil and groundwater relating to the historic deployment of AFFF via the installation of two impermeable caps (as indicated on Figure 3). The cap installations were completed in the Fall of 2020, and additional details are included in the report titled "*Immediate Response Action Plan Status Report 8*" dated October 2020 which is available for direct download from the MassDEP Searchable Sites Database using RTN 4-26347.

Additionally, 1,4-dioxane is noted as a contaminate of concern at the Airport. It has been detected in one deep monitoring well (HW-L [d]) on the Airport property and within several monitoring wells located off-Airport property, both hydraulically upgradient, cross-gradient and down-gradient. A potential source of 1,4-dioxane at the Airport is a historic release of 1,1,1-trichloroethane (1,1,1-TCA, RTN 4-00823) from an oil/water separator associated with a floor drain in the former Provincetown Boston Airlines hangar (currently leased to Cape Air) and from the use of aircraft deicing fluids. However, multiple groundwater samples collected from the former 1,1,1-TCA release area in the North Ramp did not detect 1,4-dioxane above the laboratory reporting limit (Figure 4).

A second potential source of 1,4-dioxane is from Aircraft deicing fluids. These fluids are not discharged to the unpaved surface but, instead, are currently discharging directly to the municipal sewer under an approved connection. Historic deicing (pre-2015) was conducted on the paved surface and the sprayed fluid was vacuumed up and directly discharged to the municipal sewer system under an approved discharge. Two of the deicing locations are located upgradient of HW-L(d), and groundwater testing downgradient of these locations did not identify 1,4-dioxane above the laboratory reporting limit. The third deicing location was historically located approximately 1,500 feet cross-gradient to HW-L and groundwater testing in the vicinity of this de-icing pad also did not identify 1,4-dioxane above the laboratory reporting limit. Considering the depth at which the 1,4-dioxane has been detected at the Airport and Maher Wells (70 to 123 feet below grade), the 1,4-dioxane appears to be from an off-Airport source located more than 6,000 feet hydraulically upgradient. The location of the current and former deicing areas is shown on Figure 3. The estimated extent of the 1,4-dioxane plume is depicted on Figure 2 and a cross-sectional representation of analytical data from monitoring wells is presented on Figures 5 and 6.

3.0 DISPOSAL SITE INFORMATION

Pursuant to 310 CMR 40.0835(4)(a), (b) and (c), a Phase II Comprehensive Site Assessment shall include the following Disposal Site information.

3.1 Disposal Site Name and Location

Pursuant to 310 CMR 40.0835(4) (a) the Disposal Site name and location are set forth below.

Cape Cod Gateway Airport
480 Barnstable Road
Hyannis, Massachusetts 02601

3.2 Disposal Site Map

Pursuant to 310 CMR 40.0835(4)(b), Figure 2 provides a detailed Disposal Site Map depicting all investigatory sampling points relevant to the Phase II and the boundaries of the Disposal Site.

3.3 Disposal Site History

Pursuant to 310 CMR 40.0835(4)(c), the Disposal Site History is set forth below.

3.3.1 General Airport Description

The Airport is located in Hyannis, Massachusetts, and provides scheduled airline service, general aviation services, and other aviation related activities. The Airport is owned by the Town of Barnstable and is managed through the Barnstable Municipal Airport Commission ("BMAC"). The Airport began as a private airport consisting of a single grass runway before being given to the Town of Barnstable in the 1930's. With the outbreak of World War II, the Airport was taken over by the federal government for wartime training and defense purposes. During the 1940's, the United States Navy used the Airport and expanded the airfield to include three runways. In 1946, the Airport was returned to a two-runway municipal airport (each runway has a designation at each end, being 15-33 and 6-24). In 1948, the Airport was conveyed by the United States government (pursuant to the Surplus Property Act of 1944) to the Town of Barnstable, acting by and through its Airport Commission.

Currently, the Airport is comprised of approximately 645 acres of land, with approximately 140 acres that are impervious (e.g., paved areas such as parking lots, runways, taxiways, aircraft parking aprons, concrete walkways, and building rooftops). The Airport's structures include the main terminal and the Air Traffic Control Tower ("ATCT"), which are located south of the runways and taxiways, as well as several hangars used for general aviation and operations services. In addition, the current ARFF/SRE Building is located in the southeast corner of the property. The Airport is situated in an area of Hyannis zoned for Business and Industrial uses. A topographic map with the Airport property boundary outlined is attached as Figure 1, and the area impacted by the release of PFAS and 1,4-Dioxane is indicated on Figure 2.

3.3.2 General Regulatory History

The evaluation for 1,4-dioxane at the Airport began in July 2015 when the MassDEP requested samples be collected from existing monitoring wells to evaluate the presence or absence of this analyte on Airport property. The request was related to the detection of 1,4-dioxane at the Maher Well field, located south of the Airport property, and the potential for the detection to be attributed to historic releases from a floor drain at the former Provincetown Boston Airlines hangar (currently leased to Cape Air) located on the North Ramp (RTN 4-823, closed). The historic release had been known to contain 1,1,1-TCA, which is a product known to potentially contain 1,4-dioxane.

In August 2016, the Airport conducted an initial round of groundwater sampling to evaluate the presence of PFAS compounds, also at the request of MassDEP. Subsequently, a Notice of Responsibility (NOR), dated November 10, 2016, was issued to the Airport by the MassDEP. The NOR requested that the Airport conduct additional field investigations to evaluate:

- The source(s) of PFAS including PFOS and PFOA detected in groundwater at the Airport;
- The source(s) of 1,4-dioxane detected in a monitoring well downgradient of the Airport on the Maher Well field property; and

- To identify potential impacts to public water supply wells operated by the Hyannis Water District at the Mary Dunn and Maher Well fields.

A proposed Immediate Response Action (IRA) plan was submitted to the MassDEP for approval in response to the NOR. Subsequently, a meeting was held by MassDEP at the Airport that included other stakeholders including the Barnstable Department of Public Works, the Hyannis Water District, and Barnstable County representatives (representing the Fire Training Academy). At the meeting, IRA plans were coordinated between the Airport and Fire Training Academy including sampling locations, type of analysis, groundwater modeling, goals, and next steps. The IRA plan served as the guide for the soil and groundwater testing conducted since November 2016 to follow up on the results of the previous analyses.

In June 2019, the MassDEP issued a Request for Modified Immediate Response Action Plan/Interim Deadline dated June 18, 2019 (the "Modified IRA Request") to the Airport. The Modified IRA Request asked that the Airport propose response actions to *"reduce infiltration of precipitation through PFAS-impacted soil, such as temporarily capping the source areas; excavating and properly disposing of the PFAS-impacted soil; or some equivalent approach".* The Airport's response is documented in the report titled "*Final Immediate Response Action Plan Modification",* prepared by HW and dated December 2019 (the "IRA Modification"). The IRA Modification included details for the installation of an impermeable cap in two select areas to reduce precipitation infiltration. The two areas are identified as the Deployment Area and the ARFF/SRE Area. The two capped areas total approximately 94,100-square feet and represent a majority of the known PFAS source areas at the time of the report relating to the historic use of AFFF. The caps were completed in September 2020 and are documented in the report titled "*Immediate Response Action Plan Status Report 8".* The surficial extent of the two capped areas is indicated on Figure 4.

3.3.3 Sources of PFAS at the Airport

The source of PFAS related to Airport operations is from the use of AFFF for training and emergencies. Personnel working at the Airport since the 1980's were consulted to determine when AFFF use occurred for training purposes or during an actual aircraft accident. Details concerning AFFF usage is set forth below.

<u>AFFF Usage for Testing and Training</u>

- Historical Airport purchase records indicate that a fluorotelomer-based AFFF (Chem-Guard 3% mil spec) has been purchased by the Airport over the last twenty years, and interviews with staff indicated that this type of foam was also purchased as early as the 1980s. With the exception of the events detailed below, AFFF was not intentionally sprayed due to cost and limited supply of AFFF.
    - Further information regarding foam use was provided through interviews with Art Jenner and Bob Holzman who have worked at the Airport since the 1980's. Both are firefighters and first responders and stated that fluorotelomer based foam was

purchased by the Airport since the 1980s. Additionally, according to the ITRC document titled *"Aqueous Film-Forming Foam (AFFF)"* dated August 2020 (refer to Attachment A), fluorotelomer-based AFFF has been available since the 1970s and other AFFF formulations have been available since the late 1960s.

- FAA regulations require a Tri-Annual Drill which is a full-scale live exercise that simulates a major airport disaster to test the emergency coordination and response skills of the Airport and other first responders. AFFF was used at the Deployment Area between 1994 and 2004 for triannual drills and between 2004 and 2015 for annual AFFF mixture testing. Two firefighting personnel, employed by the Airport since the 1980's, indicated that foam was not used prior to 1991 due to cost, limited availability, and lack of an FAA requirement mandating foam usage. With the exception of the drill in 1991, as shown on the Figure 3, all drills occurred at the unpaved Deployment Area, indicated on Figure 3. The tri-annual drills occurred as follows:
  - July 17, 1991
  - Nov. 16, 1994
  - Nov. 17, 1997
  - Nov. 2, 2000
  - Oct. 18, 2003
  - Oct. 25, 2006
  - Oct. 22, 2009
  - Oct. 11, 2012
  - Oct. 28, 2015 (No AFFF used during this drill – just water)
  - Sept 5, 2018 (No AFFF used during this drill – just water)
- There was one triannual drill in 1991 that occurred in an area on the north ramp of the Airport where HW investigated and collected soil data from six sampling locations (Figure 3). With the exception of a detection of PFHxS at location 1991B 0-1', none of the soil samples exceeded the applicable Method 1 Standard for any of the MassDEP six regulated PFAS compounds (Table 3). The detection of PFHxS at this location is not consistent with the Airport's use of AFFF and is consistent with the 20 background samples (Table 6) collected and discussed in addital detail below. Furthermore, soil samples consistent with the Airports AFFF contain elevated levels of 6:2 FTS, PFNA, and PFHpA. None of these compounds were detected in sample 1991B 0-1'.
- Beginning in 2004, annual testing of the AFFF mixture became an FAA requirement. The test was conducted to ensure that the foam used by the Airport consists of the appropriate AFFF to water mixture (3%). Historically, the test consisted of shooting the mixture of AFFF from the fire rescue vehicle at a small square target. Adjustments were then made, if needed, to allow for proper spray coverage consistent with the FAA

regulations. According to Airport personnel, testing of the foam consistency prior to 2004 was not completed due to the cost, supply of AFFF and lack of an FAA mandate.

- Approximately 80 gallons of 3-percent AFFF concentrate was historically used annually beginning in 2004 to conduct the test (see table below).
- All testing has been conducted in the same unpaved location on the Airport since 2004 (Deployment Area).
- The Airport purchased an Ecological Cart in 2016 so that the AFFF mixture could be verified without using or spraying foam. The Airport has not used AFFF for testing purposes since 2016. The Ecological Cart was the first unit purchased by a Massachusetts airport and well before FAA approval for universal airport usage.

- FAA regulations require a supply of AFFF concentrate on hand to resupply two trucks. The concentrate is stored in the ARFF/SRE Building located in the ARFF/SRE Area as indicated on Figure 2. As of January 2022, the Airport has 907 gallons of AFFF concentrate on hand. This includes 500 gallons within containers and 407 gallons within the fire trucks.
- Expired AFFF that is no longer useable is removed by Global Remediation, a licensed waste disposal company. As indicated on the manifests included in Appendix C, Global Remediation removed 100-gallons of AFFF concentrate on June 13, 2019 and 50-gallons on March 4, 2020.

The current ARFF/SRE Building was constructed in 1996, and PFAS is assumed to have been released in this area through what is presumed to be incidental spillage, dripping from fire hoses s hung to dry, and cleaning of equipment in the event of accidentally engaging the foam pump button. Prior to 1996, the Airport fire truck was housed in the former ARFF/SRE Building located adjacent to the former terminal along the North Ramp (see attached Figure 2). This building was demolished in 2011. Based on interviews with two firefighting staff who have worked at the Airport since the 1980s, AFFF containers were also stored in this building. The building did have two floor drains that were closed prior to 1997 (discharge location unknown) and a third-floor drain that was traced to a catch basin that discharged to Upper Gate Pond. The former building was surrounded in its entirety by asphalt and, according to stormwater plans from 1999, storm drains in proximity to the building also discharge to Upper Gate Pond.

Investigation conducted in the vicinity of the former ARFFF/SRE Building did not identify any of the regulated Six PFAS analytes in soil above the laboratory reporting limit (HW-X(m) [7-9] , Table 4) . Groundwater testing in the area did identify concentrations of the Sum of Six PFAS (HW-X[s] and HW-X[m], Table 2) above the applicable Method 1 GW-1 Standard, however the impacts are not consistent with the Airports AFFF release. The detections appear to be related to the off-Airport PFAS source(s) that are migrating onto the Airport. Additionally, testing of surface water from Upper Gate Pond did not identify any of the Sum of Six PFAS analytes above the laboratory reporting limit.
Interior floor drains within the current ARFF/SRE building historically discharged to the adjacent grass area that was capped in the fall of 2020 to reduce infiltration of stormwater. In the event

the foam pump was accidentally engaged, equipment was rinsed by pumping water through it and then discharging the water to the adjacent grass area that has since been capped. Stormwater, in the vicinity of the recently capped area, also historically infiltrated into this area and included both the building's roof and surrounding paved surface areas. The interior floor drains historically discharged to this area but were closed and connected to a permitted discharge to the Barnstable Wastewater Treatment Plant in the early 2000's. As part of the cap installed in 2020, stormwater was redirected away from this area and instead infiltrates beyond the PFAS impacted area. The oil/water separator is inspected quarterly by Airport staff and then pumped, cleaned, and serviced by Global Remediation, as needed. As indicated on the manifest in Appendix C, 1,290-gallons of the oil/water separator liquid was pumped on October 29, 2017. The oil/water separator is located within the extent of the PFAS plume at the location indicated on Figure 2.

Within MassDEP's Notice of Audit Findings, there was mention of additional available records of past foam usage for fire training exercises at the Airport. HW reviewed these additional records which included a picture from a YouTube video provided in an email to MassDEP from an outside party during the audit process. HW viewed this video, which documents a fire training exercise at the Airport in 1956. However, AFFF with PFAS was manufactured in the United States beginning in the late 1960s, according to the ITRC document titled *"AFFF"* dated August 2020 (see Attachment A), about 10 years after the exercise shown in the video. This event included in the photo took place before AFFF was manufactured with PFAS compounds, and therefore, it does not constitute a release of PFAS at the Airport.

Additionally, it is important to note that the Barnstable Fire Training Academy (BFTA), the neighboring parcel, came into existence in 1956, per the BFTA website. This facility was built to provide a location for local fire departments to conduct local and regional training exercises and, as such, the need to use the Airport as a training venue was reduced.

<u>AFFF Usage for Emergencies</u>

- Personnel working at the Airport since the 1980's were consulted to determine when AFFF use occurred during an actual aircraft accident and only two instances were identified. Please note that AFFF is <u>NOT</u> used during an incident unless there is a spark of fire. The majority of accidents do not result in the use of AFFF. Airport personnel identified the following aircraft emergencies where AFFF was used: The 1981 crash of a Beech 18 aircraft east of runway 24 between Yarmouth Road and the Airport (off-Airport property). The 2016 crash of a Cirrus aircraft in the parking lot of the rental car facility west of the terminal building. Approximately 10 gallons of the 3-percent AFFF concentrate was used during the crash response, and 100% of this AFFF liquid was contained within a solid bottom catch basin and removed via a vacuum truck by Global Remediation during response actions. There was no known release to groundwater. A copy of the waste disposal manifests is included in Appendix C.

AFFF Purchase Quantity and Usage

Historical Airport purchase records indicate that a fluorotelomer-based AFFF (Chem-Guard 3% mil spec) has been purchased by the Airport over the last twenty years, and interviews with staff indicated that this type of foam was also purchased as early as the 1980s. According to Airport available purchase, the following quantities of AFFF concentrate have been purchased and used by the Airport since 2000:

Year	AFFF Type	AFFF 3% Concentrate Purchased	Approximate AFFF 3% Concentrate Used for Training	Approximate AFFF 3% Concentrate Used for Tri-Annual Drill	Approximate AFFF 3% Concentrate Used for Annual Testing	Approximate Total AFFF Concentrate Used Annually	Approximate Total AFFF Concentrate and Water Mix	Approximate AFFF Stockpiled Based on Use*
		(Gal.)	(Gal.)	(Gal.)	(Gal.)	(Gal.)	(Gal.)	(Gal.)
2000	Chem-Guard 3% mil-spec foam	200	0	40	0	40	1333	485
2001	None purchased	0	0	0	0	0	0	485
2002	Chem-Guard 3% mil-spec foam	30	0	0	0	0	0	515
2003	Chem-Guard 3% mil-spec foam	40	0	40	0	80	2667	475
2004	Chem-Guard 3% mil-spec foam	40	0	0	80	80	2667	435
2005	None purchased	0	0	0	80	80	2667	355
2006	Chem-Guard 3% mil-spec foam	220	0	40	80	120	4000	455
2007	Chem-Guard 3% mil-spec foam	25	0	0	80	80	2667	400

Year	AFFF Type	AFFF 3% Concentrate Purchased (Gal.)	Approximate AFFF 3% Concentrate Used for Training (Gal.)	Approximate AFFF 3% Concentrate Used for Tri-Annual Drill (Gal.)	Approximate AFFF 3% Concentrate Used for Annual Testing (Gal.)	Approximate Total AFFF Concentrate Used Annually (Gal.)	Approximate Total AFFF Concentrate and Water Mix (Gal.)	Approximate AFFF Stockpiled Based on Use* (Gal.)
2008	Chem-Guard 3% mil-spec foam	90	0	0	80	80	2667	410
2009	Chem-Guard 3% mil-spec foam	90	0	40	80	120	4000	380
2010	Chem-Guard 3% mil-spec foam	100	0	0	80	80	2667	400
2011	Chem-Guard 3% mil-spec foam	180	0	0	80	80	2667	500
2012	None purchased	0	0	40	80	120	4000	380
2013	None purchased	0	0	0	80	80	2667	300
2014	Chem-Guard 3% mil-spec foam	180	0	0	80	80	2667	400
2015	Chem-Guard 3% mil-spec foam	265	80	0	80	160	5333	505
2016**	Chem-Guard 3% mil-spec foam	250	0	0	0	0	0	755
2017	None purchased	0	0	0	0	0	0	755
2018	None purchased	0	0	0	0	0	0	755

Year	AFFF Type	AFFF 3% Concentrate Purchased	Approximate AFFF 3% Concentrate Used for Training	Approximate AFFF 3% Concentrate Used for Tri-Annual Drill	Approximate AFFF 3% Concentrate Used for Annual Testing	Approximate Total AFFF Concentrate Used Annually	Approximate Total AFFF Concentrate and Water Mix	Approximate AFFF Stockpiled Based on Use*
		(Gal.)	(Gal.)	(Gal.)	(Gal.)	(Gal.)	(Gal.)	(Gal.)
2019	Chem-Guard 3% mil-spec foam	105	0	0	0	0	0	860
2020	None purchased	0	0	0	0	0	0	860***
Total Quantity Between 2000-2020		1,815	80	200	960	1,280	42,667	Not Applicable

Notes:

* The Airport is required by FAA regulations to have enough stockpiled AFFF on hand to resupply two (2) trucks. Therefore at least 407 gallons of the 3% AFFF concentrate is regularly stored at ARFF building. This excludes the 407 gallons that are stored in the two ARFF trucks.

** In May 2016, the Airport transitioned to the new formulation of Chemguard (a modern fluorotelomer AFFF). The prior formulation was the older fluorotelomer based version.

*** The total on-hand AFFF quantity as of January 2022 is 907 gallons. This includes 500 gallons within containers and 407 gallons within the fire trucks.

PFAS from Non-Airport Related Sources

To determine the extent of the Airport's AFFF PFAS Plumes, analytical testing of numerous groundwater wells surrounding the Airport property (Figure 7) have been completed. These wells include locations off Airport property that are hydraulically upgradient, cross-gradient and downgradient. As indicated on Table 4 and Figure 7, most these wells have detections of PFAS above the MassDEP Sum of Six standard, and based on groundwater flow, these concentrations are entering the Airport from different areas as well as impacting the Maher Wells.
The additional PFAS plumes are unrelated to the Airport's AFFF PFAS plume. These plumes appear to be originating from the Barnstable Fire Training Academy PFAS Release Site (RTN 4-26179) and other unknown locations located upgradient, cross-gradient and downgradient of the Airport. Radar plots, which are included in Appendix D, were used to help distinguish the Airport's PFAS AFFF plume from other non-Airport related PFAS sources.

It should be noted that the AFFF used by the Airport over at least the last 20 years is a fluorotelomer based foam, with 6:2-FTS (a MassDEP non-regulated PFAS analyte) comprising a significant percentage of the PFAS compounds (see below in Section 5.1.1). However, it is important to note that other PFAS compounds, including PFOA and PFOS and the regulated PFAS compounds, are also present in the soil and groundwater in the release areas at the Airport. Our documentation of PFAS concentrations in each soil (Table 3) and groundwater sample (Table 4), includes a total PFAS concentration, individual concentrations for each of the MassDEP regulated six PFAS compounds, a total sum-of-six concentration, and 6:2-FTS concentration data. These results are provided on multiple figures and data tables included in this report. Data on the MassDEP Sum of Six compounds were used to determine if groundwater concentrations exceeded the Method 1 GW-1 standard as required under the MCP and Total PFAS and 6:2-FTS concentration data was used to evaluate other unregulated PFAS analytes to help distinguish Airport related and non-Airport related PFAS sources.

Included in the following Sections, HW analyzed the environmental fate and transport of PFAS at the Airport property and surrounding parcels. HW focused primarily on the PFAS analyte 6:2-FTS for tracking the extent of the regulated PFAS compounds for two primary reasons:

1. To distinguish the Airport releases from other non-airport related sources of PFAS impacting groundwater at the Airport, as described below via the radar plots.
2. To evaluate the downgradient migration of the plumes from the Deployment Area and ARFF building, as described in Section 4.3.2.

See Section 5.1.1 for additional detail regarding 6:2-FTS.

Radar Plots

HW utilized radar plots to differentiate individual PFAS concentrations (Attachment D). A radar plot is a graphical representation of analytical data that is used to create a distinguishable fingerprint. These plots illustrate the relative concentration of each PFAS compound in a graphic representation of the Airport source composition compared to other non-airport related sources. To generate a radar plot, each PFAS groundwater sample was statistically normalized to the individual total PFAS concentration. The Total PFAS concentration is the sum of all laboratory reported PFAS analytes in a sample. Each PFAS analyte was then divided by Total PFAS to calculate the percent each analyte contributed to the Total PFAS concentration. These percentages were then plotted for each sampling location and the graphical representation of the data set was compared.

It is noted that radar plots were completed for groundwater only. No radar plots were presented for soil regardless of PFAS concentration, due to the fact that these groundwater radar plots are representative of the AFFF PFAS that has leached from the soil into the underlying groundwater. Radar plots for the soil are not necessary as it is easy to distinguish soil impacted with AFFFF relating to Airport operations from other non-AFFF sources as indicated by the high level of total PFAS including 6:2-FTS. Additionally, SPLP testing of soil sample DL8 (4) from the Deployment Area indicated that 95 percent of the total PFAS released from this sample was 6:25 FTS at a concentration of 25 ug/l and Sum of Six PFAS at 0.717 ug/l. This high level of 6:2 FTS is distinguishable in both soil and groundwater samples relating to the Airports historic use of a fluorotelomer base AFFF foam.

This forensic analysis was necessary to differentiate the various plumes identified, and radar plots are regularly used by environmental professionals to identify individual sources of contamination found at a site and evaluate the impacts to downgradient resources when comingled plumes exist. PFAS compounds were detected in every well sampled at the Airport, and there is documented evidence from wells located upgradient and off-Airport property that indicate PFAS contamination from upgradient sources is flowing through groundwater across the Airport property.

The radar plots document the Airport AFFF releases and potential other releases as these plot have distinguishable shapes from one another (See Attachment D). The plots characterize the PFAS at that specific location and then, in evaluation, that characterization was considered in light of fate and transport characteristics to provide Site specific interpretation. As seen in the radar plots included in Attachment D, the Airport AFFF releases have a unique chemical signature compared to that of the Fire Training Academy plume that migrates under the Airport or compared to other off site sources impacting groundwater below the Airport from the west. HW developed the radar plots based on the concentration of each PFAS compound measured at a monitoring well at the time the sample was taken. Nearby ponds or pumping wells do not limit the use of these plots in identifying the PFAS sources on and near the Airport. The sample radar plots provided can be used to compare the relative percent PFAS concentrations in groundwater samples from the Deployment Area source at the Airport to the Fire Training Academy source area. They show a distinct difference in the chemical composition of these two sources. The PFAS composition detected at the Maher Well field closely resembles that from the Fire Training Academy. Radar Plots for all monitoring wells sampled between 2016 and November 2020 are included in Attachment D.

As illustrated in Figure 2, the two plumes from the Airport are not near any ponds and are upgradient of the Maher Well field. The Fire Training Academy plume migrates through and below Mary Dunn Pond before it flows below the Airport. The radar plots from samples taken at wells upgradient and downgradient of Mary Dunn Pond are consistent, indicating that the pond does not influence them.

The radar plots for well HW-I(s), HW-J, HW-F, HW-H, and HW-E, located within and surrounding the Deployment Area, were used to identify and document the chemical signature of the PFAS plume associated with the Airport' PFAS release at the Deployment Area and the ARFF building. If a non-fluorotelomer-based foam was used at this location, it is still represented in the radar plot signature from these wells. The same process was used for samples taken near the ARFFF/SRE Building area.

For a comparative example, the radar plot from HW-I(s) is a good representation of the Airport's plume relating to AFFF, which is recognizable by a high percentage of 6:2-FTS and a low percentage of PFOS. Additionally, 6:2-FTS does not degrade into PFOS or PFHxS (*Fact Sheet on*

C6 Fluorinated Surfactants, Dr. Jan-Erik Jonsson), and, in fact, it migrates faster (additional details below) in groundwater than any of the regulated MassDEP PFAS analytes. Groundwater monitoring studies have shown that the predominant degradation product of fluorotelomer based AFFF is 6:2-FTS (*Fact Sheet on C6 Fluorinated Surfactants, Dr. Jan-Erik Jonsson).* Therefore, by focusing on 6:2-FTS, a distinguishable analyte, HW is able to differentiate the Airport plume, related specifically to the documented use of fluorotelomer AFFF, from potential other sources of PFAS within the vicinity of the Airport property.

As indicated above, the 6:2 FTS in only used to verify the extent of the Airport's PFAS plume. The Airport and HW acknowledge that multiple other PFAS analytes including the six regulated by MassDEP are included in the Airport's plume. Concentrations of the MassDEP six regulated PFAS compounds are located in the Airport's PFAS plume at concentrations above the applicable Method 1 GW-1 Standard. Due to the multiple PFAS detections both hydraulically upgradient, cross-gradient and downgradient of the Airport, forensic interpretation is necessary to distinguish PFAS sources.

Refer to Figure 2 for a depiction of the Airport AFFF Plume and other non-airport related PFAS plumes. Cross-sections including Radar Plots also document the extent of the Airport and other PFAS plumes. Refer to Figures 5 and 8 through 13 for select cross-sections depicting the vertical and horizontal extent of the AFFF plumes. Refer to Figure 7 for a depiction of the Sum of Six PFAS concentration detected at each monitoring well location.

3.3.4 Sources of 1,4-Dioxane

1,4-dioxane is a synthetic chemical that is completely mixable in water. It has been detected in one deep monitoring well (HW-L [d]) located at the Airport and within several off-Airport monitoring wells located hydraulically upgradient, cross-gradient and downgradient of the Airport. A potential source of 1,4-dioxane at the Airport is a historic release of 1,1,1-TCA (RTN 4-00823) from an oil/water separator associated with a floor drain in the former Provincetown Boston Airlines hangar (currently leased to Cape Air) located on the North Ramp (RTN 4-823, closed). 1,4-dioxane is also known to be an ingredient in aircraft deicing fluids. The Airport installed a centralized deicing and aircraft washing pad in 2015 which directs deicing fluids (Type I propylene glycol based) and fluids used in aircraft washing to the Barnstable Water Pollution Control Facility. Prior to 2015, deicing activates were conducted at the South Ramp, Rectrix Aerodrome, and East Ramp at the locations indicated on Figure 4. Following application of deicing fluids prior to 2015, Airport maintenance personnel recovered residual deicing fluid on the asphalt pavement utilizing a TYMCO™ Model 600 vacuum recovery unit mounted on a Freightliner™ FC 80 chassis. Prior to deicing activities, magnetic catch basin covers were placed over storm drains in proximity. Recovered deicing fluid was subsequently discharged to the Barnstable municipal sewer system under an agreement with the Town of Barnstable.

According to Airport personnel, the quantity of deicing fluid used at the Airport averages less than 100 gallons per year. Usage data, provided below for 2015-2020, show low levels of use with almost all values well below 100 gallons. Deicing fluid usage data for 2015-2020 was as follows:

- 2015 – 210 gallons
- 2016 – 63 gallons
- 2017 – 22 gallons
- 2018 – 42 gallons
- 2019 – 42 gallons
- 2020 – 64 gallons

With such a limited use, the potential for the fluid to migrate off the paved areas where it was applied was limited, and it was feasible for the Airport to vacuum it up after application. The location of the current and former deicing pads is indicated on Figure 4. An MSDS sheet (Appendix E) provided by the Airport indicate that the deicing fluid is propylene glycol based and contains less than 5 parts per billion (ppb) of 1,4-dioxane. The deicing activities are conducted consistent with an EPA Stormwater Permit and Stormwater Pollution Prevention Plan prepared by a professional engineer.

Multiple groundwater samples collected from the former 1,1,1-TCA release area (HW-1, HW-5, HW-12, HW-29, OW-6, HW-4m, HW-4d, HW-207s, HW-207d, HW-19d and HW-204) in the North Ramp did not detect 1,4-dioxane above the laboratory reporting limit (Figure 4). As indicated above, Aircraft deicing fluids are not discharged to the unpaved surface and have been discharged to the municipal sewer under an approved connection/approved discharge. Historic deicing (pre-2015) was conducted on the paved surface and was vacuumed up and directly discharged to the municipal sewer system under an approved discharge.

Groundwater testing downgradient of two of these locations (HW-L[s], HW-L[m], and HW-19d) did not identify 1,4-dioxane above the laboratory reporting limit. The third deicing location is located approximately 2,000 feet cross-gradient to HW-L (d) and does not have a hydraulic connection to this area. Groundwater testing at wells HW-E and HW-J downgradient of the third deicing pad did not identify 1,4-dioxane above the laboratory detection limit.

HW created a water table map specific to the Airport property based on data taken on April 27, 2020 from monitoring wells used during this investigation. It is attached as Figure 14. As indicated on the map, groundwater flows onto the Airport property from the west and northwest, migrates to the southeast, and exits the property at the southeast corner of the Airport. The water table maps also clearly show that HW-L(d) is hydraulically cross-gradient to the historic deicing pad located approximately 2,000 feet northeast of the well, near the Deployment Area. Groundwater flow from this historic deicing area would flow to the east-southeast.

Considering the depth at which the 1,4-dioxane has been detected at the Airport and Maher Wells (70 to 123 feet below grade) and in the particle tracking model, detailed below, the 1,4-dioxane appears to be from a source located more than 6,000 feet hydraulically upgradient and off-Airport property. 1,4-dioxane has also been detected in two wells (HW-V[m] and HW-U[d]) located hydraulically upgradient and off-Airport Property at depths consistent with the particle tracking model, detailed below, supporting the Conceptual Site Model that the detection of 1,4-dioxane in HW-L(d) and the Maher Well field is related to an off-Airport release.

All floor drains within the hangers and businesses located on the airfield have either been closed, connected to a tight tank, and/or connected to the sanitary sewer to meet the EPA and MassDEP discharge requirements. Significant groundwater monitoring has been conducted throughout the Airport in proximity to hanger buildings with historic floor drains and in proximity to de-icing areas. A figure depicting the sample locations and subsequent concentration of 1,4-dioxane is indicated on Figure 4. This information clearly indicates that the 1,4-dioxane source is not related to the Airport. Tabulated analytical data is presented on Table 7.

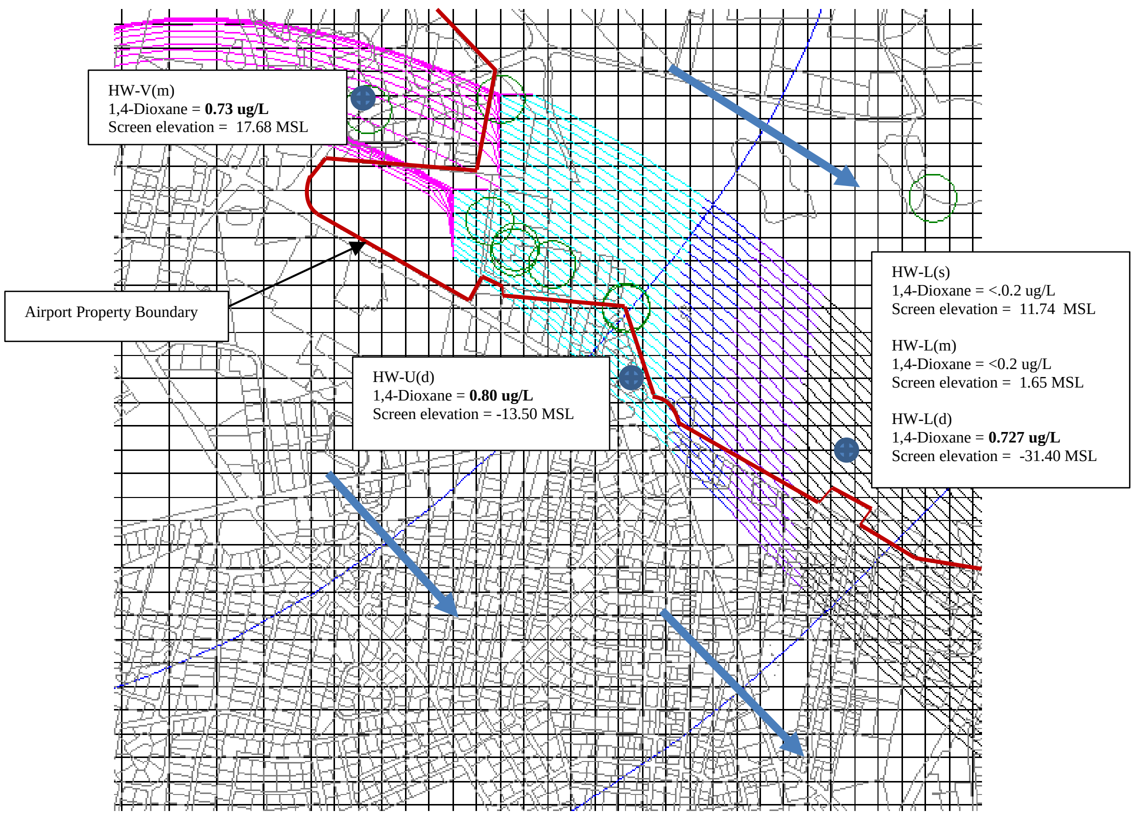
According to the EPA document titled *"Technical Fact Sheet – 1,4-dioxane"* dated November 2017, additional sources of 1,4-dioxane, unrelated to deicing, include:

- **Solvent Stabilizer** – historically, 90% of 1,4-dioxane use was to stabilize chlorinated solvents such as 1,1,1-TCA. Use of 1,4-dioxane as a solvent stabilizer was phased out under the 1995 Montreal Protocol.
- **Consumer Products** - 1,4-dioxane has been found as a by-product in paint strippers, dyes, greases, anti-freeze, and aircraft deicing fluids, and in some consumer products such as deodorants, shampoos, and cosmetics.
- **Pharmaceuticals and Plastic Manufacture** - 1,4-dioxane is used in the manufacture of pharmaceuticals as a purifying agent and is a by-product in the manufacture of polyethylene terephthalate plastic.
- **Food** - 1,4-dioxane may be present in some food supplements, food containing residues from packaging adhesives or on food crops treated with pesticides that contain 1,4-dioxane.

Some examples of how these materials can be released to the environment include:

- Releases to the ground surface, groundwater and/or surface water from industrial/commercial facilities where spills of materials containing 1,4-dioxane have occurred;
- Releases to groundwater and/or surface water from wastewater treatment plants where wastewater treatment methods were not designed to remove 1,4-dioxane compounds from the waste stream;
- Releases to groundwater and surface water from residential septic systems where 1,4-dioxane compounds were used in the household;
- Releases to the ground surface, groundwater and/or surface water from industrial facilities where polyethylene terephthalate plastic was manufactured; and
- Releases to groundwater and/or surface water from landfills were 1,4-dioxane wastes were disposed of.

Considering the depth of the 1,4-dioxane impacts, it is likely that the detection is related to an off-site source. To verify that the source of 1,4-dioxane detected in HW-L(d) and the Maher Well field was related to an off-site source, HW advanced monitoring wells HW-U(d) and HW-V(m) at locations off-Airport property and hydraulically upgradient of the Airport (see Figure 4). The well screen depths for these locations were chosen based on groundwater model particle tracks that simulate how groundwater migrates in the aquifer below the Airport. The particle tracks indicated that the depth of the 1,4-dioxane detected at the Airport and the Maher Well field was likely related to a release site located more than 6,000 feet upgradient of the Airport. The particle tracking model uses annualized average pumping rates for 2004-2008 from the Maher Wells, Mary Dun Wells, and the Airport Well. The particle tracking is shown below, and arrows depict the groundwater flow path:



The model above shows how a particle of 1,4-dioxane migrated onto the Airport property from off-site upgradient locations HW-V(m) and HW-U(d) and how the 1,4-dioxane plume migrates to the Maher Well field. The particle tracking figure is a plan view version showing the contributing area to the Maher Well field, and the particle flow path colors correspond to the falling depth of the particle. The variation in colors documents how the water flows downward into the aquifer as it migrates from upgradient areas across the Airport. The model was created by working backwards from HW-L(d) to depict the 1,4-dioxane flow path and particle depth during migration. The model was then used to pick the location and screen depth for monitoring wells HW-V(m) and HW-U(d). The model predicted that if 1,4-dioxane was detected at a depth between -27 and -32 feet below mean sea level (MSL) in HW-L(d) and not detected at the depths associated with

HW-L(s) or HW-L(m), the potential source of the release was located more than 6,000 feet away (off-Airport property). The model suggested that 1,4-dioxane would be located within the cyan colored hatching (HW-U[d] location) at a depth of -8 to -13 feet below MSL and within the magenta-colored hatching at a screen depth of 12 to 17 feet above MSL. HW subsequently installed monitoring well locations HW-V(m) and HW-U(d) to the corresponding depth predicted by the model. 1,4-dioxane was detected in both new monitoring well locations (HW-V[m] at 0.8 ug/l and HW-U[d] at 0.73 ug/l) at concentrations consistent with that detected downgradient and on Airport Property (HW-L[d] at 0.75 ug/L).

While the Maher wells are pumped regularly, the pumping will have little to no effect on the vertical plume migration as it travels from HW-V(m) to HW-U(d) to HWL(d) as these areas are upgradient of, and outside the area where the pumping of the wells would adjust the rate of travel or the depth of the plume.

Additionally, the plume is located cross gradient of the nearby ponds on the Airport and would not interact with them. This is especially true as the plume is located 30-40 feet below the water table as it passes south of the ponds. The ponds themselves are quite shallow and do not interact with groundwater found that far below the water table. There are no surface water outflows from the ponds that would cause groundwater to migrate upward to discharge to the ponds or an outlet stream. The ponds will only interact with shallow groundwater.

Overall, based on the mapping of groundwater flow, water quality data from across the Airport that tracks the plume, new shallow groundwater data showing no 1,4-dioxane in the vicinity of the deicing area on the East Ramp and North Ramp, and particle tracking data from the U.S Geological Survey groundwater model for this area of Hyannis, the 1,4-dioxane plume does not originate at the Airport but is from an upgradient source to the west-northwest of the Airport.

Based on the results of the modeling and laboratory data, it appears that the detection of 1,4-dioxane at the Airport and the Maher Wells is likely related to an unknown off-site source located more than 6,000 feet upgradient of the Airport. A graphical representation of the 1,4-dioxane plume is indicated on Cross Section-1 in Figure 6 and the location of HW-V(m), HW-U9(d), and HW-L(d) in relation to the Airport property boundary is included on Figure 4. The Cross Section-6 shows how the plume moves down into the aquifer as it travels across the Airport. A plan view of the location of wells used to create the cross-section is included as Figure 5.

The plume moves downward at a consistent rate, based on the amount of recharge to the aquifer from rainfall that infiltrates into the ground. The cross-section documents wells screened in the aquifer above the mapped plume in which no 1,4-dioxane was detected. It also documents that the concentration of 1,4-dioxane in the plume is relatively stable as it moves across the Airport property, ranging from 0.8 ug/L upgradient of the Airport in well HW-V(m) to 0.732 ug/L downgradient of the Airport in Well OW-9(dd) (See figure 4). The direction of groundwater flow and relatively stable detection levels of 1,4-dioxane suggest that there is a long-term, consistent source of 1,4-dioxane upgradient of the Airport impacting groundwater quality.

4.0 DISPOSAL SITE HYDROGEOLOGICAL CHARACTERISTICS

Pursuant to 310 CMR 40.0835(4)(d), the Site hydrogeological characteristics including details of subsurface investigation and hydrogeologic conditions are set forth below.

4.1 Subsurface Investigations and Assessments Conducted

Pursuant to 310 CMR 40.0835(4)(d)1, a description of all relevant geologic, hydrologic, geophysical, and other subsurface investigations conducted at the Disposal Site are set forth below. All laboratory reports have previously been submitted to the MassDEP and are therefore not included in this submission.

- An initial round of three soil samples were collected on December 9, 2016. One sample was taken from each location where it was determined that AFFF had been used at the Airport. The areas included the MCI Drill Area, the Deployment Area, and the 1991 Drill Location. Refer to Figure 3 for soil sample locations and to Table 3 for tabulated PFAS in soil results.
- To evaluate potential off-site sources of PFAS and 1,4-dioxane, groundwater monitoring wells were installed at six locations in April 2017. Well locations include in the vicinity of potential sources of PFAS at the current ARFF/SRE Area, at the Deployment Area, and at upgradient locations outside of the Airport. Refer to Figure 4 and 7 for monitoring well locations and Tables 4 and 7 for tabulated groundwater results.
- Groundwater from the new wells was initially sampled for PFAS and 1,4-dioxane in April 2017. Additional groundwater samples and one surface water sample were collected for analysis of PFAS on June 20, 2017. Refer to Figure 4 and 7 for sampling locations and Tables 4, 5 and 7 for tabulated results.
- A second round of soil samples were collected on June 20, 2017 adjacent to the ARFF/SRE Building and within the Deployment Area to begin to determine the extent of PFAS within the surface soils. Based on the results of these analyses, a third round of samples from these two locations were collected on September 26, 2017. The third round of sampling was designed to further delineate the extent of PFAS in soils both horizontally and vertically, with samples taken at the ground surface and at two and four feet below ground surface (BGS). Soil samples were submitted for analysis of PFAS. Refer to Table 3 for tabulated soil results and Figure 3 for sampling locations.
- One sample of AFFF concentrate was analyzed for PFAS compounds to evaluate the foam. The analysis was inconclusive (only 225.5 ug/l of total PFAS was detected) and it is assumed that the sample was not homogeneous (i.e., had separated in the foam bucket) and that the addition of water to the concentrate may affect how precursor PFAS analytes transform into various other detectable PFAS compounds. Refer to Table 8 for tabulated AFFF results.

- Six PFAS soil samples were also analyzed for leaching potential using a synthetic precipitation leaching procedure (SPLP) test between September and October 2017. The chosen samples included four samples from within the boundaries of the PFAS sites at the Airport and two samples from runway reconstruction soils stockpiled at the Airport. Refer to Table 9 for tabulated SPLP results.
- In October 2017, 20 surficial soil samples were collected both on and off Airport property to determine the background concentration of PFAS in the area not related to the application of AFFF at the locations indicated on Figure 15. Refer to Table 6 for soil results.
- In October 2017, three composite soil samples were taken from piles of soil associated with the redevelopment of Runway 15/33. These piles were located on Airport property at the site of the former Mildred's Restaurant and were analyzed for PFAS compounds to evaluate if soil removed from the Airport as part of this redevelopment contained PFAS. Refer to Table 6 for tabulated soil results.
- On August 14, 2018, 24 PFAS surface soil samples were collected in proximity to the ARFF/SRE Building Area and the Deployment Area. PFAS compounds were previously detected in these areas and additional samples were collected to determine the vertical extent of PFAS impacts in soil and to refine the soil disposal site boundary at the Airport. Refer to Table 3 for soil results and Figure 3 for sampling locations.
- In October 2018, three soil borings (DL11, DL14, and HW-F) were advanced in the Deployment Area. One soil boring (ARFF3) was advanced, and one surface soil sample (HW-3) was collected near the ARFF/SRE Building to further delineate the extent of PFAS in soils both horizontally and vertically. All soil borings were advanced using direct push methods. Refer to Table 3 for soil results and Figure 3 for sampling locations.
- In October 2018, six monitoring wells were installed at the Airport. A cluster of three wells (HW-G(s), HW-G(m), and HW-G(d)) was installed at an upgradient location to evaluate potential off-site sources of PFAS. Three additional wells (HW-H, HW-I, and HW-J) were installed southeast of the Deployment Area adjacent to the East Ramp. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- In November 2018, six groundwater samples were collected to evaluate PFAS concentrations in the Deployment Area. Four groundwater samples and one surface water sample from Mary Dunn Pond were also collected for analysis of oxygen and hydrogen isotopes to determine the contribution of pond water from Mary Dunn Pond to the four downgradient monitoring wells. The analysis was inconclusive in tracing the contribution of pond water in the downgradient monitoring wells. Refer to Tables 4, 5, and 10 for groundwater and surface water results and Figure 7 for sampling locations.
- In December 2018, two soil samples were collected from the 1991 Drill Location to determine if PFAS detected in the area are related to background conditions. Refer to Table 3 for soil results and Figure 3 for sampling locations.
- In December 2018, 12 groundwater samples were collected for analysis of PFAS, and 13 groundwater samples were collected for analysis of oxygen and hydrogen isotopes to

determine the contribution of pond water from Mary Dunn Pond to the 13 downgradient wells. Groundwater samples were also collected from four monitoring wells in the Maher wellfield for analysis of 1,4-dioxane. Refer to Tables 4, 5, and 10 for groundwater and surface water results and Figure 7 for locations.

- In February 2019, three additional surface soil samples were collected to further delineate the soil Disposal Site boundary around the ARFF/SRE building. Refer to Table 3 for soil results and Figure 3 for sampling locations
- In May and June 2019, HW installed nine groundwater monitoring wells to delineate the vertical and horizontal extent of PFAS and 1,4-dioxane at the Airport and on adjacent hydraulically upgradient properties. Refer to Tables 4 and 7 for groundwater results and Figures 4 and 7 for sampling locations.
- In June 2019, eight groundwater samples were collected from newly installed groundwater monitoring wells HW-L, HW-K, HW-I (m), HW-I (d), HW-M, HW-D(d), HW-D (dd), and HW-N for PFAS. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- In July 2019, one groundwater sample was collected from the newly installed groundwater monitoring wells HW-O for PFAS. One groundwater sample was collected from HW-L for 1,4-dioxane. Refer to Tables 2 and 5 for groundwater results and Figures 3 and 13 for sampling locations.
- In July 2019, two surface water samples were collected from Upper Gate and Lewis Ponds for PFAS analysis. Refer to Table 8 for surface water results and Figure 2 for sampling locations.
- In August 2019, four groundwater samples were collected from monitoring wells HW-N, HW-A(d), HW-O, and HW-1 to evaluate potential sources of 1,4-dioxane entering the Airport from unknown upgradient sources(s). One groundwater sample was also collected from groundwater monitoring well HW-E for PFAS. Refer to Tables 4 and 7 for groundwater results and Figure 4 and 7 for sampling locations.
- In August 2019, soil sample DL 11 (0-1) was collected from the Deployment Area. Refer to Table 3 For soil results and Figure 3 for the sampling location.
- In August 2019, six spray water samples were collected from discharge locations on a fire truck at the Airport. The samples were collected to verify that the valve mechanism that controls the mixing of AFFF with water was working appropriately. PFAS should not be detected in the spray water. PFAS was detected in each of the six samples collected above the GW-1 standard. Refer to Tables 2 for spray water results.
- On September 27, 2019, HW collected groundwater samples from six monitoring wells located on the Airport for 1,4-dioxane analysis. Refer to Table 7 for groundwater results and Figure 4 for sampling locations.
- In November 2019, the Airport replaced the valve mechanism in the fire truck to ensure that AFFF was no longer mixing with the water despite the mechanism not being engaged.

In December 2019, HW resampled the six discharge locations from the fire truck at the Airport. PFAS was detected at various concentrations at each location, but all were below the GW-1 standard. Refer to Tables 2 for spray water results.

- Between May 5 and May 21, 2020, HW collected 16 groundwater samples for PFAS analysis. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- Between May 5 and May 13, 2020, HW collected groundwater samples from four monitoring wells for 1,4-dioxane analysis. Refer to Table 7 for groundwater results and Figure 4 for sampling locations.
- Between September 14 and September 24, HW and Desmond Well Drilling installed 13 monitoring wells at the locations indicated on Figure 7.
- On September 17, 2020, HW collected groundwater samples from the three Maher Wells (ME-1 through ME-3) for PFAS analysis. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- Between September 14 and September 30, 2020, HW collected 21 soil samples for PFAS analysis. Refer to Table 3 for soil results and Figure 3 for soi sampling results.
- Between October 1 and October 7, 2020, HW collected groundwater samples from 16 monitoring wells for PFAS. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- On October 2 and 7, 2020, HW collected groundwater samples from four monitoring wells for 1,4-dioxane analysis. Refer to Table 7 for groundwater results and Figure 4 for sampling locations.
- On November 5 and 6, 2020, HW collected five groundwater samples for PFAS analysis. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- On November 17, 2020 HW collected two roof samples (rubber membrane and asphalt shingle) from the ARFF/SRE building for SPLP PFAS. The testing was completed to determine if roofing materials were a potential source of PFAS in groundwater through stormwater infiltration. PFAS was detected in each of the samples collected. Although the leachate is not considered drinking water, the concentration of the MassDEP Sum of 6 were below the Method 1 GW-1 and GW-3 standards. Refer to Table 9 for SPLP PFAS results.
- On February 18 and 19, 2021, HW conducted hydraulic conductivity testing at three monitoring locations. Refer to Section 4.3.1 for additional details.
- Between March 17^{th} and March 19, 2021 HW collected 21 groundwater samples for PFAS analysis. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- Between April 5^{th} and April 7^{th}, 2021, HW and Desmond Well Drilling installed monitoring wells HW-U(s), HW-U(m), HW-W(m), HW-W(d) and HW-W (dd) at the locations indicated on Figure 7.

- Between April 6th and 19th, 2021, HW collected 17 soil samples for TOC analysis from the three locations indicated on Figure 16. The TOC samples were collected from various depths between ground surface and 65 feet below grade. Refer to Table 11 for tabulated analytical results.
- On April 19, 2021, HW sampled the recently installed monitoring wells HW-U(s), HW-U(m) HW-W(m), HW-W(d) and HW-W (dd) for further analysis of PFAS compounds in groundwater. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.
- In September 2021, HW installed two groundwater monitoring wells adjacent to, and downgradient of, the former Operations Building (HW-X[s] and HW-X[m]). A soil sample was collected from the unsaturated zone in the boring for well HW-X(s). Refer to Table 3 for PFAS soil results and Tables 4 and 7 for groundwater results. The sampling locations are indicated on Figure 7.
- Between September 1 and 11, 2021 HW collected 26 groundwater samples for PFAS analysis. Refer to Table 4 for groundwater results and Figure 7 for sampling locations.

4.2 Soil Boring and Monitoring Well Construction Logs

Pursuant to 310 CMR 40.0835(4)(d)2, copies of soil boring and monitoring well logs completed by HW and others are included in Appendix F. It should be noted that some of the boring logs are not available due to the age of installation (pre-2000's). Additionally, soil boring logs were not created for shallow surface samples due to the consistency of the soil through the Airport.

4.3 Geologic and Hydrogeologic Conditions

Pursuant to 310 CMR 40.0835(4)(d)3, a characterization of all geologic and hydrogeologic conditions at the Disposal Site is set forth below.

4.3.1 Groundwater Characteristics

Pursuant to 310 CMR 40.0835(4)(d)3a, a discussion of groundwater potentiometric surface, gradient, flow rate, and flow direction is set forth below.

Groundwater Flow

HW developed numerous water table maps for past projects at the Airport and has a clear understanding of the groundwater flow directions across the site. Figures 2, 3, 4, and 7 document groundwater contours which were developed by the U.S. Geological Survey as part of their regional groundwater model for the Sagamore lens aquifer that includes the area of Hyannis in which the Airport is located. The groundwater contours were used as they provide broader information regarding the migration of groundwater at the Airport, and in upgradient and downgradient areas, allowing us to evaluate how groundwater flows across the Airport and downgradient towards the Maher Well field.

HW created an additional water table map specific to the Airport property, based on data taken on April 27, 2020, from monitoring wells used by HW during this investigation. It is attached as Figure 14, and these water table maps illustrate how groundwater flows onto the Airport property from the west and northwest, migrates to the southeast, and then exits the property to the southeast corner of the Airport.

Groundwater elevations, measured by HW throughout the project, are also included on Table 4. Based upon the groundwater elevations, the estimated hydraulic gradient is set forth below.

Start (Well ID)	**End (Well ID)**	**Distance (Feet)**	**Change in Groundwater Elevation (feet)**	**Hydraulic Gradient (Feet per foot)**	**Well Start Location**	**Well End Location**
HW-1	HW-23	1,477	2.7	0.0018	North Ramp	North Ramp
HW-1	HW-4M	325	0.66	0.0020	North Ramp	North Ramp
HW-23	HW-L(d)	3,175	9.42	0.0029	North Ramp	ARFF/SRE Area
HW-302	OW-9(s)	1,201	6.57	0.0054	Steamship Parking Lot	Maher Well Field
HW-E	HW-I(s)	507	1.57	0.0030	Deployment Area	Deployment Area
Average Hydraulic Gradient				0.00302		

Hydraulic Conductivity

To determine the hydraulic conductivity, HW completed a series of drawdown pump tests using a submersible pump and a transducer capable of logging the fluctuation of the water level in hundredths of a foot in 0.5-second intervals. In general, the tests were completed over a 30-minute period at a pumping rate of 0.25 to 0.33-cubic feet per minute. Details from the pump test are indicated below.

Well ID	Well Location	Depth to Water	Total Well Depth	Screen Length	Maximum Drawdown	Pump Rate (cubic feet per minute)	Calculated Hydraulic Conductivity
HW-I(s)	Deployment Area	18.410	25.09	10	18.732	0.33	117 feet per day
HW-F	Deployment Area	20.242	26.82	10	20.483	0.25	114 feet per day
OW-19(m)	Maher Well Field	26.942	76.14	10	27.417	0.33	78 feet per day
Average Hydraulic Conductivity							103 feet per day

Appendix G provides the worksheets that include the data and formulas used to calculate hydraulic conductivity.

Groundwater velocity at the Airport is estimated by the following equation:

$$\text{Velocity (ft/d)} = \frac{\text{Hydraulic Conductivity (ft/d)} \times \text{Hydraulic Gradient (ft/ft)}}{\text{Effective Porosity}}$$

ft/d = feet per day
ft/ft = feet per foot

Based on experience in the area, effective porosity is assumed to be 33 percent (25-50 percent, Freeze and Cherry, 1979). Therefore, based on the slope of the water table in this area, the porosity of the aquifer, and the hydraulic conductivity of the aquifer based on tests from wells HW-1(s), HW-F, and OW-19(m), the average groundwater velocity is estimated to be 0.94 feet per day or 344 feet per year.

4.3.2 Migration of PFAS Compounds in Unsaturated Soil Above the Aquifer

Research conducted at the Joint Base Cape Cod (Weber, et al, 2017) documented that it took between 7-30 years for PFAS from AFFF sprayed at their fire training area to migrate to groundwater. The depth to water below the Deployment Area is approximately 25 feet, similar to that seen at Joint Base Cape Cod. The subsurface glacial soils in that area are similar to what exists at the Airport site indicating that PFAS compounds will adhere to the soils and only migrate slowly down to groundwater. The concentrations of PFAS measured in soils at the Deployment Area (1,524 ug/kg of Total PFAS at sample location MCI Drill (0-1)) are significantly higher than in groundwater directly below this site (15.5 ug/l of Total PFAS at sample location HW-I[s]) supporting this hypothesis. Based on HW mapping of the groundwater plume, it took approximately 21 years for PFAS compounds to enter the aquifer from the Deployment Area (1,524 ug/kg of Total PFAS at sample location MCI Drill (0-1)). This is based on the following assumptions:

- The groundwater plume in the Deployment Area is currently mapped with analytical data to be a maximum of 1,700 feet in length.
- The plume is moving in groundwater at approximately 285 feet per year (see details below) indicating that the PFAS analytes first entered groundwater in approximately 2015.
- The first application of PFAS in the Deployment Area occurred in 1994.

In addition, the limited use of AFFF at the Airport and the migration of PFAS from the ground surface to the aquifer plays a significant role in determining how long it took for PFAS compounds in the AFFF to enter the aquifer and begin to move with groundwater. AFFF was only used once per year at the Deployment Area beginning in 2004 until 2015 to confirm that the firefighting equipment used by the Airport was operating properly. Every three years, a mass casualty drill was also conducted at this location during which AFFF was also used, between the years of 1994 and 2012. These events were all required by FAA. Based on purchase records from the Airport, 1,280 gallons of AFFF were used from 2000-2015, at which time the use of AFFF for training purposes was suspended. The organic carbon in the surface soil and subsurface soils readily bound up the PFAS compounds from the foam spraying and slowed their migration downward.

Migration of PFAS Compounds in Groundwater

HW calculated the rate of PFAS transport in groundwater, separate from the migration through the surficial soils. An explanation of the calculation is provided below followed by an assessment of the transport time in groundwater for one PFAS compound: 6:2-FTS. This compound is associated with the type of AFFF used by the Airport. Although it is not currently one of the MassDEP six regulated PFAS compounds, it has a lower retardation rate compared to the other six PFAS analytes currently regulated in Massachusetts and therefore moves more quickly through groundwater as indicated on Figure 17. The use of 6:2-FTS is therefore a good representation of the maximum distance that the six regulated PFAS analytes has migrated from the Deployment Area and the ARFF/SRE Area.

<u>Retardation Factor Calculation</u>

The migration of PFAS in groundwater is slower than the velocity at which groundwater moves through the aquifer. This is because the PFAS compounds interact with the organic carbon present in the saturated soils, thereby slowing, or retarding the rate at which they move in the aquifer. The rate at which they move through the aquifer can be determined by calculating the retardation factor for a particular compound using the following formula:

$Rf = 1 + d*Kd/n$

Rf = retardation factor

d = aquifer bulk density = 1.5

n = porosity = 33 percent = 0.33

kd = (soil) distribution coefficient = foc * Koc
foc = fraction organic carbon

Koc = organic carbon/water partition coefficient

The retardation factor is then used to calculate the slower flow rate for the plume in the aquifer based on the known rate of groundwater flow.

Select soil samples were collected for TOC at the locations indicated on Figure 16. The TOC ranged from less than the laboratory reporting limit to 28,900 mg/kg as indicated on Table 11. HW calculated the retardation factor using the various statistical inputs calculated from the TOC data that are included on Table 12.

Surficial TOC samples were obtained adjacent to the documented PFAS contaminated areas in soil. Surficial or saturated soil samples from below the two source areas could not be collected because both areas have been capped to prevent further release of PFAS compounds to groundwater. Drilling a soil boring to collect soil for TOC analysis from these areas could impact the integrity of these caps. Therefore, surficial TOC samples were collected from locations both within and adjacent to the Deployment Area plume and from the multiple depths within the aquifer adjacent to the downgradient edge of the plume. Data from these areas are appropriate to use for evaluation of soil migration in both surficial soils and in areas deep in the aquifer.

The various TOC ranges documented above were used to calculate multiple retardation rates for PFAS transport, providing the rate at which each of the six regulated PFAS compounds and 6:2-FTS is traveling through groundwater while considering the substantial amount of time the PFAS compounds are bound by high TOC in the surficial soil. The TOC concentrations in the aquifer soils are significantly lower than what is detected in the soils above the water table. A TOC range was used to demonstrate that only evaluating soils in the aquifer will severely overestimate plume migration from the point of release. Once the plume reaches groundwater, it will move at a rate of285 feet or so per year. Only evaluating the deep aquifer soils will not account for the significant amount of time it takes for the PFAS analytes to move through the unsaturated zone.

The octanol/water portioning coefficient (Koc)values used by HW were obtained from the Environmental Protection Agency CompTox Chemical Dashboard to calculate the retardation rate for PFAS compounds in groundwater (https://comptox.epa.gov/dashboard). The Koc value for each of these PFOS compounds was then multiplied by the applicable TOC value (Table 12) to develop a range of portioning coefficient (Kd) values. The Kd value was then used to calculate the retardation rate for each of these PFAS compounds. This rate is multiplied by the documented groundwater flow velocity to calculate the rate at which each compound moves in groundwater. Refer to Table 12 for additional details on the calculations. As indicate above, applying a range of TOC values helps to account for the time taken for PFAS to migrate through soil (high TOC Values with slow migration) and groundwater (low TOC values with fast migration).

Only taking into account groundwater migration will overestimate the plume migration from the initial date at which AFFF was applied at the Deployment Area or released near the ARFF building.

Again, 6:2-FTS was chosen specifically to evaluate the downgradient migration of the plumes from the Deployment Area and ARFF building. The purpose of this investigation was, in part, to determine a reasonable physical extent of the plumes from these areas. The Koc for 6.2-fluorotelemer is lower than the Koc for each of the six PFAS compounds regulated by MassDEP. Therefore, it does not bind to the organic carbon present in the aquifer soils at the same rate as the other PFAS compounds. Its retardation rate is somewhat lower, and it travels faster in groundwater compared to the regulated compounds. Refer to Figure 17 for a depiction of the general AFRR particle track in soil and groundwater.

<u>Migration of 6:2-FTS in Groundwater</u>

Based on the site-specific TOC data, our calculations show that 6:2-FTS in the PFAS plume will travel in groundwater at a maximum of 285 feet per year. This is based on a total organic carbon concentration of 48 mg/kg. The concentrations of TOC from test locations below the water table were below the laboratory reporting limit for the analytical method used in the analysis. The detection limit ranged from 93.5 to 96.9, so 48 mg/kg represents one half the average of the reporting limit and is a reasonable estimate for the TOC concentration in the aquifer soils. Tabulated TOC data is included on Table 11.

As described previously and as documented with recent groundwater sampling, HW mapped the downgradient boundary of the main Airport plume as no more than 1,700 feet downgradient of the Deployment Area. **This suggests that PFAS in Deployment Area soils reached groundwater approximately six years ago and indicates that it took approximately 21 years for the PFAS to migrate through the site soils before reaching groundwater (original application of AFFF in the deployment area was in 1994)**. This is consistent with the rate of transport discussed in the Massachusetts Military Reservation study from Weber, et al (2017), and with the groundwater testing data and forensic analysis provided in this Phase II. Additional details regarding the retardation factor calculation are set forth below.

- The retardation calculation is site specific as it relies on site specific TOC, hydraulic gradient, and hydraulic conductivity data. By applying a range of TOC values, HW considered the amount of time it took for PFAS to migrate through the unsaturated soil (high TOC) to reach groundwater. The groundwater velocity range presented accounts for migration in both unsaturated and saturated soils. The low end of the range (38 feet per year) considers migration in both unsaturated and saturated soils, and the high end of the range (285 feet per year) is migration in groundwater only. As discussed above, it can take significant time for PFAS to migrate through unsaturated soils. To form an accurate Conceptual Site Model, the amount of time for migration in the unsaturated soils must be considered.

- The hydraulic gradient was calculated as an average from multiple wells located in the Deployment Area, ARFF/SRE Area, North Ramp, Steamship Parking Lot, and the Maher Well field. The average hydraulic gradient (0.00302 feet per foot) calculated from multiple wells is consistent with the hydraulic gradient calculated in the Deployment Area (0.0030 feet per foot). The average hydraulic conductivity was calculated from pump tests conducted at two wells located in the Deployment Area and one well located near the Maher Well field. The use of "average" values for hydraulic gradient and hydraulic conductivity provides a conservative and realistic approach for calculating plume migration and accounts for the non-homogeneity of the subsurface saturated soils located in the aquifer.
- The Weber, et al study of the Massachusetts Military Reservation provides field-based calculations of the Kd and Koc values for PFAS compounds present in the plume they analyzed. The table below compares PFOS and 6:2-FTS Log Koc values presented in the Weber, et al study to the EPA CompTox Koc calculated for the Airport in this Phase II Report.

Value	Cape Code Study	Airport
Log Koc for PFOS	3.37+/- 0.27	3.16
Log Koc for 6:2-FTS	2.62+/- 1.01	2.97

The EPA CompTox Koc values presented in this Phase II Report for both PFOS and 6:2-FTS were within the site-specific laboratory-based values presented in Weber, et al. This indicates that the KOC values for these two analytes were similar. Refer to Table 12 for the KOC values used by the Airport.

HW initially focused on plume migration through the soils and groundwater, developing an average rate of transport through both media. The Weber, et al study, emphasized that it can take significant amount of time for PFAS analytes to migrate in the unsaturated zone before entering groundwater. The calculations provided above show that the plume may have been migrating in the groundwater for approximately six years, after taking approximately 21 years to enter the aquifer system. This assumes a very low TOC concentration in the aquifer soils based on tests conducted in proximity to the Maher Well Field.

Overall, the current location of the plume from the Deployment Area and ARFF/SRE Area is mapped based on the laboratory analysis of groundwater samples in and around the plume and supported by the forensic data described in this report and the retardation calculations discussed here. The location of the plume also fall within the migration values presented above.

4.3.3 Soil Characteristics

Pursuant to 310 CMR 40.0835(4)(d)3b, a discussion of soil type(s), stratigraphy, and permeability is set forth below.

In general, soils at the Airport in proximity to the Deployment Area and ARFF/SRE Area consisted of fine to medium sand, with some coarse sand, gravel, and cobbles down to a depth of approximately 70 feet below ground surface. Below 70 feet, a layer consisting of gray silt and clay exists. The materials encountered during the soil borings are consistent with those described by the USGS soil survey for Barnstable Outwash Plain Deposits (Oldale, 1974). Bedrock was not encountered in any of the soil borings. The location of the soil borings and monitoring wells are indicated on Figures 3, 4 and 7. Soil boring logs are included in Appendix F. It should be noted that soil boring logs were not completed for shallow soil samples and that some of the monitoring well logs from pre-2000 are not available. Analytical data suggests that soil within the two capped areas have PFAS impacts that exceed the current MassDEP S1/GW-1 standard that extend to at least 16 feet below grade as well as detectable PFAS concentrations below the MassDEP S1/GW-1 Standard at the soil/groundwater interface. The surficial extent of PFAS in soil exceeding the applicable Method 1 standards are indicated on Figure 3.

4.3.4 Bedrock Characteristics

Pursuant to 310 CMR 40.0835(4)(d)3c, a discussion of bedrock type and characteristics, depths, and contours is set forth below.

As indicated above, bedrock was not encountered in any of the soil borings and is expected to be located at a depth greater than 125 feet below grade.

4.3.5 Potential for Flooding

Pursuant to 310 CMR 40.0835(4)(d)3d, an evaluation and description of the potential for flooding is set forth below.

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map, the Airport is within Zone X, an area of minimal flood hazard determined to be outside the 500-year flood (Figure 18). The Airport property is not at a high risk for flooding. A small amount of forested area near Mary Dunn Pond, within the Airport property boundary, is within an area with a 0.2% annual chance of flood hazard. Refer to Figure 18 for a depiction of FEMA flood zones at and within proximity to the Airport. HW is unaware of any flooding that has taken place at the Airport. As such, it is unlikely that flooding will impact the extent of soil impacts at the Airport.

5.0 ENVIRONMENTAL FATE AND TRANSPORT

Pursuant to 310 CMR 40.0835(4)(e), environmental fate and transport of OHM detected at the Disposal Site is set forth below.

5.1 Fate and Transport Characteristics

Pursuant to 310 CMR 40.0835(4)(e)1, an evaluation of the environmental fate and transport characterizes the OHM identified at the Disposal Site, including, without limitation, mobility, stability, volatility, persistence, and bioaccumulation potential of the OHM is set forth below. The OHM includes details on all six PFAS compounds regulated by the MassDEP, 6:2-FTS, and potential degradation products and 1,4-dioxane.

5.1.1 AFFF Usage, Release, and Degradation Potential

Based on interviews with Airport staff who have worked at the Airport since the 1980s, AFFF was only intentionally sprayed at the Airport during tri-annual drills (1991, 1994, 1997, 2000, 2003, 2006, 2009, and 2012), during an Airport Emergency (1981 and 2016 aircraft crash), and once per year between 2004 and 2015 as part of the FAA annual foam testing requirement (14 CRF 139). Airport personnel also indicated that fluorotelomer-based AFFF had been used at the Airport since at least the 1980s when foam usage was limited to 35-gallons for use in one fire rescue vehicle. AFFF was used at the Deployment Area between 1994 and 2004 for triannual drills and between 2004 and 2015 for annual AFFF mixture testing. Two firefighting personnel, employed by the Airport since the 1980's, indicated that foam testing was not conducted prior to 1991 due to cost, limited availability, and lack of an FAA requirement mandating foam usage. With the exception of the events detailed above, AFFF was not intentionally sprayed due to cost and limited supply of AFFF. With the exception of the 1991 drill, all drills and AFFF testing have been conducted at the unpaved Deployment Area.

In addition to the tests and training usage with AFFF, daily (approximately 5 gallons) and monthly (100 gallons) testing of the fire apparatus is conducted with just water. The test is conducted to verify that the fire apparatus pumps are operational. No foam is intentionally sprayed during these tests. The spray water from the fire trucks were tested for PFAS in 2019 to verify that the valve mechanism that segregated the AFFF was working properly. The analytical results indicated that AFFF was being mixed with the water unintentionally from the internal AFFF holding tanks. It was determined that the valve that segregates the AFFF was faulty and was the cause of the unintentional mixing. The faulty valve was replaced, and a maintenance schedule has been initiated. Subsequent testing of the spray water indicates that PFAS levels are less than the current GW-1 standard. The combination of tri-annual drills, the annual AFFF testing, and, to a lesser extent, the daily and monthly spraying of water have contributed to the AFFF related PFAS impacts in the Deployment Area. The Airport stopped using AFFF in the tri-annual training drills in 2015 and purchased an ecological cart in 2016 to stop spraying AFFF as part of the annual FAA testing requirement. Refer to Table 2 for tabulated analytical data from the spray testing.

The current ARFF/SRE Building was constructed in 1996, and PFAS is assumed to have been released in this area through, what is presumed to be, incidental spillage, dripping from hanging fire house apparatus to dry, and cleaning of equipment in the event of accidentally engaging the foam pump button. Interior floor drains that were closed in the early 2000's within the ARFF/SRE building historically discharged to the adjacent grass area that was capped in the fall of 2020.
Prior to 1996, the Airport fire truck was housed in the former Operations Building located adjacent to the former terminal along the North Ramp (see attached Figure 2). This building was

demolished in 2011. Based on interviews with two firefighting staff who have worked at the Airport since the 1980s, AFFF containers were also stored in this building.

In the event the foam pump was accidentally engaged, equipment was rinsed by pumping water through it and then discharging the water to the adjacent grass area that has since been capped. Stormwater, in the vicinity of the recently capped area, also historically infiltrated into this area and included both the building's roof and surrounding paved surface areas. The interior floor drains historically discharged to this area but were closed in the early 2000's and connected to a permitted discharge to the Barnstable Wastewater Treatment Plant. As part of the cap installed in 2020, stormwater was redirected away from this area and instead infiltrates beyond the PFAS impacted soil areas.

Degradation Potential

HW conducted additional research regarding PFAS to better understand the fate and transport and the degradation potential of PFAS while traveling through both soil and groundwater.

<u>Short-Chain PFAS vs. Long-Chain PFAS</u>

According to the document titled "*Aqueous Film-Forming Foam*" prepared by the Interstate Technology ITRC, legacy fluorotelomer-based AFFF (1970s to 2016) historically contains predominantly short-chain (C6) PFAS with formulations ranging from about 50–98% short-chains with the balance as long-chain PFAS. Additionally, the long-chain PFAS content of these foams has the potential to break down in the environment to PFOA and other PFCAs, but not to PFOS or other PFSAs (Weiner et al. 2013). This is consistent with the radar plots in the AFFF source areas which indicate 6:2 FTS constitutes over 80% of the sum of the total PFAS analytes reported by the laboratory.

According to the article titled "*Quantitative Determination of Fluorotelomer Sulfonates in Groundwater by LC MS/MS"*, "groundwater monitoring studies have shown the predominant breakdown product of the short-chain C6 fluorosurfactants contained in telomer-based AFFF to be 6:2 fluorotelomer sulfonate (6:2-FTS)". This statement is consistent with the analytical results collected from the Airport source areas that indicate upwards of 83 percent of the total PFAS detected in monitoring well HW-I[s], the well with the highest concentration of Total PFAS on Airport property , was related to 6:2-FTS. This well, located within the Airport Deployment Area, was tested in November 2018 (82.4%) and then again in May 2020 (83.7%). The detection of this analyte at such a high percentage is representative of studies that indicate that fluorotelomer-based AFFF short chain PFAS transform into 6:2-FTS. Additionally, for comparison, spray water samples collected from the fire hose spray water before the valve mechanism was fixed contained 6:2-FTS at 79 percent.

According to the chart below prepared by ITRC and obtained from their document titled "*Naming Conventions for Per and Polyfluoroalkyl Substance*", short chain PFCAs include PFBA, PFPeA, PFHxA, and PFHpA. Of these included in the chart, MassDEP currently regulates the short chain PFCA compound PFHpA.

Number of Carbons	4	5	6	7	8	9	10	11	12
PFCAs	Short-chain PFCAs				Long-chain PFCAs				
	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
PFSAs	PFBS	PFPeS	PFHxS	PFHpS	PFOS	PFNS	PFDS	PFUnS	PFDoS
	Short-chain PFSAs		Long-chain PFSAs						

Biotransformation

A study by Zang et al (2016) titled "*Biotransformation potential of 6:2 Fluorotelomer Sulfonate (6:2 FTSA) in aerobic and anaerobic sediment*" evaluated the biodegradation of 6:2 FTS in aerobic river sediment and concluded that it could take place fairly rapidly in this environment. This study is not relevant to the aquifer at the Airport as there is no river sediment or similar organic material at concentration that would promote the biodegradation of 6:2 FTS. Similarly, a study by Wang (2010) showed that 6:2 FTS could potentially biodegrade in aerobic conditions using wastewater sludge as the medium. Again, this type of organic material is not present in the aquifer below the Airport. Considering that 6:2-FTS has been detected in HW-S(s) which is located approximately 700 feet downgradient of HW-I(s) at very similar percentages (76 and 83.7 percent, respectively), significant biotransformation of 6:2-FTS is not occurring and the 6:2 FTS analyte appears to be stable.

It is possible, with the right conditions, for 6:2-FTS to biodegrade into one or more perflourocarboxylic acids (PFCAs). HW evaluated this issue by looking at the relative concentrations of 6:2-FTS versus the PFCA compounds using data from wells within the plume from the Deployment Area. The concentration of 6:2-FTS did decrease between well HW-I(s) in the Deployment Area and well HW-S[s] approximately 700 feet downgradient, as indicated previously. However, there was no significant increase in the PFCA concentrations in the downgradient well, and the reduction in 6:2-FTS concentration between these two wells is attributed to dilution and dispersion. The concentration of Total PFAS, 6:2-FTS, PFOA, PFOS, and the short chain PFCAs are indicated below in ug/l.

Analyte	HW-I(s) 5/8/2020	HW-S(s) 10/1/2020	HW-19(m) 10/1/2020
Total PFAS	15.5358	4.8958	0.37335
6:2-FTS	13.0	3.7	0.00095
PFBA	0.021	0.086	0.033
PFPeA	0.81	0.42	0.13
PFHxA	0.51	0.25	0.027
PFHpA	0.54	0.11	0.03
PFOA	0.29	0.062	0.011
PFOS	0.04	0.1	0.047

Based on the table above, the 6:2-FTS appears to be relatively stable and is a helpful analyte to monitor the AFFF plume movement. Additionally, as discussed in later sections of this report and Section 4.3.2, 6:2-FTS moves faster in groundwater than the MassDEP Sum of Six regulated analytes (Figure 17). As such, 6:2-FTS is helpful in tracking the extent of the Airport AFFF plume. The extent of the AFFF plume in the vicinity of the Deployment Area is based on forensics, analytical results, and PFAS fate and transport mechanisms. As a conservative measure, the Deployment Area Plume has been depicted on Figure 2 as being slightly upgradient of OW-19 which does not appear to have PFAS impacts consistent with the Airport AFFF plume. A distance of approximately 1,100 feet exists between HW-S(s) and OW-19.

Considering that the source in the ARFF/SRE Area is related to incidental spillage and/or a single release event, it is not a chronic source like the Deployment Area. This is evident when reviewing the concentration (in ug/L) of 6:2-FTS, PFOA, PFOS, and the short chain PFCAs throughout the ARFF/SRE plume as indicated below.

Analyte	**HW-P(s) 10/1/2020**	**HW-302 12/3/2018**	**HW-3 5/5/2020**	**RB-1(s) 5/8/2020**	**RB-1(m) 5/8/2020**
Total PFAS	0.2458	0.3427	0.96981	0.08008	0.2015
6:2-FTS	0.011	0.13	0.13	ND	0.038
PFBA	0.041	0.014	0.0056	0.0033	0.01
PFPeA	0.1	0.042	0.33	0.0078	0.041
PFHxA	0.045	0.027	0.21	0.0058	0.021
PFHpA	0.026	0.015	0.1	0.0042	0.011
PFOA	0.0084	0.030	0.054	0.007	0.013
PFOS	0.00097	0.031	0.1	0.038	0.049

Considering the stability of 6:2-FTS and the fact that it migrates faster than any of the MassDEP regulated PFAS analytes, it appears that AFFF related compounds were released at some point in time after 1996 (ARFF/SRE Building was constructed in 1996) in the vicinity of monitoring well HW-P(s) and HW-P(m). Based on forensics, analytical results, and PFAS fate and transport mechanisms, the AFFF plume in the vicinity of ARFF/SRE Building has migrated approximately 900 to 1,000 feet. The Maher Wells are located an additional 1,000 feet downgradient of the Airport's AFFF plume. The extent of the Airport's AFFF plume is indicated on Figure 2.

As indicated on Figure 2, PFAS impacted groundwater is migrating onto the Airport from off-Airport upgradient sources that are not consistent with the AFFF specific PFAS plume associated with Airport. Additionally, as indicated on Figure 2, the PFAS plume associated with the Airport does not appear to have migrated to the Maher Wells as of when the last samples were collected. However, it is also understood that the Airport's PFAS Plume is migrating toward the Maher Wells. Additional groundwater testing is planned as part of ongoing IRA activates to further support the Conceptual Site Model and to help prepare the Phase III report.

The Airport has controlled a majority of the sources of PFAS in soil relating to the historic deployment of AFFF via two non-permeable caps installed within the vicinity of this release. The cap installations were completed in September 2020 and additional details are included in the report titled "*Immediate Response Action Plan Status Report 8"* dated October 2020 which is available for direct download from the MassDEP Searchable Sites Database using RTN 4-26347. Considering that PFAS have been detected in soil in both areas down to groundwater, the cap will prevent the further vertical migration of PFAS in soil.

Ultimately, the radar plots developed by HW clearly document which groundwater samples are related to the Airport sources and which are associated with offsite sources. The Airport groundwater plume contains all but one of the sum-of-six compounds regulated by MassDEP (PFDA) and unregulated PFAS compounds including a high concentration of 6:2-FTS. The relative concentrations of each PFAS compound (both regulated and unregulated) were used to confirm if a groundwater sample was related to the Airport releases.

HW concludes that the aquifer conditions in the vicinity of the Airport do not contribute to the biodegradation of 6:2-FTS. This is supported by the measured concentrations of 6:2-FTS and PFCAs in the Deployment Area plume. As discussed above, while these concentrations decreased in downgradient locations, the concentrations of the potential degradation compounds did not increase in a proportional manner.

5.1.2 Vapor Pressure

To continue to understand the fate and transport of PFAS and PFAS related compounds in soil and groundwater, additional chemical characteristics need to be considered. For instance, vapor pressure is a measurement of the tendency of a material to change into the gaseous or vapor state. The higher the vapor pressure, the more volatile a substance is. According to the EPA Comp Tox, the following vapor pressures are applicable to the six PFAS compounds regulated by MassDEP, 6:2-FTS and 1,4-dioxane:

Analyte	**Vapor Pressure (millimeters of mercury)**
Perfluorodecanoic Acid (PFDA)	1.53×10^{-3}
Perfluoroheptanoic Acid (PFHpA)	0.229
Perfluorohexanesulfonic Acid (PFHxS)	8.10×10^{-9}
Perfluorooctanoic Acid (PFOA)	0.952
Perfluorooctanesulfonic Acid (PFOS)	2.48×10^{-6}
Perfluorononanoic Acid (PFNA)	8.72×10^{-3}
6:2 fluorotelomer sulfonate (6:2-FTS)	8.24×10^{-7}
1,4-dioxane	38.1

5.1.3 Henry's Law Constant

The Henry's Law Constant describes the air-water partitioning of a gas dissolved in a liquid. Compounds with high Henry's Law Constants prefer to exist in the vapor phase rather than the dissolved phase. According to the EPA CompTox, the following Henry's Law Constants are applicable to the six PFAS compounds regulated by MassDEP, 6:2-FTS and 1,4-dioxane:

Analyte	Henry's Law Constant (atm-m^3/mole)
PFDA	$1.50x10^{-10}$
PFHpA	$2.09x10^{-10}$
PFHxS	$1.94x10^{-10}$
PFOA	$1.92x10^{-10}$
PFOS	$1.80x10^{-11}$
PFNA	$1.18x10^{-9}$
6:2-FTS	$1.83x10^{-10}$
1,4-dioxane	$4.80x10^{-6}$

5.1.4 Solubility

The solubility of a substance is the degree to which the substance (the solute) will dissolve into a solvent (i.e., water). The higher the solubility, the more solute will dissolve into the solvent. According to the EPA CompTox, the following solubility are applicable to the six PFAS compounds regulated by MassDEP, 6:2-FTS and 1,4-dioxane:

Analyte	Solubility (moles per liter)
PFDA	$5.25x10^{-3}$
PFHpA	0.324
PFHxS	$6.08x10^{-4}$
PFOA	$1.37x10^{-2}$
PFOS	$1.13x10^{-3}$
PFNA	$2.80x10^{-3}$
6:2-FTS	0.669
1,4-dioxane	11.42

5.1.5 Persistence

The persistence of a chemical is the length of time that a chemical can exist in the environment before being destroyed or transformed by natural processes. According to the EPA, a chemical is characterized as persistent if it has a half-life greater than two days. According to the EPA

CompTox, the following biodegradation half-life is applicable to the six PFAS compounds regulated by MassDEP, 6.2-FTS and 1,4-dioxane:

Analyte	Biodegradation Half Life (days)
PFDA	4.94
PFHpA	4.47
PFHxS	4.45
PFOA	4.94
PFOS	4.92
PFNA	4.94
6:2-FTS	4.95
1,4-dioxane	9.36

5.1.6 Bioaccumulation Potential

The bioaccumulation factor ("BCF") is an indication of the potential for a compound to bioaccumulate in the environment. The higher the BCF, the more likely it is to bioaccumulate. According to the EPA, a chemical is characterized as bioaccumulative if it has a BCF factor greater than 1,000. A chemical with a BCF greater than 5,000 is considered very bioaccumulative.

Analyte	Bioaccumulation Factor (unitless)
PFDA	49.3
PFHpA	92.2
PFHxS	175
PFOA	7,670
PFOS	1,900
PFNA	165
6:2-FTS	188
1,4-dioxane	0.925

5.2 Migration Pathways

Pursuant to 310 CMR 40.0835(4)(e)2, identification and characterization of existing and potential migration pathways of the OHM at and from the Disposal Site, including, as appropriate, air, soil, groundwater, soil gas, preferential migration pathways such as subsurface utility lines and other subsurface void spaces, surface water, sediment, and food chain pathways are set forth below.

5.2.1 Soil Migration

Based on the PFAS composition from soil samples collected both on and off the Airport, samples taken from the Deployment Area show that the AFFF used by the Airport contains all six of the PFAS compounds regulated by MassDEP (except PFDA in groundwater) along with other PFAS compounds. The data from areas outside the Deployment Area and the ARFF building locations do not indicate the same composition of PFAS compounds associated with the AFFF used by the Airport.

Based on the concentration of PFAS detected in soil (Table 3), none of the six regulated PFAS compounds exceed the proposed Upper Concentration Limit in soil of 4,000 ug/kg. Additionally, the Airport stopped all AFFF foam testing in 2015. AFFF use will only occur at the Airport in the event of an emergency. Also, as indicated on Figure 4, two impermeable caps were installed in September 2020 over a majority of the known PFAS in soil source area to reduce the potential for infiltration and migration. As indicated above, 1,4-Dioxane does not appear to be attributed to the Airport based on groundwater analytical data and particle tracking.

5.2.2 Groundwater Migration

Based on the concentration of PFAS detected in groundwater (Table 4), none of the six regulated PFAS compounds exceed the Upper Concentration Limit in groundwater of 5,000 to 100,000 ug/L. Additionally, as indicated above, two impermeable caps were installed in Fall 2020 over a majority of the known PFAS in soil source area to reduce the potential for infiltration and migration of PFAS in groundwater. Stormwater management systems were also constructed in these areas to allow for stormwater to infiltrate outside of the known PFAS in soil source areas. Moreover, the Airport stopped all AFFF foam testing in 2015

The extent of the PFAS plume related to the use of AFFF at the Airport is indicated on Figure 2 along with the estimated extent of other non-Airport related PFAS and 1,4-dioxane plumes. The vertical and horizontal extent of the PFAS and 1,4-dioxane plumes are also indicated on Figures 5 through 13. These figures also document that the 1,4-dioxane plume is migrating onto the Airport from an unknown source. 1,4-dioxane concentrations detected in groundwater are included on Table 7 and as indicated above, the Airport does not appear to be the source of 1,4-dioxane in groundwater.

Conversely, 1,4-dioxane migrates quickly from soil to ground water, so testing of groundwater in the vicinity of a potential release site is appropriate to determine if a release occurred. As explained above, groundwater testing in the vicinity of the historic deicing pads and historic solvent release area confirms that they are not the source of the 1,4-dioxane plume. Groundwater data clearly indicates that the source of the 1,4-dioxane is from an off-site location located hydraulically upgradient of HW-V(m).

The 1,4-dioxane plume is shown to enter the Airport near well HW-V(m) and flows southeast until it leaves the Airport property and flows towards the Maher Well field. HW created an updated hydrogeologic cross section (Figure 6) that shows how the plume moves down into the aquifer as it travels across the Airport. It moves downward at a consistent rate, based on the amount of recharge to the aquifer from rainfall that infiltrates into the ground. The cross-section documents wells screened in the aquifer above the mapped plume in which no 1,4-dioxane was detected. It also documents that the concentration of 1,4-dioxane in the plume is relatively stable as it moves across the Airport property, ranging from 0.8.ug/L upgradient of the Airport in well HW-V(m) to 0.732 ug/L downgradient of the Airport in Well OW-9(dd).

The direction of groundwater flow and relatively stable detection levels of 1,4-dioxane suggest that there is a long-term, consistent source of 1,4-dioxane upgradient of the Airport impacting groundwater quality.

1,4-dioxane was detected in well OW-18(d) at a depth of approximately 100 feet below the water table. Based on the hydrogeologic analysis, if a release occurred at the historic deicing area, it would move downward at a rate of approximately one feet of depth per 100 feet of horizontal transport. The well is located approximately 1,700 feet from the deicing area, so any 1,4-dioxane would be found at a depth 15-20 feet below the water table, not 100 feet below the water table. Additionally, sampling of HW-J which is downgradient of the former de-icing area and screened appropriately to detect a release in this area, did not contain 1,4-dioxane above the laboratory reporting limit.

The combination of these observations strongly supports the conclusion that no deicing fluid impacted groundwater at this location.

Ultimately, groundwater is flowing from the Deployment Area and ARFF/SRE Building towards the Maher Well field. This indicates that the PFAS plume from these source is headed in that direction and will likely reach the Maher Well field. Bi-annual monitoring is being conducted to track the plume migration and is being reported in IRA Status Reports submitted to MassDEP.

5.2.3 Preferential Migration Pathways

No subsurface utilities or other preferential pathways are located within the Disposal Site.

5.2.4 Air and Soil Vapor Migration

Considering the depth of groundwater (greater than 15 feet), the concentration of OHM in soil and groundwater and the vapor pressures of the OHM, vapor phase migration is unlikely.

5.2.5 Surface Water and Sediment Migration Pathways

As indicated on Figure 2, surface water samples were collected from Upper Gate Pond, Lewis Pond, and from a stormwater drainage basin located adjacent to the K-Mart Plaza. All results (Table 5) were below the laboratory reporting limit and/or below the Method 1 GW-1 and GW-3

Standard for the six regulated PFAS analytes. There is currently no surface water standard for PFAS. Additionally, based on the extent of the Airport's PFAS plume as indicated on Figure 2, surface water and sediments are unlikely to be impacted by the Airport AFFF release. It should be noted that PFAS, including the MassDEP six regulated compounds, have been identified at levels above the Method 1 GW-1 Standard entering the Airport in groundwater from the west from unknown upgradient source(s). However, the ponds themselves are quite shallow and do not interact with deeper groundwater found that far below the water table. There are no surface water outflows from the ponds that would cause groundwater to migrate upward to discharge to the ponds or an outlet stream. The ponds will only interact with shallow groundwater.

5.3 Potential for Groundwater to Impact Indoor Air

Pursuant to 310 CMR 40.0835(4) (e) 3, an evaluation of the potential for soil, groundwater, or NAPL to be a source of vapors of OHM to indoor air of occupied structures is set forth below.

Considering the depth of groundwater (greater than 15 feet), the concentration of OHM in soil and groundwater and the vapor pressures of the OHM, vapor phase migration into indoor air is unlikely.

6.0 NATURE AND EXTENT OF OHM IMPACT

Pursuant to 310 CMR 40.0835(4) (f), a discussion of the nature and extent of OHM impact at the disposal site is set forth below.

6.1 Characterization of Source and Nature of OHM Impact

Pursuant to 310 CMR 40.0835(4)(f), a characterization of the nature, and vertical and horizontal extent of OHM-impacts at the Disposal Site, including any and all source(s), the presence, distribution and stability of any non-aqueous phase liquid (NAPL), tabulation of analytical testing results, and, where appropriate, a characterization of background concentrations of OHM is set forth below.

As indicated above, the Disposal Site is the location of a release of PFAS compounds to soil and groundwater associated with the historic use of AFFF. The source of PFAS related to Airport operations is from the use of AFFF for training and emergencies and incidental spillage. Annual testing per FAA regulations is required to ensure that there is the appropriate AFFF to water mixture. Historically, the test consisted of essentially shooting the mixture of AFFF from the fire rescue vehicle at a small square target. The Airport has since purchased an ecological unit to test to the AFFF mixture without the need of physically mixing or spraying the foam. AFFF usage at the Airport is limited to emergencies only and most of the known sources within the Deployment Area and ARFF/SRE Building Area were capped in September 2020.

6.2 Extent of OHM Impact

Pursuant to 310 CMR 40.0835(4)(f), a characterization of the vertical and horizontal extent of OHM impact at the Disposal Site is indicated on Figures 2 through 13 and Tables 2 through 9. Additional details are set forth below.

The estimated horizontal extent of OHM impacts at the Airport is indicated on Figures 2 through 13. Based on the spatial distribution and extent of PFAS impacted soil and groundwater, the vertical extent of PFAS impacted media is estimated to be from the ground surface to approximately 56 feet below grade. A graphical representation of the vertical and horizontal extent of PFAS is set forth on Figure 3,5 and 7 through 13. As indicated on Figure 2, the Airport is also being impacted with 1,4-dioxane and PFAS plumes from off-site sources.

6.3 Characterization of Background Conditions

Pursuant to 310 CMR 40.0835(4)(f), a characterization of background concentrations of OHM impact at the disposal site is set forth below.

Background levels of PFAS in soil have been detected at the Airport as well as throughout the Town of Barnstable. To determine background levels at the Airport and surrounding area, HW collected 20 soil samples (7 soil on-Airport and 13 off-airport) at the locations indicated on Figure 15. Total PFAS concentrations ranged from less than the laboratory reporting limit to 5.45 ug/kg.

Eight of the background samples collected off Airport property exceeded the applicable Method 1 S-1 soil standards for various PFAS analytes including PFOS. Tabulated analytical data is included on Table 6. One of the background samples collected at the Airport exceeded the applicable Method 1 S-1 standard for PFOS (BG-4 0-1’). The detection of PFOS at this location is consistent with the other background samples collected, and it is not representative of the Airports AFFF release. Further, as indicated on Table 3, soil samples consistent with the Airports AFFF contain elevated levels of various other regulated PFAS compounds including PFNA and PFHpA. With the exception of PFOS, no other regulated compound was detected above the laboratory method detection limit sample BG-4 0-1’.

It should be noted that the single exceedance from the 1991 Drill Area (1991B [0-1]), and in proximity to the Steamship Parking Lot (A10), is consistent with background and does not appear to be related to the AFFF release associated with Airport operations. Refer to Table 3 for tabulated PFAS results.

7.0 EXPOSURE ASSESSMENT

Pursuant to 310 CMR 40.0835(4) (g), an exposure assessment, including the identification and characterization of all potential human and environmental receptors that could be impacted by OHM at or migrating from the Disposal Site, and, as appropriate, the quantification of exposure of OHM-impact at the Disposal Site is set forth below.

7.1 Potential Human Receptors

Pursuant to 310 CMR 40.0835(4) (f), potential human receptors are identified and characterized below.

<u>Human Receptors Exposed to Soil</u>

The two PFAS release areas at the Airport (the ARFF/SRE Area and the Deployment Area) are located within restricted and secured areas where the public are not allowed access. A majority of the PFAS source areas have also been capped with either asphalt or 30-mil geomembrane. Additionally, the highest concentration of one of the six regulated PFAS compounds (100 ug/kg) detected in Airport soils is less than the Method 2 S-1 soil category (300 ug/kg) which is protective of a direct contact exposure.

As indicated above, with the exception of HW-L(d), 1,4-dioxane has not been detected in any of the groundwater wells tested at the Airport. As such, 1,4-dioxane is presumed to not be located in site soils at the Airport.

<u>Human Receptors Exposed to Groundwater</u>

The Airport is located within a current drinking water source area, designated as Zone II to various public drinking water supply wells. As documented in the Phase I Report, the Airport and downgradient residential properties were confirmed to have municipally supplied drinking water. No private drinking water wells at the Airport or downgradient properties were identified by HW or the Town of Barnstable Department of Public Works, Water Supply Division, and the Town of Yarmouth Health Department. Additionally, the municipal water supplier is aware that public water supply wells have been impacted with PFAS and 1,4-dioxane. The water supplier is treating the drinking water accordingly to continue to provide drinking water to the residents that meets regulatory drinking water standards. A majority of the PFAS detected in the vicinity of the public drinking water supply wells appears to be from other non-Airport related sources including the Barnstable Fire Training Academy. As indicated above, 1,4-dioxane does not appear to be associated with a release from the Airport.

7.2 Potential Environmental Receptors

Pursuant to 310 CMR 40.0835(4) (f), potential environmental receptors are identified and characterized below.

Surface water samples collected from Upper Gate and Lewis Pond were all below the laboratory reporting limits for the six regulated PFAS analytes. The laboratory reporting limit is also less than the Method 1 GW-1. There are currently no PFAS standards for surface water.

There has been no evidence of fish kills or stressed vegetation detected in surface water at the Airport. Fishing and hunting are not allowed at the Airport. Also, a majority of the PFAS source areas have been caped and access to these areas are restricted with a fence. A priority resource map is included as Figure 19.

As indicated above, the release of 1,4-dioxane does not appear to be associated with the Airport.

8.0 RISK CHARACTERIZATION

Pursuant to 310 CMR 40.0900, the characterization of risk of harm to health, safety, public welfare, and the environment is set forth below.

8.1 Soil Classification

Pursuant to 310 CMR 40.0933, the applicable soil category is selected based upon the frequency, intensity of use, and accessibility of the Disposal Site by adults and children. Pursuant to 310 CMR 40.0923, risk characterization shall consider current and reasonably foreseeable Disposal Site activities.

8.1.1 Frequency of Use

Frequency of use indicates how often a receptor makes use of, or has access to, the Disposal Site. The frequency is classified as either "High," "Low," or "Not Present" based on the criteria set forth in 310 CMR 40.0933(4)(a).

The Disposal Site is located within a restricted area of the Airport where access to adults is provided for work related activities. Therefore, the frequency of use for adults is considered "high".

8.1.2 Intensity of Use

The intensity of use is based on the kind of activities and uses that occur at a Disposal Site and are classified as either "High" or "Low." Pursuant to 310 CMR 40.0933(4)(b)(1), Site activities and uses which have potential to disturb soil and thus result in either direct contact with the soil itself or inhalation of soil-derived dust shall be characterized as high intensity use.
Based upon the current use, passive activities which do not disturb the soil, such as walking and driving, are likely to occur in the area. As such, the intensity of use would be considered "low".

8.1.3 Accessibility

Soils are classified as "Accessible," "Potentially Accessible" and "Isolated" based upon the depth to OHM impact and the presence of impervious material, if any. Pursuant to 310 CMR 40.0933(4)(c) impacted soils located within the first three feet of the surface in unpaved areas would be considered "Accessible." Soils from three to 15 feet below grade in unpaved areas, or soils from less than fifteen feet below grade in paved areas, would be considered "Potentially

Accessible.” Soils greater than 15 feet below grade or beneath the footprint of a building would be considered as “Isolated”. Therefore, soils at the Disposal Site are considered “accessible”.

8.1.4 Disposal Site Specific Soil Classification

Pursuant to 310 CMR 40.0933(9), the appropriate soil classification for a Disposal Site with “high” frequency and “low” intensity of use for adults (foreseeable future uses) and where impacted soils are “Accessible” soils are classified as S-2. However, as a conservative measure, soils at the Airport will be compared to the S-1 standards.

8.2 Groundwater Classification

Pursuant to 40.0932, groundwater classification is based on several factors including the current and potential use as a drinking water source, proximity to buildings and ecological risks. Groundwater is organized into three categories: GW-1, GW-2, and GW-3.

1. The GW-1 classification applies to groundwater located within a current or potential drinking water source area. The Method 1 GW-1 Standards address potential exposure to drinking impacted groundwater.
2. The GW-2 classification applies to groundwater located within 30 feet of an existing or planned building and where the average annual depth to groundwater is 15 feet or less. The Method 1 GW-2 Standards address potential exposure to vapors collecting in buildings above or adjacent to impacted groundwater.
3. The GW-3 classification applies to all groundwater that can potentially impact surface water bodies. Pursuant to 310 CMR 40.0932(2), all groundwater is considered a potential source of discharge to a surface water body. Therefore, the GW-3 classification applies to all groundwater within the boundaries of the Commonwealth of Massachusetts.

8.2.1 Disposal Site Specific Groundwater Classification

- As set forth above, the Disposal Site is located within a drinking water source area. Therefore, the GW-1 groundwater classification is applicable to groundwater at the Disposal Site.
- As indicated on Table 4, groundwater in the vicinity of structures at the Airport are located at a depth greater than 15 feet below grade. Therefore, the GW-2 classification is not applicable to the Disposal Site.
- As set forth above, the GW-3 classification is applicable to all the groundwater located within the boundaries of the Commonwealth of Massachusetts. Therefore, the GW-3 groundwater classification is also applicable to the Disposal Site.

8.3 Method 1 Risk Characterization

Pursuant to 310 CMR 40.0973(7), a condition of *No Significant Risk* ("NSR") of harm to health, safety, public welfare, and the environment exists if no soil or groundwater Exposure Point Concentration ("EPC") is greater than the applicable MCP Method 1 Soil and Groundwater Standards. A Method 1 Risk Characterization was conducted to assess risk to human health, safety, public welfare, and the environment associated with the release of OHM at the Airport as set forth below.

8.3.1 Risk Posed by OHM Impacted Soil

As set forth in in Table 3, concentrations of PFAS were reported above applicable Method 1 S-1 Soil Standards. No compounds were detected in soil in excess of upper concentration limits ("UCLs"). Therefore, a level of NSR has not been achieved at the Disposal Site with respect to OHM-impacted soil.

8.3.2 Risk Posed by OHM Impacted Groundwater

As set forth in Tables 4 and 7, concentrations of PFAS and 1,4-dioxane were reported above the applicable Method 1 GW-1 Groundwater Standards. No compounds were detected in groundwater in excess of the GW-3 Standard or UCLs. Therefore, a level of NSR has not been achieved for the Disposal Site with respect to OHM-impacted groundwater.

9.0 CONCEPTUAL SITE MODEL

- An extensive investigation program that included the interviewing of Airport staff, the collection of 125 soil samples for PFAS analysis, three surface water samples for PFAS analysis, 158 groundwater samples for PFAS analysis, eight fire truck spray samples for PFAS analysis, 45 groundwater samples for 1,4-dioxane analysis, eight SPLP samples for PFAS analysis, 13 groundwater samples for stable isotope analysis and one AFFF sample for PFAS analysis was completed as part of this Phase II. This information has been used to delineate the nature and extent of both PFAS and 1,4-dioxane at the Airport.
- Based on interviews with Airport staff who have worked at the Airport since the 1980s, AFFF was only intentionally sprayed at the Airport during tri-annual drills (1991, 1994, 1997, 2000, 2003, 2006, 2009 and 2012), during an Airport Emergency (1981-off Airport property and 2016 aircraft crash) and once per year between 2004 and 2015 as part of the FAA annual foam testing requirement (14 CRF 139). Airport personnel also indicated that fluorotelomer-based AFFF had been used at the Airport since at least the 1980's when foam usage was limited to 35-gallons for use in one fire rescue vehicle. With the exception of the events detailed above, AFFF was not intentionally sprayed due to cost, limited supply and/or the lack of an FAA requirement (prior to 2004). With the exception of the 1991 drill, all drills and AFFF testing have been conducted at the unpaved Deployment Area. The Airport stopped using AFFF in the tri-annual training drills in 2015

and purchased an ecological cart in 2016 to stop spraying foam as part of the annual FAA testing requirement.

- HW created a water table map specific to the Airport property based on data taken on April 27, 2020 from monitoring wells used during this investigation. It is attached as Figure 14. As indicated on the map, groundwater flows onto the Airport property from the west and northwest, migrates to the southeast, and exits the property at the southeast corner of the Airport.
- The 1,4-dioxane detected at the Maher Wells is related to an unknown source that is hydraulically upgradient of both the Airport and the Maher Wells. The source has been detected in the shallow groundwater within proximity to the commercial properties located along Airport Road as indicated by detections in monitoring well HW-V(m). The release migrates both vertically and horizontally as it passes through the Airport Rotary as indicated by detections in monitoring well HW-U(d), the Airport (HW-L[d]) and then the Maher Wells. Additional details and supporting information that the Airport is not the source of 1,4-dioxane have been presented above.
- PFAS has been detected in groundwater at multiple locations both on and off Airport Property at locations both hydraulically upgradient, cross-gradient and downgradient to the Airport. As discussed above, radar plots were developed as an environmental forensic technique to determine if the groundwater impacts were consistent with the Airports AFFF release.
- The Airport has purchase records since 2000 that document the type of AFFF used is Chem-Guard 3% mil spec which is a fluorotelomer-based AFFF. This type of foam contains multiple PFAS analytes including those regulated by MassDEP. However, a very large percentage of the detectable PFAS analytes is 6:2 FTS which is a distinguishing analyte to differentiate the Airport's AFFF release from other PFAS sources. Airport personnel interviewed indicated that this type of foam has been purchased since the 1980s.
- As indicated above, the Airport's AFFF plume can be traced by the high concentration of 6:2 FTS relative to the other PFAS analytes included in the AFFF. Additionally, the 6:2 FTS analyte moves quicker in groundwater than the six PFAS analytes currently regulated MassDEP. Since the Airports AFFF has been a fluorotelomer based product for at least the last 20 years as indicated by purchase records, it is easier to distinguish the Airports PFAS contribution to the widespread PFAS problem in the area by tracing the high concentration of 6:2 FTS as it leaves the Airport.
- AFFF was introduced to the ARFF/SRE Area through what is assumed to be incidental spillage, drippings from the hanging of fire house apparatus after use and cleaning of equipment in the event of an accidental foam discharge. Prior to being closed in the early 2000's Interior floor drains within the building historically discharged to the adjacent grass area that was recently capped in 2020. In the event of accidental foam discharge, equipment was rinsed by pumping water through it and discharging that water to the adjacent grass area that has since been capped.

- ARFF was introduced to the Deployment through the drills described above, ARFFF consistency testing, and from daily (approximately 5 gallons) and monthly (100 gallons) testing of the fire apparatus. As detailed above, the spray water from the fire trucks were tested for PFAS in 2019 to verify that the valve mechanism that segregated the AFFF was working properly. The analytical results indicated that AFFF was being mixed with the water unintentionally from the internal AFFF holding tanks. It was determined that the valve that segregates the AFFF was faulty and was the cause of the unintentional mixing. The faulty valve was replaced, and a maintenance schedule has been initiated. Subsequent testing of the spray water indicates that PFAS levels are less than the current GW-1 standard.
- HW reviewed the PFAS groundwater data to verify that the 6:2 FTS was stable and not significantly degrading to short chain PFCAs. Additional details are set forth above.
- The information presented above was used to estimate the extent of the Disposal Site boundary as indicated on Figure 2. Additional leaching of PFAS to groundwater from the two Airport source areas has been minimized by the installation of two impermeable caps at the locations indicated on Figure 3.

10.0 PUBLIC INVOLVEMENT

Pursuant to 310 CMR 40.1403 and the Final PIP dated September 16, 2019, notification of the updated Phase II will be provided to all individuals on Table 1. This includes the Chief Municipal Officer and the Board of Health for both Barnstable and Yarmouth.

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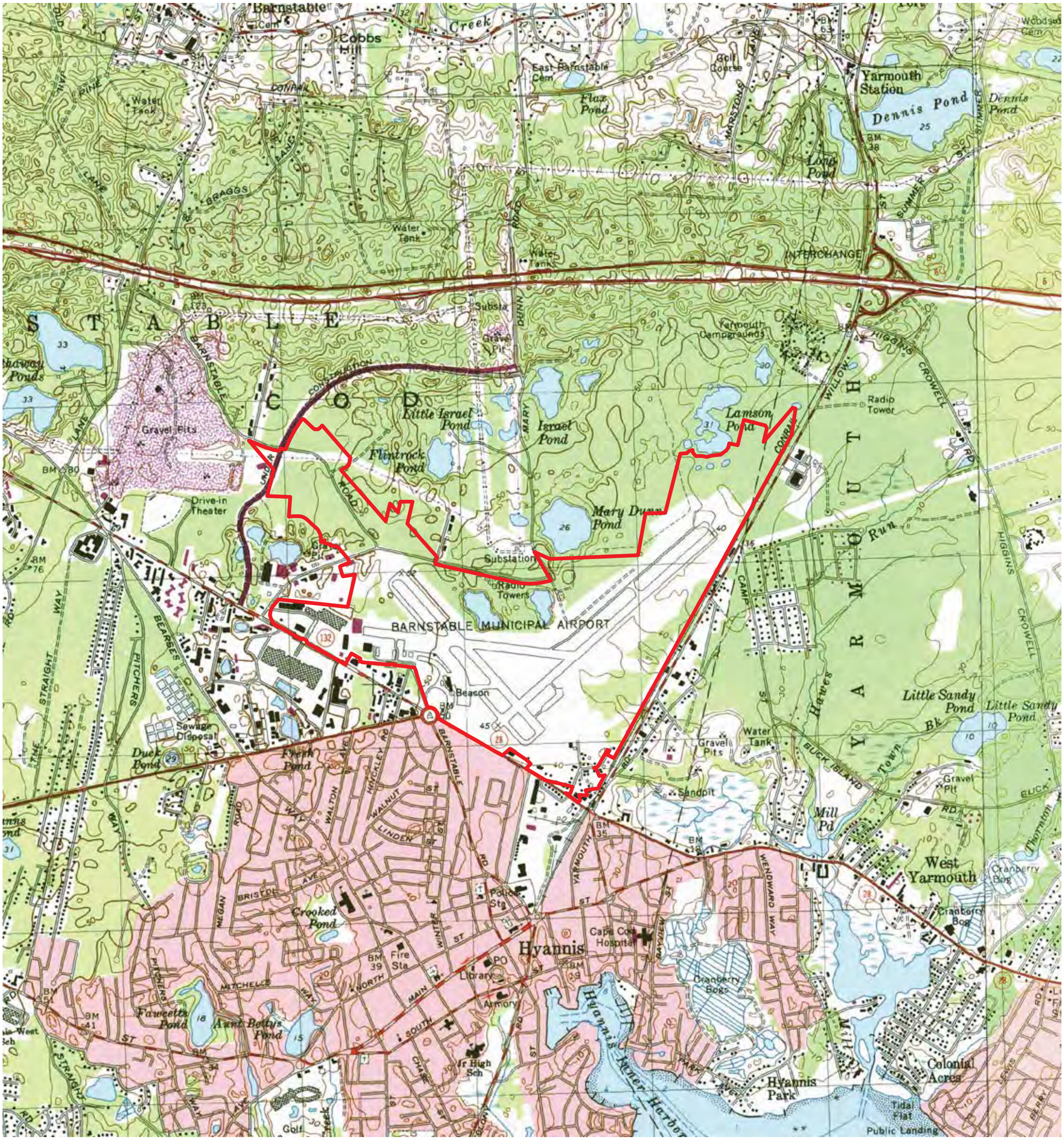
10. *CompTox Chemicals Dashboard,* Environemtnal Protection Agency, https://comptox.epa.gov/dashboard
11. *Geochemical and Hydrologic Factors Controlling Subsurface Transport of Poly-and Perfluoroalkly Substances, Cape Cod, Massachusetts*, Environmental Science and Technology March 2017, Andrea K. Weber, Larry B. Barber, Denis R. LeBlanc, Elsie M. Sunderland, and Chad D. Vecitis.
12. *6:2 fluorotelomer sulfonate aerobic biotransformation in activated sludge of wastewater treatment plants,* Chemosphere November 2010, Ning Wang, Jinxia Liu, Robert C Buck, Stephen H Korzeniowski, Barry W Wolstenholme, Patrick W Folsom, and Lisa M Sulecki.

FIGURES



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**Hyannis Topographic Quadrangle*

Legend

Airport Property Line

N

Miles

0.5

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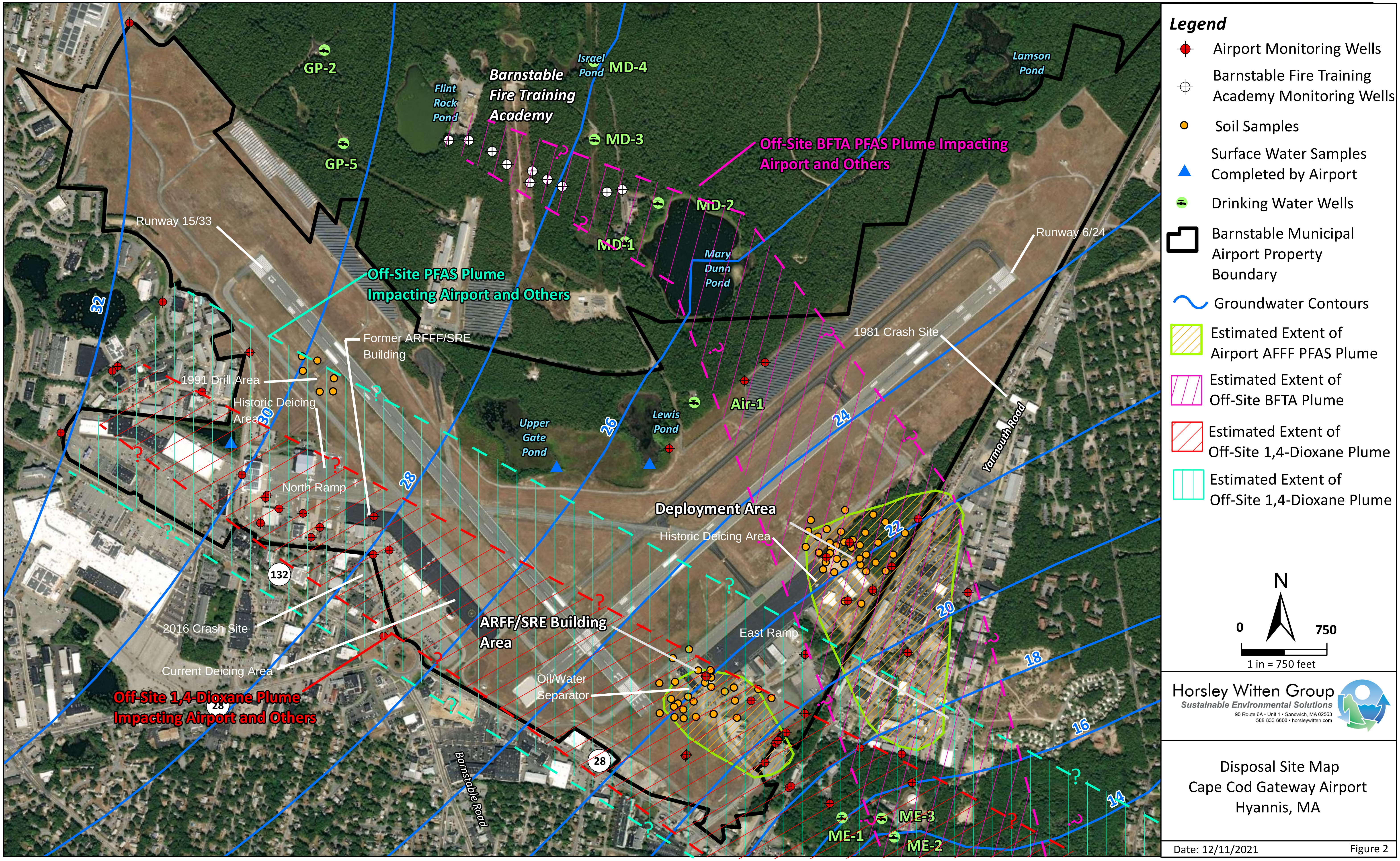
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

USGS Locus
Cape Cod Gateway Airport
Hyannis, MA

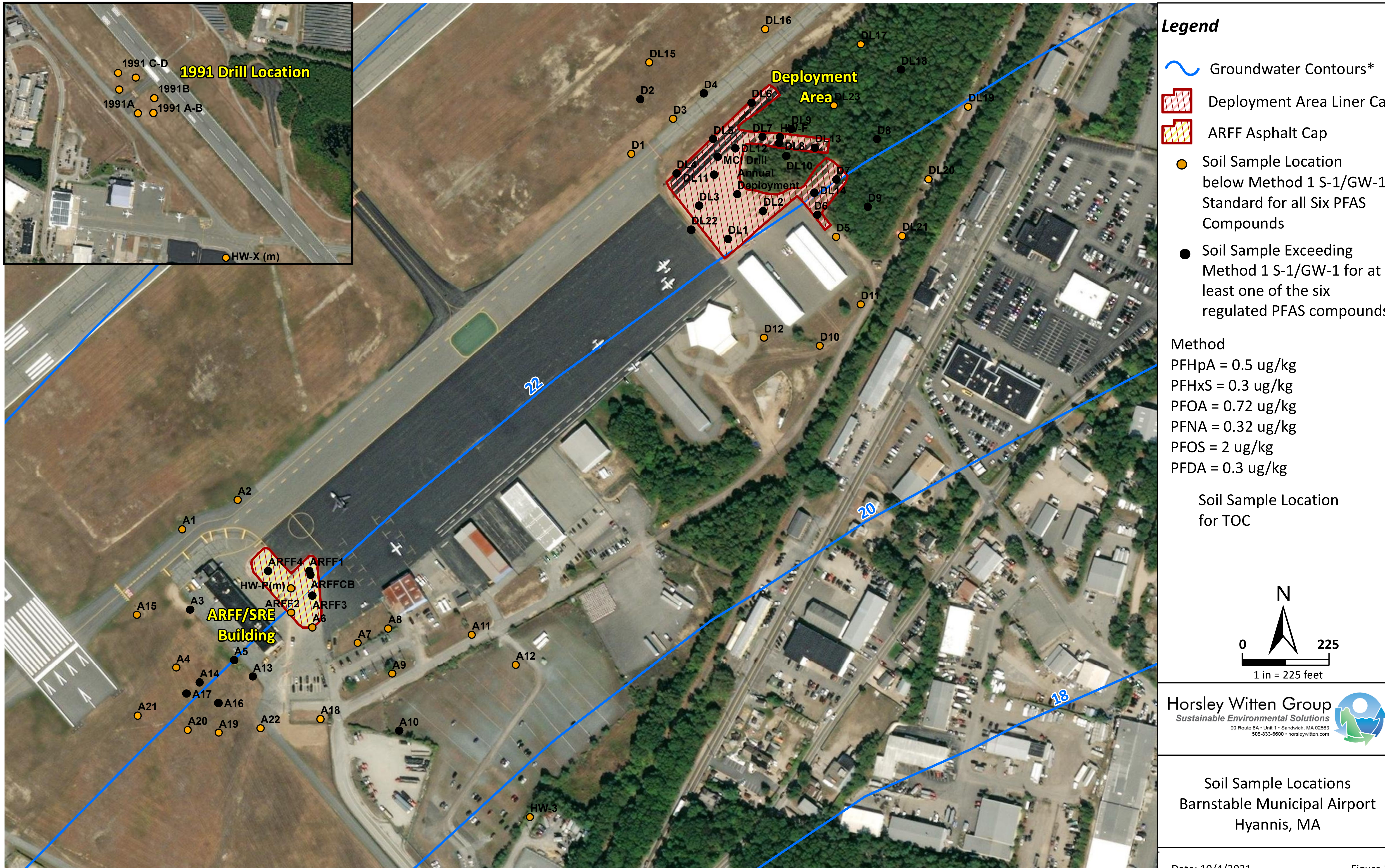
Date: 4/17/2018

Figure 1



* Cape Cod Commission (CCC) Groundwater Contours

Path: K:\Projects\HYA\21084 PFOS Phase III\GIS\Maps\Disposal Site Map bjm 2.mxd



* Cape Cod Commission (CCC) Groundwater Contours

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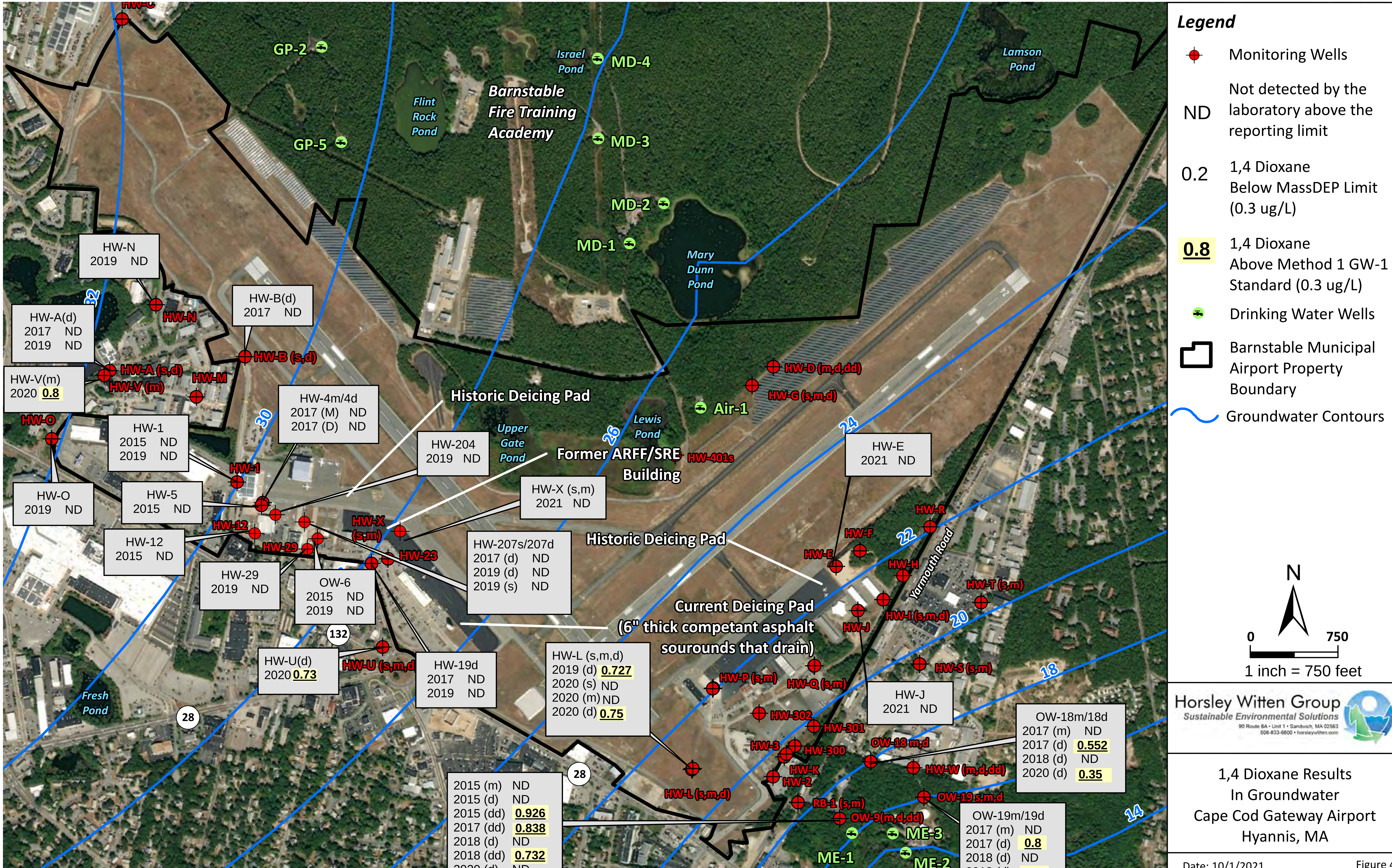

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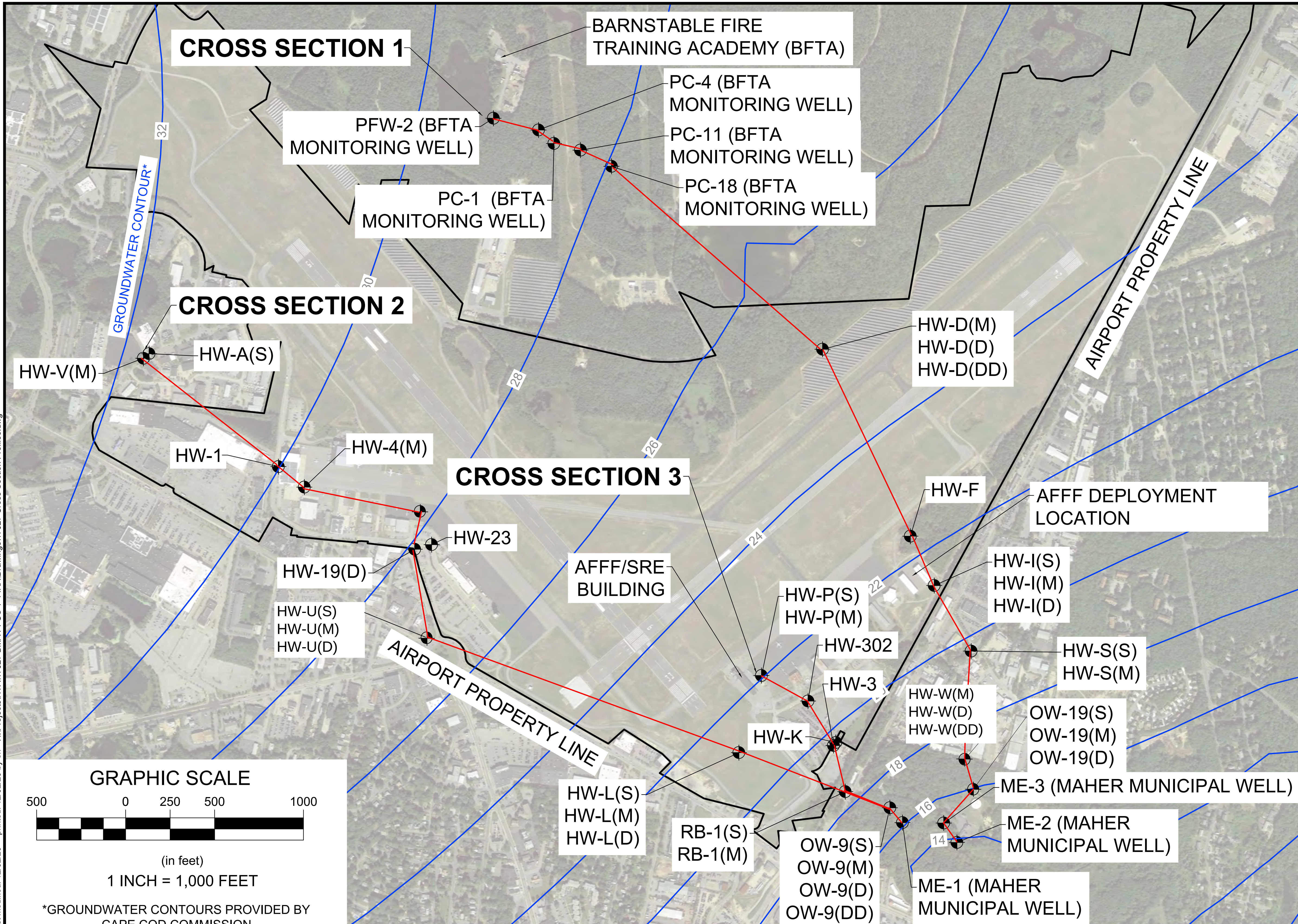

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Date: DEC 2020 | Design By: N/A | Drawn By: EWH | Checked By: BJM

Plan Set:
HYDROLOGIC CROSS SECTION PLAN
CAPE COD GATEWAY AIRPORT
HYANNIS, MASSACHUSETTS

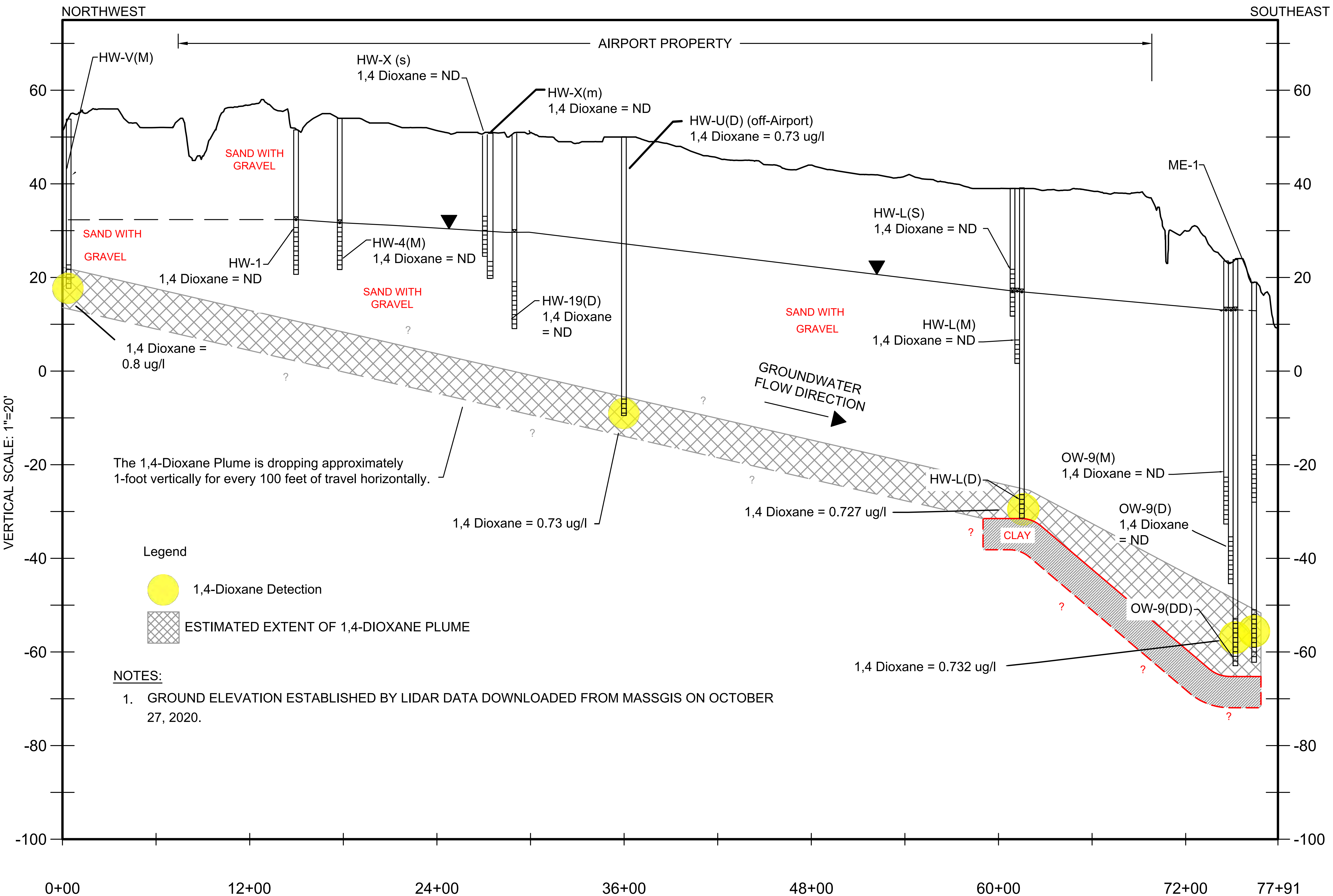
Plan Title:
FIGURE 5

Prepared For:
BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601
Phone: ----
Fax: ----

Registration:

Project Number: 17027

Sheet Number: 1 of 7



CROSS SECTION 1 PROFILE

HORIZONTAL SCALE: 1"=600'

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Date: DEC 2020 | Design By: N/A | Drawn By: EWH | Checked By: BJM

Plan Set: HYDROLOGIC CROSS SECTION CAPE COD GATEWAY AIRPORT HYANNIS, MASSACHUSETTS

Plan Title: CROSS SECTION 1 FIGURE 6

Prepared For: BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601

Survey & Preliminary Layout Provided By: Horsley Witten Group, Inc.
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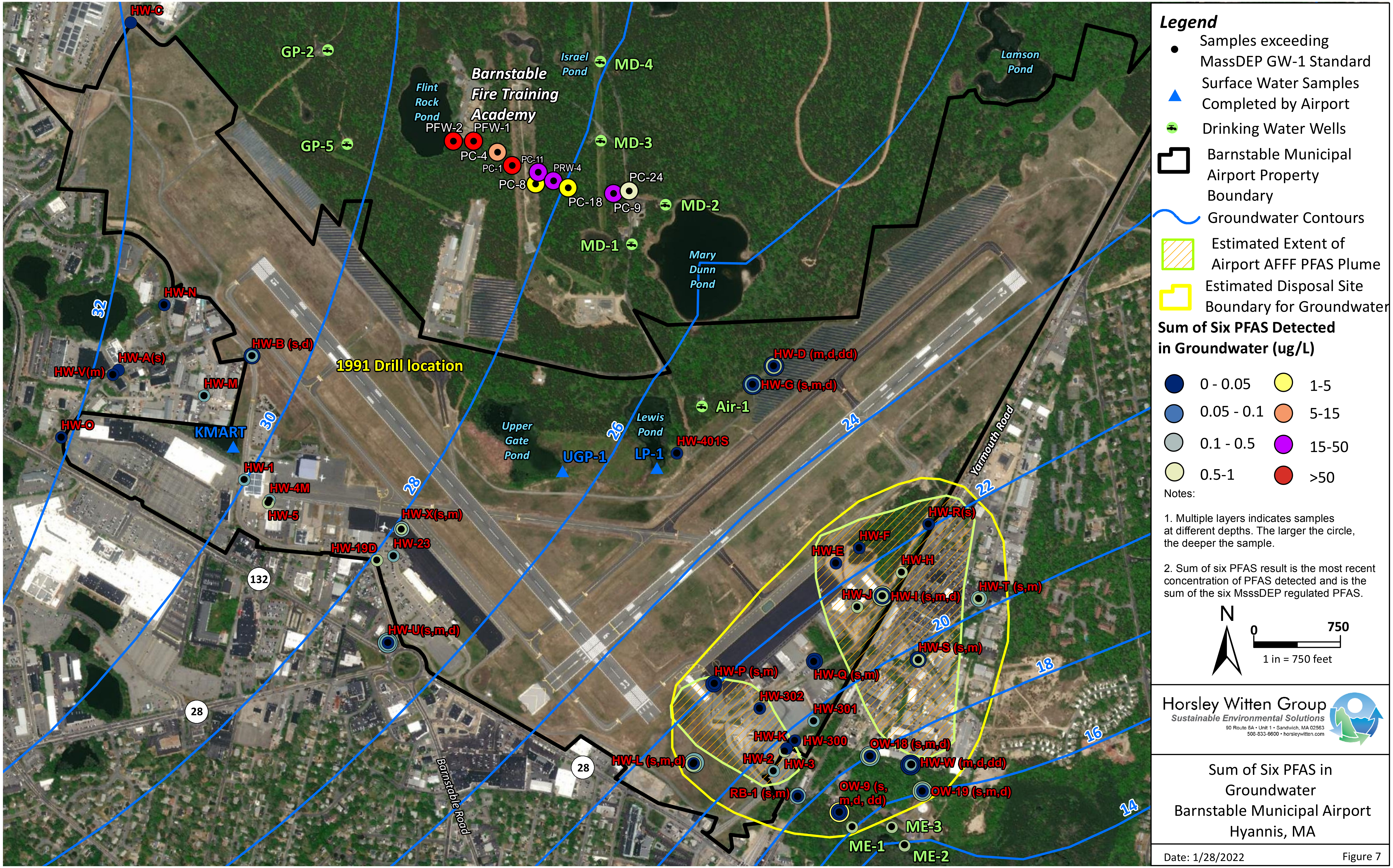
Registration:

Project Number: 17027

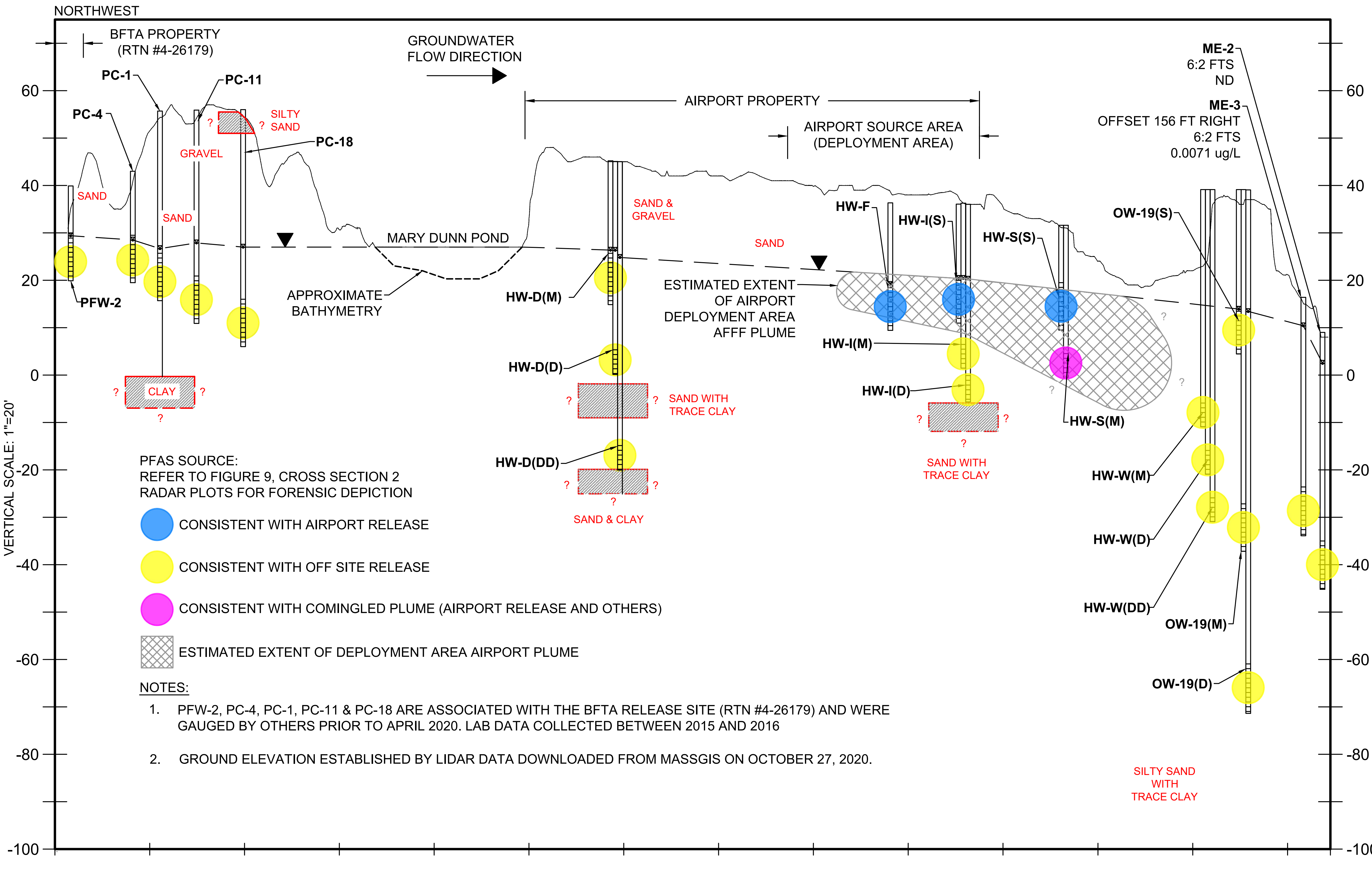
Sheet Number: Figure 2

last modified: 12/02/20 printed: 12/02/20 by eh H:\Projects\HYA\17027 bma pfos 1-4 ira\Drawings\17027 Cross Section Profiles.dwg



* Cape Cod Commission (CCC) Groundwater Contours

Path: H:\Projects\HYA\17027 BMA PFOS 1-4 IRA\GIS\Maps\220128_GWPFASrecentSoS.mxd



NOTES:

1. PFW-2, PC-4, PC-1, PC-11 & PC-18 ARE ASSOCIATED WITH THE BFTA RELEASE SITE (RTN #4-26179) AND WERE GAUGED BY OTHERS PRIOR TO APRIL 2020. LAB DATA COLLECTED BETWEEN 2015 AND 2016
2. GROUND ELEVATION ESTABLISHED BY LIDAR DATA DOWNLOADED FROM MASSGIS ON OCTOBER 27, 2020.

CROSS SECTION 2 PROFILE

HORIZONTAL SCALE: 1"=600'

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Drawn By: EWH
Design By: N/A
Date: APRIL 2021

Plan Set:

HYDROLOGIC CROSS SECTION
BARNSTABLE MUNICIPAL AIRPORT
HYANNIS, MASSACHUSETTS

Plan Title:
CROSS SECTION 2 FIGURE 8

Prepared For:
BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601

Registration:

Project Number: 17027

Sheet Number: 8 of 7

last modified: 05/06/21 printed: 05/06/21 by eh H:\Projects\HYA\17027 BMA PFOS 1-4 IRA\Drawings\17027 Cross Section Profiles_recover.dwg

NOTE:

REFER TO APPEDIX D FOR RADAR PLOTS WITH ANALYTICS AND NORMALIZED PFAS DATA.

PFW-2
(3/30/2016)

PFAS DETECTION RELATED TO BFTA RELEASE

PC-4
(3/8/2016)

PFAS DETECTION RELATED TO BFTA RELEASE

PC-1
(3/3/2016)

PFAS DETECTION RELATED TO BFTA RELEASE

PC-11
(5/12/2016)

PFAS DETECTION RELATED TO BFTA RELEASE

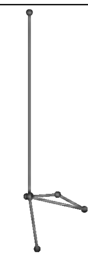
PC-18
(6/17/2015)

PFAS DETECTION RELATED TO BFTA RELEASE

HW-D(M)
(5/13/2020)

PFAS DETECTION CONSISTENT WITH BFTA RELEASE

HW-F
(5/5/2020)



PFAS DETECTION CONSISTENT WITH AIRPORT RELEASE

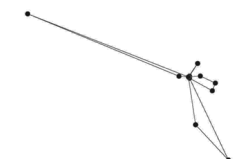
HW-I(S)
(5/8/2020)

PFAS DETECTION CONSISTENT WITH AIRPORT RELEASE

HW-S(S)
(10/1/2020)

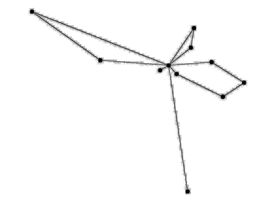
PFAS DETECTION CONSISTENT WITH AIRPORT RELEASE

HW-W(M)
(4/19/2021)



PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

OW-19(S)
(3/18/2021



PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

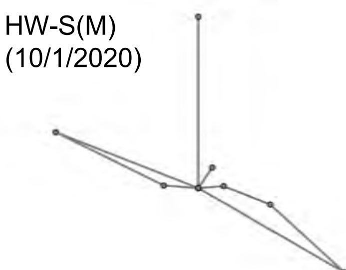
HW-D(D)
(5/13/2020)

PFAS DETECTION CONSISTENT WITH BFTA RELEASE

HW-I(M)
(5/8/2020)

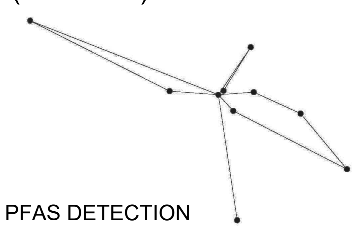
PFAS DETECTION CONSISTENT WITH BFTA RELEASE

HW-S(M)
(10/1/2020)



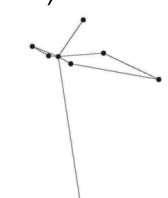
PFAS DETECTION CONSISTENT WITH COMINGLED PLUME

HW-W(D)
(4/19/2021)



PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

OW-19(M)
(3/19/2021)

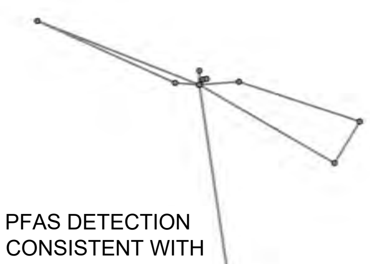


PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

HW-D(DD)
(5/13/2020)

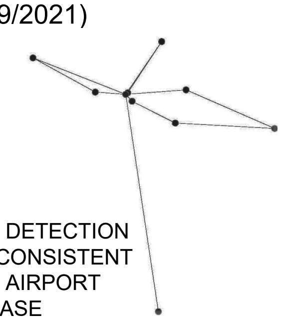
PFAS DETECTION CONSISTENT WITH BFTA RELEASE

HW-I(D)
(5/8/2020)



PFAS DETECTION CONSISTENT WITH BFTA RELEASE

HW-W(DD)
(4/19/2021)



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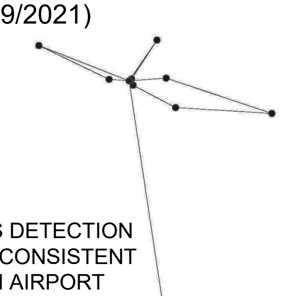
OW-19(D)
(3/19/2021)



PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

ME-3
(9/17/2020)

PFAS DETECTION CONSISTENT WITH BFTA RELEASE

ME-2
(9/17/2020)

PFAS DETECTION CONSISTENT WITH BFTA RELEASE

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Date: DEC 2020
Design By: N/A
Drawn By: EWH
Checked By: BJM

Plan Set:
HYDROLOGIC CROSS SECTION
CAPE COD GATEWAY AIRPORT
HYANNIS, MASSACHUSETTS

Plan Title:
CROSS SECTION 2 RADAR PLOTS - FIGURE 9

Prepared For:
BARNSTABLE
MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601

Registration:

Project Number: 17027

Sheet Number: 3 of 7

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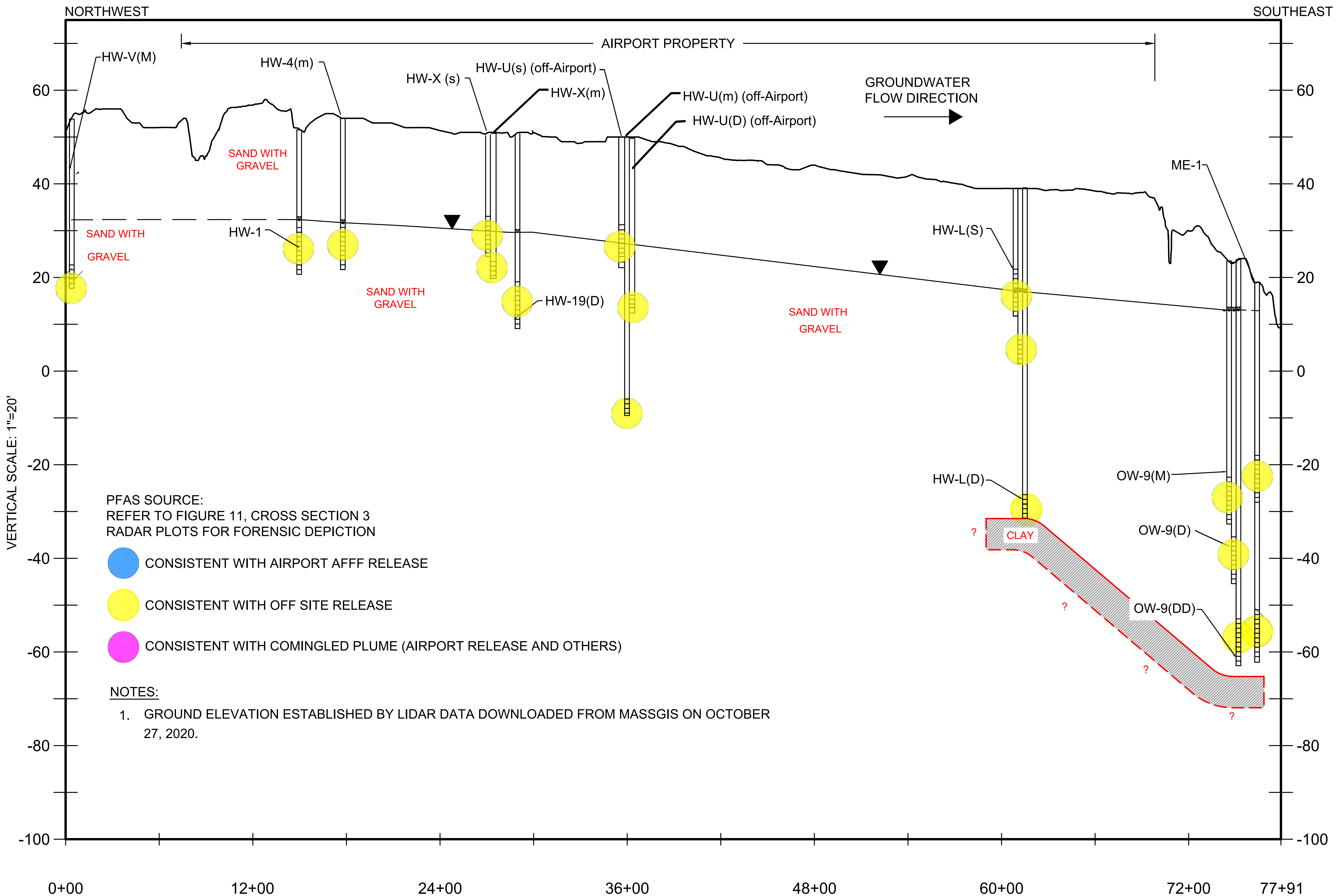

NOTES:

1. GROUND ELEVATION ESTABLISHED BY LIDAR DATA DOWNLOADED FROM MASSGIS ON OCTOBER 27, 2020.

CROSS SECTION 3 PROFILE

HORIZONTAL SCALE: 1"=600'

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Drawn By: EWH
Design By: N/A
Date: DEC 2020

Plan Set: HYDROLOGIC CROSS SECTION
CAPE COD GATEWAY AIRPORT
HYANNIS, MASSACHUSETTS

Plan Title: CROSS SECTION 3 FIGURE 10

Prepared For:
BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601

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Sandwich, MA 02563
Phone: (508) 833-6600
Fax: (508) 833-3150

Registration:

Project Number: 17027

Sheet Number: Figure 2

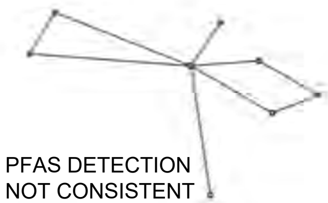
HW-V(M)
(10/2/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-A(s)
(4/7/2017)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-1
(11/1/2018)



PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

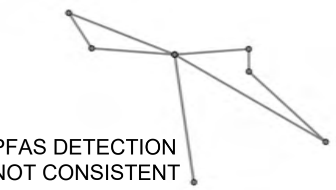
HW-4(M)
(4/5/2017)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-19(D)
(11/7/2018)

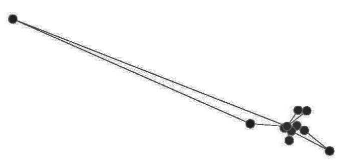
PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-23
(11/1/2018)



PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-U(s)
(4/19/2021)



PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-L(S)
(10/7/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

RB-1(S)
(11/5/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

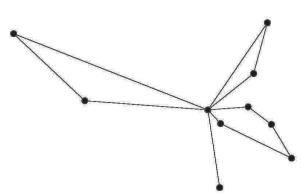
OW-9(S)
(5/8/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

ME-1
(9/17/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-U(M)
(4/19/2021)



PFAS DETECTION
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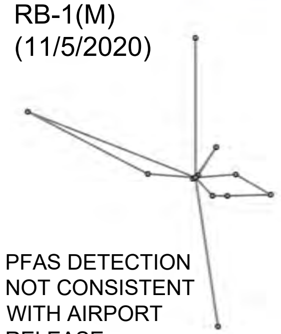
WITH AIRPORT
RELEASE

HW-L(M)
(10/7/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

RB-1(M)
(11/5/2020)

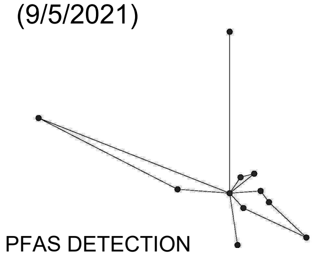


PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

OW-9(M)
(5/8/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-U(D)
(9/5/2021)



PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

HW-L(D)
(10/7/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

OW-9(D)
(5/5/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

OW-9(DD)
(10/2/2020)

PFAS DETECTION
NOT CONSISTENT
WITH AIRPORT
RELEASE

NOTE:

REFER TO APPEDIX D FOR
RADAR PLOTS WITH ANALYTICS
AND NORMALIZED PFAS DATA.

Revisions

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Drawn By: EWH
Checked By: BJM

Plan Set:
HYDROLOGIC CROSS SECTION
CAPE COD GATEWAY AIRPORT
HYANNIS, MASSACHUSETTS

Plan Title:
CROSS SECTION 3 RADAR PLOTS - FIGURE 11

Prepared For:
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MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601
Phone: ----
Fax: ----

Registration:

Project Number:
17027

Sheet Number:
5 of 7

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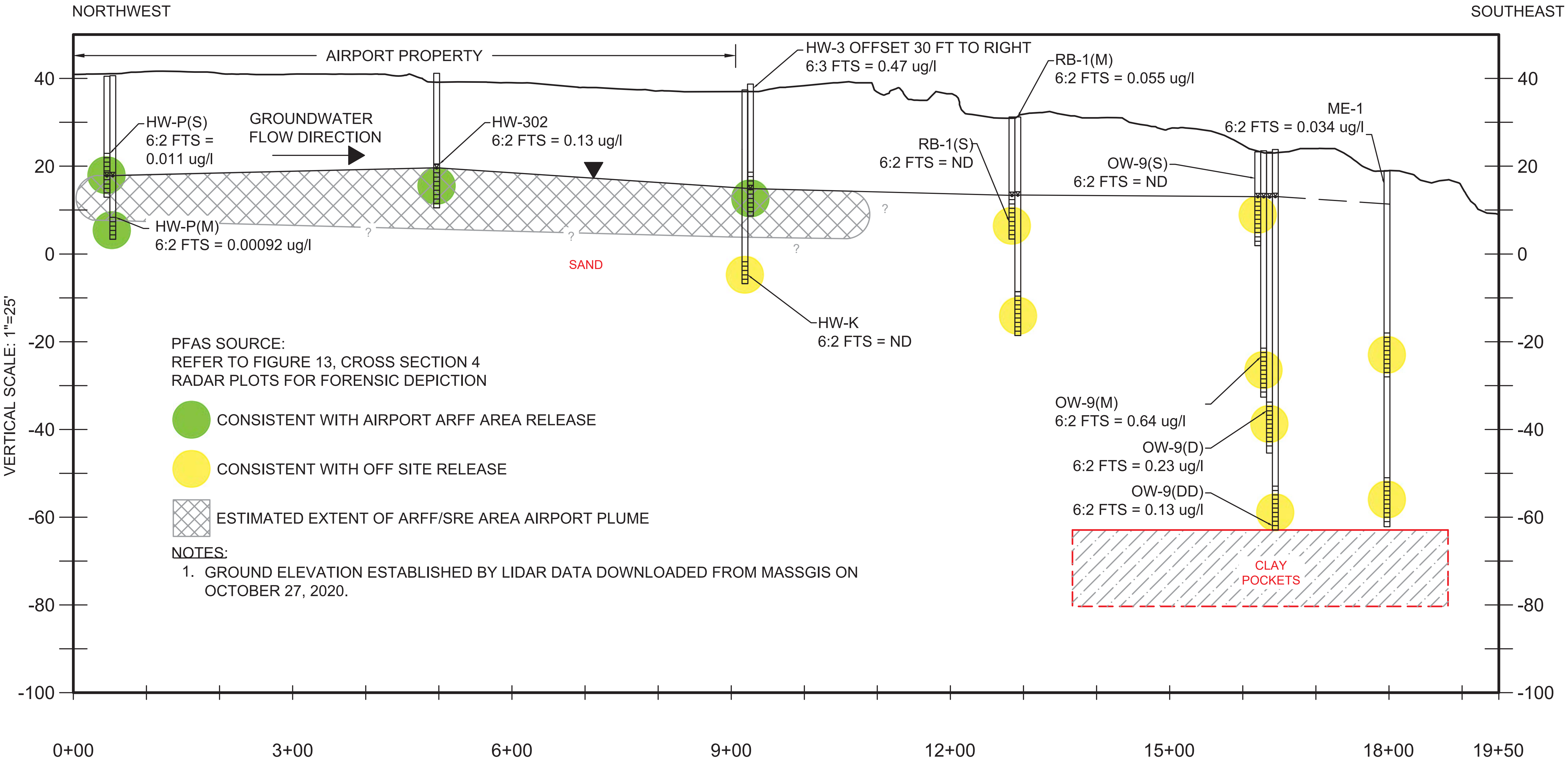

CROSS SECTION 4 PROFILE

HORIZONTAL SCALE: 1"=150'

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HYDROLOGIC CROSS SECTION
CAPE COD GATEWAY AIRPORT
HYANNIS, MASSACHUSETTS

CROSS SECTION 4 - FIGURE 12

Prepared For:
BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601

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Sandwich, MA 02563
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Registration:

Project Number: 17027

Sheet Number: 6 of 7

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HW-P(S)
(10/1/2020)

AIRPORT SOURCE CAPPED AND RELEASE HAS MIGRATED)

HW-302
(12/3/2018)

PFAS DETECTION CONSISTENT WITH COMINGLED PLUME

HW-K
(5/21/2020)

PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

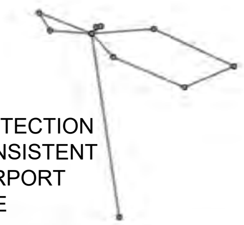
HW-3
(5/5/2020)

PFAS DETECTION CONSISTENT WITH COMINGLED PLUME

RB-1(S)
(11/5/2020)

PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

OW-9(S)
(5/8/2020)



PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

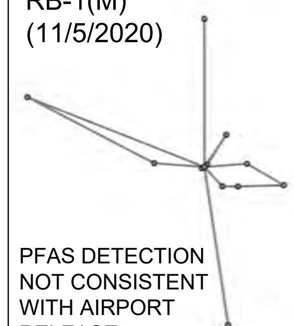
ME-1
(9/17/2020)

PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

HW-P(M)
(10/1/2020)

AIRPORT SOURCE CAPPED AND RELEASE HAS MIGRATED)

RB-1(M)
(11/5/2020)



PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

OW-9(M)
(5/8/2020)

PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

OW-9(D)
(5/5/2020)

PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

OW-9(DD)
(10/2/2020)

PFAS DETECTION NOT CONSISTENT WITH AIRPORT RELEASE

NOTE:

REFER TO APPEDIX D FOR RADAR PLOTS WITH ANALYTICS AND NORMALIZED PFAS DATA.

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Drawn By: EWH
Design By: N/A
Date: DEC 2020

Plan Set:
HYDROLOGIC CROSS SECTION
CAPE COD GATEWAY AIRPORT
HYANNIS, MASSACHUSETTS

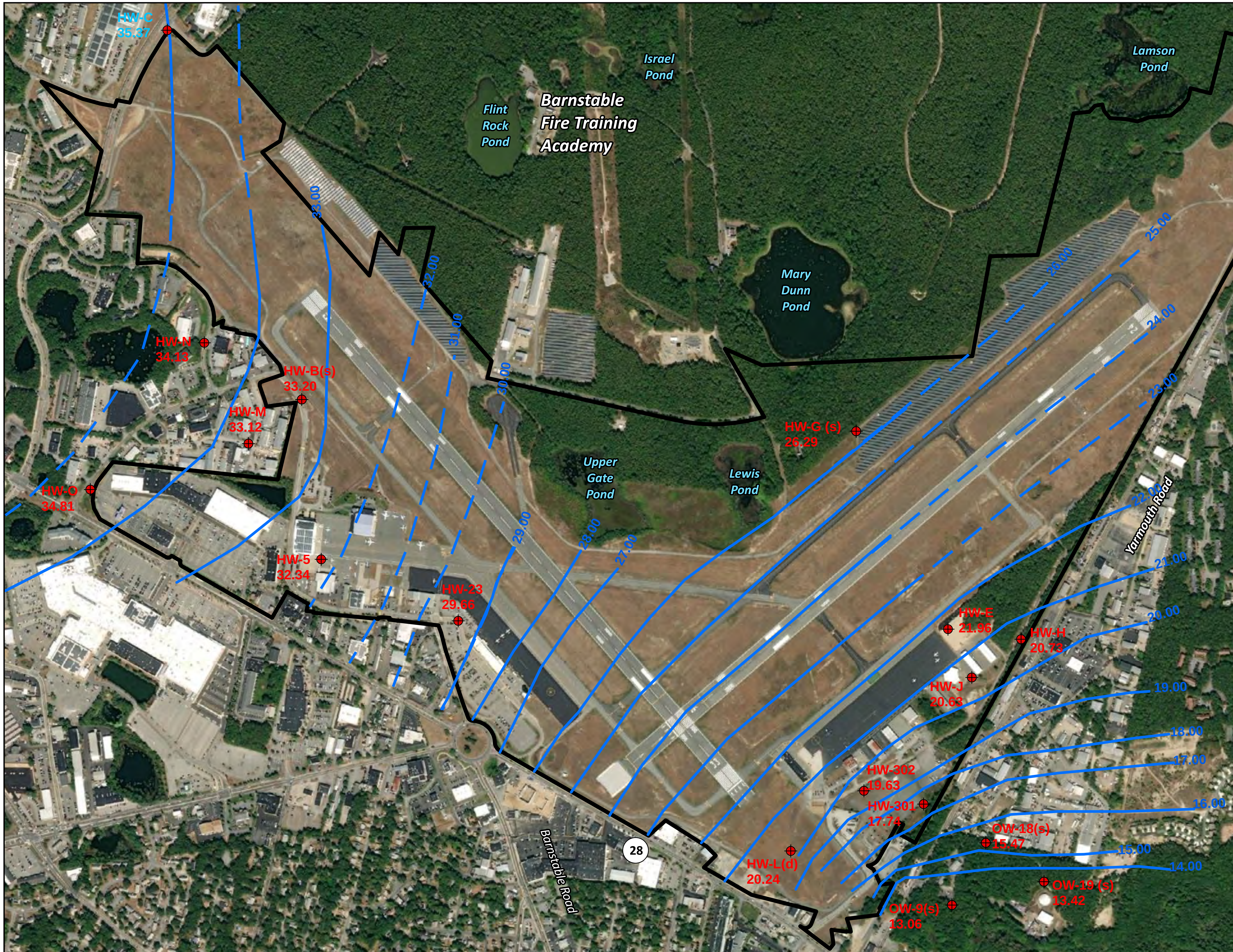
Plan Title:
CROSS SECTION 4 RADAR PLOTS - FIGURE 13

Prepared For:
BARNSTABLE
MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601

Registration:

Project Number:
17027

Sheet Number:
7 of 7



Legend

Barnstable Municipal Airport Property Boundary

Groundwater Contours

Monitoring Well Location

20.72 Groundwater Elevation

N

0 750

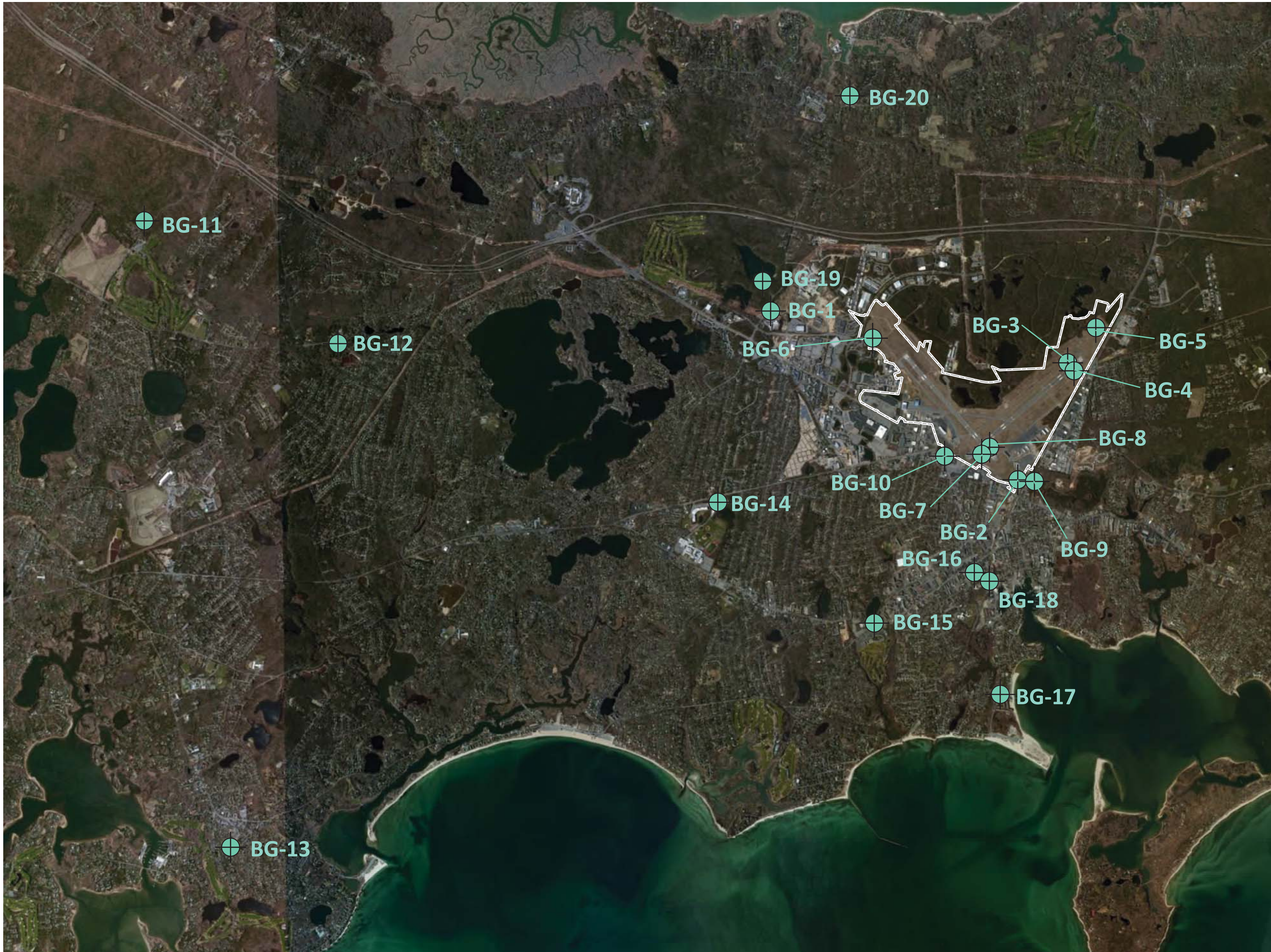
1 in = 750 feet

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

Water Table Map
Based on Water Level Measurements from April 27, 2020
Cape Cod Gateway Airport
Hyannis, MA

Date: 10/1/2021

Figure 14



Legend

Background PFAS sample locations

Barnstable Municipal Airport Property Boundary

N

0 1,750 Feet

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

Background
PFAS Sample Locations
Cape Cod Gateway Airport
Hyannis, MA

Date: 11/25/2020 Figure 15

Path: H:\Projects\HYA\17027 BMA PFOS 1-4 IRA\GIS\Maps\180110_PFOS_BackgroundSampleLocations.mxd

Legend

Groundwater Contours

Approximate Location of TOC Sample

Deployment Area Liner Cap

ARFF Asphalt Cap

N

0 400

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

TOC Sample Locations
Cape Cod Gateway Airport
Hyannis, MA

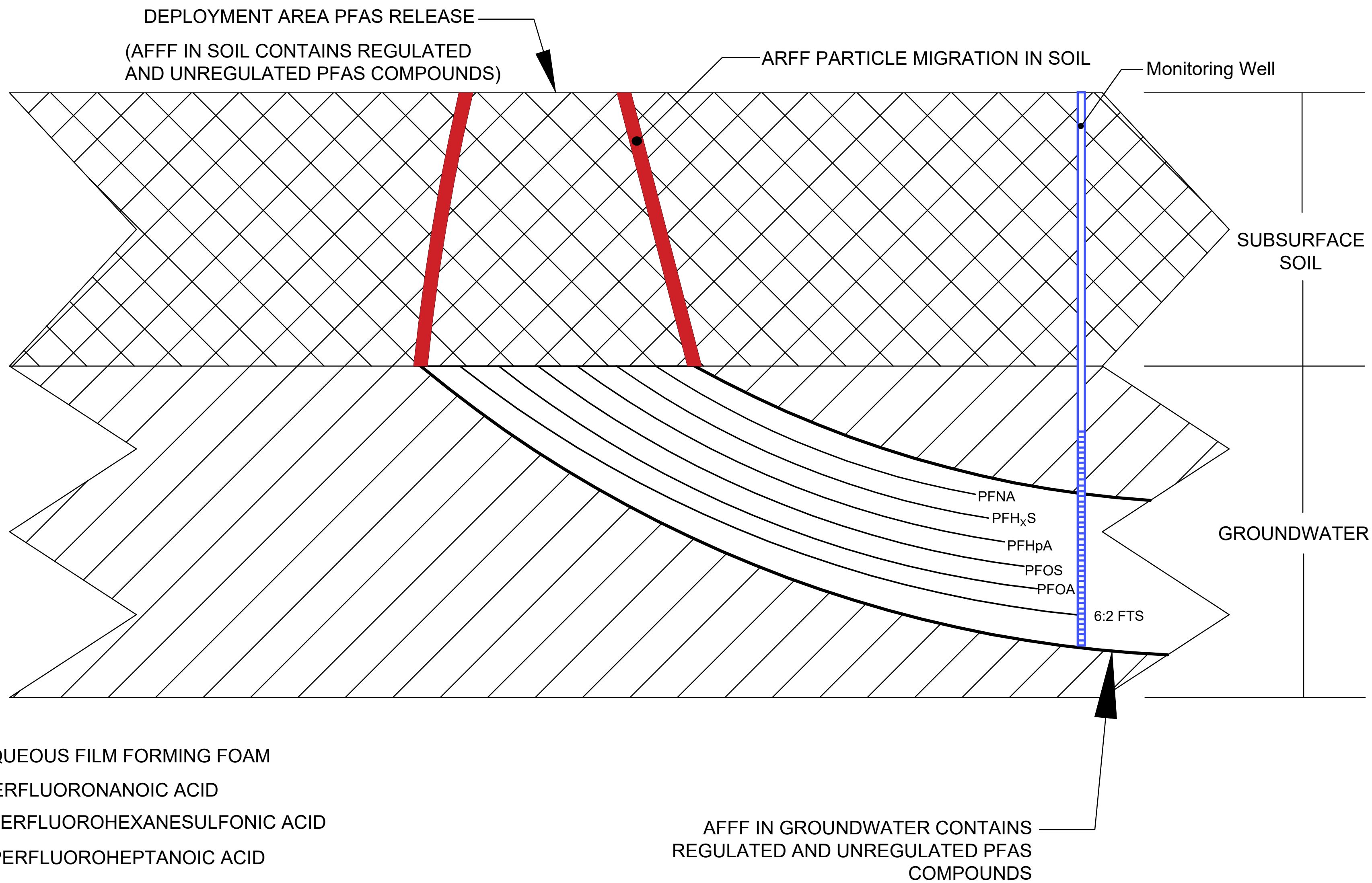
Date: 8/9/2021 Figure 16

* Cape Cod Commission (CCC) Groundwater Contours

Path: K:\Projects\HYA\17027 BMA PFOS 1-4 IRA\GIS\Maps\TOC Sample Locations.mxd

GENERAL AFFF PARTICLE TRACK IN SOIL AND GROUNDWATER SHOWING MASSDEP 6 PFAS AND 6:2 FTS

(NOT TO SCALE)



H:\Projects\HYA\21084 PFOS Phase III\Drawings\PARTICLE SKETCH.dwg

NOTES:

AFFF=AQUEOUS FILM FORMING FOAM

PFNA=PERFLUORONANOIC ACID

PFH_XS=PERFLUOROHEXANESULFONIC ACID

PFHpA=PERFLUOROHEPTANOIC ACID

PFOS=PERFLUOROOCTANE SULFONATE

PFOA=PERFLUOROOCTANOIC ACID

6:2 FTS = 6:2 FLUOROTELOMOR SULFONATE

PFAS= PER AND POLY-FLUOROALKYL SUBSTANCES

FIGURE 17

*Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services *2016 NAIP imagery service

Document Path: H:\Projects\HYA\19122 HYA Master Plan Update\GIS\Maps\191118_FEMA.mxd

MassDEP - Bureau of Waste Site Cleanup

Phase 1 Site Assessment Map: 500 feet & 0.5 Mile Radii

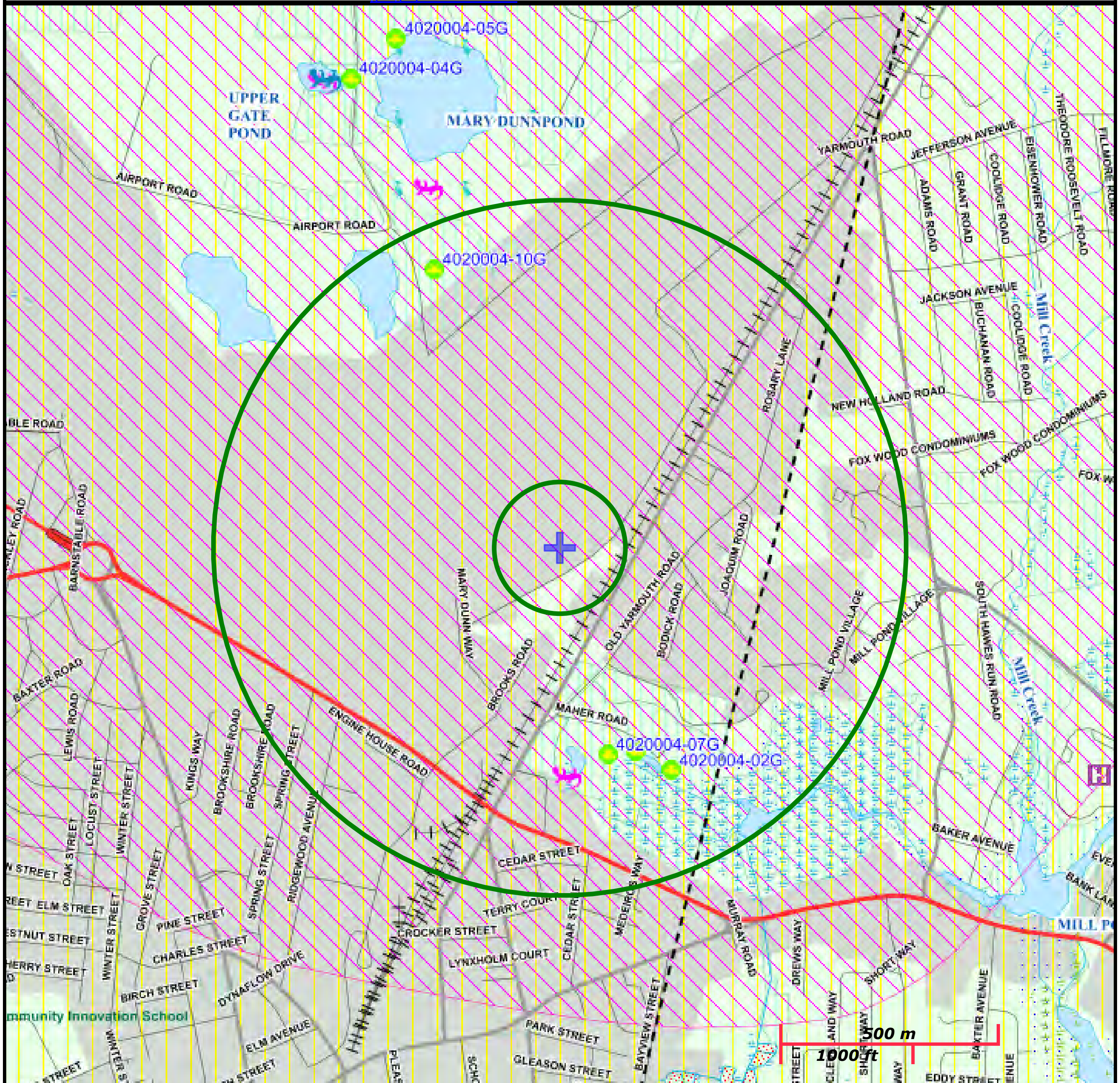
Site Information:

480 BARNSTABLE ROAD BARNSTABLE, MA

NAD83 UTM Meters:
4613410mN , 393907mE (Zone: 19)
November 25, 2020

The information shown is the best available at the date of printing. However, it may be incomplete. The responsible party and LSP are ultimately responsible for ascertaining the true conditions surrounding the site. Metadata for data layers shown on this map can be found at:
https://www.mass.gov/orgs/massgis-bureau-of-geographic-information.

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection



Roads: Limited Access, Divided, Other Hwy, Major Road, Minor Road, Track, Trail

Boundaries: Town, County, DEP Region; Train; Powerline; Pipeline; Aqueduct

Basins: Major, PWS; Streams: Perennial, Intermittent, Man Made Shore, Dam

Aquifers: Medium Yield, High Yield, EPA Sole Source

Non Potential Drinking Water Source Area: Medium, High (Yield)

PWS Protection Areas: Zone II, IWPA, Zone A

Hydrography: Open Water, PWS Reservoir, Tidal Flat

Wetlands: Freshwater, Saltwater, Cranberry Bog

FEMA 100yr Floodplain; Protected Open Space; ACEC

Est. Rare Wetland Wildlife Hab; Vernal Pool: Cert., Potential

Solid Waste Landfill; PWS: Com.GW, SW, Emerg., Non-Com.

Figure 19 - Priority Resource Map

TABLES

Table 1
Community Notification List
Barnstable Municipal Airport Public Involvement Plan

NAME	ADDRESS	NAME	ADDRESS
Brad Schiff	bschiff@pierce-cote.com	Charlie Bloom	29 Oak Street Hyannis, MA 02601
Bronwen Walsh	bwalsh@barnstablepatriot.com	Cheryl Osimo	MBCC PO Box 202 Franklin, MA 02038
Chanda Beaty	chanda123@yahoo.com	Christian Cook	37 Maple Avenue Hyannis, MA 02601
David Dow	ddow420@comcast.net	Daniel Knapik	Town Administrator Town of Yarmouth 424 Rte. 28 West Yarmouth, MA 02673
Geoff Spillane	gspillane@capecodonline.com	Daniel Santos	Department of Public Works Town of Barnstable 397 Main Street Hyannis, MA 02601
Gerard Martin	gerard.martin@mass.gov	Darcy Karie	Conservation Commission Town of Barnstable 397 Main Street Hyannis, MA 02601
Gordon Starr	gordon.m.starr@gmail.com	David Beaty	137 Harbor Bluff Road Hyannis, MA 02601
Keith Lewison	keith.lewison@gmail.com	Eric Kristofferson	Hyannis Fire Department 95 High School Road Ext. Hyannis, MA 02601
Lisa Connors	lconnors@pierce-cote.com	Hans Keijser	Department of Public Works Town of Barnstable 397 Main Street
Paul Neary	nearyprecinct6@gmail.com	Janine Voiles	67 Coolidge Road West Yarmouth, MA 02673
Steve Seymour	steveseymour@comcast.net	Jeanny Fichter	1640 Old Stage Rd. West Barnstable, MA 02668
Tom Cambareri	tomcambareri@gmail.com	Karl Von Hone	Yarmouth Natural Resources Town of Yarmouth 424 Route 28 West Yarmouth, MA 02673
Sue Phelan	suephelan@comcast.net	Luiz Gonzaga	92 High School Rd. Hyannis, MA 02601
Chris Greeley	greeleyc@comcast.net	M. Curley	39 Oak Ridge Road Osterville, MA 02655
Amanda Rose	504 Pitchers Way Hyannis, MA 02601	Maia Fitzstevens	Silent Spring Institute 320 Nevada Street, Suite 302 Newton, MA 02460
Angela Gallagher	MassDEP Southeast Regional Office Bureau of Waste Site Cleanup 20 Riverside Drive Lakeville, MA 02347	Mainur Kote	106 Betty's Path West Yarmouth, MA 02673
Anthony Alva	184 Mockingbird Lane Marstons Mills, MA 02646	Mainur Kote	106 Betty's Path West Yarmouth, MA 02673
Araceli Alcantara	67 Coolidge Road West Yarmouth, MA 02673	Margo Pisacano	73 Harbor Bluff Road Hyannis, MA 02601
Arthur Beatty	699 Cotuit Road Marstons Mills, MA 02648	Mark Ells	Town Manager Town of Barnstable 397 Main Street Hyannis, MA 02601
Bruce Murphy	Health Department Town of Yarmouth 1146 Route 28 South Yarmouth, MA 02664	Mark Forest	Board of Selectmen c/o Town Administrator's Office 1146 Route 28 South Yarmouth, MA 02664
Ronald Beaty	245 Parker Rd. West Barnstable, MA 02668	Mr. Michael Gorenstein	Department of Public Works Town of Barnstable 397 Main Street
Rong Jian Liu	5 Fishing Brook Road Yarmouth, MA 02664	Nancy Wentzel-Johnson	PO Box 342 Hyannis, MA 02601
Scott Beaty	29 Washington Avenue West Yarmouth, MA 02673	Peter Burke	Hyannis Fire Department 95 High School Road Ext. Hyannis, MA 02602
Sue Phelan	Green Cape - PO Box 631 West Barnstable, MA 02668	Richard A. Zoino	92 High School Road Hyannis, MA 02601
Sylvia Laselva	358 Sea Street Hyannis, MA 02673	Richard Rougeau	306 Longbeach Road Centerville, MA 02632
Vilson Kote	106 Betty's Path West Yarmouth, MA 02673	Thomas McKean	Board of Health Town of Barnstable 397 Main Street Hyannis, MA 02601

Table 2. Fire Truck Spray Water PFAS Results ug/L

	Fire Truck Spray Water Spray											
Sample ID	Hose		Roof		Bumper		Officer Side Handline		Driver side-Rear		Officer side-Rear	
Sample Date	8/22/2019	11/12/2019	8/22/2019	11/12/2019	8/22/2019	11/12/2019	8/22/2019	11/12/2019	8/22/2019	11/12/2019	8/22/2019	11/12/2019
Perfluoroheptanoic acid (PFHpA)	0.073	<0.002	0.0045	<0.002	0.0039	<0.002	0.027	<0.002	0.0055	<0.002	0.081	0.0021
Perfluorohexanesulfonic acid (PFHxS)	0.0059	<0.002	0.0033	<0.002	0.0039	<0.002	0.004	<0.002	0.0048	<0.002	0.0043	<0.002
Perfluorononanoic acid (PFNA)	0.011	<0.002	0.0026	<0.002	0.0031	<0.002	0.013	<0.002	0.003	<0.002	0.016	<0.002
Perfluorooctanoic acid (PFOA)	0.088	0.0062	0.0087	<0.002	0.01	<0.002	0.039	<0.002	0.011	<0.002	0.076	0.0041
Perfluorooctane sulfonate (PFOS)	0.009	0.0021	0.0068	<0.002	0.006	<0.002	0.0087	<0.002	0.0093	<0.002	0.0086	<0.002
Perfluorodecanoic Acid (PFDA)	0.014	<0.002	0.004	<0.002	0.0045	<0.002	0.032	<0.002	0.0049	<0.002	0.032	<0.002
Total PFAS	5.7017	0.3391	0.9195	0.0205	0.7817	0.0167	4.1098	0.0481	0.8302	0.0087	5.4701	0.086
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.2009**	0.0083	**0.0299**	<0.002	**0.0314**	<0.002	**0.1237**	<0.002	**0.0385**	<0.002	**0.2179**	0.0041

Notes:

< = Not detected by the laboratory above the reporting limit. Reporting limit shown.

Results in ug/L, micrograms per liter.

Bold results above proposed MassDEP GW-1 standard (0.02 ug/L)

Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U or <).

Table 3. Soil Results for PFAS Compounds ug/kg

Sample Location			ARFF Building																		
Sample ID	Method 1 Standard		ARFF1 (0-1')	ARFF1 (2')	ARFF1 (4')	ARFF2 (0-1')	ARFF3 (0-1')	ARFF3 (10-12)	ARFF4 (0-1')	ARFFCB (0-1)	A1 (0-1')	A2 (0-1')	A3 (0-1')	A4 (0-1')	A5 (0-1')	A5 (2-4')	A6 (0-1')	A7 (0-1')	A8 (0-1')	A9 (0-1')	A10 (0-1')
Sample Date	S-1/GW-1	S-1/GW-3	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	10/9/2018	9/26/2017	9/26/2017	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	9/24/2020	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018
Perfluoroheptanoic acid (PFHpA)	0.5	300	**0.82 J**	**1.8**	**0.66 J**	0.17 U	**0.60 J**	0.32 J	**0.75 J**	**0.60 J**	0.19 U	0.19 U	0.38 J	0.19 U	**1.1**	0.089 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.23 U	0.23 U	0.23 U	0.23 U	**0.64 J**	0.24 U	0.23 U	0.23 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.12 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U
Perfluorooctanoic acid (PFOA)	0.72	300	**0.75 J**	**2.6**	**0.75 J**	0.26 U	**0.78 J**	**1.9**	**0.97 J**	**0.90 J**	0.25 U	0.25 U	0.37 J	0.30 J	**1.9**	0.228 J	0.25 U	0.25 U	0.25 U	0.34 J	0.25 U
Perfluorononanoic acid (PFNA)	0.32	300	**2.5**	**5.7**	**1.4**	0.20 J	**0.91 J**	**3.1**	**2.9**	0.17 U	0.22 U	0.22 U	**0.51 J**	0.22 U	**0.87 J**	0.148 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
Perfluorooctane sulfonate (PFOS)	2	300	**4.5**	**2.7**	1.1	0.29 J	**4.4**	1.1	1.0	1.1	0.26 U	0.26 U	0.29 J	0.26 U	0.26 U	0.257 U	0.26 U	0.38 J	0.26 U	0.85 J	0.26 U
Perfluorodecanoic Acid (PFDA)	0.3	300	**4.4**	**1.2**	**0.62 J**	0.13 U	**1.6**	0.28 U	**0.85 J**	0.13 U	0.28 U	0.28 U	**0.42 J**	0.28 U	**1.4**	0.133 U	0.28 U	0.28 U	0.28 U	0.28 U	**0.33 J**
																			Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si		
Total PFAS	NA	NA	120.06	41.75	46.85	1.16	23.72	11.03	11.9	95.43	0	0	6.2	1.14	161.07	0.613	1.5	1.35	0.48	1.92	1.1
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	12.97	14	4.53	0.49	8.93	6.42	6.47	2.6	0	0	1.97	0.3	5.27	0.228	0	0.38	0	1.19	0.33

Sample Location			ARFF Building (cont.)																
Sample ID	Method 1 Standard		A11 (0-1')	A12 (0-1')	A13 (0-1')	A13 (0-1')	A14 (0-1')	A14 (0-1')	A15 (0-1')	A15 (0-1')	A16 (0-1')	A17 (0-1')	A18 (0-1)	A19 (0-1)	A20 (0-1)	A20 (2-4)	A21 (0-1)	A22 (0-1)	HW-P(M) [8-10]	HW-P(M) [18-20]	DL1(0-1')
Sample Date	S-1/GW-1	S-1/GW-3	8/14/2018	8/14/2018	2/27/2019	9/29/2020	2/27/2019	5/13/2020	2/27/2019	5/13/2020	9/17/2020	9/17/2020	9/29/2020	9/24/2020	9/24/2020	9/24/2020	9/24/2020	9/29/2020	9/18/2020	9/18/2020	6/20/2017
Perfluoroheptanoic acid (PFHpA)	0.5	300	0.19 U	0.19 U	**<2.0**	0.396 J	**<1.9**	**0.51 J**	**<2.0**	0.21 U	0.067 J	**1.07**	0.076 J	0.101 J	0.09 U	0.09 U	0.045 U	0.096 J	0.044 U	0.043 U	0.30 J
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.24 U	0.24 U	**<2.0**	0.058 U	**<1.9**	0.24 U	**<2.0**	0.21 U	0.085 J	0.058 U	0.054 U	0.059 U	0.121 U	0.121 U	0.06 U	0.055 U	0.059 U	0.058 U	0.23 U
Perfluorooctanoic acid (PFOA)	0.72	300	0.25 U	0.25 U	**<2.0**	0.67 J	**<1.9**	0.68 J	**<2.0**	0.14 U	0.088 J	**0.989**	0.111 J	0.129 J	0.196 J	0.147 J	0.042 U	0.069 J	0.089 J	0.046 J	0.26 U
Perfluorononanoic acid (PFNA)	0.32	300	0.22 U	0.22 U	**<2.0**	**1.2**	**<1.9**	**0.54 J**	**<2.0**	0.15 U	0.119 J	**0.774 J**	0.281 J	0.246 J	0.15 U	0.15 U	0.075 U	0.11 J	0.073 U	0.072 U	0.17 U
Perfluorooctane sulfonate (PFOS)	2	300	0.26 U	0.26 U	<2.0	1.3	<1.9	0.32 J	<2.0	0.29 J	**2.02**	0.573 J	1.15	0.611 J	0.259 U	0.26 U	0.276 J	0.559 J	0.0127 U	0.0124 U	0.40 J
Perfluorodecanoic Acid (PFDA)	0.3	300	0.28 U	0.28 U	**<2.0**	**0.34 J**	**<1.9**	**0.95 J**	**<2.0**	0.15 U	0.074 J	0.147 J	0.146 J	0.066 U	0.134 U	0.134 U	0.067 U	0.119 J	0.065 U	0.064 U	**0.63 J**
Total PFAS	NA	NA	0.43	0	0.0	5.2	0	13.15	0.0	0.45	3.131	11.267	2.652	1.409	0.316	0.147	0.571	1.412	0.411	0.09	11.14
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	0	0	0	3.916	0	3	0	0.29	2.453	3.553	1.764	1.087	0.196	0.147	0.276	0.953	0.089	0.046	1.33

Sample Location			Deployment Area																		
Sample ID	Method 1 Standard		DL2 (0-1')	DL2 2'	DL2 4'	DL3 (0-1')	DL3 2'	DL3 4'	DL4 (0-1')	DL4 2'	DL4 4'	DL5 (0-1')	DL5 2'	DL5 4'	DL6 (0-1')	DL7 (0-1')	DL8 (2')	DL8 (4')	DL9 (0-1')	DL10 (0-1')	DL 11 (0-1')
Sample Date	S-1/GW-1	S-1/GW-3	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	9/26/2017	6/20/2017	6/20/2017	6/20/2017	9/26/2017	6/20/2017	6/20/2017	9/26/2017
Perfluoroheptanoic acid (PFHpA)	0.5	300	**1.9**	**1.2**	0.48 J	**0.84 J**	0.17 U	0.17 U	0.31 J	0.17 U	0.17 U	**2.5**	0.40 J	0.50 J	**5.0**	**2.5 J**	**2.9 J**	**4.7 J**	**0.66 J**	**1.3**	**2.1**
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	**1.8**	**1.3**	**0.59 J**	**0.34 J**	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	**0.49 J**	**0.49 J**	0.23 U	0.23 U	**2.3 U**	**2.3 U**	**2.3 U**	**0.35 J**	**0.94 J**	**0.82 J**
Perfluorooctanoic acid (PFOA)	0.72	300	**1.6**	**4.1**	**0.74 J**	**0.80 J**	0.26 U	0.26 U	**0.83 J**	0.26 U	0.26 U	**3.7**	**1.6**	0.26 U	0.26 U	**4.2 J**	**25**	**22**	0.68 J	**1.7**	**4.7**
Perfluorononanoic acid (PFNA)	0.32	300	**0.81 J**	**2.5**	0.17 U	**0.55 J**	0.17 U	0.17 U	**2.7**	0.17 U	**3.7**	0.19 J	0.17 U	0.17 U	0.19 J	**9.6 J**	**46**	**1.7 U**	0.22 J	0.17 U	**16**
Perfluorooctane sulfonate (PFOS)	2	300	**12**	1.5	0.21 U	0.51 J	0.21 U	0.21 U	2.0	0.21 U	0.50 J	0.21 U	0.21 U	0.21 U	0.21 U	**3.9 J**	**14**	**2.1 U**	0.38 J	0.26 J	**29**
Perfluorodecanoic Acid (PFDA)	0.3	300	0.13 U	0.13 U	0.13 U	**1.4**	0.13 U	0.13 U	**1.3**	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	**1.3 U**	**1.3 U**	**1.3 U**	0.13 U	0.13 U	**1.8**
																			Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si		
Total PFAS	NA	NA	24.41	12.17	2.38	84.86	9.56	13.81	9.6	0.88	5.9	11.03	2.49	0.5	18.59	404.4	1727.2	949.6	6.38	9.1	85.22
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	18.11	10.6	1.81	4.44	0	0	7.14	0	4.2	6.88	2.49	0.5	5.19	20.2	87.9	26.7	2.29	4.2	54.42

Sample Location			Deployment Area (cont.)																
Sample ID	Method 1 Standard		DL 11 (0-1')	DL11 (4-6')	DL11 (10-12')	DL11 (14-16')	DL12 (0-1')	DL13 (0-1')	DL14 (0-1')	DL14 (4-6')	DL14 (10-12')	DL14 (14-16')	DL15 (0-1)	DL16 (0-1)	DL17 (0-1)	DL18 (0-1)	DL19 (0-1)	DL20 (0-1)	DL21 (0-1)	DL22 (2-4)	DL22 (6-8)
Sample Date	S-1/GW-1	S-1/GW-3	8/20/2019	10/4/2018	10/4/2018	10/4/2018	9/26/2017	9/26/2017	9/26/2017	10/4/2018	10/4/2018	10/4/2018	9/30/2020	9/30/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020
Perfluoroheptanoic acid (PFHpA)	0.5	300	**1.8**	**1.3**	0.31 J	0.23 J	**1.2**	**1.6**	**4.9**	0.36 J	0.19 U	**1.4**	0.175 U	0.138 J	0.167 U	0.319 J	0.145 U	0.157 U	0.158 U	0.109 J	0.481 J
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	**<0.9**	0.24 U	0.24 U	0.24 U	0.23 U	0.23 U	**0.71 J**	0.24 U	0.24 U	**0.74 J**	0.235 U	0.057 U	0.224 U	0.159 J	0.194 U	0.21 U	0.212 U	0.057 U	0.07 J
Perfluorooctanoic acid (PFOA)	0.72	300	**5.2**	**2.9**	**1.9**	0.50 J	**4.6**	**2.4**	**23**	0.58 J	0.32 J	**2.9**	0.334 J	0.223 J	0.166 J	**0.979 J**	0.135 U	0.146 U	0.159 J	0.447 J	**1.32**
Perfluorononanoic acid (PFNA)	0.32	300	**2.4**	**2.5**	0.22 U	0.22 U	**7.3**	**1.5**	**10**	0.22 U	0.22 U	**10**	0.292 U	0.285 J	0.277 U	0.296 J	0.241 U	0.261 U	0.263 U	**5.46**	**2.66**
Perfluorooctane sulfonate (PFOS)	2	300	1.5	0.26 U	0.26 U	0.26 U	**23**	0.66 J	**7.6**	0.26 U	0.26 U	**2.3**	0.505 U	0.575 J	0.481 U	1.05 J	0.418 U	0.452 U	0.456 U	**20.3**	**8.85**
Perfluorodecanoic Acid (PFDA)	0.3	300	**8.7**	0.28 U	0.28 U	0.28 U	**0.66 J**	**7.4**	**9.6**	0.28 U	0.28 U	0.28 U	0.26 U	0.181 J	0.248 U	0.167 J	0.215 U	0.233 U	0.235 U	**0.834 J**	**0.383 J**
Total PFAS	NA	NA	91.5	11.07	6.82	7.63	108.56	521.26	598.24	50.11	21.22	116.64	4.523	2.269	0.628	4.84	0	0	0.68	66.813	41.988
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	19.6	6.7	2.21	0.73	36.76	13.56	55.81	0.94	0.32	17.34	0.334	1.402	0.166	2.97	0	0	0.159	27.15	13.764

Sample Location			**Deployment Area**																		
Sample ID	Method 1 Standard		DL22 (18-20)	DL23 (0-1)	D1 (0-1')	D2 (0-1')	D3 (0-1')	D4 (0-1')	D5 (0-1')	D6 (0-1')	D7 (0-1')	D8 (0-1')	D9 (0-1')	D10 (0-1')	D11 (0-1')	D12 (0-1')	HW-F (10-12')	HW-F (14-16')	HW-3 (0-1')	MCI Drill (0-1)	Annual Deployment (0-1)
Sample Date	S-1/GW-1	S-1/GW-3	9/25/2020	9/29/2020	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	10/4/2018	10/4/2018	10/9/2018	12/9/2016	12/9/2016
Perfluoroheptanoic acid (PFHpA)	0.5	300	0.073 J	0.24 J	0.19 U	0.21 J	0.19 U	**0.95 J**	0.22 J	0.25 J	**7.8**	**1.0**	**2.7**	0.19 U	0.19 U	0.19 U	0.32 J	**1.3**	0.19 U	**8.4**	**20**
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.059 U	0.134 J	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	**0.31 J**	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	**0.5 J**	**4 U**
Perfluorooctanoic acid (PFOA)	0.72	300	0.176 J	0.471 J	0.25 U	0.33 J	0.25 U	**1.1**	0.25 U	0.28 J	**14**	**2.2**	**3**	0.25 U	0.25 U	0.25 U	0.25 U	**1.4**	0.25 U	**23**	**100**
Perfluorononanoic acid (PFNA)	0.32	300	**0.476 J**	0.176 J	0.22 U	**0.67 J**	0.22 U	**0.98 J**	0.22 U	0.22 U	**10**	**0.59 J**	**0.83 J**	0.22 U	0.22 U	0.32 J	0.22 U	0.22 U	0.22 U	**14**	**31**
Perfluorooctane sulfonate (PFOS)	2	300	1.18	0.725 J	0.26 U	0.66 J	0.38 J	**2.9**	0.26 U	0.26 U	**3.4**	**2.1**	0.67 J	0.54 J	0.91 J	0.44 J	0.26 U	0.26 U	0.26 U	**24**	1.9 J
Perfluorodecanoic Acid (PFDA)	0.3	300	0.065 U	0.266 J	0.28 U	0.28 U	0.28 U	**0.40 J**	0.28 U	**0.66 J**	**8.6**	**1.3**	**1.6**	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	**20**	**69**
								Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si													
Total PFAS	NA	NA	11.352	4.053	0.74	1.87	0.94	11.42	3.01	9.06	151.24	24.61	43.41	0.83	1.62	1.47	25.27	146.5	0	1,524	5,972.9
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	1.905	2.012	0	1.87	0.38	6.33	0.22	1.19	43.8	7.5	8.8	0.54	0.91	0.76	0.32	2.7	0	89.9	221.9

Sample Location			**1991 Drill Location**						**Old ARFF/SRE Building**
Sample ID	Method 1 Standard		1991A (0-1')	1991B (0-1')	1991C (0-1')	1991D (0-1')	1991A-B (3-4')	1991C-D (2-3')	HW-X(m) [7-9]
Sample Date	S-1/GW-1	S-1/GW-3	8/14/2018	8/14/2018	8/14/2018	8/14/2018	12/14/2018	12/14/2018	9/7/2021
Perfluoroheptanoic acid (PFHpA)	0.5	300	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.043 U
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.24 U	**0.66 J**	0.24 U	0.24 U	0.24 U	0.24 U	0.058 U
Perfluorooctanoic acid (PFOA)	0.72	300	0.25 U	0.26 J	0.25 U	0.25 U	0.25 U	0.25 U	0.04 U
Perfluorononanoic acid (PFNA)	0.32	300	0.22 U	0.22 U	0.22 U	0.30 J	0.22 U	0.22 U	0.072 U
Perfluorooctane sulfonate (PFOS)	2	300	0.49 J	1.1	0.55 J	0.36 J	0.30 J	0.42 J	0.124 U
Perfluorodecanoic Acid (PFDA)	0.3	300	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.064 U
				Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si					
Total PFAS	NA	NA	0.49	3.18	0.55	0.66	0.3	0.42	0.139
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	0.49	2.02	0.55	0.66	0.3	0.42	0.124 U

Notes:
< = Not detected by the laboratory above the reporting limit. Reporting limit shown.
J = Estimated concentration between the method detection limit and reporting limit.
Results in ug/kg, micrograms per kilogram.
U= Not detected by the Laboratory above the method detection limit. Method detection limit shown.
Bold results above the proposed Method 1 S-1/GW-1 standard.
Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U or <).
Sum of six includes estimated values and does not include non-detects (U or <).

Table 4. Groundwater Results for PFAS Compounds ug/L

Sample Location	North Ramp												
Sample ID	HW-1	HW-1	HW-1	HW-4M	HW-5	HW-5	HW-5	HW-23	HW-23	HW-19D	HW-19D	HW-X(s)	HW-X(m)
Sample Date	7/1/2016	6/20/2017	11/1/2018	4/5/2017	7/1/2016	4/7/2017	11/1/2018	6/20/2017	11/1/2018	6/20/2017	11/7/2018	9/10/2021	9/10/2021
TOC Elevation	51.51	51.51	51.51	54.02	54.98	54.98	54.98	50.65	50.65	49.10	49.10	NA	NA
Depth to Groundwater	21.63	25.00	21.83	26.20	24.94	26.75	25.27	22.70	24.01	21.29	22.19	24.74	25.21
Groundwater Elevation	29.88	26.51	29.68	27.82	30.04	28.23	29.71	27.95	26.64	27.81	26.91	NA	NA
Total Well Depth	30.84	30.84	30.84	32.32	27.80	27.80	27.80	28.11	28.11	41.30	41.30	29.24	36.82
Perfluoroheptanoic acid (PFHpA)	0.01	0.0042 J	0.013 J	0.007 J	0.0041	0.0084 J	0.0074 U	0.0045J	0.0098 J	0.0052 J	0.0080 J	0.0061	0.0034
Perfluorohexanesulfonic acid (PFHxS)	0.018	0.065	0.018 J	0.02	0.011	0.018 J	0.0056 U	0.021	0.023	0.046	0.045	0.047	0.0021
Perfluorononanoic acid (PFNA)	<0.002	0.0057 J	0.0087 U	0.0046 U	<0.002	0.0046 U	0.0088 J	0.0038 U	0.0087 U	0.0065 J	0.0087 U	0.00049 J	0.002
Perfluorooctanoic acid (PFOA)	0.033	0.022	0.031	0.011 J	0.031	0.020 J	0.011 J	0.0046 U	0.011 J	0.017 J	0.014 J	0.013	0.0062
Perfluorooctane sulfonate (PFOS)	0.017	0.24	0.028	0.043	0.12	0.052	0.12	0.0079 J	0.015 J	0.061	0.069	0.068	0.034
Perfluorodecanoic Acid (PFDA)	NA	0.0040 U	0.0061 U	0.0040 U	NA	0.0040 U	0.0061 U	0.0040 U	0.0061 U	0.0040 U	0.0061 U	0.00050 U	0.0042
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	0.0032 U	0.0066 U	0.0038 J	NA	0.0037 J	0.0066 U	0.0032 U	0.0066 U	0.0032 U	0.0066 U	0.002 J	0.00035 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six													
Total PFAS	0.078	0.4247	0.15	0.1162	0.1661	3.0021	0.1507	0.0745	0.0858	0.1758	0.16	0.18221	0.10025
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.078**	**0.3369**	**0.09**	**0.081**	**0.1661**	**0.0984**	**0.1398**	**0.0334**	**0.0588**	**0.1357**	**0.136**	**0.13459**	**0.0519**

Sample Location	Lewis Pond Area	Airport Road/Iyannough Road Area														
Sample ID	HW-401S	HW-A(S)	HW-B(S)	HW-B(S)	HW-B(D)	HW-C	HW-M	HW-N	HW-O	HW-U(s)	HW-U(s)	HW-U(m)	HW-U(m)	HW-U(d)	HW-U(d)	HW-V(m)
Sample Date	4/7/2017	4/7/2017	4/7/2017	10/26/2018	10/26/2018	4/7/2017	6/24/2019	6/24/2019	7/2/2019	4/19/2021	9/5/2021	4/19/2021	9/5/2021	10/2/2020	9/5/2021	10/2/2020
TOC Elevation	41.58	55.34	51.84	51.84	51.95	69.25	53.69	49.49	43.46	NA	NA	NA	NA	48.80	48.80	53.83
Depth to Groundwater	17.95	24.62	22.26	21.59	21.66	38.50	20.32	15.48	3.62	23.59	24.53	23.50	24.49	24.66	25.24	22.90
Groundwater Elevation	23.63	30.72	29.58	30.25	30.29	30.75	33.37	34.01	39.84	NA	NA	NA	NA	24.14	23.56	30.93
Total Well Depth	23.60	32.00	30.23	30.23	57.20	42.15	26.92	22.33	14.10	28.83	28.83	38.93	38.93	62.30	62.30	36.15
Perfluoroheptanoic acid (PFHpA)	0.0043 J	0.0048 J	0.049	0.012 J	0.0074 U	0.0033 U	0.007	0.0034	<0.002	0.002 J	0.004	0.0018 J	0.0049	0.01	0.01	0.0033
Perfluorohexanesulfonic acid (PFHxS)	0.011 J	0.0079 J	0.044	0.047	0.0056 U	0.0034 U	0.016	0.033	0.0043	0.01	0.0034	0.0043	0.011	0.018	0.022	0.0032
Perfluorononanoic acid (PFNA)	0.0046 U	0.0046 U	0.0046 U	0.0087 U	0.0087 U	0.0046 U	<0.002	<0.002	<0.002	0.0013 J	0.0017 J	0.00083 J	0.0011 J	0.0016	0.005	0.0017
Perfluorooctanoic acid (PFOA)	0.0046 U	0.0026 U	0.0094 J	0.020 J	0.012 J	0.0026 U	0.027	0.0088	0.0039	0.0075	0.0047	0.0055	0.0094	0.01	0.013	0.0063
Perfluorooctane sulfonate (PFOS)	0.012 J	0.0026 U	0.026	0.019 J	0.010 J	0.0026 U	0.0074	0.004	0.017	0.06	0.029	0.0093	0.027	0.023	0.051	0.0059
Perfluorodecanoic Acid (PFDA)	0.0040 U	0.0040 U	0.0040 U	0.0061 U	0.0061 U	0.0040 U	<0.002	<0.002	0.0021	0.00064 J	0.0011 J	0.00038 U	0.001 U	0.00062 U	0.0025 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.004 J	0.0032 U	0.0032 U	0.0066 U	0.0066 U	0.0034 J	<0.002	<0.002	0.002 U	0.0011 U	0.00034 U	0.0011 U	0.00075	0.0012	0.04	0.00039 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six																
Total PFAS	0.0313	0.0779	0.4561	0.186	0.0465	0.0034	0.0927	0.0727	0.0585	0.09704	0.06596	0.03622	0.0839	0.0889	0.1775	0.0543
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0273**	0.0127	**0.1284**	**0.098**	**0.022**	<0.0046	**0.0574**	**0.0492**	**0.0273**	**0.08144**	**0.0439**	**0.02173**	**0.0534**	**0.0588**	**0.0987**	**0.0204**

Sample Location	ARFF Building Area												
Sample ID	HW-L (s)	HW-L (m)	HW-L (d)	HW-L (d)	HW-P (s)	HW-P (s)	HW-P (s)	HW-P (m)	HW-P (m)	HW-P (m)	HW-Q (s)	HW-Q (s)	HW-Q (m)
Sample Date	10/7/2020	10/7/2020	6/19/2019	10/7/2020	10/1/2020	3/18/2021	9/8/2021	10/1/2020	3/18/2021	9/8/2021	10/1/2020	11/6/2020	10/1/2020
TOC Elevation	39.07	38.98	39.15	39.15	40.51	40.51	40.51	40.64	40.64	40.64	37.89	37.89	37.90
Depth to Groundwater	21.96	21.88	19.40	22.22	22.69	22.09	23.54	22.80	22.20	23.67	21.45	22.04	21.41
Groundwater Elevation	17.11	17.10	19.75	16.93	17.82	18.42	16.97	17.84	18.44	16.97	16.44	15.85	16.49
Total Well Depth	27.33	37.33	70.55	70.55	27.60	27.60	27.60	38.30	38.30	38.30	26.60	26.60	36.79
Perfluoroheptanoic acid (PFHpA)	0.00053 U	0.0064	0.0078	0.0065	0.026	0.0067	0.004	0.003	0.017	0.016	0.0018 J	0.0021	0.00053 U
Perfluorohexanesulfonic acid (PFHxS)	0.0013	0.023	0.033	0.015	0.0018	0.00074 J	0.00056 J	0.00085	0.0015 J	0.0013 J	0.013	0.0087	0.0019
Perfluorononanoic acid (PFNA)	0.00063 U	0.0025	0.0033	0.0022	0.0061	0.002	0.0013 J	0.0011	0.006	0.0099	0.00063 U	0.00063 U	0.00075
Perfluorooctanoic acid (PFOA)	0.00071 U	0.01	0.025	0.018	0.0084	0.0042	0.0017 J	0.0018	0.0096	0.01	0.0049	0.0062	0.00095
Perfluorooctane sulfonate (PFOS)	0.0014	0.07	0.049	0.039	0.00097	0.00049 J	0.00054 U	0.0011	0.0035	0.003	0.0041	0.0075	0.0049
Perfluorodecanoic Acid (PFDA)	0.00062 U	0.00062 U	<0.002	0.0019	0.00085	0.0004 J	0.00048 U	0.00062 U	0.00038 U	0.00048 U	0.00062 U	0.00062 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.00039 U	0.022	0.0021	0.00078	0.011	0.0034	0.0014 J	0.00092	0.0011 U	0.00036 U	0.00039 U	0.00039 U	0.00039 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six													
Total PFAS	0.0027	0.18375	0.1823	0.12348	0.2478	0.06294	0.05055	0.02967	0.17311	0.15362	0.0307	0.0346	0.00944
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.0027	**0.1119**	**0.1181**	**0.0826**	**0.04412**	0.01453	0.00756	0.00785	**0.0376**	**0.0402**	**0.0238**	**0.0245**	0.0085

Sample Location	Deployment Area											
Sample ID	HW-I (s)	HW-I (s)	HW-I (s)	HW-I (s)	HW-I (m)	HW-I (m)	HW-I (m)	HW-I (m)	HW-I (d)	HW-I (d)	HW-I (d)	HW-I (d)
Sample Date	11/7/2018	5/8/2020	3/17/2021	9/8/2021	6/24/2019	5/8/2020	3/17/2021	9/8/2021	6/24/2019	5/8/2020	3/17/2021	9/11/2021
TOC Elevation	36.08	36.08	36.08	36.08	36.27	36.27	36.27	36.27	36.02	36.02	36.02	36.02
Depth to Groundwater	18.35	15.39	18.42	19.94	16.33	15.61	18.66	20.17	16.20	15.49	18.52	20.04
Groundwater Elevation	17.73	20.69	17.66	16.14	19.94	20.66	17.61	16.10	19.82	20.53	17.50	15.98
Total Well Depth	25.10	25.10	25.10	25.10	34.80	34.80	34.80	34.80	41.67	41.67	41.67	41.67
Perfluoroheptanoic acid (PFHpA)	0.2	0.54	0.032	0.097	0.0032	0.0012	0.00086 J	0.0014 J	0.0053	0.0046	0.0065	0.0083
Perfluorohexanesulfonic acid (PFHxS)	0.18	0.22	0.021	0.036	0.019	0.0091	0.0052	0.0078	0.057	0.018	0.031	0.05
Perfluorononanoic acid (PFNA)	0.16	0.082	0.065	0.033	<0.002	0.00078	0.00048 U	0.00046 J	<0.002	0.00063 U	0.00075 J	0.00084 J
Perfluorooctanoic acid (PFOA)	0.26	0.29	0.05	0.063	0.0061	0.0018	0.0014 J	0.0016 J	0.0047	0.0028	0.0043	0.0053
Perfluorooctane sulfonate (PFOS)	0.066	0.04	0.028	0.02	0.014	0.014	0.013	0.016	0.012	0.02	0.038	0.039
Perfluorodecanoic Acid (PFDA)	0.012 U	0.00062 U	0.0038 U	0.00047 U	<0.002	0.00062 U	0.00038 U	0.00050 U	<0.002	0.00062 U	0.00038 U	0.00048 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	11	13	1.7	2.1	0.002 U	0.00039 U	0.0011 U	0.00037 U	<0.002	0.0016	0.0011 U	0.00054 J
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six												
Total PFAS	13.346	15.5383	2.082	2.73304	0.0718	0.03308	0.02516	0.03254	0.1367	0.08985	0.15585	0.16687
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.866**	**1.172**	**0.196**	**0.249**	**0.0423**	**0.02688**	**0.02046**	**0.02726**	**0.079**	**0.0454**	**0.08055**	**0.10344**

Sample Location	Deployment Area																
Sample ID	HW-J	HW-J	HW-J	HW-E	HW-E	HW-E	HW-E	HW-E	HW-E	HW-F	HW-F	HW-F	HW-F	HW-F	HW-H	HW-H	HW-R(s)
Sample Date	11/7/2018	3/17/2021	9/10/2021	4/5/2017	11/7/2018	8/19/2019	5/5/2020	3/17/2021	9/8/2021	4/5/2017	11/7/2018	5/5/2020	3/17/2021	9/8/2021	11/7/2018	5/8/2020	10/1/2020
TOC Elevation	37.10	37.10	37.10	38.45	38.45	38.45	38.45	38.45	38.45	36.32	36.32	36.32	36.32	36.32	38.47	38.47	35.72
Depth to Groundwater	19.18	19.34	20.60	19.05	19.38	17.82	16.16	23.35	25.02	19.60	20.08	16.82	20.01	21.72	20.39	17.37	18.33
Groundwater Elevation	17.92	17.76	16.50	19.40	19.07	20.63	22.29	15.10	13.43	16.72	16.24	19.50	16.31	14.60	18.08	21.10	17.39
Total Well Depth	24.30	24.30	24.30	26.22	26.22	26.22	26.22	26.22	26.22	26.89	26.89	26.89	26.89	26.89	27.09	27.09	23.67
Perfluoroheptanoic acid (PFHpA)	0.025	0.044	0.02	0.15	0.0074 U	0.0053	0.044	0.014	0.0018 J	0.34	0.0074 U	0.23	0.39	0.0051	0.077	0.28	0.021
Perfluorohexanesulfonic acid (PFHxS)	0.0056 U	0.088	0.01	0.042	0.0056 U	0.0021	0.011	0.0015 J	0.00088 J	0.019J	0.0056 U	0.005	0.012 U	0.00037 U	0.0056 U	0.0031	0.02
Perfluorononanoic acid (PFNA)	0.028	0.035 J	0.015	0.0087 J	0.0087 U	<0.002	0.0052	0.00048 U	0.00037 U	0.0046 U	0.0087 U	0.00081	0.0097 U	0.00037 U	0.0087 U	0.00063 U	0.0031
Perfluorooctanoic acid (PFOA)	0.026	0.061	0.0091	0.053	0.0033 U	0.0047	0.027	0.00095 J	0.00094 J	0.075	0.0033 U	0.02	0.052	0.00074 U	0.0050 J	0.002	0.014
Perfluorooctane sulfonate (PFOS)	0.13	0.25	0.08	0.047	0.0060 U	<0.002	0.0037	0.00082 J	0.00064 U	0.0026 U	0.0060 U	0.00086	0.0076 U	0.00065 U	0.0060 U	0.00068 U	0.016
Perfluorodecanoic Acid (PFDA)	0.0061 U	0.0076 U	0.00050 U	0.0040 U	0.0061 U	<0.002	0.00062 U	0.00038 U	0.00052 U	0.0040 U	0.0061 U	0.00062 U	0.0076 U	0.00053 U	0.0061 U	0.00062 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.68	0.44	0.13	2	0.0066 U	0.069	0.86	0.0035	0.00039 U	5.7	0.0066 U	1.5	4.8	0.0049	1.5	0.13	0.037
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six																	
Total PFAS	1.074	1.217	0.511	3.2257	0	0.14	1.04526	0.04812	0.01342	12.96	0.084	2.65637	8.422	0.159	4.452	1.26666	0.2171
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.209**	**0.478**	**0.1341**	**0.3007**	0.0087 U	0.0121	**0.0909**	0.01727	0.00362	**0.434**	0.0087 U	0.25667	**0.442**	0.0051	**0.082**	**0.2851**	**0.0741**

Sample Location	Yarmouth Road											
Sample ID	HW-R(s)	HW-R(s)	HW-S (s)	HW-S (s)	HW-S (s)	HW-S (m)	HW-S (m)	HW-S (m)	HW-T (s)	HW-T (m)	RB-1 (s)	RB-1 (s)	RB-1 (s)
Sample Date	3/17/2021	9/8/2021	10/1/2020	3/18/2021	9/3/2021	10/1/2020	3/18/2021	9/3/2021	10/1/2020	10/1/2020	11/5/2020	3/18/2021	9/5/2021
TOC Elevation	35.72	35.72	31.60	31.60	31.60	31.59	31.59	31.59	28.97	29.11	NA	NA	NA
Depth to Groundwater	17.37	19.00	16.88	16.29	17.30	17.01	16.35	17.37	13.41	13.58	17.87	16.91	18.64
Groundwater Elevation	18.35	16.72	14.72	15.31	14.30	14.58	15.24	14.22	15.56	15.53	NA	NA	NA
Total Well Depth	23.67	23.67	22.10	22.10	22.10	32.04	32.04	32.04	18.54	28.96	27.80	27.80	27.80
Perfluoroheptanoic acid (PFHpA)	0.005	0.021	0.11	0.14	0.11	0.00096	0.0011 J	0.0012 J	0.0039	0.022	0.0042	0.0054	0.0077
Perfluorohexanesulfonic acid (PFHxS)	0.01	0.0046	0.055	0.083	0.064	0.0064	0.0073	0.0053	0.17	0.019	0.0084	0.03	0.0051
Perfluorononanoic acid (PFNA)	0.001 J	0.00034 U	0.1	0.024	0.1	0.00063 U	0.00057 J	0.00055 J	0.00074	0.0032	0.0047	0.0025	0.0026
Perfluorooctanoic acid (PFOA)	0.004	0.004	0.062	0.078	0.13	0.0013	0.0018 J	0.0014 J	0.0067	0.011	0.007	0.0087	0.0093
Perfluorooctane sulfonate (PFOS)	0.0023	0.0053	0.1	0.03	0.048	0.0058	0.006	0.0094	0.21	0.025	0.038	0.04	0.01
Perfluorodecanoic Acid (PFDA)	0.00038 U	0.00049 U	0.00062 U	0.0038 U	0.012 U	0.00062 U	0.00038 U	0.00047 U	0.00062 U	0.0014	0.00062 U	0.00038 U	0.00045 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.0048	0.003	3.7	3.1	5.2	0.0065	0.0067	0.0036	0.00039 U	0.00039 U	0.00039 U	0.0011 U	0.00034 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six													
Total PFAS	0.04878	0.2549	4.8958	4.3105	6.1418	0.02471	0.03263	0.02873	0.44114	0.3254	0.08008	0.1175	0.06755
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0223**	**0.0349**	**0.427**	**0.355**	**0.452**	0.01446	**0.02667**	0.01785	**0.39134**	**0.0816**	**0.0623**	**0.0866**	**0.0347**

Sample Location	Yarmouth Road			Solar Field								
Sample ID	RB-1 (m)	RB-1 (m)	RB-1 (m)	HW-D (m)	HW-D (m)	HW-D (d)	HW-D (d)	HW-D (dd)	HW-D (dd)	HW-G(S)	HW-G(M)	HW-G(D)
Sample Date	11/5/2020	3/18/2021	9/5/2021	4/7/2017	5/13/2020	6/24/2019	5/13/2020	6/24/2019	5/13/2020	12/3/2018	12/3/2018	12/3/2018
TOC Elevation	NA	NA	NA	45.20	45.20	45.08	45.08	45.05	45.05	44.99	45.11	44.93
Depth to Groundwater	17.79	16.85	18.57	18.83	18.34	18.99	18.23	20.60	19.97	20.69	20.75	20.71
Groundwater Elevation	NA	NA	NA	26.37	26.86	26.09	26.85	24.45	25.08	24.30	24.36	24.22
Total Well Depth	49.85	49.85	48.85	30.32	30.32	44.94	44.94	65.05	65.05	28.45	38.25	48.28
Perfluoroheptanoic acid (PFHpA)	0.011	0.013 J	0.0073	0.0033 U	0.00053 U	0.021	0.017	<0.002	0.00053 U	0.0074 U	0.0074 U	0.0074 U
Perfluorohexanesulfonic acid (PFHxS)	0.01	0.017 J	0.0099	0.0089 J	0.00077 U	0.062	0.039	0.0092	0.008	0.0056 U	0.012 J	0.0056 U
Perfluorononanoic acid (PFNA)	0.0068	0.0072 J	0.0044	0.0046 U	0.00063 U	0.015	0.019	0.0041	0.0029	0.0087 U	0.011 J	0.0087 U
Perfluorooctanoic acid (PFOA)	0.013	0.013 J	0.012	0.0046 U	0.00071 U	0.0088	0.0076	<0.002	0.00071 U	0.0033 U	0.0033 U	0.0033 U
Perfluorooctane sulfonate (PFOS)	0.049	0.075	0.055	0.022	0.0011	0.095	0.12	0.013	0.013	0.0060 U	0.036	0.0060 U
Perfluorodecanoic Acid (PFDA)	0.00075	0.0038 U	0.0033	0.0040 U	0.00062 U	<0.002	0.00062 U	<0.002	0.00062 U	0.0061 U	0.0061 U	0.0061 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.038	0.055	0.013	0.0032 U	0.00039 U	0.0022	0.00039 U	0.002 U	0.00039 U	0.0066 U	0.0066 U	0.0066 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six												
Total PFAS	0.2015	0.2642	0.1561	0.0309	0.0011	0.2768	0.24993	0.0263	0.02444	0	0.059	0
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0913**	**0.1252**	**0.0919**	**0.0309**	0.0011	**0.2018**	**0.2026**	**0.0263**	**0.0239**	0.0087 U	**0.059**	0.0087 U

Sample Location	Steamship Parking Lot																				
Sample ID	HW-2	HW-2	HW-2	HW-3	HW-3	HW-3	HW-3	HW-3	HW-3	HW-300	HW-300	HW-300	HW-301	HW-302	HW-302	HW-302	HW-302	HW-K	HW-K	HW-K	HW-K
Sample Date	7/1/2016	5/5/2020	9/1/2021	7/1/2016	4/5/2017	10/26/2018	5/5/2020	3/17/2021	9/1/2021	7/1/2016	3/17/2021	9/2/2021	7/1/2016	7/1/2016	12/3/2018	3/17/2021	9/1/2021	6/19/2019	5/21/2020	3/18/2021	9/2/2021
TOC Elevation	40.41	40.41	40.41	38.74	38.74	38.74	38.74	38.74	38.74	36.09	36.09	36.09	39.46	41.17	41.17	41.17	41.17	37.70	37.70	37.70	37.70
Depth to Groundwater	27.48	25.33	30.20	25.81	25.70	26.06	23.64	26.19	28.35	22.52	22.86	23.02	25.05	23.52	22.65	24.04	26.15	20.88	20.56	22.87	24.24
Groundwater Elevation	12.93	15.08	10.21	12.93	13.04	12.68	15.10	12.55	10.39	13.57	13.23	13.07	14.41	17.65	18.52	17.13	15.02	16.82	17.14	14.83	13.46
Total Well Depth	32.80	32.80	32.80	33.08	33.08	33.08	33.08	33.12	33.11	30.33	30.30	30.34	30.42	30.45	30.45	30.44	30.40	44.18	44.18	44.17	44.18
Perfluoroheptanoic acid (PFHpA)	0.0071	0.035	0.046	0.016	0.1	0.10	0.1	0.084	0.035	0.0096	0.0028	0.0029	0.002	0.019	0.015 J	0.0066	0.0062	0.0051	0.0028	0.0044	0.0086
Perfluorohexanesulfonic acid (PFHxS)	0.0035	0.0066	0.0056 J	0.0043	0.020 J	0.012 J	0.0087	0.0064 J	0.0057 J	0.012	0.0099	0.00066 J	0.038	0.0063	0.016 J	0.0022	0.004	<0.002	0.001	0.00066 J	0.0015 J
Perfluorononanoic acid (PFNA)	<0.002	0.016	0.004 J	0.0063	0.027	0.023	0.021	0.019 J	0.014 J	<0.002	0.00099 J	0.0028	<0.002	0.054	0.0097 J	0.0066	0.005	<0.002	0.0012	0.0037	0.003
Perfluorooctanoic acid (PFOA)	0.0063	0.039	0.012	0.0091	0.065	0.057	0.054	0.064	0.016 J	0.0052	0.0044	0.0044	0.0037	0.033	0.03	0.005	0.0065	0.0041	0.0019	0.0036	0.0038
Perfluorooctane sulfonate (PFOS)	0.012	0.053	0.026	0.084	0.15	0.053	0.1	0.056	0.044	0.017	0.015	0.017	0.011	0.014	0.031	0.0041	0.015	<0.002	0.0016	0.0015 J	0.0019
Perfluorodecanoic Acid (PFDA)	NA	0.00062 U	0.0025 U	NA	0.0040 U	0.0061 U	0.0014	0.0038 U	0.0052 U	NA	0.00038 U	0.0006 J	NA	NA	0.0061 U	0.00086 J	0.001 J	<0.002	0.00062 U	0.00038 U	0.00046 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	0.15	0.071	NA	0.47	0.12	0.13	0.47	0.2	NA	0.0011 U	0.00034 U	NA	NA	0.13	0.012	0.0062	0.002 U	0.00039 U	0.0011 U	0.00034 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six																					
Total PFAS	0.0289	0.42678	0.4136	0.1197	1.603	0.952	0.96981	1.1394	0.6867	0.0438	0.05509	0.03812	0.0547	0.1263	0.3427	0.08304	0.09793	0.0348	0.0275	0.04486	0.09217
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0289**	**0.1496**	**0.0936**	**0.1197**	**0.362**	**0.245**	**0.2851**	**0.2294**	**0.1147**	**0.0438**	**0.03309**	**0.02832**	**0.0547**	**0.1263**	**0.1017**	**0.02536**	**0.0377**	0.0092	0.0085	0.0138	0.0188

Sample Location	Maher Wells								
Sample ID	OW-9S	OW-9S	OW-9S	OW-9M	OW-9M	OW-9D	OW-9D	OW-9D	OW-9DD
Sample Date	7/5/2016	12/3/2018	5/8/2020	12/3/2018	5/8/2020	7/5/2016	12/3/2018	5/5/2020	4/11/2017
TOC Elevation	23.25	23.25	23.25	23.53	23.53	23.22	23.22	23.22	23.81
Depth to Groundwater	12.23	10.80	10.14	11.11	10.45	12.48	10.82	10.15	12.10
Groundwater Elevation	11.02	12.45	13.11	12.42	13.08	10.74	12.40	13.07	11.71
Total Well Depth	21.35	21.35	21.35	56.20	56.20	68.63	68.63	68.63	86.75
Perfluoroheptanoic acid (PFHpA)	0.014	0.048	0.0064	0.11	0.0061	0.0028	0.033	0.044	0.034
Perfluorohexanesulfonic acid (PFHxS)	<0.003	0.023	0.011	0.0056 U	0.0033	0.012	0.12	0.18	0.12
Perfluorononanoic acid (PFNA)	0.0077	0.0087 U	0.0033	0.044	0.0037	0.0036	0.1	0.15	0.059
Perfluorooctanoic acid (PFOA)	0.007	0.032	0.0043	0.052	0.0035	0.0052	0.057	0.088	0.055
Perfluorooctane sulfonate (PFOS)	0.0074	0.024	0.0058	0.0081 J	0.01	0.041	0.52	0.72	0.5
Perfluorodecanoic Acid (PFDA)	NA	0.0061 U	0.00062 U	0.0061 U	0.00062 U	NA	0.0061 U	0.00062 U	0.0040 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	0.0066 U	0.00039 U	0.64	0.0049	NA	0.19	0.23	0.13
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six									
Total PFAS	0.0361	0.618	0.06678	1.7141	0.0816	0.0646	1.217	1.5845	1.02
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0361**	**0.127**	**0.0308**	**0.2141**	**0.0266**	**0.0646**	**0.83**	**1.182**	**0.768**

Sample Location	Maher Wells															
Sample ID	OW-9DD	OW-9DD	ME-1*	ME-2**	ME-3***	OW-18S	OW-18S	OW-18S	OW-18M	OW-18M	OW-18M	OW-18D	OW-18D Duplicate	OW-18D	OW-18D	OW-18D
Sample Date	12/3/2018	10/2/2020	9/17/2020	9/17/2020	9/17/2020	7/5/2016	12/7/2018	5/8/2020	7/5/2016	12/7/2018	5/8/2020	7/5/2016	7/5/2016	4/11/2017	12/7/2018	5/13/2020
TOC Elevation	23.81	23.81	NA	NA	NA	39.03	39.03	39.03	39.30	39.30	39.30	38.84	38.84	38.84	38.84	38.84
Depth to Groundwater	11.30	13.04	3.60	6.50	6.00	24.40	24.29	23.45	25.82	24.72	23.93	25.95	25.95	25.55	24.28	23.47
Groundwater Elevation	12.51	10.77	NA	NA	NA	14.63	14.74	15.58	13.48	14.58	15.37	12.89	12.89	13.29	14.56	15.37
Total Well Depth	86.75	86.75	81.20	54.20	50.30	31.23	31.23	31.23	74.44	74.44	74.44	123.36	123.36	123.36	123.36	123.36
Perfluoroheptanoic acid (PFHpA)	0.015 J	0.0085	0.011	0.0055	0.0036	0.0071	0.0074 U	0.0039	0.0029	0.0074 U	0.0074	0.0071	0.0063	0.015J	0.014 J	0.012
Perfluorohexanesulfonic acid (PFHxS)	0.042	0.019	0.03	0.04	0.018	0.0068	0.0056 U	0.0085	0.016	0.073	0.07	0.01	0.011	0.13	0.13	0.03
Perfluorononanoic acid (PFNA)	0.038	0.018	0.017	0.003	0.004	<0.002	0.0087 U	0.0032	0.0076	0.0087 U	0.0027	0.0065	0.0058	0.0046 U	0.0087 U	0.0028
Perfluorooctanoic acid (PFOA)	0.020 J	0.01	0.016	0.0077	0.012	0.018	0.012 J	0.01	0.0058	0.0060 J	0.0096	0.0059	0.0059	0.025	0.019 J	0.0095
Perfluorooctane sulfonate (PFOS)	0.14	0.049	0.11	0.095	0.072	0.0083	0.028	0.016	0.044	0.24	0.18	0.018	0.019	0.22	0.32	0.041
Perfluorodecanoic Acid (PFDA)	0.0061 U	0.00062 U	0.00062 U	0.00062 U	0.00062 U	NA	0.0061 U	0.00062 U	NA	0.0061 U	0.00062 U	NA	NA	0.0040 U	0.0061 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.062	0.02	0.034	0.00039 U	0.0071	NA	0.0066 U	0.00039 U	NA	0.0066 U	0.00039 U	NA	NA	0.0032 U	0.0066 U	0.00039 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six																
Total PFAS	0.39	0.169	0.2873	0.2009	0.14005	0.0402	0.0573	0.05953	0.0763	0.3891	0.4357	0.0475	NA	0.506	0.5504	0.1832
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.255**	**0.1045**	**0.184**	**0.1512**	**0.1096**	**0.0402**	**0.04**	**0.0416**	**0.0763**	**0.319**	**0.2697**	**0.0475**	**0.048**	**0.39**	**0.483**	**0.0953**

Sample Location	Maher Wells															
Sample ID	OW-19(S)	OW-19(S)	OW-19(S)	OW-19(M)	OW-19(M)	OW-19(M)	OW-19D	OW-19D	OW-19D	OW-19D	HW-W(m)	HW-W(m)	HW-W(d)	HW-W(d)	HW-W(dd)	HW-W(dd)
Sample Date	11/6/2020	3/18/2021	9/2/2021	11/6/2020	3/19/2021	9/3/2021	4/11/2017	5/13/2020	3/19/2021	9/11/2021	4/19/2021	9/5/2021	4/19/2021	9/5/2021	4/19/2021	9/5/2021
TOC Elevation	NA	NA	NA	NA	NA	NA	39.06	39.06	39.06	39.06	NA	NA	NA	NA	NA	NA
Depth to Groundwater	27.38	26.27	28.47	27.57	27.15	28.65	26.73	25.64	27.52	28.90	28.96	30.17	28.73	21.93	28.67	29.89
Groundwater Elevation	NA	NA	NA	NA	NA	NA	12.33	13.42	11.54	10.16	NA	NA	NA	NA	NA	NA
Total Well Depth	34.56	34.56	34.56	76.28	76.28	76.28	110.42	110.33	110.33	110.33	52.04	52.04	61.78	61.78	72.10	72.10
Perfluoroheptanoic acid (PFHpA)	0.0042	0.0044	0.0056	0.03	0.044	0.014	0.0051 J	0.011	0.018	0.022	0.01	0.0034	0.0021	0.01	0.0091	0.0073
Perfluorohexanesulfonic acid (PFHxS)	0.0031	0.0064	0.0027	0.027	0.014 J	0.015	0.029	0.12	0.026	0.028	0.012	0.015	0.0088	0.0064	0.0086	0.0048
Perfluorononanoic acid (PFNA)	0.0024	0.0012 J	0.0025	0.002	0.0048 U	0.0021	0.006 J	0.0017	0.0029	0.00088 J	0.00077 J	0.001 J	0.0013 J	0.0025	0.0014 J	0.002
Perfluorooctanoic acid (PFOA)	0.011	0.007	0.0066	0.011	0.0094 J	0.0037	0.0046 U	0.023	0.0097	0.007	0.0041	0.0024	0.0029	0.0094	0.0046	0.0069
Perfluorooctane sulfonate (PFOS)	0.025	0.015	0.031	0.047	0.027	0.029	0.029	0.31	0.047	0.053	0.075	0.042	0.012	0.017	0.015	0.0081
Perfluorodecanoic Acid (PFDA)	0.0027	0.001 J	0.00048 U	0.00062 U	0.0038 U	0.00046 U	0.0040 U	0.00062 U	0.00038 U	0.00048 U	0.00038 U	0.00046 U	0.00038 U	0.00046 U	0.00038 U	0.00049 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.0011 U	0.0011 U	0.00036 U	0.00095	0.011 U	0.00035 U	0.0032 U	0.00039 U	0.0011 U	0.00036 U	0.0011 U	0.0029	0.0011 U	0.00042 J	0.0011 U	0.00036 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six																
Total PFAS	0.0707	0.0634	0.07307	0.37335	0.3974	0.16133	0.0936	0.5463	0.3127	0.31489	0.17849	0.17264	0.04339	0.08666	0.10469	0.0563
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0484**	**0.035**	**0.0484**	**0.117**	**0.0944**	**0.0638**	**0.0691**	**0.4657**	**0.1036**	**0.11088**	**0.09707**	**0.06380**	**0.0271**	**0.0453**	**0.0387**	**0.0291**

Notes:
< = Not detected by the laboratory above the reporting limit. Reporting limit shown.
J = Estimated concentration between the method detection limit and reporting limit.
Results in ug/L, micrograms per liter.
U= Not detected by the Laboratory above the method detection limit. Method detection limit shown.
Bold results above Method 1 GW-1 standard (0.02 ug/L).
Sum of six includes estimated values and does not include non-detects (U or <).
Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U or <)
NA = Not Applicable.
* = ME-1 is screened from 37 to 47 and 70 to 80 feet below grade.
** = ME-2 is screened from 44 to 54 feet below grade.
*** = ME-3 is screened from 40 to 50 feet below grade.
The Method 1 GW-3 Standard for the individual analytes in the Sum of Six ranges from 500 to 40,000 ug/L.

Table 5. Surface Water Results for PFAS ug/L

	Surface Water		
Sample ID	Kmart	LP-1	UGP-1
Sample Date	6/20/2017	7/11/19	7/11/19
Perfluoroheptanoic acid (PFHpA)	0.0033 U	<0.01	<0.02
Perfluorohexanesulfonic acid (PFHxS)	0.0034 U	<0.01	<0.02
Perfluorononanoic acid (PFNA)	0.0043 J	<0.01	<0.02
Perfluorooctanoic acid (PFOA)	0.0026 U	<0.01	<0.02
Perfluorooctane sulfonate (PFOS)	0.0046 U	<0.01	<0.02
Perfluorodecanoic Acid (PFDA)	0.0040 U	<0.01	<0.02
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six			
Total PFAS	0.0174	0.018	0.047
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.0043	<0.01	<0.02

Notes:

< = Not detected by the laboratory above the reporting limit. Reporting limit shown.

J = Estimated concentration between the method detection limit and reporting limit.

Results in ug/L, micrograms per liter.

U= Not detected by the laboratory above the method detection limit. Method detection limit shown.

Sum of six includes estimated values and does not include non-detects (U or <).

Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U or <).

Currently MassDEP has not issued a surface water standard for PFAS.

The Method 1 GW-1 Standard for the Sum of Six is 0.02 ug/l.

The Method 1 GW-3 Standard for the individual analytes in the Sum of Six range from 500 to 40,000 ug/l.

Table 6: Background PFAS Levels in Soil and Soil Stock Pile Samples

Background Sample Locations																									
Sample ID	Method 1 Standard		Stockpile West	Stockpile East	Loam Pile	BG-1 0-1'	BG-2 0-1'	BG-3 0-1'	BG-4 0-1'	BG-5 0-1'	BG-6 0-1'	BG-7 0-1'	BG-8 0-1'	BG-9 0-1'	BG-10 0-1'	BG-11 0-1'	BG-12 0-1'	BG-13 0-1'	BG-14 0-1'	BG-15 0-1'	BG-16 0-1'	BG-17 0-1'	BG-18 0-1'	BG-19 0-1'	BG-20 0-1'
Sample Date	S-1/GW-1	S-1/GW-3	10/10/2017	10/10/2017	10/10/2017	10/26/2017	10/26/2017	10/26/2017	10/26/2017	10/26/2017	10/26/2017	10/26/2017	10/26/2017	10/26/2017	10/26/2017	12/14/2017	12/14/2017	12/14/2017	12/14/2017	12/14/2017	12/14/2017	12/14/2017	12/14/2017	12/14/2017	12/14/2017
Sample Location			On-Airport	On-Airport	On-Airport	Off-Airport	On-Airport	On-Airport	On-Airport	On-Airport	On-Airport	On-Airport	On-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport	Off-Airport
Perfluoroheptanoic acid (PFHpA)	0.5	300	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.18 J	0.17 U	0.18 J	0.17 U	0.17 U	0.23 J	0.17 U	0.17 U	0.19 U	0.19 U	0.19 U	0.19 U	0.44 J	0.19 U	0.19 U	0.35 J	0.19 U	0.46 J
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.24 U	**0.39 J**	0.24 U	0.24 U	**0.57 J**	**0.47 J**	0.24 U	**0.49 J**	0.24 U	0.24 U
Perfluorooctanoic acid (PFOA)	0.72	300	0.26 U	0.26 U	0.26 U	0.58 J	0.26 U	0.26 U	0.16 U	0.47 J	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	**0.75 J**	0.67 J	0.33 J	0.25 U	0.46 J	0.37 J	0.36 J	0.5 J	0.25 U	**0.86 J**
Perfluorononanoic acid (PFNA)	0.32	300	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.22 U	0.29 J	0.22 U	0.22 U	**0.53 J**	0.22	**0.67 J**	**0.41 J**	0.22 U	0.22 U
Perfluorooctane sulfonate (PFOS)	2	300	0.38 J	0.39 J	0.81 J	0.21 U	0.7 J	0.38 J	**2.3**	0.41 J	0.32 J	0.33 J	0.31 J	1.3	0.62 J	0.41 J	0.76 J	0.99	0.26 U	**3.1**	2	0.36 J	**2.3**	0.41 J	0.44 J
Perfluorodecanoic Acid (PFDA)	0.3	300	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.28 U	0.28 U	**0.36 J**	0.28 U	**0.31 J**	**0.41 J**	0.28 U	**0.41 J**	0.28 U	0.28 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six																									
Total PFAS	NA	NA	1.78	0.91	0.81	1.47	0.7	0.56	3.21	1.31	0.32	0.3	0.84	1.3	0.62	1.16	2.73	1.68	0	6.79	3.77	5.09	5.45	0.41	2.43
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	0.38	0.39	0.81	0.58	0.7	0.56	2.3	1.06	0.32	0.33	0.54	1.3	0.62	1.16	2.11	1.68	0	5.41	3.47	1.39	4.46	0.41	1.76

Notes:
J = Estimated concentration between the method detection limit and reporting limit.
Results in ug/kg, micrograms per kilogram.
U= Not detected by the Laboratory above the method detection limit. Method detection limit shown.
Bold results above the proposed Method 1 S-1/GW-1 standard.
Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U or <).
Sum of six includes estimated values and does not include non-detects (U or <).

Table 7 - 1,4 Dioxane Groundwater Results ug/L

Sample Location	North Ramp																	Airport Road/Iyannough Road Area							ARFF Building			
Sample ID	HW-1	HW-1	HW-5	HW-12	OW-6	OW-6	HW-4M	HW-4D	HW-204	HW-29	HW-207S	HW-207D	HW-207D	HW-19D	HW-19D	HW-X(s)	HW-X(m)	HW-A(D)	HW-A(D)	HW-B(D)	HW-N	HW-O	HW-U(d)	HW-V(m)	HW-L(s)	HW-L(m)	HW-L(d)	HW-L(d)
Sample Date	5/7/2015	8/5/2019	5/7/2015	5/7/2015	5/7/2015	9/27/2019	4/5/2017	4/5/2017	9/27/2019	9/27/2019	9/27/2019	4/5/2017	9/27/2019	4/5/2017	9/27/2019	9/10/2021	9/10/2021	4/5/2017	8/5/2019	4/5/2017	8/5/2019	8/5/2019	10/2/2020	10/2/2020	10/7/2020	10/7/2020	7/2/2019	5/13/2020
1,4-Dioxane	<0.152	<0.25	<0.150	<0.150	<0.150	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.19	<0.22	<0.25	<0.25	<0.25	<0.25	<0.25	**0.73**	**0.8**	<0.2	<0.2	**0.727**	**0.75**

Sample Location	Maher Well Field															Deployment Area	
Sample ID	OW-9M	OW-9D	OW-9D	OW-9D	OW-9DD	OW-9DD	OW-9DD	OW-18M	OW-18D	OW-18D	OW-18D	OW-19M	OW-19D	OW-19D	OW-19D	HW-E	HW-J
Sample Date	5/28/2015	5/28/2015	12/3/2018	5/5/2020	5/28/2015	4/11/2017	12/3/2018	4/11/2017	4/11/2017	12/7/2018	5/13/2020	4/11/2017	4/11/2017	12/7/2018	5/13/2020	9/10/2021	9/10/2021
1,4-Dioxane	<0.141	<0.141	<0.25	<0.19	**0.926**	**0.838**	**0.732**	<0.25	**0.552**	<0.25	**0.35**	<0.25	**0.800**	<0.25	**0.3**	<0.20	<0.20

Notes:
Results in ug/L, micrograms per liter.
< = Not detected by the laboratory above the reporting limit. Reporting limit shown.
Bold results above Method 1 GW-1 standard (0.3 ug/L).
The Method 1 GW-2 standard for 1,4-dioxane is 6,000 ug/l.
The Method 1 GW-3 standard for 1,4-dioxane is 50,000 ug/l.

Table 8. ARFF Concentrate Analytical Results ug/L

Sample ID	Foam Mix
Sample Date	12/9/2016
Perfluoroheptanoic acid (PFHpA)	3.4 J
Perfluorohexanesulfonic acid (PFHxS)	2.1 J
Perfluorononanoic acid (PFNA)	93
Perfluorooctanoic acid (PFOA)	19
Perfluorooctane sulfonate (PFOS)	5 U
Perfluorodecanoic Acid (PFDA)	2.8 J
6:2 FTS	33
Total PFAS	222.5
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	120.3

Notes:

1. U = Not detected by the laboratory above the Method Detection Limit. Method Detection Limit shown.
2. Results in ug/L, micrograms per liter.
3. Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U).
4. Sample is AFFF concentrate.
5. J = Estimated concentration between the Method Detection Limit and the Laboratory Reporting Limit.

Table 9. SPLP Results ug/L

Sample ID	DL4 4'	DL5 2'	DL8 (4')	DL14(0-1')	Stockpile West	Stockpile East	ARFF Rubber Roof	ARFF Asphalt Roof
Sample Date	9/26/2017	9/26/2017	9/26/2017	9/26/2017	10/10/2017	10/10/2017	11/17/2020	11/17/2020
Perfluoroheptanoic acid (PFHpA)	0.011 U	0.011 U	0.065 J	0.17	0.011 U	0.011 U	0.00279	0.0002 U
Perfluorohexanesulfonic acid (PFHxS)	0.0072 U	0.0072 U	0.036 U	0.01 J	0.0072 U	0.0072 U	0.00034 U	0.00036 U
Perfluorononanoic acid (PFNA)	0.16	0.0032 U	0.052 J	0.37	0.0032 U	0.0032 U	0.00068 J	0.00028 U
Perfluorooctanoic acid (PFOA)	0.012 J	0.042	0.6	0.87	0.0037 U	0.0037 U	0.0073	0.00021 U
Perfluorooctane sulfonate (PFOS)	0.013 J	0.0072 U	0.036 U	0.19	0.0072 U	0.0072 U	0.00045 U	0.00202
Perfluorodecanoic Acid (PFDA)	0.0052 U	0.0052 U	0.026 U	0.34	0.0052 U	0.0052 U	0.000364 J	0.000271 U
6:2 FTS	0.067	0.0072 U	25	7.13	0.034 J	0.024 J	0.0154 J	0.0017 J
Total PFAS	0.195	0.042	26.25	20.195	0.034	0.024	0.072723	0.07957
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.185	0.042	0.717	1.95	0.011 U	0.011 U	0.011133	0.00202

Notes:

1. U = Not detected by the laboratory above the Method Detection Limit. Method Detection Limit shown.
2. Results in ug/L, micrograms per liter.
3. Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U).

Table 10: Ratio of Stable Isotopes Oxygen-18 and Hydrogen-2 Laboratory Results

Sample Date	Lab Sample ID	HW Sample ID	Stable Isotope Oxygen-18			Stable Isotope Hydrogen-2		
			δ18O (V-SMOW)	Atm %	Expected Values	δ18O (V-SMOW)	Atm %	Expected Values
11/7/2018	1811299-2	HW-I	-6.92	0.20	-	-40.41	0.01494	-
			-6.77	0.20	-	-40.17	0.01495	-
	1811299-4	HW-E	-6.79	0.20	-	-38.56	0.01497	-
			-6.85	0.20	-	-38.87	0.01497	-
	1811299-5	HW-F	-6.9	0.20	-	-38.28	0.01498	-
			-6.88	0.20	-	-38.15	0.01498	-
	1811299-7	SW-2	-2.67	0.20	-	-18.65	0.01528	-
			-2.61	0.20	-	-20.42	0.01526	-
						-23.04	0.01521	-
12/3/2018	1812198-1	HW-G(S)	-6.74	0.20	-	-38.19	0.01498	-
			-6.93	0.20	-	-37.87	0.01498	-
	1812198-2	HW-G(M)	-7.53	0.20	-	-44.34	0.01498	-
			-7.57	0.20	-	-44.39	0.01498	-
	1812198-3	HW-G(D)	-7.18	0.20	-	-44.15	0.01489	-
			-7.45	0.20	-	-44.56	0.01488	-
	1812198-4	OW-9S	-7.29	0.20	-	-41.86	0.01492	-
			-7.41	0.20	-	-42.94	0.0149	-
	1812198-5	OW-9D	-7.76	0.20	-	-47.91	0.01483	-
			-7.71	0.20	-	-46.82	0.01484	-
					-	-47.20	0.01484	-
	1812198-6	OW-9DD	-7.52	0.20	-	-45.58	0.01486	-
			-7.57	0.20	-	-45.48	0.01487	-
	1812198-7	OW-9M	-7.13	0.20	-	-41.44	0.01493	-
			-7.24	0.20	-	-43.40	0.0149	-
12/7/2018	1812232-1	OW-18S	-7.58	0.20	-	-49.29	0.01481	-
			-7.54	0.20	-	-49.66	0.0148	-
	1812232-2	OW-18M	-6.95	0.20	-	-42.64	0.01491	-
			-6.89	0.20	-	-42.57	0.01491	-
	1812232-3	OW-18D	-7.28	0.20	-	-44.76	0.01488	*
			-7.36	0.20	-	-41.61	0.01493	*
QA/QC	IAEA OH-14	-	-5.64	0.20	-5.6	-37.45	0.01499	-37.70
	IAEA OH-15	-	-9.59	0.20	-9.41	-77.89	0.01436	-78
	IAEA OH-16	-	-15.72	0.20	-15.41	-	-	-113.8
	Antarc IC	-	-29.83	0.19	-30	-	-	-239.69

Table 11: Total Organic Carbon Levels (mg/kg)

Total Organic Carbon Concentration																	
Sample ID	HW-W dd 3-5 ft	HW-W dd 8-10 ft	HW-W dd 18-20 ft	HW-W dd 23-25 ft	HW-W dd 28-30 ft	HW-W dd 33-35 ft	HW-W dd 38-40 ft	HW-W dd 43-45 ft	HW-W dd 48-50 ft	HW-W dd 58-60 ft	HW-W dd 63-65 ft	S1 0-2ft	S1 2-4ft	S1 4-6ft	S2 0-2ft	S2 2-4ft	S2 4-6ft
Sample Date	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	4/19/2021	4/19/2021	4/19/2021	4/19/2021	4/19/2021	4/19/2021
Sample Depth (ft below grade)	3-5	8-10	18-20	23-25	28-30	33-35	38-40	43-45	48-50	58-60	63-65	0-2	2-4	4-6	0-2	2-4	4-6
Sample Location	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Deployment Area	Deployment Area	Deployment Area	Deployment Area	Deployment Area	Deployment Area
Total Organic Carbon	94.8 U	94.3 U	96.5 U	93.9 U	95.7 U	93.5 U	96.9 U	95.7 U	95.7 U	95.7 U	95.7 U	28,900	1,150	180	1,550	95.1 U	3,500

Notes:
Results in mg/kg, milligrams per kilogram.
U= Not detected by the Laboratory above the method detection limit. Method detection limit shown.

Table 12: Retardation Factor Calculations for MassDEP Six PFAS Analytes and 6:2 FTS

Retardation Factor Calculation

Rf = 1 + d*Kd/n

Rf = retardation factor
d = aquifer bulk density = 1.5
n = porosity = 33 percent = 0.33
kd = (soil) distribution coefficient = foc Koc
foc = fraction organic carbon
Koc = organic carbon/water partition coefficient

EPA Physical Properties for PFAS

Values from EPA Comp Tool Box

PFAS	Koc (L/kg)	PFAS	PFAS Density (g/cm3)
PFHpA	2,110	PFHpA	1.71
PFHxS	2,300	PFHxS	1.84
PFOA	1,160	PFOA	1.72
PFNA	2,830	PFNA	1.78
PFOS	1,460	PFOS	1.84
PFDA	397	PFDA	1.79
6:2FTS	947	6:2FTS	1.68

TOC Data Barnstable County Fire Training and EPA Default

Location	TOC Decimal Value (excel)	Percent	Concentration
BFTA	0.0002	0.02	200 ppm
EPA Default	0.002	0.2	2000 ppm

Cape Cod Gateway Airport and Water Department Property TOC Data

TOC Decimal Value	TOC Percent	TOC Concentration (ppm)	Notes
0.002109	0.2109	2,109	Average TOC (all data)
0.00858	0.858	8,580	95th Percentile (all data)
0.00036	0.036	360	Average TOC (surface samples excluded)
0.001855	0.1855	1,855	95th percentile (surface samples excluded)
0.000048	0.0048	48	Half the laboratory reporting limit

Retardation Factors From 2020 Phase II Report (Using EPA and Fire Training TOC Values)

Retardation Factor Calculation TOC = 200 ppm

(Barnstable County Fire Training TOC Data)

PFAS	d	kd	n	Rf=
PFHpA	1.5	0.4	0.3	2.92
PFHxS	1.5	0.5	0.3	3.09
PFOA	1.5	0.2	0.3	2.05
PFNA	1.5	0.6	0.3	3.57
PFOS	1.5	0.3	0.3	2.33
PFDA	1.5	0.1	0.3	1.36
6:2FTS	1.5	0.2	0.3	1.86

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **185 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 11.35 years

Retardation Factor Calculation TOC = 2,000

(EPA Default TOC Value)

PFAS	d	kd	n	Rf=
PFHpA	1.5	4.22	0.3	20.18
PFHxS	1.5	4.6	0.3	21.91
PFOA	1.5	2.32	0.3	11.55
PFNA	1.5	5.66	0.3	26.73
PFOS	1.5	2.92	0.3	14.27
PFDA	1.5	0.794	0.3	4.61
6:2FTS	1.5	1.894	0.3	9.61

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **35.8 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 58.66 years

Retardation Factors With Site Specific TOC Data

Retardation Factor Calculation TOC = 2,109 ppm

(Average TOC Data from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	4.4	0.3	21.23
PFHxS	1.5	4.9	0.3	23.05
PFOA	1.5	2.4	0.3	12.12
PFNA	1.5	5.2	0.3	24.86
PFOS	1.5	3.1	0.3	15.00
PFDA	1.5	0.8	0.3	4.81
6:2FTS	1.5	2	0.3	10.08

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **34 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 61.8 years

Retardation Factor Calculation TOC = 8,580

(95th Percentile TOC Data from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	18.1	0.3	83.29
PFHxS	1.5	19.73	0.3	90.70
PFOA	1.5	9.953	0.3	46.24
PFNA	1.5	24.28	0.3	111.37
PFOS	1.5	12.53	0.3	57.94
PFDA	1.5	3.406	0.3	16.48
6:2FTS	1.5	8.125	0.3	37.93

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **9.069 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 231.56 years

Table 12: Retardation Factor Calculations for MassDEP Six PFAS Analytes and 6:2 FTS

Retardation Factor Calculation

Rf = 1 + d*Kd/n

Rf = retardation factor
d = aquifer bulk density = 1.5
n = porosity = 33 percent = 0.33
kd = (soil) distribution coefficient = foc Koc
foc = fraction organic carbon
Koc = organic carbon/water partition coefficient

EPA Physical Properties for PFAS

Values from EPA Comp Tool Box

PFAS	Koc (L/kg)		PFAS Density (g/cm3)
PFHpA	2,110	PFHpA	1.71
PFHxS	2,300	PFHxS	1.84
PFOA	1,160	PFOA	1.72
PFNA	2,830	PFNA	1.78
PFOS	1,460	PFOS	1.84
PFDA	397	PFDA	1.79
6:2FTS	947	6:2FTS	1.68

TOC Data Barnstable County Fire Training and EPA Default

Location	TOC Decimal Value (excel)	Percent	Concentration
BFTA	0.0002	0.02	200 ppm
EPA Default	0.002	0.2	2000 ppm

Cape Cod Gateway Airport and Water Department Property TOC Data

TOC Decimal Value	TOC Percent	TOC Concentration (ppm)	Notes
0.002109	0.2109	2,109	Average TOC (all data)
0.00858	0.858	8,580	95th Percentile (all data)
0.00036	0.036	360	Average TOC (surface samples excluded)
0.001855	0.1855	1,855	95th percentile (surface samples excluded)
0.000048	0.0048	48	Half the laboratory reporting limit

Retardation Factors With Site Specific TOC Data (Continued)

Retardation Factor Calculation TOC = 360 ppm

(Average TOC Value with Surface Samples Excluded from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	0.8	0.3	4.45
PFHxS	1.5	0.8	0.3	4.76
PFOA	1.5	0.4	0.3	2.90
PFNA	1.5	1	0.3	5.63
PFOS	1.5	0.5	0.3	3.39
PFDA	1.5	0.1	0.3	1.65
6:2FTS	1.5	0.3	0.3	2.55

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **135 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 15.56 years

Retardation Factor Calculation TOC = 1,855

(95th percentile TOC Value with Surface Samples Excluded from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	3.914	0.3	18.79
PFHxS	1.5	4.267	0.3	20.39
PFOA	1.5	2.152	0.3	10.78
PFNA	1.5	5.25	0.3	24.86
PFOS	1.5	2.708	0.3	13.31
PFDA	1.5	0.736	0.3	4.35
6:2FTS	1.5	1.757	0.3	8.98

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **38.29 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 54.85 years

Retardation Factor Calculation TOC = 50 ppm

(Half of the laboratory reporting limit for samples in saturated soils)

PFAS	d	kd	n	Rf=
PFHpA	1.5	0.1	0.3	1.46
PFHxS	1.5	0.1	0.3	1.50
PFOA	1.5	0.1	0.3	1.25
PFNA	1.5	0.1	0.3	1.62
PFOS	1.5	0.1	0.3	1.32
PFDA	1.5	0	0.3	1.09
6:2FTS	1.5	0	0.3	1.21

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **285 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 7.37 years

Table 13: September 2021 Groundwater Quality Data

9/1/2021	HW-302	*DTW*	*26.15*		*TWD*	*30.4*	Each Well Volume	0.68	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-302	5	3.4	13	89.5	9.43	44.6	5.18	221.6	3.6
9/1/2021	HW-2	*DTW*	*30.2*		*TWD*	*32.8*	Each Well Volume	0.42	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-2	5	2.08	12.3	38.3	4.1	207.6	6.21	26.2	9.1
9/1/2021	HW-3	*DTW*	*28.35*		*TWD*	*33.13*	Each Well Volume	0.76	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-3	5	3.82	13.2	92.4	9.68	262.9	5.68	215.8	13.1
9/2/2021	HW-K	*DTW*	*24.24*		*TWD*	*44.18*	Each Well Volume	3.19	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-K	5	15.95	12.6	94.1	10.01	47.5	5.23	226.6	2.1
9/2/2021	HW-300	*DTW*	*23.02*		*TWD*	*30.34*	Each Well Volume	1.17	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-300	5	5.86	19.4	50.2	4.62	38.3	5.27	241.6	1.9
9/2/2021	OW-19(s)	*DTW*	*28.47*		*TWD*	*34.67*	Each Well Volume	0.99	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
OW-19(s)	5	4.96	11.3	56.3	6.16	195.2	5.85	223	2.1
9/3/2021	OW-19(m)	*DTW*	*28.65*		*TWD*	*76.25*	Each Well Volume	7.62	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
OW-19(m)	5	38.08	12.3	22.9	2.45	82.2	5.57	150.8	2
9/3/2021	HW-S(m)	*DTW*	*17.37*		*TWD*	*32.12*	Each Well Volume	2.36	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-S(m)	5	11.80	12.7	70.7	7.51	62.7	5.26	239.2	1.5
9/3/2021	HW-S(s)	*DTW*	*17.3*		*TWD*	*22.17*	Each Well Volume	0.78	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-S(s)	5	3.90	13.4	57.1	5.96	142	5.17	254.1	5.7
9/5/2021	HW-W(dd)	*DTW*	*29.89*		*TWD*	*72.09*	Each Well Volume	6.75	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-W(dd)	5	33.76	12.7	78.7	8.35	48.5	5.2	240.2	2.1
9/5/2021	HW-W(d)	*DTW*	*21.93*		*TWD*	*61.78*	Each Well Volume	6.38	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-W(d)	5	31.88	12.8	72.9	7.71	49.8	5.08	275.6	2.1
9/5/2021	HW-W(m)	*DTW*	*30.17*		*TWD*	*52.08*	Each Well Volume	3.51	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-W(m)	5	17.53	13.3	25.2	2.64	79	5.76	247.6	1.5
9/5/2021	RB-1(m)	*DTW*	*18.57*		*TWD*	*48.85*	Each Well Volume	4.84	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
RB-1(m)	5	24.22	13	26.4	2.79	268.7	5.01	279	1.7
9/5/2021	RB-1(s)	*DTW*	*18.64*		*TWD*	*27.8*	Each Well Volume	1.47	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
RB-1(s)	5	7.33	13.9	74.7	7.72	133.8	5.21	277.3	53.7
9/5/2021	HW-U(d)	*DTW*	*25.24*		*TWD*	*62.38*	Each Well Volume	5.94	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-U(d)	5	29.71	14.5	2.8	0.28	1760	6.09	16.2	2.7

Table 13: September 2021 Groundwater Quality Data

9/5/2021	HW-U(m)	*DTW*	*24.49*		*TWD*	*38.94*	Each Well Volume	2.31	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-U(m)	5	11.56	14.3	11.1	1.13	702	4.89	249	2.1
9/5/2021	HW-U(s)	*DTW*	*24.53*		*TWD*	*28.82*	Each Well Volume	0.69	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-U(s)	5	3.43	14.6	83.8	8.52	328.6	5.88	234.8	10.4
9/8/2021	HW-I(s)	*DTW*	*19.94*		*TWD*	*25.17*	Each Well Volume	0.84	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-I(s)	5	4.18	13.6	-	9.28	52.8	5.38	222.7	3.5
9/8/2021	HW-I(m)	*DTW*	*20.17*		*TWD*	*34.79*	Each Well Volume	2.34	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-I(m)	5	11.70	12.4	37.1	3.96	72	5.28	233.2	2.2
9/8/2021	HW-I(d)	*DTW*	*20.04*		*TWD*	*41.67*	Each Well Volume	3.46	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-I(d)	5	17.30	12.2	10.4	1.11	187.2	5.41	156	2
9/8/2021	HW-E	*DTW*	*25.02*		*TWD*	*30.26*	Each Well Volume	0.84	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-E	5	4.19	12.3	94	10.06	43.8	5.16	248.7	20.9
9/8/2021	HW-F	*DTW*	*21.72*		*TWD*	*26.9*	Each Well Volume	0.83	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-F	5	4.14	11.7	95.1	10.33	46.1	5.2	267.5	3.7
9/8/2021	HW-R(s)	*DTW*	*19*		*TWD*	*23.67*	Each Well Volume	0.75	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-R(s)	5	3.74	12.7	30.8	3.26	106.5	5.35	276.4	16.4
9/8/2021	HW-P(s)	*DTW*	*23.54*		*TWD*	*27.61*	Each Well Volume	0.65	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-P(s)	5	3.26	13.8	91.5	9.47	56.3	5.37	269.6	5.9
9/8/2021	HW-P(m)	*DTW*	*23.67*		*TWD*	*38.28*	Each Well Volume	2.34	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-P(d)	5	11.69	12.7	87.4	9.27	55.3	5.11	298.7	6
9/10/2021	HW-X(s)	*DTW*	*24.74*		*TWD*	*29.24*	Each Well Volume	0.72	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-X(s)	5	3.60	15.8	80	7.94	68.7	5.25	166.4	3.9
9/10/2021	HW-X(m)	*DTW*	*25.1*		*TWD*	*36.82*	Each Well Volume	1.88	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-X(m)	5	9.38	14.9	38.1	3.85	343.4	5.45	100.5	3.1
9/10/2021	HW-J	*DTW*	*20.6*		*TWD*	*24.28*	Each Well Volume	0.59	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-J	5	2.94	14.8	85.8	8.69	47.9	5.08	267.2	7
9/11/2021	OW-19(d)	*DTW*	*28.9*		*TWD*	*110.34*	Each Well Volume	13.03	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
OW-19(d)	5	65.15	12.3	13.3	1.42	113.6	5.82	167.9	2.1

Table 13: September 2021 Groundwater Quality Data

Notes:
DTW = Depth to water in feet below grade.
TWD = Total well depth in feet below grade.
Well Volume = Amount of groundwater in gallons to purge to meet five well volumes.
Each Well Volume = Amount of groundwater purged from each well volume in gallons.
Degree C = Groundwater temperature in Celsius.
DO = Dissolved oxygen.
mg/L = milligrams per liter.
SPC (us/cm) = specific conductance in microSiemens per centimeter.
ORP mV= Oxidation reduction potential in millivolts.
NTU = Nephelometric Turbidity Unit.

APPENDICIES

APPENDIX A

NOTICE OF AUDIT FINDINGS RESPONSE

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

November 10, 2021

Mr. John T. Handrahan
Acting Deputy Regional Director
Bureau of Waste Site Cleanup
Massachusetts Department of Environmental Protection
Southeast Regional Office
20 Riverside Drive
Lakeville, MA 02347

RE: Response to Notice of Audit Findings Cape Cod Gateway Airport
Enforcement #00011495 Release Tracking # 4-0026347

Dear Mr. Handrahan

On behalf of the Cape Cod Gateway Airport (the Airport), the Horsley Witten Group, Inc. (HW) has prepared this response to the issues and questions raised in the Massachusetts Department of Environmental Protection's (DEP) audit of the Phase II Comprehensive Site Assessment (Phase II Report) prepared by HW on behalf of the Airport (HW, March 2021).

The audit from DEP focuses on two primary issues. The first issue is whether or not all probable sources of 1,4-dioxane associated with the Airport were addressed in the Phase II Report. The second issue focused on whether or not per and polyfluoroalkyl substances (PFAS) currently detected in the drinking water wells at the Maher Wellfield originated from the use of aircraft fire fighting foam (AFFF) at the Airport or from other sources upgradient of the Airport. This second concern involved questions as to whether of not all sources of AFFF at the Airport had been identified.

HW believes the source of 1,4-dioxane is not located on Airport property and has provided additional information and explanations to document this claim. In addition, HW continues to believe that the PFAS plumes from the two locations where AFFF was used at the Airport have not yet reached the Maher Wellfield. The Phase II Report provided substantial information regarding the hydrogeologic setting at the Airport and surrounding areas. It also provided significant data regarding the locations and concentrations of 1,4-dioxane and PFAS compounds on Airport property and in upgradient and downgradient locations. In preparing this response, HW acknowledges we could have provided more clarity in the Phase II Report to support our conclusions and we have worked to more fully explain and document our conclusions in this response.

Our response to the issues raised in the Notice of Audit Findings are provided below. Upon receipt of any comments from DEP on this response, we will update the Phase II Report to incorporate this information. Our proposed schedule to complete the work to revise the Phase II Report and also submit the Phase III Report is outlined as follows:

Submission of the response to the Notice of Audit Findings	November 10, 2021
Receipt of comments/question from DEP regarding this response	December 10, 2021
Submission of a revised Phase II Report	January 28, 2022
Submission of the Phase III Report	April 1, 2022

We respectfully request your approval of this proposed schedule and if you have any questions about the information provided below, please let us know.

Sincerely,

HORSLEY WITTEN GROUP, INC.

Bryan Massa, LSP
Senior Scientist

Attachments:

Response to Notice of Audit Findings
Cape Cod Gateway Airport
Enforcement #00011495 Release Tracking # 4-0026347

Introduction

On behalf of the Cape Cod Gateway Airport (the Airport), HW has prepared this response to the issues and questions raised in the DEP audit review of the Phase II Report prepared by HW on behalf of the Airport (HW, March, 2021). The first section of this response provides answers to questions regarding the source of 1,4-dioxane impacting groundwater at the Airport. The second section provides answers to questions about the investigation of historical locations where AFFF containing PFAS were used at the Airport and also provides additional detail on the mapping of the known PFAS plumes associated with the Airport. Each comment or question raised by DEP in the Notice of Audit Finding is provided here in *italics*, followed by HW's response.

Sources of 1,4-dioxane Impacting Groundwater at the Airport

The Phase II concludes that the presence of 1,4-dioxane at and around the Site has been mainly attributed to off-site sources. That conclusion is made primarily from the depth of detection of 1,4-dioxane in the aquifer. Current on-site potential sources of 1,4-dioxane were evaluated in the Phase II; however, other potential on-site historical sources were not adequately addressed. Specifically, the following data gaps were noted:

- *Section 2.0 states that "the third deicing location was historically located approximately 1,500 feet cross-gradient to HW-L and does not have a hydraulic connection to this area". The Phase II did not demonstrate, based on localized groundwater flow patterns, that there is no hydraulic connection between the third deicing area and HW-L.*

  The only wells downgradient of the third deicing area that were sampled and analyzed for 1,4-dioxane were Maher sentry wells OW-18m and OW-18d. Groundwater from these sentry wells contained 1,4-dioxane at concentrations exceeding the GW-1 standard. No locations between the third de-icing area and the Maher sentry wells were analyzed for 1,4-dioxane nor was technical justification provided to forego sampling in this area.

The Phase II Report provides multiple lines of evidence that the detection of 1,4-dioxane at the Maher Wells and HW-L(d) are related to unknown off-site source(s) located northeast of the Airport, somewhere in the vicinity of well HW-V(m). Particle tracking, groundwater flow direction, deicing fluid management practices, analytical data, and cross-sections support this conclusion. At the request of DEP, HW is providing additional details that support the Phase II Report findings that the detection of 1,4-dioxane is not related to the Airport.

To more clearly explain our position that the third de-icing location does not have a hydraulic connection to HW-L, HW provides the following three-part clarification:

1. Verifying direction of groundwater flow
2. Verifying the location of the 1,4-dioxane plume
3. Providing additional groundwater sampling

Verifying the Direction of Groundwater Flow

Available groundwater flow data for the Airport and surrounding areas is one line of evidence that supports the 1,4-dioxane in groundwater did not originate at the Airport. HW developed numerous water table maps for past projects at the Airport and has a clear understanding of the groundwater flow directions across the site. Figures 2, 4, 11, 12 and 13 in the Phase II Report used groundwater contours developed by the U.S. Geological Survey as part of their regional groundwater model for the Sagamore lens aquifer that includes the area of Hyannis where the Airport is located. We used these contours as they provide broader information regarding the migration of groundwater at the Airport, and in upgradient and downgradient areas, allowing us to evaluate how groundwater flows across the Airport and downgradient towards the Maher wellfield. Groundwater elevations measured by HW throughout the project were also included on Table 3 in the Phase II Report.

In response to DEP's audit, HW created an updated water table map specific to the Airport property based on data taken on April 27, 2020 from monitoring wells used by HW during this investigation. It is attached here as Figure 1 and will be incorporated into the updated Phase II Report. The map shows groundwater flow conditions that match the regional water table contours provided in the Phase II Report. These water table maps clearly show that groundwater flows onto the Airport property from the west and northwest, migrates to the southeast and exits the property at the southeast corner of the Airport.

The water table maps also clearly show that HW-L(d) is hydraulically cross-gradient to the historic deicing pad located approximately 2,000 feet northeast of the well, near the Deployment Area. As such this deicing pad has no hydraulic connection to HW-L(d). Groundwater flow from this historic deicing area would flow to the east-southeast.

Verifying the Location and Flow of 1,4-dioxane

The 1,4-dioxane plume is shown to enter the Airport near well HW-V(m) and flows southeast until it leaves the Airport property and flows towards the Maher Wellfield. HW created an updated hydrogeologic cross section (attached as Figure 2) that shows how the plume moves down into the aquifer as it travels across the Airport. It moves downward at a consistent rate, based on the amount of recharge to the aquifer from rainfall that infiltrates into the ground. The cross-section documents wells screened in the aquifer above the mapped plume in which no 1,4-dioxane was detected. It also documents that the concentration of 1,4-dioxane in the plume is relatively stable as it moves across the Airport property, ranging from 0.8.ug/L upgradient of the Airport in well HW-V(m) to 0.732 ug/L downgradient of the Airport in Well OW-9(dd).

The direction of groundwater flow and relatively stable detection levels of 1,4-dioxane suggest that there is a long-term, consistent source of 1,4-dioxane upgradient of the Airport impacting groundwater quality.

1,4-dioxane was detected in well OW-18(d) at a depth of approximately 100 feet below the water table. Based on the hydrogeologic analysis provided in the Phase II Report, if a release occurred at this historic deicing area, it would move downward at a rate of approximately one feet of depth per 100 feet of horizontal transport. The well is located approximately 1,700 feet from the deicing area, so any 1,4-dioxane would be found at a depth 15-20 feet below the water table, not 100 feet below the water table. Additionally, sampling of HW-J which is downgradient of the former de-icing area and screened appropriately to detect a release in this area, did not contain 1,4-dioxane above the laboratory reporting limit.

The combination of these observations strongly support the conclusion that no deicing fluid impacted groundwater at this location.

Providing Additional Groundwater Sampling

In the Phase II Report audit, DEP asserts that 1,4-dioxane detected at OW-18(d) may be related to this historic deicing pad. While HW, believes the lack of hydraulic connection ultimately answer this concern, we continued to explore this issue. The Phase II Report documents that deicing fluid in this area was historically recovered with a vacuum unit. The Airport is required under FAA Advisory Circular 150/5380-6C to maintain asphalt areas for aircraft safety purposes and as such, asphalt in this deicing area is competent and free of significant cracks that would provide a pathway to the subsurface.

To further evaluate if this deicing pad impacted groundwater, HW sampled well HW-J, located approximately 350 feet downgradient of this location, and HW-E located approximately 150 feet east northeast (Figure 3). Both wells are screened at the water table. 1,4-dioxane was not detected above the laboratory method reporting limit in either well. Tabulated analytical data is included on Table 1 and laboratory reports are also attached.

To further document that the Airport is not contributing to the 1,4-dioxane plume, HW advanced a monitoring well pair HW-X (s,m) downgradient of the historic deicing pad located on the North Ramp of the Airport near the new terminal building (refer to the attached Figure 3). The two new wells did not have any detections of 1,4-dioxane above the laboratory reporting limit. These wells are included in the hydrogeologic cross section discussed above (Figure 2) which shows the 1,4-dioxane plume is well below the location of this deicing pad and is coming from an upgradient source. Please note that the current deicing pad is connected to a permitted discharge to the municipal sewer system, which is surrounded by competent asphalt, free of significant cracks to the subsurface as indicated in the picture below. The area is also sloped such that runoff is directed directly to the drain.

Current Deicing Pad Sloped Into Drains That Connects to Town Sewer

- *No soil analysis for 1,4-dioxane was completed and no technical justification was provided for the lack of soil sampling and analysis. The report states that deicing occurred prior to 2015 on paved areas. These areas are surrounded by unpaved areas, and it is possible that 1,4-dioxane migrated to the soil and leached to groundwater. The soil surrounding the pavement and under the pavement was not analyzed, and there is no description of the condition of the pavement, such as cracks or breaks.*

1,4-dioxane migrates quickly from soil to ground water, so testing of groundwater in the vicinity of a potential release site is appropriate to determine if a release occurred. As explained above, groundwater testing in the vicinity of the historic deicing pads confirms that they are not the source of the 1,4-dioxane plume. Groundwater data clearly indicates that the source of the 1,4-dioxane is from an off-site location located hydraulically upgradient of HW-V(m).

- *The Phase II states that all floor drains have been closed or connected to a tight tank and/or connected to the sanitary sewer. However, it is possible that discharges occurred prior to the closure of the drains and affected the groundwater. This was not discussed in the report.*

Significant groundwater monitoring has been conducted throughout the Airport in proximity to hanger buildings with historic floor drains. The groundwater data provided in the Phase II Report and in this document ruled out these historic deicing locations as sources of 1,4-dioxane and confirms the source is from an off-site location located hydraulically upgradient of HW-V(m).

- *The Phase II relies on a particle tracking model that did not account for the environmental fate and transport characteristics of 1,4-dioxane. The annualized average pumping rates of the Maher Wells used in the particle tracking model are not representative of the periods of the highest levels of withdrawal during the summers. The effects of the nearby ponds, the Airport Well, and the Mary Dunn wells were also not addressed in the model.*

The particle tracking information in the Phase II Report was provided to help document how the 1,4-dioxane plume migrates to the Maher Wellfield. The particle tracking figure in the report is a plan view version showing the contributing area to the Maher Wellfield. The variation in colors shown in the particle tracks documents how the water flows downward into the aquifer as it migrates from upgradient areas across the Airport. The pumping of the Maher wells will have little to no effect on the vertical plume migration as it travels from HW-V(m) to HW-U(d) to HW-L(d) as these areas are upgradient of, and outside the area where the pumping of the wells would adjust the rate of travel or the depth of the plume.

Additionally, the plume is located cross gradient of the two ponds on the Airport and would not interact with them. This is especially true as the plume is located 30-40 feet below the water table as it passes south of the ponds. The ponds themselves are quite shallow, and do not interact with deeper groundwater found that far below the water table. There are no surface water outflows from the ponds that would cause groundwater to migrate upward to discharge to the ponds or an outlet stream. The ponds will only interact with shallow groundwater.

Overall, the information provided in the Phase II Report, and supplemented here, documents that the 1,4-dioxane plume does not originate at the Airport but is from an upgradient source to the west-northwest of the Airport. This is based on the mapping of groundwater flow, water quality data from across the Airport that tracks the plume, new shallow groundwater data showing no 1,4-dioxane in the vicinity of the deicing area on the East Ramp and North Ramp, and particle tracking data from the U.S Geological Survey groundwater model for this area of Hyannis.

Finally, the Phase II Report stated that approximately 700 gallons of deicing fluid is used each year at the Airport. This is an error. Usage data below for 2015-2020, and representative of previous years, show much lower levels of use with almost all values well below 100 gallons. With such a limited use, the potential for the fluid to migrate off the paved areas where it was applied was limited and it was feasible for the Airport to vacuum it up after application.

- 2015 – 210 gallons
- 2016 – 63 gallons
- 2017 – 22 gallons
- 2018 – 42 gallons
- 2019 – 42 gallons
- 2020 – 64 gallons

Migration of PFAS in Groundwater from Airport Release Locations

The information provided below documents that these are the only two sites at the Airport where AFFF containing PFAS has been released to soil and groundwater. It also further explains the information used to document the downgradient extent of the groundwater plumes from these two areas.

- *The Phase II states that the PFAS contamination documented at the Airport has not impacted the Maher Wells. Evidence presented in the Phase II report to support that conclusion includes results of pump tests, radar plots, groundwater migration rates, and the current formulation of aqueous film forming foam (AFFF) used at the Airport. MassDEP's review of the Phase II identified the following:*
    - *Available records indicate that fire training exercises using foam occurred at the Airport in the past. These areas were not discussed in the Phase II.*

<u>History of Use and Relevant Activity</u>

The Phase II Report provided the results of HW's research into the locations of AFFF usage at the Airport and the volume of AFFF that was used at these locations. The volume of AFFF used is based on purchase records going back to 2000 and on interviews with Airport staff who participated in the drills, yearly foam testing, or emergency response actions when AFFF was used since the 1980s. (See Phase II Report Section 3.3.3 page 7 through 12). As indicated in Section 3.3.3, AFFF was used at the Deployment Area between 1994 and 2004 for triannual drills and between 2004 and 2015 for annual AFFF mixture testing. Two firefighting personnel who have worked at the Airport since the 1980's indicated that foam was not used prior to 1991 due to cost, limited availability, and lack of an FAA requirement mandating foam usage.

There was one triannual drill in 1991 that occurred in an area on the north ramp of the Airport where HW investigated and collected soil data from six sampling locations (See Phase II report, Figure 3, and Table 2). With the exception of a detection of PFHxS at location 1991B 0-1', none of the soil samples exceeded the applicable Method 1 Standard for any of the MassDEP regulated six PFAS compounds. The detection of PFHxS at this location is not consistent with the Airport's use of AFFF and is consistent with the 20 background samples collected (see Phase II Report, Section 6.3 Page 32, Figure 14, and Table 7). Furthermore, as indicated on Table 2, soil samples consistent with the Airports AFFF contain elevated levels of 6:2 FTS, PFNA, and PFHpA. None of these compounds were detected in sample 1991B 0-1'.

In 2016, there was an aircraft accident adjacent to the rental car parking lot where approximately 10 gallons of AFFF concentrate was sprayed. The AFFF was collected in a catch basin with a solid bottom and was pumped out with a vacuum truck for disposal, with no known release to groundwater. There are no other known locations where AFFF was used. As discussed further below, the extensive soil and groundwater sampling (See Phase II Report Tables 2 and 3 and Figures 3 and 13) conducted at the Airport did not identify other areas where an unknown event might have taken place.

HW understands that the available records mentioned in DEP's Notice of Audit Findings regarding other areas is a picture from a YouTube video provided in an email to MassDEP from an outside party during the audit process. HW viewed this video which documents a fire training exercise at the Airport in 1956. This took place before AFFF was manufactured with PFAS compounds, and therefore it does not constitute a release of PFAS at the Airport. According to the Interstate Technology Regulatory Counsel (ITRC) document titled Aqueous Film-Forming Foam (AFFF) dated August 2020 (see Attachment A), AFFF with PFAS was manufactured in the United States beginning in the late 1960s, about 10 years after the exercise shown in the video.

It is important to note that the Barnstable Fire Training Academy came into existence in 1956 (https://www.barnstablecounty.org/bcfta-history/). This facility was built to provide a location for local fire departments to conduct local and regional training exercises and, as such, the need to use the Airport as a training venue was reduced.

Summary of Findings for Potential Release outside the Two Areas Identified by HW

1991 Triannual Drill on North Ramp	Groundwater and soils samples show no evidence of a release consistent with AFFF
2016 Aircraft Accident	AFFF was contained and collected
1956 Fire Training Exercise	PFAS not a constituent of fire fighting materials at this time in history.

Sampling Data

HW reviewed the PFAS composition from more than 220 samples in soil and groundwater both on and off the Airport, in part to determine if there is evidence of other locations where AFFF may have been used. Samples taken from the Deployment Area show that the AFFF used by the Airport contains all six of the sum-of-six compounds regulated by DEP (except PFDA in groundwater) along with other PFAS compounds (Phase II report, Section 2, Page 2 and Tables 2 and 3). The data from areas outside the Deployment Area and the ARFF building locations do not indicate the same composition of PFAS compounds associated with the AFFF used by the Airport.

As discussed below, HW collected additional samples for PFAS analysis in September 2021 from the location of the former operations building on the North Ramp where fire-fighting equipment was stored prior to the building of the current ARFF building in 1996. None of the MassDEP six regulated PFAS compounds were detected above the laboratory method detection limit in soil and groundwater results were not consistent with the Airport's AFFF composition.

Based on this evidence, HW concludes the two release areas at the Airport are the Deployment Area and at the land area adjacent to current ARFF Building (Phase II report, Figure 2, 3, 5,6, 7, 8,9,10, 12 and 13). Caps were installed in both these areas in September 2020 to minimize the continued migration of PFAS compounds to groundwater.

- *The Phase II Report does not address where the AFFF was stored, and where the hoses and equipment were cleaned, prior to the 1996 construction of the Airport Rescue and Fire Fighting/Snow Removal Equipment (ARFF/SRE) building, a documented PFAS source area.*

Prior to 1996, the Airport fire truck was housed in the former Operations Building located adjacent to the former terminal along the North Ramp (see attached Figure 3). This building was demolished in 2011. Based on interviews with two firefighting staff who have worked at the Airport since the 1980s, AFFF containers were also stored in this building. The building did have two floor drains that were closed prior to 1997 (discharge location unknown) and a third floor drain that was traced to a catch basin that discharged to Upper Gate Pond.

The operations building was surrounded in its entirety by asphalt and, according to stormwater plans from 1999, storm drains in proximity to the building also discharge to Upper Gate Pond. Surface water testing of Upper Gate Pond did not identify any of the MassDEP sum-of-six compounds above the laboratory reporting limit (Phase II report, Table 8 and Figure 13). It should be noted that PFAS, including the MassDEP sum-of-six compounds, have been identified at levels above the Method 1 Standards entering the Airport in groundwater from the west from unknown upgradient source(s) as documented in the Phase II Report.

In September, 2021, HW installed two groundwater monitoring wells adjacent to, and downgradient of the former Operations Building. One well (HW-X[s]) was screened at the water table. Well HW-X(m) was screened at a depth of 11.61 feet below the water table. A soil sample collected from the unsaturated zone in the boring for well HW-X(s) did not contain any of the regulated MassDEP six PFAS compounds above the laboratory reporting limit. Groundwater results from both wells exceeded the DEP Sum-of-six standard. However, the 6:2 FTS concentration in well HW-x(s) was an estimated value of 0.002 ug/L, below the laboratory reporting limit. This is less than 1 % of the total PFAS concentration in the sample. The AFFF used at the Airport contains significant amounts of 6:2 FTS. If there was a release of Airport AFFF at this location, the 6:2 FTS concentration would be significantly higher than the other PFAS compounds detected in the sample. The location of the two new monitoring wells is indicated on the attached Figure 3 and tabulated analytical data is attached on Tables 2 and 3.

- *The Phase II Report contends that only fluorotelomer-based AFFF, specifically Chem-Guard 3% Mil-Spec, was used at the Site. This fluorotelomer-based AFFF is mostly comprised of 6:2 fluorotelomer sulfonate (6:2 FTS), a PFAS compound that is not included in the PFAS6 list (the PFAS compounds regulated by MassDEP, which include PFOA, PFOS, perfluoroheptanoic acid or PFHpA, perfluorohexane sulfonic acid or PFHxS, perfluorononanoic acid or PFNA, and perfluorodecanoic acid or PFDA). Anecdotal information provided by the Airport staff was used to support the statement that only fluorotelomer-based AFFF was used at the Airport since at least 1980. While anecdotal information is helpful, lines of evidence are necessary to verify this information, especially in the absence of analytical data for historical supplies of AFFF. Fluorotelomer-based AFFF is documented to degrade to perfluorocarboxylic acids (PFCAs) which do not include perfluorooctane sulfonic acid (PFOS). However, the following data as described in the Phase II either disputes the sole use of a fluorotelomer-based AFFF or supports a foam mixture containing other PFAS compounds:*

<u>Purchase Records</u>

HW's information on the fluorotelomer based AFFF used at the Airport is documented in purchase records provided by the Airport that date back to 2000 that show that one type of AFFF, the Chem Guard 3%, has been purchased during that time frame. Further information regarding foam use during and before this time was provided through interviews with Art Jenner and Bob Holzman who have worked at the Airport since the 1980's. Both are firefighters and first responders and stated that the 6.2 FTS based foam was purchased by the Airport since the 1980s. Additionally, according to the ITRC document titled AFFF dated August 2020 (refer to Attachment A), fluorotelomer-based AFFF has been available since the 1970s and other AFFF formulations have been available since the late 1960s.

Line of Evidence

As documented above, the AFFF used by the Airport in this timeframe is a fluorotelomer based foam, with 6.2 FTS comprising a significant percentage of the PFAS compounds (See Phase II Report, Section 5.1.1 Page 25). However, it is important to note that other PFAS compounds including PFOA and PFOS and the other sum-of-six compounds are also present in the soil and groundwater in the release areas at the Airport. Our documentation of PFAS concentrations in each soil and groundwater sample includes a total PFAS concentration, individual concentrations for each of the sum-of-six compounds, a total sum-of-six concentration and 6:2-FTS concentration data. These results are provided on multiple figures and data tables in the Phase II Report (Figure 12 and 13 and Tables 2 and 3). Data on the sum-of-six compounds were used to determine if groundwater concentrations exceeded the GW-1 standard as required under the MCP and Total PFAS and 6:2FTS concentration data was used to evaluate other unregulated PFAS analytes that are also part of the Airports AFFF Plume.

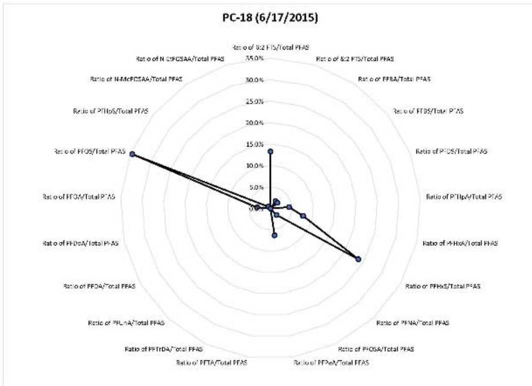
The Phase II Report provided information on 6.2-FTS for two primary reasons:

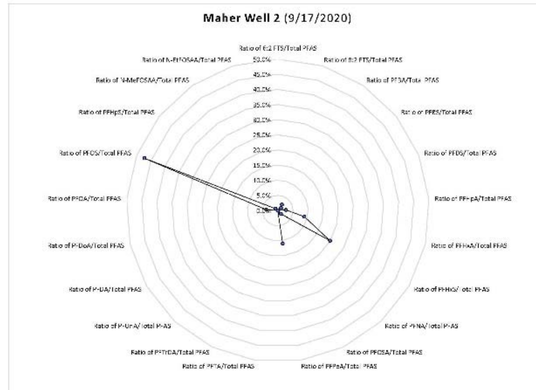
1. To distinguish the Airport releases from other non-airport related sources of PFAS impacting groundwater at the Airport.

2. To evaluate the downgradient migration of the plumes from the Deployment Area and ARFF building.

Distinguishing the Source of PFAS

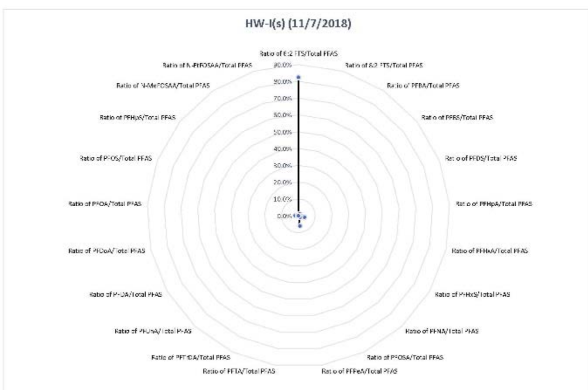
The forensic analysis described in the Phase II Report (Section 3.3.3 Page 12) details how radar plots showing the relative concentration of each PFAS compound were used to provide a graphic representation of the Airport source composition compared to other non-airport related sources. This was necessary as PFAS compounds were detected in every well sampled at the Airport and there is documented evidence from wells located upgradient and off-Airport property that indicate PFAS contamination from upgradient sources is flowing through groundwater across the Airport property. The radar plots clearly document the Airport AFFF releases. These releases have a unique chemical signature compared to that of the Fire Training Academy plume that migrates under the Airport and compared to other offsite sources impacting groundwater below the Airport from the west. The sample radar plots provided below compare the relative percent PFAS concentrations in groundwater samples from the Deployment Area source at the Airport and the Fire Training Academy source area. They show a distinct difference in the chemical composition of these two sources. The PFAS composition detected at the Maher wellfield closely resembles that from the Fire Training Academy. Radar Plots for all monitoring wells were included in the Phase II Report.





Fire Training Academy PFAS Plume Signature

MAHER Well 2 PFAS Signature



Airport PFAS Plume Signature

Maher Well 3 PFAS Signature

<u>Evaluating Downgradient Migration of Plumes</u>

The second use of the 6.2-fluorotelemer data was to evaluate the downgradient migration of the plumes from the Deployment Area and ARFF building. The purpose of this investigation was, in part, to determine a reasonable physical extent of the plumes from these areas. The octanol/water portioning coefficient (Koc) for 6.2-fluorotelemer is lower than the Koc for each of the sum-of-six compounds regulated by DEP. Therefore, it does not bind to the organic carbon present in the aquifer soils at the same rate as the other PFAS compounds. Its retardation rate is somewhat lower, and it travels faster in groundwater compared to the regulated compounds (See Phase II, Section 4.3.1, Page 21). This information was further described in the Memorandum dated July 27, 2021 (Attachment B) provided to the DEP on July 29, 2021. Figure 4 (attached) shows the relative rate of transport of these compounds in groundwater based on their Koc values and the concentration of total organic carbon (TOC) from samples taken within the aquifer at the Airport.

HW used the 6.2 FTS data and the radar plots to confirm whether a groundwater sample is representative of the Airport AFFF source. HW also used the 6.2-fluorotelemer data to map the downgradient edge of the plume from each release area recognizing that the rate of retardation of this compound is slower than all the MassDEP regulated sum-of-six compounds detected in groundwater (as shown in Figure 4). The plume from each release clearly contains the regulated sum-of-six compounds and other non-regulated PFAS compounds. HW used the sum-of-six concentration data to determine if each groundwater sample contained concentrations above or below the GW-1 standard for the sum-of-six compounds. Further explanation is provided for each of the bullet points below.

- *Shallow soil samples obtained from the deployment area contained PFOS and PFOA at concentrations that exceeded S-1/GW-1 standards.*

PFOS and PFOA as well as each of the other sum-of-six compounds (and other unregulated compounds) are present in the soils at the Deployment Aarea and the ARFF release site (See Phase II Report, Table 2). With the exception of PFDA, they are also present in groundwater below these release locations and in downgradient groundwater samples taken within the defined plume from these release areas. HW used the sum-of-six total concentration in the groundwater samples to delineate the plume associated with each release and to evaluate whether the groundwater concentrations are above or below the GW-1 for the sum-of-six compounds. This is documented in Tables 2 and 3 and Figures 2, 3, 12, 13 and cross-sections 5 through 10 in the Phase II Report.

- *AFFF from the Airport supply was sampled and analyzed in 2016. Laboratory data indicates that five of the PFAS6 compounds are present in the AFFF. PFOS was reported as not present above a detection limit of 5 micrograms per liter (µg/L). Given that the GW-1 standard for PFOS is 0.02 µg/L, the data cannot be used to conclude that the Airport AFFF does not contain PFOS. Other PFAS6 compounds, including PFOA, were present in the foam mixture.*

HW agrees that the detection limit used in this analysis is high and we did not rely on these data for any of our analyses in the Phase II Report regarding the type of foam used, or the composition or location of the groundwater plumes associated with the two release sites. The data were collected to give us an initial evaluation of the composition of the foam in the Airport's inventory five years ago. Since then, HW gathered additional data PFAS compounds present in soil and groundwater; data that was used to map the groundwater plumes associated with the Airport releases. HW did not conclude that the Airport AFFF does not contain PFOS.

- *The spray water from the equipment at the Airport was sampled and analyzed in 2019 and found to contain PFAS6, including PFOS.*

HW sampled the water pumped from the fire-fighting truck at the Airport to determine if the truck could be releasing PFAS compounds to the environment when only water was sprayed. This testing revealed that the valve that operated the foam equipment allowed small concentrations of AFFF to be discharged even when the valve was closed. This mechanical issue was fixed and the spray water was retested within three months. Subsequent testing results shows that the equipment no longer discharges regulated PFAS above the GW-1 standards when just water is sprayed from the truck. Again, as previously mentioned HW agrees that the AFFF used by the Airport contains the DEP sum-of-six compounds as well as unregulated compounds.

The initial sample of water sprayed from the truck did show concentrations of all sum-of-six compounds as well as 6.2-fluorotelemer. As documented in the Phase II Report in Section 5.1.1 page 25, spray water contained 79 percent 6:2 FTS which is consistent with groundwater samples collected in the Deployment Area source which contained 83 percent 6:2 FTS. The remaining percentages included both DEP sum-of-six and unregulated PFAS analytes. This further documents the specific compounds contained in the AFFF used at the Airport; data which HW used as one of the many lines of evidence to differentiate between plumes connected to the two Airport release sites and plumes associated with other upgradient sources.

- *Based on this information, it is reasonable to conclude that AFFF usage at the Airport includes or historically included PFAS6 compounds.*

The AFFF used at the airport contains each of the sum-of-six PFAS compounds as well as 6.2-FTS and other unregulated PFAS compounds. HW provided data on the concentrations of each of the six compounds for soil and groundwater samples along with total PFAS and 6:2 FTS; data that was used to differentiate between an AFFF release and background PFAS at the Airport. The concentration data for 6:2 FTS was also used to map the downgradient edge of the two plumes associated with the Airport as this compound moves more readily in groundwater than the sum-of-six compounds detected in the Airport plume areas. Further information on the relative rates of transport for these compounds in groundwater is provided below.

- *Background soil data was obtained in October 2017. One background sample, BG-4 0-1', was obtained from near Runway 24 and contained PFAS exceeding the S-1/GW-1 standard. This area was not further evaluated as a potential source area.*

As indicated in the Phase II Report (Section 6.3 Page 32), PFOS was detected above the applicable standard in one of the background samples collected at the Airport (BG-4 O-1'). The detection of PFOS at this location is consistent with the other background samples collected and it is not representative of the Airports AFFF release. Further, as indicated on Table 2, soil samples consistent with the Airports AFFF contain elevated levels of various other regulated PFAS compounds including PFNA and PFHpA. With the exception of PFOS, no other regulated compound was detected above the laboratory method detection limit sample BG-4 0-1'.

- *While the Phase II did not use site-specific data to calculate groundwater and plume velocity, the Airport consultant provided MassDEP with site-specific data and calculations on July 29, 2021. Three locations were used to obtain new soil data for the purposes of obtaining site specific Total Organic Carbon (TOC). These calculated values were used in the modeling to conclude that the contamination at the Airport has not reached the Maher Wells. MassDEP notes the following issues regarding the calculations:*

HW used multiple lines of evidence in the Phase II Report to map the downgradient extent of each plume related to the two release sites at the Airport. The plumes associated with the Airport releases were identified with the radar plots that document that the contaminants downgradient of the Deployment Area and ARFF Building sites are associated with the Airport releases and not with an offsite source. Then the extent of plume migration was also mapped using analytical data from monitoring wells, the direction of groundwater flow in the vicinity of the release, and the groundwater flow velocity in the aquifer. Plume migration was also evaluated using the retardation coefficient for each of the PFAS chemicals in groundwater that accounts for the adsorption of the PFAS compounds to the organic carbon within the aquifer which slows the rate of plume migration relative to groundwater flow.

The Phase II Report discussed information on the migration of PFAS in soil and groundwater providing an overall estimate of the time it took since AFFF use began at the Deployment Area until it migrated in groundwater to the downgradient end of the plume. Upon further review, HW developed a more detailed evaluation of the migration of PFAS compounds in groundwater, accounting for the site-specific groundwater flow velocity, the extent of organic carbon in the subsurface soils, and literature values for the octanol/water partition coefficient (Koc). This information was used to calculate the retardation rate for DEP regulated PFAS compounds detected in the Airport plume and 6:2 FTS. As explained in the July 29, 2021 memo, it further documents the downgradient end of the plume confirms the accuracy of the mapping provided in the Phase II Report. Further data on the specific comments on this issue are provided below.

- *The three TOC samples were obtained outside of the documented PFAS contaminated areas in soil.*

Aquifer soil samples from below the two source areas could not be collected because both areas have been capped to prevent further release of PFAS compounds to groundwater. Drilling a soil boring to collect aquifer soil for TOC analysis could impact the integrity of these caps. Therefore, surficial TOC samples were collected from locations both within and adjacent to the Deployment Area plume and from the multiple depths within the aquifer adjacent to the downgradient edge of the plume. Data from these areas are appropriate to use for evaluation of soil migration in both surficial soils and in areas deep in the aquifer.

- *The retardation factors were calculated using an average TOC concentration, instead of a range of concentrations, which is not appropriate given the large variation in TOC concentrations (not present above detection limits up to 28,900 µg/kg).*

The July 29, 2021 Memorandum documents that TOC concentrations were evaluated using various TOC ranges as indicated on Table 2 in Attachment B. These ranges were as following:

- Average (all data) – 2,109 PPM
- 95th percentile – 8,580 PPM
- Average TOC (surface soil from 0-2 feet excluded) – 360 PPM
- 95th percentile (surface soil from 0-2 feet excluded) – 1,855 PPM
- Half of the non-detect values – 50 PPM

The various TOC ranges documented above were used to calculate multiple retardation rates for PFAS transport, providing the rate at which each of the six regulated PFAS compounds and 6:2 FTS is traveling through groundwater and considering the substantial amount of time the PFAS compounds are bound by high TOC in the surficial soil. The TOC concentrations in the aquifer soils are significantly lower than what is detected in the soils above the water table. A TOC range was used to demonstrate that only evaluating soils in the aquifer will severely overestimate plume migration from the point of release. Once the plume reaches groundwater, it will move at very quick rate (285 feet or more per year). Only evaluating the deep aquifer soils will not account for the significant amount of time it takes for the PFAS analytes to move through the unsaturated zone.

- *An average soil adsorption coefficient (Koc) was used in estimating the contaminant migration rate, resulting in a potentially artificially low contamination migration rate.*

As described below, HW used a specific literature Koc value for calculating retardation rates. for the DEP six regulated PFAS compounds and 6:2 FTS in groundwater. The following equation was used in these calculations:

Rf = 1 + d*Kd/n, where:

Rf = retardation factor

d = aquifer bulk density = 1.5

n = porosity = 33 percent = 0.33

kd = (soil) distribution coefficient = foc * Koc

foc = fraction organic carbon

Koc = organic carbon/water partition coefficient

HW used Koc values obtained from the Environmental Protection Agency CompTox Chemical Dashboard to calculate the retardation rate for PFAS compounds in groundwater (https://comptox.epa.gov/dashboard). The Koc value for each of these PFOS compound was then multiplied by the TOC value applicable for groundwater (50 ppm, Table 2, Attachment B) to develop a portioning coefficient (Kd) value. The Kd value was then used to calculate the retardation rate for each of these PFAS compound in groundwater. This rate is multiplied by the documented groundwater flow velocity to calculate the rate at which each compound moves in groundwater. Refer to Table 2 in Attachment B for additional details on the calculations.

The retardation calculations prepared by HW show that 6:2 FTS moves more quickly in groundwater compared to the detected DEP sum-of-six compounds (all but PFDA have been detected in groundwater). As discussed above, Figure 4 shows the relative rate of transport for the five detected compounds regulated by DEP and for 6:2 FTS. As 6:2 FTS moves more quickly, HW used the concentration data for this compound to augment our mapping of the downgradient edge of the plumes from the two Airport release sites.

- *Since the organic content and Koc significantly influence the determination of the extent of the groundwater plumes, the conclusion that the PFAS plume has not reached the Maher Wells is not supported.*

Summary of Previous Relevant Discussion

The Phase II Report and the data provided in the July 29, 2021 Memorandum documents that the plumes from the Deployment Area and ARFFF Area has not yet reached the Maher Wellfield. This is based on sound assumptions and multiple lines of evidence, including:

- The direction of groundwater flow: Groundwater is flowing from the Deployment Area towards the Maher Wellfield. This indicates that the plume from this source is headed in that direction and will likely reach the Maher Wellfield. Bi-annual monitoring is being conducted to track the plume migration and is being reported in IRA Status Reports submitted to DEP.

- The rate of groundwater flow: HW calculated an average groundwater flow velocity of 344 feet/year based on the slope of the water table in this area, the porosity of the aquifer and the hydraulic conductivity of the aquifer based on tests from wells HW-I(s), HW-F and OW-19 (m). This data was provided in the Phase II Report (Section 4.3.1, page 21).

- The retardation rate for each PFAS compound: The retardation rates for groundwater documented in the Memorandum document how the rate of transport of each compound is impacted as they adsorb to the organic carbon. This retardation slows the rate at which the contaminants migrate in groundwater relative to the actual groundwater flow velocity as presented in Figure 4. 6:2 FTS moves more quickly than the detected sum-of-six compounds (all but PFDA have been detected in groundwater), at a calculated rate of 285 feet/year. Therefore, HW has used this compound to track the downgradient edge of the plume.

- The chemical composition of the Airport plumes: The radar plots developed by HW clearly document which groundwater samples are related to the Airport sources, and which are associated with offsite sources. The Airport groundwater plume contains all but one (PFDA) of the sum-of-six compounds regulated by DEP and unregulated PFAS compounds including a high concentration of 6:2 FTS. The relative concentrations of each PFAS compound (both regulated and unregulated) were used to confirm if a groundwater sample was related to the Airport releases.

Addition Evidence Related to Subsurface Travel

In addition, the limited use of AFFF at the Airport and the migration of PFAS from the ground surface to the aquifer plays a significant role in determining how long it took for PFAS compounds in the AFFF to enter the aquifer and begin to move with groundwater as indicated in the July 29, 2021 Memorandum. AFFF was only used once per year at the Deployment Area beginning in 2004 until 2015 to confirm that the firefighting equipment used by the Airport was operating properly. Every three years, a mass casualty drill was also conducted at this location during which AFFF was also used between 1994 and 2012. These events were all required by FAA. Based on purchase records from the Airport, 1,280 gallons of AFFF were used from 2000-2015, at which time the use of AFFF for training purposes was suspended. The organic carbon in the surface soil and subsurface soils readily bound up the PFAS compounds from the foam spraying and slowed their migration downward.

Research conducted at the Joint Base Cape Cod and included in the article titled “Geochemical and Hydrologic Factors Controlling Subsurface Transport of Poly-and Perfluoroalkyl Substances, Cape Cod” documented that it took between 7-30 years for PFAS from AFFF sprayed at their fire training area to migrate to groundwater. The subsurface glacial soils in that area are similar to what exists at the Airport site indicating that PFAS compounds will adhere to the soils and only migrate slowly down to groundwater. The concentrations of PFAS measured in soils at the Deployment Area (1,524 ug/kg of Total PFAS at sample location MCI Drill (0-1)) are significantly higher than in groundwater directly below this site (15.5 ug/l of Total PFAS at sample location HW-I[s]) supporting this hypothesis. Based on HW mapping of the groundwater plume from this site, it took approximately 21 years for PFAS compounds to enter the aquifer from the Deployment Area (1,524 ug/kg of Total PFAS at sample location MCI Drill (0-1)). This is based on the following assumptions:

- The groundwater plume in the Deployment Area is currently mapped with analytical data to be a maximum of 1,700 feet in length.
- The plume is moving in groundwater at approximately 285 feet per year indicating that the PFAS analytes first entered groundwater in approximately 2015.
- The first application of PFAS in the Deployment Area occurred in 1994.

HW’s physical assessment, including groundwater sampling and analyses, clearly shows that the mapping of the downgradient edge of the plume from each source area has not yet migrated to the Maher wellfield. The information provided in the Phase II Report will be updated and expanded to further explain our rationale for this conclusion.

- *The Airport completed a pump test on three Airport monitoring wells to calculate a site-specific hydraulic conductivity but did not provide the generated data. Therefore, it is not possible to verify the quality of the data used in determining the hydraulic conductivity.*

As indicated in the Phase II Report in Section 4.3.1, page 20:

To determine the hydraulic conductivity, HW completed a series of drawdown pump tests using a submersible pump and a transducer capable of logging the fluctuation of the water level in hundredths of a foot in 0.5-second intervals. In general, the tests were completed over a 30-minute period at a pumping rate of 0.25 to 0.33-cubic feet per minute. Details from the pump test are provided below.

Well ID	Well Location	Depth to Water	Total Well Depth	Screen Length	Maximum Drawdown	Pump Rate (cubic feet per minute)	Calculated Hydraulic Conductivity
HW-I(s)	Deployment Area	18.416	25.09	10	18.732	0.33	117 feet per day
HW-F	Deployment Area	20.242	26.82	10	20.483	0.25	114 feet per day
OW-19(m)	Maher Well Field	26.942	76.14	10	27.417	0.33	78 feet per day
Average Hydraulic Conductivity							103 feet per day

Attachment C provides the worksheets that include the data and formulas used to calculate hydraulic conductivity. They will be included in the revised Phase II Report as well.

- *Groundwater geochemical data was not provided.*

This information is attached as Table 4 and includes representative water quality data collected during the most recent groundwater sampling event just prior to sample collection after purging five well volumes were completed.

- *Site-specific groundwater flow patterns were not presented in the Phase II as required by 310 CMR 40.0835(4)(d) nor was Technical Justification provided to forego evaluating site specific groundwater characteristics.*

HW's experience with the groundwater table at this site is documented earlier in this response. HW created an updated water table map based on data taken on April 27, 2020 from monitoring wells used by HW during this investigation. It is attached as Figure 1 and will be incorporated into the updated Phase II Report. The map shows groundwater flow conditions that clearly match the regional water table contours provided in the Phase II Report.

- *The report states that radar plots were used to help distinguish the Airport's PFAS AFFF plume from other non-Airport related PFAS sources. The Phase II states that the "…Airport's plume relating to AFFF which is recognizable by a high percentage of 6:2 FTS and low percentage of PFOS." The Airport used these radar plots to assert that the Airport PFAS fingerprint is not consistent with the PFAS fingerprint in the Maher wells and thus, the PFAS from the Airport has not impacted the Maher Wells. It does not consider the effects of the physical and chemical properties on the fate, transport and distribution of the different PFAS compounds over the nearly 40-year history of AFFF usage. However, the use of the radar plots at a single point in time as a "distinguishable fingerprint" is not appropriate based on the following: It does not consider the effects of the physical and chemical properties on the fate, transport and distribution of the different PFAS compounds over the nearly 40-year history of AFFF usage.*

The radar plots are based on the relative concentration of each PFAS compound in samples from the wells included in the analysis. The plots are based on concentration data at specific monitoring wells and are independent of fate and transport. The plots characterize the PFAS at that specific location and then, in evaluation, that characterization was considered in light of fate and transport characteristics to provide Site specific interpretation.

The radar plots for well HW-I(s), HW-J, HW-F, HW-H and HW-E located within and surrounding the Deployment Area were used to identify and document the chemical signature of the PFAS plume associated with the main Airport release. The groundwater sample(s) on which it is based is representative of all the AFFF sprayed at this location over time as the groundwater data on which the radar plots are based is from wells screened directly below the release site. If a non-fluorotelomer-based foam was used at this location it is still represented in the radar plot signature from these wells. The same process was used for samples taken near the ARFFF Building area.

• *No radar plots were presented for soil, which contains PFAS6 compounds, to compare to the groundwater radar plots.*

The groundwater radar plots are representative of the AFFF PFAS that has leached from the soil into the underlying groundwater. Radar plots for the soil are not necessary as it is easy to distinguish soil impacted with AFFFF relating to Airport operations from other non-AFFF sources as indicated by the high level of total PFAS including 6:2-FTS.

• *The radar plots are limited, in part, because they cannot consider the influence of the nearby pumping wells and ponds.*

Radar plots are regularly used by environmental professionals to identify individual sources of contamination found at a site and evaluate the impacts to downgradient resources when comingled plumes exist. HW developed the radar plots based on the concentration of each PFAS compound measured at a monitoring well at the time the sample was taken. Nearby ponds or pumping wells do not limit the use of these plots in identifying the PFAS sources on and near the Airport. The two plumes from the Airport are not near any ponds and are still upgradient of the Maher wellfield wells, the closest wells to the Airport sites. The Fire Training Academy plume migrates through and below Mary Dunn Pond before it flows below the Airport. The radar plots from samples taken at wells upgradient and downgradient of Mary Dunn Pond are consistent, indicating that the pond does not influence them.

- *Therefore, the radar plots as presented in the Phase II are not an appropriate tool to assert that the Maher Wells are not impacted by the Airport PFAS release.*

The radar plots are used in the Phase II Report to distinguish the Airport related groundwater plumes to those connected to upgradient sources, including the Fire Training Academy. HW's conclusions that the plumes associated with the Airport release have not impacted the Maher wellfield is discussed in detail above. The radar plots were used in that assessment to support these conclusions as they help document the downgradient edge of the Airport plumes. The primary information used in this assessment includes the direction of groundwater flow, the rate of transport of PFAS compounds in groundwater, the composition of the plume connected to the Airport releases based on multiple rounds of groundwater sampling, and the mass of AFFF used at the Airport at the Deployment Area.

- *The Phase II used the comparison of the percentages of contaminants from different monitoring wells to support the assertion that significant biodegradation was not occurring at the site. This basis is not adequate in the absence of a discussion of the concentration gradients resulting from the physical and chemical interactions between the aquifer and the contaminants.*

As stated in the Notice of Audit Findings, it is possible, with the right conditions, for 6:2 FTS to biodegrade into one or more perflourocarboxylic acids (PFCAs). HW evaluated this issue in the Phase II Report (Section 5.1.1, pages 23 through 27) by looking at the relative concentrations of 6:2 FTS versus the PFCA compounds using data from wells within the plume from the Deployment Area. The concentration of 6:2 FTS did decrease between well HW-I(s) in the Deployment Area and well HW-S[s] approximately 700 feet downgradient. However, there was no significant increase in the PFCA concentrations in the downgradient well and the reduction in 6:2 FTS concentration between these two wells is attributed to dilution and dispersion.

Since the Phase II Report was submitted, HW has reviewed additional literature regarding the potential biodegradation of PFAS compounds in groundwater under the conditions found at the Airport. The primary question evaluated was whether or not 6:2 FTS could biodegrade into other PFAS compounds in the aerobic, sand and gravel aquifer below the Airport.

A study by Zang et al (2016) evaluated the biodegradation of 6:2 FTS in aerobic river sediment and concluded that it could take place fairly rapidly in this environment. This study is not relevant to the aquifer at the Airport as there is no river sediment or similar organic material at concentration that would promote the biodegradation of 6:2 FTS. Similarly, a study by Wang (2010) showed that 6:2 FTS could potentially biodegrade in aerobic conditions using wastewater sludge as the medium. Again, this type of organic material is not present in the aquifer below the Airport.

Based on the literature review discussed above, HW concludes that the aquifer conditions in the vicinity of the Airport do not support the biodegradation of 6:2 FTS. This is supported by the measured concentrations of 6:2 FTS and PFCAs in the Deployment Area plume. As discussed above, while these concentrations decreased in downgradient locations, the concentrations of the potential breakdown compounds did not increase in a proportional manner.

HW stands by the conclusions that the PFAS plumes from the two locations where AFFF was used at the Airport have not yet impacted the Maher Wellfield. The Phase II Report will be updated to include the explanations provided here to clarify and support these conclusions. In addition, HW recognizes that the PFAS plumes from the Airport sources are migrating towards the wellfield and the Phase III Report will be developed recognizing that the Airport plumes could eventually impact the Maher Wellfield.

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Weber, Andrea K., Barber, Larry B., LeBlanc, Denis R., Sunderland, Elsie M. and Vecitis, Chad D. 2017. Geochemical and Hydrologic Factors Controlling Subsurface Transport of Poly-and Perfluoroalkly Substances, Cape Cod, Massachusetts. Environmental Science and Technology Article.

Wang N, J Liu 1, R Buck, S Korzeniowski, B Wolstenholme, P Folsom, and L Sulecki. 2010. 6:2 Fluorotelomer sulfonate aerobic biotransformation in activated sludge of wastewater treatment plants. Chemosphere.

Weber AK, LB Barbar, D Leblanc, E Sunderland and C Vetis. 2017. Geochemical and hydrologic factors controlling subsurface transport of poly and perfluoroalkyl substances. Environmental Science and Technology.

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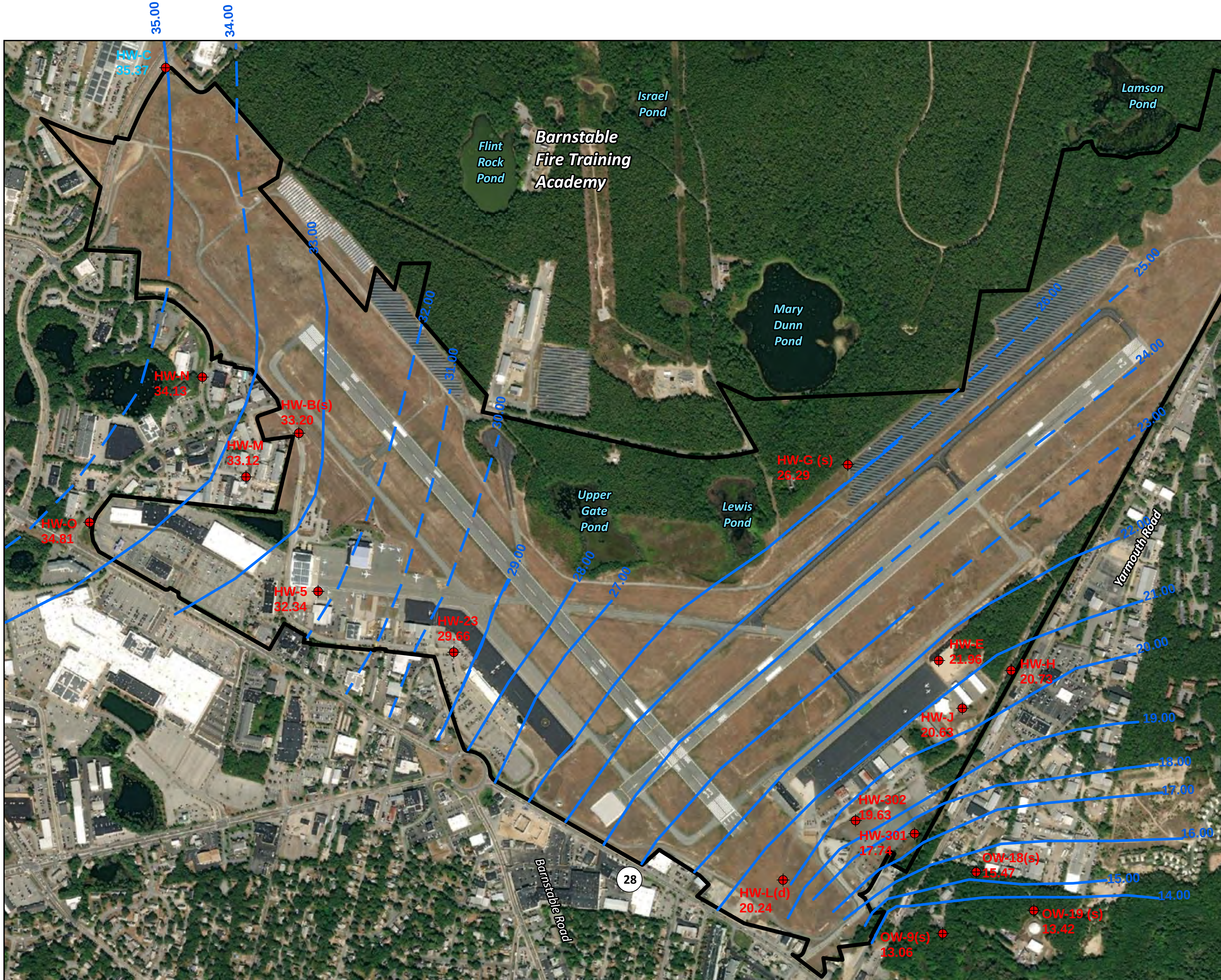
FIGURES



Legend

Barnstable Municipal Airport Property Boundary

Groundwater Contours

Monitoring Well Location

20.72 Groundwater Elevation

N

0 750

1 in = 750 feet

Horsley Witten Group

Sustainable Environmental Solutions

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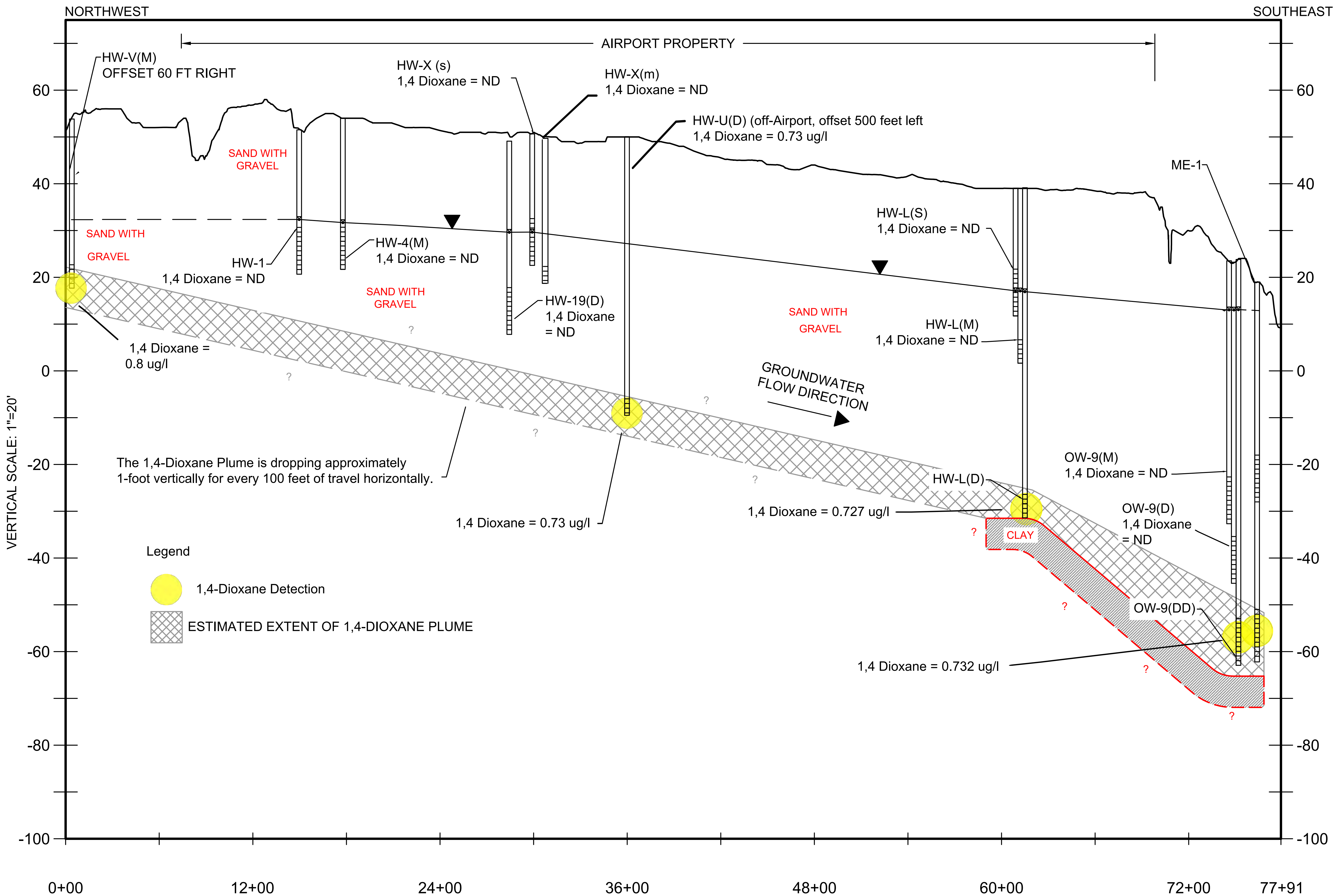
Water Table Map
Based on Water Level Measurements
from April 27, 2020
Cape Cod Gateway Airport
Hyannis, MA

Date: 10/1/2021

Figure 1



CROSS SECTION 2 PROFILE

HORIZONTAL SCALE: 1"=600'

last modified: 12/02/20 printed: 12/02/20 by eh H:\Projects\HYA\17027 bma pfos 1-4 ira\Drawings\17027 Cross Section Profiles.dwg

Revisions

Rev.	Date	By	Appr.	Description

Horsley Witten Group, Inc.
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Date: DEC 2020 | Design By: N/A | Drawn By: EWH | Checked By: BJM

Plan Set: HYDROLOGIC CROSS SECTION CAPE COD GATEWAY AIRPORT HYANNIS, MASSACHUSETTS

Plan Title: CROSS SECTION FIGURE 2

Prepared For: BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD
HYANNIS, MA 02601

Survey & Preliminary Layout Provided By: Horsley Witten Group, Inc.
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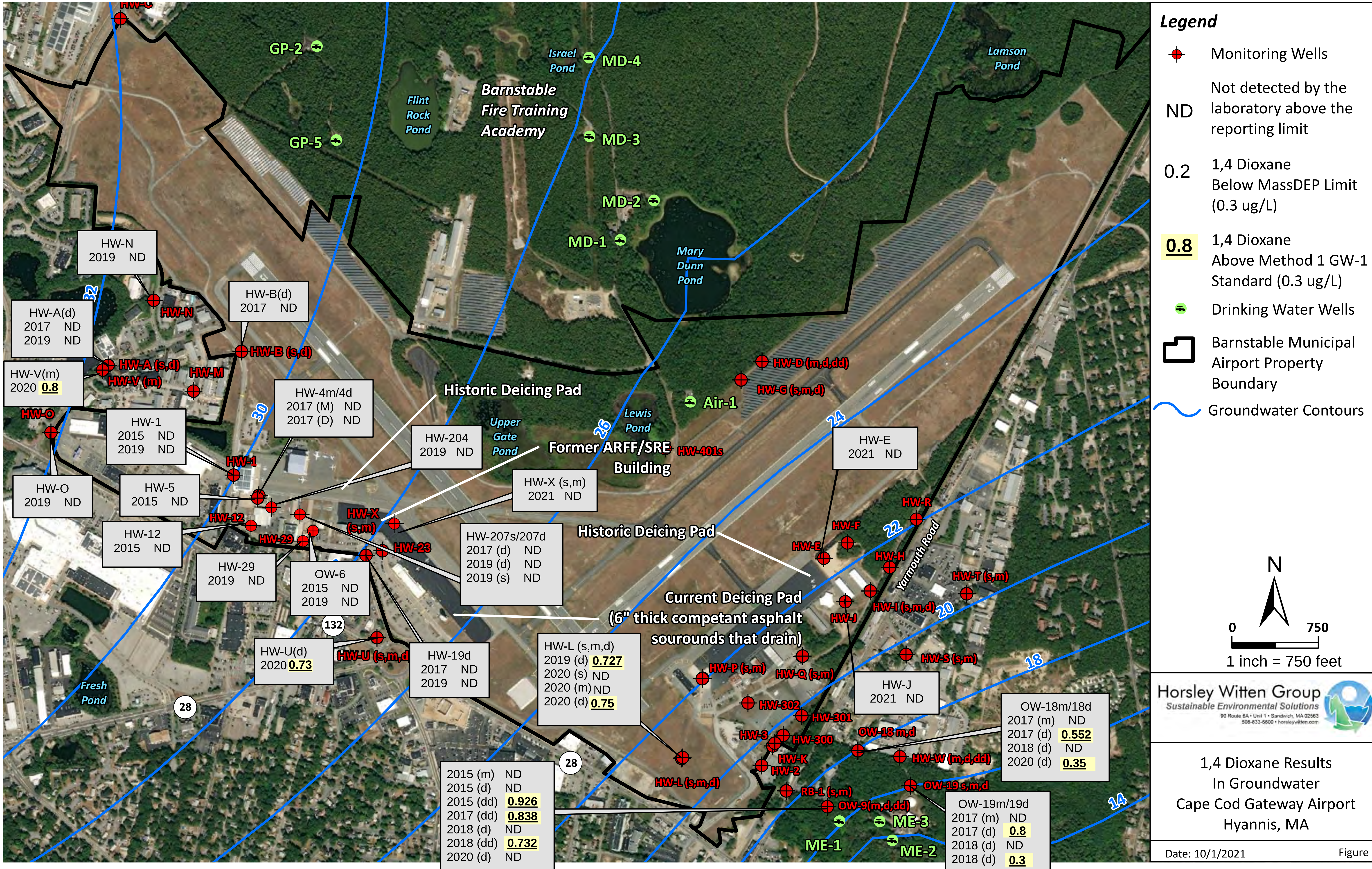
Registration:

Project Number: 17027

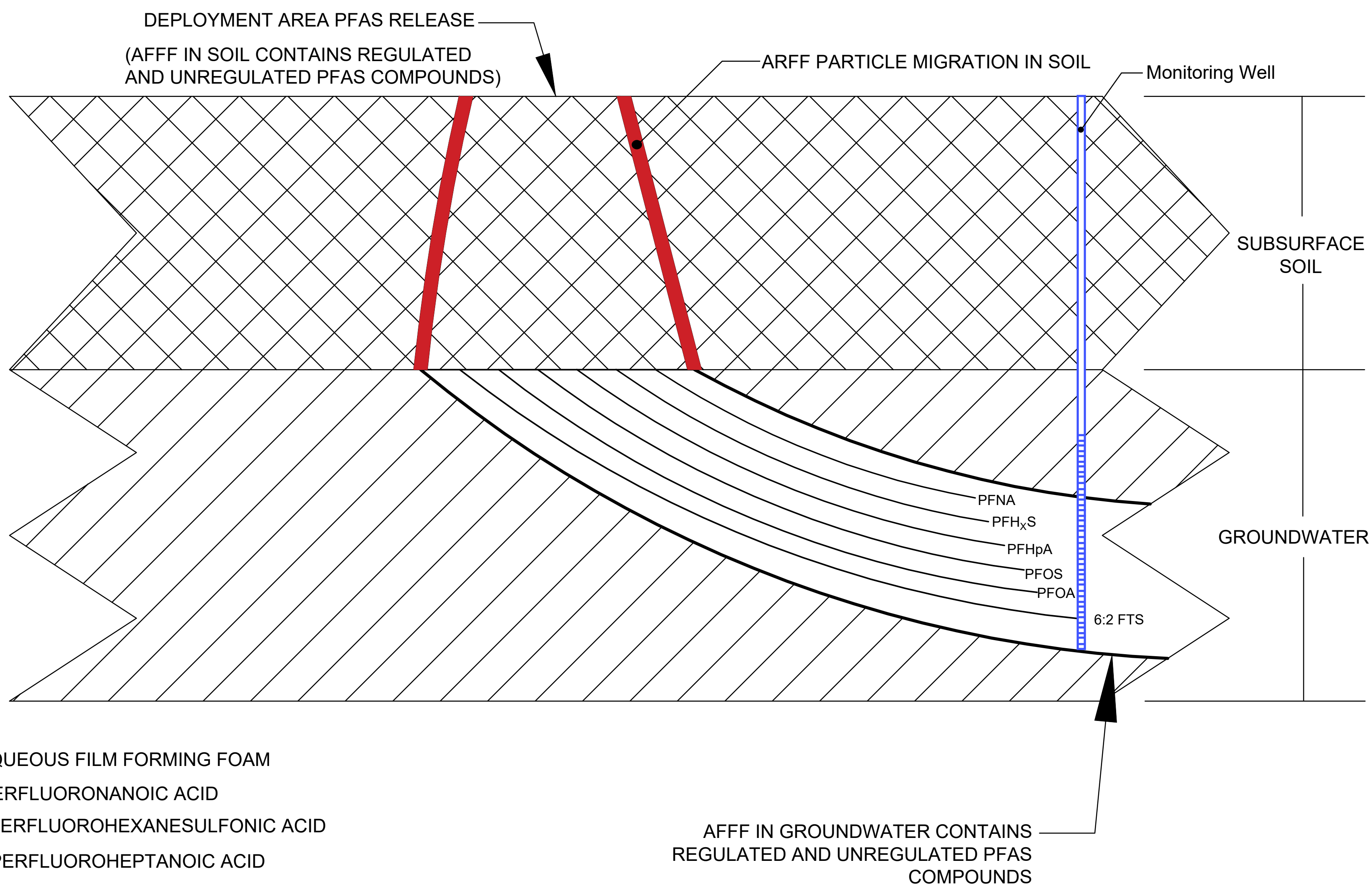
Sheet Number: Figure 2



Path: H:\Projects\HYA\17027 BMA PFOS 1-4 IRA\GIS\Maps\210409_DioxaneMap.mxd

GENERAL AFFF PARTICLE TRACK IN SOIL AND GROUNDWATER SHOWING MASSDEP 6 PFAS AND 6:2 FTS

(NOT TO SCALE)



NOTES:

AFFF=AQUEOUS FILM FORMING FOAM

PFNA=PERFLUORONANOIC ACID

PFH_XS=PERFLUOROHEXANESULFONIC ACID

PFHpA=PERFLUOROHEPTANOIC ACID

PFOS=PERFLUOROOCTANE SULFONATE

PFOA=PERFLUOROOCTANOIC ACID

6:2 FTS = 6:2 FLUOROTELOMOR SULFONATE

PFAS= PER AND POLY-FLUOROALKYL SUBSTANCES

FIGURE 4

H:\Projects\HYA\21084 PFOS Phase III\Drawings\PARTICLE SKETCH.dwg

TABLES

Table 1 - 1,4 Dioxane Groundwater Results ug/L

Sample Location	North Ramp																	Airport Road/Iyannough Road Area							ARFF Building			
Sample ID	HW-1	HW-1	HW-5	HW-12	OW-6	OW-6	HW-4M	HW-4D	HW-204	HW-29	HW-207S	HW-207D	HW-207D	HW-19D	HW-19D	HW-X(s)	HW-X(m)	HW-A(D)	HW-A(D)	HW-B(D)	HW-N	HW-O	HW-U(d)	HW-V(m)	HW-L(s)	HW-L(m)	HW-L(d)	HW-L(d)
Sample Date	5/7/2015	8/5/2019	5/7/2015	5/7/2015	5/7/2015	9/27/2019	4/5/2017	4/5/2017	9/27/2019	9/27/2019	9/27/2019	4/5/2017	9/27/2019	4/5/2017	9/27/2019	9/10/2021	9/10/2021	4/5/2017	8/5/2019	4/5/2017	8/5/2019	8/5/2019	10/2/2020	10/2/2020	10/7/2020	10/7/2020	7/2/2019	5/13/2020
1,4-Dioxane	<0.152	<0.25	<0.150	<0.150	<0.150	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.19	<0.22	<0.25	<0.25	<0.25	<0.25	<0.25	**0.73**	**0.8**	<0.2	<0.2	**0.727**	**0.75**

Sample Location	Maher Well Field															Deployment Area	
Sample ID	OW-9M	OW-9D	OW-9D	OW-9D	OW-9DD	OW-9DD	OW-9DD	OW-18M	OW-18D	OW-18D	OW-18D	OW-19M	OW-19D	OW-19D	OW-19D	HW-E	HW-J
Sample Date	5/28/2015	5/28/2015	12/3/2018	5/5/2020	5/28/2015	4/11/2017	12/3/2018	4/11/2017	4/11/2017	12/7/2018	5/13/2020	4/11/2017	4/11/2017	12/7/2018	5/13/2020	9/10/2021	9/10/2021
1,4-Dioxane	<0.141	<0.141	<0.25	<0.19	**0.926**	**0.838**	**0.732**	<0.25	**0.552**	<0.25	**0.35**	<0.25	**0.800**	<0.25	**0.3**	<0.20	<0.20

Notes:
Results in ug/L, micrograms per liter.
< = Not detected by the laboratory above the reporting limit. Reporting limit shown.
Bold results above Method 1 GW-1 standard (0.3 ug/L).
The Method 1 GW-2 standard for 1,4-dioxane is 6,000 ug/l.
The Method 1 GW-3 standard for 1,4-dioxane is 50,000 ug/l.

Table 2. Soil Results for PFAS Compounds ug/kg

Sample Location			ARFF Building												
Sample ID	Method 1 Standard		ARFF1 (0-1')	ARFF1 (2')	ARFF1 (4')	ARFF2 (0-1')	ARFF3 (0-1')	ARFF3 (10-12)	ARFF4 (0-1')	ARFFCB (0-1)	A1 (0-1')	A2 (0-1')	A3 (0-1')	A4 (0-1')	A5 (0-1')
Sample Date	S-1/GW-1	S-1/GW-3	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	10/9/2018	9/26/2017	9/26/2017	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018
Perfluoroheptanoic acid (PFHpA)	0.5	300	**0.82 J**	**1.8**	**0.66 J**	0.17 U	**0.60 J**	0.32 J	**0.75 J**	**0.60 J**	0.19 U	0.19 U	0.38 J	0.19 U	**1.1**
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.23 U	0.23 U	0.23 U	0.23 U	**0.64 J**	0.24 U	0.23 U	0.23 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U
Perfluorooctanoic acid (PFOA)	0.72	300	**0.75 J**	**2.6**	**0.75 J**	0.26 U	**0.78 J**	**1.9**	**0.97 J**	**0.90 J**	0.25 U	0.25 U	0.37 J	0.30 J	**1.9**
Perfluorononanoic acid (PFNA)	0.32	300	**2.5**	**5.7**	**1.4**	0.20 J	**0.91 J**	**3.1**	**2.9**	0.17 U	0.22 U	0.22 U	**0.51 J**	0.22 U	**0.87 J**
Perfluorooctane sulfonate (PFOS)	2	300	**4.5**	**2.7**	1.1	0.29 J	**4.4**	1.1	1.0	1.1	0.26 U	0.26 U	0.29 J	0.26 U	0.26 U
Perfluorodecanoic Acid (PFDA)	0.3	300	**4.4**	**1.2**	**0.62 J**	0.13 U	**1.6**	0.28 U	**0.85 J**	0.13 U	0.28 U	0.28 U	**0.42 J**	0.28 U	**1.4**
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	NA	0.93 J	0.74 J	1	0.23 U	0.61 J	4.2	0.65 J	2.2	0.26 U	0.26 U	0.26 U	0.26 U	18
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si															
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	12.97	14	4.53	0.49	8.93	6.42	6.47	2.6	0	0	1.97	0.3	5.27

Sample Location	ARFF Building												
Sample ID	A5 (2-4')	A6 (0-1')	A7 (0-1')	A8 (0-1')	A9 (0-1')	A10 (0-1')	A11 (0-1')	A12 (0-1')	A13 (0-1')	A13 (0-1')	A14 (0-1')	A14 (0-1')	A15 (0-1')
Sample Date	9/24/2020	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	2/27/2019	9/29/2020	2/27/2019	5/13/2020	2/27/2019
Perfluoroheptanoic acid (PFHpA)	0.089 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	**<2.0**	0.396 J	**<1.9**	**0.51 J**	**<2.0**
Perfluorohexanesulfonic acid (PFHxS)	0.12 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	**<2.0**	0.058 U	**<1.9**	0.24 U	**<2.0**
Perfluorooctanoic acid (PFOA)	0.228 J	0.25 U	0.25 U	0.25 U	0.34 J	0.25 U	0.25 U	0.25 U	**<2.0**	0.67 J	**<1.9**	0.68 J	**<2.0**
Perfluorononanoic acid (PFNA)	0.148 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	**<2.0**	**1.2**	**<1.9**	**0.54 J**	**<2.0**
Perfluorooctane sulfonate (PFOS)	0.257 U	0.26 U	0.38 J	0.26 U	0.85 J	0.26 U	0.26 U	0.26 U	<2.0	1.3	<1.9	0.32 J	<2.0
Perfluorodecanoic Acid (PFDA)	0.133 U	0.28 U	0.28 U	0.28 U	0.28 U	**0.33 J**	0.28 U	0.28 U	**<2.0**	**0.34 J**	**<1.9**	**0.95 J**	**<2.0**
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.355 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	<2.0	0.173 U	<1.9	0.25 U	<2.0
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si													
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.228	0	0.38	0	1.19	0.33	0	0	0	3.916	0	3	0

Sample Location	ARFF Building											
Sample ID	A15 (0-1')	A16 (0-1')	A17 (0-1')	A18 (0-1)	A19 (0-1)	A20 (0-1)	A20 (2-4)	A21 (0-1)	A22 (0-1)	HW-P(M) [8-10]	HW-P(M) [18-20]	DL1(0-1')
Sample Date	5/13/2020	9/17/2020	9/17/2020	9/29/2020	9/24/2020	9/24/2020	9/24/2020	9/24/2020	9/29/2020	9/18/2020	9/18/2020	6/20/2017
Perfluoroheptanoic acid (PFHpA)	0.21 U	0.067 J	**1.07**	0.076 J	0.101 J	0.09 U	0.09 U	0.045 U	0.096 J	0.044 U	0.043 U	0.30 J
Perfluorohexanesulfonic acid (PFHxS)	0.21 U	0.085 J	0.058 U	0.054 U	0.059 U	0.121 U	0.121 U	0.06 U	0.055 U	0.059 U	0.058 U	0.23 U
Perfluorooctanoic acid (PFOA)	0.14 U	0.088 J	**0.989**	0.111 J	0.129 J	0.196 J	0.147 J	0.042 U	0.069 J	0.089 J	0.046 J	0.26 U
Perfluorononanoic acid (PFNA)	0.15 U	0.119 J	**0.774 J**	0.281 J	0.246 J	0.15 U	0.15 U	0.075 U	0.11 J	0.073 U	0.072 U	0.17 U
Perfluorooctane sulfonate (PFOS)	0.29 J	**2.02**	0.573 J	1.15	0.611 J	0.259 U	0.26 U	0.276 J	0.559 J	0.0127 U	0.0124 U	0.40 J
Perfluorodecanoic Acid (PFDA)	0.15 U	0.074 J	0.147 J	0.146 J	0.066 U	0.134 U	0.134 U	0.067 U	0.119 J	0.065 U	0.064 U	**0.63 J**
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.22 U	0.17 U	0.172 U	0.161 U	0.175 U	0.358 U	0.359 U	0.179 U	0.164 U	0.221 J	0.172 U	0.39 J
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si												
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.29	2.453	3.553	1.764	1.087	0.196	0.147	0.276	0.953	0.089	0.046	1.33

Sample Location			Deployment Area												
Sample ID	Method 1 Standard		DL2 (0-1')	DL2 2'	DL2 4'	DL3 (0-1')	DL3 2'	DL3 4'	DL4 (0-1')	DL4 2'	DL4 4'	DL5 (0-1')	DL5 2'	DL5 4'	DL6 (0-1')
Sample Date	S-1/GW-1	S-1/GW-3	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	9/26/2017	6/20/2017	9/26/2017	9/26/2017	6/20/2017
Perfluoroheptanoic acid (PFHpA)	0.5	300	**1.9**	**1.2**	0.48 J	**0.84 J**	0.17 U	0.17 U	0.31 J	0.17 U	0.17 U	**2.5**	0.40 J	0.50 J	**5.0**
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	**1.8**	**1.3**	**0.59 J**	**0.34 J**	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	**0.49 J**	**0.49 J**	0.23 U	0.23 U
Perfluorooctanoic acid (PFOA)	0.72	300	**1.6**	**4.1**	**0.74 J**	**0.80 J**	0.26 U	0.26 U	**0.83 J**	0.26 U	0.26 U	**3.7**	**1.6**	0.26 U	0.26 U
Perfluorononanoic acid (PFNA)	0.32	300	**0.81 J**	**2.5**	0.17 U	**0.55 J**	0.17 U	0.17 U	**2.7**	0.17 U	**3.7**	0.19 J	0.17 U	0.17 U	0.19 J
Perfluorooctane sulfonate (PFOS)	2	300	**12**	1.5	0.21 U	0.51 J	0.21 U	0.21 U	2.0	0.21 U	0.50 J	0.21 U	0.21 U	0.21 U	0.21 U
Perfluorodecanoic Acid (PFDA)	0.3	300	0.13 U	0.13 U	0.13 U	**1.4**	0.13 U	0.13 U	**1.3**	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U	0.13 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	NA	0.23 U	0.23 U	0.57 J	3.1	1.5	1	0.24 J	0.23 U	1.7	0.23 U	0.23 U	0.23 U	2
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si															
Total PFAS	NA	NA	24.41	12.17	2.38	84.86	9.56	13.81	9.6	0.88	5.9	11.03	2.49	0.5	18.59
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	18.11	10.6	1.81	4.44	0	0	7.14	0	4.2	6.88	2.49	0.5	5.19

Sample Location	Deployment Area												
Sample ID	DL7 (0-1')	DL8 (2')	DL8 (4')	DL9 (0-1')	DL10 (0-1')	DL 11 (0-1')	DL 11 (0-1')	DL11 (4-6')	DL11 (10-12')	DL11 (14-16')	DL12 (0-1')	DL13 (0-1')	DL14 (0-1')
Sample Date	6/20/2017	6/20/2017	9/26/2017	6/20/2017	6/20/2017	9/26/2017	8/20/2019	10/4/2018	10/4/2018	10/4/2018	9/26/2017	9/26/2017	9/26/2017
Perfluoroheptanoic acid (PFHpA)	**2.5 J**	**2.9 J**	**4.7 J**	**0.66 J**	**1.3**	**2.1**	**1.8**	**1.3**	0.31 J	0.23 J	**1.2**	**1.6**	**4.9**
Perfluorohexanesulfonic acid (PFHxS)	**2.3 U**	**2.3 U**	**2.3 U**	**0.35 J**	**0.94 J**	**0.82 J**	**<0.9**	0.24 U	0.24 U	0.24 U	0.23 U	0.23 U	**0.71 J**
Perfluorooctanoic acid (PFOA)	**4.2 J**	**25**	**22**	0.68 J	**1.7**	**4.7**	**5.2**	**2.9**	**1.9**	0.50 J	**4.6**	**2.4**	**23**
Perfluorononanoic acid (PFNA)	**9.6 J**	**46**	**1.7 U**	0.22 J	0.17 U	**16**	**2.4**	**2.5**	0.22 U	0.22 U	**7.3**	**1.5**	**10**
Perfluorooctane sulfonate (PFOS)	**3.9 J**	**14**	**2.1 U**	0.38 J	0.26 J	**29**	1.5	0.26 U	0.26 U	0.26 U	**23**	0.66 J	**7.6**
Perfluorodecanoic Acid (PFDA)	**1.3 U**	**1.3 U**	**1.3 U**	0.13 U	0.13 U	**1.8**	**8.7**	0.28 U	0.28 U	0.28 U	**0.66 J**	**7.4**	**9.6**
6:2 Fluorotelomer sulfonate (6:2 FTS)	290	1600	900	0.23 U	0.23 U	7.8	30	4.1	4.4	6.7	62	320	230
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si													
Total PFAS	404.4	1727.2	949.6	6.38	9.1	85.22	91.5	11.07	6.82	7.63	108.56	521.26	598.24
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	20.2	87.9	26.7	2.29	4.2	54.42	19.6	6.7	2.21	0.73	36.76	13.56	55.81

Sample Location	Deployment Area										
Sample ID	DL14 (4-6')	DL14 (10-12')	DL14 (14-16')	DL15 (0-1)	DL16 (0-1)	DL17 (0-1)	DL18 (0-1)	DL19 (0-1)	DL20 (0-1)	DL21 (0-1)	DL22 (2-4)	DL22 (6-8)
Sample Date	10/4/2018	10/4/2018	10/4/2018	9/30/2020	9/30/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020	9/25/2020
Perfluoroheptanoic acid (PFHpA)	0.36 J	0.19 U	**1.4**	0.175 U	0.138 J	0.167 U	0.319 J	0.145 U	0.157 U	0.158 U	0.109 J	0.481 J
Perfluorohexanesulfonic acid (PFHxS)	0.24 U	0.24 U	**0.74 J**	0.235 U	0.057 U	0.224 U	0.159 J	0.194 U	0.21 U	0.212 U	0.057 U	0.07 J
Perfluorooctanoic acid (PFOA)	0.58 J	0.32 J	**2.9**	0.334 J	0.223 J	0.166 J	**0.979 J**	0.135 U	0.146 U	0.159 J	0.447 J	**1.32**
Perfluorononanoic acid (PFNA)	0.22 U	0.22 U	**10**	0.292 U	0.285 J	0.277 U	0.296 J	0.241 U	0.261 U	0.263 U	**5.46**	**2.66**
Perfluorooctane sulfonate (PFOS)	0.26 U	0.26 U	**2.3**	0.505 U	0.575 J	0.481 U	1.05 J	0.418 U	0.452 U	0.456 U	**20.3**	**8.85**
Perfluorodecanoic Acid (PFDA)	0.28 U	0.28 U	0.28 U	0.26 U	0.181 J	0.248 U	0.167 J	0.215 U	0.233 U	0.235 U	**0.834 J**	**0.383 J**
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.67 J	0.30 J	64	0.698 U	0.168 U	0.664 U	0.19 U	0.577 U	0.625 U	0.629 U	7.49	11.7
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si												
Total PFAS	50.11	21.22	116.64	4.523	2.269	0.628	4.84	0	0	0.68	66.813	41.988
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.94	0.32	17.34	0.334	1.402	0.166	2.97	0	0	0.159	27.15	13.764

Sample Location											**Deployment Area**	
Sample ID	Method 1 Standard		DL22 (18-20)	DL23 (0-1)	D1 (0-1')	D2 (0-1')	D3 (0-1')	D4 (0-1')	D5 (0-1')	D6 (0-1')	D7 (0-1')	D8 (0-1')
Sample Date	S-1/GW-1	S-1/GW-3	9/25/2020	9/29/2020	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018	8/14/2018
Perfluoroheptanoic acid (PFHpA)	0.5	300	0.073 J	0.24 J	0.19 U	0.21 J	0.19 U	**0.95 J**	0.22 J	0.25 J	**7.8**	**1.0**
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.059 U	0.134 J	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	**0.31 J**
Perfluorooctanoic acid (PFOA)	0.72	300	0.176 J	0.471 J	0.25 U	0.33 J	0.25 U	**1.1**	0.25 U	0.28 J	**14**	**2.2**
Perfluorononanoic acid (PFNA)	0.32	300	**0.476 J**	0.176 J	0.22 U	**0.67 J**	0.22 U	**0.98 J**	0.22 U	0.22 U	**10**	**0.59 J**
Perfluorooctane sulfonate (PFOS)	2	300	1.18	0.725 J	0.26 U	0.66 J	0.38 J	**2.9**	0.26 U	0.26 U	**3.4**	**2.1**
Perfluorodecanoic Acid (PFDA)	0.3	300	0.065 U	0.266 J	0.28 U	0.28 U	0.28 U	**0.40 J**	0.28 U	**0.66 J**	**8.6**	**1.3**
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	NA	2.67	0.181 U	0.26 U	0.26 U	0.26 U	0.26 U	0.78 J	1.2	12	0.26 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si												
Total PFAS	NA	NA	11.352	4.053	0.74	1.87	0.94	11.42	3.01	9.06	151.24	24.61
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	1.905	2.012	0	1.87	0.38	6.33	0.22	1.19	43.8	7.5

Sample Location	**Deployment Area**								
Sample ID	D9 (0-1')	D10 (0-1')	D11 (0-1')	D12 (0-1')	HW-F (10-12')	HW-F (14-16')	HW-3 (0-1')	MCI Drill (0-1)	Annual Deployment (0-1)
Sample Date	8/14/2018	8/14/2018	8/14/2018	8/14/2018	10/4/2018	10/4/2018	10/9/2018	12/9/2016	12/9/2016
Perfluoroheptanoic acid (PFHpA)	**2.7**	0.19 U	0.19 U	0.19 U	0.32 J	**1.3**	0.19 U	**8.4**	**20**
Perfluorohexanesulfonic acid (PFHxS)	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	**0.5 J**	**4 U**
Perfluorooctanoic acid (PFOA)	**3**	0.25 U	0.25 U	0.25 U	0.25 U	**1.4**	0.25 U	**23**	**100**
Perfluorononanoic acid (PFNA)	**0.83 J**	0.22 U	0.22 U	0.32 J	0.22 U	0.22 U	0.22 U	**14**	**31**
Perfluorooctane sulfonate (PFOS)	0.67 J	0.54 J	0.91 J	0.44 J	0.26 U	0.26 U	0.26 U	**24**	1.9 J
Perfluorodecanoic Acid (PFDA)	**1.6**	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	**20**	**69**
6:2 Fluorotelomer sulfonate (6:2 FTS)	6.6	0.26 U	0.26 U	0.26 U	24	140	0.26 U	270	4300
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si									
Total PFAS	43.41	0.83	1.62	1.47	25.27	146.5	0	1,524	5,972.9
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	8.8	0.54	0.91	0.76	0.32	2.7	0	89.9	221.9

Sample Location			**1991 Drill Location**						**Old ARFF/SRE Building**
Sample ID	Method 1 Standard		1991A (0-1')	1991B (0-1')	1991C (0-1')	1991D (0-1')	1991A-B (3-4')	1991C-D (2-3')	HW-X(m) [7-9]
Sample Date	S-1/GW-1	S-1/GW-3	8/14/2018	8/14/2018	8/14/2018	8/14/2018	12/14/2018	12/14/2018	9/7/2021
Perfluoroheptanoic acid (PFHpA)	0.5	300	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.043 U
Perfluorohexanesulfonic acid (PFHxS)	0.3	300	0.24 U	**0.66 J**	0.24 U	0.24 U	0.24 U	0.24 U	0.058 U
Perfluorooctanoic acid (PFOA)	0.72	300	0.25 U	0.26 J	0.25 U	0.25 U	0.25 U	0.25 U	0.04 U
Perfluorononanoic acid (PFNA)	0.32	300	0.22 U	0.22 U	0.22 U	0.30 J	0.22 U	0.22 U	0.072 U
Perfluorooctane sulfonate (PFOS)	2	300	0.49 J	1.1	0.55 J	0.36 J	0.30 J	0.42 J	0.124 U
Perfluorodecanoic Acid (PFDA)	0.3	300	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.064 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	NA	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.26 U	0.171 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Si									
Total PFAS	NA	NA	0.49	3.18	0.55	0.66	0.3	0.42	0.139
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	NA	NA	0.49	2.02	0.55	0.66	0.3	0.42	0.124 U

Notes:
< = Not detected by the laboratory above the reporting limit. Reporting limit shown.
J = Estimated concentration between the method detection limit and reporting limit.
Results in ug/kg, micrograms per kilogram.
U= Not detected by the Laboratory above the method detection limit. Method detection limit shown.
Bold results above the proposed Method 1 S-1/GW-1 standard.
Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U or <).
Sum of six includes estimated values and does not include non-detects (U or <).

Table 3. Groundwater Results for PFAS Compounds ug/L

Sample Location	North Ramp													Lewis Pond Area
Sample ID	HW-1	HW-1	HW-1	HW-4M	HW-5	HW-5	HW-5	HW-23	HW-23	HW-19D	HW-19D	HW-X(s)	HW-X(m)	HW-401S
Sample Date	7/1/2016	6/20/2017	11/1/2018	4/5/2017	7/1/2016	4/7/2017	11/1/2018	6/20/2017	11/1/2018	6/20/2017	11/7/2018	9/10/2021	9/10/2021	4/7/2017
TOC Elevation	51.51	51.51	51.51	54.02	54.98	54.98	54.98	50.65	50.65	49.10	49.10	NA	NA	41.58
Depth to Groundwater	21.63	25.00	21.83	26.20	24.94	26.75	25.27	22.70	24.01	21.29	22.19	24.74	25.21	17.95
Groundwater Elevation	29.88	26.51	29.68	27.82	30.04	28.23	29.71	27.95	26.64	27.81	26.91	NA	NA	23.63
Total Well Depth	30.84	30.84	30.84	32.32	27.80	27.80	27.80	28.11	28.11	41.30	41.30	29.24	36.82	23.60
Perfluoroheptanoic acid (PFHpA)	0.01	0.0042 J	0.013 J	0.007 J	0.0041	0.0084 J	0.0074 U	0.0045J	0.0098 J	0.0052 J	0.0080 J	0.0061	0.0034	0.0043 J
Perfluorohexanesulfonic acid (PFHxS)	0.018	0.065	0.018 J	0.02	0.011	0.018 J	0.0056 U	0.021	0.023	0.046	0.045	0.047	0.0021	0.011 J
Perfluorononanoic acid (PFNA)	<0.002	0.0057 J	0.0087 U	0.0046 U	<0.002	0.0046 U	0.0088 J	0.0038 U	0.0087 U	0.0065 J	0.0087 U	0.00049 J	0.002	0.0046 U
Perfluorooctanoic acid (PFOA)	0.033	0.022	0.031	0.011 J	0.031	0.020 J	0.011 J	0.0046 U	0.011 J	0.017 J	0.014 J	0.013	0.0062	0.0046 U
Perfluorooctane sulfonate (PFOS)	0.017	0.24	0.028	0.043	0.12	0.052	0.12	0.0079 J	0.015 J	0.061	0.069	0.068	0.034	0.012 J
Perfluorodecanoic Acid (PFDA)	NA	0.0040 U	0.0061 U	0.0040 U	NA	0.0040 U	0.0061 U	0.0040 U	0.0061 U	0.0040 U	0.0061 U	0.00050 U	0.0042	0.0040 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	0.0032 U	0.0066 U	0.0038 J	NA	0.0037 J	0.0066 U	0.0032 U	0.0066 U	0.0032 U	0.0066 U	0.002 J	0.00035 U	0.004 J
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six														
Total PFAS	0.078	0.4247	0.15	0.1162	0.1661	3.0021	0.1507	0.0745	0.0858	0.1758	0.16	0.18221	0.10025	0.0313
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.078**	**0.3369**	**0.09**	**0.081**	**0.1661**	**0.0984**	**0.1398**	**0.0334**	**0.0588**	**0.1357**	**0.136**	**0.13459**	**0.0519**	**0.0273**

Sample Location	Airport Road/Iyannough Road Area														
Sample ID	HW-A(S)	HW-B(S)	HW-B(S)	HW-B(D)	HW-C	HW-M	HW-N	HW-O	HW-U(s)	HW-U(s)	HW-U(m)	HW-U(m)	HW-U(d)	HW-U(d)	HW-V(m)
Sample Date	4/7/2017	4/7/2017	10/26/2018	10/26/2018	4/7/2017	6/24/2019	6/24/2019	7/2/2019	4/19/2021	9/5/2021	4/19/2021	9/5/2021	10/2/2020	9/5/2021	10/2/2020
TOC Elevation	55.34	51.84	51.84	51.95	69.25	53.69	49.49	43.46	NA	NA	NA	NA	48.80	48.80	53.83
Depth to Groundwater	24.62	22.26	21.59	21.66	38.50	20.32	15.48	3.62	23.59	24.53	23.50	24.49	24.66	25.24	22.90
Groundwater Elevation	30.72	29.58	30.25	30.29	30.75	33.37	34.01	39.84	NA	NA	NA	NA	24.14	23.56	30.93
Total Well Depth	32.00	30.23	30.23	57.20	42.15	26.92	22.33	14.10	28.83	28.83	38.93	38.93	62.30	62.30	36.15
Perfluoroheptanoic acid (PFHpA)	0.0048 J	0.049	0.012 J	0.0074 U	0.0033 U	0.007	0.0034	<0.002	0.002 J	0.004	0.0018 J	0.0049	0.01	0.01	0.0033
Perfluorohexanesulfonic acid (PFHxS)	0.0079 J	0.044	0.047	0.0056 U	0.0034 U	0.016	0.033	0.0043	0.01	0.0034	0.0043	0.011	0.018	0.022	0.0032
Perfluorononanoic acid (PFNA)	0.0046 U	0.0046 U	0.0087 U	0.0087 U	0.0046 U	<0.002	<0.002	<0.002	0.0013 J	0.0017 J	0.00083 J	0.0011 J	0.0016	0.005	0.0017
Perfluorooctanoic acid (PFOA)	0.0026 U	0.0094 J	0.020 J	0.012 J	0.0026 U	0.027	0.0088	0.0039	0.0075	0.0047	0.0055	0.0094	0.01	0.013	0.0063
Perfluorooctane sulfonate (PFOS)	0.0026 U	0.026	0.019 J	0.010 J	0.0026 U	0.0074	0.004	0.017	0.06	0.029	0.0093	0.027	0.023	0.051	0.0059
Perfluorodecanoic Acid (PFDA)	0.0040 U	0.0040 U	0.0061 U	0.0061 U	0.0040 U	<0.002	<0.002	0.0021	0.00064 J	0.0011 J	0.00038 U	0.001 U	0.00062 U	0.0025 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.0032 U	0.0032 U	0.0066 U	0.0066 U	0.0034 J	<0.002	<0.002	0.002 U	0.0011 U	0.00034 U	0.0011 U	0.00075	0.0012	0.04	0.00039 U
Total PFAS	0.0779	0.4561	0.186	0.0465	0.0034	0.0927	0.0727	0.0585	0.09704	0.06596	0.03622	0.0839	0.0889	0.1775	0.0543
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.0127	**0.1284**	**0.098**	**0.022**	<0.0046	**0.0574**	**0.0492**	**0.0273**	**0.08144**	**0.0439**	**0.02173**	**0.0534**	**0.0588**	**0.0987**	**0.0204**

Sample Location	ARFF Building Area												
Sample ID	HW-L (s)	HW-L (m)	HW-L (d)	HW-L (d)	HW-P (s)	HW-P (s)	HW-P (s)	HW-P (m)	HW-P (m)	HW-P (m)	HW-Q (s)	HW-Q (s)	HW-Q (m)
Sample Date	10/7/2020	10/7/2020	6/19/2019	10/7/2020	10/1/2020	3/18/2021	9/8/2021	10/1/2020	3/18/2021	9/8/2021	10/1/2020	11/6/2020	10/1/2020
TOC Elevation	39.07	38.98	39.15	39.15	40.51	40.51	40.51	40.64	40.64	40.64	37.89	37.89	37.90
Depth to Groundwater	21.96	21.88	19.40	22.22	22.69	22.09	23.54	22.80	22.20	23.67	21.45	22.04	21.41
Groundwater Elevation	17.11	17.10	19.75	16.93	17.82	18.42	16.97	17.84	18.44	16.97	16.44	15.85	16.49
Total Well Depth	27.33	37.33	70.55	70.55	27.60	27.60	27.60	38.30	38.30	38.30	26.60	26.60	36.79
Perfluoroheptanoic acid (PFHpA)	0.00053 U	0.0064	0.0078	0.0065	0.026	0.0067	0.004	0.003	0.017	0.016	0.0018 J	0.0021	0.00053 U
Perfluorohexanesulfonic acid (PFHxS)	0.0013	0.023	0.033	0.015	0.0018	0.00074 J	0.00056 J	0.00085	0.0015 J	0.0013 J	0.013	0.0087	0.0019
Perfluorononanoic acid (PFNA)	0.00063 U	0.0025	0.0033	0.0022	0.0061	0.002	0.0013 J	0.0011	0.006	0.0099	0.00063 U	0.00063 U	0.00075
Perfluorooctanoic acid (PFOA)	0.00071 U	0.01	0.025	0.018	0.0084	0.0042	0.0017 J	0.0018	0.0096	0.01	0.0049	0.0062	0.00095
Perfluorooctane sulfonate (PFOS)	0.0014	0.07	0.049	0.039	0.00097	0.00049 J	0.00054 U	0.0011	0.0035	0.003	0.0041	0.0075	0.0049
Perfluorodecanoic Acid (PFDA)	0.00062 U	0.00062 U	<0.002	0.0019	0.00085	0.0004 J	0.00048 U	0.00062 U	0.00038 U	0.00048 U	0.00062 U	0.00062 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.00039 U	0.022	0.0021	0.00078	0.011	0.0034	0.0014 J	0.00092	0.0011 U	0.00036 U	0.00039 U	0.00039 U	0.00039 U
Total PFAS	0.0027	0.18375	0.1823	0.12348	0.2478	0.06294	0.05055	0.02967	0.17311	0.15362	0.0307	0.0346	0.00944
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	0.0027	**0.1119**	**0.1181**	**0.0826**	**0.04412**	0.01453	0.00756	0.00785	**0.0376**	**0.0402**	**0.0238**	**0.0245**	0.0085

Sample Location														
Sample ID	HW-I (s)	HW-I (s)	HW-I (s)	HW-I (s)	HW-I (m)	HW-I (m)	HW-I (m)	HW-I (m)	HW-I (d)	HW-I (d)	HW-I (d)	HW-I (d)	HW-J	HW-J
Sample Date	11/7/2018	5/8/2020	3/17/2021	9/8/2021	6/24/2019	5/8/2020	3/17/2021	9/8/2021	6/24/2019	5/8/2020	3/17/2021	9/11/2021	11/7/2018	3/17/2021
TOC Elevation	36.08	36.08	36.08	36.08	36.27	36.27	36.27	36.27	36.02	36.02	36.02	36.02	37.10	37.10
Depth to Groundwater	18.35	15.39	18.42	19.94	16.33	15.61	18.66	20.17	16.20	15.49	18.52	20.04	19.18	19.34
Groundwater Elevation	17.73	20.69	17.66	16.14	19.94	20.66	17.61	16.10	19.82	20.53	17.50	15.98	17.92	17.76
Total Well Depth	25.10	25.10	25.10	25.10	34.80	34.80	34.80	34.80	41.67	41.67	41.67	41.67	24.30	24.30
Perfluoroheptanoic acid (PFHpA)	0.2	0.54	0.032	0.097	0.0032	0.0012	0.00086 J	0.0014 J	0.0053	0.0046	0.0065	0.0083	0.025	0.044
Perfluorohexanesulfonic acid (PFHxS)	0.18	0.22	0.021	0.036	0.019	0.0091	0.0052	0.0078	0.057	0.018	0.031	0.05	0.0056 U	0.088
Perfluorononanoic acid (PFNA)	0.16	0.082	0.065	0.033	<0.002	0.00078	0.00048 U	0.00046 J	<0.002	0.00063 U	0.00075 J	0.00084 J	0.028	0.035 J
Perfluorooctanoic acid (PFOA)	0.26	0.29	0.05	0.063	0.0061	0.0018	0.0014 J	0.0016 J	0.0047	0.0028	0.0043	0.0053	0.026	0.061
Perfluorooctane sulfonate (PFOS)	0.066	0.04	0.028	0.02	0.014	0.014	0.013	0.016	0.012	0.02	0.038	0.039	0.13	0.25
Perfluorodecanoic Acid (PFDA)	0.012 U	0.00062 U	0.0038 U	0.00047 U	<0.002	0.00062 U	0.00038 U	0.00050 U	<0.002	0.00062 U	0.00038 U	0.00048 U	0.0061 U	0.0076 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	11	13	1.7	2.1	0.002 U	0.00039 U	0.0011 U	0.00037 U	<0.002	0.0016	0.0011 U	0.00054 J	0.68	0.44
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six														
Total PFAS	13.346	15.5383	2.082	2.73304	0.0718	0.03308	0.02516	0.03254	0.1367	0.08985	0.15585	0.16687	1.074	1.217
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.866**	**1.172**	**0.196**	**0.249**	**0.0423**	**0.02688**	**0.02046**	**0.02726**	**0.079**	**0.0454**	**0.08055**	**0.10344**	**0.209**	**0.478**

Sample Location	Deployment Area														
Sample ID	HW-J	HW-E	HW-E	HW-E	HW-E	HW-E	HW-E	HW-F	HW-F	HW-F	HW-F	HW-F	HW-H	HW-H	HW-R(s)
Sample Date	9/10/2021	4/5/2017	11/7/2018	8/19/2019	5/5/2020	3/17/2021	9/8/2021	4/5/2017	11/7/2018	5/5/2020	3/17/2021	9/8/2021	11/7/2018	5/8/2020	10/1/2020
TOC Elevation	37.10	38.45	38.45	38.45	38.45	38.45	38.45	36.32	36.32	36.32	36.32	36.32	38.47	38.47	35.72
Depth to Groundwater	20.60	19.05	19.38	17.82	16.16	23.35	25.02	19.60	20.08	16.82	20.01	21.72	20.39	17.37	18.33
Groundwater Elevation	16.50	19.40	19.07	20.63	22.29	15.10	13.43	16.72	16.24	19.50	16.31	14.60	18.08	21.10	17.39
Total Well Depth	24.30	26.22	26.22	26.22	26.22	26.22	26.22	26.89	26.89	26.89	26.89	26.89	27.09	27.09	23.67
Perfluoroheptanoic acid (PFHpA)	0.02	0.15	0.0074 U	0.0053	0.044	0.014	0.0018 J	0.34	0.0074 U	0.23	0.39	0.0051	0.077	0.28	0.021
Perfluorohexanesulfonic acid (PFHxS)	0.01	0.042	0.0056 U	0.0021	0.011	0.0015 J	0.00088 J	0.019J	0.0056 U	0.005	0.012 U	0.00037 U	0.0056 U	0.0031	0.02
Perfluorononanoic acid (PFNA)	0.015	0.0087 J	0.0087 U	<0.002	0.0052	0.00048 U	0.00037 U	0.0046 U	0.0087 U	0.00081	0.0097 U	0.00037 U	0.0087 U	0.00063 U	0.0031
Perfluorooctanoic acid (PFOA)	0.0091	0.053	0.0033 U	0.0047	0.027	0.00095 J	0.00094 J	0.075	0.0033 U	0.02	0.052	0.00074 U	0.0050 J	0.002	0.014
Perfluorooctane sulfonate (PFOS)	0.08	0.047	0.0060 U	<0.002	0.0037	0.00082 J	0.00064 U	0.0026 U	0.0060 U	0.00086	0.0076 U	0.00065 U	0.0060 U	0.00068 U	0.016
Perfluorodecanoic Acid (PFDA)	0.00050 U	0.0040 U	0.0061 U	<0.002	0.00062 U	0.00038 U	0.00052 U	0.0040 U	0.0061 U	0.00062 U	0.0076 U	0.00053 U	0.0061 U	0.00062 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.13	2	0.0066 U	0.069	0.86	0.0035	0.00039 U	5.7	0.0066 U	1.5	4.8	0.0049	1.5	0.13	0.037
Total PFAS	0.511	3.2257	0	0.14	1.04526	0.04812	0.01342	12.96	0.084	2.65637	8.422	0.159	4.452	1.26666	0.2171
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.1341**	**0.3007**	0.0087 U	0.0121	**0.0909**	0.01727	0.00362	**0.434**	0.0087 U	0.25667	**0.442**	0.0051	**0.082**	**0.2851**	**0.0741**

Sample Location			Yarmouth Road										
Sample ID	HW-R(s)	HW-R(s)	HW-S (s)	HW-S (s)	HW-S (s)	HW-S (m)	HW-S (m)	HW-S (m)	HW-T (s)	HW-T (m)	RB-1 (s)	RB-1 (s)	RB-1 (s)
Sample Date	3/17/2021	9/8/2021	10/1/2020	3/18/2021	9/3/2021	10/1/2020	3/18/2021	9/3/2021	10/1/2020	10/1/2020	11/5/2020	3/18/2021	9/5/2021
TOC Elevation	35.72	35.72	31.60	31.60	31.60	31.59	31.59	31.59	28.97	29.11	NA	NA	NA
Depth to Groundwater	17.37	19.00	16.88	16.29	17.30	17.01	16.35	17.37	13.41	13.58	17.87	16.91	18.64
Groundwater Elevation	18.35	16.72	14.72	15.31	14.30	14.58	15.24	14.22	15.56	15.53	NA	NA	NA
Total Well Depth	23.67	23.67	22.10	22.10	22.10	32.04	32.04	32.04	18.54	28.96	27.80	27.80	27.80
Perfluoroheptanoic acid (PFHpA)	0.005	0.021	0.11	0.14	0.11	0.00096	0.0011 J	0.0012 J	0.0039	0.022	0.0042	0.0054	0.0077
Perfluorohexanesulfonic acid (PFHxS)	0.01	0.0046	0.055	0.083	0.064	0.0064	0.0073	0.0053	0.17	0.019	0.0084	0.03	0.0051
Perfluorononanoic acid (PFNA)	0.001 J	0.00034 U	0.1	0.024	0.1	0.00063 U	0.00057 J	0.00055 J	0.00074	0.0032	0.0047	0.0025	0.0026
Perfluorooctanoic acid (PFOA)	0.004	0.004	0.062	0.078	0.13	0.0013	0.0018 J	0.0014 J	0.0067	0.011	0.007	0.0087	0.0093
Perfluorooctane sulfonate (PFOS)	0.0023	0.0053	0.1	0.03	0.048	0.0058	0.006	0.0094	0.21	0.025	0.038	0.04	0.01
Perfluorodecanoic Acid (PFDA)	0.00038 U	0.00049 U	0.00062 U	0.0038 U	0.012 U	0.00062 U	0.00038 U	0.00047 U	0.00062 U	0.0014	0.00062 U	0.00038 U	0.00045 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.0048	0.003	3.7	3.1	5.2	0.0065	0.0067	0.0036	0.00039 U	0.00039 U	0.00039 U	0.0011 U	0.00034 U
Total PFAS	0.04878	0.2549	4.8958	4.3105	6.1418	0.02471	0.03263	0.02873	0.44114	0.3254	0.08008	0.1175	0.06755
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0223**	**0.0349**	**0.427**	**0.355**	**0.452**	0.01446	**0.02667**	0.01785	**0.39134**	**0.0816**	**0.0623**	**0.0866**	**0.0347**

Sample Location	Yarmouth Road			Solar Field								
Sample ID	RB-1 (m)	RB-1 (m)	RB-1 (m)	HW-D (m)	HW-D (m)	HW-D (d)	HW-D (d)	HW-D (dd)	HW-D (dd)	HW-G(S)	HW-G(M)	HW-G(D)
Sample Date	11/5/2020	3/18/2021	9/5/2021	4/7/2017	5/13/2020	6/24/2019	5/13/2020	6/24/2019	5/13/2020	12/3/2018	12/3/2018	12/3/2018
TOC Elevation	NA	NA	NA	45.20	45.20	45.08	45.08	45.05	45.05	44.99	45.11	44.93
Depth to Groundwater	17.79	16.85	18.57	18.83	18.34	18.99	18.23	20.60	19.97	20.69	20.75	20.71
Groundwater Elevation	NA	NA	NA	26.37	26.86	26.09	26.85	24.45	25.08	24.30	24.36	24.22
Total Well Depth	49.85	49.85	48.85	30.32	30.32	44.94	44.94	65.05	65.05	28.45	38.25	48.28
Perfluoroheptanoic acid (PFHpA)	0.011	0.013 J	0.0073	0.0033 U	0.00053 U	0.021	0.017	<0.002	0.00053 U	0.0074 U	0.0074 U	0.0074 U
Perfluorohexanesulfonic acid (PFHxS)	0.01	0.017 J	0.0099	0.0089 J	0.00077 U	0.062	0.039	0.0092	0.008	0.0056 U	0.012 J	0.0056 U
Perfluorononanoic acid (PFNA)	0.0068	0.0072 J	0.0044	0.0046 U	0.00063 U	0.015	0.019	0.0041	0.0029	0.0087 U	0.011 J	0.0087 U
Perfluorooctanoic acid (PFOA)	0.013	0.013 J	0.012	0.0046 U	0.00071 U	0.0088	0.0076	<0.002	0.00071 U	0.0033 U	0.0033 U	0.0033 U
Perfluorooctane sulfonate (PFOS)	0.049	0.075	0.055	0.022	0.0011	0.095	0.12	0.013	0.013	0.0060 U	0.036	0.0060 U
Perfluorodecanoic Acid (PFDA)	0.00075	0.0038 U	0.0033	0.0040 U	0.00062 U	<0.002	0.00062 U	<0.002	0.00062 U	0.0061 U	0.0061 U	0.0061 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.038	0.055	0.013	0.0032 U	0.00039 U	0.0022	0.00039 U	0.002 U	0.00039 U	0.0066 U	0.0066 U	0.0066 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six												
Total PFAS	0.2015	0.2642	0.1561	0.0309	0.0011	0.2768	0.24993	0.0263	0.02444	0	0.059	0
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0913**	**0.1252**	**0.0919**	**0.0309**	0.0011	**0.2018**	**0.2026**	**0.0263**	**0.0239**	0.0087 U	**0.059**	0.0087 U

Sample Location	Steamship Parking Lot																				
Sample ID	HW-2	HW-2	HW-2	HW-3	HW-3	HW-3	HW-3	HW-3	HW-3	HW-300	HW-300	HW-300	HW-301	HW-302	HW-302	HW-302	HW-302	HW-K	HW-K	HW-K	HW-K
Sample Date	7/1/2016	5/5/2020	9/1/2021	7/1/2016	4/5/2017	10/26/2018	5/5/2020	3/17/2021	9/1/2021	7/1/2016	3/17/2021	9/2/2021	7/1/2016	7/1/2016	12/3/2018	3/17/2021	9/1/2021	6/19/2019	5/21/2020	3/18/2021	9/2/2021
TOC Elevation	40.41	40.41	40.41	38.74	38.74	38.74	38.74	38.74	38.74	36.09	36.09	36.09	39.46	41.17	41.17	41.17	41.17	37.70	37.70	37.70	37.70
Depth to Groundwater	27.48	25.33	30.20	25.81	25.70	26.06	23.64	26.19	28.35	22.52	22.86	23.02	25.05	23.52	22.65	24.04	26.15	20.88	20.56	22.87	24.24
Groundwater Elevation	12.93	15.08	10.21	12.93	13.04	12.68	15.10	12.55	10.39	13.57	13.23	13.07	14.41	17.65	18.52	17.13	15.02	16.82	17.14	14.83	13.46
Total Well Depth	32.80	32.80	32.80	33.08	33.08	33.08	33.08	33.12	33.11	30.33	30.30	30.34	30.42	30.45	30.45	30.44	30.40	44.18	44.18	44.17	44.18
Perfluoroheptanoic acid (PFHpA)	0.0071	0.035	0.046	0.016	0.1	0.10	0.1	0.084	0.035	0.0096	0.0028	0.0029	0.002	0.019	0.015 J	0.0066	0.0062	0.0051	0.0028	0.0044	0.0086
Perfluorohexanesulfonic acid (PFHxS)	0.0035	0.0066	0.0056 J	0.0043	0.020 J	0.012 J	0.0087	0.0064 J	0.0057 J	0.012	0.0099	0.00066 J	0.038	0.0063	0.016 J	0.0022	0.004	<0.002	0.001	0.00066 J	0.0015 J
Perfluorononanoic acid (PFNA)	<0.002	0.016	0.004 J	0.0063	0.027	0.023	0.021	0.019 J	0.014 J	<0.002	0.00099 J	0.0028	<0.002	0.054	0.0097 J	0.0066	0.005	<0.002	0.0012	0.0037	0.003
Perfluorooctanoic acid (PFOA)	0.0063	0.039	0.012	0.0091	0.065	0.057	0.054	0.064	0.016 J	0.0052	0.0044	0.0044	0.0037	0.033	0.03	0.005	0.0065	0.0041	0.0019	0.0036	0.0038
Perfluorooctane sulfonate (PFOS)	0.012	0.053	0.026	0.084	0.15	0.053	0.1	0.056	0.044	0.017	0.015	0.017	0.011	0.014	0.031	0.0041	0.015	<0.002	0.0016	0.0015 J	0.0019
Perfluorodecanoic Acid (PFDA)	NA	0.00062 U	0.0025 U	NA	0.0040 U	0.0061 U	0.0014	0.0038 U	0.0052 U	NA	0.00038 U	0.0006 J	NA	NA	0.0061 U	0.00086 J	0.001 J	<0.002	0.00062 U	0.00038 U	0.00046 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	0.15	0.071	NA	0.47	0.12	0.13	0.47	0.2	NA	0.0011 U	0.00034 U	NA	NA	0.13	0.012	0.0062	0.002 U	0.00039 U	0.0011 U	0.00034 U
Total PFAS	0.0289	0.42678	0.4136	0.1197	1.603	0.952	0.96981	1.1394	0.6867	0.0438	0.05509	0.03812	0.0547	0.1263	0.3427	0.08304	0.09793	0.0348	0.0275	0.04486	0.09217
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0289**	**0.1496**	**0.0936**	**0.1197**	**0.362**	**0.245**	**0.2851**	**0.2294**	**0.1147**	**0.0438**	**0.03309**	**0.02832**	**0.0547**	**0.1263**	**0.1017**	**0.02536**	**0.0377**	0.0092	0.0085	0.0138	0.0188

Sample Location	Maher Wells								
Sample ID	OW-9S	OW-9S	OW-9S	OW-9M	OW-9M	OW-9D	OW-9D	OW-9D	OW-9DD
Sample Date	7/5/2016	12/3/2018	5/8/2020	12/3/2018	5/8/2020	7/5/2016	12/3/2018	5/5/2020	4/11/2017
TOC Elevation	23.25	23.25	23.25	23.53	23.53	23.22	23.22	23.22	23.81
Depth to Groundwater	12.23	10.80	10.14	11.11	10.45	12.48	10.82	10.15	12.10
Groundwater Elevation	11.02	12.45	13.11	12.42	13.08	10.74	12.40	13.07	11.71
Total Well Depth	21.35	21.35	21.35	56.20	56.20	68.63	68.63	68.63	86.75
Perfluoroheptanoic acid (PFHpA)	0.014	0.048	0.0064	0.11	0.0061	0.0028	0.033	0.044	0.034
Perfluorohexanesulfonic acid (PFHxS)	<0.003	0.023	0.011	0.0056 U	0.0033	0.012	0.12	0.18	0.12
Perfluorononanoic acid (PFNA)	0.0077	0.0087 U	0.0033	0.044	0.0037	0.0036	0.1	0.15	0.059
Perfluorooctanoic acid (PFOA)	0.007	0.032	0.0043	0.052	0.0035	0.0052	0.057	0.088	0.055
Perfluorooctane sulfonate (PFOS)	0.0074	0.024	0.0058	0.0081 J	0.01	0.041	0.52	0.72	0.5
Perfluorodecanoic Acid (PFDA)	NA	0.0061 U	0.00062 U	0.0061 U	0.00062 U	NA	0.0061 U	0.00062 U	0.0040 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	NA	0.0066 U	0.00039 U	0.64	0.0049	NA	0.19	0.23	0.13
Total PFAS	0.0361	0.618	0.06678	1.7141	0.0816	0.0646	1.217	1.5845	1.02
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0361**	**0.127**	**0.0308**	**0.2141**	**0.0266**	**0.0646**	**0.83**	**1.182**	**0.768**

Sample Location	Maher Wells															
Sample ID	OW-9DD	OW-9DD	ME-1*	ME-2**	ME-3***	OW-18S	OW-18S	OW-18S	OW-18M	OW-18M	OW-18M	OW-18D	OW-18D Duplicate	OW-18D	OW-18D	OW-18D
Sample Date	12/3/2018	10/2/2020	9/17/2020	9/17/2020	9/17/2020	7/5/2016	12/7/2018	5/8/2020	7/5/2016	12/7/2018	5/8/2020	7/5/2016	7/5/2016	4/11/2017	12/7/2018	5/13/2020
TOC Elevation	23.81	23.81	NA	NA	NA	39.03	39.03	39.03	39.30	39.30	39.30	38.84	38.84	38.84	38.84	38.84
Depth to Groundwater	11.30	13.04	3.60	6.50	6.00	24.40	24.29	23.45	25.82	24.72	23.93	25.95	25.95	25.55	24.28	23.47
Groundwater Elevation	12.51	10.77	NA	NA	NA	14.63	14.74	15.58	13.48	14.58	15.37	12.89	12.89	13.29	14.56	15.37
Total Well Depth	86.75	86.75	81.20	54.20	50.30	31.23	31.23	31.23	74.44	74.44	74.44	123.36	123.36	123.36	123.36	123.36
Perfluoroheptanoic acid (PFHpA)	0.015 J	0.0085	0.011	0.0055	0.0036	0.0071	0.0074 U	0.0039	0.0029	0.0074 U	0.0074	0.0071	0.0063	0.015J	0.014 J	0.012
Perfluorohexanesulfonic acid (PFHxS)	0.042	0.019	0.03	0.04	0.018	0.0068	0.0056 U	0.0085	0.016	0.073	0.07	0.01	0.011	0.13	0.13	0.03
Perfluorononanoic acid (PFNA)	0.038	0.018	0.017	0.003	0.004	<0.002	0.0087 U	0.0032	0.0076	0.0087 U	0.0027	0.0065	0.0058	0.0046 U	0.0087 U	0.0028
Perfluorooctanoic acid (PFOA)	0.020 J	0.01	0.016	0.0077	0.012	0.018	0.012 J	0.01	0.0058	0.0060 J	0.0096	0.0059	0.0059	0.025	0.019 J	0.0095
Perfluorooctane sulfonate (PFOS)	0.14	0.049	0.11	0.095	0.072	0.0083	0.028	0.016	0.044	0.24	0.18	0.018	0.019	0.22	0.32	0.041
Perfluorodecanoic Acid (PFDA)	0.0061 U	0.00062 U	0.00062 U	0.00062 U	0.00062 U	NA	0.0061 U	0.00062 U	NA	0.0061 U	0.00062 U	NA	NA	0.0040 U	0.0061 U	0.00062 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.062	0.02	0.034	0.00039 U	0.0071	NA	0.0066 U	0.00039 U	NA	0.0066 U	0.00039 U	NA	NA	0.0032 U	0.0066 U	0.00039 U
Sum of Laboratory Reported PFAS (Total PFAS) and Sum of Six																
Total PFAS	0.39	0.169	0.2873	0.2009	0.14005	0.0402	0.0573	0.05953	0.0763	0.3891	0.4357	0.0475	NA	0.506	0.5504	0.1832
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.255**	**0.1045**	**0.184**	**0.1512**	**0.1096**	**0.0402**	**0.04**	**0.0416**	**0.0763**	**0.319**	**0.2697**	**0.0475**	**0.048**	**0.39**	**0.483**	**0.0953**

Sample Location																
Sample ID	OW-19(S)	OW-19(S)	OW-19(S)	OW-19(M)	OW-19(M)	OW-19(M)	OW-19D	OW-19D	OW-19D	OW-19D	HW-W(m)	HW-W(m)	HW-W(d)	HW-W(d)	HW-W(dd)	HW-W(dd)
Sample Date	11/6/2020	3/18/2021	9/2/2021	11/6/2020	3/19/2021	9/3/2021	4/11/2017	5/13/2020	3/19/2021	9/11/2021	4/19/2021	9/5/2021	4/19/2021	9/5/2021	4/19/2021	9/5/2021
TOC Elevation	NA	NA	NA	NA	NA	NA	39.06	39.06	39.06	39.06	NA	NA	NA	NA	NA	NA
Depth to Groundwater	27.38	26.27	28.47	27.57	27.15	28.65	26.73	25.64	27.52	28.90	28.96	30.17	28.73	21.93	28.67	29.89
Groundwater Elevation	NA	NA	NA	NA	NA	NA	12.33	13.42	11.54	10.16	NA	NA	NA	NA	NA	NA
Total Well Depth	34.56	34.56	34.56	76.28	76.28	76.28	110.42	110.33	110.33	110.33	52.04	52.04	61.78	61.78	72.10	72.10
Perfluoroheptanoic acid (PFHpA)	0.0042	0.0044	0.0056	0.03	0.044	0.014	0.0051 J	0.011	0.018	0.022	0.01	0.0034	0.0021	0.01	0.0091	0.0073
Perfluorohexanesulfonic acid (PFHxS)	0.0031	0.0064	0.0027	0.027	0.014 J	0.015	0.029	0.12	0.026	0.028	0.012	0.015	0.0088	0.0064	0.0086	0.0048
Perfluorononanoic acid (PFNA)	0.0024	0.0012 J	0.0025	0.002	0.0048 U	0.0021	0.006 J	0.0017	0.0029	0.00088 J	0.00077 J	0.001 J	0.0013 J	0.0025	0.0014 J	0.002
Perfluorooctanoic acid (PFOA)	0.011	0.007	0.0066	0.011	0.0094 J	0.0037	0.0046 U	0.023	0.0097	0.007	0.0041	0.0024	0.0029	0.0094	0.0046	0.0069
Perfluorooctane sulfonate (PFOS)	0.025	0.015	0.031	0.047	0.027	0.029	0.029	0.31	0.047	0.053	0.075	0.042	0.012	0.017	0.015	0.0081
Perfluorodecanoic Acid (PFDA)	0.0027	0.001 J	0.00048 U	0.00062 U	0.0038 U	0.00046 U	0.0040 U	0.00062 U	0.00038 U	0.00048 U	0.00038 U	0.00046 U	0.00038 U	0.00046 U	0.00038 U	0.00049 U
6:2 Fluorotelomer sulfonate (6:2 FTS)	0.00039 U	0.0011 U	0.00036 U	0.00095	0.011 U	0.00035 U	0.0032 U	0.00039 U	0.0011 U	0.00036 U	0.0011 U	0.0029	0.0011 U	0.00042 J	0.0011 U	0.00036 U
Total PFAS	0.0707	0.0634	0.07307	0.37335	0.3974	0.16133	0.0936	0.5463	0.3127	0.31489	0.17849	0.17264	0.04339	0.08666	0.10469	0.0563
Sum of Six (PFHpA,PFHxS,PFOA, PFOS, PFNA, and PFDA)	**0.0484**	**0.035**	**0.0484**	**0.117**	**0.0944**	**0.0638**	**0.0691**	**0.4657**	**0.1036**	**0.11088**	**0.09707**	**0.06380**	**0.0271**	**0.0453**	**0.0387**	**0.0291**

Notes:
< = Not detected by the laboratory above the reporting limit. Reporting limit shown.
J = Estimated concentration between the method detection limit and reporting limit.
Results in ug/L, micrograms per liter.
U= Not detected by the Laboratory above the method detection limit. Method detection limit shown.
Bold results above Method 1 GW-1 standard (0.02 ug/L).
Sum of six includes estimated values and does not include non-detects (U or <).
Total PFAS is the sum of all laboratory detected PFAS analytes including estimated values and does not include non-detects (U or <).
NA = Not Applicable.
* = ME-1 is screened from 37 to 47 and 70 to 80 feet below grade.
** = ME-2 is screened from 44 to 54 feet below grade.
*** = ME-3 is screened from 40 to 50 feet below grade.
The Method 1 GW-3 Standard for the individual analytes in the Sum of Six ranges from 500 to 40,000 ug/l.

Table 4: September 2021 Groundwater Quality Data

9/1/2021	HW-302	*DTW*	*26.15*		*TWD*	*30.4*	Each Well Volume	0.68	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-302	5	3.4	13	89.5	9.43	44.6	5.18	221.6	3.6
9/1/2021	HW-2	*DTW*	*30.2*		*TWD*	*32.8*	Each Well Volume	0.42	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-2	5	2.08	12.3	38.3	4.1	207.6	6.21	26.2	9.1
9/1/2021	HW-3	*DTW*	*28.35*		*TWD*	*33.13*	Each Well Volume	0.76	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-3	5	3.82	13.2	92.4	9.68	262.9	5.68	215.8	13.1
9/2/2021	HW-K	*DTW*	*24.24*		*TWD*	*44.18*	Each Well Volume	3.19	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-K	5	15.95	12.6	94.1	10.01	47.5	5.23	226.6	2.1
9/2/2021	HW-300	*DTW*	*23.02*		*TWD*	*30.34*	Each Well Volume	1.17	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-300	5	5.86	19.4	50.2	4.62	38.3	5.27	241.6	1.9
9/2/2021	OW-19(s)	*DTW*	*28.47*		*TWD*	*34.67*	Each Well Volume	0.99	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
OW-19(s)	5	4.96	11.3	56.3	6.16	195.2	5.85	223	2.1
9/3/2021	OW-19(m)	*DTW*	*28.65*		*TWD*	*76.25*	Each Well Volume	7.62	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
OW-19(m)	5	38.08	12.3	22.9	2.45	82.2	5.57	150.8	2
9/3/2021	HW-S(m)	*DTW*	*17.37*		*TWD*	*32.12*	Each Well Volume	2.36	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-S(m)	5	11.80	12.7	70.7	7.51	62.7	5.26	239.2	1.5
9/3/2021	HW-S(s)	*DTW*	*17.3*		*TWD*	*22.17*	Each Well Volume	0.78	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-S(s)	5	3.90	13.4	57.1	5.96	142	5.17	254.1	5.7
9/5/2021	HW-W(dd)	*DTW*	*29.89*		*TWD*	*72.09*	Each Well Volume	6.75	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-W(dd)	5	33.76	12.7	78.7	8.35	48.5	5.2	240.2	2.1
9/5/2021	HW-W(d)	*DTW*	*21.93*		*TWD*	*61.78*	Each Well Volume	6.38	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-W(d)	5	31.88	12.8	72.9	7.71	49.8	5.08	275.6	2.1
9/5/2021	HW-W(m)	*DTW*	*30.17*		*TWD*	*52.08*	Each Well Volume	3.51	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-W(m)	5	17.53	13.3	25.2	2.64	79	5.76	247.6	1.5
9/5/2021	RB-1(m)	*DTW*	*18.57*		*TWD*	*48.85*	Each Well Volume	4.84	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
RB-1(m)	5	24.22	13	26.4	2.79	268.7	5.01	279	1.7
9/5/2021	RB-1(s)	*DTW*	*18.64*		*TWD*	*27.8*	Each Well Volume	1.47	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
RB-1(s)	5	7.33	13.9	74.7	7.72	133.8	5.21	277.3	53.7
9/5/2021	HW-U(d)	*DTW*	*25.24*		*TWD*	*62.38*	Each Well Volume	5.94	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-U(d)	5	29.71	14.5	2.8	0.28	1760	6.09	16.2	2.7

Table 4: September 2021 Groundwater Quality Data

9/5/2021	HW-U(m)	*DTW*	*24.49*		*TWD*	*38.94*	Each Well Volume	2.31	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-U(m)	5	11.56	14.3	11.1	1.13	702	4.89	249	2.1
9/5/2021	HW-U(s)	*DTW*	*24.53*		*TWD*	*28.82*	Each Well Volume	0.69	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-U(s)	5	3.43	14.6	83.8	8.52	328.6	5.88	234.8	10.4
9/8/2021	HW-I(s)	*DTW*	*19.94*		*TWD*	*25.17*	Each Well Volume	0.84	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-I(s)	5	4.18	13.6	-	9.28	52.8	5.38	222.7	3.5
9/8/2021	HW-I(m)	*DTW*	*20.17*		*TWD*	*34.79*	Each Well Volume	2.34	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-I(m)	5	11.70	12.4	37.1	3.96	72	5.28	233.2	2.2
9/8/2021	HW-I(d)	*DTW*	*20.04*		*TWD*	*41.67*	Each Well Volume	3.46	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-I(d)	5	17.30	12.2	10.4	1.11	187.2	5.41	156	2
9/8/2021	HW-E	*DTW*	*25.02*		*TWD*	*30.26*	Each Well Volume	0.84	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-E	5	4.19	12.3	94	10.06	43.8	5.16	248.7	20.9
9/8/2021	HW-F	*DTW*	*21.72*		*TWD*	*26.9*	Each Well Volume	0.83	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-F	5	4.14	11.7	95.1	10.33	46.1	5.2	267.5	3.7
9/8/2021	HW-R(s)	*DTW*	*19*		*TWD*	*23.67*	Each Well Volume	0.75	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-R(s)	5	3.74	12.7	30.8	3.26	106.5	5.35	276.4	16.4
9/8/2021	HW-P(s)	*DTW*	*23.54*		*TWD*	*27.61*	Each Well Volume	0.65	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-P(s)	5	3.26	13.8	91.5	9.47	56.3	5.37	269.6	5.9
9/8/2021	HW-P(m)	*DTW*	*23.67*		*TWD*	*38.28*	Each Well Volume	2.34	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-P(d)	5	11.69	12.7	87.4	9.27	55.3	5.11	298.7	6
9/10/2021	HW-X(s)	*DTW*	*24.74*		*TWD*	*29.24*	Each Well Volume	0.72	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-X(s)	5	3.60	15.8	80	7.94	68.7	5.25	166.4	3.9
9/10/2021	HW-X(m)	*DTW*	*25.1*		*TWD*	*36.82*	Each Well Volume	1.88	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-X(m)	5	9.38	14.9	38.1	3.85	343.4	5.45	100.5	3.1
9/10/2021	HW-J	*DTW*	*20.6*		*TWD*	*24.28*	Each Well Volume	0.59	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
HW-J	5	2.94	14.8	85.8	8.69	47.9	5.08	267.2	7
9/11/2021	OW-19(d)	*DTW*	*28.9*		*TWD*	*110.34*	Each Well Volume	13.03	
	Well volume	Volume	Degree C	DO %	DO mg/L	SPC (µs/cm)	pH	ORP mV	NTU
OW-19(d)	5	65.15	12.3	13.3	1.42	113.6	5.82	167.9	2.1

Table 4: September 2021 Groundwater Quality Data

Notes:
DTW = Depth to water in feet below grade.
TWD = Total well depth in feet below grade.
Well Volume = Amount of groundwater in gallons to purge to meet five well volumes.
Each Well Volume = Amount of groundwater purged from each well volume in gallons.
Degree C = Groundwater temperature in Celsius.
DO = Dissolved oxygen.
mg/L = milligrams per liter.
SPC (us/cm) = specific conductance in microSiemens per centimeter.
ORP mV= Oxidation reduction potential in millivolts.
NTU = Nephelometric Turbidity Unit.

ATTACHMENT A

- Aqueous Film-Forming Foam, prepared by Interstate Technology Reglatory Council, dated August 2020

Aqueous Film-Forming Foam (AFFF)

1 Introduction

Aqueous film-forming foam (AFFF) is a highly effective firefighting product intended for fighting high-hazard flammable liquid fires. AFFF products are synthesized by combining hydrocarbon foaming agents with fluorinated surfactants to achieve a product that has been used at military installations, civilian airports, petroleum refineries, bulk storage facilities, and chemical manufacturing plants (Hu et al. 2016; CONCAWE 2016).

This fact sheet is targeted to local, state, and federal regulators and tribes in environmental, health and safety roles as well as AFFF users at municipalities, airports, and industrial facilities. This fact sheet is not intended to replace manufacturer specifications or industry guidance for AFFF use, or to discuss alternatives in detail. It is only intended to educate users on AFFF use to reduce and eliminate potential harm to human health and the environment. Additional information is available in the Guidance Document.

ITRC has developed a series of fact sheets that summarize recent science and emerging technologies regarding PFAS. The information in this and other PFAS fact sheets is more fully described in the ***ITRC PFAS Technical and Regulatory Guidance Document (Guidance Document)*** (*https://pfas-1.itrcweb.org/*).

This fact sheet outlines methods to properly identify, handle, store, capture, collect, manage, and dispose of AFFF to limit potential environmental impacts, and includes:

- Definition of AFFF
- Best Management Practices for AFFF use
- Regulations Affecting Sale and Use
- Foam Research and Development

2 What is AFFF?

Class B firefighting foams are commercial surfactant solutions that are designed and used to combat Class B flammable fuel fires. All Class B foams are not the same. Although not usually categorized this way from a fire protection viewpoint, they can be divided into two broad categories from a per- and polyfluoroalkyl substances (PFAS) perspective: fluorinated foams that contain PFAS and fluorine-free foams (F3) that do not contain PFAS.

There are six groups of Class B foams that contain PFAS and four groups of Class B foams that do not contain PFAS. Figure 1 illustrates all categories of Class B foams. This fact sheet focuses on AFFF only as these are the primary foams that contain fluorosurfactants.

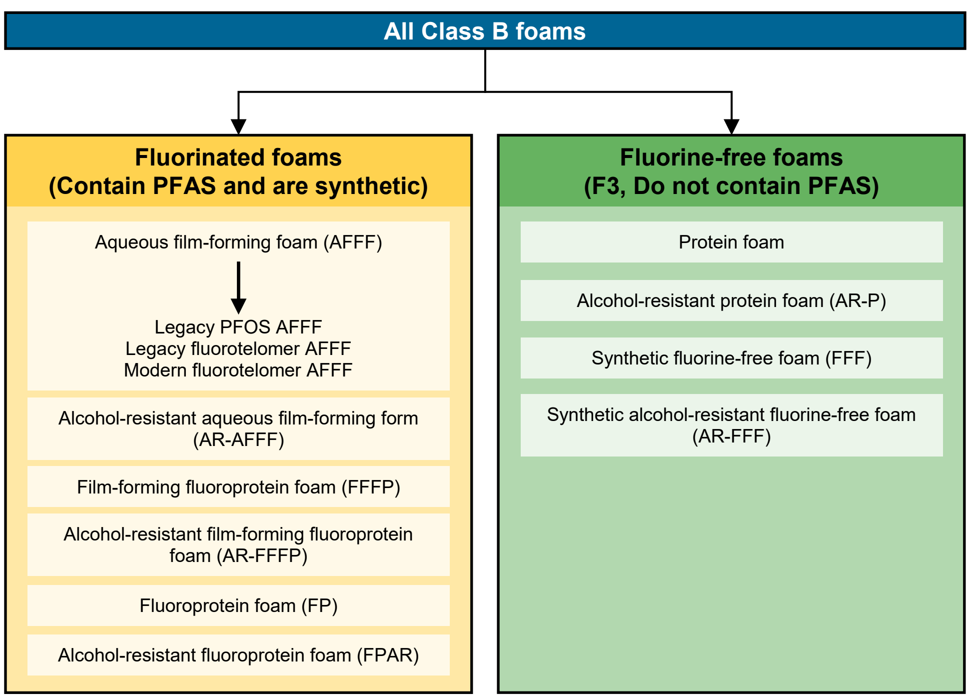


Figure 1. Types of Class B foams.
Source: S. Thomas, Wood, PLC. Used with permission.

Aqueous Film-Forming Foam (AFFF) *continued*

AFFF is considered a fluorinated foam and when mixed with water, the resulting solution achieves the interfacial tension characteristics needed to produce an aqueous film that spreads across the surface of a hydrocarbon fuel (petroleum greases, tars, oils and gasoline; and solvents and alcohols) to extinguish the fire and to form a vapor barrier between the fuel and atmospheric oxygen to prevent re-ignition. This film formation is the defining feature of AFFF.

AFFF has been used at chemical plants, flammable liquid storage and processing facilities, merchant operations (oil tankers, offshore platforms), municipal services (fire departments, firefighting training centers), oil refineries, terminals, and bulk fuel storage farms, aviation operations (aircraft rescue and firefighting, hangars), in some industrial fire extinguishers, and military facilities.

There are three possible types of AFFF, each is presented in Figure 1:

- legacy PFOS AFFF (manufactured in the US from the late1960s through 2002)
- legacy fluorotelomer AFFF (contain some long-chain PFAS) (manufactured in the US from the 1970s until 2016)
- modern fluorotelomer AFFF (short-chain PFAS became the predominant fluorochemicals used in manufacturing in response to USEPA 2010/2015 voluntary PFOA Stewardship Program)

Most foam manufacturers now produce Class B F3s. Performance of these foams should be evaluated carefully as future purchasing decisions are made. Organizations should determine whether a Class B F3 can achieve the required performance specifications for their specific flammable liquid hazards as part of pre-planning for replacement materials (FFFC 2016). As of publication, F3s do not meet the performance requirements of the Mil-Spec and therefore are not used at federal- and FAA-regulated facilities (FAA 2020). A mandate within the FAA Reauthorization Act of 2018 (enacted October 5, 2018) directs the FAA to stop requiring the use of fluorinated foam no later than 3 years from the date of enactment (October 4, 2021), so F3 use is anticipated at FAA-regulated facilities in the near future. The National Defense Authorization Act of fiscal Year 2020 (signed into law Dec 20, 2019) requires the DOD to phase out its use of AFFF at all military installations by Oct. 1, 2024, with limited exceptions, and immediately stop military training exercises with AFFF. The secretary of the Navy must publish specifications for PFAS-free firefighting foam at all military installations and ensure that the foam is available for use by Oct. 1, 2023.

3 Best Management Practices (BMPs) for Class B AFFF Use

Firefighting foams are an important tool to protect human health and property from flammable liquid fire threats. Proper management and usage strategies combined with the ongoing refinement of environmental regulations will allow an informed selection of the viable options to sustainably use firefighting foams. BMPs should be established for the use of any firefighting foam to prevent possible releases to the environment that can lead to soil, groundwater, surface water, and potentially drinking water contamination. The discharge of firefighting foams to the environment is of concern because of the potential negative impact they can have on ecosystems and biota. AFFF, due to the presence of PFAS, poses a unique challenge to protecting the environment when it is released. Specifically, for AFFF, the amount of PFAS from foam that may enter groundwater depends on the type and amount of foam used, the degree of containment, when and where the foam was used, the type of soil and the depth to groundwater. AFFF is typically discharged on land but can run off into surface water or stormwater or infiltrate to groundwater. A conceptual site model (CSM) is presented in Figure 2.

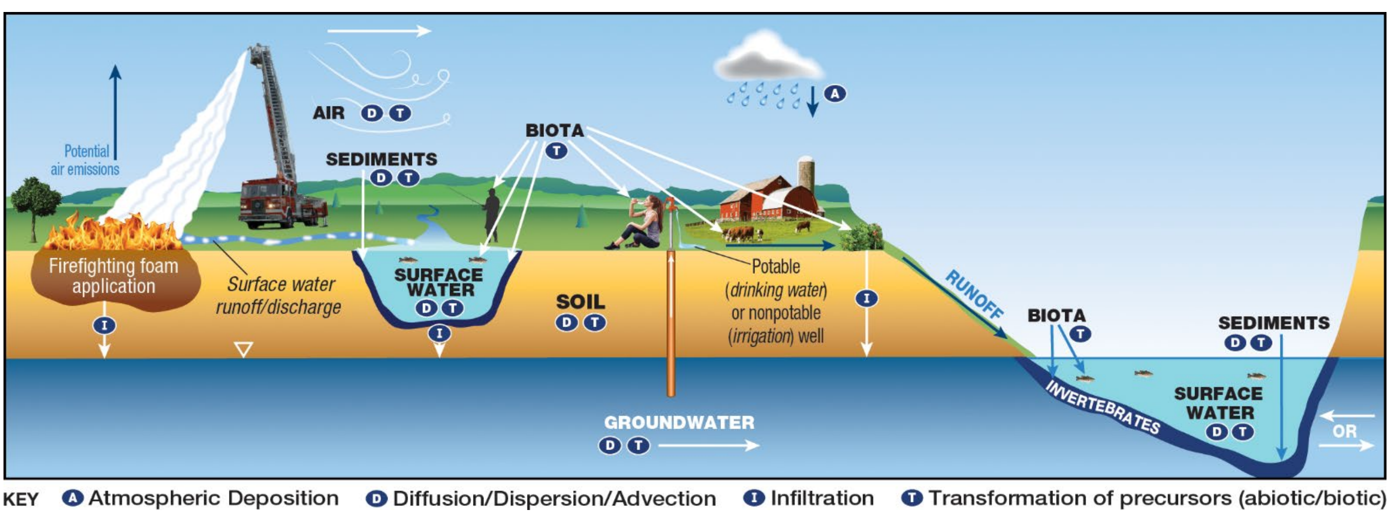


Figure 2. CSM for fire training areas.

Source: Adapted from figure by L. Trozzolo, TRC. Used with permission.

BMPs should consider the entire life cycle for AFFF, including procurement and inventory, foam systems and operations, emergency firefighting operations, immediate investigative and clean-up actions, treatment and disposal and system replacement.

The procurement and inventory of foam should be carefully considered. Foams should be selected that meet the performance specification requirements governing the use. Foams procured should be documented, labelled clearly and adequately contained. Foam use and disposal should be carefully tracked and recorded.

When evaluating foam systems and operations, from fixed-system testing, mobile firefighting equipment testing and appropriate training exercises, engineering and administrative controls as well as personal protective equipment (PPE) should be carefully evaluated. During emergency firefighting operations following a release of firefighting foam, PPE should be used correctly, maintained, and decontaminated routinely. Immediate investigative and clean-up actions include initial mitigation efforts such as source control, containment tactics, and recovery tactics.

BMPs start with pre-planning and deciding which foam to keep in stock. The team should consider key factors such as these:

- Whether F3 alternatives can meet site-specific performance requirements
- Site-specific evaluation of likely fire hazards and potential risks for life, public safety, and property
- Potential environmental, human health, and financial liabilities associated with AFFF releases
- Site constraints, including existing equipment retrofit requirements to adapt to alternate foams

The treatment and disposal of AFFF products and environmental media impacted with PFAS can be complex, time consuming, and costly. Practitioners should be aware of approved and available disposal options prior to the generation of PFAS-impacted waste or the start of an AFFF replacement project to avoid potentially lengthy waste storage timeframes. Currently, available disposal options for AFFF and PFAS-impacted materials are limited and each option has its advantages and disadvantages. More information is included in the Guidance Document.

Firefighting foam replacement is complex and could require a complete system review and, potentially, redesign and modification of system components to meet the new objectives or material and performance requirements. Foam replacement should include an evaluation of specific hazards and application objectives, a review of applicable performance standards, an understanding of engineering requirements for foam product storage and application, and a check to ensure that the foam product is approved for use for the specific hazards being mitigated.

4 Regulations Affecting the Sale and Use of AFFF

There are many State, Federal, and International regulations and guidance documents governing the procurement, use, and disposal of AFFF. Activities range from AFFF take-back programs and prohibition of manufacture, sale, use, and import of AFFF through to restrictions and requirements for disposal. Refer to the Guidance Document for further information.

Figure 3. Life cycle considerations for AFFF.
Source: S. Thomas, Wood, PLC. Used with permission.

5 Foam Research and Development

A substantial amount of research related to AFFF alternatives and replacement chemistries has recently been completed and/or is being considered at the time of publication. For more information related to this topic, please refer to the Guidance Document. Several organizations globally have made investments in research and development around AFFF from the assessment of their use, environmental impacts, as well as socioeconomic impacts of transiton to and performance specifications of F3 alternatives.

6 References and Acronyms

The references cited in this fact sheet and further references can be found at https://pfas-1.itrcweb.org/references/.
The acronyms used in this fact sheet and in the Guidance Document can be found at https://pfas-1.itrcweb.org/acronyms/.

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August 2020

ATTACHMENT B

- Retardation Memo

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

MEMORANDUM

To: Katie Servis and Matt Elia

From: Bryan Massa

Date: July 27, 2021

Re: Additional Information on Transport of PFAS Compounds in Subsurface Soils and Groundwater, Cape Cod Gateway Airport, Hyannis, MA

The Horsley Witten Group, Inc. (HW) provided details on the rate of transport of per and polyfluoroalkyl substances (PFAS) in subsurface soils and groundwater at the Airport in the Phase II Comprehensive Site Assessment submitted to the Massachusetts Department of Environmental Protection in March 2021 (the "Phase II Report"). The information in the Phase II Report evaluated the combined rate of transport as the contaminants moved down through the surficial and subsurface soils to the water table and then began moving through the aquifer in the direction of groundwater flow. Based on new information we reviewed regarding the transport of PFAS compounds in the unsaturated soils above the water table, we have reorganized our information to discuss 1) transport of PFAS in the subsurface soils, and 2) transport of PFAS compounds in groundwater. Our overall conclusions on the migration of the PFAS plume from the Deployment Area and ARFF/SRE Area have not changed, but this memo provides additional details on how the contaminants move both in soil and groundwater.

Migration of PFAS Compounds in Unsaturated Soil Above the Aquifer

It can take a considerable amount of time for PFAS to migrate through soil. This is documented in the article titled *Geochemical and Hydraulic Factors Controlling Subsurface Transport of Poly-and Perfluoroalkyl Substances, Cape Cod, Massachusetts* (Weber, et al, 2017) which is related to PFAS assessments conducted at the Massachusetts Military Reservation. Page 4274 of the Weber article indicates "the PFOS present at F586 in 2015 was introduced to the saturated zone around 2000. PFOS transport through the 17-m (41 feet) thick unsaturated zone would have, therefore, taken between 3 and 30 years". This statement verifies that it can take a significant amount of time for PFAS to migrate through unsaturated soils before reaching groundwater. The depth to water below the Deployment Area is approximately 25 feet. As discussed in the Phase II Report, the aqueous film forming foam (AFFF) was only used once a year, sometimes twice a year. The limited release of PFAS compounds and the depth to water at the Deployment Area suggest that it took significant time for the compounds to migrate through the soils into groundwater. The calculations discussed below provide further information on this timing.

Migration of PFAS Compounds in Groundwater

HW has updated our calculations on the rate of PFAS transport in groundwater, separating this migration from the transport through the surficial soils. An explanation of the calculation is provided below followed by an assessment of the transport time in groundwater for one PFAS compound: 6:2 FTS. This compound is associated with the type of AFFF used by the Airport. Although it is not currently one of the MassDEP six regulated PFAS compounds, it has a lower retardation rate compared to the other compounds currently regulated in Massachusetts (known as the Sum of Six). The use of 6:2 FTS is therefore a good representation of the maximum distance the Sum of Six has migrated from the Deployment Area and the ARFF/SRE Area.

Retardation Factor Calculation

The migration of PFAS in groundwater is slower than the velocity at which groundwater moves through the aquifer. This is because the PFAS compounds interact with the organic carbon present in the saturated soils, thereby slowing, or retarding the rate at which they move in the aquifer. The rate at which they move through the aquifer can be determined by calculating the retardation factor for a particular compound using the following formula:

Rf = 1 + d*Kd/n

Rf = retardation factor
d = aquifer bulk density = 1.5
n = porosity = 33 percent = 0.33
kd = (soil) distribution coefficient = foc * Koc
foc = fraction organic carbon
Koc = organic carbon/water partition coefficient

The retardation factor is then used to calculate the slower flow rate for the plume in the aquifer based on the known rate of groundwater flow.

The Phase II Report by HW utilized a total organic carbon (TOC) concentration range between 200 (data from the Barnstable Fire Training Academy) and 2,000 (EPA default TOC value) mg/kg or parts per million (ppm). Subsequent testing for TOC determined ranges that were less than the laboratory reporting limit to 28,900 ppm. Tabulated TOC data and a statistical analysis is included as Table 1. HW recalculated the retardation factor using the various statistical inputs calculated from the TOC data that are attached on Table 2. The KOC values used by HW were obtained from the Environmental Protection Agency's CompTox Chemicals Dashboard.

Migration of 6:2 FTS in Groundwater

Based on the site-specific TOC data, HW analyzed the travel time for 6:2 FTS, the PFAS compound that has the lowest retardation rate when compared to the six PFAS compounds currently regulated by MassDEP. It therefore moves more quickly in groundwater than the other PFAS compounds. Our calculations show that 6:2 FTS in the PFAS plume will travel in groundwater at a maximum of 285 feet per year. This is based on a total organic carbon concentration of 48 mg/kg. The concentrations of TOC from test locations below the water table were below the laboratory reporting limit for the analytical method used in the analysis. The detection limit ranged from 93.5 to 96.9, so 48 mg/kg represents one half the average of the reporting limit and is a reasonable estimate for the TOC concentration in the aquifer soils.

As described in the Phase II Report and as documented with recent groundwater sampling, HW has mapped the downgradient boundary of the main Airport plume as no more than 1,700 feet downgradient of the Deployment Area. This suggests that PFAS in Deployment Area soils reached groundwater approximately six years ago and indicates that it took approximately 21 years for the PFAS to migrate through the site soils before reaching groundwater (original application of AFFF in the deployment area was in 1994). This is consistent with the rate of transport discussed in Weber, et al, and with the water quality data and forensic analysis provided in the Phase II Report. Additional details regarding the retardation factor calculation are set forth below.

- The retardation calculation is site specific as it relies on site specific TOC, hydraulic gradient and hydraulic conductivity data. By applying a range of TOC values in the Phase II Report, HW considered the amount of time it took for PFAS to migrate through the unsaturated soil to reach groundwater. <u>The groundwater velocity range presented by HW in the Phase II Report accounts for migration in both unsaturated and saturated soils.</u> The low end of the range considers migration in both unsaturated and saturated soils and the high end of the range is migration in groundwater only. As discussed above, it can take significant time for PFAS to migrate through unsaturated soils. To form an accurate Conceptual Site Model, the amount of time for migration in the unsaturated soils must be considered.

- As indicated in the Phase II report, the hydraulic gradient was calculated as an average from multiple wells located in the Deployment Area, ARFF/SRE Area, North Ramp, Steamship Parking Lot and the Maher Well Field. The average hydraulic gradient (0.00302 feet per foot) calculated from multiple wells is consistent with the hydraulic gradient calculated in the Deployment Area (0.0030 feet per foot). The average hydraulic conductivity was calculated from pump tests conducted at two wells located in the Deployment Area and one well located in the Maher Well field. The use of “average” values for hydraulic gradient and hydraulic conductivity provides a conservative and realistic approach for calculating plume migration and accounts for the non-homogeneity of the subsurface saturated soils located in the aquifer.

- The Weber, et al study provides field-based calculations of the Kd and Koc values for PFAS compounds present in the plume they analyzed. The table below compares PFOS and 6:2FTS Log K_{oc} values presented in the Weber, et al study to the EPA CompTox Koc presented in the Phase II Report.

Value	Cape Cod Study	Phase II Report
Log K_{oc} for PFOS	3.37+/- 0.27	3.16
Log K_{oc} for 6:2FTS	2.62+/- 1.01	2.97

The EPA CompTox K_{oc} values presented in the Phase II Report for both PFOS and 6:2 FTS were within the site specific laboratory based values presented in Weber, et al. This indicates that the KOC values for these two analytes were similar.

Summary and Conclusion

HW's Phase II Report initially looked at plume migration through the soils and groundwater, developing an average rate of transport through both media. The Weber, et al study points out that it can take significant amount of time for PFAS analytes to migrate in the unsaturated zone before entering groundwater. The calculations provided above show that the plume may have been migrating in groundwater for approximately six years, after taking approximately 21 years to enter the aquifer system. This assumes a very low TOC concentration in the aquifer soils based on tests conducted in proximity to the Maher well field.

The basis for the "average" migration value (66 feet per year) presented in the Airport's Phase II was to provide a conservative estimate of travel time that accounts for both travel in the unsaturated and saturated zones. This average accounts for slow migration in the unsaturated zone (less than 66 feet per year) and a faster migration in the saturated zone (greater than 66 feet per year). Not accounting for the significant time to migrate in the unsaturated zone will significantly overestimate the migration of the plume in groundwater.

Overall, the current location of the plume from the Deployment Area and ARFF/SRE Area is mapped based on the laboratory analysis of groundwater samples in and around the plume and supported by the forensic data described in the Phase II Report and the retardation calculations discussed here.

Attachments

- Table 1 - TOC Data
- Table 2 – Retardation Factor Calculations
- Geochemical and Hydrologic Factors Controlling Subsurface Transport of Poly- and Perfluoroalkyl Substances, Cape Cod, Massachusetts, Weber et al.

Table 1: Total Organic Carbon Levels (mg/kg)

Total Organic Carbon Concentration																	
Sample ID	HW-W dd 3-5 ft	HW-W dd 8-10 ft	HW-W dd 18-20 ft	HW-W dd 23-25 ft	HW-W dd 28-30 ft	HW-W dd 33-35 ft	HW-W dd 38-40 ft	HW-W dd 43-45 ft	HW-W dd 48-50 ft	HW-W dd 58-60 ft	HW-W dd 63-65 ft	S1 0-2ft	S1 2-4ft	S1 4-6ft	S2 0-2ft	S2 2-4ft	S2 4-6ft
Sample Date	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	04/06/2021	4/19/2021	4/19/2021	4/19/2021	4/19/2021	4/19/2021	4/19/2021
Sample Depth (ft below grade)	3-5	8-10	18-20	23-25	28-30	33-35	38-40	43-45	48-50	58-60	63-65	0-2	2-4	4-6	0-2	2-4	4-6
Sample Location	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Water Department Property	Deployment Area	Deployment Area	Deployment Area	Deployment Area	Deployment Area	Deployment Area
Total Organic Carbon	94.8 U	94.3 U	96.5 U	93.9 U	95.7 U	93.5 U	96.9 U	95.7 U	95.7 U	95.7 U	95.7 U	28,900	1,150	180	1,550	95.1 U	3,500
TOC Statistics																	
Average TOC (all data)	2,109																
95 percentile (all data)	8,580																
Average TOC (Surface Samples [0-2ft] Excluded)	360																
95 percentile (Surface Samples [0-2ft] Excluded)	1,855																
Half of the Non-Detect Values	48																

Notes:
Results in mg/kg, milligrams per kilogram.
U= Not detected by the Laboratory above the method detection limit. Method detection limit shown.
Average and 95th percentile includes non-detect samples at one half the detection limit.

Table 2: Retardation Factor Calculations for MassDEP Six PFAS Analytes and 6:2 FTS

Retardation Factor Calculation

Rf = 1 + d*Kd/n

Rf = retardation factor
d = aquifer bulk density = 1.5
n = porosity = 33 percent = 0.33
kd = (soil) distribution coefficient = foc Koc
foc = fraction organic carbon
Koc = organic carbon/water partition coefficient

EPA Physical Properties for PFAS

Values from EPA Comp Tool Box

PFAS	Koc (L/kg)	PFAS Density (g/cm3)	
PFHpA	2,110	PFHpA	1.71
PFHxS	2,300	PFHxS	1.84
PFOA	1,160	PFOA	1.72
PFNA	2,830	PFNA	1.78
PFOS	1,460	PFOS	1.84
PFDA	397	PFDA	1.79
6:2FTS	947	6:2FTS	1.68

TOC Data Barnstable County Fire Training and EPA Default

Location	TOC Decimal Value (excel)	Percent	Concentration
BFTA	0.0002	0.02	200 ppm
EPA Default	0.002	0.2	2000 ppm

Cape Cod Gateway Airport and Water Department Property TOC Data

TOC Decimal Value	TOC Percent	TOC Concentration (ppm)	Notes
0.002109	0.2109	2,109	Average TOC (all data)
0.00858	0.858	8,580	95th Percentile (all data)
0.00036	0.036	360	Average TOC (surface samples excluded)
0.001855	0.1855	1,855	95th percentile (surface samples excluded)
0.000048	0.0048	48	Half the laboratory reporting limit

Retardation Factors from Phase II Report

Retardation Factor Calculation TOC = 200 ppm

(Barnstable County Fire Training TOC Data)

PFAS	d	kd	n	Rf=
PFHpA	1.5	0.4	0.3	2.92
PFHxS	1.5	0.5	0.3	3.09
PFOA	1.5	0.2	0.3	2.05
PFNA	1.5	0.6	0.3	3.57
PFOS	1.5	0.3	0.3	2.33
PFDA	1.5	0.1	0.3	1.36
6:2FTS	1.5	0.2	0.3	1.86

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **185 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 11.35 years

Retardation Factor Calculation TOC = 2,000

(EPA Default TOC Value)

PFAS	d	kd	n	Rf=
PFHpA	1.5	4.22	0.3	20.18
PFHxS	1.5	4.6	0.3	21.91
PFOA	1.5	2.32	0.3	11.55
PFNA	1.5	5.66	0.3	26.73
PFOS	1.5	2.92	0.3	14.27
PFDA	1.5	0.794	0.3	4.61
6:2FTS	1.5	1.894	0.3	9.61

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **35.8 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 58.66 years

Retardation Factors With Site Specific TOC Data

Retardation Factor Calculation TOC = 2,109 ppm

(Average TOC Data from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	4.4	0.3	21.23
PFHxS	1.5	4.9	0.3	23.05
PFOA	1.5	2.4	0.3	12.12
PFNA	1.5	5.2	0.3	24.86
PFOS	1.5	3.1	0.3	15.00
PFDA	1.5	0.8	0.3	4.81
6:2FTS	1.5	2	0.3	10.08

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **34 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 61.8 years

Retardation Factor Calculation TOC = 8,580

(95th Percentile TOC Data from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	18.1	0.3	83.29
PFHxS	1.5	19.73	0.3	90.70
PFOA	1.5	9.953	0.3	46.24
PFNA	1.5	24.28	0.3	111.37
PFOS	1.5	12.53	0.3	57.94
PFDA	1.5	3.406	0.3	16.48
6:2FTS	1.5	8.125	0.3	37.93

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **9.069 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 231.56 years

Table 1: Retardation Factor Calculations for MassDEP Six PFAS Analytes and 6:2 FTS

Retardation Factor Calculation

Rf = 1 + d*Kd/n

Rf = retardation factor
d = aquifer bulk density = 1.5
n = porosity = 33 percent = 0.33
kd = (soil) distribution coefficient = foc Koc
foc = fraction organic carbon
Koc = organic carbon/water partition coefficient

EPA Physical Properties for PFAS

Values from EPA Comp Tool Box

PFAS	Koc (L/kg)	PFAS	PFAS Density (g/cm3)
PFHpA	2,110	PFHpA	1.71
PFHxS	2,300	PFHxS	1.84
PFOA	1,160	PFOA	1.72
PFNA	2,830	PFNA	1.78
PFOS	1,460	PFOS	1.84
PFDA	397	PFDA	1.79
6:2FTS	947	6:2FTS	1.68

TOC Data Barnstable County Fire Training and EPA Default

Location	TOC Decimal Value (excel)	Percent	Concentration
BFTA	0.0002	0.02	200 ppm
EPA Default	0.002	0.2	2000 ppm

Cape Cod Gateway Airport and Water Department Property TOC Data

TOC Decimal Value	TOC Percent	TOC Concentration (ppm)	Notes
0.002109	0.2109	2,109	Average TOC (all data)
0.00858	0.858	8,580	95th Percentile (all data)
0.00036	0.036	360	Average TOC (surface samples excluded)
0.001855	0.1855	1,855	95th percentile (surface samples excluded)
0.000048	0.0048	48	Half the laboratory reporting limit

Retardation Factors With Site Specific TOC Data (Continued)

Retardation Factor Calculation TOC = 360 ppm

(Average TOC Value with Surface Samples Excluded from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	0.8	0.3	4.45
PFHxS	1.5	0.8	0.3	4.76
PFOA	1.5	0.4	0.3	2.90
PFNA	1.5	1	0.3	5.63
PFOS	1.5	0.5	0.3	3.39
PFDA	1.5	0.1	0.3	1.65
6:2FTS	1.5	0.3	0.3	2.55

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **135 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 15.56 years

Retardation Factor Calculation TOC = 1,855

(95th percentile TOC Value with Surface Samples Excluded from Cape Cod Gateway Airport and Water Department Property)

PFAS	d	kd	n	Rf=
PFHpA	1.5	3.914	0.3	18.79
PFHxS	1.5	4.267	0.3	20.39
PFOA	1.5	2.152	0.3	10.78
PFNA	1.5	5.25	0.3	24.86
PFOS	1.5	2.708	0.3	13.31
PFDA	1.5	0.736	0.3	4.35
6:2FTS	1.5	1.757	0.3	8.98

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **38.29 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 54.85 years

Retardation Factor Calculation TOC = 50 ppm

(Half of the laboratory reporting limit for samples in saturated soils)

PFAS	d	kd	n	Rf=
PFHpA	1.5	0.1	0.3	1.46
PFHxS	1.5	0.1	0.3	1.50
PFOA	1.5	0.1	0.3	1.25
PFNA	1.5	0.1	0.3	1.62
PFOS	1.5	0.1	0.3	1.32
PFDA	1.5	0	0.3	1.09
6:2FTS	1.5	0	0.3	1.21

Plume Migration Estimate in years (Velocity/6:2 FTS Rf)

Velocity is 344 feet per year (pump test/Freeze and Cherry)

Migration: **285 feet per year**

Distance from Deployment Area to OW-19 is 2,100 feet
Estimated time to travel is 7.37 years

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Geochemical and Hydrologic Factors Controlling Subsurface Transport of Poly- and Perfluoroalkyl Substances, Cape Cod, Massachusetts

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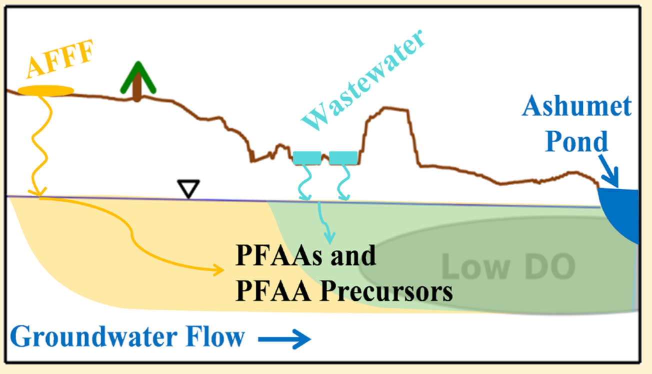
Supporting Information

ABSTRACT: Growing evidence that certain poly- and perfluoroalkyl substances (PFASs) are associated with negative human health effects prompted the U.S. Environmental Protection Agency to issue lifetime drinking water health advisories for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) in 2016. Given that groundwater is a major source of drinking water, the main objective of this work was to investigate geochemical and hydrological processes governing the subsurface transport of PFASs at a former fire training area (FTA) on Cape Cod, Massachusetts, where PFAS-containing aqueous film-forming foams were used historically. A total of 148 groundwater samples and 4 sediment cores were collected along a 1200-m-long downgradient transect originating near the FTA and analyzed for PFAS content. The results indicate that unsaturated zones at the FTA and at hydraulically downgradient former domestic wastewater effluent infiltration beds both act as continuous PFAS sources to the groundwater despite 18 and 20 years of inactivity, respectively. Historically different PFAS sources are evident from contrasting PFAS composition near the water table below the FTA and wastewater-infiltration beds. Results from total oxidizable precursor assays conducted using groundwater samples collected throughout the plume suggest that some perfluoroalkyl acid precursors at this site are transporting with perfluoroalkyl acids.



INTRODUCTION

Poly- and perfluoroalkyl substances (PFASs) are common contaminants in the aquatic environment because of their widespread use in consumer and industrial applications, such as protective coatings, and as a major component in aqueous film-forming foams (AFFFs).[1−4] PFASs have been associated with cancer, immune dysfunction in children, obesity, and thyroid disease, among other adverse health outcomes.[5−8] Given that groundwater is a major source of drinking water and constitutes approximately 22% of total water use in the United States,[9] there is an urgent need to understand the subsurface fate and transport of PFASs.

Groundwater, soil, and surface water contamination from use of AFFFs during fire-related emergencies and fire-training activities has caused increasing concern for groundwater quality because AFFFs are a highly concentrated PFAS point source.[3,10] Fire training areas (FTAs) are potential sources of long-term PFAS influx to the unsaturated zone and groundwater, particularly where hydrocarbon fires were repeatedly extinguished with AFFFs over unlined soil. Studies conducted at several sites impacted by use of AFFFs report groundwater concentrations of perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA, also known as perfluorooctanoate in the anionic form) above the U.S. Environmental Protection Agency (EPA) lifetime drinking water health advisory level of 70 ng L^{-1} for the combined concentration of PFOS and PFOA, with some sites reaching up to 5 orders of

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magnitude above this limit.[11−18] Other PFASs do not presently have EPA health advisories.

AFFF formulations are complex mixtures that generally contain 1−5% w/w PFASs,[10] and are diluted with water before use such that the final solution contains 1−6% v/v of the initial formulation. In 2004, the U.S. inventory of AFFFs was estimated to be 3.75 × 10^7 kg.[19] Major users include the military (29%), commercial aviation (16%), fire departments (14%), and the petrochemical industry (39%).[19] Polyfluoroalkyl substances, often a major constituent of AFFFs and other products, can transform into perfluoroalkyl acids (PFAAs), which are extremely recalcitrant to further transformation.[20−26] PFAAs include both perfluorinated sulfonates and carboxylates.

Another significant source of PFASs to the aquatic environment is their use in consumer products and discharge from wastewater treatment plants (WWTPs).[27−29] PFASs are typically not removed through the treatment process, and some PFAAs have been shown to increase in concentration during treatment as a result of PFAA precursor (from now on referred to as precursor) transformation.[27−29]

The main objective of this study was to provide information on the factors affecting subsurface mobility of PFASs and the potential for precursor transformation at a site with groundwater contamination from both FTA and WWTP sources. High resolution spatial data at sites contaminated with PFASs are currently lacking and there is limited knowledge of the complex processes controlling PFAS subsurface fate and transport. To address this gap, groundwater samples were collected from wells located along a 1200-m-long transect oriented in the direction of the regional groundwater flow on western Cape Cod, MA. The upgradient wells are located around a former FTA, and 580−690 m downgradient along the flow path is a former WWTP where secondarily treated domestic wastewater effluent was disposed of into infiltration beds. Concentrations of PFASs were measured in groundwater samples collected from wells located at various depths and distances from the FTA to characterize subsurface distributions in a shallow, unconfined sand and gravel aquifer. Sediment cores were collected adjacent to selected groundwater sampling locations and analyzed for PFASs to determine in situ sediment/water distribution coefficient (K_d) values. In addition, total oxidizable precursor assays were conducted in the laboratory on selected groundwater samples to determine the presence of precursor compounds and the potential for transformation to PFAAs. The results of this study provide a unique data set on a complex groundwater contamination plume originating from multiple sources.

■ METHODS

Site Description and Hydrologic Setting. The study was conducted on western Cape Cod, Massachusetts (Figures 1 and S1), at the U.S. Geological Survey (USGS) Cape Cod Toxic Substances Hydrology Research Site[30] located on Joint Base Cape Cod. At this site, a groundwater contaminant plume resulting from disposal of treated domestic wastewater has been the subject of long-term hydrogeology and biogeochemistry research.[31−40] The FTA at Joint Base Cape Cod (FTA-1) was used from 1958 to 1985, and records indicate that jet fuel, chlorinated hydrocarbons, transformer oils, paint thinners, and gasoline were released at the site.[41] Use of AFFFs at FTA-1 likely began in 1970 and continued until 1985, with one additional application in 1997.[42,43] Thermal soil remediation targeting fuel constituents and chlorinated solvents was

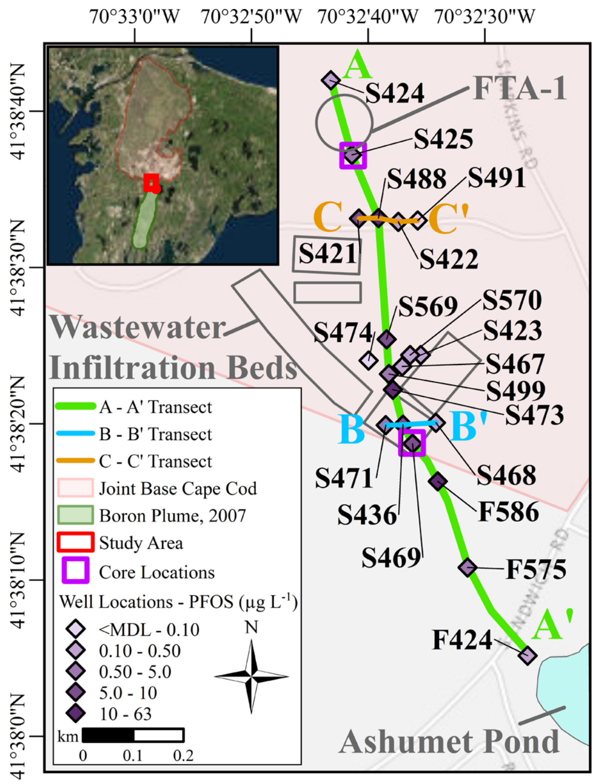

Figure 1. Locations and identifiers of groundwater monitoring sites (diamond symbols) sampled during 2015 at the Cape Cod study site. Symbol shading corresponds to the maximum PFOS concentration at each site because PFOS was often the highest PFAS concentration in groundwater samples. Nearly all locations were sampled at multiple depths. The boron plume indicates the extent of the wastewater plume.[34]

undertaken at FTA-1 in 1997.[43] The soil was excavated to a maximum depth of 11 m below land surface (the water table is approximately 17 m below land surface) and heated to between 157 and 204 °C before being backfilled.[43] Because PFOA is thermally stable up to 300 °C, and perfluorinated sulfonates require even higher temperatures for thermolysis,[44,45,46] the soil treatment was unlikely to have reduced concentrations of PFAAs. Some precursors may have been thermolyzed to form PFAAs.

FTA-1 is located 580 m upgradient of a WWTP, where domestic wastewater produced on the military base was treated from 1936 to 1995 and the effluent disposed of into the sand and gravel aquifer through infiltration beds (Figure 1).[47] Wastewater effluent disposal to the aquifer resulted in a large and chemically complex contaminant plume currently characterized by low dissolved oxygen (DO) concentrations and elevated concentrations of dissolved organic carbon (DOC), nitrate, phosphate, ammonium, boron, and organic micropollutants.[35,36,39] Boron is used as an indicator for the wastewater plume location (Figure 1).[34]

The glacial outwash sediments that comprise the unconfined aquifer at the study site consist of medium to coarse sand and gravel. Hydraulic properties measured during a large-scale tracer experiment at the site include a hydraulic conductivity of 110 m d^{-1}, porosity of 0.39, and average flow velocity of 0.42 m d^{-1}.[48,49] Recharge to the aquifer from precipitation is 73 cm $year^{-1}$.[50] The water table altitude can fluctuate by ∼1 m $year^{-1}$

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Table 1. Compound Names, Abbreviations, and Key Properties of Poly- and Perfluoroalkyl Substances and the Organic Carbon Normalized Sediment/Water Partition Coefficients (K_{oc}) Measured in This Study, as Well as Select K_{oc} Values from the Literature[a]

compound name	abbrev.	mol formula	mol wt	pK_a [53,54]	av log K_{oc} (this study)	av log K_{oc} (lit., laboratory-based)[55−58] low−high range provided	av log K_{oc} (lit., field-based)[12,59,60] low−high range provided
				perfluorinated carboxylates			
perfluorobutanoate	PFBA	$C_3F_7COO^-$	213	0.4		1.72 ± 0.29−1.88 ± 0.11	2.17 ± 1.10
perfluoropentanoate	PFPeA	$C_4F_9COO^-$	263	−0.1	**2.17 ± 0.77**	1.37 ± 0.46−1.71 ± 0.07	1.85 ± 0.70
perfluorohexanoate	PFHxA	$C_5F_{11}COO^-$	313	−0.16	**2.56 ± 0.17**	1.31 ± 0.29−1.90 ± 0.04	1.91 ± 0.39−2.06 ± 0.67
perfluoroheptanoate	PFHpA	$C_6F_{13}COO^-$	363	−0.19	**2.76 ± 0.09**	0.23 ± 0.92−1.63 ± 0.15	2.04 ± 0.48−2.19 ± 0.65
perfluorooctanoate	PFOA	$C_7F_{15}COO^-$	413	−0.2	**2.61 ± 0.69**	−0.22 ± 1.26−2.4 ± 0.12	1.9 ± 0.1−2.31 ± 0.35
perfluorononanoate	PFNA	$C_8F_{17}COO^-$	463	−0.21	**2.82 ± 0.01**	1.83 ± 0.43−2.39 ± 0.09	2.33 ± 0.31−2.4 ± 0.1
perfluorodecanoate	PFDA	$C_9F_{19}COO^-$	513	−0.21	**3.39 ± 0.02**	2.59 ± 0.45−2.96 ± 0.15	3.17 ± 0.14−3.6 ± 0.1
perfluoroundecanoate	PFUnDA	$C_{10}F_{21}COO^-$	563	−0.21	**4.31 ± 0.08**	3.30 ± 0.11−3.56	4.8 ± 0.2
perfluorododecanoate	PFDoDA	$C_{11}F_{23}COO^-$	613	−0.21			
				perfluorinated sulfonates			
perfluorobutane sulfonate	PFBS	$C_4F_9SO_3^-$	299	0.14		−0.76 ± 0.58−1.79 ± 0.10	2.06 ± 0.77
perfluorohexane sulfonate	PFHxS	$C_6F_{13}SO_3^-$	399	0.14	**2.32 ± 0.15**	0.66 ± 0.65−2.05 ± 0.08	2.28 ± 0.70−3.6 ± 0.1
perfluorooctane sulfonate	PFOS	$C_8F_{17}SO_3^-$	499	0.14	**3.37 ± 0.27**	2.40 ± 0.46−3.7 ± 0.56	3.14 ± 0.66−3.8 ± 0.1
perfluorodecane sulfonate	PFDS	$C_{10}F_{21}SO_3^-$	599	0.14	**3.63**	3.53 ± 0.12	
				perfluoroalkyl sulfonamides			
perfluorooctane sulfonamide[b]	FOSA	$C_8F_{17}SO_2NH_2$	499	6.52	**4.86**	4.1 ± 0.35	4.3 ± 0.2
				fluorotelomer sulfonates[b]			
6:2 fluorotelomer sulfonate	6:2 FtS	$C_6F_{13}CH_2CH_2SO_3^-$	427	0.36	**2.62 ± 1.01**		
8:2 fluorotelomer sulfonate	8:2 FtS	$C_8F_{17}CH_2CH_2SO_3^-$	527		**3.65 ± 0.54**		

[a]See referenced work for details. The poly- and perfluoroalkyl substances are reported in anionic form (except for perfluorooctane sulfonamide). K_{oc} values from this study are calculated from measured K_d values and fraction of organic carbon (f_{oc}) values (see Table S2), and may be uncertain based on the difficulty in quantifying low total organic carbon values (<0.0003). [b]Perfluorooctane sulfonamide and the fluorotelomer sulfonates are specific perfluoroalkyl acid precursor compounds analyzed for this study.

depending on precipitation[49] and is about 17 and 6.5 m below land surface at FTA-1 and the infiltration beds, respectively.

Groundwater and Aquifer Sediment Sampling. Groundwater samples (Figures 1 and S1) were collected according to USGS field protocols[51] during 2014 and 2015 from a network of monitoring-well clusters, multilevel samplers, and continuous multichannel tubing wells (herein, all sampling types are referred to as wells). Sediment cores were collected at S425 (one 1-m core) and at S469 (three 1-m cores) using a piston-type coring device (see Methods section of SI).

A total of 148 groundwater samples were collected during June and December 2014 (19 samples), May−July 2015 (118 samples), and November 2015 (11 samples) from 25 well locations. Note that most well locations (Figure 1) have multiple depths associated with each site.[52] The 1200-m-long A−A′ longitudinal transect (Figure 1) includes 11 well locations (81 sampling points) along the direction of groundwater flow. There are 9 additional well locations (37 sampling points) located transverse to the A−A′ transect (Figure 1), including the B−B′ and C−C′ transects (Figure S2). During June 2014, 5 additional well locations were sampled that are located at greater downgradient distances than the A−A′ transect (Figure S1). Unless otherwise noted, the discussion and statistics focus on the major sampling in May−July 2015 to minimize any temporal variability. All distances within the A−A′ transect are given along the direction of groundwater flow relative to the estimated center of FTA-1 based on site maps.[41] The transect passes through the infiltration beds and ends near Ashumet Pond (Figure 1). Ancillary water quality analyses[37] were conducted and include specific conductance, pH, temperature, DO, phosphate, nitrate, and DOC.[52]

Analytical Materials. Native and isotopically labeled PFAS standards were purchased from Wellington Laboratories (Guelph, Canada). The PFAS compound names, abbreviations, and key properties are listed in Table 1. Details on the analytical internal standards are listed in Table S1. A Barnstead NANOpure Infinity (Lake Balboa, CA) water system provided deionized water (DI) with a resistivity of >18 MΩ cm^{-1}. Other materials are described in the SI.

Sample Analysis. Samples were analyzed for PFASs with liquid chromatography-tandem mass spectrometry (LC-MS/MS) using modifications of previously described methods (see SI).[12,21] All groundwater samples, laboratory DI water blanks, and calibration curve points were prepared in a 50:50 water/methanol solution with internal standards. Samples were analyzed with an Agilent (Santa Clara, CA) 6460 triple quadrupole LC-MS/MS in negative ion mode using an Agilent Poroshell 120 EC-C18 column with mobile phases of 2 mM ammonium acetate in water and 2 mM ammonium acetate in methanol. Duplicate measurements of ∼30% of the samples produced good sample reproducibility (<20% relative standard deviation on average) for 6:2 FtS and PFAAs with a chain length of C_9 or less. 8:2 FtS and FOSA had relative standard

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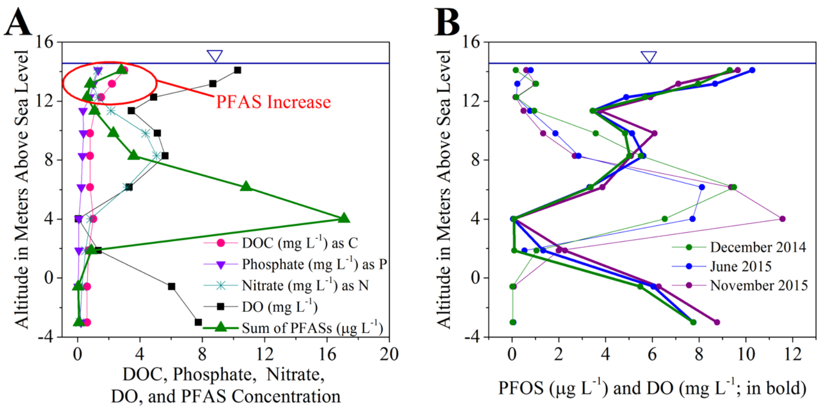

Figure 2. Vertical profiles at well S469 located in the wastewater infiltration beds showing (A) geochemical conditions and distribution of the sum of poly- and perfluoroalkyl substances (PFASs) in June 2015 and (B) time series profiles for dissolved oxygen (DO) and perfluorooctane sulfonate (PFOS). In June 2015, PFOS is on average 46% of the total molar concentration of the sum of measured PFASs at well S469. Inverted triangles show the position of the water table.

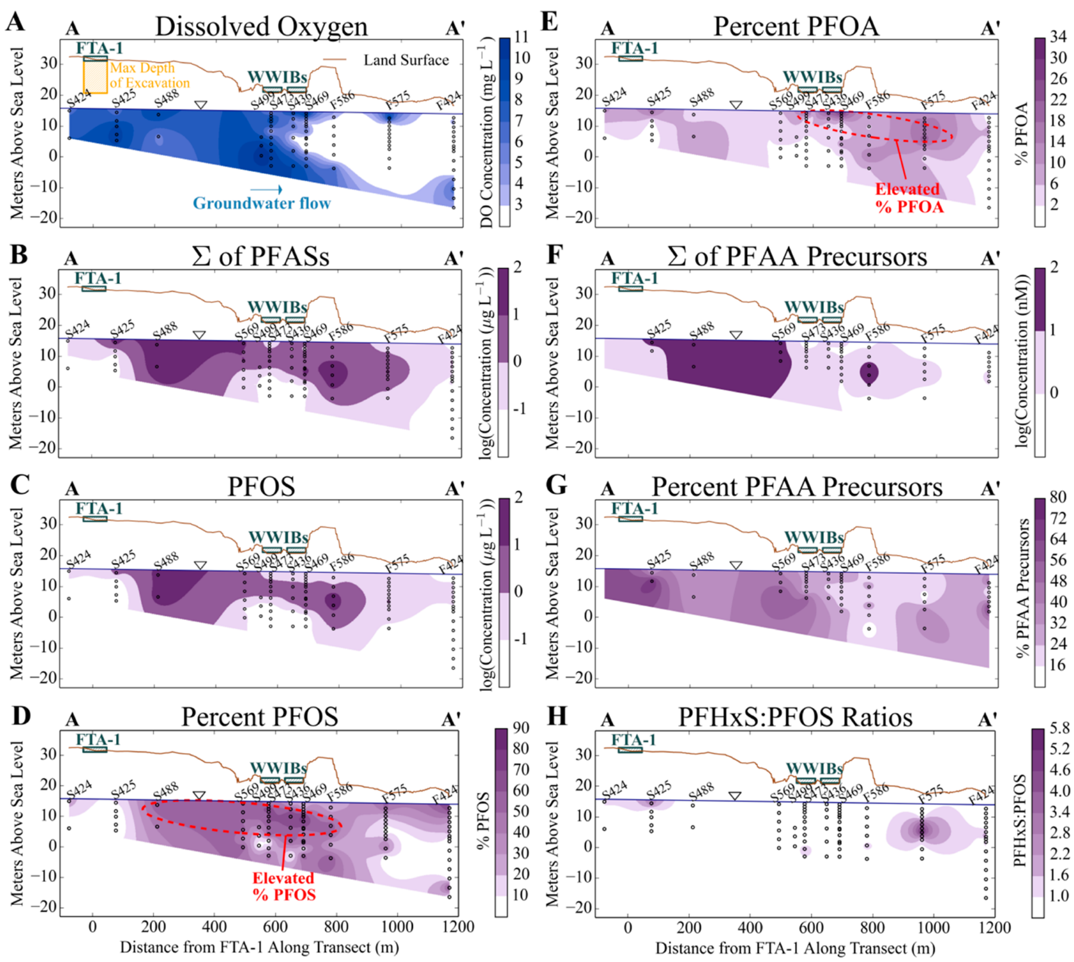

Figure 3. Vertical sections along longitudinal transect A–A′ showing (A) dissolved oxygen concentrations (max = 11 mg L^{-1}), (B) the sum of poly- and perfluoroalkyl substance (PFAS) concentrations listed in Table 1 (max = 95 μg L^{-1}), (C) perfluorooctane sulfonate (PFOS) concentrations (max = 63 μg L^{-1}), (D) PFOS molar percentage of total measured PFASs (max = 82%), (E) perfluorooctanoate (PFOA) molar percentage of total measured PFASs (max = 32%), (F) the molar sum of perfluoroalkyl acid (PFAA) precursors as determined by the total oxidizable precursor assay (max = 78 nM), (G) precursor molar percentage of total PFASs (the sum of precursors and measured perfluoroalkyl acids pre-oxidation) (max = 78%), and (H) the perfluorohexane sulfonate (PFHxS):PFOS ratios (max = 5.8). [Circles indicate sampling sites. Inverted triangles indicate the water table. FTA-1 refers to the fire training area and WWIBs refers to wastewater infiltration beds. Box beneath FTA-1 in panel (A) shows maximum depth of soil excavated and thermally treated in 1997. Vertical exaggeration is 10× for all vertical sections. The lower boundary of the colored areas is the line connecting the maximum sampled depths, and the upper boundary is set at the water table.]

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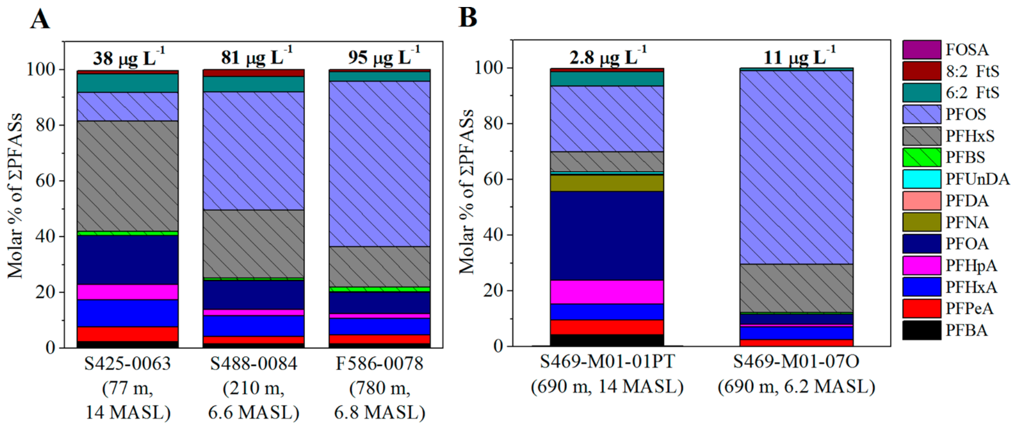

Figure 4. Molar percentages of individual poly- and perfluoroalkyl substances (PFASs) in groundwater collected (A) at well S425, located near FTA-1, and wells S488 and F586, located at 210 and 780 m downgradient from FTA-1, respectively, at the depths with the highest concentrations, and (B) at well S469, located 690 m downgradient from FTA-1 in the wastewater treatment plant infiltration beds, from just below the water table (14 m altitude) and from the deeper (6.2 m altitude) portions of the PFAS plume. [See Table 1 for explanation of abbreviations. Total PFAS concentration is shown at the top of each column, and distance from FTA-1 (m), followed by the altitude in meters above sea level (MASL) are shown in parentheses below each well name.]

deviations of 42% and 71% (FOSA concentration near method detection limit), respectively.

Total Oxidizable Precursor Assays. A slightly modified PFAS total oxidizable precursor assay developed by Houtz and Sedlak[61] and Houtz et al.[21] was employed here. For each of the 46 groundwater samples analyzed, 3 mL of a 120 mM potassium persulfate and 250 mM sodium hydroxide solution was added to 3 mL of groundwater sample in an 8 mL HDPE bottle and heated for 6 h at 85 °C in a circulating water bath.[21,61] Samples were cooled, neutralized with hydrochloric acid,[21,61] and stored at 4 °C until offline solid phase extraction (SPE) and LC-MS/MS analysis (see SI for experimental details and recoveries). Total oxidizable precursor experiments were duplicated for 30% of the samples. The relative standard deviation for duplicates was <15% on average for all PFAAs with C_9 or shorter chain lengths.

Partition Coefficient Experiments. Sediment cores were collected from the same depths as selected corresponding groundwater samples at the FTA-1 (near well S425) and infiltration bed (near well S469) sites to determine in situ K_d values. Subsamples of each sediment core were centrifuged at 4000 rpm for 20 min, and the pore water was removed for LC-MS/MS analysis. The sediment was dried, sieved to <2.36 mm, homogenized and extracted for PFAS content three times with 0.1% ammonium hydroxide in methanol (see SI for details).[21,62] Sediment samples were analyzed for PFASs, organic carbon, and mineralogy as described in the SI (Tables S2 and S3).

■ RESULTS AND DISCUSSION

Spatial Analysis. Vertical profiles of water chemistry show variations with depth below the water table reflecting aquifer geochemical conditions and source zone influences. The full set of chemical results for all groundwater analysis are presented elsewhere.[52] At well S469, which is located in one of the infiltration beds, concentrations of DOC and phosphate decreased rapidly with depth below the water table, the nitrate peak occurred at an altitude of 8 m, the DO minimum occurred at an altitude of 2−4 m, and total PFASs had a distinct peak at an altitude of 4 m (Figure 2A). The vertical relationships at S469 were stable over time, and the maximum PFOS concentrations coincided with the DO minimum (Figure 2B). The low DO zone downgradient from S469 (Figure 3A) is a distinct characteristic of the wastewater plume from the infiltration beds, that developed from microbial activity during attenuation of the wastewater contaminants.[35,63,64]

The A−A′ longitudinal transect shows that the sum of PFASs (Figure 3B) forms a relatively shallow (<30 m below land surface) plume that originates beneath FTA-1, extends over 1200 m downgradient in the direction of groundwater flow, and passes beneath (and mixes with) the PFAS plume that originates at the infiltration beds. The sum of PFASs is referenced here primarily to describe the plume shape, while individual PFASs provide insight into sources, transport, and transformation. The width of the PFAS plume is relatively narrow as evidenced by the transverse B−B′ and C−C′ cross sections (Figures 1 and S2), but may widen downgradient from the infiltration beds. The maximum concentrations of PFOS (63 μg L^{-1}; Figure 3C) and sum of PFASs (95 μg L^{-1}; Figure 3B) were observed at F586 (780 m downgradient from FTA-1). The maximum PFOA (8.0 μg L^{-1}) and PFHxS (18 μg L^{-1}) concentrations occurred at S488 (210 m downgradient from FTA-1).[52] The molar perfluorinated sulfonate:perfluorinated carboxylate ratios for the groundwater ranged from 0.3 to 14, with a median of 2.8. Except for FOSA, all PFASs are strong acids (Table 1) that are anionic at the groundwater pH (ranged from 4.7 to 6.3).[53,54]

PFAS Sources. The distribution of PFASs in the groundwater immediately downgradient from FTA-1, particularly the elevated PFOS concentrations, along with the occurrence of branched isomers (Figure S3) confirms their origin from electrochemical fluorination−based AFFFs, as expected because of the history of electrochemical fluorination−based AFFF military usage.[19,21,65] The detection of 6:2 FtS and 8:2 FtS in groundwater similarly indicates that fluorotelomer-based AFFFs also were used at this site,[65] although likely less frequently than electrochemical fluorination-based AFFFs, as evident from the observed prevalence of perfluorinated sulfonates and presence of branched isomers.

The FTA-1 and infiltration beds appear to be two distinct long-term PFAS contaminant sources to the aquifer as evidenced by elevated concentrations just below the water

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table at both sites (Figures 2A and 3B). Further, the compositionally distinct PFAS signatures from these locations indicate two different sources. The composition of the shallow groundwater below FTA-1 (S425, 14 m altitude) is consistent with the characteristics of AFFF formulations and precursor transformation (Figure 4A). PFHxA and PFHxS, expected products of precursor transformation (since previously investigated AFFFs contained significant quantities of C_6 precursors),[21] account for about 50% of the PFASs, and the remainder is primarily PFOA, PFOS, and 6:2 FtS. The deeper downgradient wells (S488 and F586 at 6.6 and 6.8 m altitude, respectfully, Figure 4A) reflect an AFFF source based on the high sum of PFAS concentrations, with PFOS ranging from 42 to 59% of the molar sum of PFASs. The predominance of PFOS along the plume (Figure 3C and 3D), the known history of fire training with AFFF, and the clear outline of the PFOS plume emanating from the FTA (Figure 3C) indicate that the high PFAS concentrations (Figure 3B) result from the FTA-1 source.

The PFAS composition of shallow groundwater beneath the infiltration beds (S469, 14 m altitude, Figure 4B) has a lower proportion of PFHxS and a higher proportion of PFOA than shallow groundwater from the same altitude beneath FTA-1 (S425). Concentrations of total PFASs at S469 were generally greatest at 4−6 m in altitude (from the influence of the upgradient FTA source) and decreased steadily upward before increasing just below the water table (Figure 2A), indicating the infiltration beds also are a continuing PFAS source, but with lower concentrations. Domestic wastewater is a well-known source of PFASs.[27−29,66] Enrichment of PFOA and other PFAAs in the shallow groundwater beneath and downgradient from the infiltration beds (the percent PFOA is nearly twice that at FTA-1; Figure 4) indicates that the secondary treated wastewater had a different PFAS composition than the FTA-1 source. The influence of wastewater can be seen most clearly by the elevated proportions of PFOA in Figure 3E. PFOA is a major component of PFASs in wastewater (reaching 1050 ng L^{-1} in one U.S. wastewater treatment plant) and has been shown to increase in concentration through the wastewater treatment process as a result of precursor transformation.[27,28,66,67] PFNA concentrations also have been shown to increase during treatment as a result of precursor transformation.[28] Notably, PFNA concentrations were highest in the shallow sample from S469 at the infiltration beds (Figure 4B).

Formulations of AFFF previously measured by others had PFOS:PFOA ratios ranging from 49 to 110.[21] The historical PFAS composition of the WWTP effluent is unknown, but the profile at S469 indicates that the composition of the shallow, lower concentration groundwater is consistent with a wastewater source and the composition of the deeper, higher concentration groundwater is consistent with an FTA source (Figures 2A and 4B). In the groundwater downgradient from the infiltration beds, the two PFAS sources comingle and the high concentrations emanating from the FTA-1 overwhelm the lower wastewater concentrations. For example, the sampling location at F586 containing the maximum PFOS concentration at the field site (63 μg L^{-1}) also has 7.5% PFOA, greater than the median value of 4.5% PFOA (Figure 3C and 3E).

Because domestic wastewater disposal at the infiltration beds ceased in 1995,[35] the persistence of elevated PFAS concentrations near the water table suggests that they are sorbed to the unsaturated and saturated zone sediments beneath the infiltration beds and are slowly being desorbed and transported to the groundwater. Precursors retained in the unsaturated zone also could be transforming into more mobile PFAAs, which then migrate to the saturated zone. Similar processes of sorption, desorption, and precursor transformation in the unsaturated zone and shallow saturated zone also are likely occurring at the FTA-1 source area. Overall, the unsaturated zones continue to be a source of PFASs to the groundwater after 18 years (FTA-1) and 20 years (infiltration beds) of inactivity.

Sorption and Advective Transport. Results from the field-determined in situ K_d values were normalized to the fraction of sediment organic carbon (f_{oc} ranged from 0.00013 to 0.0003), and the average log K_{oc} ($K_{oc} = K_d/f_{oc}$) values ranged from 2.2 to 4.9 L kg C^{-1} (Tables 1 and S2, see SI for calculations). The PFAS K_{oc} results from this study are similar to other investigations where observed field-determined values are typically higher than laboratory-derived values. McGuire et al.[12] suggested that higher perfluorinated carboxylate log K_{oc} values may be due in part to carboxylate precursor breakdown during the sediment extraction process. The high K_{oc} values in this study suggest that other sorption mechanisms besides partitioning into sediment organic carbon are important for low organic carbon sediments. The aquifer mineralogy consists predominantly of quartz and feldspar with only trace amounts of metal oxides and clay minerals (Table S3).

Once PFOS is introduced into the groundwater beneath FTA-1, it is estimated to take 15 years to travel the 780 m distance to F586, where the highest PFOS concentrations were observed. This estimate is based on simple 1-D advective transport along the transect, a groundwater velocity of 0.42 m d^{-1}, and a PFOS K_d value of 0.45 L kg^{-1} (log $K_{oc} = 3.37$, $f_{oc} = \sim 0.00019$). On the basis of the estimated 15-year transport time to F586, the PFOS present at F586 in 2015 was introduced to the saturated zone around 2000. PFOS transport through the 17-m-thick unsaturated zone would have, therefore, taken between 3 and 30 years, given that AFFF use occurred between 1970 and 1997. PFOA, PFNA, and PFAAs with C_4−C_7 chain lengths are predicted to be transported farther than PFOS based on lower in situ K_{oc} and K_d values (Tables 1 and S2). However, the observed distribution of PFOA is similar to PFOS, possibly due to the in situ production of PFAAs from precursor transformation. The leading edge of the FTA-1 PFAS plume has likely been transported farther downgradient than the A−A′ transect, as suggested by detection of PFOS in wells located up to ∼4 km downgradient from FTA-1 (Figure S1).

Influence of Wastewater Disposal on Groundwater Geochemistry. Following the cessation of treated wastewater disposal at the infiltrations beds in 1995, the mobile components of the wastewater plume, such as boron, have been transported beyond the A−A′ transect.[34] However, there is still a residual impact of wastewater disposal on the aquifer, clearly defined by the low DO zone downgradient from the infiltration beds (Figure 3A) more than 20 years after disposal ended. The highest PFOS concentration (Figure 3C) occurred in the zone with low DO concentrations.

Historical hydrologic loading of the treated wastewater to the aquifer is estimated to have been between 380 and 5700 m^3 d^{-1} between 1936 and 1995.[68] Specific conductance of the effluent ranged from 340 to 520 μS cm^{-1} and DOC concentrations ranged from 6.4 to 19 mg L^{-1}.[35,47] Continuous monitoring of groundwater quality at S469 since the end of wastewater disposal in 1995 has shown slowly decreasing DOC concentrations that continue to persist (3.0 mg L^{-1} during

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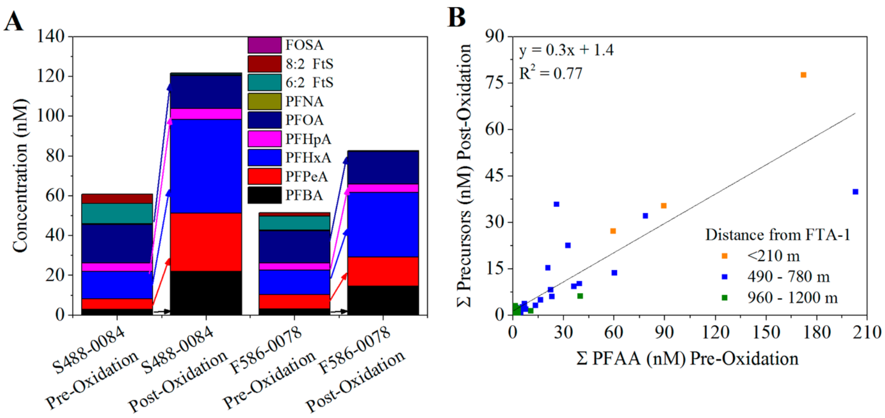

Figure 5. Results from the total oxidizable precursor assay conducted on selected groundwater samples. (A) Concentrations of poly- and perfluoroalkyl substances in groundwater samples from wells S488-0084 and F586-0078 pre- and post-oxidation and (B) linear relationship between the groundwater sample molar sum of perfluoroalkyl acid (PFAA) concentrations pre-oxidation and the molar sum of precursors post-oxidation (n = 46). [FTA-1 is the fire training area. Compound abbreviations can be found in Table 1.]

June 2015 sampling, Figure S4A) above background levels because of desorption of organic carbon from the aquifer sediments.[35,63] Specific conductance also has remained elevated (183 μS cm^{-1} at S469 during June 2015 sampling), and DO concentrations remain low because of persistent biogeochemical oxygen demand (Figures 2 and 3A).[35]

The persistent wastewater-related geochemical conditions encountered by the FTA-1 PFAS plume as it passed through the residual wastewater plume include elevated concentrations of dissolved ions and sediment organic carbon, both factors that can influence PFAS transport.[55,56,69] Groundwater beneath the infiltration beds remained oxic to suboxic during the period of wastewater disposal because of the introduction of oxygenated treated wastewater.[63,64] The oxygenated conditions resulted in stability of iron and manganese oxide grain coatings on the aquifer sediments.[63,64,70] The increased sediment organic carbon and ionic interactions resulting from wastewater loading may have enhanced PFAS sorption beneath the infiltration beds through both hydrophobic and electrostatic interactions. The higher K_{oc} values for PFOS indicate greater sorption to the sediments than PFOA and shorter chain length PFAAs.

The PFASs that were sorbed to the aquifer sediments under wastewater disposal conditions were potentially remobilized following cessation of disposal, owing to (1) reduction in dissolved ion concentrations, (2) desorption of sediment organic carbon, and (3) reductive dissolution of positively charged iron and manganese oxide grain coatings following the onset of anoxic conditions beneath the infiltration beds.[35,64,70] Electrostatic interactions with dissolved iron(II) may promote transport of PFOS.[71] The slow desorption of sediment organic carbon beneath the infiltration beds releases DOC and other hydrophobically sorbed contaminants, including PFASs, while a reduction in dissolved ion concentrations may increase the repulsion between the negatively charged quartz and feldspar aquifer sediments (Table S3)[31] and anionic PFASs. A combination of factors likely led to the elevated PFOS concentrations at F586, although elevated concentrations of shorter-chain length PFAAs, such as PFBS at well F586 (Figure S4B), also suggest remobilization.[72]

Total Oxidizable Precursor Assays. The total oxidizable precursor assay can be employed to estimate total PFAA precursor concentrations by oxidizing polyfluorinated compounds into perfluorinated carboxylates and measuring the increase in molar carboxylate concentrations.[21,61] A sulfonamide precursor with C_n (n = the number of carbons in the chain) is expected to transform into a C_n perfluorinated carboxylate upon oxidation.[21] A range of C_4 to C_{n+1} perfluorinated carboxylates are expected to form from oxidation of fluorotelomer precursors.[21] Following oxidation of selected groundwater samples, PFBA concentrations increased by a factor of 5.0 ± 3.0, PFPeA increased by a factor of 2.9 ± 1.3, PFHxA increased by a factor of 3.7 ± 2.2, PFHpA increased by a factor of 1.5 ± 0.4, PFOA increased by a factor of 1.6 ± 2.2, and PFNA increased by a factor of 1.2 ± 0.3 (Figure 5A).

The 6:2 FtS precursor is primarily transformed into PFBA, PFPeA, and PFHxA during oxidation, while 8:2 FtS is primarily transformed into PFPeA, PFHxA, PFHpA, and PFOA.[21,61] If all of the fluorotelomers measured in the samples were oxidized into the expected PFAAs, 6:2 FtS would account for 9.9 ± 9.3% of the PFBA, PFPeA, and PFHxA increase and 8:2 FtS would account for 9.1 ± 10% of the PFPeA, PFHxA, PFHpA, and PFOA increase. FOSA is expected to transform into PFOA,[21] although pre-oxidation concentrations were so low (≤164 ng/L) that it produced negligible quantities. The additional post-oxidation increase in PFAAs is due to transformation of polyfluorinated compounds that were not quantified here.

Post-oxidation, PFBA, PFPeA, and PFHxA contributed 25 ± 8.5%, 22 ± 9.9%, and 44 ± 17% of the total molar carboxylate increase, respectively, consistent with other studies,[21] and the substantial increase in PFHxA indicates that C_6 precursors were dominant in the original samples. Relatively small increases in PFHpA and PFOA indicate low abundance of C_7 and C_8 precursors. Increases in molar perfluorinated carboxylate concentrations following oxidation provide an estimate of total molar precursor concentrations,[21] which comprised 31 ± 15% of the total PFASs at the Cape Cod site, within the range of what has been previously reported (23% for groundwater, 33−63% for wastewater).[21,73] This suggests that the thermal soil remediation at FTA-1 either did not break down the precursors, or a substantial mass of precursors had passed through the unsaturated zone prior to remediation.

Precursors are cotransporting with the main FTA-1 derived PFAS plume (Figure 3F) and show a similar spatial distribution as PFOS (Figure 3C). There is a linear correlation between the sum of molar PFAA concentrations pre-oxidation and the calculated sum of molar precursor concentrations post-

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oxidation from the different sampling locations (Figure 5B). This trend does not vary substantially with distance from FTA-1, and precursors exceed 50% of the total PFAS concentration at the farthest downgradient well (Figure 3G). Precursors have been suggested to be less mobile than PFAA, although data on this topic are limited and many precursors have yet to be identified.[12,74] The results indicate that at least some precursor sorption coefficients for the low-carbon Cape Cod aquifer sediments are similar to PFAS sorption coefficients reported in this study (Table 1). Some precursors may be less mobile and retained in the unsaturated zone. A previous study on anaerobic biotransformation of 6:2 and 8:2 fluorotelomer alcohols in digester sludge (methanogenic conditions) reported low levels of PFAAs produced (≤0.4 mol % for PFHxA and PFOA) over the 181-day experiment.[24] If precursor transformation rates decrease under anaerobic conditions, then precursors would be expected to persist during transport in the low DO conditions associated with the wastewater plume downgradient from FTA-1. Overall, the finding of cotransport of PFAA precursors at this field site has implications for water resources, as precursors can increase the total PFAA mass over time through transformation.

The PFHxS:PFOS ratio can be related to the degree of precursor transformation,[12,21] and electrochemical fluorination-based AFFF formulations from 1988 to 2001 were shown to have ratios between 0.08 and 0.14.[21] The PFHxS:PFOS ratio observed in groundwater near the water table at FTA-1 (S425) was 3.1 (Figure 3H), and increased to 5.8 at F575 (960 m downgradient from FTA-1). Well F575 had minimal percentages of precursors (Figure 3G) and elevated PFHxS:PFOS ratios in the same location, suggesting different sources or that precursor transformation contributed to the PFHxS concentrations. Well F424 had PFHxS:PFOS ratios up to 3.8 (Figure 3H) and up to 68% precursors (Figure 3G), which suggests preferential transport of PFHxS relative to PFOS, and mobile precursors (perhaps intermediates).

Differential Transport: Chain Length and Head Group Effects. The relative mobility of PFASs can be assessed considering (1) the estimation of PFAS-specific retardation factors that are dependent on the sediment characteristics and geochemical conditions, (2) the estimation of precursor retardation factors, and (3) potential biotransformation of precursors into PFAAs.[22,23,25,75,76] Negligible DO in groundwater downgradient from the infiltration beds may impede current precursor transformation rates, resulting in transport without the confounding factor of in situ production. The spatially dependent percentages of each PFAA relative to total PFASs measured suggests that differential transport is occurring, as illustrated by comparing the PFOS distribution (Figure 3D) with those of shorter chain PFAAs (Figure S5). Aside from the shallow samples beneath the infiltration beds, the highest percentages of PFOA along the transect (21%) were observed 960 m downgradient from FTA-1, although this is likely a result of wastewater inputs. The proportions of PFHxS were greatest in the groundwater near FTA-1 (S425) and at the deeper altitudes along the transect (Figure S5A). High percentages of PFHpA (12%), PFHxA (20%), and PFPeA (25%) were detected at lower altitudes and farther downgradient at F575 and F424 (Figure S5B−D). These results indicate that shorter chain length PFAAs are more mobile than PFOS both vertically and horizontally. The highest percentages of PFOS (82%) were near the infiltration beds (Figure 3D) between 580 and 690 m from FTA-1, indicating that PFOS has not traveled as far compared to shorter chain length PFAAs (log K_{oc} = 2.17−2.76), reflecting its relatively high log K_{oc} value (3.37). These results contrast with those of McGuire et al.[12] who reported no evidence of differential transport, potentially owing to in situ biotransformation of precursors. At the Cape Cod site, anoxic conditions may have allowed for the observation of differential transport through the elimination or reduction of in situ PFAA production from precursors. While the observed spatial distributions are likely due to a combination of factors including multiple sources, complex hydrological history, differential transport, and precursor transformation, the differences between percentages of PFOS and PFPeA, PFHxA, PFHpA, and PFHxS suggest differential transport is a primary factor determining spatial distributions.

Conceptual Site Model and Environmental Implications. The higher concentration PFAS plume emanating from FTA-1 comingles with the lower concentration PFAS plume emanating from the infiltration beds 580 m downgradient from FTA-1. The unsaturated zones at FTA-1 and the infiltration beds are continuing sources of PFASs to the aquifer decades after source removal. This finding suggests that the unsaturated zones beneath fire training areas and wastewater infiltration beds at other sites can act as long-term PFAS sources to groundwater over several decades. Furthermore, the shallow groundwaters beneath the two unsaturated zones at this field site are compositionally distinct. The unique profiles observed here may help with source identification in cases where the point source is not known. Another significant component of the conceptual site model is the finding that some precursors are quite mobile at this field site. Therefore, monitoring of precursors downgradient from point sources is essential to accurately predict future PFAA concentrations. Finally, there is evidence of differential transport dependent on chain length and headgroup, which has not been shown previously at field sites.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.est.6b05573.

Groundwater and aquifer sediment sampling, analytical materials, sample analysis, LC-MS/MS conditions, total oxidizable precursor assay, sediment organic carbon and mineralogy, partitioning experiments, advective transport calculations, LC-MS/MS parameters, K_{oc} and TOC results, mineralogy results, groundwater total oxidizable precursor assay results, results for PFOS analysis of groundwater samples collected from the Cape Cod well network during 2014, sum of all PFASs in transverse cross sections, example chromatogram of branched and linear isomers, DOC and PFBS concentrations within the A−A′ transect, molar percentages of PFHxS, PFPeA, PFHxA, and PFHpA (PDF)

Related Articles

Data release see: https://doi.org/10.5066/F7Z899KT.

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Notes

The authors declare no competing financial interest.

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ATTACHMENT C

- Pump Test Worksheets

HW-F

Low Flow Single Well Pumping Test Analysis (Robbins, 2009)

$$K = \frac{Q * 2.303 * \log(Re/R)}{2\Pi LeH}$$

- Steady State Radial Flow Equation

K = hydraulic conductivity
Q = flow rate
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
H = Steady State drawdown
R = Borehole intake radius (includes sand pack)
Re = Radius of influence in aquifer (calculated separately)
ln = natural log
Units must be consistent

$$Re = R * \exp\left[\left(\frac{1.1}{\ln(Lw/R)}\right) + \left(\frac{C}{Le/R}\right)\right]^{-1}$$

- Bouwer and Rice, 1976

Re = Radius of influence in aquifer
R = Borehole intake radius (includes sand pack)
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
C = Dimensionl ess constant (from graph)
Lw = Distance from static watertable down to bottom of well screen
Units must be consistent

Flow Rate:

Vol=	40	gal
Time=	1296.00	s
Flow=	0.25	cf/min

Input Factors:

Total Well Depth=	26.82	ft
Initital Depth to Water=	20.242	ft
Initial Water Column=	6.578	ft
Final Depth to Water =	20.483	ft
Final Water Column=	6.337	ft
Screen Length=	10	ft
Screen Diameter =	2	in
Borehole Diameter =	6.25	in
K_h / $K/_v$ =		

Initial Calculations:

Lw=	6.578	ft
Le=	6.337	ft
H=	0.241	ft
R=	0.26	ft
Le/R=	24.33	
C=	3.00	

Final Calculations:

Re = 5.54807 ft

K_h = 0.079 ft/min -or- 113.7 ft/day

HW-I(s)

Low Flow Single Well Pumping Test Analysis (Robbins, 2009)

$$K = \frac{Q * 2.303 * \log(Re/R)}{2\Pi LeH}$$

- Steady State Radial Flow Equation

K = hydraulic conductivity
Q = flow rate
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
H = Steady State drawdown
R = Borehole intake radius (includes sand pack)
Re = Radius of influence in aquifer (calculated separately)
ln = natural log
Units must be consistent

$$Re = R * \exp\left[\left(\frac{1.1}{\ln(Lw/R)}\right) + \left(\frac{C}{Le/R}\right) \right]^{-1}$$

- Bouwer and Rice, 1976

Re = Radius of influence in aquifer
R = Borehole intake radius (includes sand pack)
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
C = Dimensionless constant (from graph)
Lw = Distance from static watertable down to bottom of well screen
Units must be consistent

Flow Rate:

Vol=	75	gal
Time=	1800.00	s
Flow=	0.33	cf/min

Input Factors:

Total Well Depth=	25.09	ft
Initital Depth to Water=	18.416	ft
Initial Water Column=	6.674	ft
Final Depth to Water =	18.732	ft
Final Water Column=	6.358	ft
Screen Length=	6.358	ft
Screen Diameter =	2	in
Borehole Diameter =	6.25	in
K_h / $K/_v$ =		

Initial Calculations:

Lw=	6.674	ft
Le=	6.358	ft
H=	0.316	ft
R=	0.26	ft
Le/R=	24.41	
C=	3.00	

Final Calculations:

Re = 5.61934 ft

K_h = 0.081 ft/min -or- 117.1 ft/day

OW-19(m)

Low Flow Single Well Pumping Test Analysis (Robbins, 2009)

$$K = \frac{Q * 2.303 * \log(Re/R)}{2\Pi LeH}$$

- Steady State Radial Flow Equation

K = hydraulic conductivity
Q = flow rate
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
H = Steady State drawdown
R = Borehole intake radius (includes sand pack)
Re = Radius of influence in aquifer (calculated separately)
ln = natural log
Units must be consistent

$$Re = R * \exp\left[\left(\frac{1.1}{\ln(Lw/R)}\right) + \left(\frac{C}{Le/R}\right) \right]^{-1}$$

- Bouwer and Rice, 1976

Re = Radius of influence in aquifer
R = Borehole intake radius (includes sand pack)
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
C = Dimensionl ess constant (from graph)
Lw = Distance from static watertable down to bottom of well screen
Units must be consistent

Flow Rate:

Vol=	75	gal
Time=	1800.00	s
Flow=	0.33	cf/min

Input Factors:

Total Well Depth=	76.14	ft
Initital Depth to Water=	26.942	ft
Initial Water Column=	49.198	ft
Final Depth to Water =	27.417	ft
Final Water Column=	48.723	ft
Screen Length=	10	ft
Screen Diameter =	2	in
Borehole Diameter =	6.25	in
K_h / $K/_v$ =		

Initial Calculations:

Lw=	49.198	ft
Le=	10	ft
H=	0.475	ft
R=	0.26	ft
Le/R=	38.40	
C=	3.00	

Final Calculations:

Re = 33.03256 ft

K_h = 0.054 ft/min -or- 78.1 ft/day

APPENDIX B

PUBLIC COMENTS

Hydrogeological Tech Memo #10

To: Dan Santos Director, Barnstable DPW
From: Tom Cambareri, Sole Source Consulting LLC
Re: **Review of Barnstable Municipal Airport-Draft Phase II Comprehensive Site Assessment (Phase II) DEP RTN # 4-26347**
Date: January 8, 2020

The following is a review of the Barnstable Municipal Airport-Draft Phase II Comprehensive Site Assessment (CSA) (Phase II).

The CSA describes a significant effort of investigation and forensic approaches to assess liability to other parties, but falls short in using the wealth of data for describing the actual extent and nature of contamination to determine the next steps for remedial action.

The CSA identifies a single PFAS compound; the 6:2 Fluorotelomer Sulfonic Acid (6:2 FTS), as a distinguishing analyte to determine if the PFAS impacted groundwater at the Airport was related to the Airport's AFFF usage or from another off-site source. While the radar plots and cross sections to evaluate different compositions is a novel idea for these relatively new PFAS contaminates, the use of a single analyte minimizes the use of a number of other factors to better describe conditions at the site and surrounding area.

Release

The CSA indicates that the Chemguard brand of AFFF comprised of 6:2 FTS was the only one use by the Airport since 2000. Historic photos and video from the 1950's to present indicate that numerous local fire departments from across the Cape would gather at the Airport for the Tri-Annual training events. Given that many departments would test and train using their own equipment, it follows that significantly more AFFF could have been used and that formulations different from that used by the Airport staff were used. It is likely that the historic use of AFFF formulations prior to 2000 included earlier and widespread AFFF formulations containing other PFAS compounds like PFOS.

Conversion

The CSA indicates that the 6:2 FTS compound does not breakdown into PFOS (8-chain sulfonic acid) and PFHxS (6-chain sulfonic acid) which it associates with the BCFTA. However, research has identified that the 6:2 FTS does breakdown under aerobic conditions (which exists in the permeable aquifer matrix of the Barnstable Outwash) into several other types of PFAS known as Per and Poly Fluoroalkyl Carboxylates (PFCAs) (Avendaño, 2013, Hees,P.V. 2019, IRTC, 2020, Zhang, 2016). Breakdown PFCAs include PFHxA (6-chain carboxylate), PFHpA (7-chain carboxylate, and PFPeA (5-chain carboxylate). Also, the manufacturing process of AFFF has been found to result in some inclusion of other PFCA compounds like PFOA like PFDA. The Airport CSA has detected these other PFCA compounds in groundwater associated with the identified on-site source areas.

My Review uses only the most recent concentrations.

Normalized Percentages vs Reportable Concentrations

The CSA makes extensive use of radar plots normalized for total PFAS to calculate the percent of each compound in the sample. However, when making comparisons to evaluate sources it is important to consider the actual concentrations of the components.

The radar plots of percent composition of extremely high concentrations samples can look similar to very low concentrations sample. e.g.The three radar plots, from upgradient monitoring cluster HW-D that identifies off-site contamination from the BCFTA, look similar but, the concentrations range from 1.1 ng/l in groundwater from the shallow well to 250 ng/l at the deep well. The concentration increase with depth indicates a stronger further upgradient source than the shallow well which is capturing lower concentration contaminates flowing from Mary Dunn Pond.

Under normal circumstances the high concentrations occur near the source and low concentrations are found further downgradient of the source as compounds degrade or transform. In addition, chronic sources (every 6 -months) like the BFTA has high concentrations of Total-PFAS in the source area (160,000 ng/l) as compared to occasional (every 3- year) sources like the Deployment Area (15,583 ng/l).

Airport Source Area Characterization

Deployment Area Cross Section

The CSA identifies the Deployment Area as an Airport source area with monitoring wells HW-F, HW-Is and HW-Ss. Groundwater in well H-Ss has 4,895 ng/l total PFAS. While the 6:2 FTS dominates the radar plot at nearly 80%, PFOS and PFHxS are present at 100 ng/l and 55 ng/l respectively. HW-Is has 15,583 ng/l of total PFAS. Again, while the 6:2 FTS dominates the radar plot at over 80%, PFOS and PFHxS are present at 40 ng/l and 220 ng/l respectively. The detections of PFOS and PFHxS in these shallow well source areas indicates that using the 6:2 FTS as the single distinguishing analyte of Airport activities is too constrained.

The inclusion of the other Per and Poly Fluoroalkyl Carboxyl Acids (PFCAs) as distinguishing analytes also needs to be considered. HW-F has 2,656 ng/l of total PFAS. While the 6:2 FTS dominates the radar plot at nearly 60%, The compound PFHpA is at 230 ng/l making 10% of the composition. The concentration of the other PFCA products; PFHxA and PFPeA have concentrations of 460 and 430 ng/l respectively. The other Deployment Area source wells mentioned above HW-Is and HW-Ss have the following detections of PFCA.

	Total PFAS	PFPHxA	PFPeA	PFHpA	PFOA	PFOS	PFHxS
HW-Is	15,583	510	810	540	290	40	220
HW-F	2656.4	460	430	230	20	5	0.8
HW-Ss	4895	250	420	110	62	55	100

(all values in ng/l)

The detections of PFOS and PFHxS and the other PFCAs in groundwater from identified source area wells demonstrate that the use of 6:2 FTS as the single distinguishing analyte constrains the identification of Airport PFAS sources. Dispersion and intermittent vertical gradients may be a cause of the significant decrease of PFAS in the intermediate and deep wells beneath the source areas, particularly at the relatively intermediate wells < 30 ft deep.

ARFF Cross Section

Cross-Section 3 through the ARFF Source indicates 3 shallow wells HW-P, HW-302 and HW-3 at the water table are comingled with off-site sources. The Total PFAS detected in groundwater from these wells is 342.7, 342.7 and 969.8, respectively. Given the depression of groundwater flow as it migrates downgradient particularly with the steep gradient along this section, it is not clear how PFAS from other sources would be found at the water table at the Airport rather than deeper from upgradient sources. While HW-3 has the highest concentration of the 6:2 FTS, the occurrence of the other PFCAs is consistent in groundwater through the section. So, expanding the distinguishing analytes to these compounds makes physical as well as chemical sense. PFOS is also a minor constituent in these wells.

Soils and the Runways

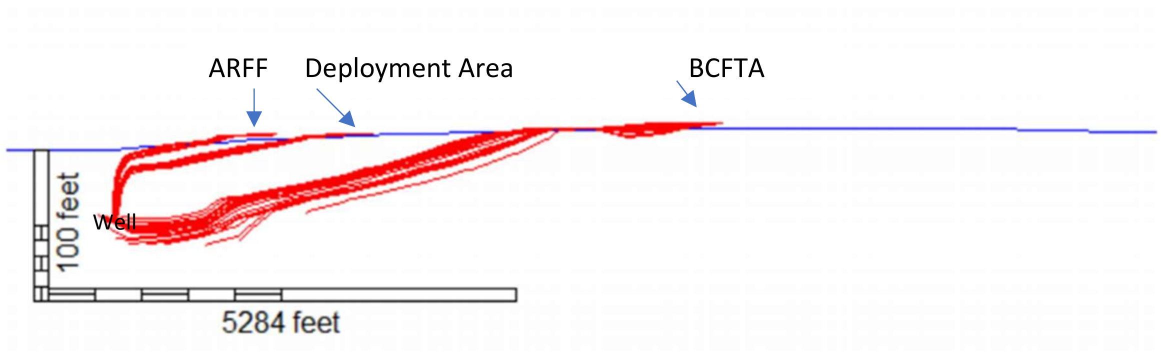
The CSA presents a collection of background soil samples. The detection of PFAS in Airport and off-site locations indicate that the occurrence of these compounds is ubiquitous and may come from atmospheric or other dilute sources. However, several of the soil samples BG3, BG4 and BG5 are taken from the northeast runway. They contain 380 to 2,300 ug/kg of PFOS which at those concentrations can leach appreciably into groundwater. Therefore, the dismissal of groundwater samples with PFOS from coming from the Airport is too strict.

Although testing of soils from 1991 training area were by and large below the detection limit the occurrence of PFAS of 3,180 ng/kg from one of the samples and the detection of PFAS in groundwater at HW-L, the only well along the groundwater flow line that runs parallel to the run way, raises the consideration to test un-investigated areas along that NE-SW alignment of the run-way.

Hydrogeology

The Maher Wells are downgradient of the Airport source areas. Groundwater flow velocities of 5.6 to 111 feet/day presented in the CSA used textbook aquifer values of 2.38 and 23.8 ft/d and measured hydraulic gradients. The reported calculated travel times are excessively high and the selected hydraulic conductivity values exceptionally low. Typical hydraulic conductivities calculated from pump tests and used in groundwater models for the Barnstable Outwash are 200 to 350 feet/day which results in typical groundwater flow velocities of 1.1 to 5.7 feet per day.

The steep hydraulic gradient from HW-320 to OW-9 is closest to the Maher Well resulting in the fastest velocity of 5.6 ft/d. The high velocity caused by active pumping results in a steep vertical gradient component that draws shallow groundwater to the deep levels and the well. Groundwater modeling and particle tracking are tools to evaluate fate and transport. An evaluation of particle paths from the BCFTA, Deployment and ARFF was prepared for the DPW and a cross sectional output is shown below (Cambareri, 2019). Modeling of particles upgradient of the wellfield shows that groundwater and the contaminants it carries are drawn into the wells whether it is deep (BCFTA) or shallow (Airport) in the aquifer.



Groundwater flows at approximately 1 ft /d across the source areas. Groundwater modeling indicates travel times of approximately 5 years for contaminates to migrate from the Deployment Area to the Maher Wells and 3 years from the ARFF. The travel time from the BCFTA is on the order of 20 years. It has been demonstrated that PFAS in soils will continue to leach into groundwater for decades thus deserving of the moniker “forever compounds.” Given the historic use of AFFF and groundwater flow velocity, it is probable for the BCFTA to be contributing PFAS to the Maher Wells. The deep well at well cluster HW-Dd and Ddd are proof that the BCFTA PFAS has crossed beneath the Airport. The HW-I m and HW-Id may show evidence of comingled sources. HW-Sm appears to be too shallow for comingling and the relatively low PFOS concentration could be part of the more historic Airport use . It is unfortunate that the County has not pursued a more detailed delineation of its PFAS impact downgradient of the Mary Dunn Pond. Particle tracking indicates that the width of impact from the BCFTA includes flow further east to discharge into Mill Creek across the Yarmouth line which was sampled by Harvard and detected 104 ng/l of PFAS6. In addition, chronic training and episodes of high precipitation likely result in slugs of high concentrations within the area of impact.

Fate and Transport

It is not clear how the CSA applies the chemical detections and hydrogeologic principles to the fate and transport of the contaminants. PFAS concentrations at the source area of the BCFTA plume is extremely high at 167,000 ng/l. It is comprised of a mixture of AFFF used at the site from the early 60s to October 2015, when last observed on the site. The BCFTA PFAS plume comprised of a mixture of AFFF with both PFOS (66%) and 6:2 FTS (9%) related contaminants that decrease to a concentration of approximately 1,000 ng/l as they migrate towards the Mary Dunn Wells. The Total-PFAS composition changes with decreasing PFOS as it converts to PFHxS and other lower carbon chain sulfonates and 6:2 FTS to lower carbon chain PFCAs. The CSA identified likely BCFTA PFAS at HW-D cluster with concentrations ranging from 244 to 250 ng/l indicating even more "dilution" as it travels downgradient.

In a similar fashion, the contaminants detected at the Airport inclusive of other types of AFFF leach to groundwater and undergo transformations as they migrate downgradient. At the Airport however, the introduction is more infrequent as mentioned earlier. Therefore, the transformations and movement of contaminates is not uniform, with slugs of high PFAS concentrations interspersed with more uniform low concentrations. We know from investigations at the JBCC, that releases of PFAS in the 1990's is being found still at the source areas and in groundwater and private wells 1000s of feet downgradient.

<u>The Maher Wells</u>
The CSA does not present the data of PFAS detected in groundwater on a map or cross sections nor are the statistics of their occurrence tabulated. The CSA indicates that based upon the chemical characterization and use of the 6:2 FTS as the distinguishing analyte, it does not appear that the Airport has contaminated the Maher Wells.

Groundwater samples from the two identified source areas have high concentrations of PFAS. Total PFAS in the Deployment Area source monitoring wells range from 2,656 ng/l to 15,583 ng/l comprised mostly of PFCAs and 6:2 FTS but also lower amounts of PFOS. Total PFAS in the ARFF source monitoring wells range from 342 to 970 ng/l. The CSA delineated PFAS plumes emanating from the two Airport source areas are inexplicably truncated before reaching the Maher wells (CSA-Figure 2).

The Maher Wells were shut down in 2016 due to the presence of PFAS and new Health Advisory. Water from the wells is now treated through a $12 million treatment plant that was just completed in 2020. The Maher wells are located along a line that is perpendicular to groundwater flow. This means groundwater flow to ME-2 on the east end is different from ME-1 on the west with the sources mixed in the middle at ME-3. The Barnstable DPW Water Supply Division sampled the Maher wells in November. The concentration of Total PFAS in groundwater from the Maher wells ranges from 467 ng/l in ME-1 to 248 ng/l in ME-2. The percentage of PFOS ranges from 30% to 43% in the Maher wells. The percentage of the 6:2 FTS is 15% in ME-1 and 3% in ME-3 with none detected in ME-2. The ME-1 sample also has the highest concentrations of the other Perfluoroalkyl Carboxylates. The CSA radar plots from an earlier September Maher well sample set has the same distribution of PFAS concentrations with the highest PFAS, 6:2 FTS, and PFCA concentrations detected in groundwater from ME-1 on the west end, that is closest to, and first downgradient well to, the Airport. The consistent presence of these high PFAs compounds at ME-1 is evidence of Airport contribution.

There are several monitoring well sets in the Maher Wellfield between the wells and the Airport. Groundwater from Maher monitoring wells OW-18M, OW-18D and OW-9D have high

Total PFAS concentrations of 4,357 ng/l, 1,832 ng/l, and 1,584 ng/l respectively. The high concentrations indicate that a source with high concentrations is close. The Deployment area has Total PFAS concentrations of 15,583 to 2,656 ng/l. The ARFF has PFAS detections of 970 to 342 ng/l. PFAS concentrations that are associated with outside sources to the west and the BCFTA coming across the Airport boundary range from 244 ng/l at HW-Dd beneath the Deployment Area and 160ng/l at HW-19d beneath the ARFF, are not nearly as high as found in the Maher monitoring wells.

1-4 Dioxane Cross Section 2

The CSA indicates that 1-4 dioxane has not been found on the site but only in deep groundwater monitoring wells and in the Maher wells. Investigation into surface source areas have not identified existing sources. While the pursuit of up and cross gradient sources off-site from the Airport has merit, it is also possible that source areas have been depleted since unlike PFAS the 1-4 dioxane does not last as long. That being said the relative persistence of 1-4 dioxane in the deep wells requires a persistent source. Additional work to depict the 1-4 dioxane concentrations is needed to set the stage for further investigation in the area.

Summary

Based upon the source locations, groundwater flow, hydrogeology, detections, concentrations, and composition of PFAS detected in soil and groundwater it is evident that the Airport contributes PFAS that are detected in the Maher Wells. The CSA demonstrates that other sources also contribute but without a better depiction of actual concentrations and taking groundwater flow and fate and transport issues it is difficult to assign relative amounts to the different sources.

The CSA should include a better description of the distribution of PFAS and 1-4 Dioxane with actual concentrations and taking groundwater flow and fate and transport issues to focus on those areas with significant concentrations.

Additional regional work is required to further account for the different sources in the Hyannis area.

References

-Avendaño, L.J., 2013., Microbial degradation of polyfluoroalkyl chemicals in the environment: A review., Env. Int. 61, 98–114

-Cambareri, 2019., Hydrogeologic Tech Memo #4, Prepared for Barnstable DPW.

-Hees,P.V. 2019, Analysis of the unknown pool of PFAS: Total Oxidizable Precursors (TOP), PFOS Precursor (PreFOS) and Telomer Degradation, Eurofins Environment Testing Sweden AB and Man-Technology, Environment Research Centre, Örebro University

-ITRC, 2020 https://pfas-1.itrcweb.org/3-firefighting-foams/#3

-Zhang, S., Lu, X., Wang N., Buck, R. C. Biotransformation potential of 6:2 fluorotelomer sulfonate (6:2 FTSA) in aerobic and anaerobic sediment. Chemosphere 2016, 154, 224-230

APPENDIX C

WASTE DISPOSAL RECORDS

Global Remediation Services Inc.

700 Richmond Street

Invoice

DATE	INVOICE #
3/25/2020	18300

BILL TO
Barnstable Municipal Airport Attn: Mary McDonald 480 Barnstable Road Hyannis, MA 02601

P.O. NO.	TERMS	DUE DATE	REP
200001	Net 30	4/24/2020	HA

ITEM	DESCRIPTION	QTY	RATE	AMOUNT
	DRUM DISPOSAL SERVICES Job 20094			
	Wednesday, March 4, 2020			
Disposal	Disposal of Waste Jet A Liquid	1	[redacted]	
Disposal	Disposal of Jet Fuel Contaminated Debris	1		
Disposal	Disposal of AFFF	1		
Materials	55-gallon Open Top Replacement Drum	1		
Materials	55-gallon Closed Top Replacement Drum	1		
Trans	Transportation	1		
MHWTF-drum	MA Hazardous Waste Transportation Fee	2		
E-Manifest Fee	EPA E-Manifest Fee	1		
			Total	$1,731.36

Please Make Checks Payable to Global Remediation Services Inc.

Phone #
(508) 828-1005

Please print or type. MA102470

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST	1. Generator ID Number: MAC300009198	2. Page 1 of: 1	3. Emergency Response Phone: 908-354-0210	4. Manifest Tracking Number: 020352130 JJK

GENERATOR

5. Generator's Name and Mailing Address
BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD GATE F
HYANNIS, MA 02601
Generator's Phone: 508-778-7770

Generator's Site Address (if different than mailing address)

6. Transporter 1 Company Name: ACV ENVIRONMENTAL SERVICES, INC — U.S. EPA ID Number: NJD003812047

7. Transporter 2 Company Name — U.S. EPA ID Number:

8. Designated Facility Name and Site Address
CYCLE CHEM, INC.
217 SOUTH FIRST STREET
ELIZABETH, NJ 07206
Facility's Phone: 908-355-5800
U.S. EPA ID Number: NJD002200046

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
X	1. RQ, UN1863, Waste Fuel, aviation, turbine engine, 3 , II	XXX1	DM	25	G	D001 D018
X	2. RQ, NA3077, Hazardous waste, solid, n.o.s. (Benzene), 9 , III	XXX 1	DM	35	P	D018
	3. NON ~~DOT~~ RCRA DOT REGULATED MATERIAL (AQUEOUS FILM FORMING MATERIAL/AAFF)	XXX1	DF	50	G	MA99 72
	4.					

14. Special Handling Instructions and Additional Information
D45196 SO 46244 LDR on FileSFSO#MA102470
1)Profile#46406 JET FUEL 1X55 2)Profile#74216 ABSORBENTS W/JET FUEL 1X55 3) Profile # 74368 Aqueous film forming (AAAF) 1X55

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: Ed Longo — Signature: [signature] — Month 3 Day 4 Year 20

INT'L

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter signature (for exports only): Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name: Jerin E. Diogu — Signature: [signature] — Month 03 Day 04 Year 20
Transporter 2 Printed/Typed Name — Signature — Month Day Year

DESIGNATED FACILITY

18. Discrepancy
18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection
Manifest Reference Number:
18b. Alternate Facility (or Generator) — U.S. EPA ID Number
Facility's Phone:
18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1. H061	2. H141	3.	4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name — Signature — Month Day Year

EPA Form 8700-22 (Rev. 12-17) Previous editions are obsolete.

DESIGNATED FACILITY TO EPA's e-MANIFEST SYSTEM

Global Remediation Services Inc.
700 Richmond Street
East Taunton, MA 02718

Invoice

DATE	INVOICE #
9/16/2016	14866

BILL TO

Dr. Basia Ann McAnaw
56 Sea Medow Circle
Centerville, MA 02632

P.O. NO.	TERMS	DUE DATE	REP
	Net 30	10/16/2016	HA

ITEM	DESCRIPTION	QTY	RATE	AMOUNT
	Wednesday, August 31, 2016 DRUM DISPOSAL SERVICES CLAIM # 1601000256			
Disposal	Disposal of speedi-dry/sand/Avgas	4	[redacted]	[redacted]
Disposal	Disposal of water firefighting foam/Avgas	5		
Trans	Transportation to licensed disposal facility	1		
Field Service	Loading Demurrage	1		
MHWTF-drum	MA Hazardous Waste Transportation Fee	9		
	cc: Barnstable Municipal Airport Daniel R. Armstrong, Jr, Regional Claims Manager			
			Total	[redacted]

Please Make Checks Payable to Global Remediation Services Inc.

Phone #
(508) 828-1005

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator ID Number: MAC300009198
2. Page 1 of: 1
3. Emergency Response Phone: (508) 872-5000
4. Manifest Tracking Number: 014393126 JJK

5. Generator's Name and Mailing Address: BARNSTABLE MUNICIPAL AIRPORT 480 BARNSTABLE ROAD HYANNIS, MA 02601
Generator's Phone: (508) 778-7770
Generator's Site Address (if different than mailing address): 480 BARNSTABLE ROAD GATE F HYANNIS MA 02601

6. Transporter 1 Company Name: CLEAN VENTURE, INC. — U.S. EPA ID Number: NJ0000027193

7. Transporter 2 Company Name: — U.S. EPA ID Number:

8. Designated Facility Name and Site Address: CYCLE CHEM INC. 217 SOUTH FIRST STREET ELIZABETH, NJ 07206
Facility's Phone: (908) 355-5800
U.S. EPA ID Number: NJD002200046

GENERATOR

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
RQ	1. UN3175 , WASTE, SOLIDS CONTAINING FLAMMABLE LIQUID, N.O.S. (ACETONE,AVIATION GASOLINE) 4.1 PG II (RQ D001 100#) ERG# 133	xx4	DM	2000	P	D001
	2.					
	3.					
	4.					

14. Special Handling Instructions and Additional Information: LDR On File 806546/800082/77232/42176/MA6136 (1)R02-9 SPEEDI DRY/SAND/ AVGAS
(1) 4X55

15. GENERATOR'S/OFFEROR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: Katie Servis — Signature: Katie Servis — Month Day Year: 8 31 16

INT'L

16. International Shipments: ☐ Import to U.S. ☐ Export from U.S. — Port of entry/exit: — Transporter signature (for exports only): — Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name: Josh Richardson — Signature: [signature] — Month Day Year: 8 31 16
Transporter 2 Printed/Typed Name: — Signature: — Month Day Year:

DESIGNATED FACILITY

18. Discrepancy
18a. Discrepancy Indication Space: ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection
Manifest Reference Number:
18b. Alternate Facility (or Generator) — U.S. EPA ID Number:
Facility's Phone:
18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)
1. H141
2.
3.
4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name — Signature — Month Day Year

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator ID Number: MAC300009198
2. Page 1 of: 1
3. Emergency Response Phone: (508) 872-5000
4. Manifest Tracking Number: 014393127 JJK

5. Generator's Name and Mailing Address: BARNSTABLE MUNICIPAL AIRPORT 480 BARNSTABLE ROAD HYANNIS, MA 02601

Generator's Phone: (508) 778-7770

Generator's Site Address (if different than mailing address): 480 BARNSTABLE ROAD GATE F HYANNIS MA 02601

6. Transporter 1 Company Name: CLEAN VENTURE, INC. — U.S. EPA ID Number: NJ0000027193

7. Transporter 2 Company Name: — U.S. EPA ID Number:

8. Designated Facility Name and Site Address: NORLITE, LLC 628 SOUTH SARATOGA STREET COHOES, NY 12047 — U.S. EPA ID Number: NYD080469935

Facility's Phone: (518) 235-0401

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
RQ	1. UN1993, WASTE FLAMMABLE LIQUIDS, N.O.S. (AVIATION GASOLINE) 3 PG II (RQ D001 100#) ERG# 128	XX5	DM	275	G	D001
	2.					
	3.					
	4.					

14. Special Handling Instructions and Additional Information: 806546/800082/77232/42177/MA6136 (1)ID-8 1000130737LF WATER FIREFIGHTING FOAM/AVGAS

(1) 5x55

PO.# 183759

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: Katie Servis — Signature: Katie Servis — Month 8 Day 31 Year 16

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit: Date leaving U.S.:

Transporter signature (for exports only):

17. Transporter Acknowledgment of Receipt of Materials

Transporter 1 Printed/Typed Name: JOSH Richardson — Signature: — Month 8 Day 31 Year 16

Transporter 2 Printed/Typed Name: — Signature: — Month Day Year

18. Discrepancy

18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator) — U.S. EPA ID Number

Facility's Phone:

18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1. 2. 3. 4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a

Printed/Typed Name — Signature — Month Day Year

GENERATOR — INT'L — TRANSPORTER — DESIGNATED FACILITY

Global Remediation Services Inc.

700 Richmond Street
East Taunton, MA 02718

Invoice

DATE	INVOICE #
6/25/2019	17625

BILL TO
Barnstable Municipal Airport Attn: Mary McDonald 480 Barnstable Road Hyannis, MA 02601

P.O. NO.	TERMS	DUE DATE	REP
190001	Net 30	7/25/2019	HA

ITEM	DESCRIPTION	QTY	RATE	AMOUNT
	DRUM DISPOSAL SERVICES Job #19181			
	site: 480 Barnstable Road Hyannis, MA			
	Thursday, June 13, 2019			
Materials	55-gal open head steel drums	2	[redacted]	
Materials	55-gal closed head steel drums	2		
Disposal	Disposal of used oil filters	1		
Disposal	Disposal of Waste Jet A fuel contaminated debris (D018)	1		
Disposal	Disposal of Jet A Fuel	1		
Disposal	Disposal of AFFF	2		
MHWTF-drum	MA Hazardous Waste Transportation Fee	2		
Trans	Transportation	1		
E-Manifest Fee	EPA E-Manifest Fee	1		
			Total	$2,146.36

Please Make Checks Payable to Global Remediation Services Inc.

Phone #
(508) 828-1005

BARNSTABLE AIRPORT

'19 JUL 1 8:42AM

MA10152

Please print or type.

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST	1. Generator ID Number MAC300009188	2. Page 1 of 1	3. Emergency Response Phone 908-354-0210	4. Manifest Tracking Number 019915614 JJK

5. Generator's Name and Mailing Address
BARNSTABLE MUNICIPAL AIRPORT
480 BARNSTABLE ROAD GATE F
HYANNIS, MA 02601
Generator's Phone: 508-778-7770

Generator's Site Address (if different than mailing address)

6. Transporter 1 Company Name
ALLSTATE POWER VAC. INC.
U.S. EPA ID Number: NJD003812047

7. Transporter 2 Company Name
U.S. EPA ID Number:

8. Designated Facility Name and Site Address
CYCLE CHEM, INC.
217 SOUTH FIRST STREET
ELIZABETH, NJ 07206
Facility's Phone: 908-355-5800
U.S. EPA ID Number: NJD002200046

GENERATOR

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes		
X	1. RQ, UN1863, Waste Fuel, aviation, turbine engine, 3 , II	1	DM	50	G	D001	D018	
	2. RQ, NA3077, Hazardous waste, solid, n.o.s. (Benzene), 9 , III	1	DM	300	P	D018		
	3. NON RCRA NON DOT REGULATED MATERIAL (DRAINED OIL FILTERS)	1	DM	100	P	27	MA99	
	4. NON RCRA NON DOT REGULATED MATERIAL (AQUEOUS FILM FORMING FOAM / AFFF)	2	DF	100	G	72	MA99	

14. Special Handling Instructions and Additional Information Document D22773 Sales Order 22611
1X55 1X55 1X55
1) 46406 JET FUEL 2) 74216 ABSORBENTS W/JET FUEL 3) 74221 USED OIL FILTERS 4) 74368 AQUEOUS FILM FORMING FOAM (AFFF)

15. GENERATOR'S/OFFEROR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: Hildebrando Rios Signature: [signature] Month Day Year 06 13 19

INT'L
16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit: Date leaving U.S.:
Transporter signature (for exports only):

TRANSPORTER
17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name: Jerin E. Dingle Signature: [signature] Month Day Year 06 13 19
Transporter 2 Printed/Typed Name: Signature: Month Day Year

DESIGNATED FACILITY
18. Discrepancy
18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection
Manifest Reference Number:
18b. Alternate Facility (or Generator) U.S. EPA ID Number
Facility's Phone:
18c. Signature of Alternate Facility (or Generator) Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.
H061	H141	H141	H141

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name Signature Month Day Year

EPA Form 8700-22 (Rev. 12-17) Previous editions are obsolete.

DESIGNATED FACILITY TO EPA's e-MANIFEST SYSTEM

Global Remediation Services Inc.

700 Richmond Street
East Taunton, MA 02718

Invoice

DATE	INVOICE #
9/29/2017	15949

BILL TO
Barnstable Municipal Airport Attn: Mary McDonald 480 Barnstable Road Hyannis, MA 02601

18004433

P.O. NO.	TERMS	DUE DATE	REP
	Net 30	10/29/2017	HA

ITEM	DESCRIPTION	QTY	RATE	AMOUNT
	Thursday, September 21, ~~1997~~ 2017 VACUUM TRUCK SERVICES site: 125 Mary Dunn Rd - Gate A Hyannis, MA			
Field Tech	Field Tech	6.5	[redacted]	
3,000-gal vacuum ...	3,000-gal vacuum truck w/driver	8		
3,000-gal vac truc...	3,000-gal vac truck w/driver (overtime)	2		
Disposal	Disposal of oil/water	1,290		
		Total		$2,390.35

'17 OCT 10 12:10PM
BARNSTABLE AIRPORT

Please Make Checks Payable to Global Remediation Services Inc.

Phone #
(508) 828-1005

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator ID Number: MAC300009199
2. Page 1 of
3. Emergency Response Phone: 508-828-1005
4. Manifest Tracking Number: 003078610 GBF

5. Generator's Name and Mailing Address:
Barnstable Municipal Airport
480 Barnstable Road
Hyannis, MA 02601-2900

Generator's Site Address (if different than mailing address):
125 Mary Dunn Road - Gate A
Hyannis, MA 02601-2900

Generator's Phone: 508-778-7770

6. Transporter 1 Company Name: Global Remediation Services Inc.
U.S. EPA ID Number: MAC300012903

7. Transporter 2 Company Name:
U.S. EPA ID Number:

8. Designated Facility Name and Site Address:
Tradebe Treatment & Recycling of Stoughton, L
441R Canton St.
Stoughton, MA 02072 USA

U.S. EPA ID Number: MAD062179890

Facility's Phone: 781-297-3530

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
	1. NA1270, Petroleum Oil, 3, PGII	001	TT	1290	G	M499
	2.					
	3.					
	4.					

14. Special Handling Instructions and Additional Information
1. Profile: 4445CLH oil/water ERG#128

DNS L/0099MA
MA Haz H151A

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: Chris Daniels
Signature: [signature]
Month/Day/Year: 09/21/17

16. International Shipments ☐ Import to U.S. ☐ Export from U.S.
Port of entry/exit:
Transporter signature (for exports only):
Date leaving U.S.:

17. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name: Alt Pelletier
Signature: [signature]
Month/Day/Year: 09/21/17

Transporter 2 Printed/Typed Name:
Signature:
Month/Day/Year:

18. Discrepancy

18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator)
U.S. EPA ID Number
Facility's Phone:

18c. Signature of Alternate Facility (or Generator)
Month/Day/Year:

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.
H135			

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a
Printed/Typed Name: Kristen Marinelli
Signature: [signature]
Month/Day/Year: 9/21/17

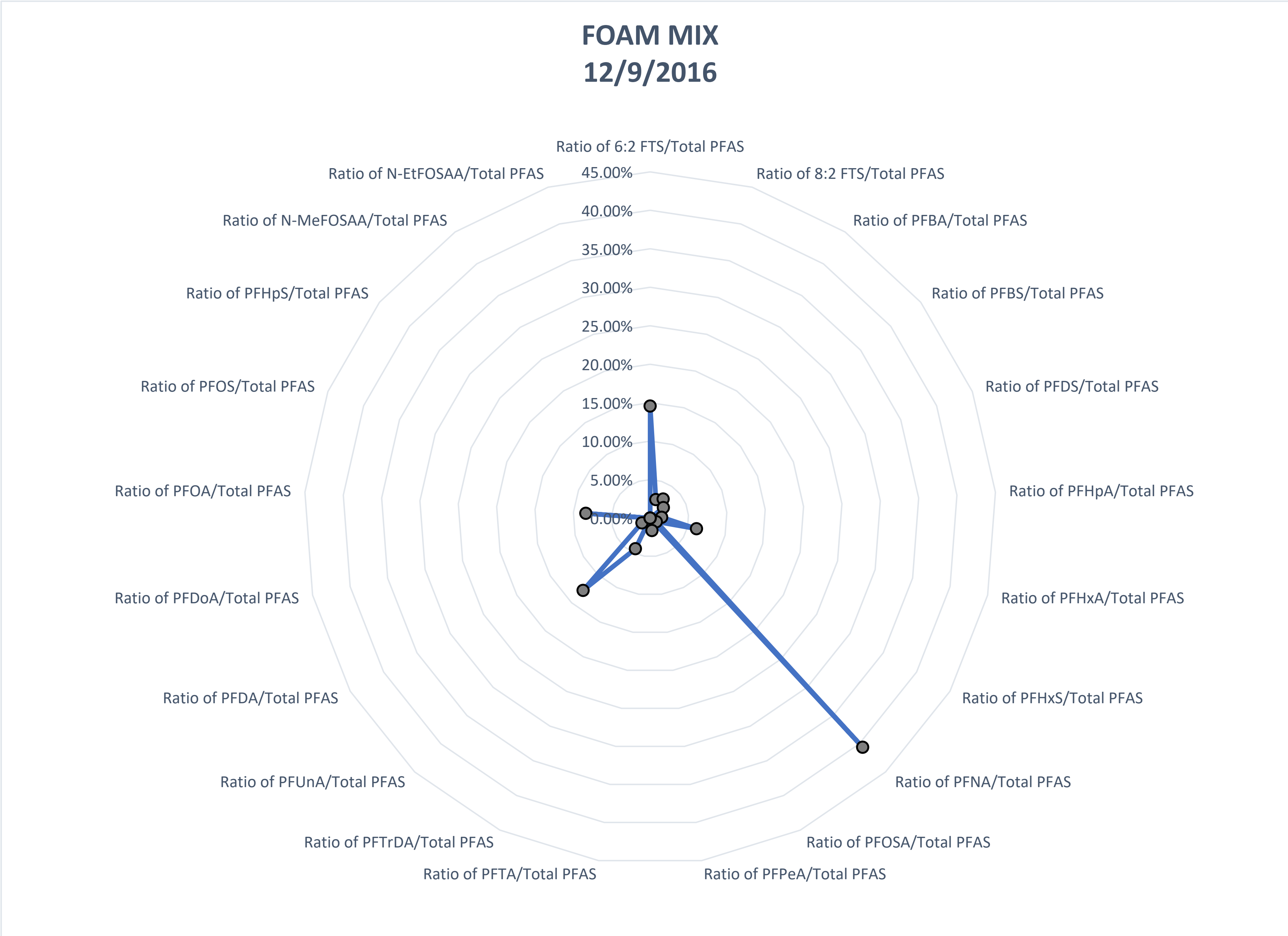
EPA Form 8700-22 (Rev. 3-05) Previous editions are obsolete.

TRANSPORTER'S COPY

GENERATOR | INT'L | TRANSPORTER | DESIGNATED FACILITY

APPENDIX D

PFAS RADAR PLOTS


FOAM MIX
12/9/2016
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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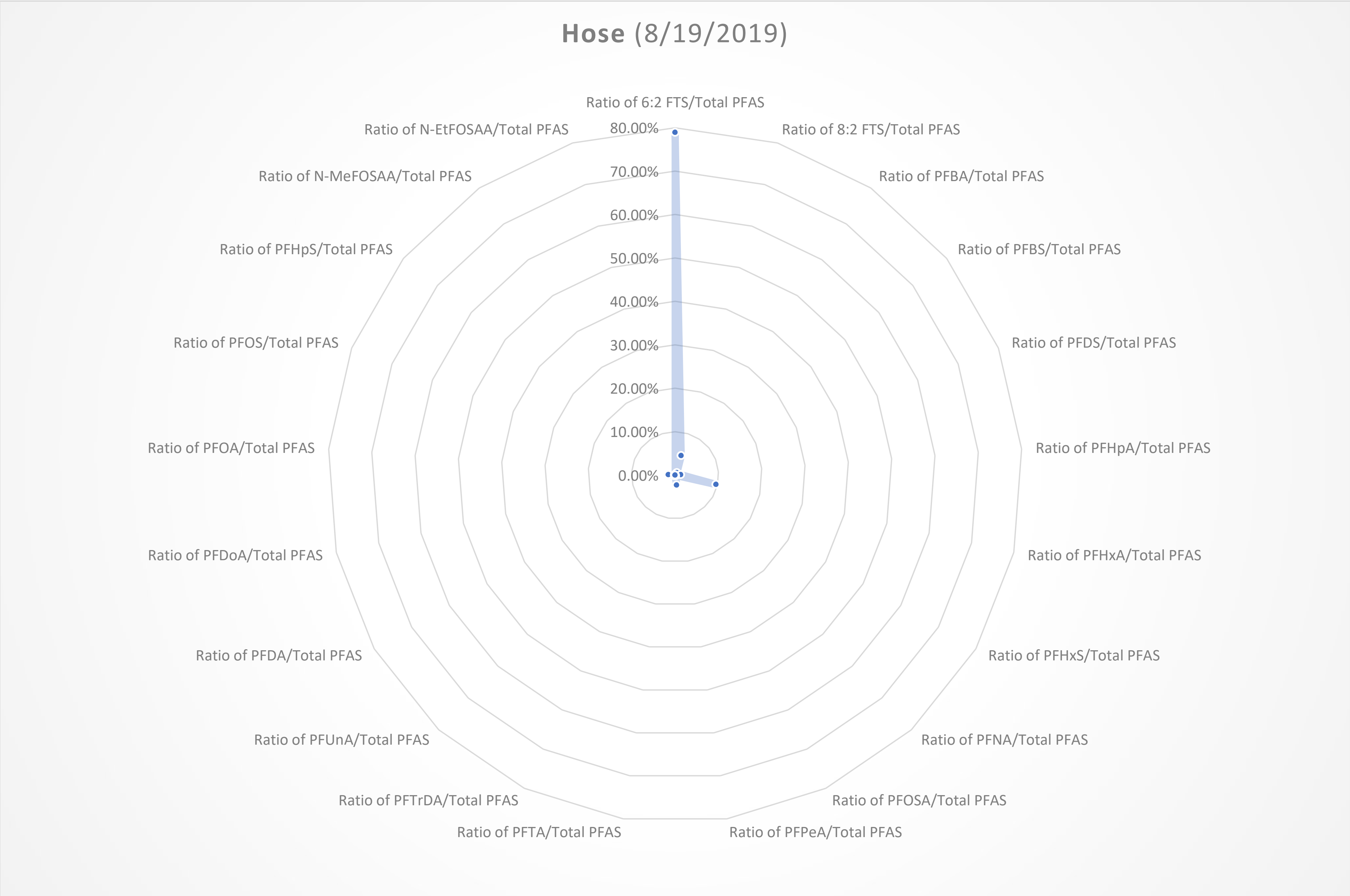
5.00%
0.00%


Hose (8/19/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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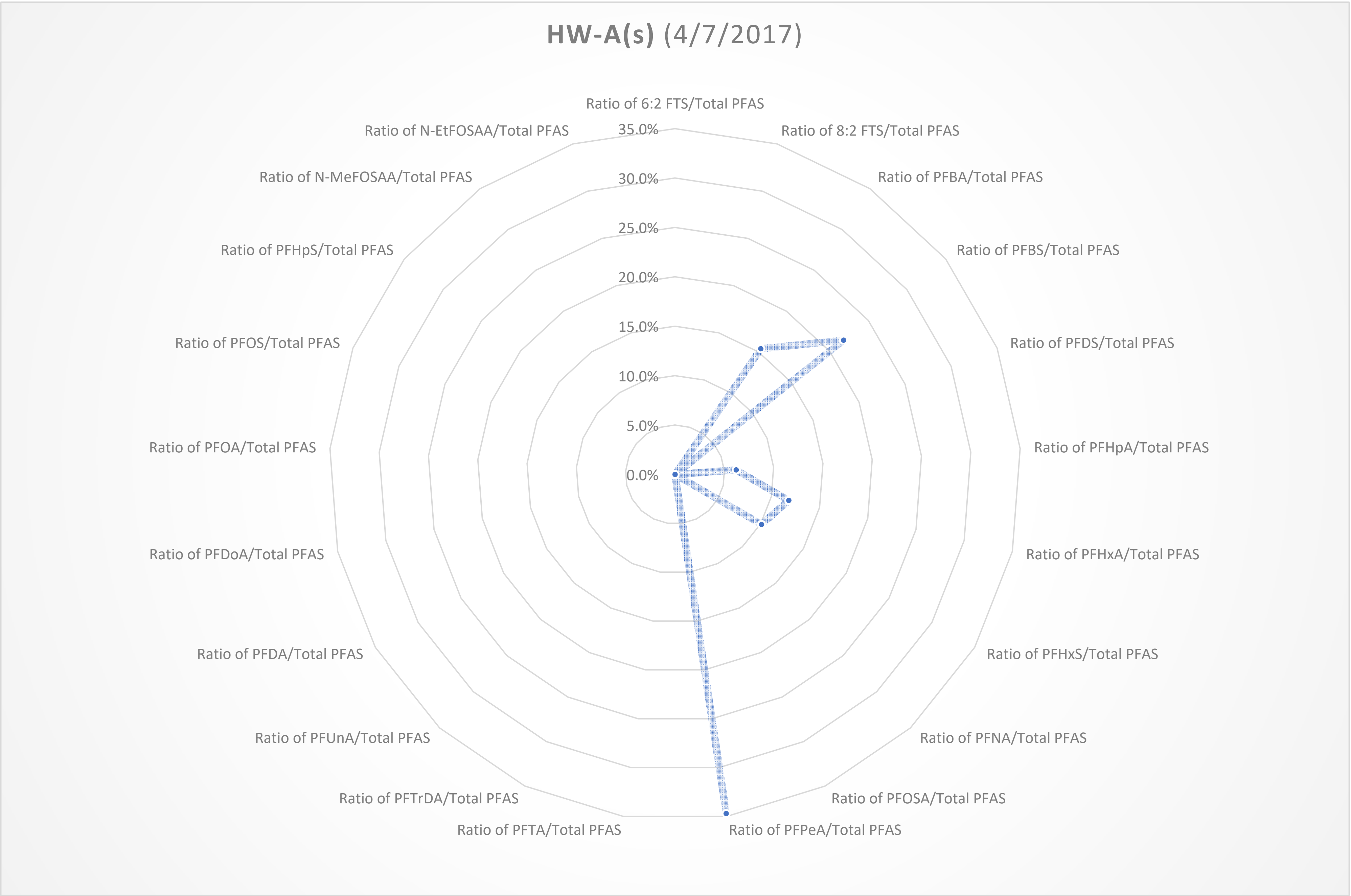
10.00%
0.00%


HW-A(s) (4/7/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
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15.0%
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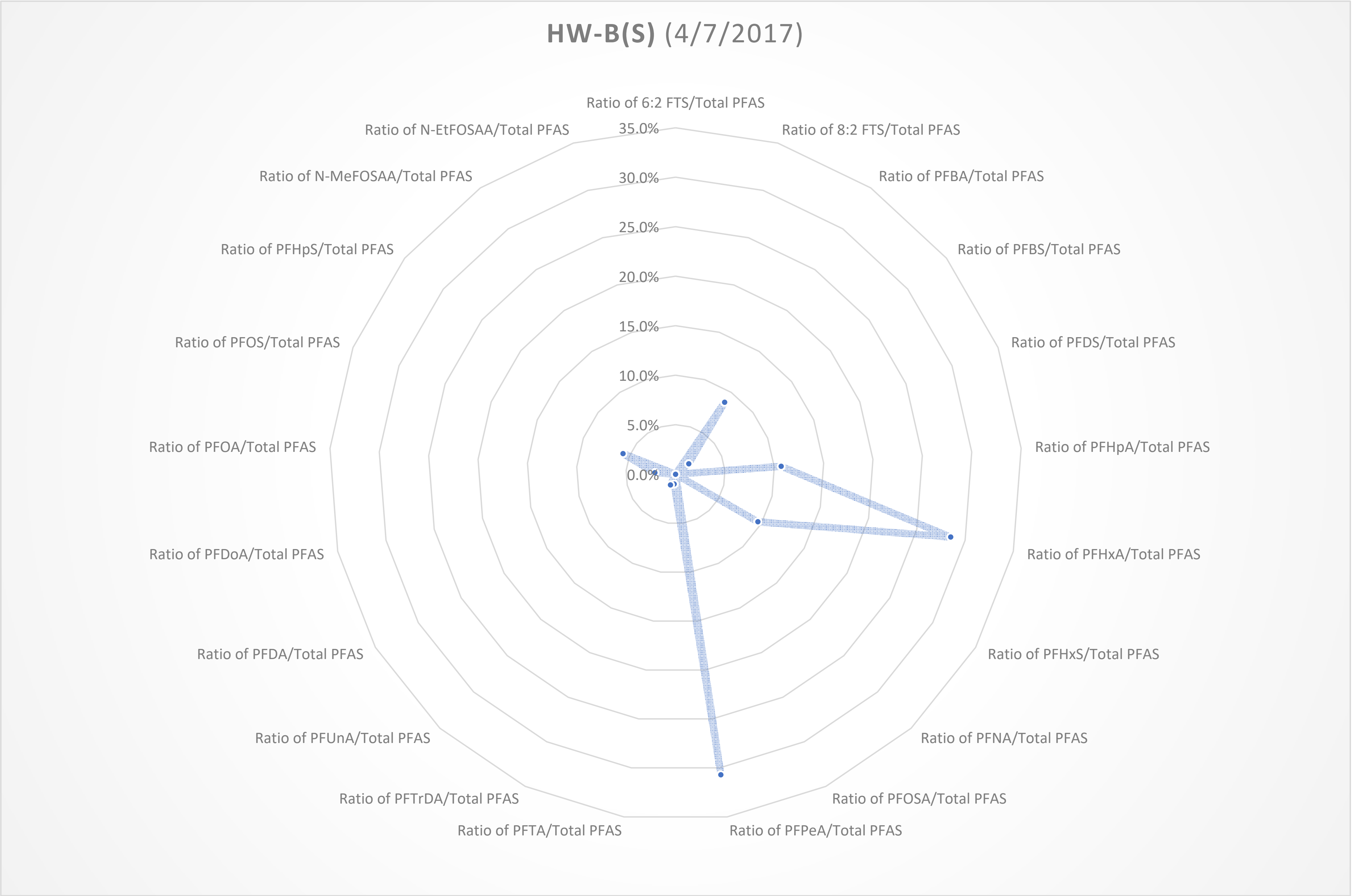
5.0%
0.0%


HW-B(S) (4/7/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
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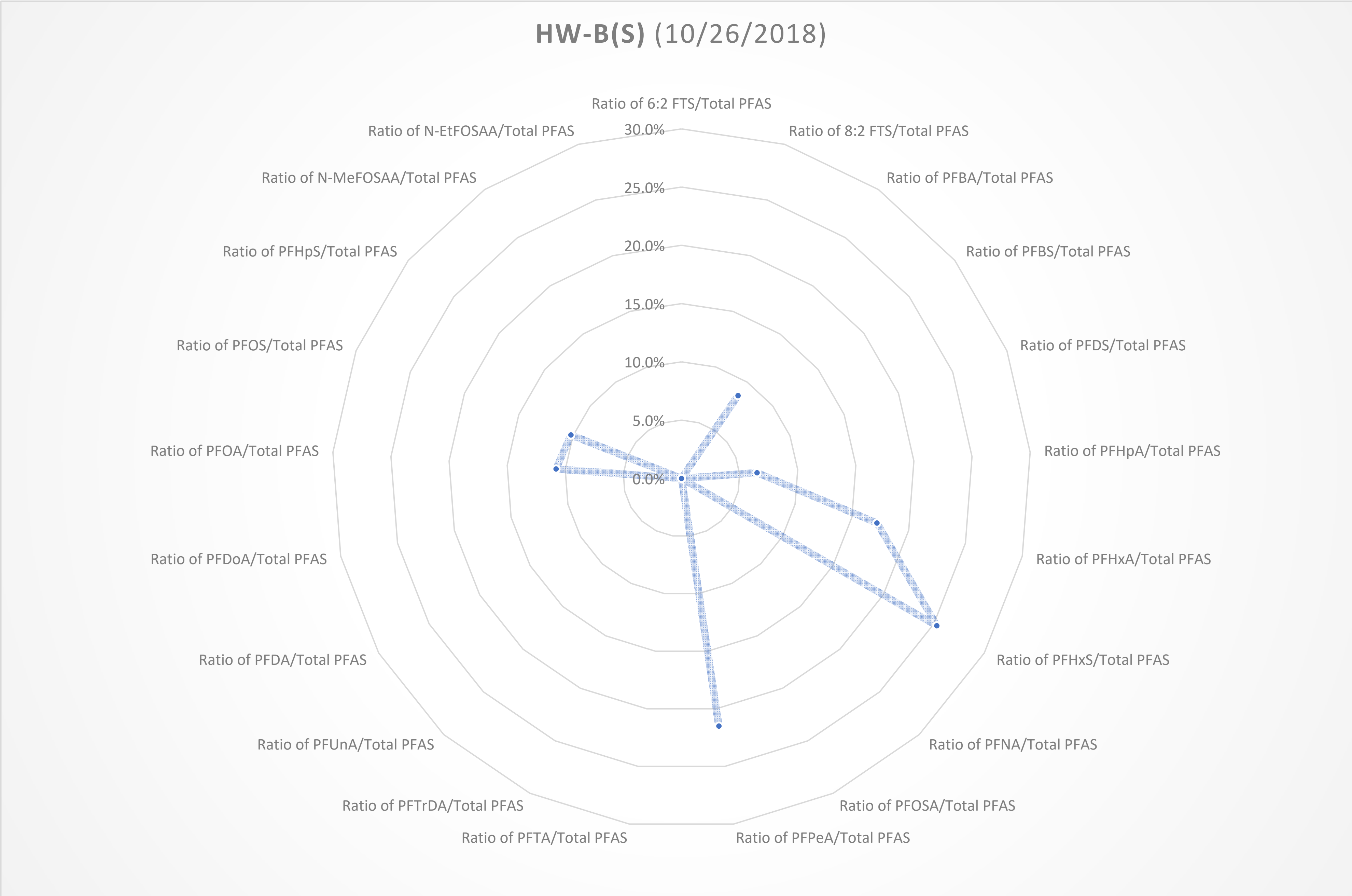
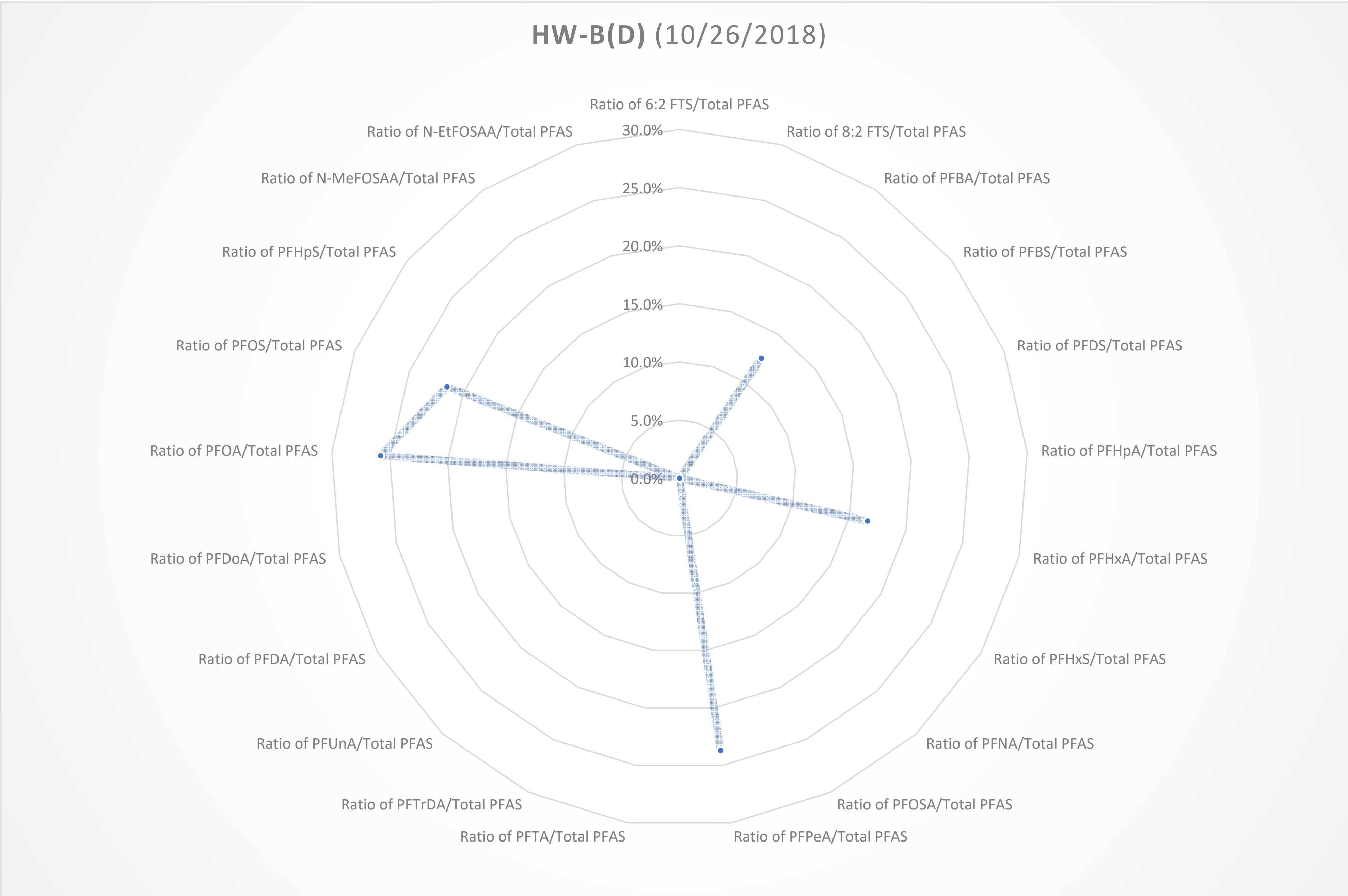

HW-B(S) (10/26/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



HW-B(D) (10/26/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
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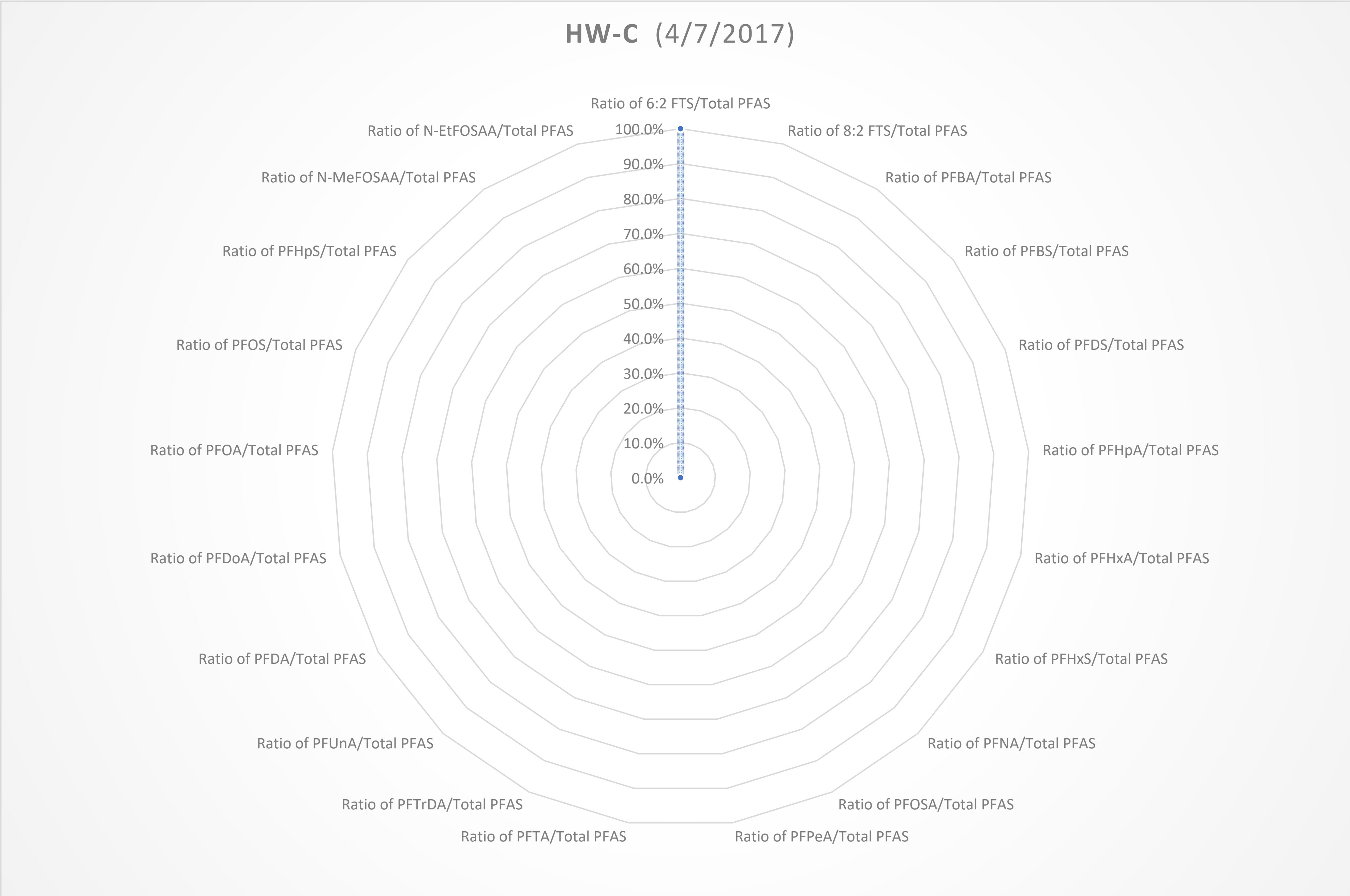
HW-C (4/7/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
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30.0%
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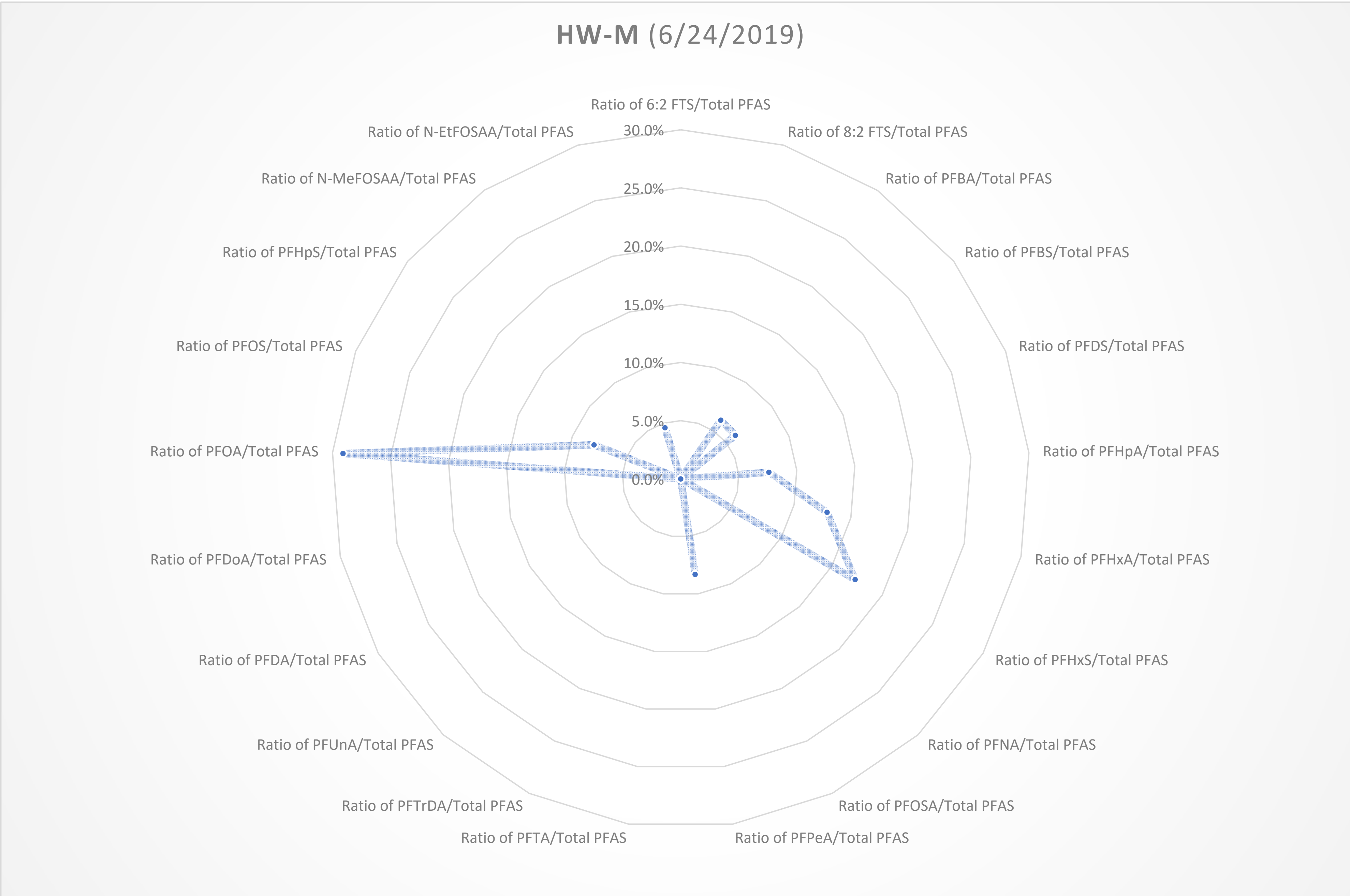
HW-M (6/24/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
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Ratio of PFTrDA/Total PFAS
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Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
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Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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25.0%
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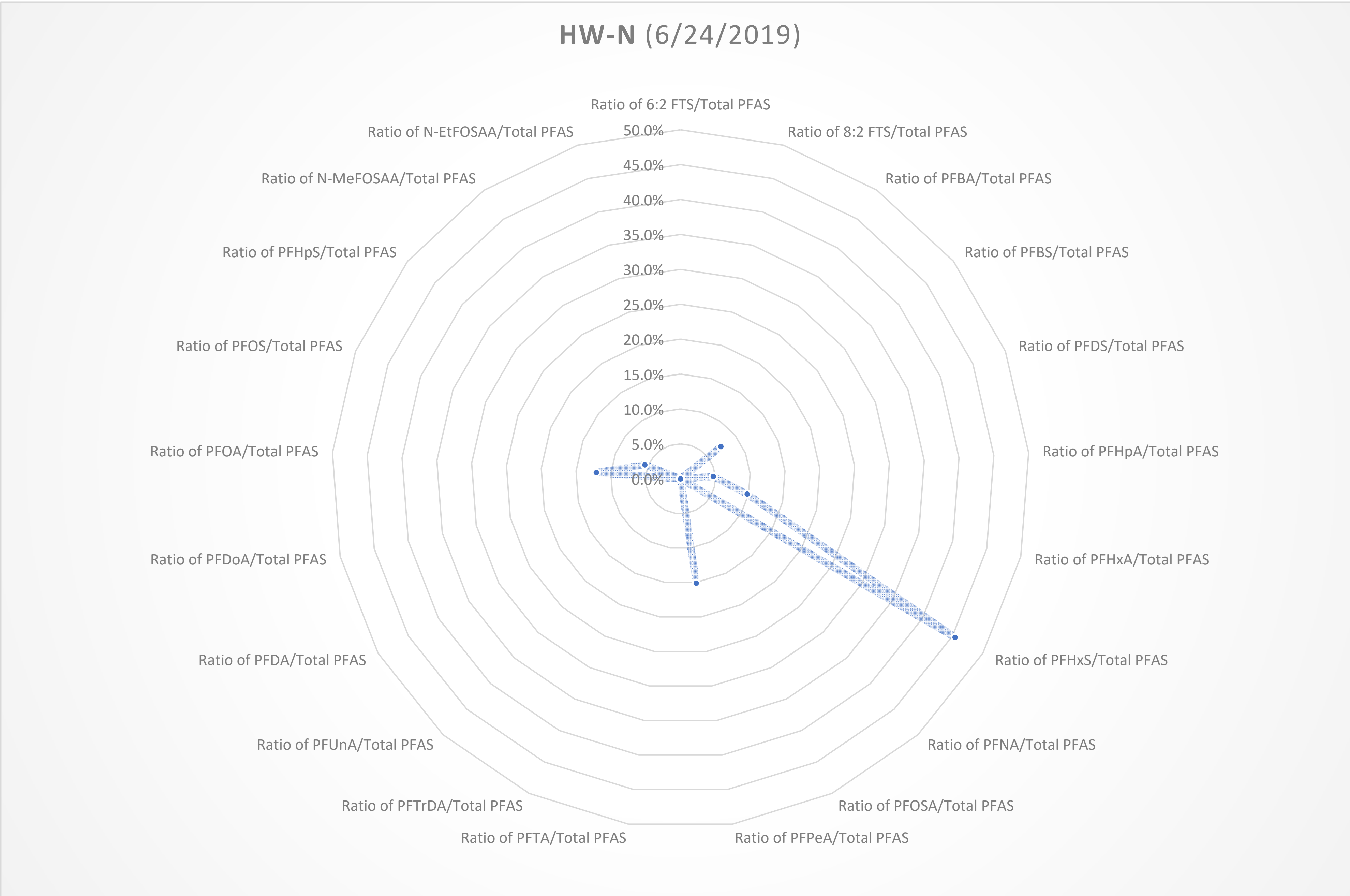
HW-N (6/24/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
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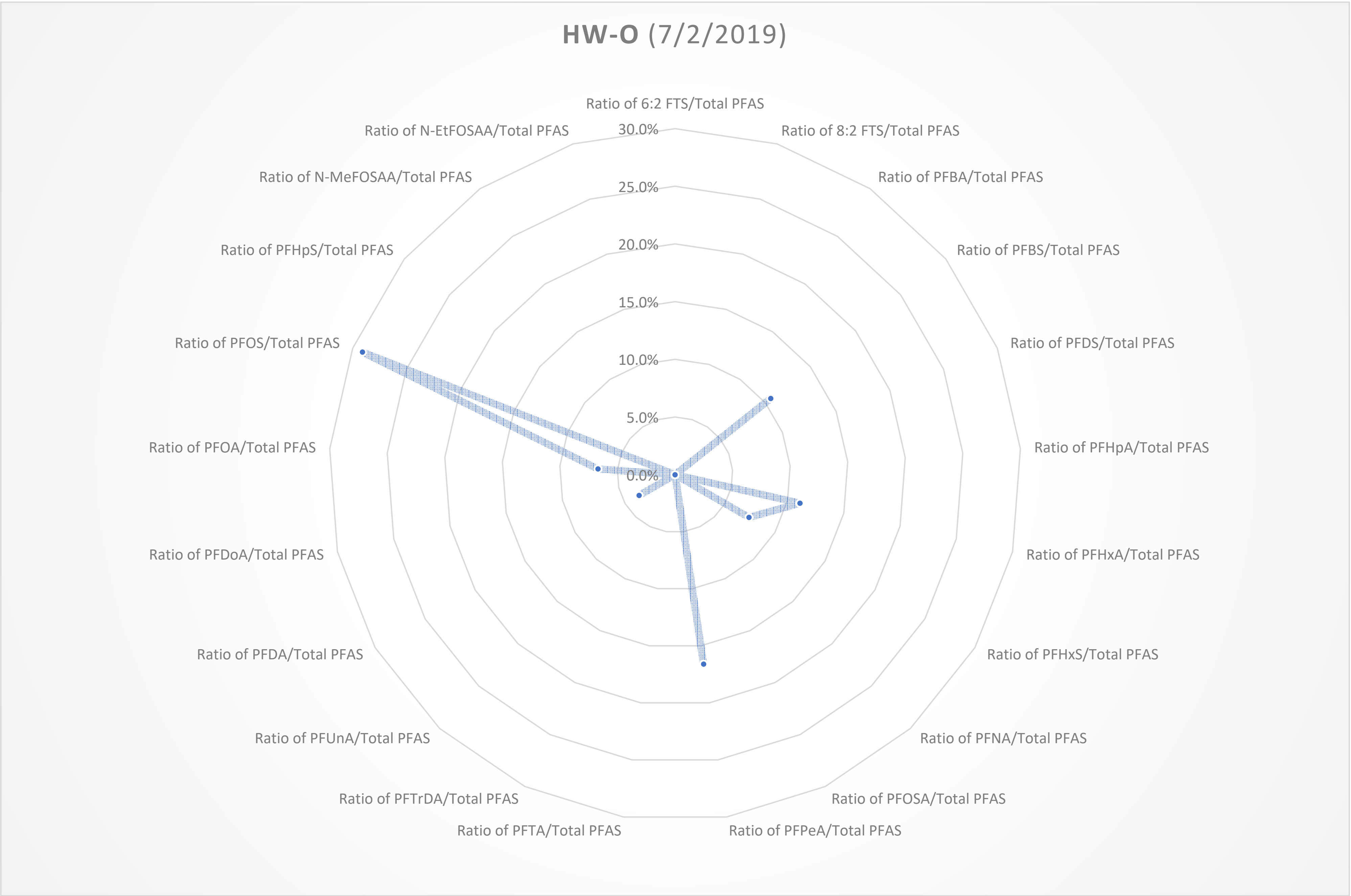
HW-O (7/2/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
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Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
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Ratio of PFTrDA/Total PFAS
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Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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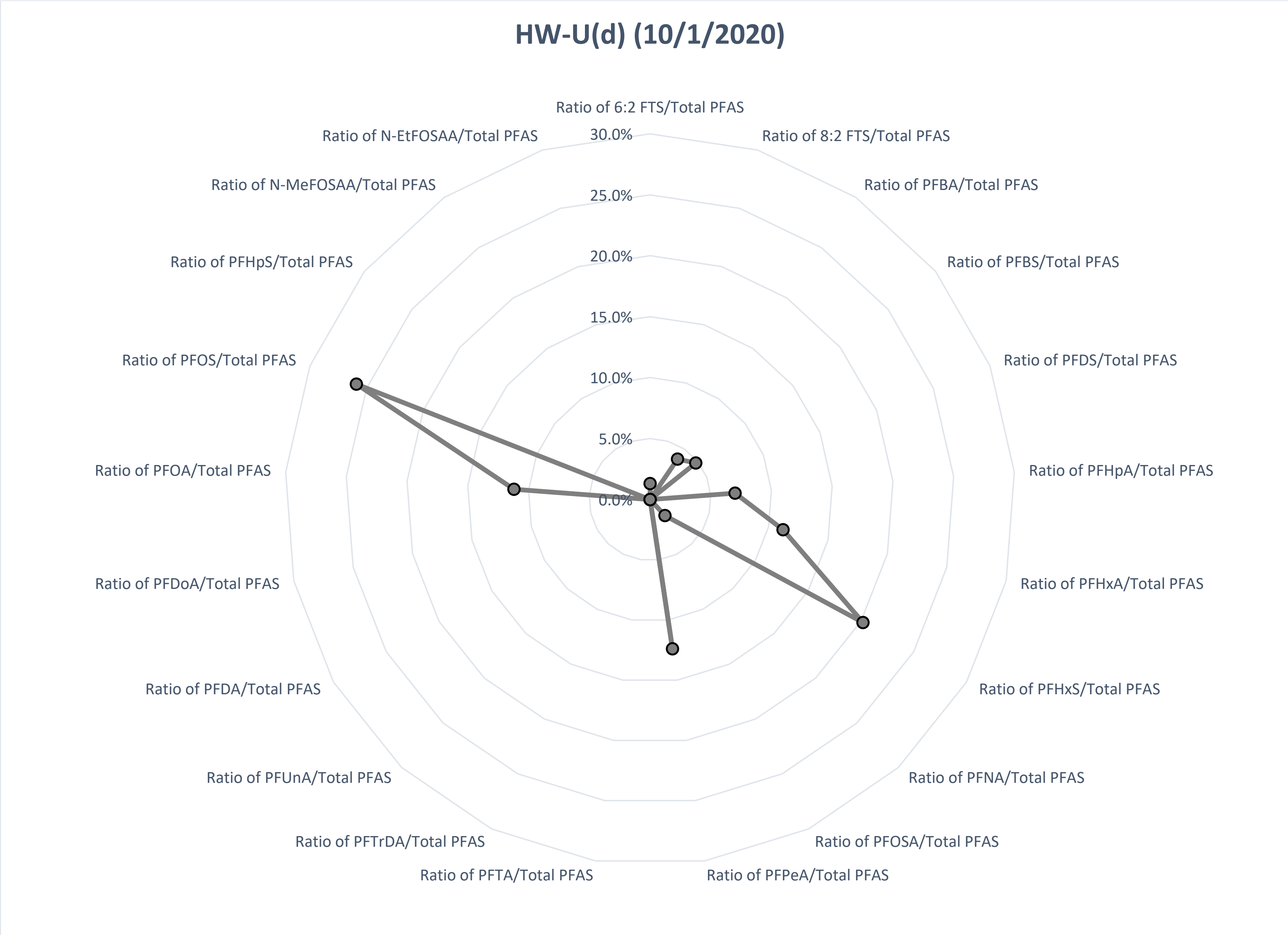
HW-U(d) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
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Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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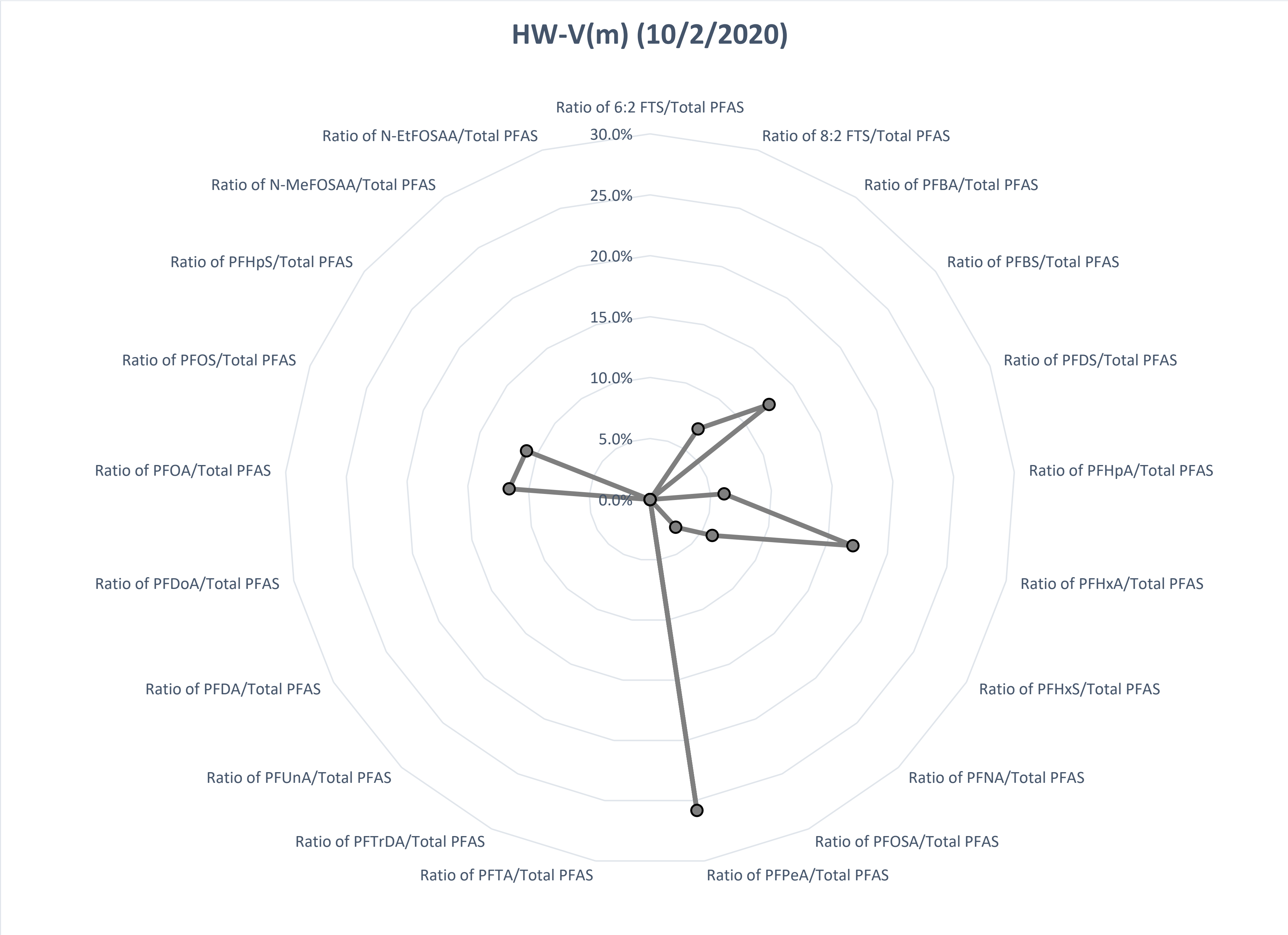
HW-V(m) (10/2/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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25.0%
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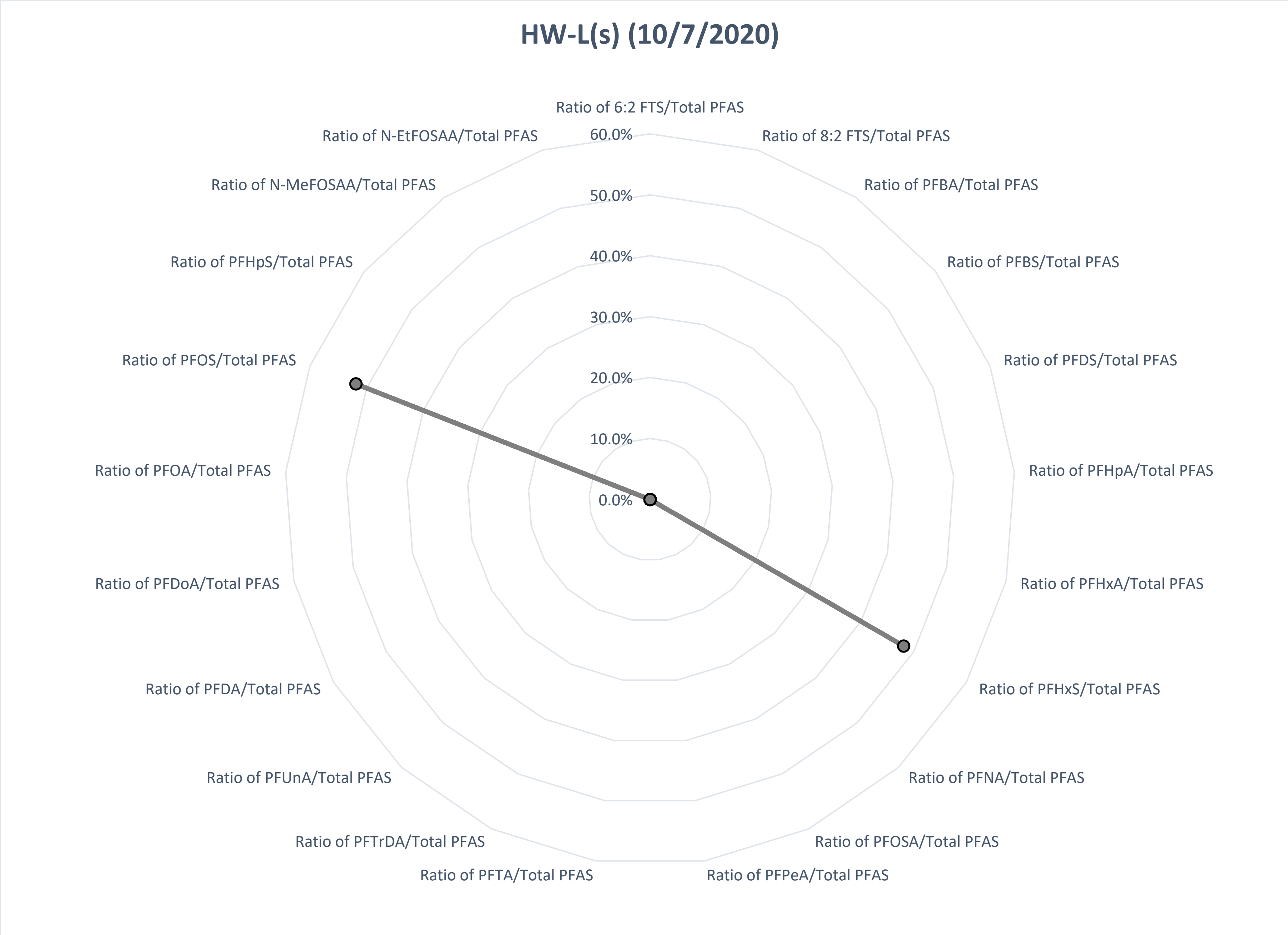
HW-L(s) (10/7/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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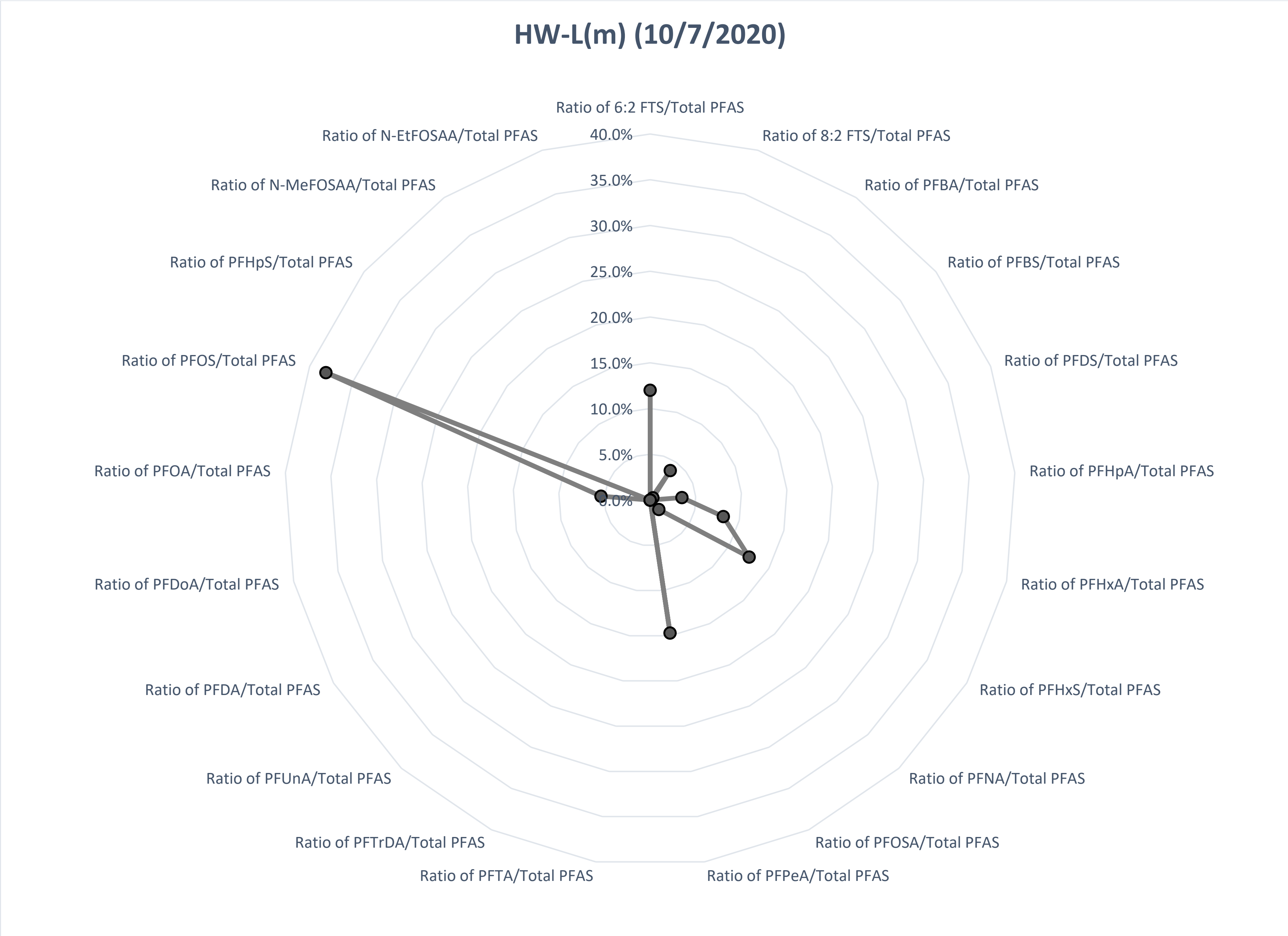
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


HW-L(m) (10/7/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
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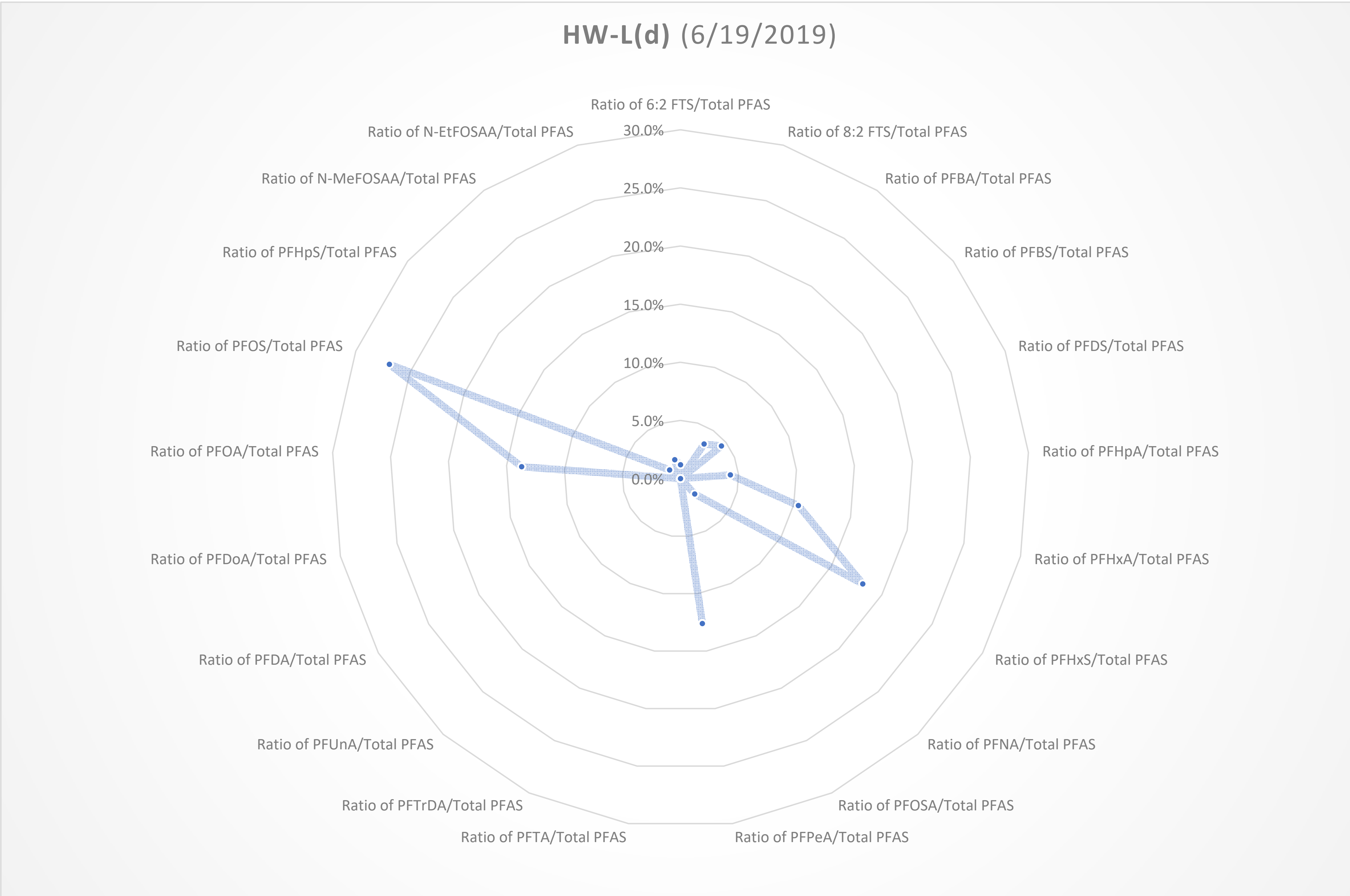
HW-L(d) (6/19/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
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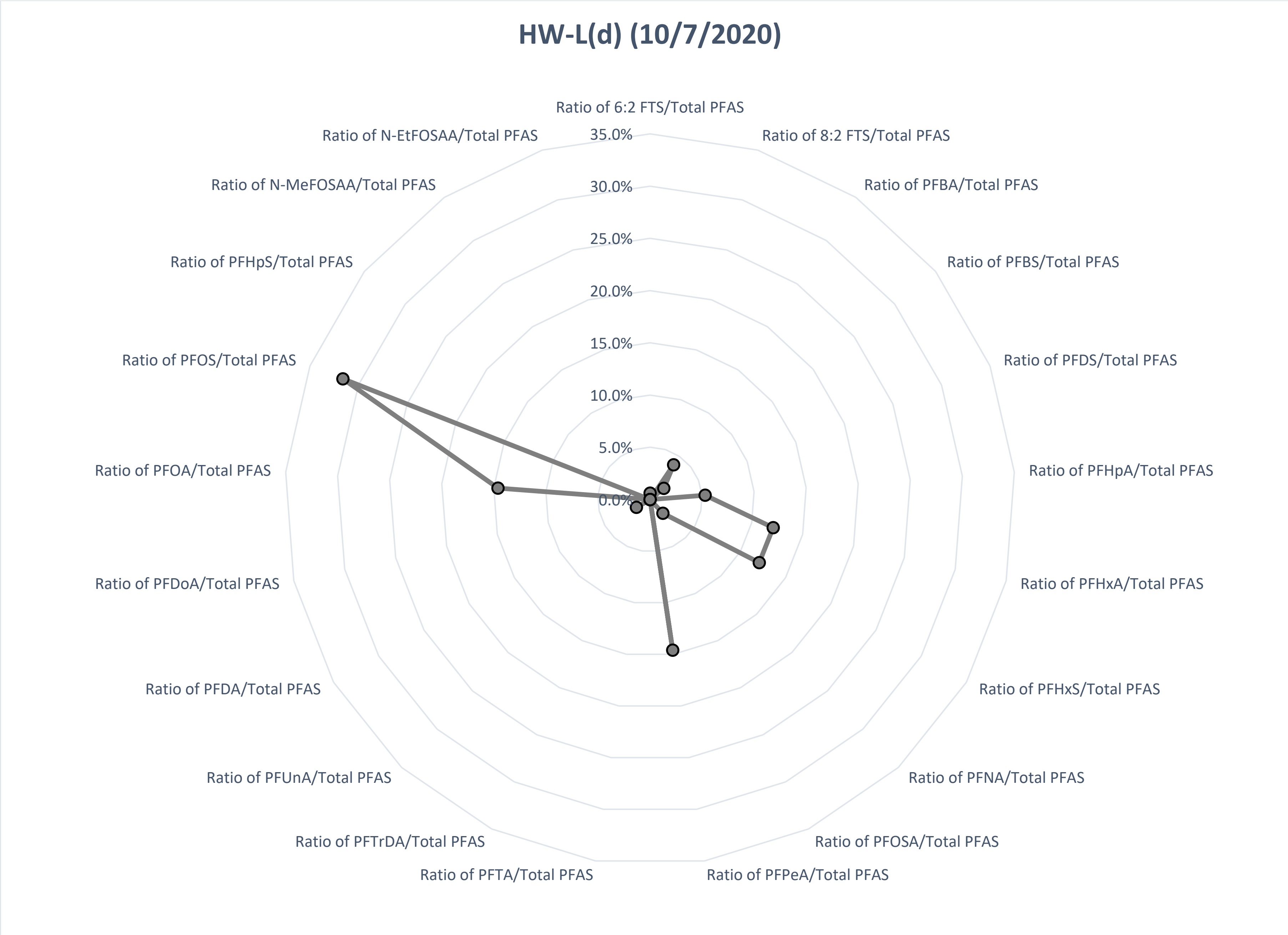
5.0%
0.0%


HW-L(d) (10/7/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
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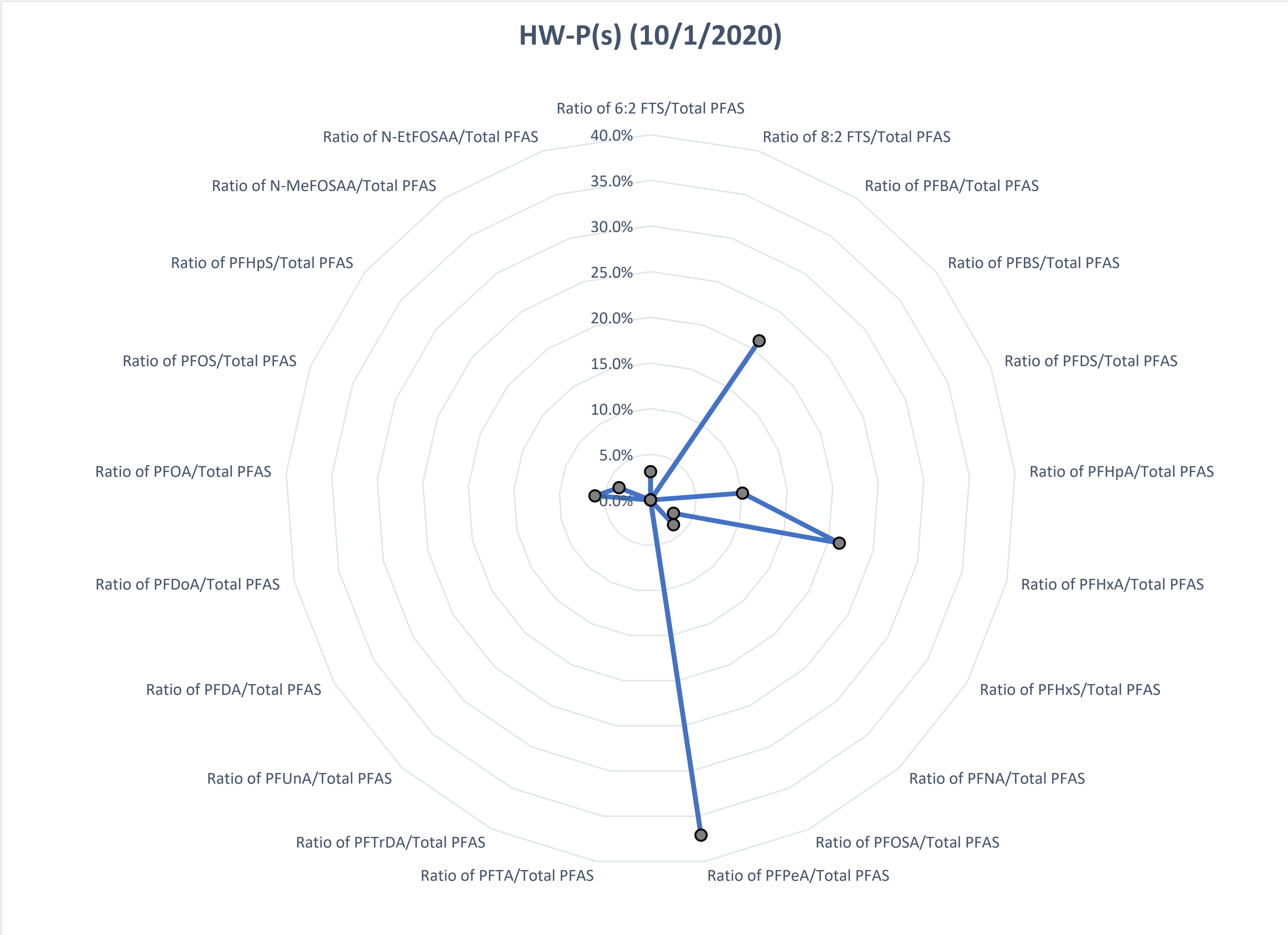
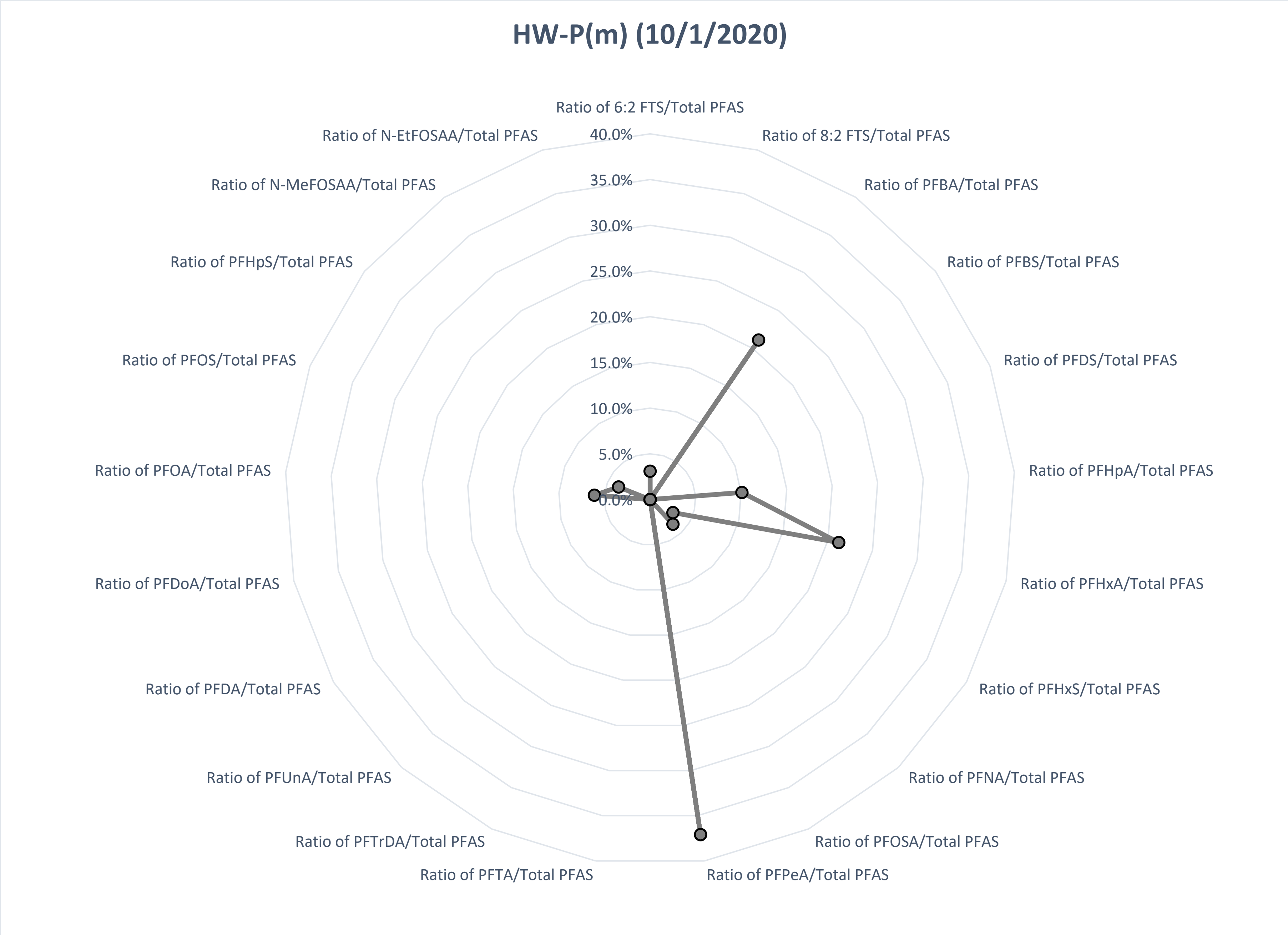
5.0%
0.0%


HW-P(s) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-P(m) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
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15.0%
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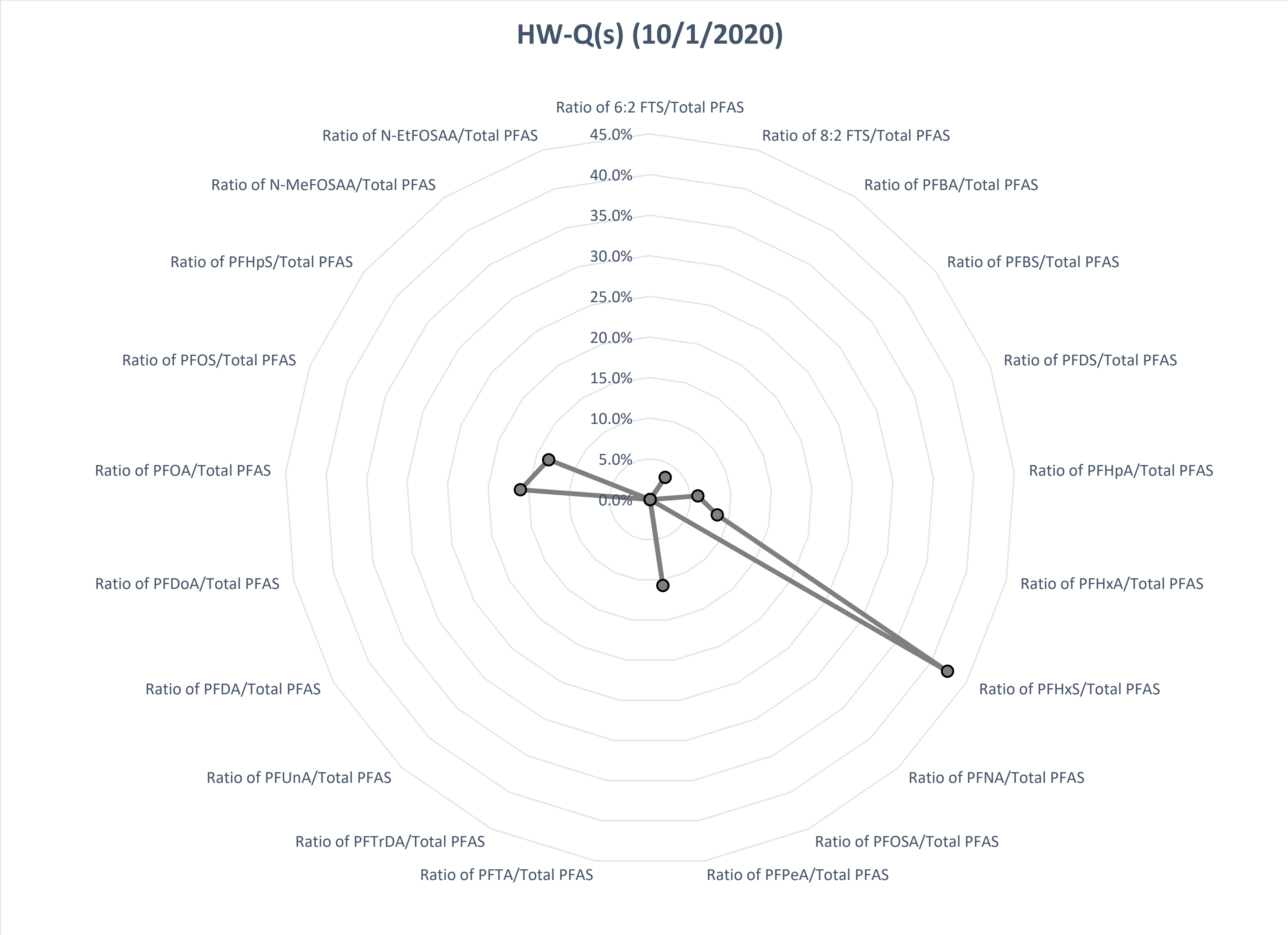
5.0%
0.0%


HW-Q(s) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
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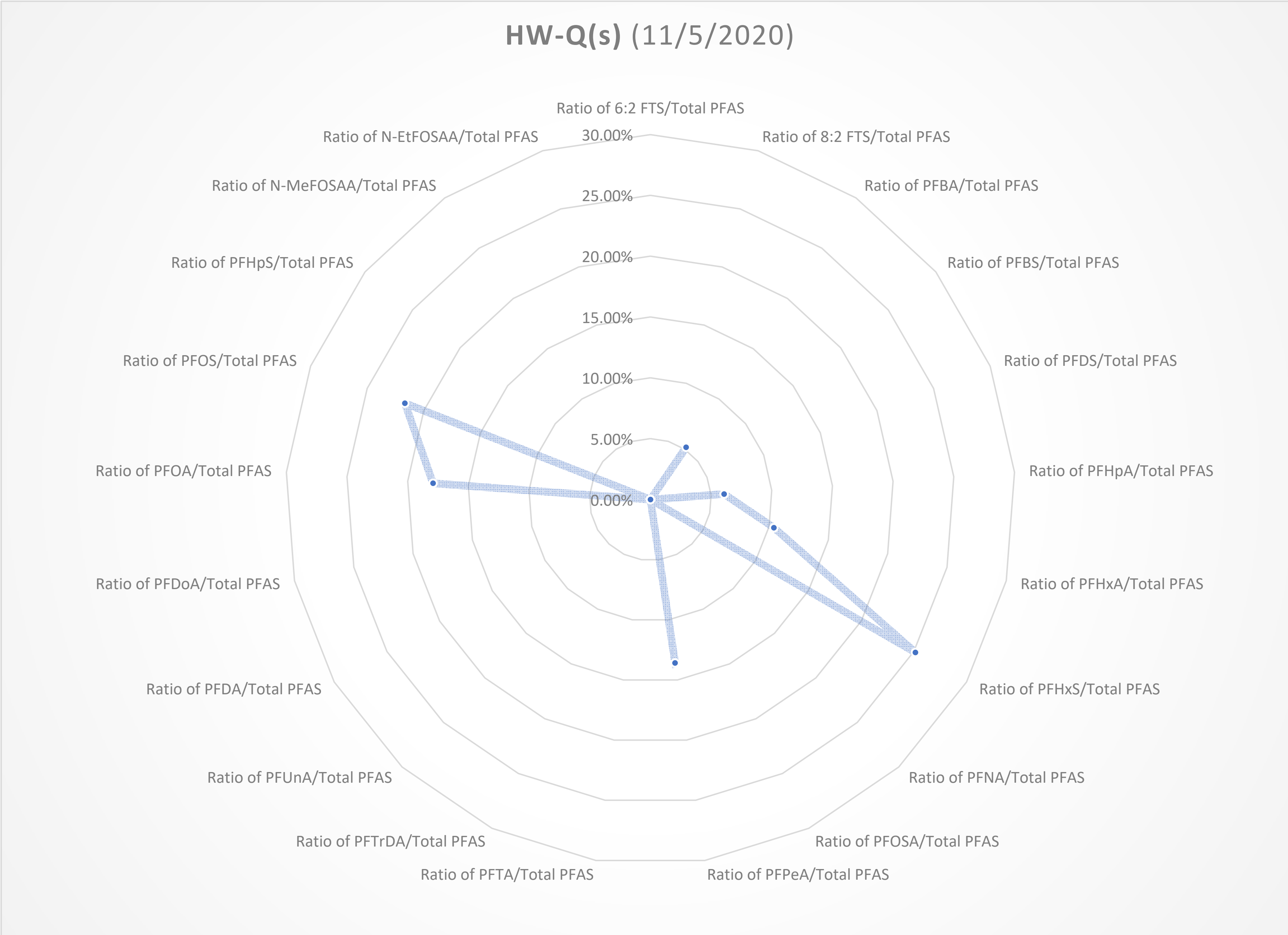
5.0%
0.0%


HW-Q(s) (11/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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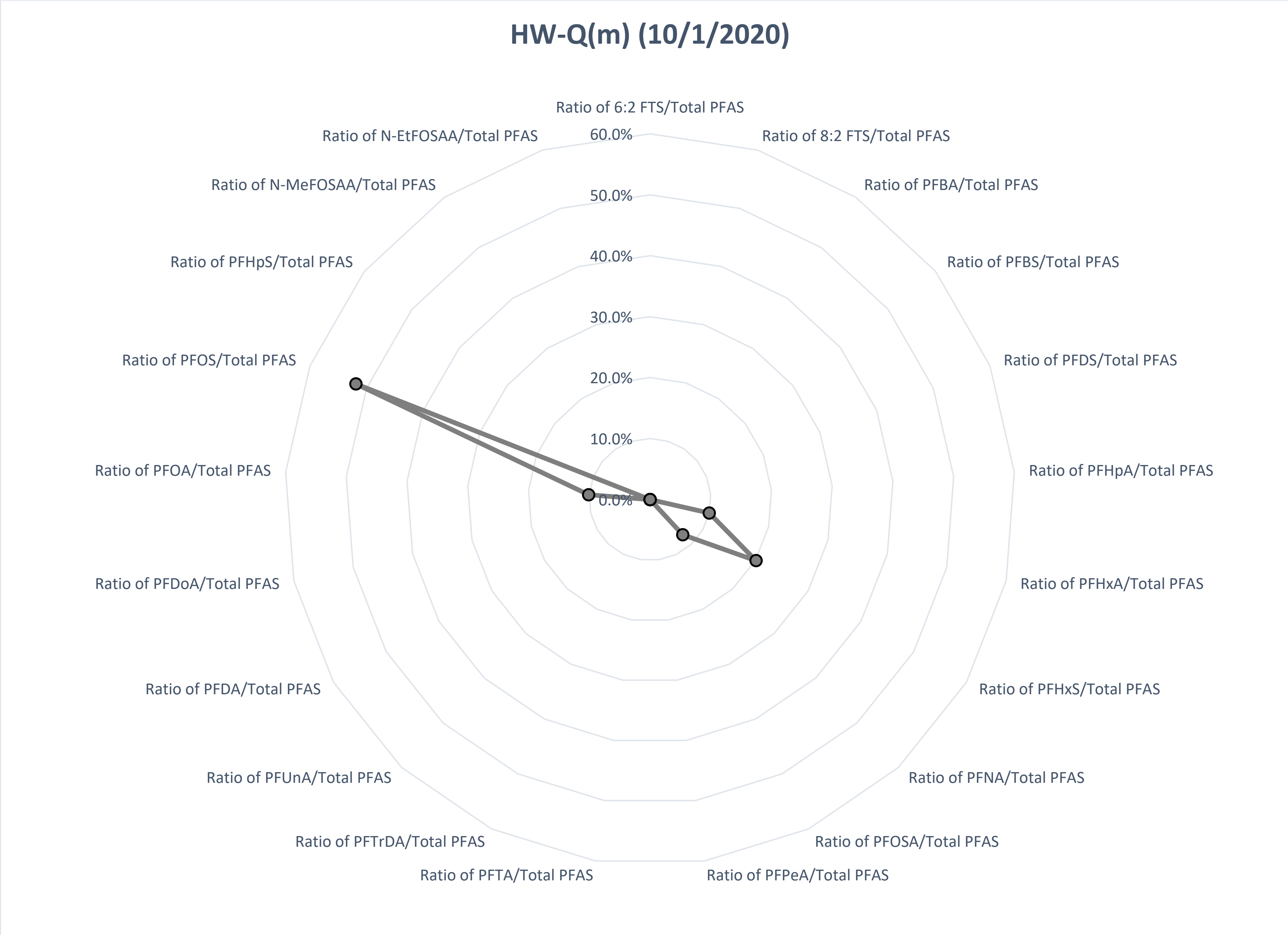
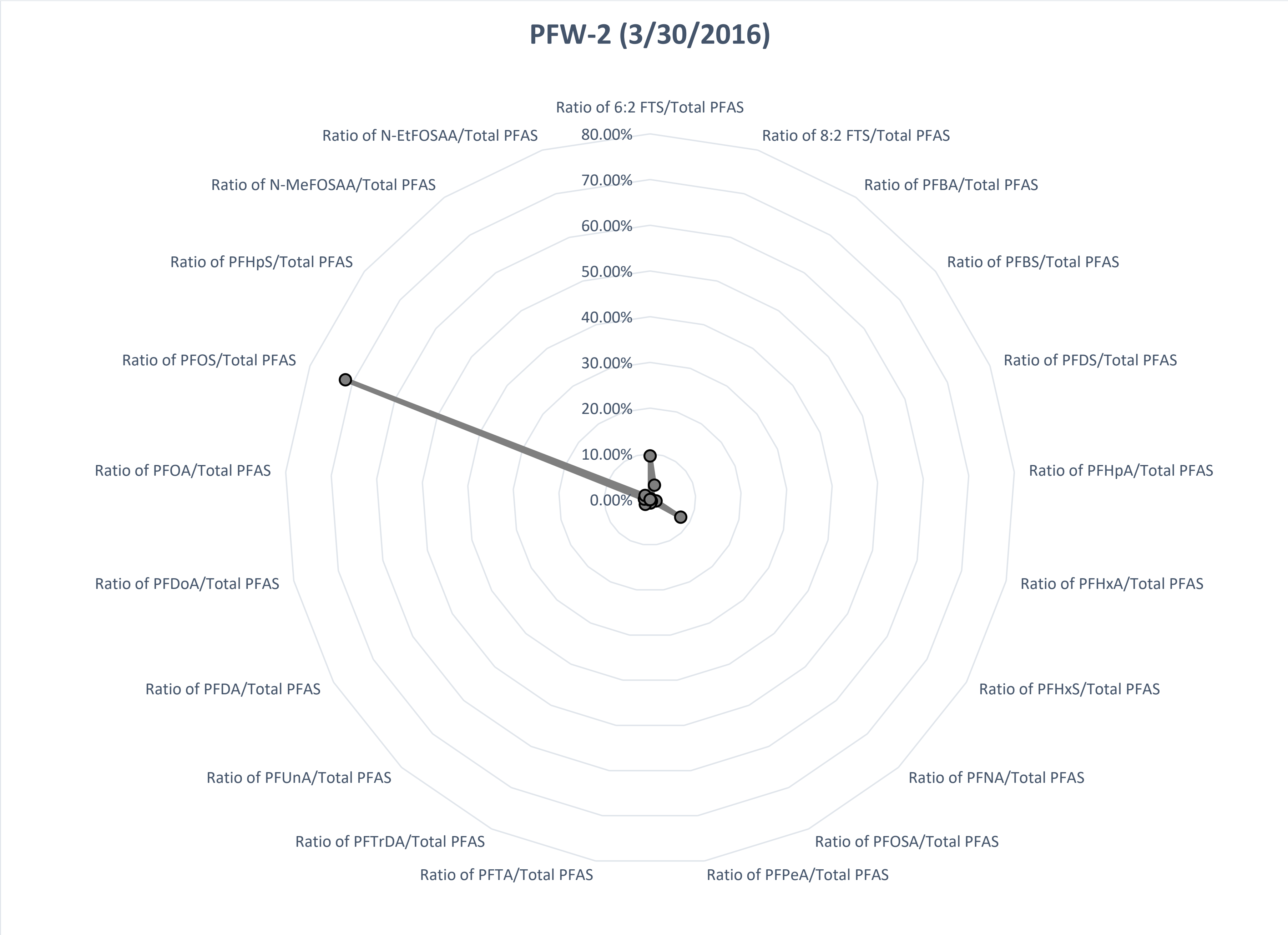
5.00%
0.00%



HW-Q(m) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


PFW-2 (3/30/2016)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
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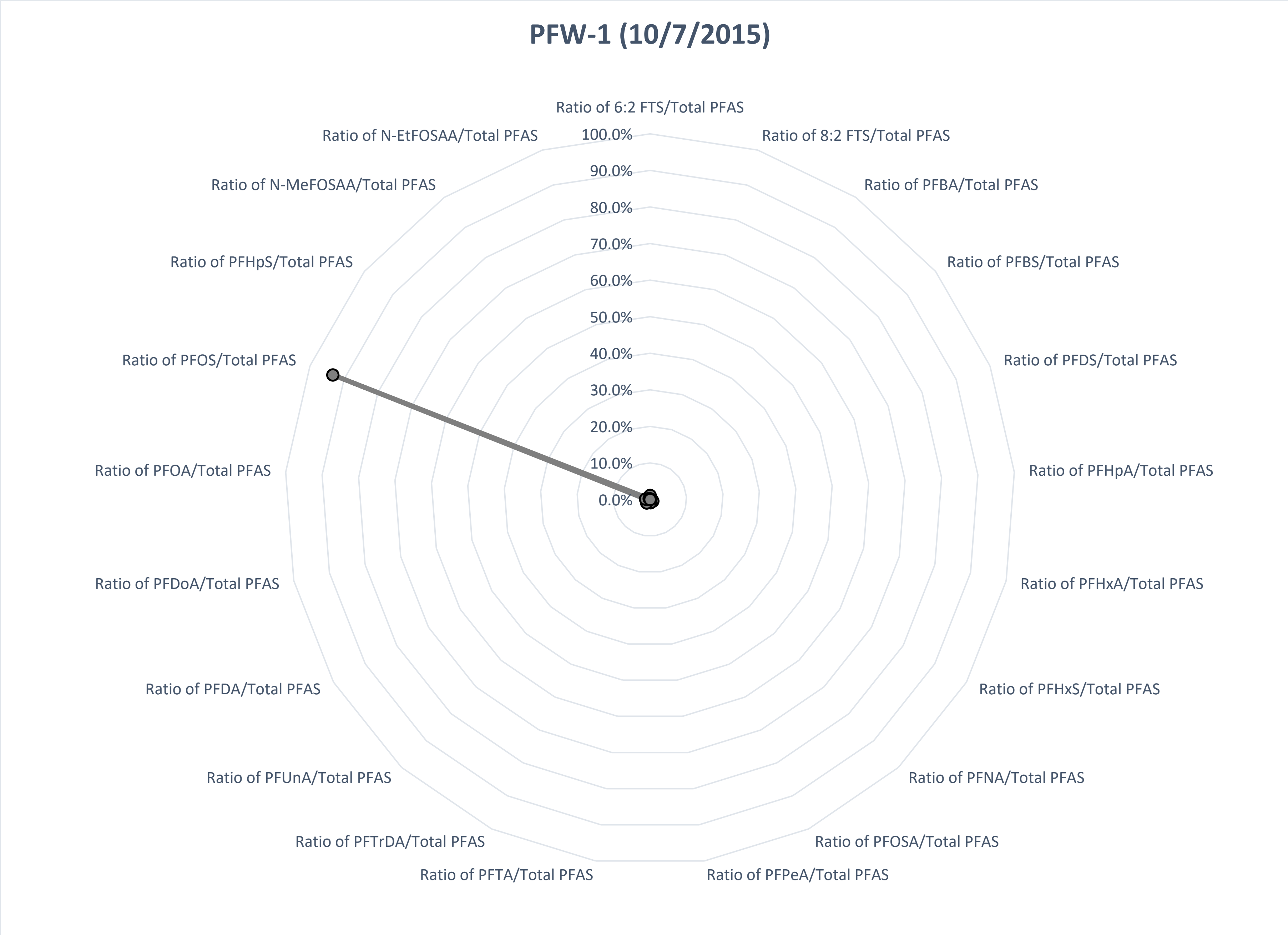
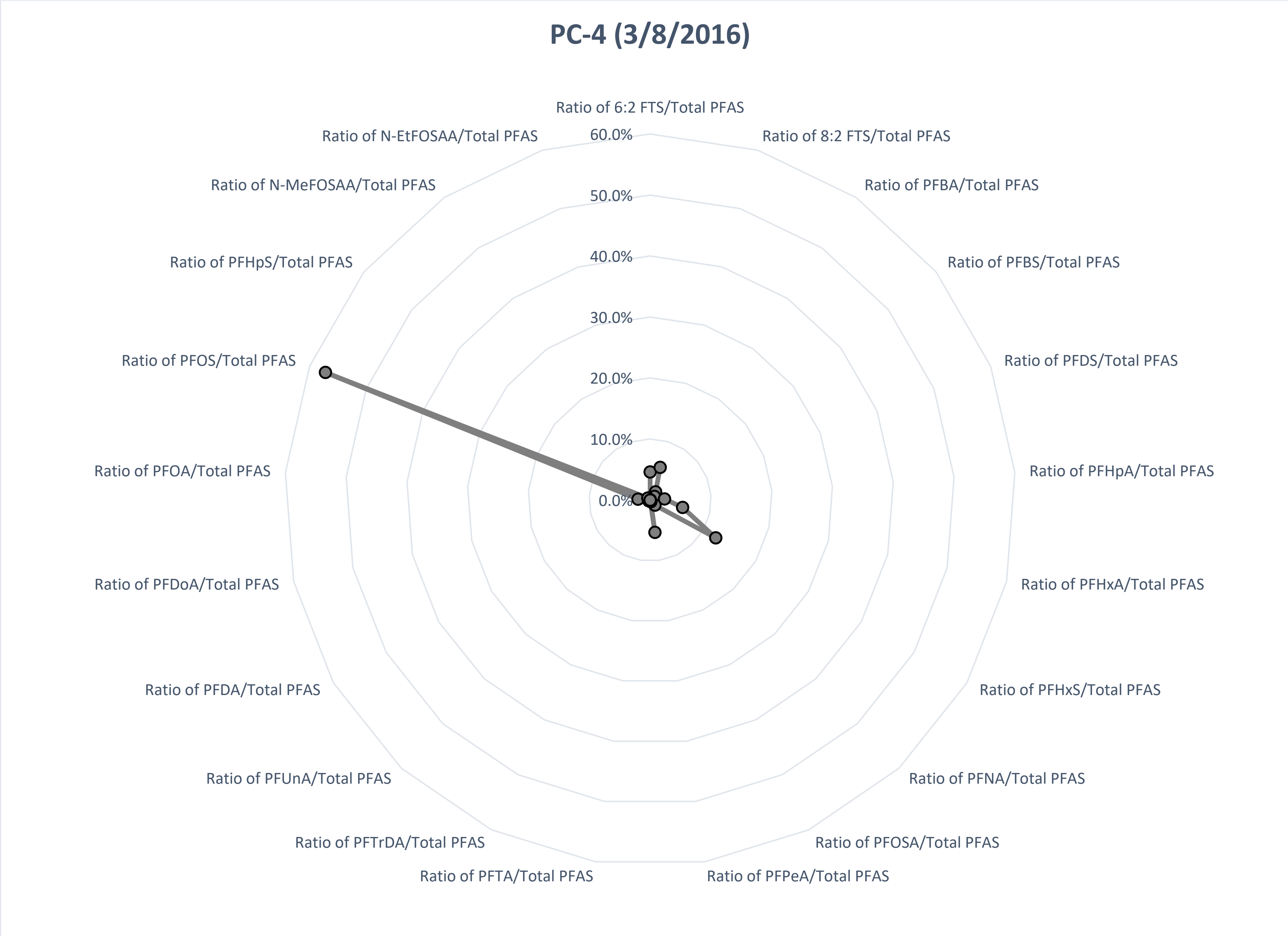
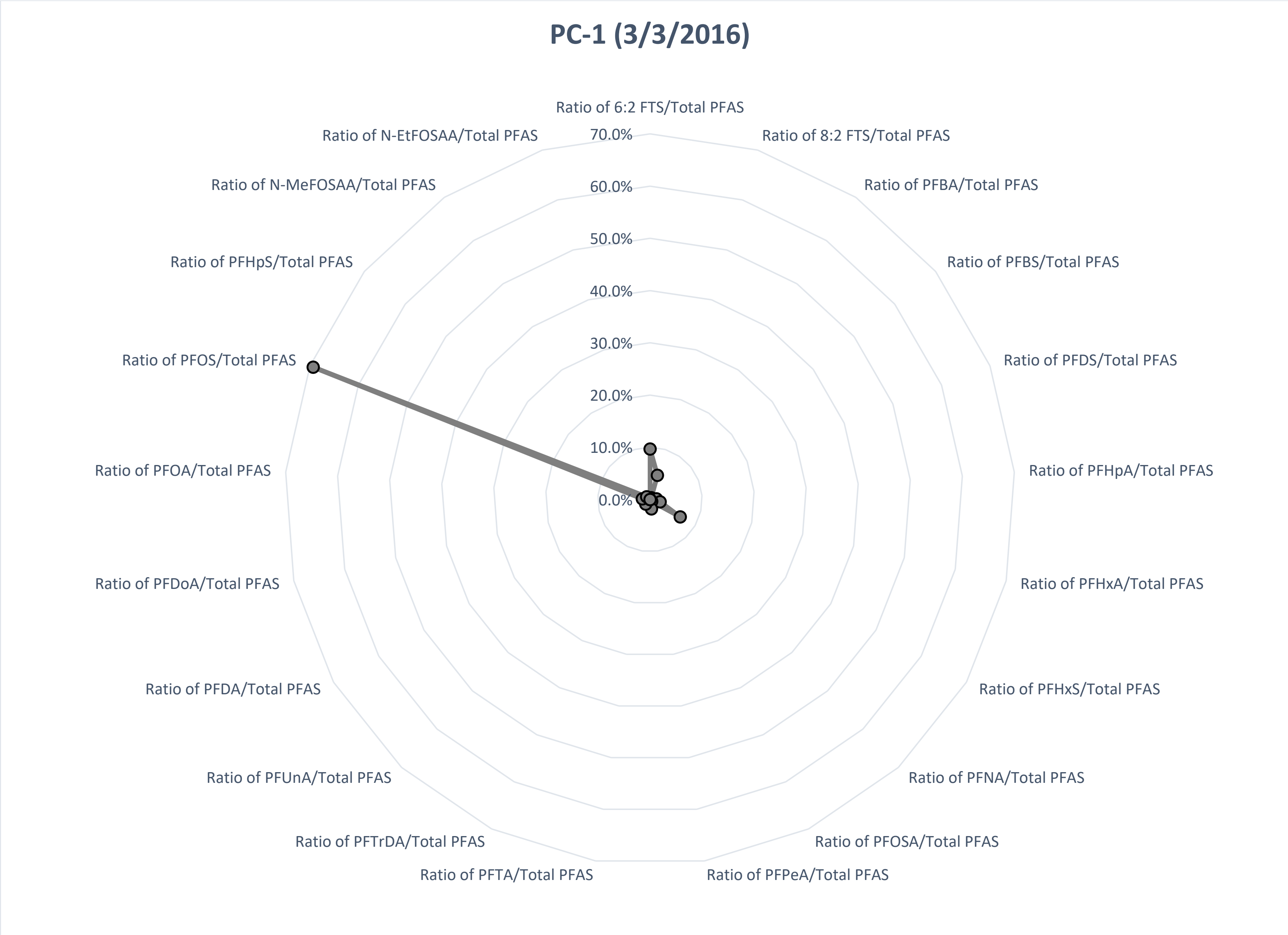
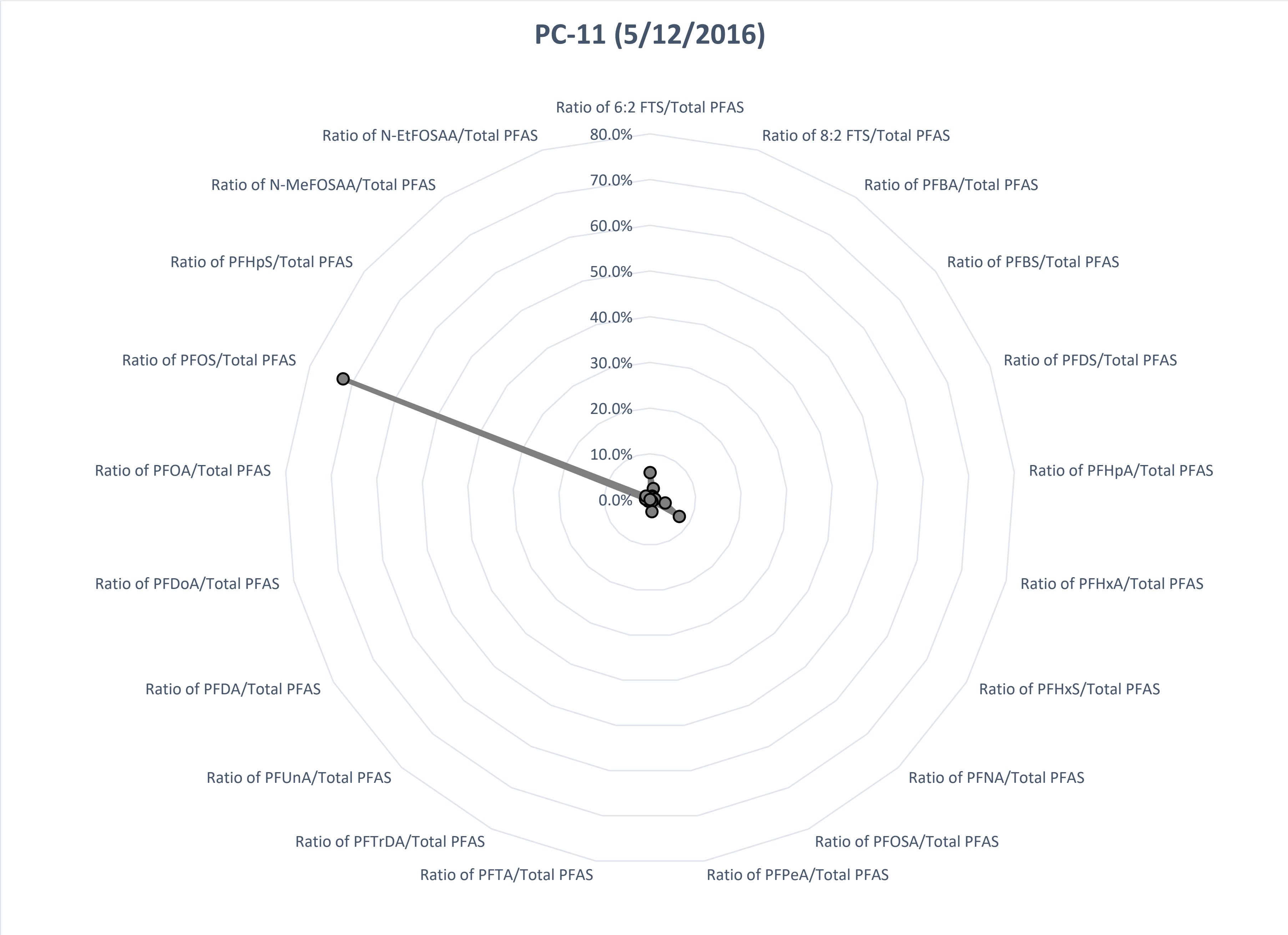
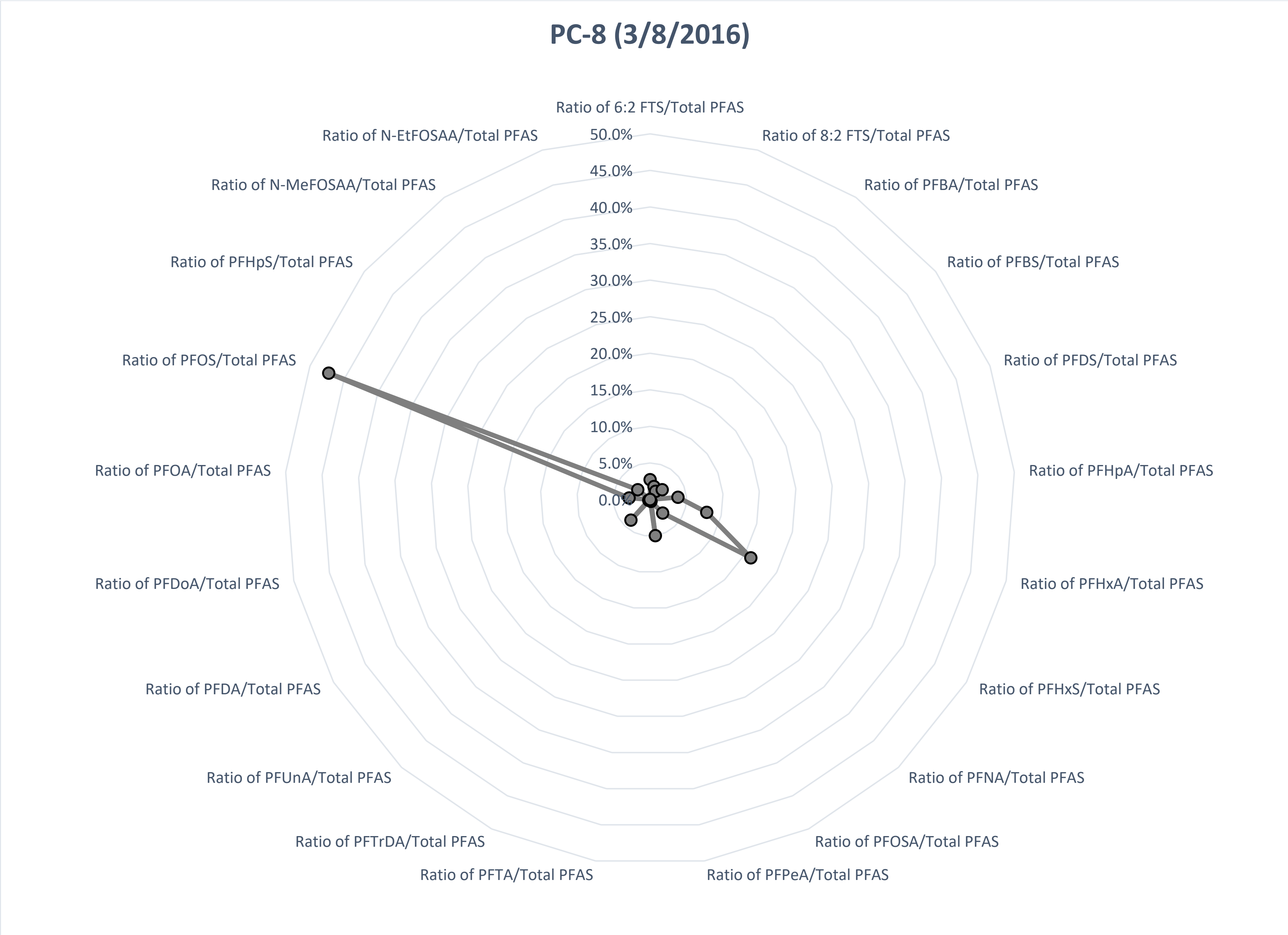
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%

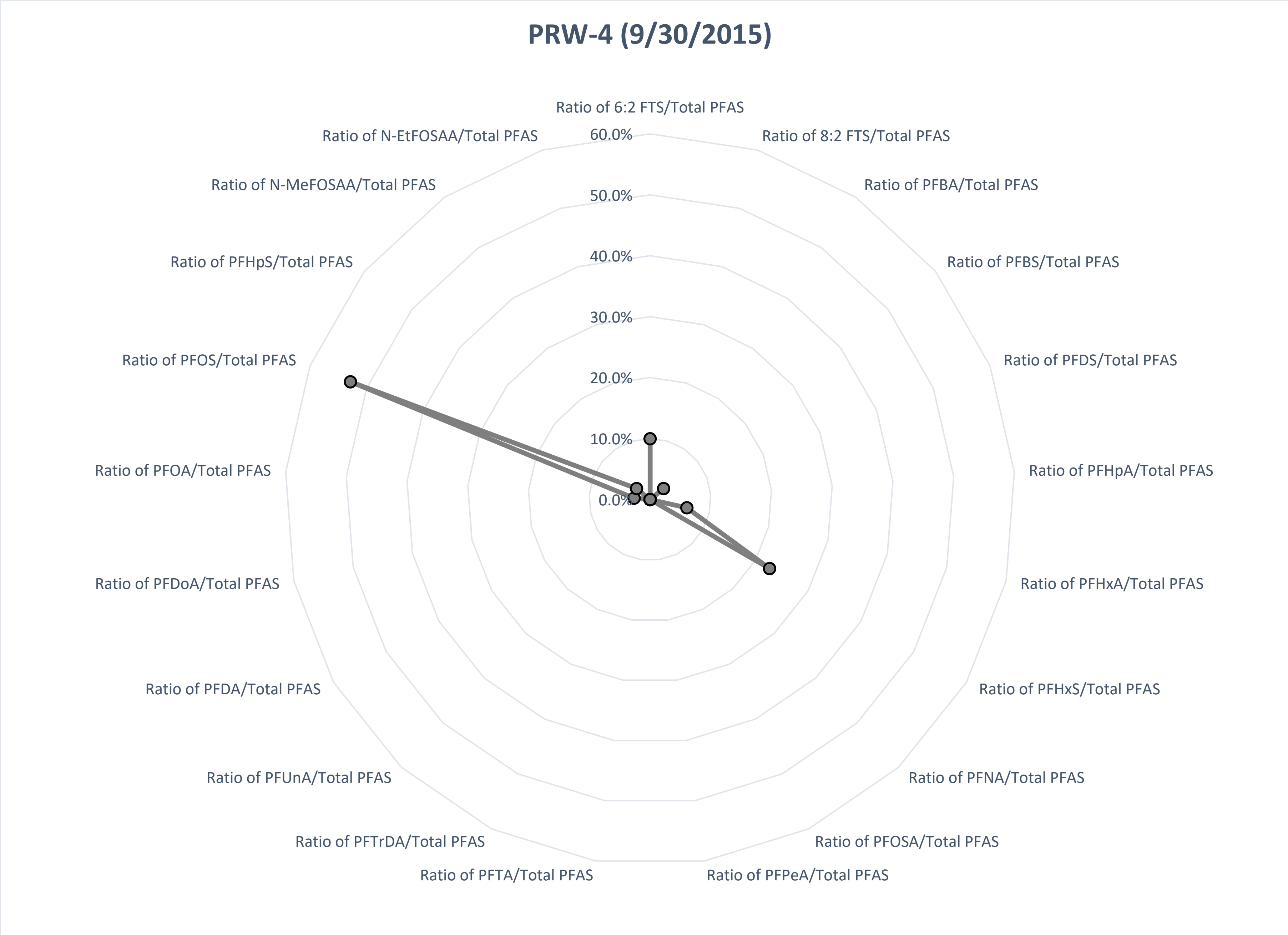

PFW-1 (10/7/2015)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%

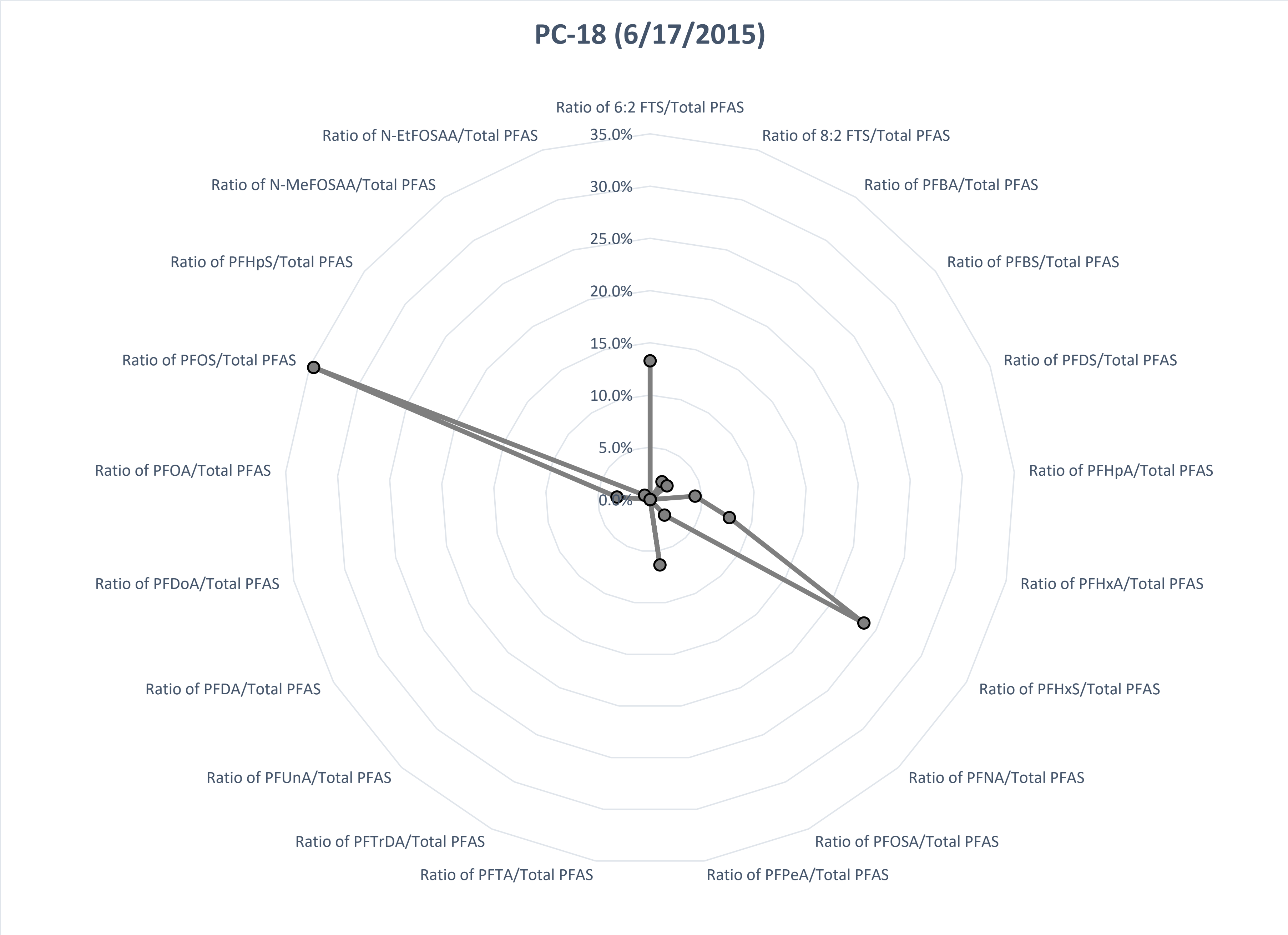

PC-4 (3/8/2016)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%

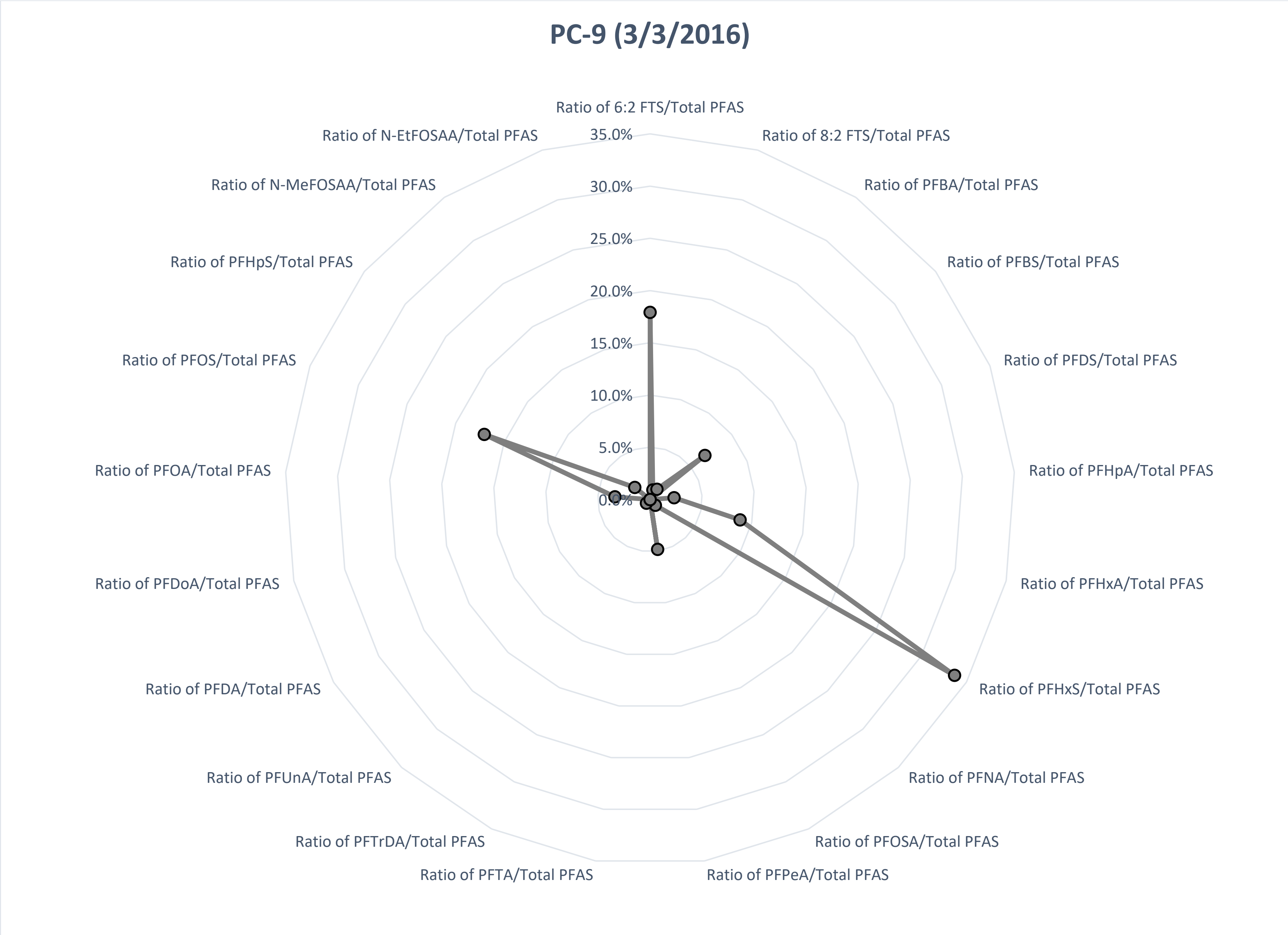

PC-1 (3/3/2016)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%

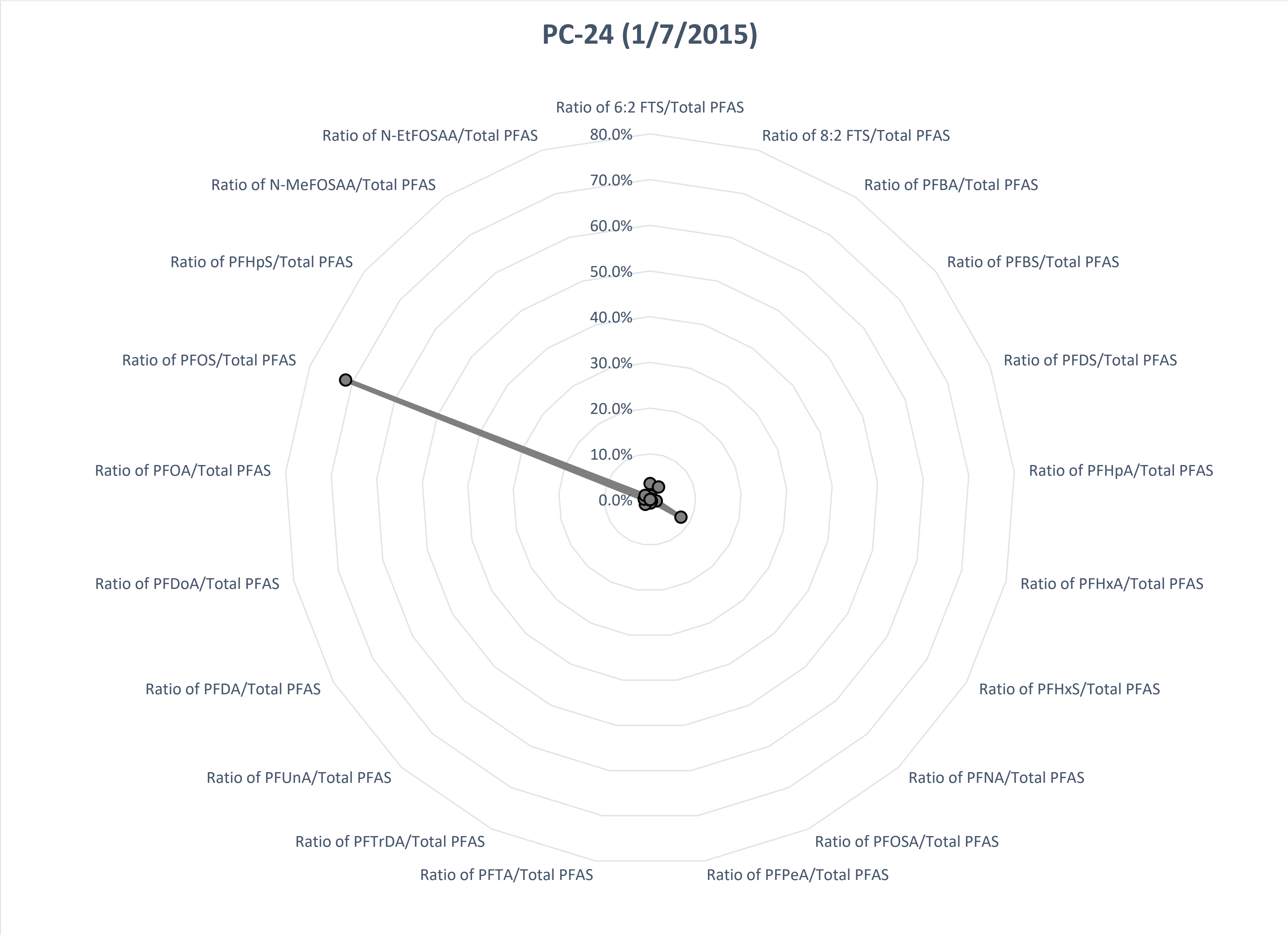

PC-11 (5/12/2016)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


PC-8 (3/8/2016)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

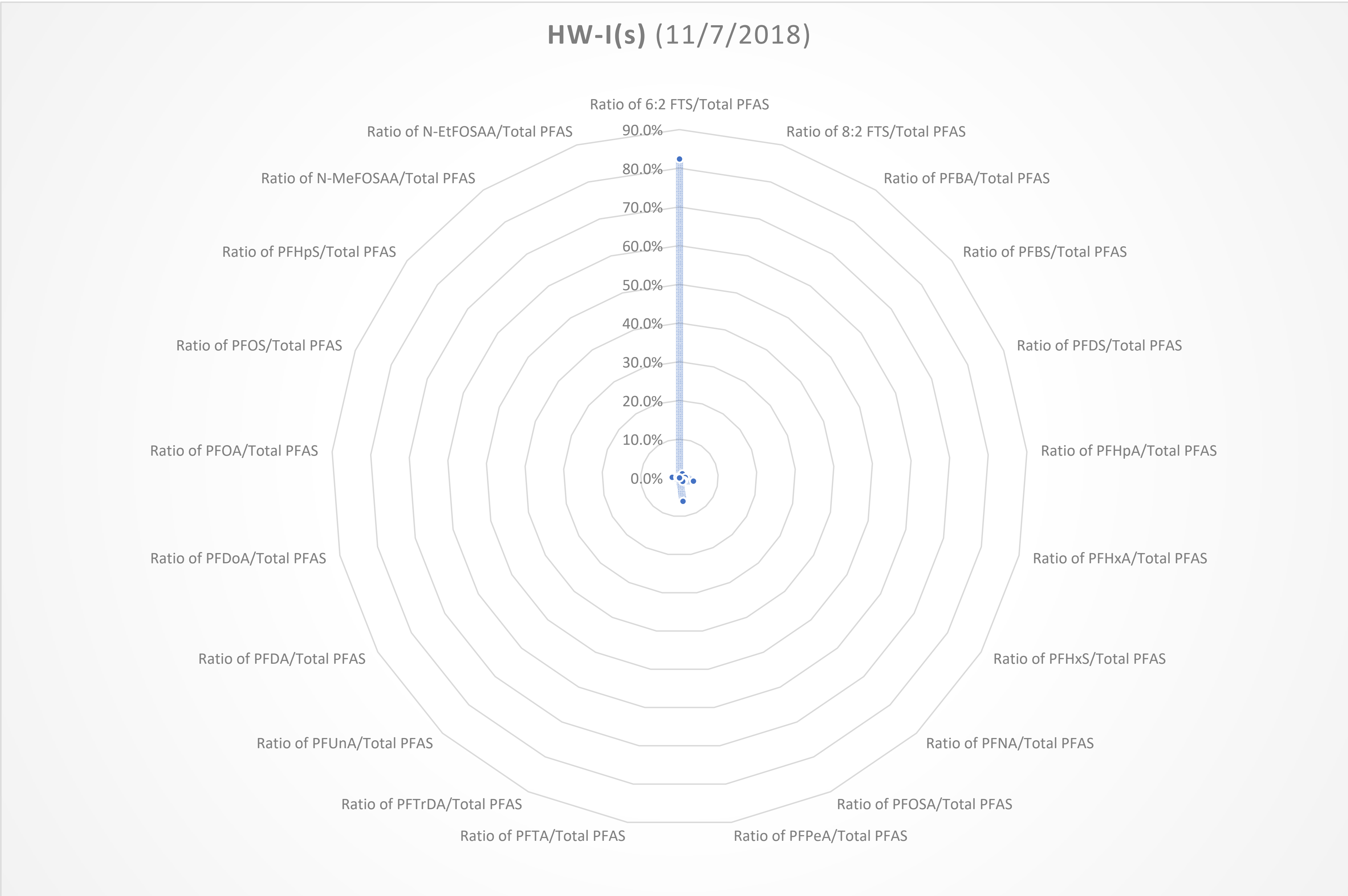

PRW-4 (9/30/2015)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%

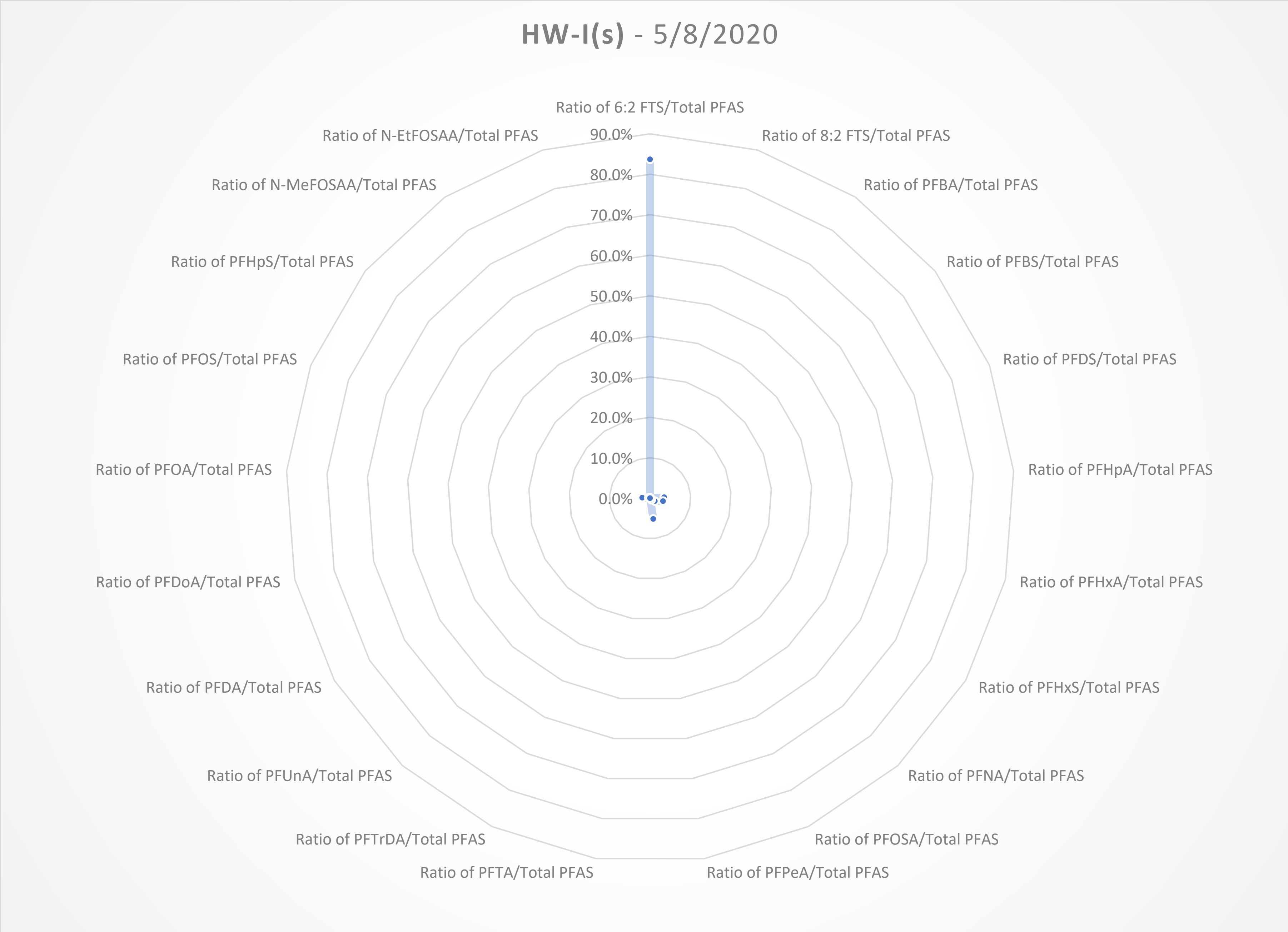

PC-18 (6/17/2015)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


PC-9 (3/3/2016)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



PC-24 (1/7/2015)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


HW-I(s) (11/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


HW-I(s) - 5/8/2020
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
90.0%
80.0%
70.0%
60.0%
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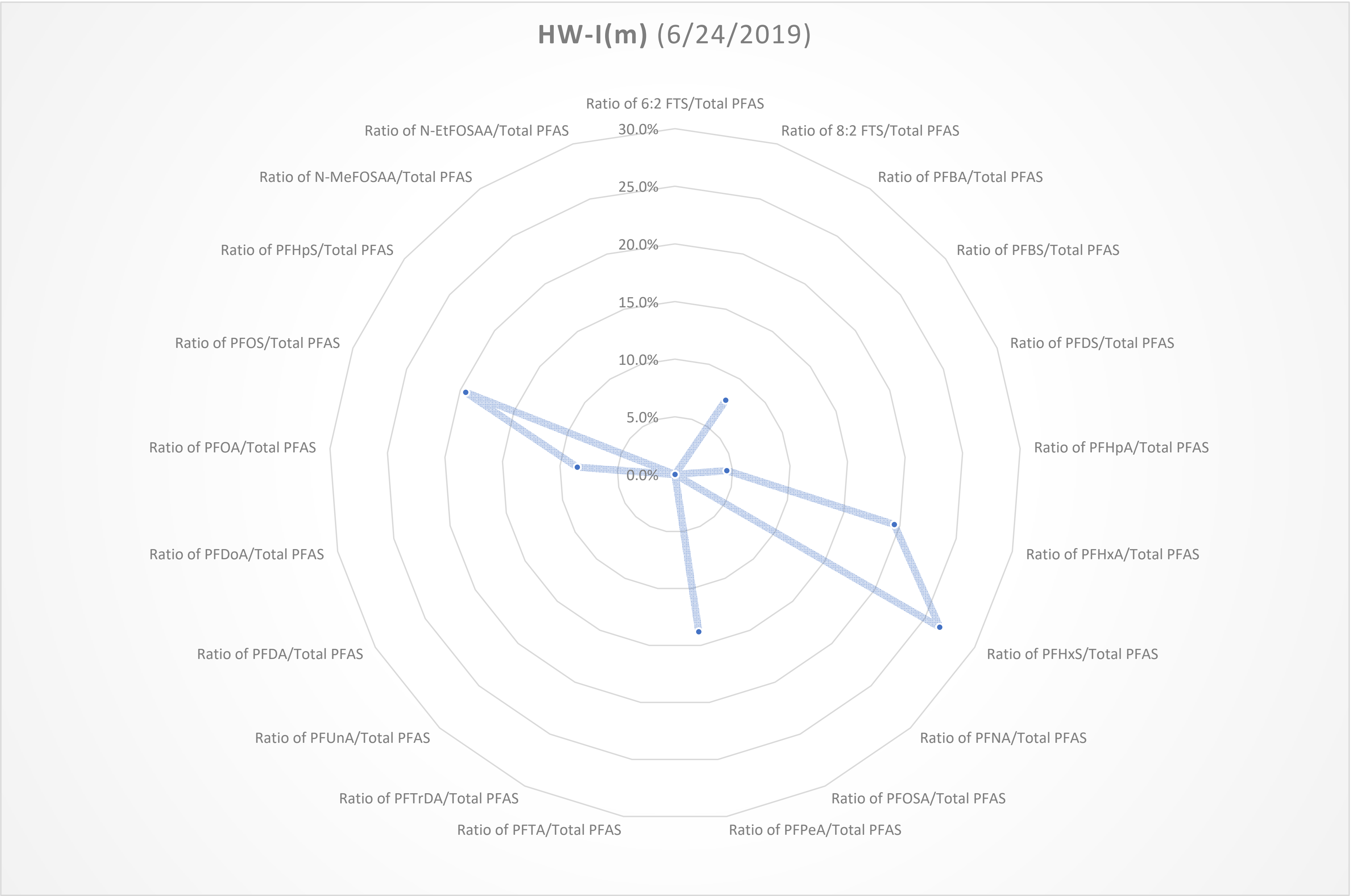
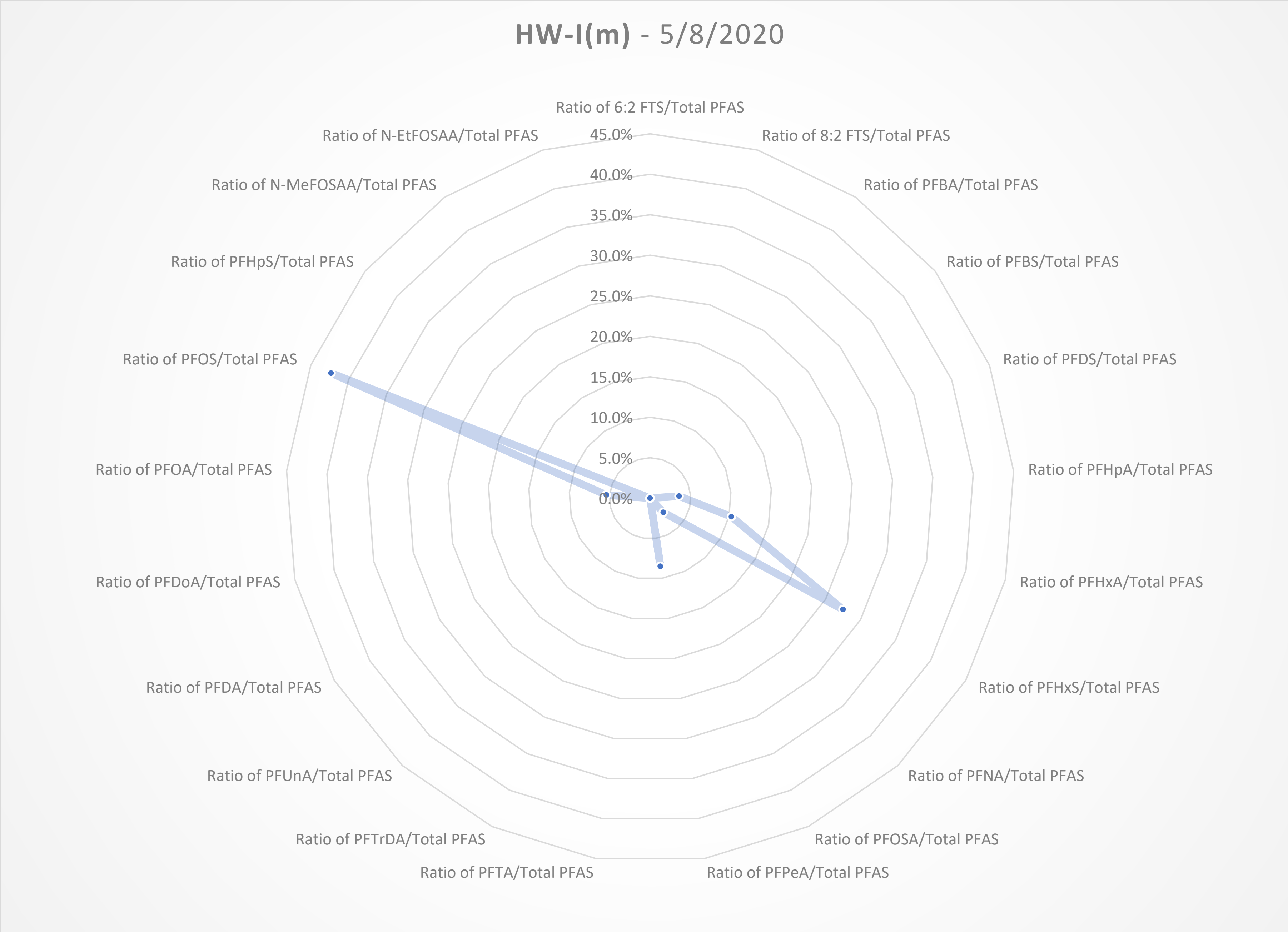
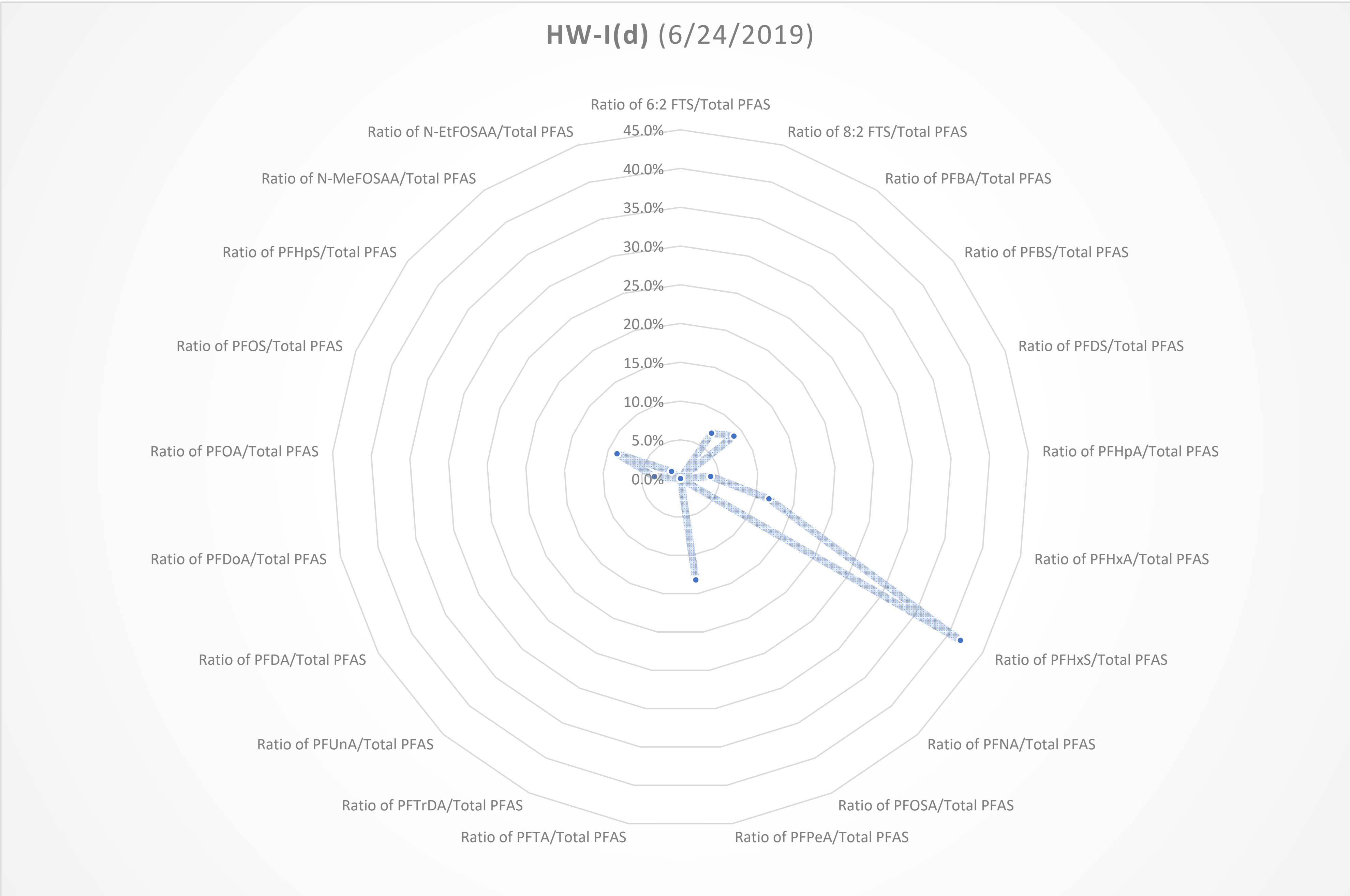
10.0%
0.0%


HW-I(m) (6/24/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-I(m) - 5/8/2020
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-I(d) (6/24/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
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15.0%
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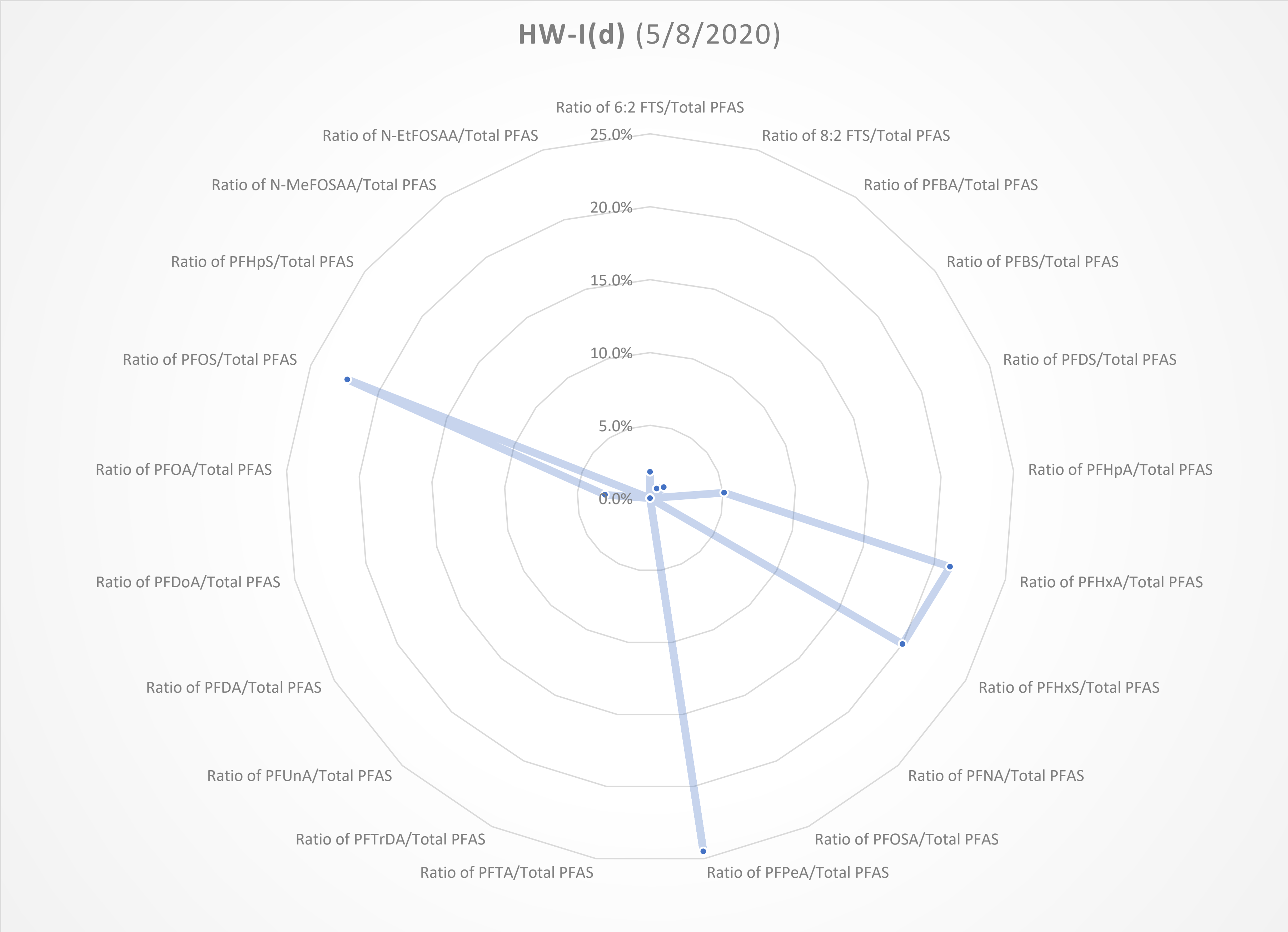
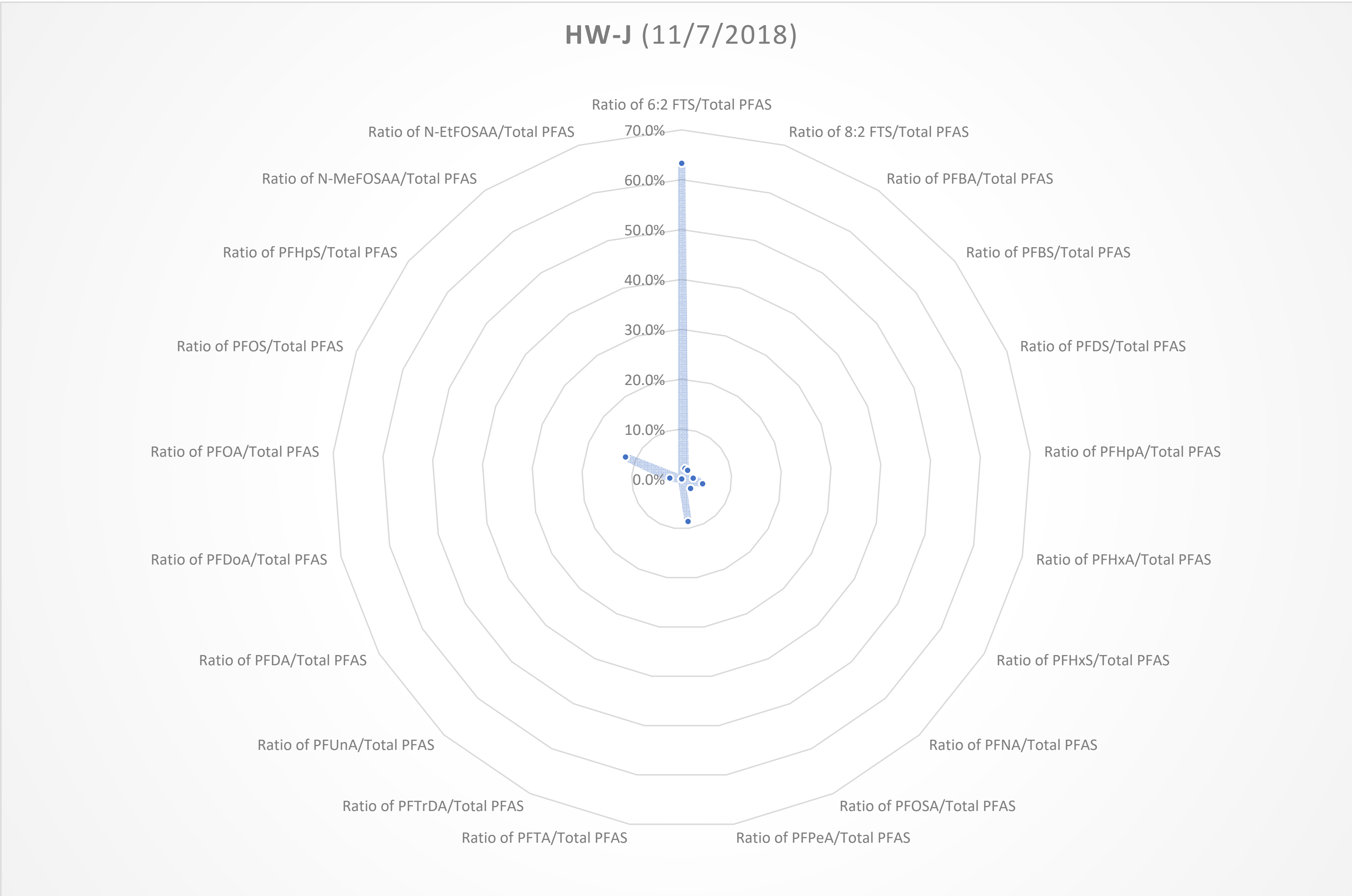
5.0%
0.0%



HW-I(d) (5/8/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



HW-J (11/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
70.0%
60.0%
50.0%
40.0%
30.0%
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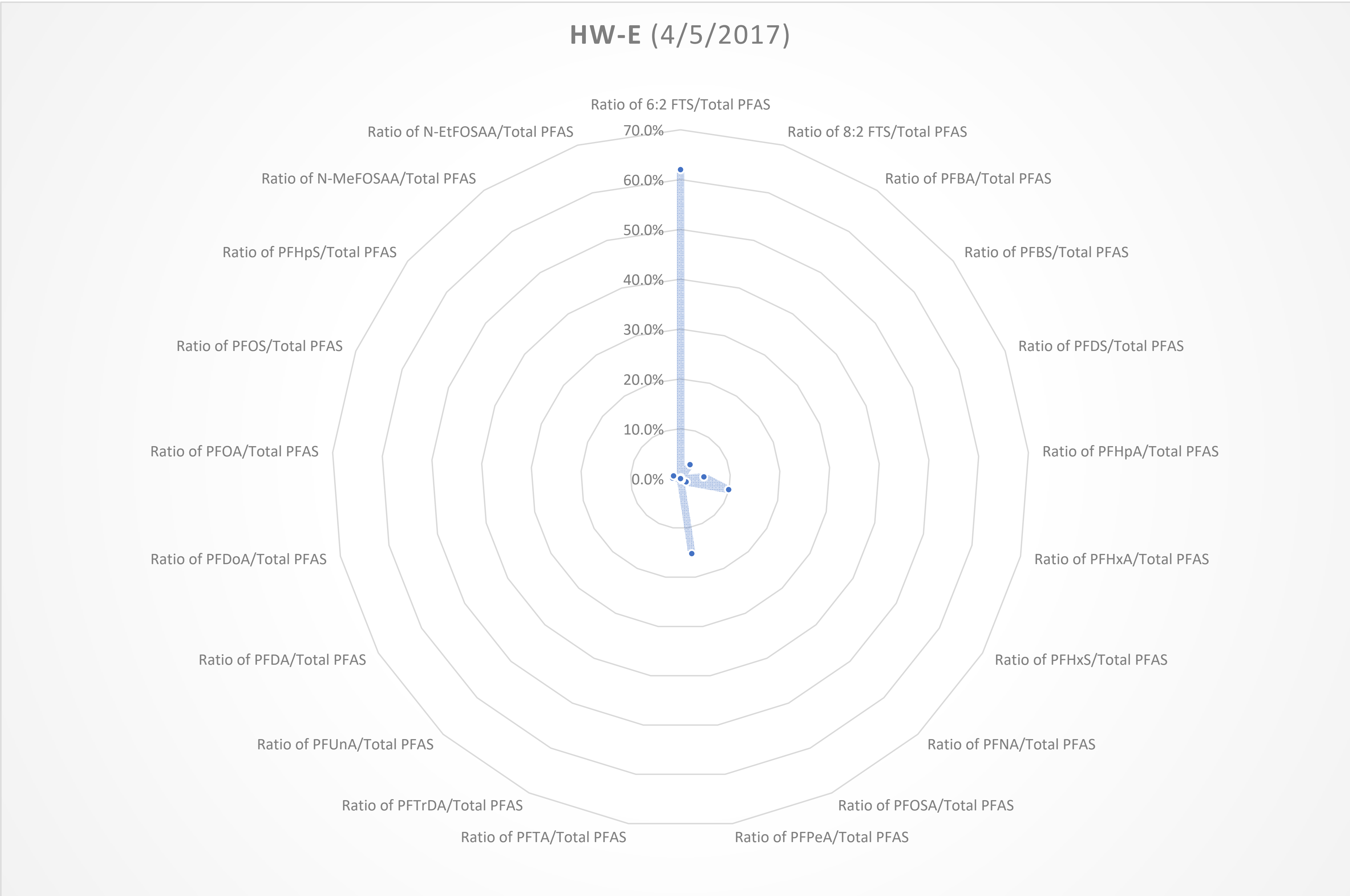
10.0%
0.0%


HW-E (4/5/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
70.0%
60.0%
50.0%
40.0%
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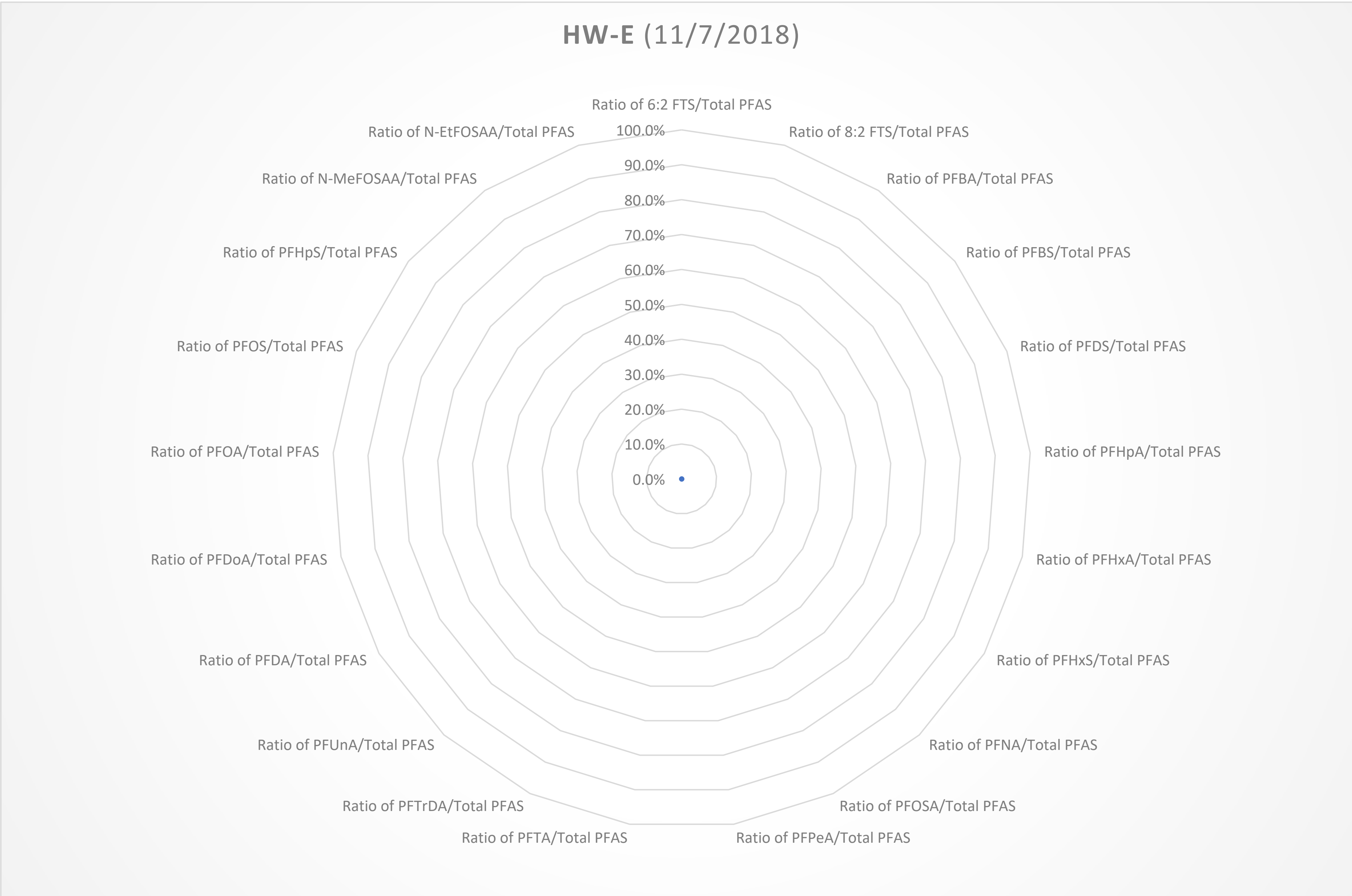
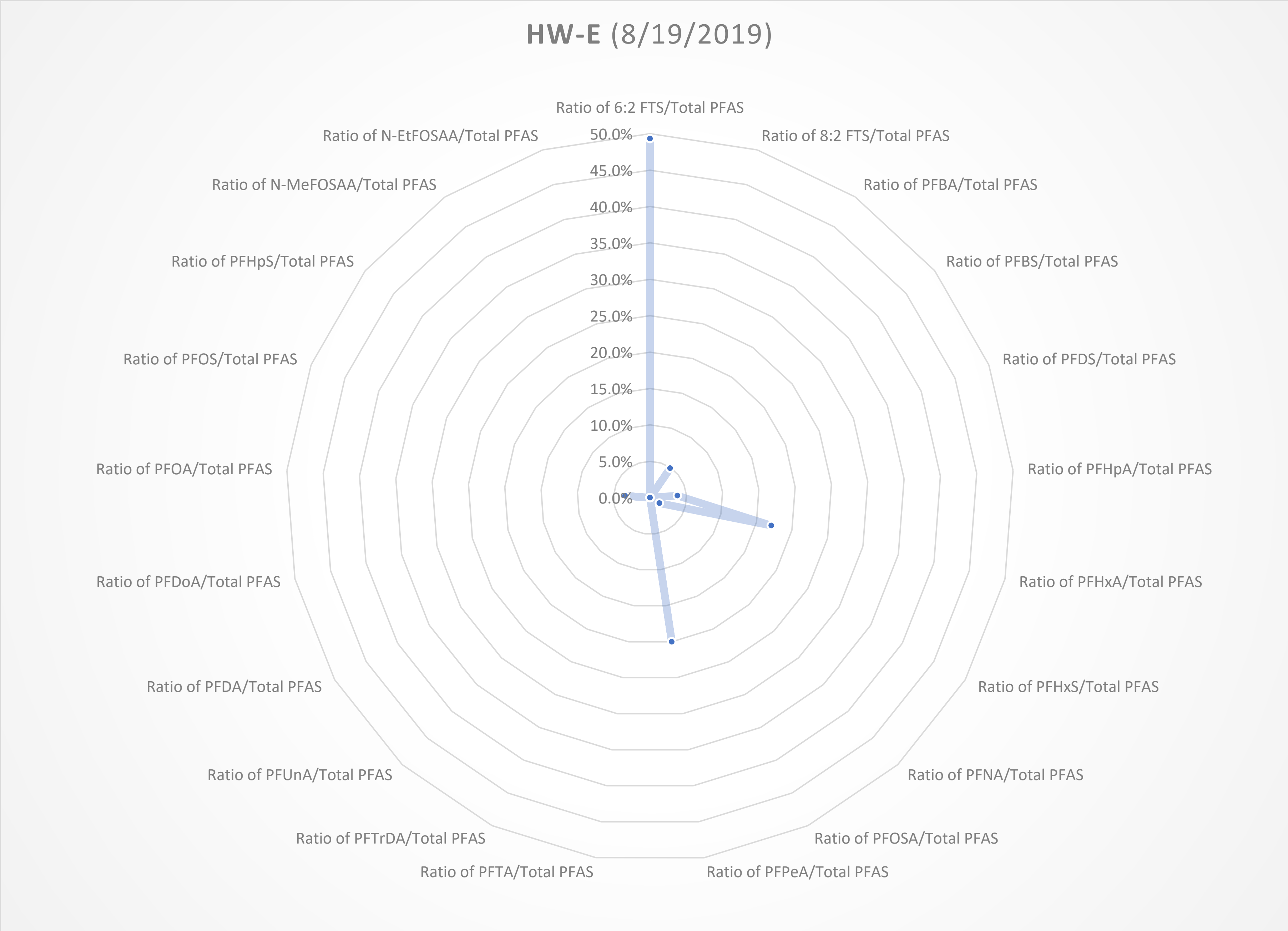
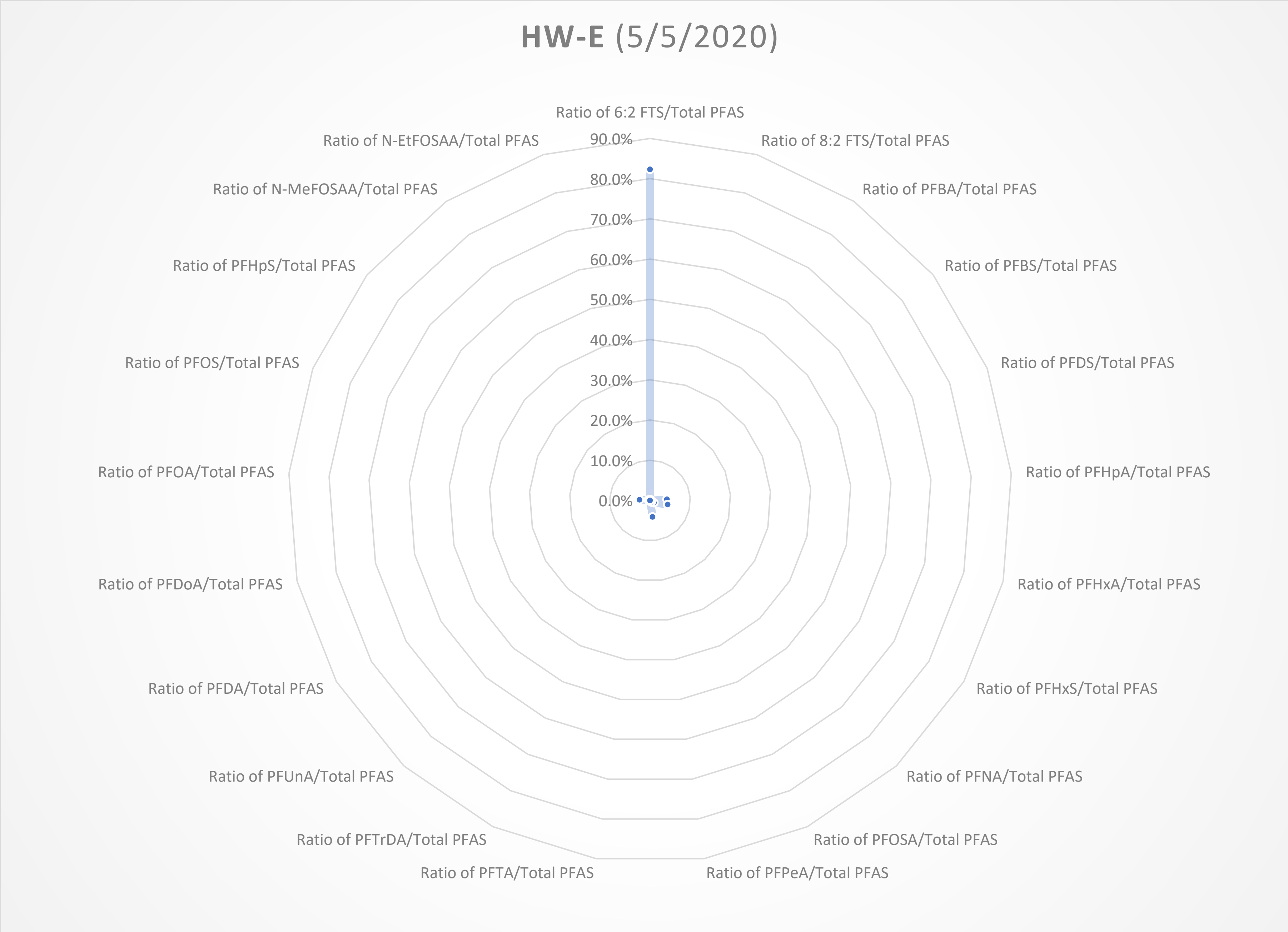
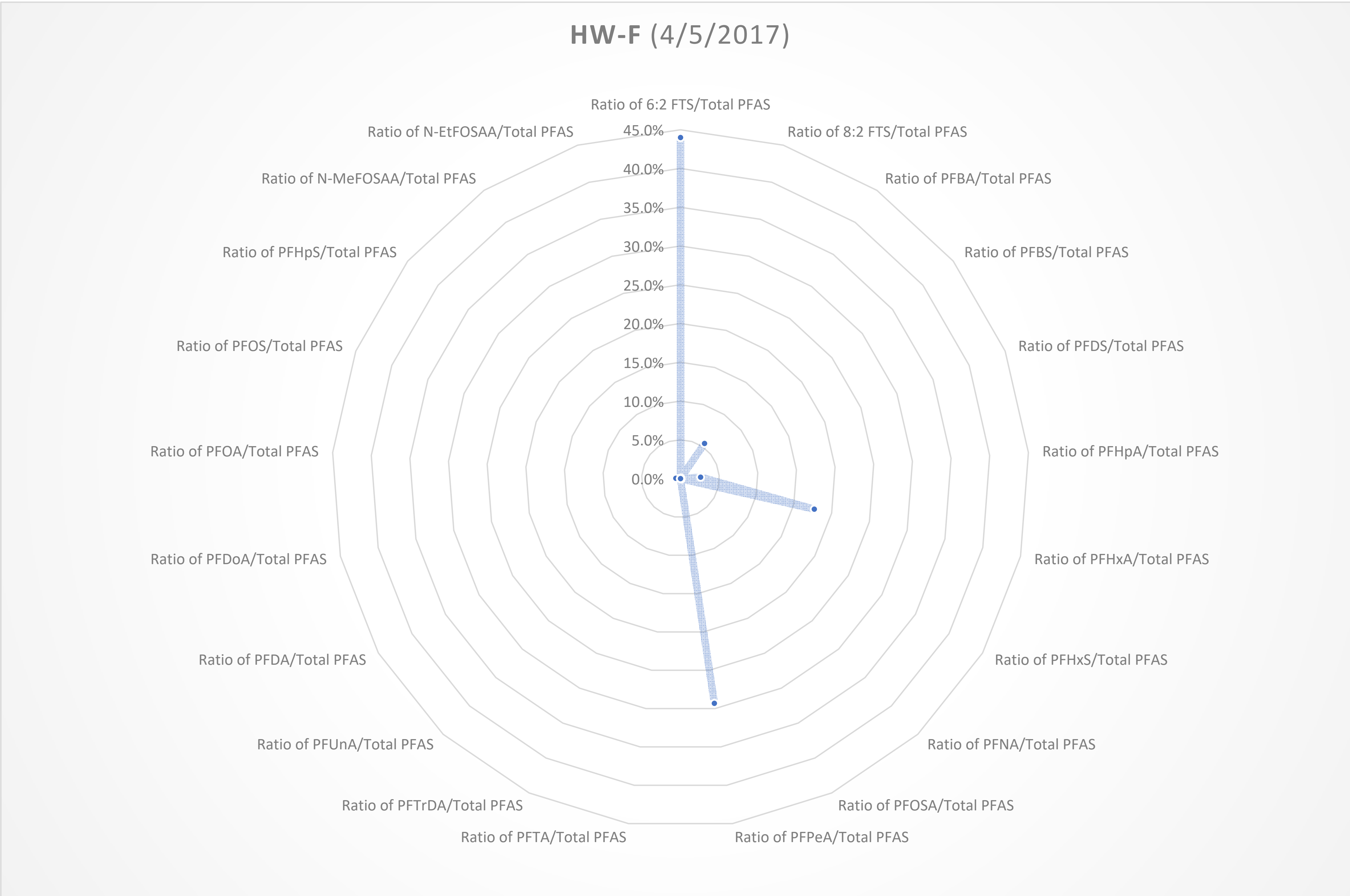
10.0%
0.0%


HW-E (11/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%

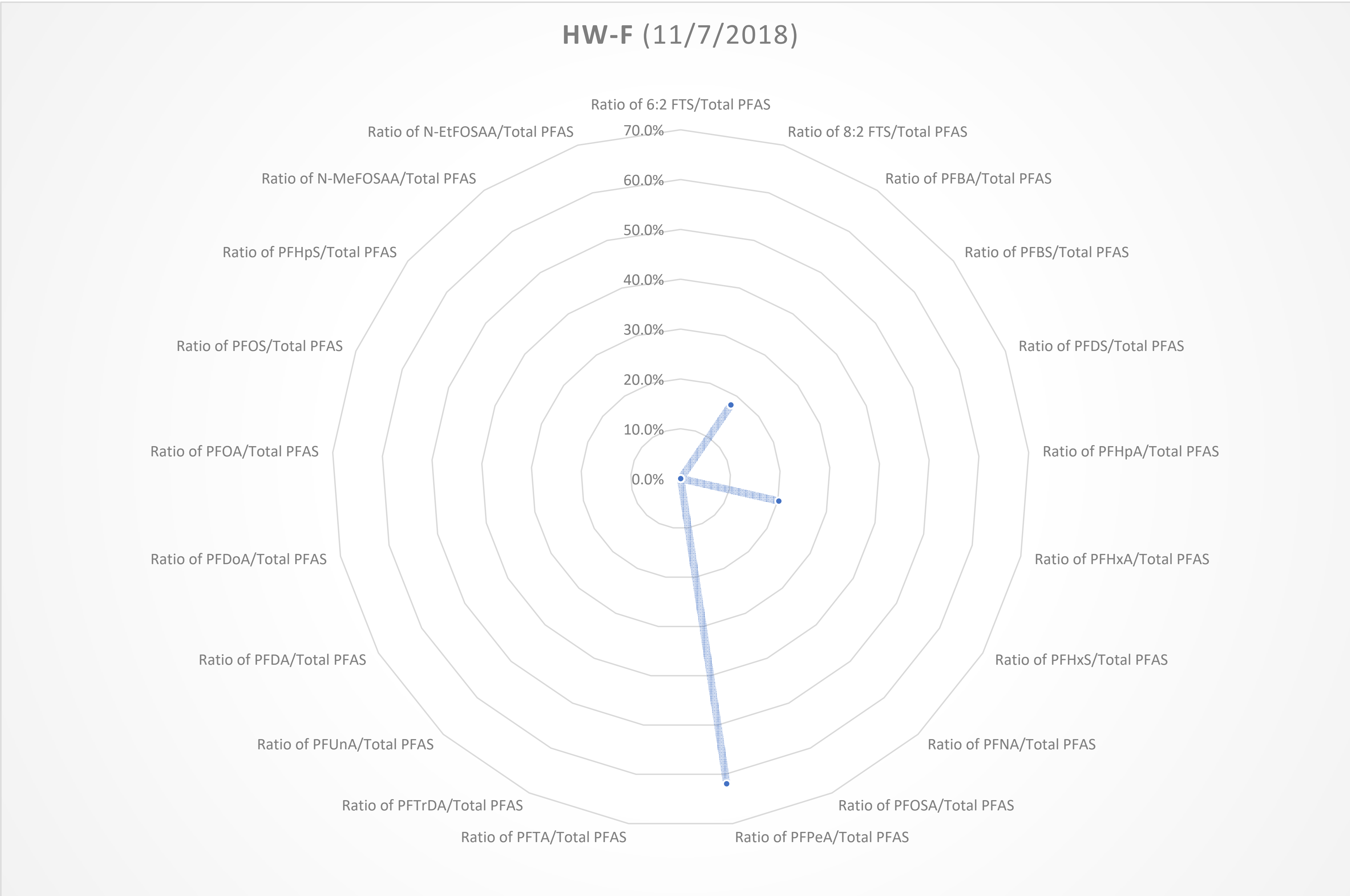


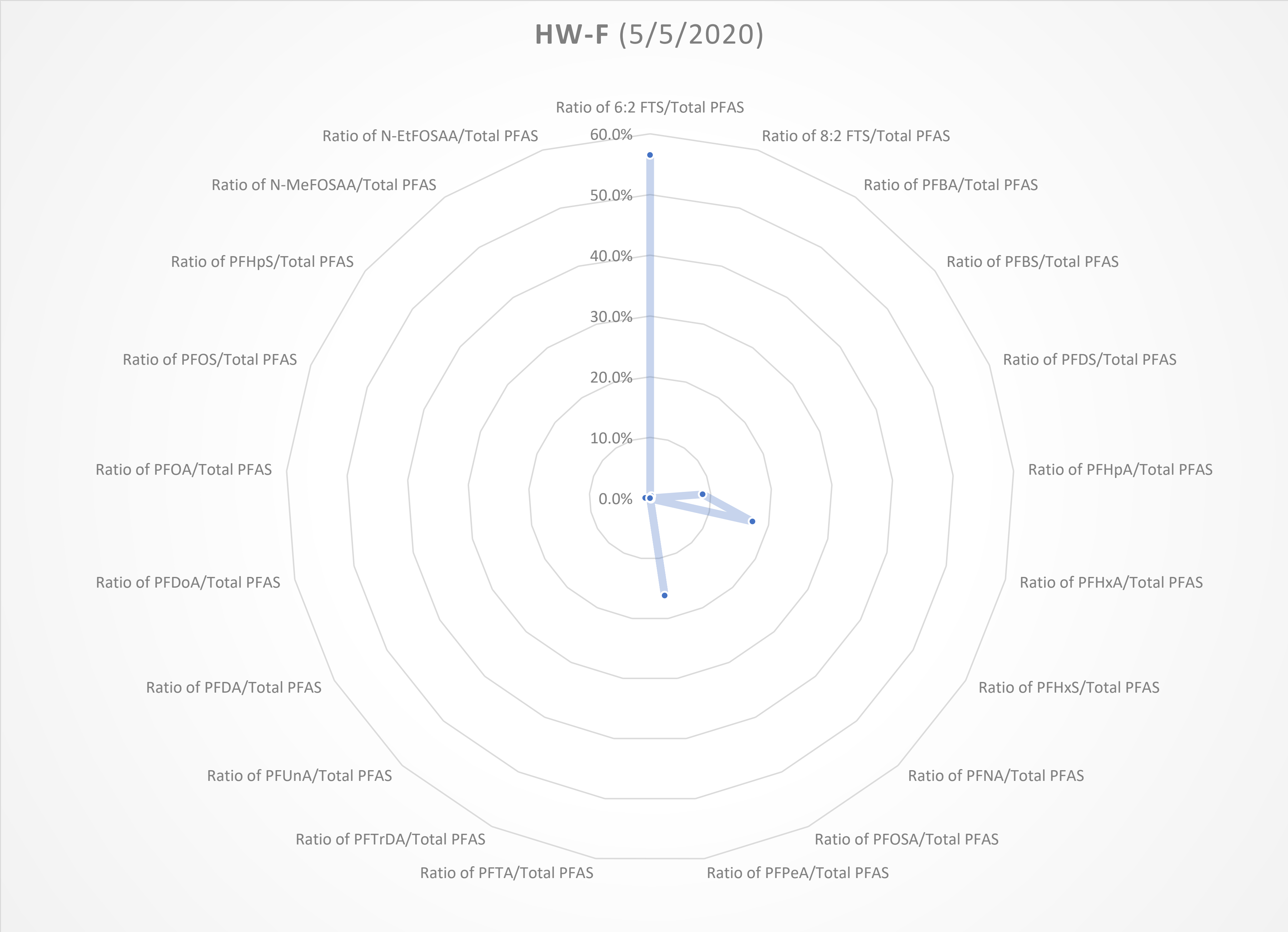
HW-E (8/19/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-E (5/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%

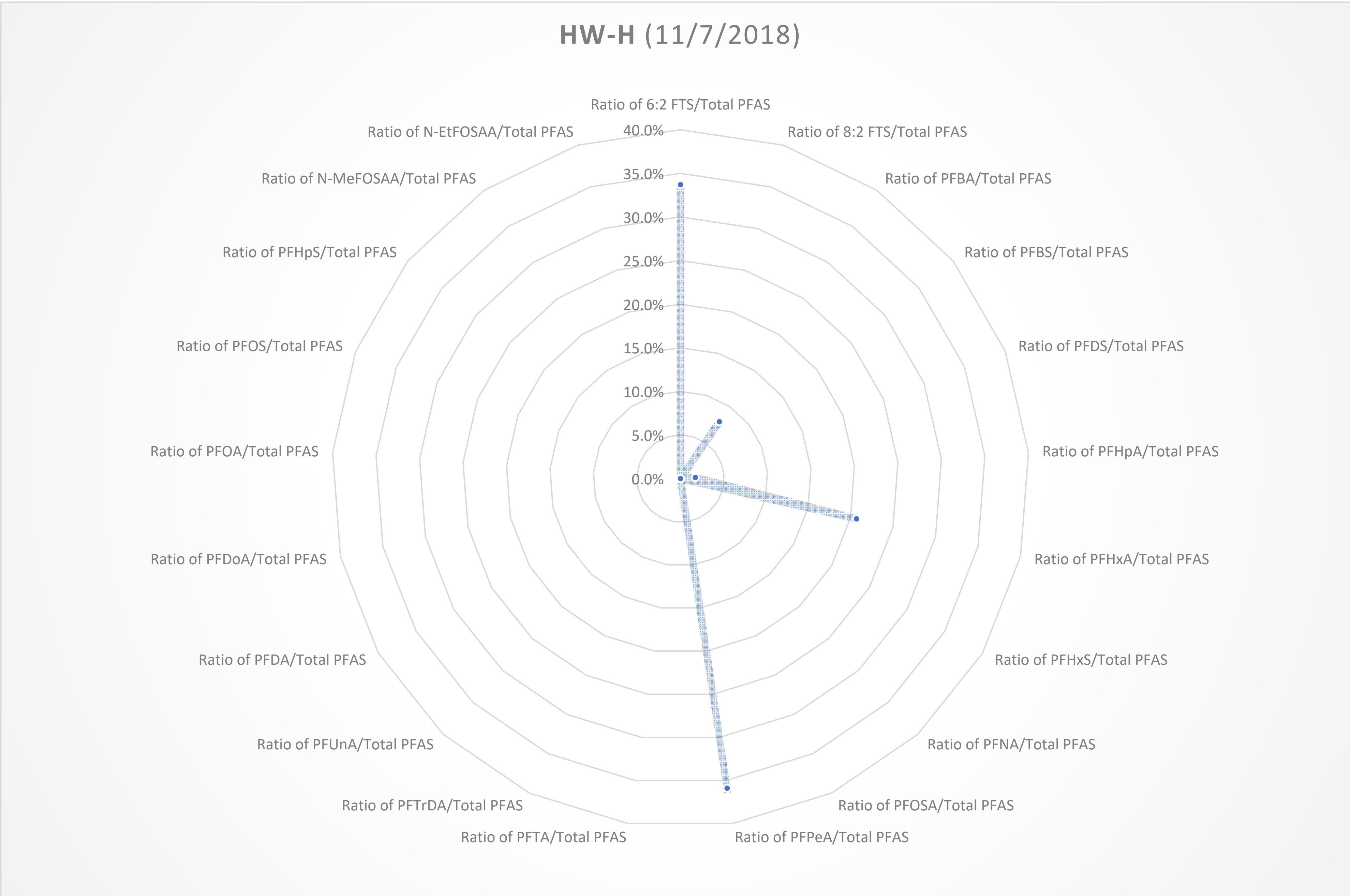


HW-F (4/5/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

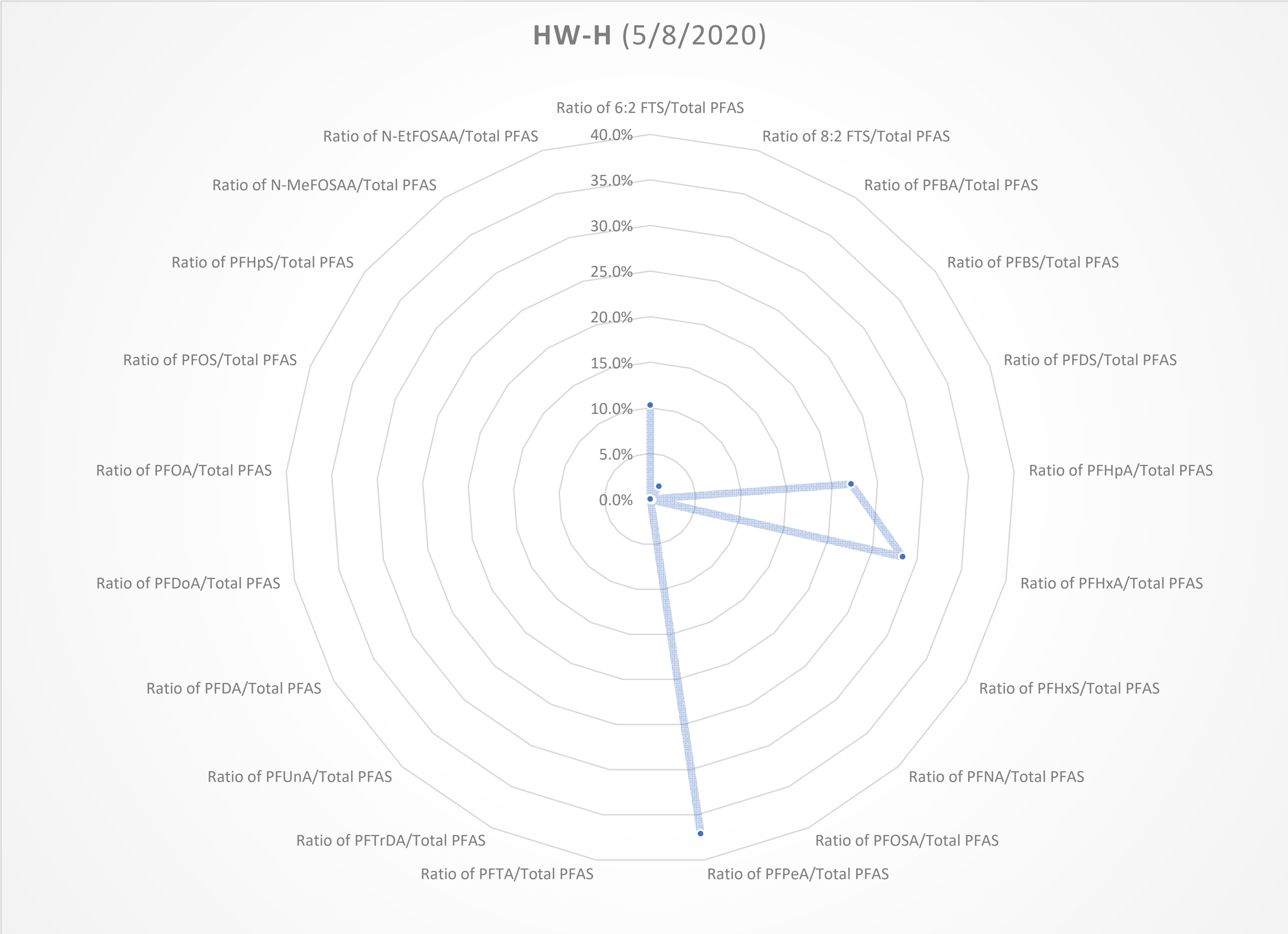

HW-F (11/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



HW-F (5/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



HW-H (11/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-H (5/8/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
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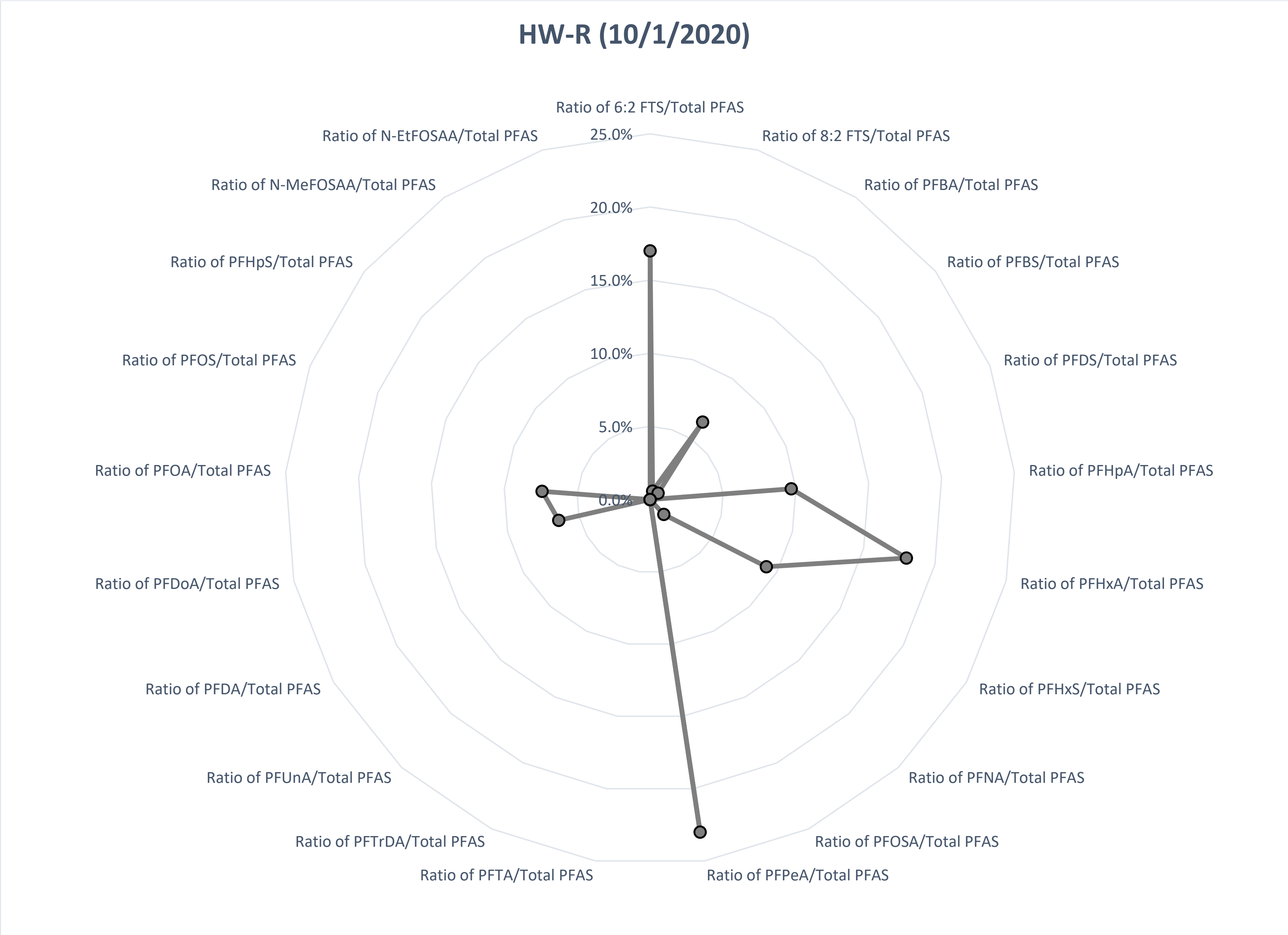
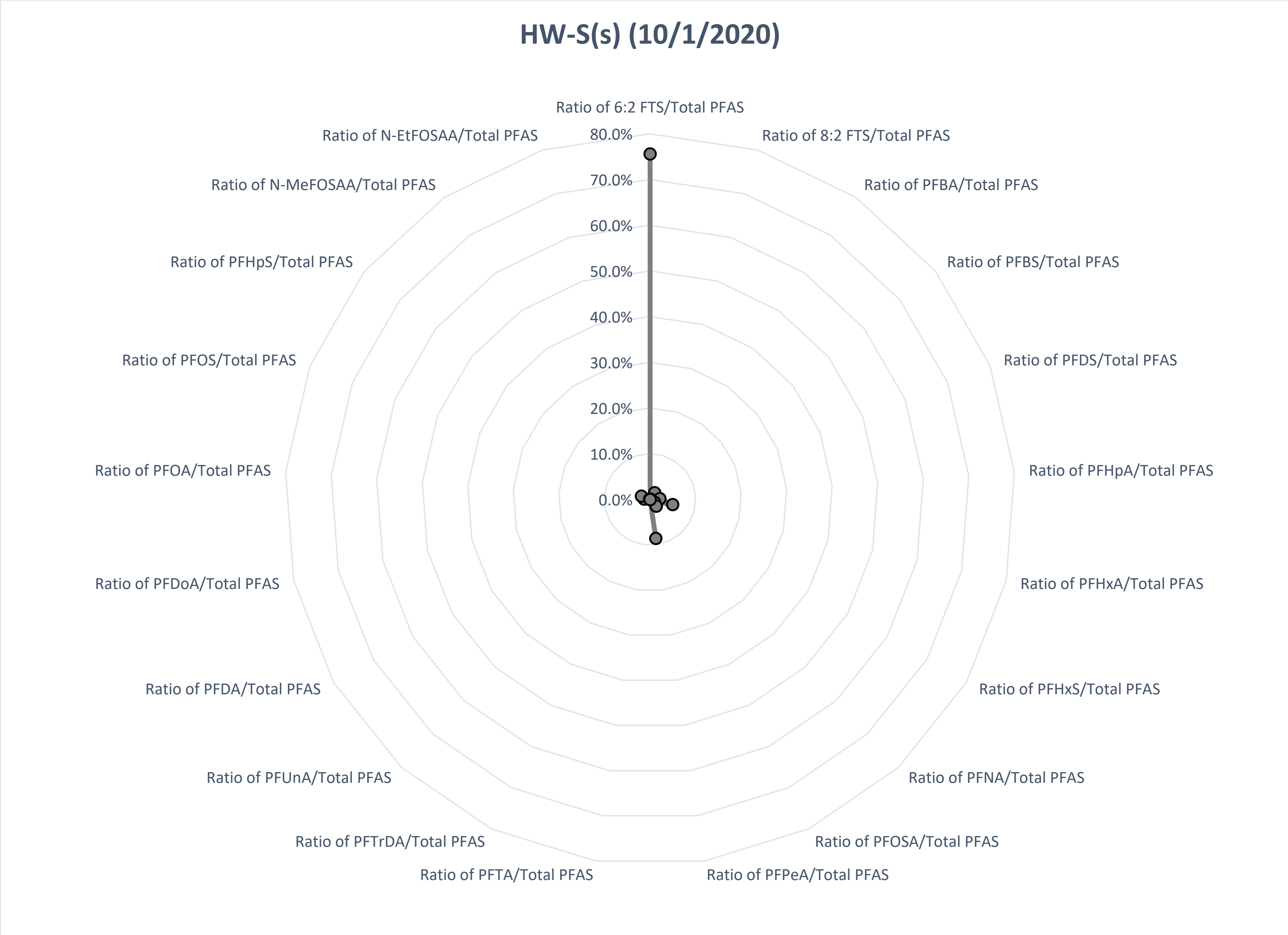
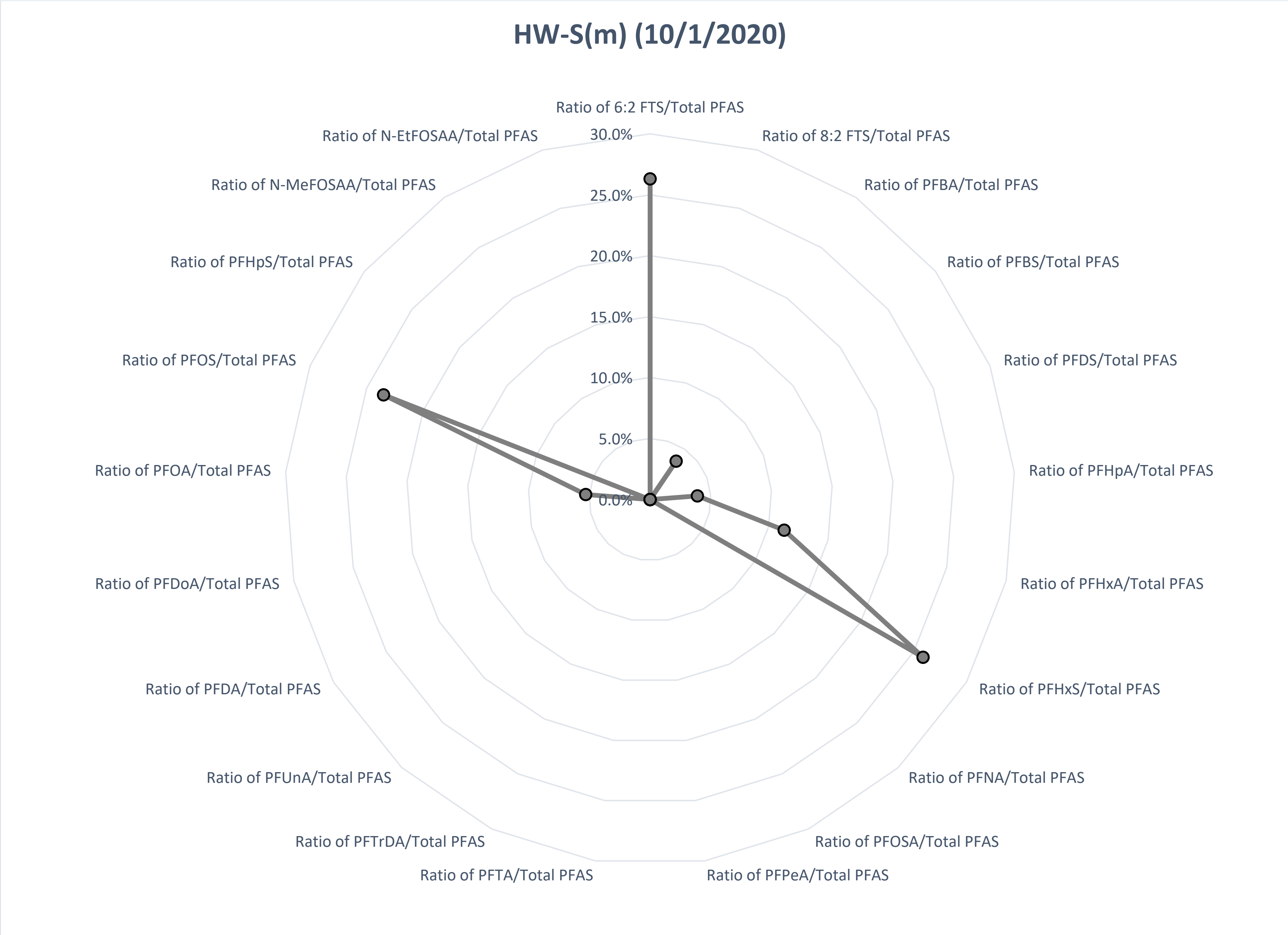
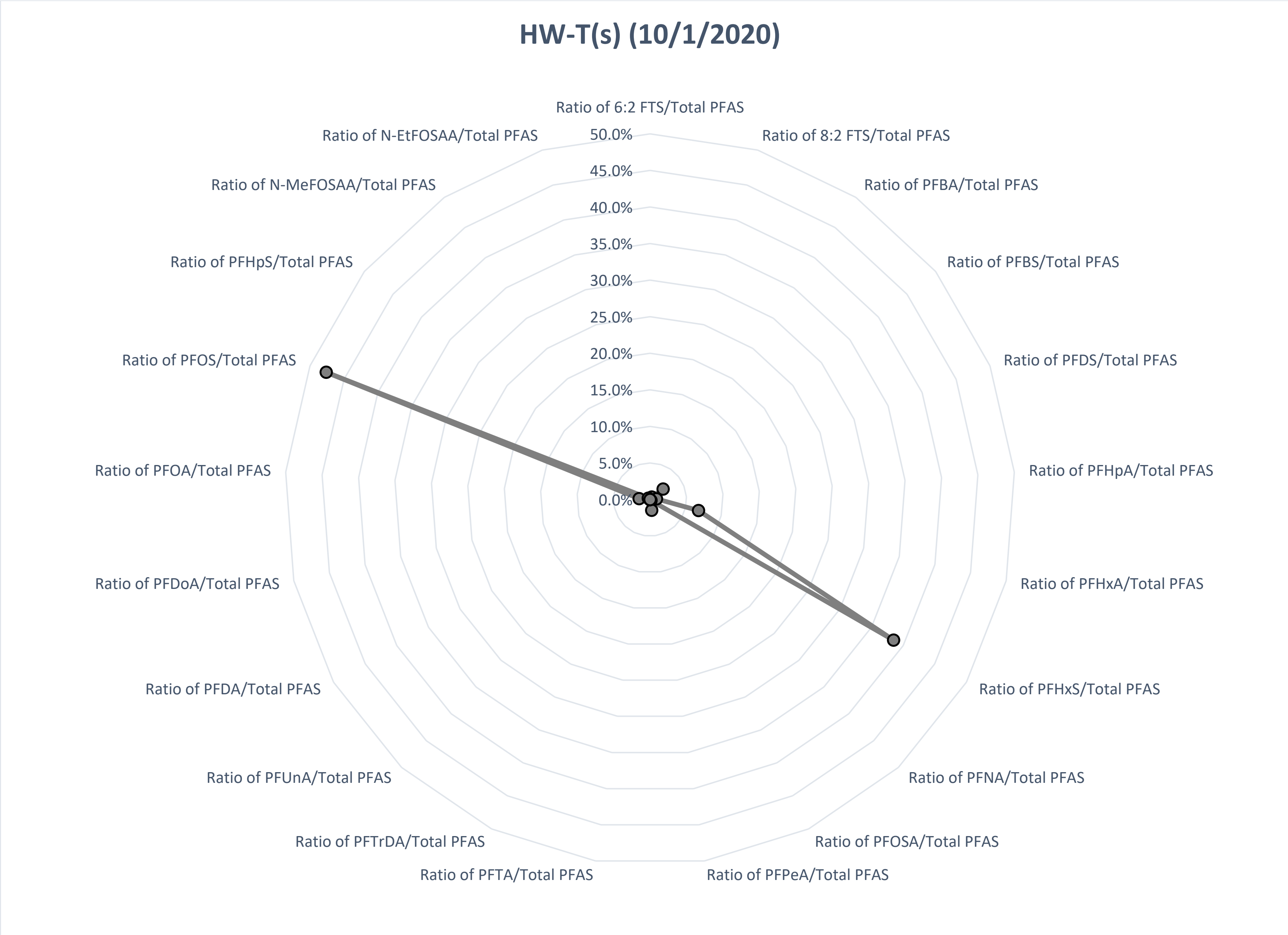
10.0%
5.0%
0.0%

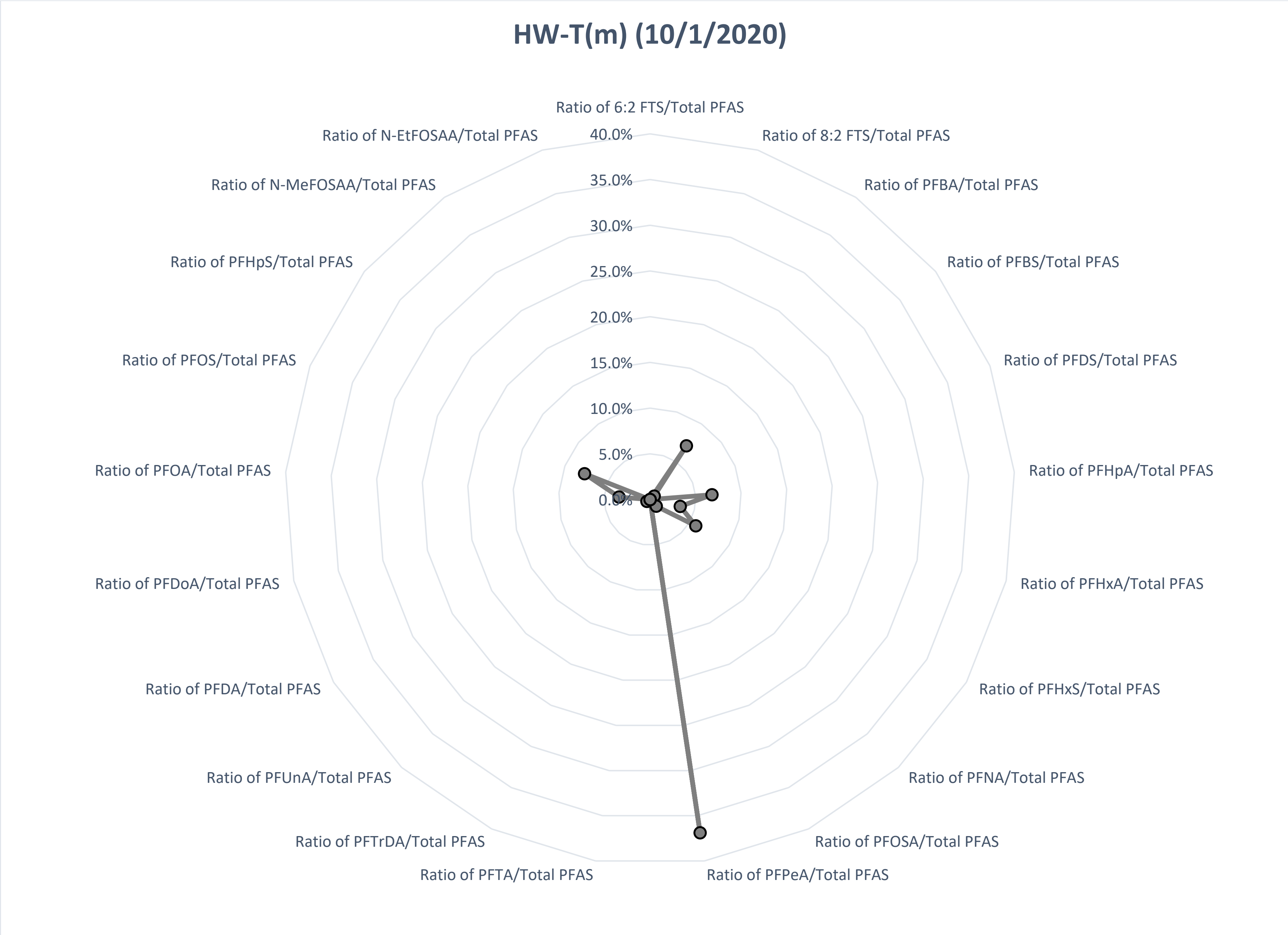

HW-R (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

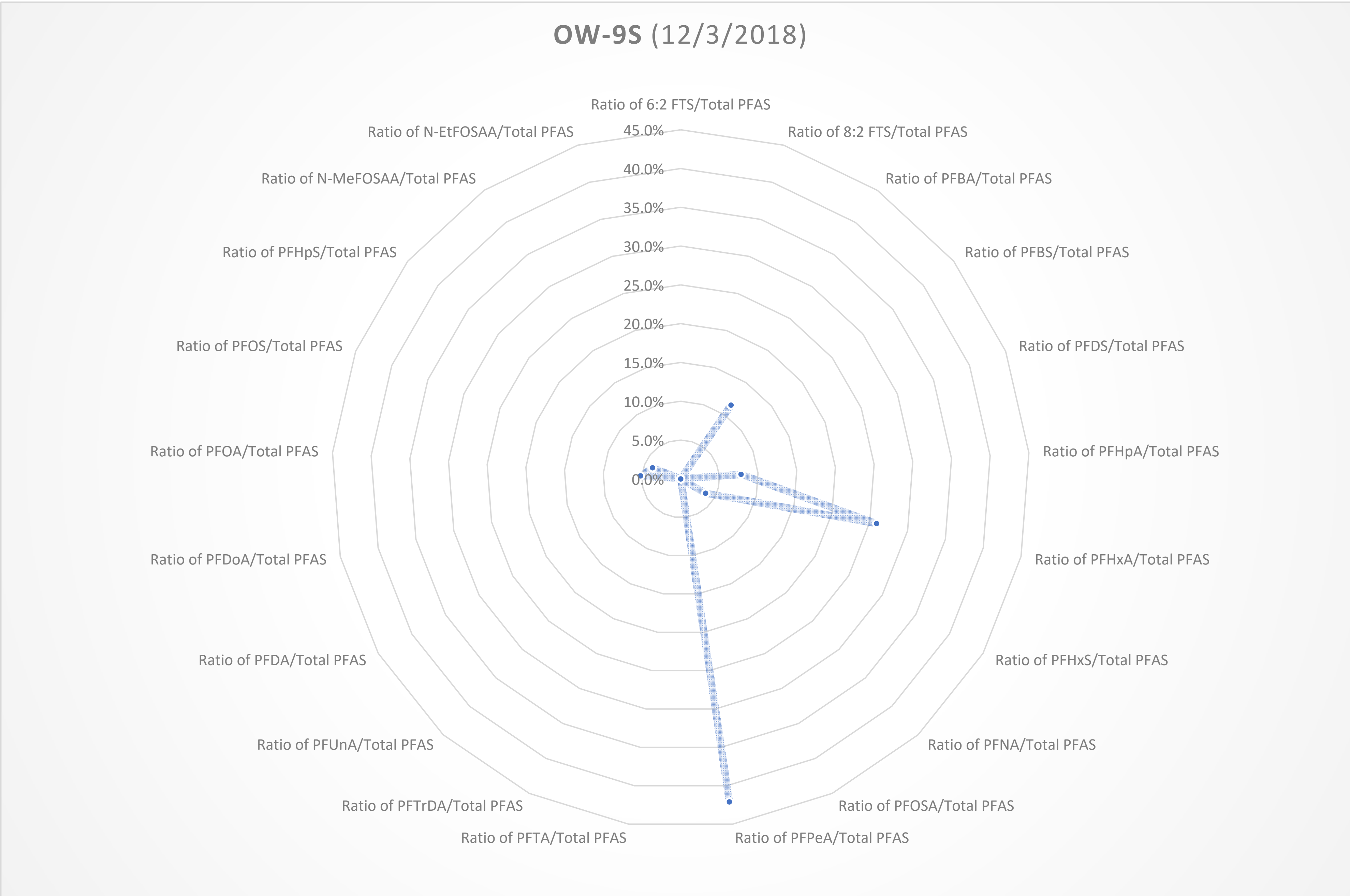


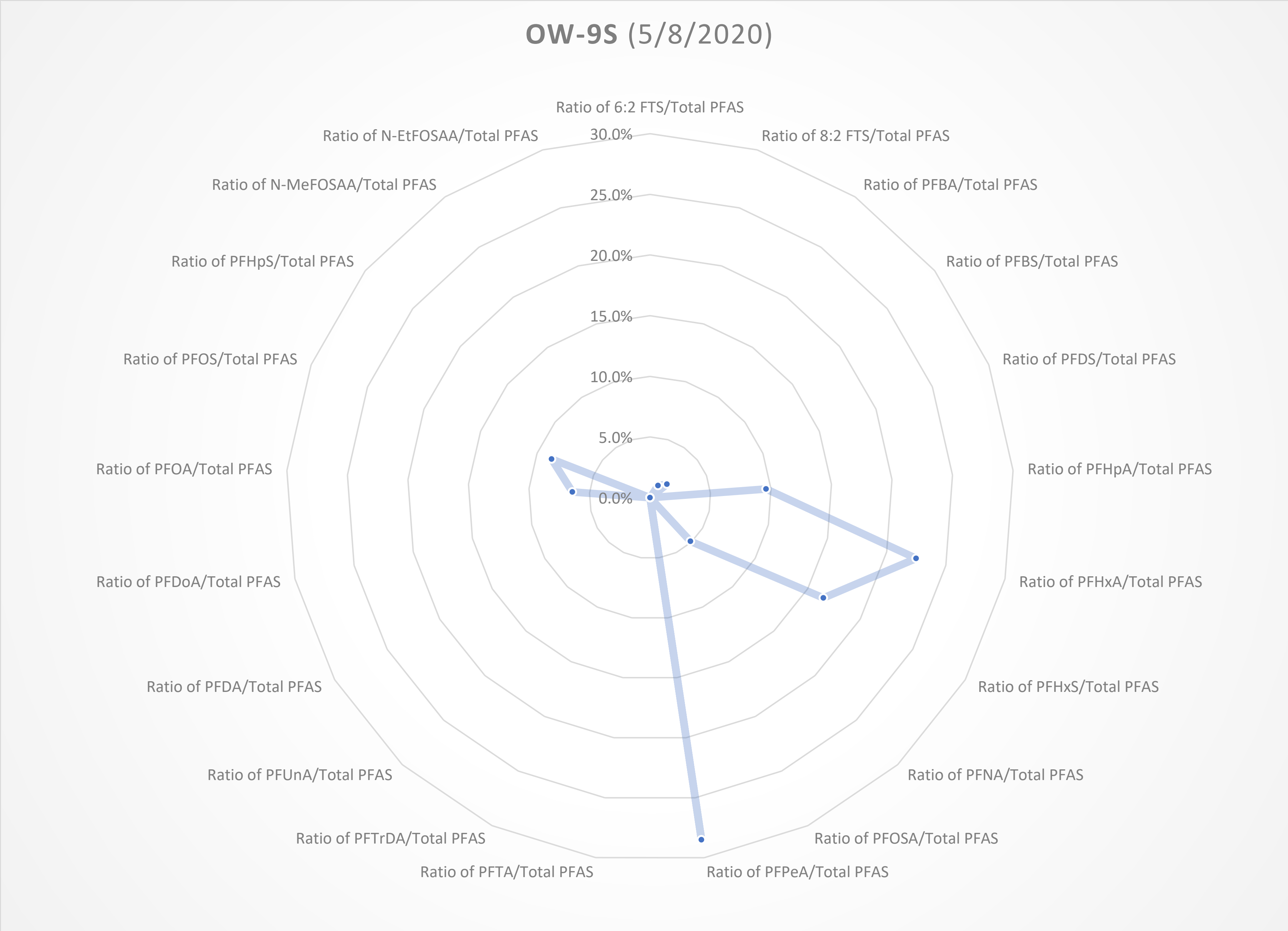
HW-S(s) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


HW-S(m) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

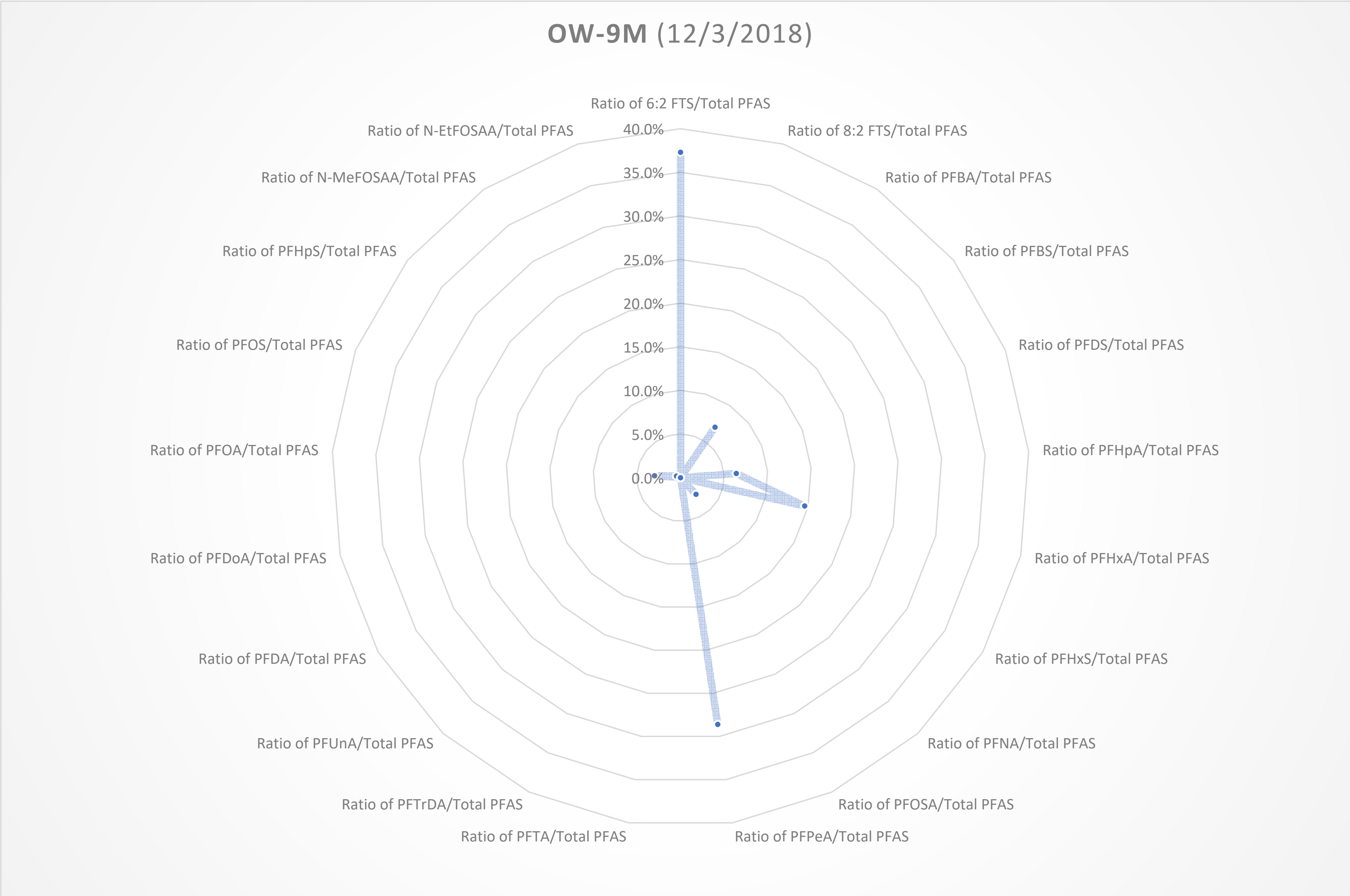

HW-T(s) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-T(m) (10/1/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


OW-9S (12/3/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



OW-9S (5/8/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



OW-9M (12/3/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
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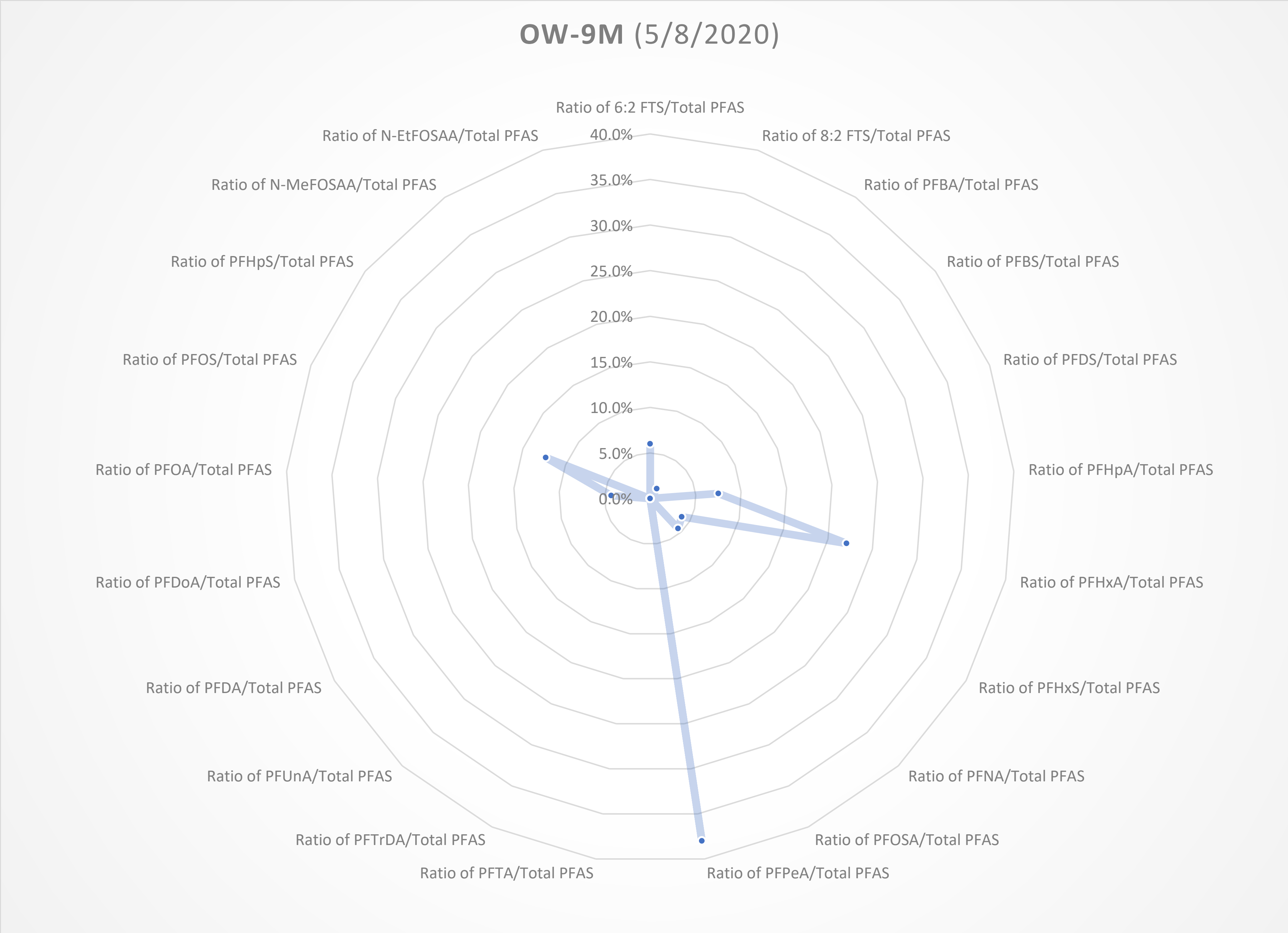
OW-9M (5/8/2020)
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Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
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25.0%
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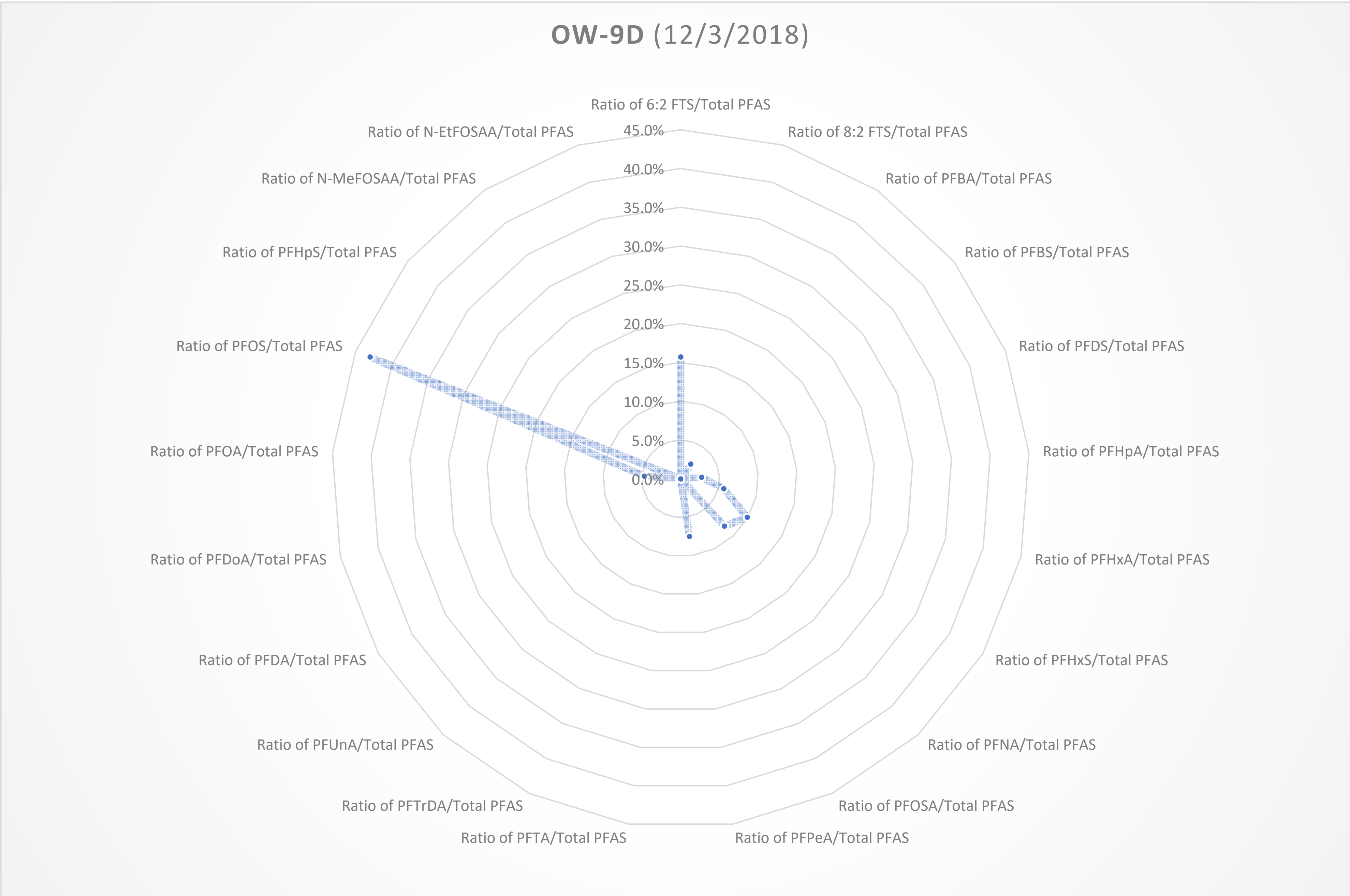
OW-9D (12/3/2018)
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Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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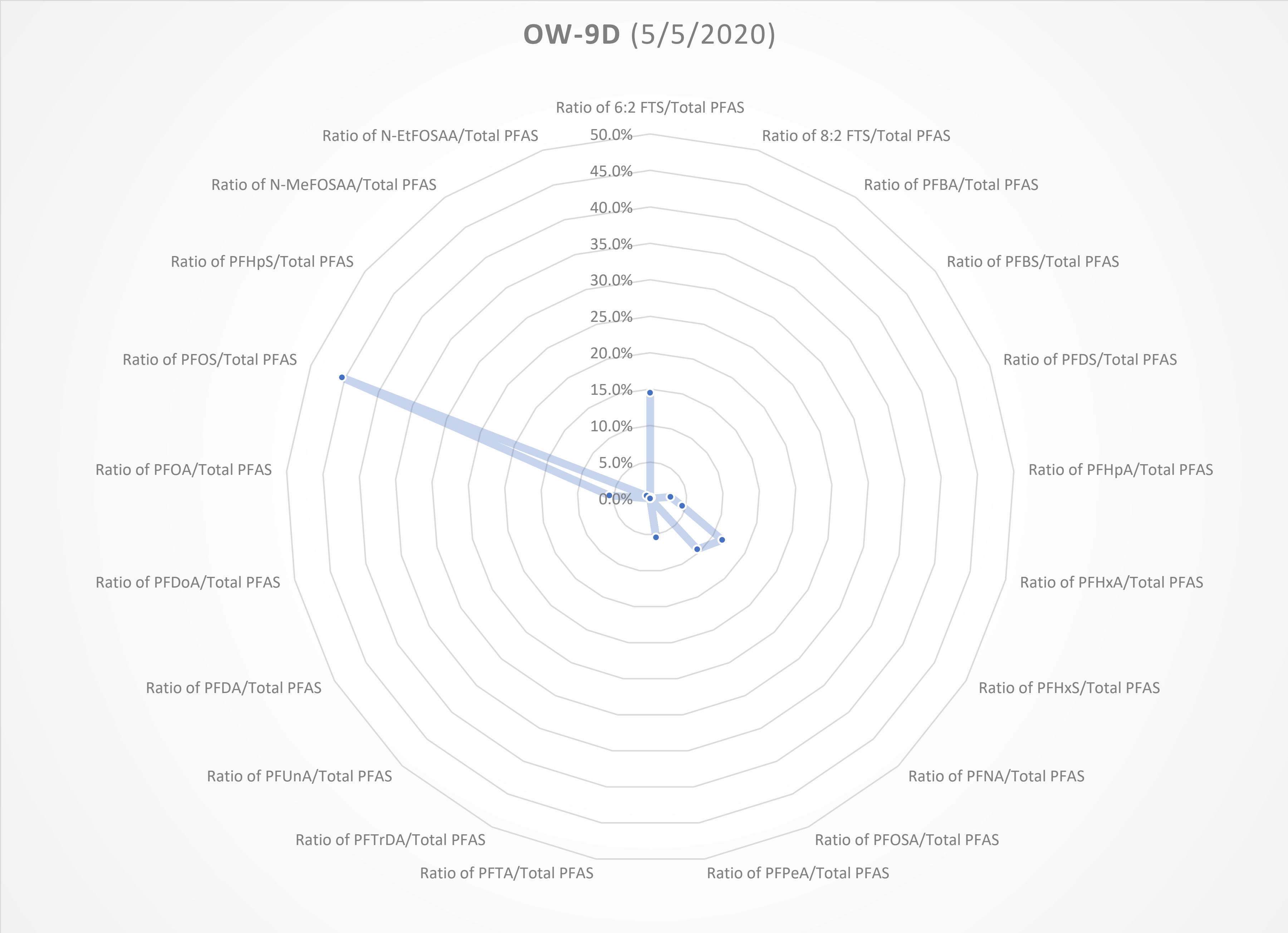
OW-9D (5/5/2020)
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Ratio of PFBS/Total PFAS
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Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
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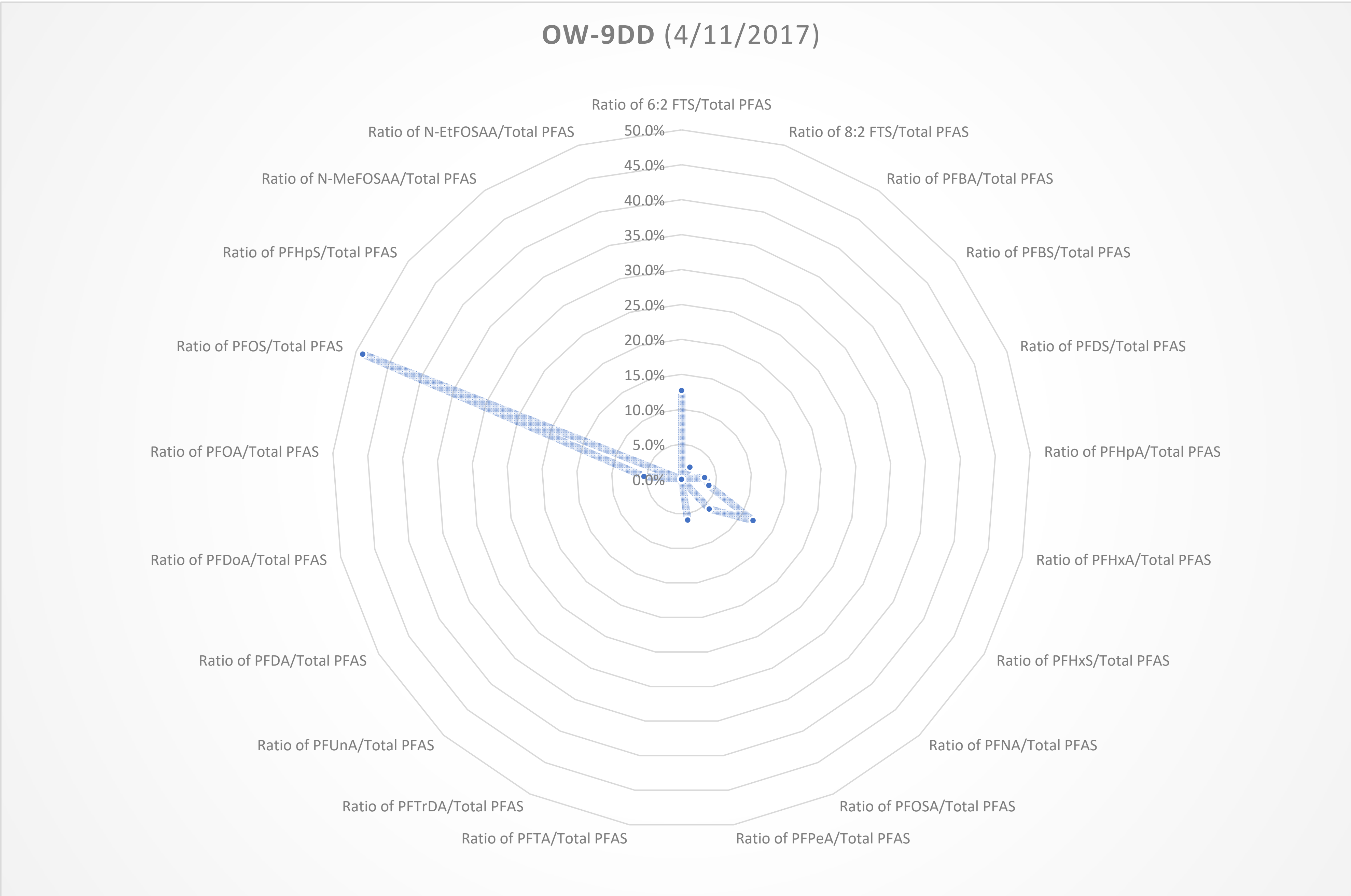
OW-9DD (4/11/2017)
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Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
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Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
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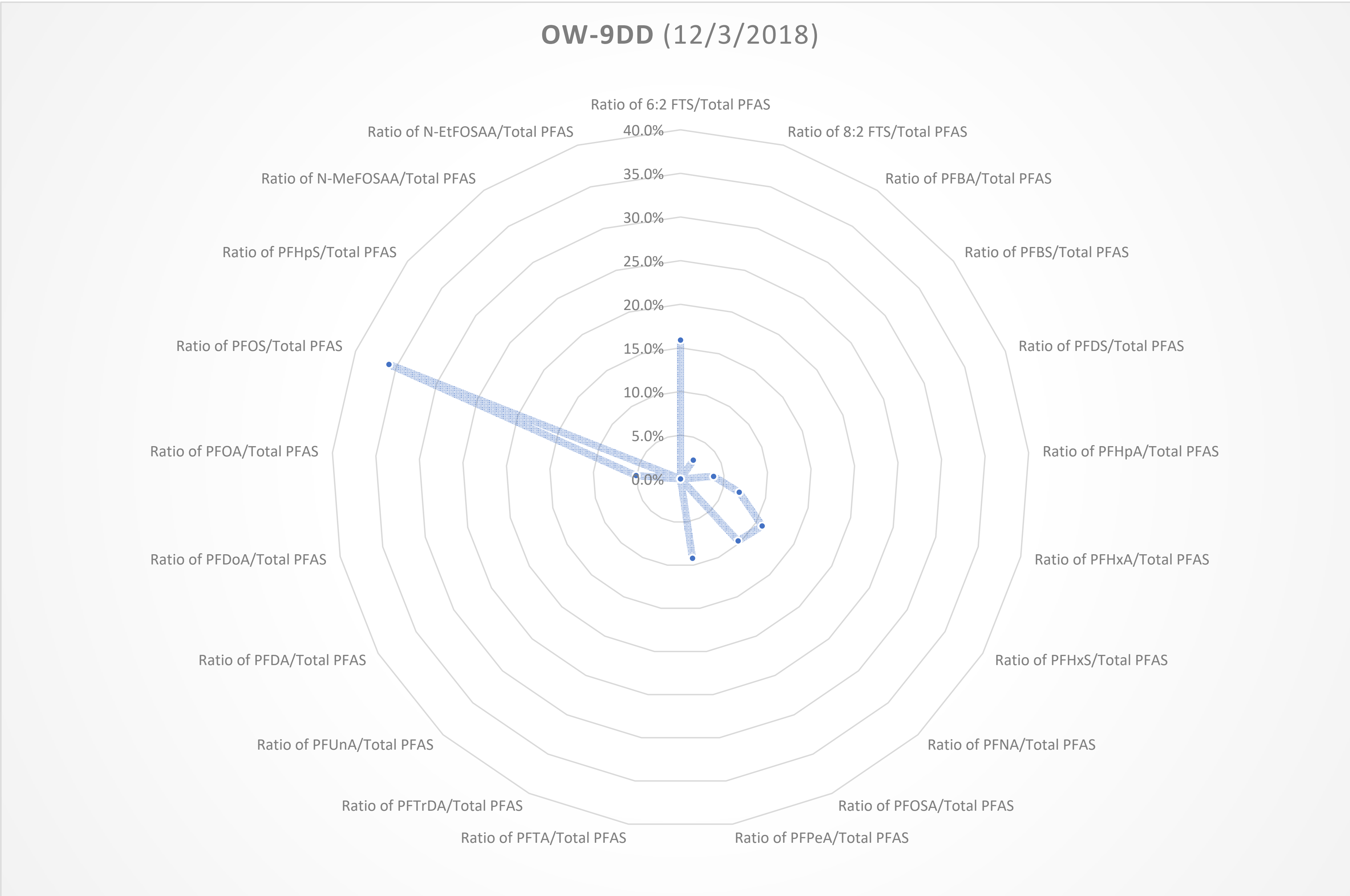
OW-9DD (12/3/2018)
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Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
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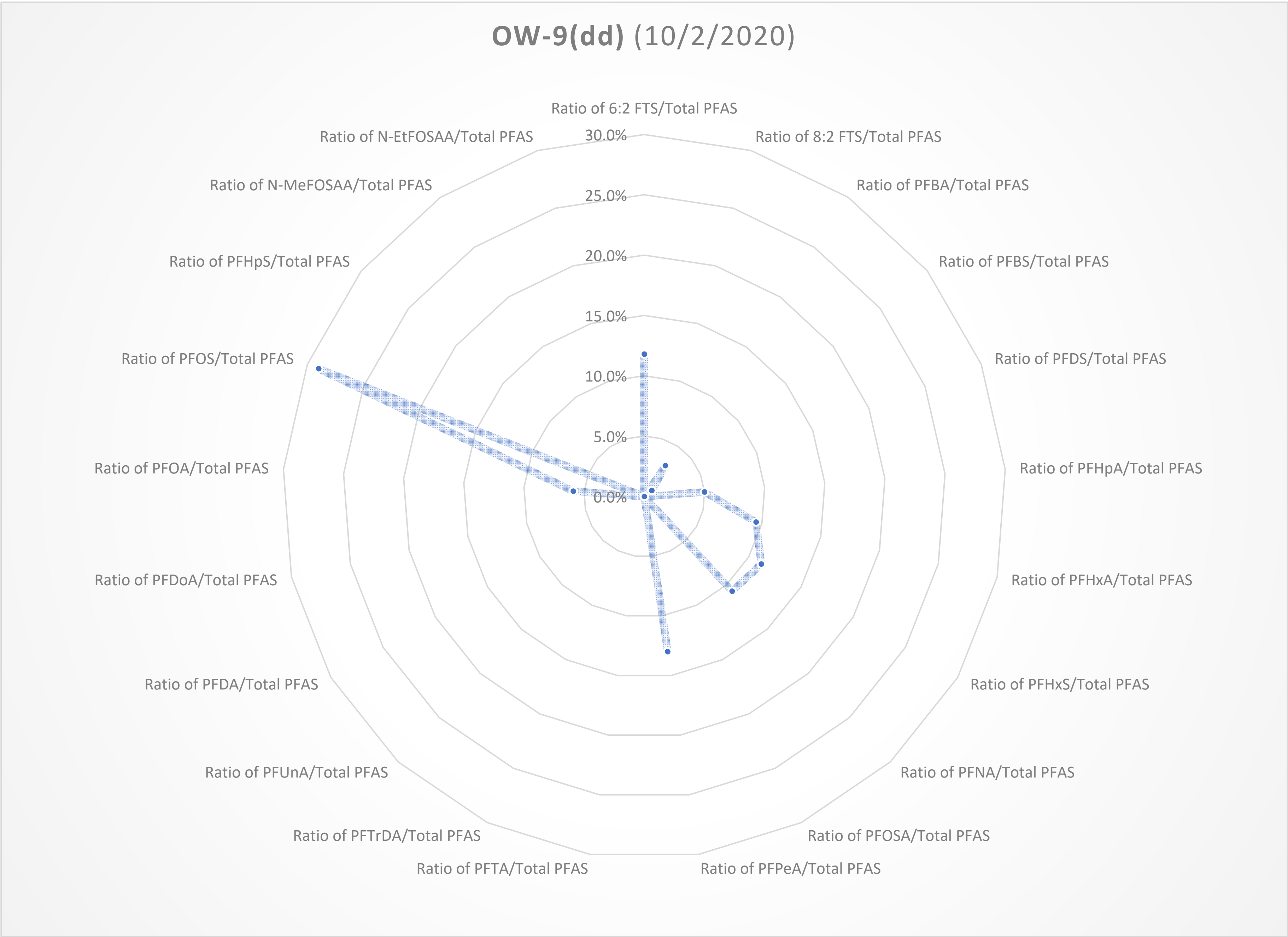
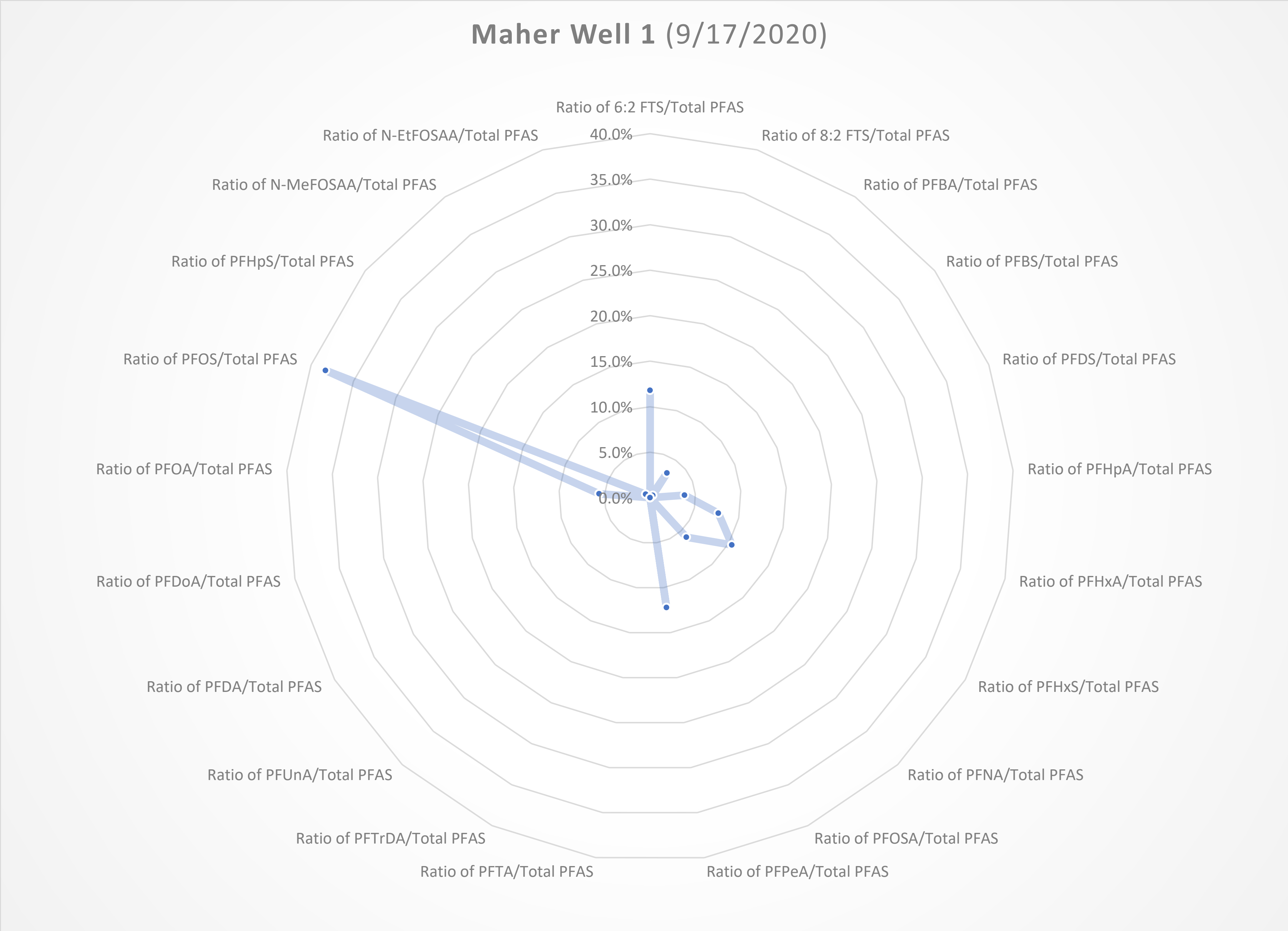
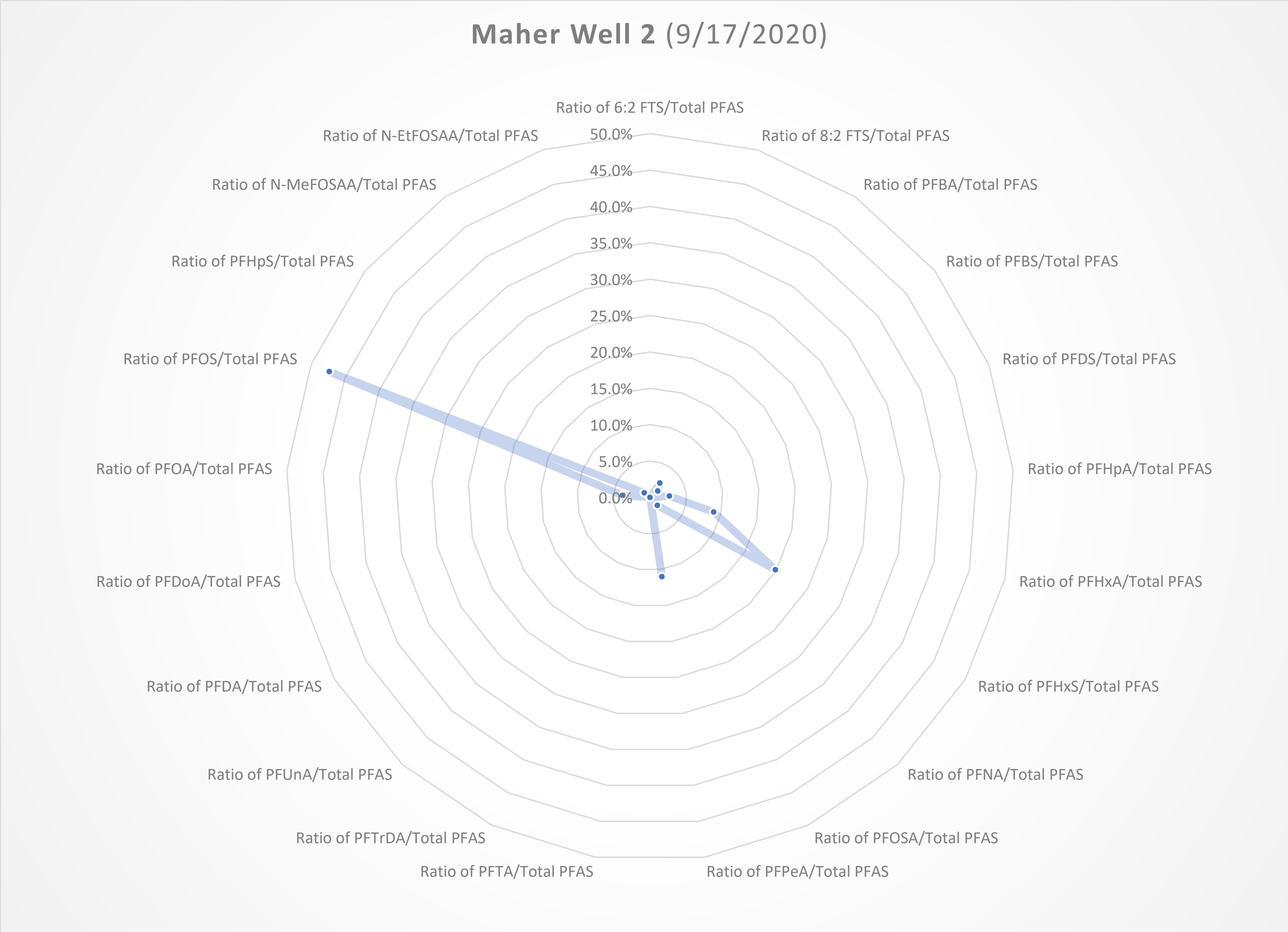
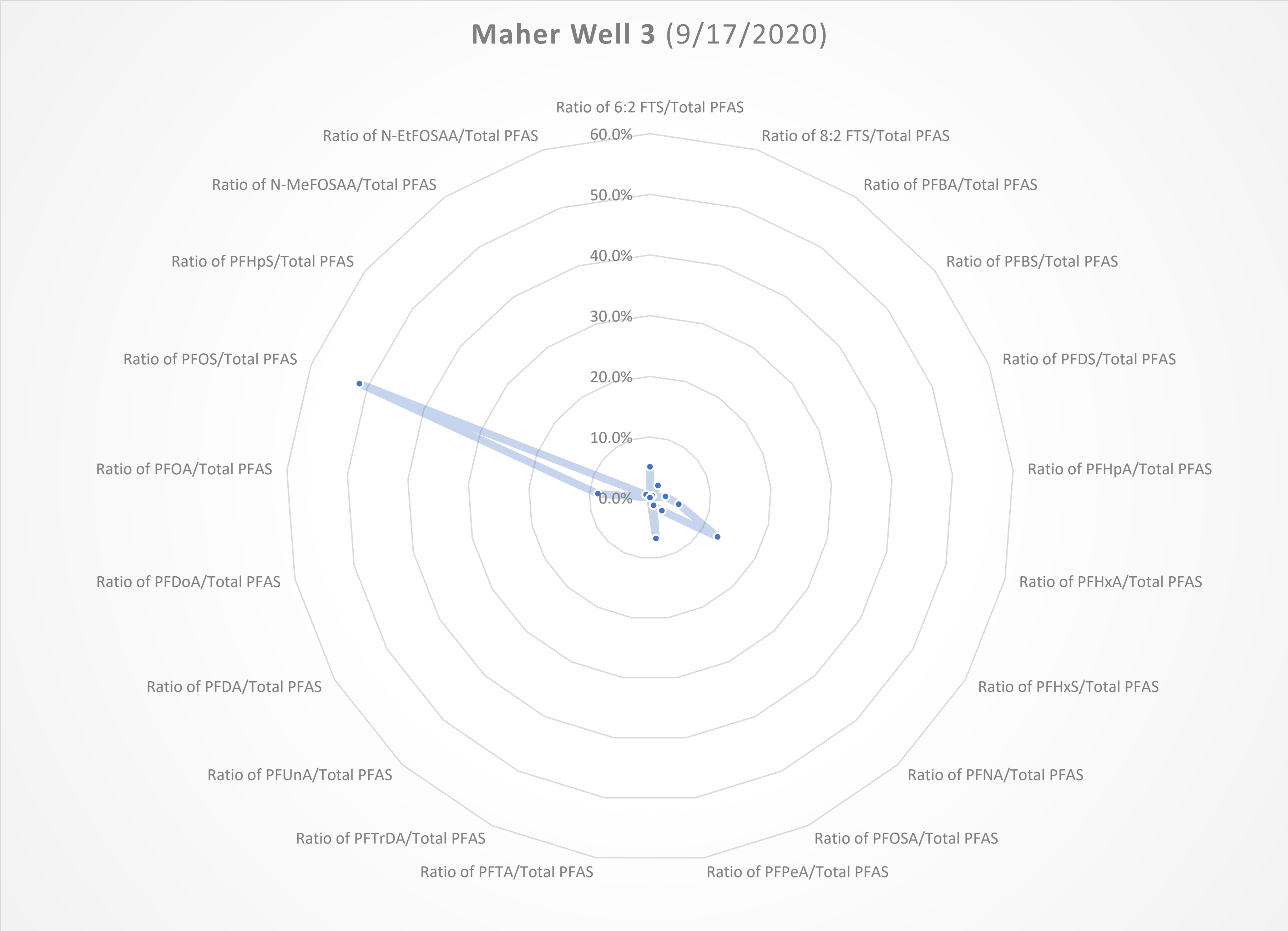
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

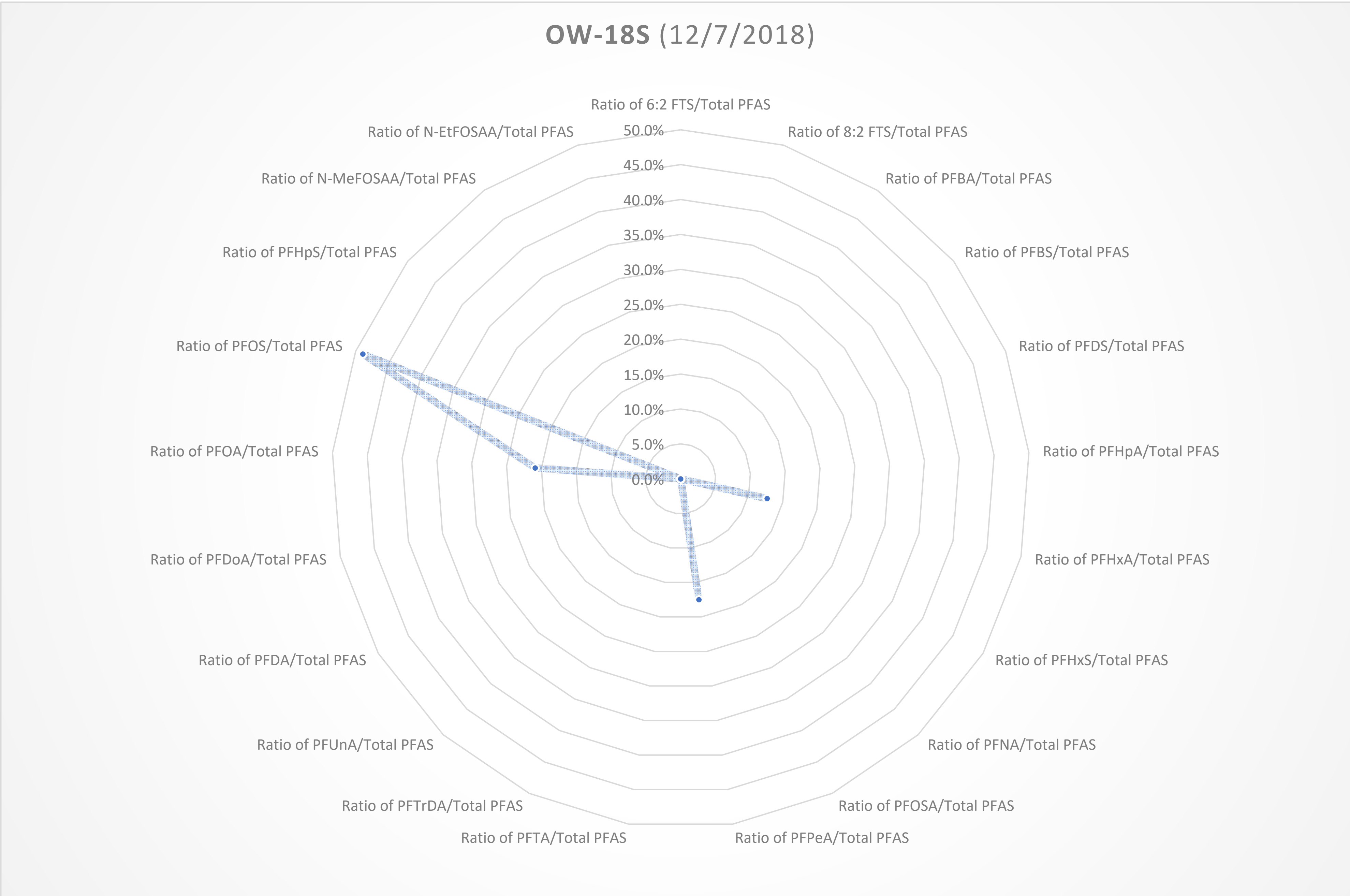

OW-9(dd) (10/2/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


Maher Well 1 (9/17/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

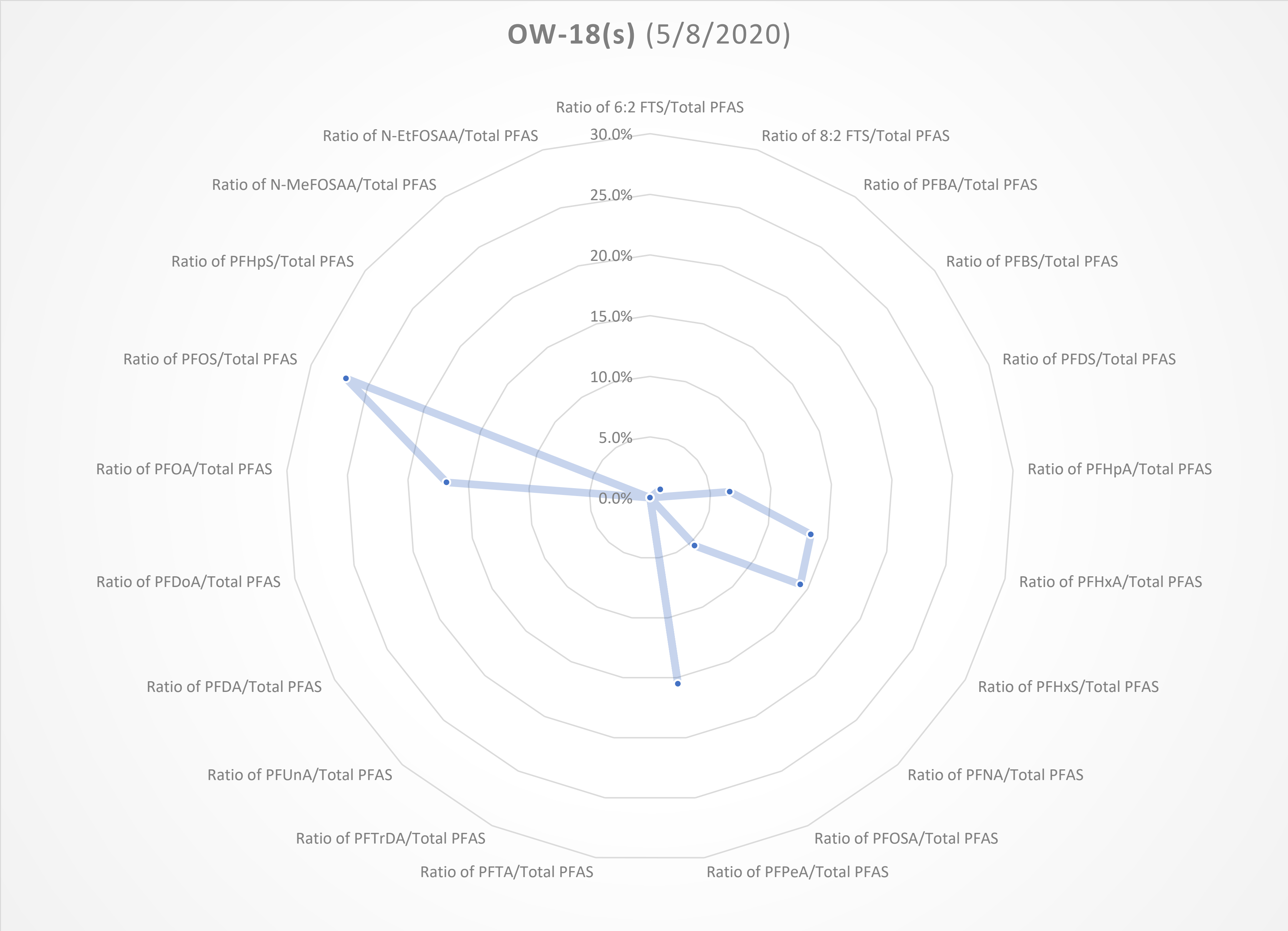

Maher Well 2 (9/17/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



Maher Well 3 (9/17/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



OW-18S (12/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


OW-18(s) (5/8/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
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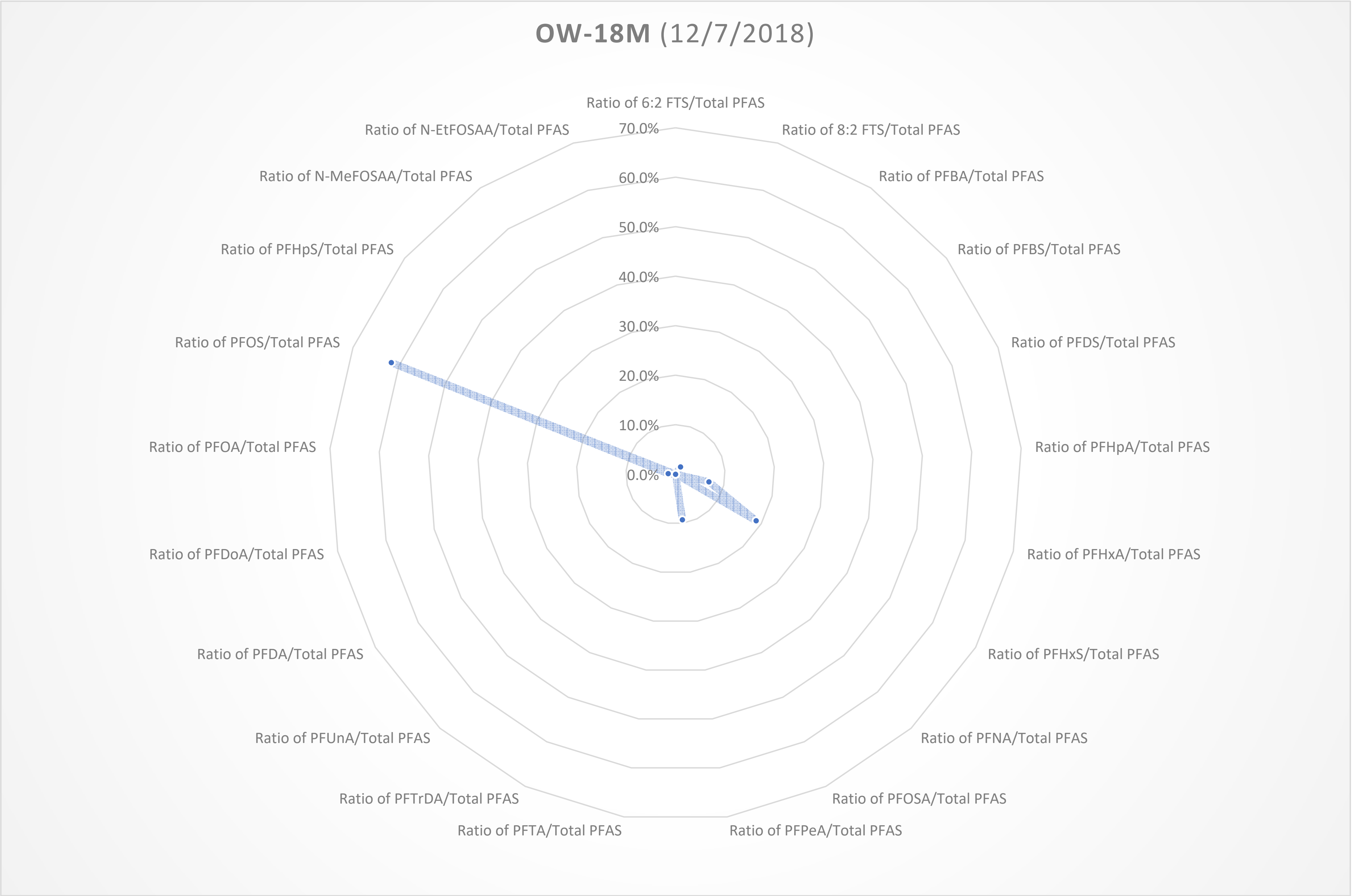
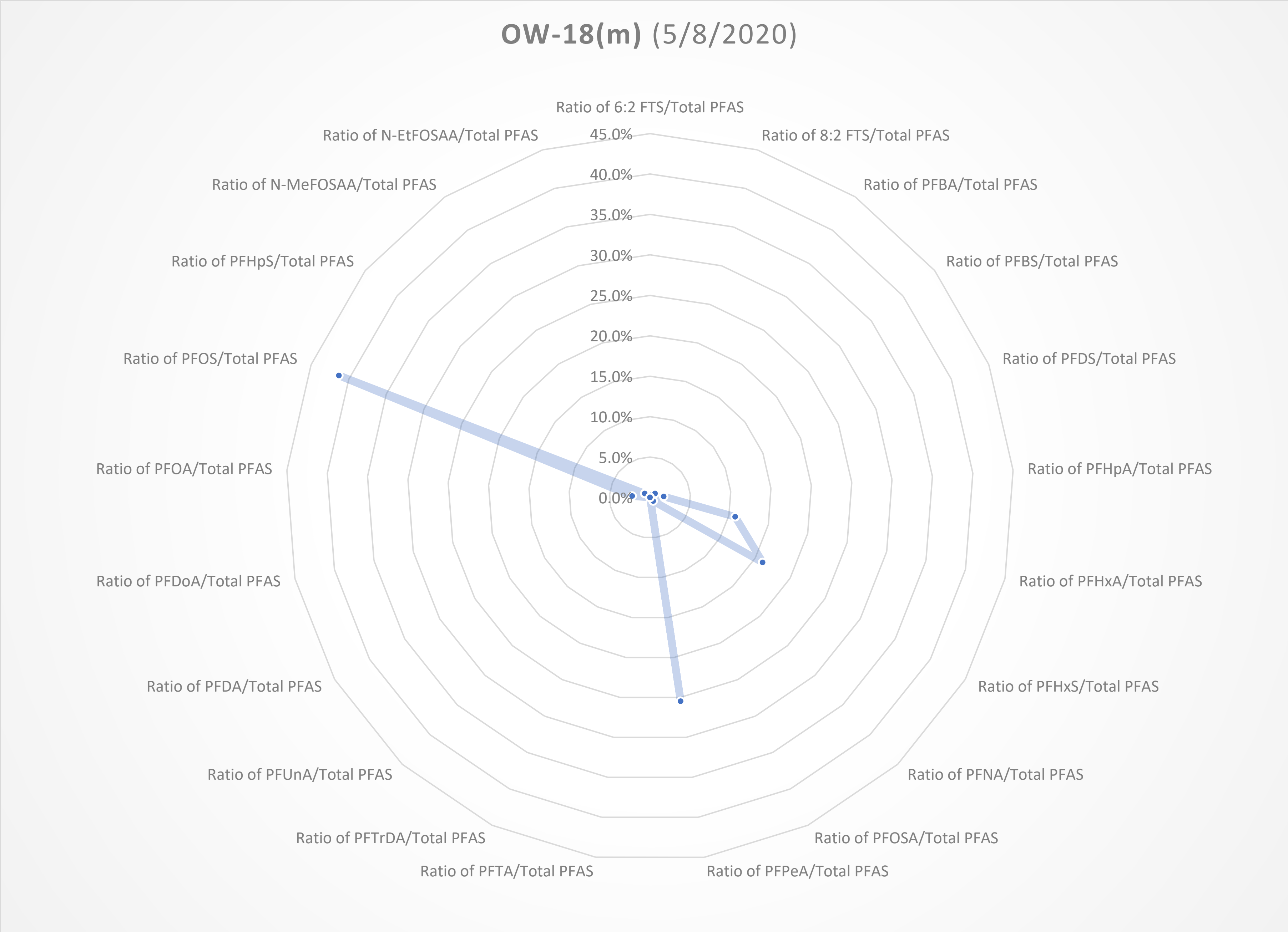
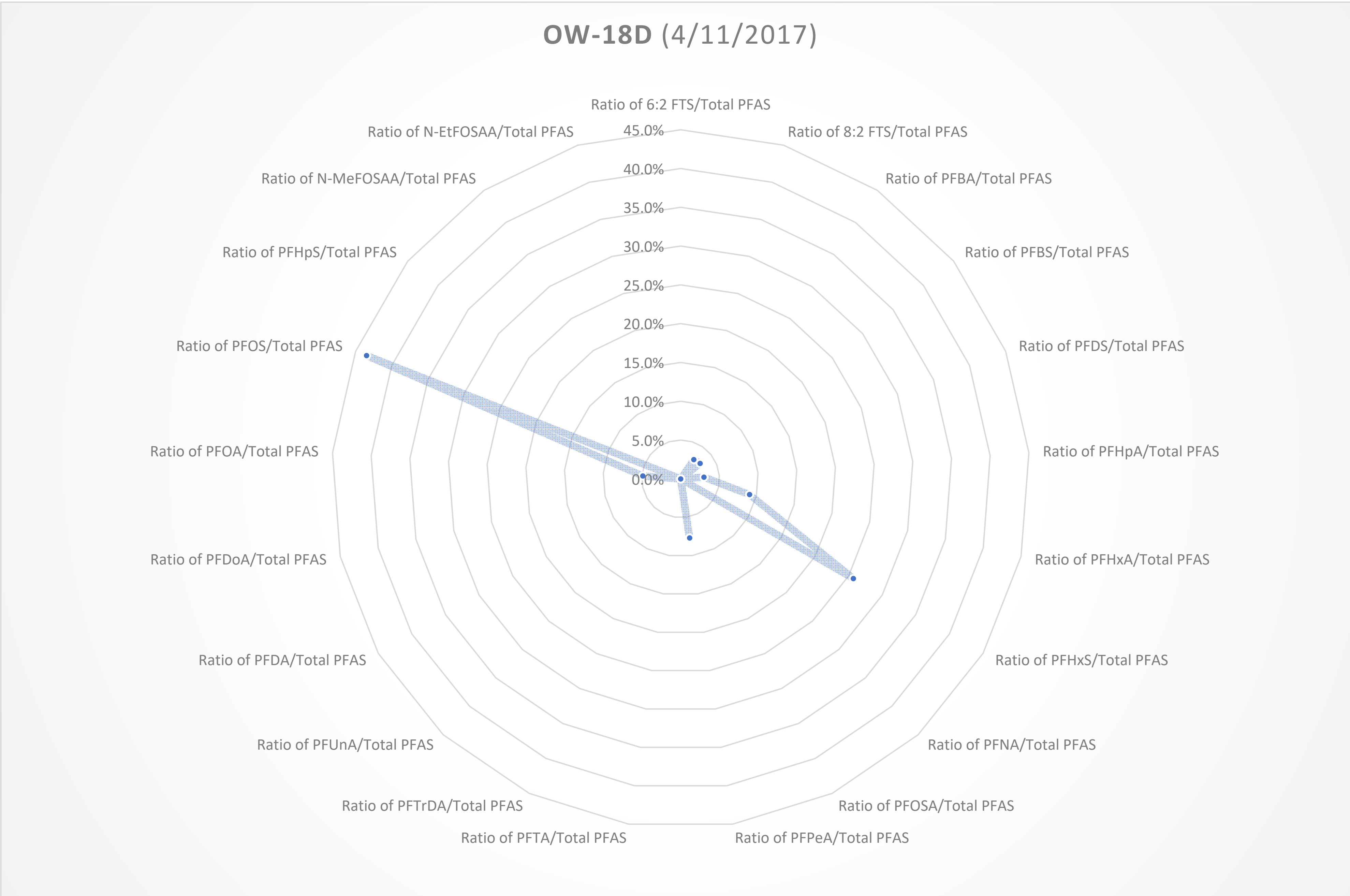
5.0%
0.0%



OW-18M (12/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


OW-18(m) (5/8/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


OW-18D (4/11/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
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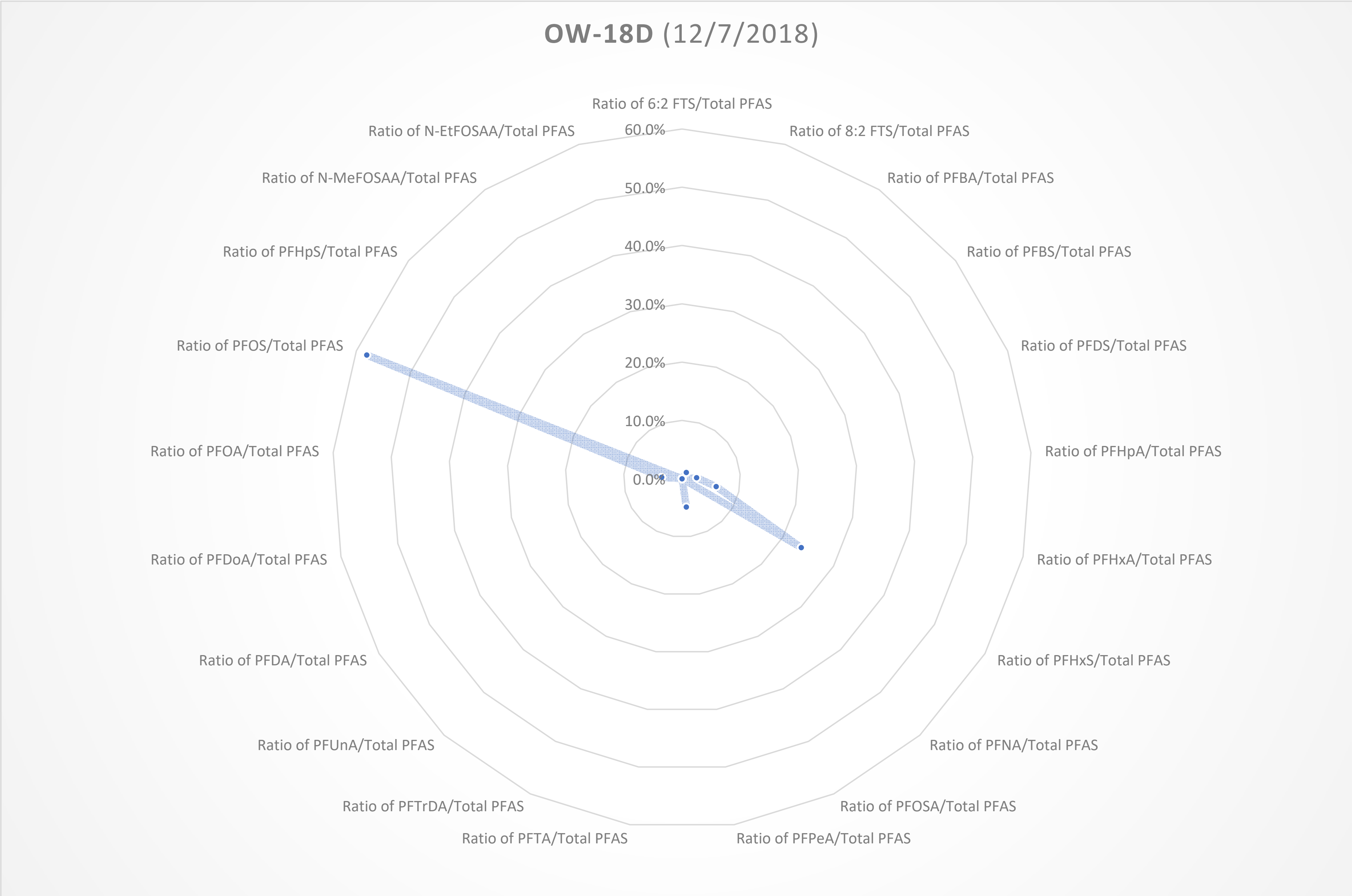
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



OW-18D (12/7/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
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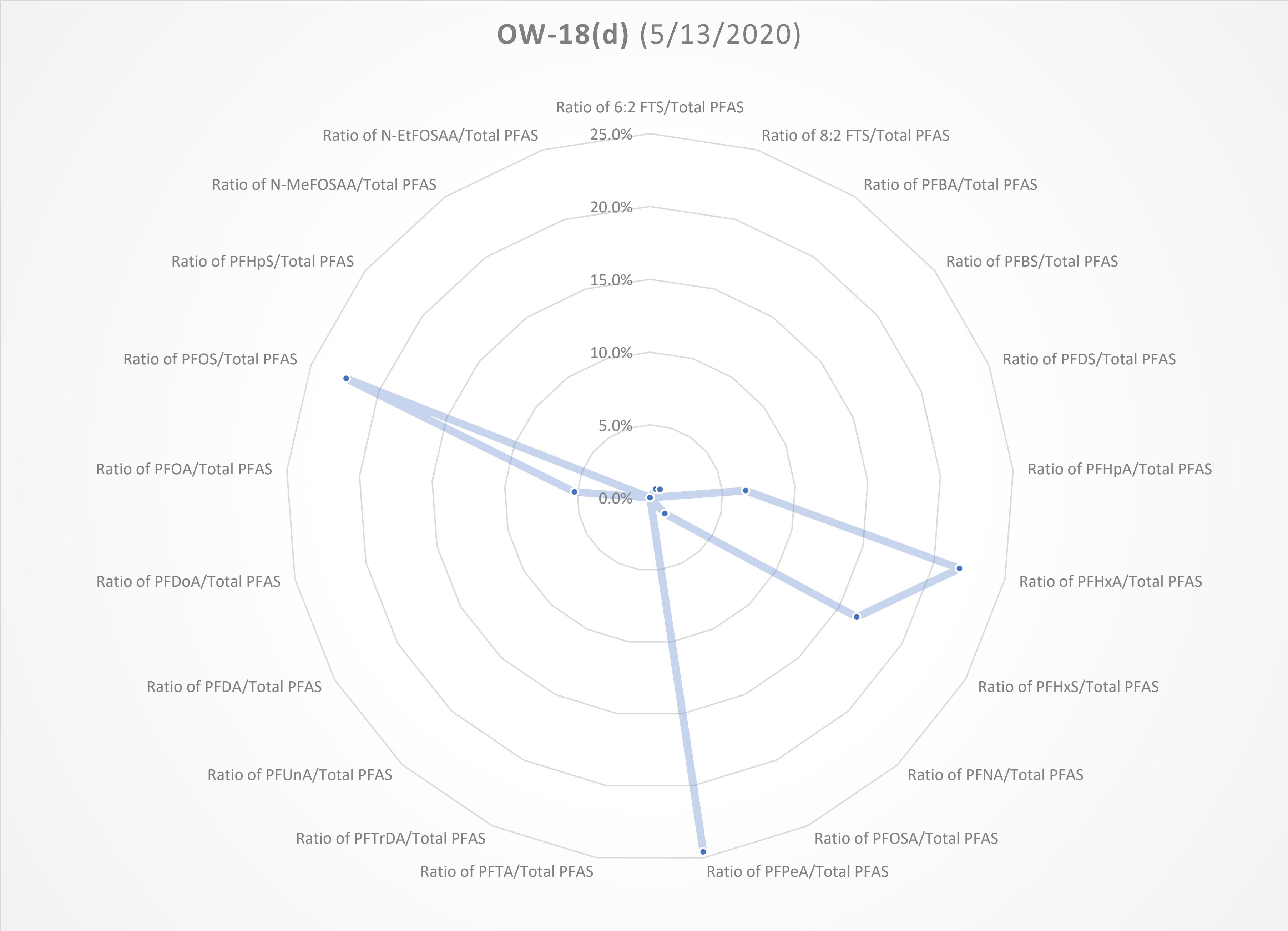
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



OW-18(d) (5/13/2020)
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Ratio of 8:2 FTS/Total PFAS
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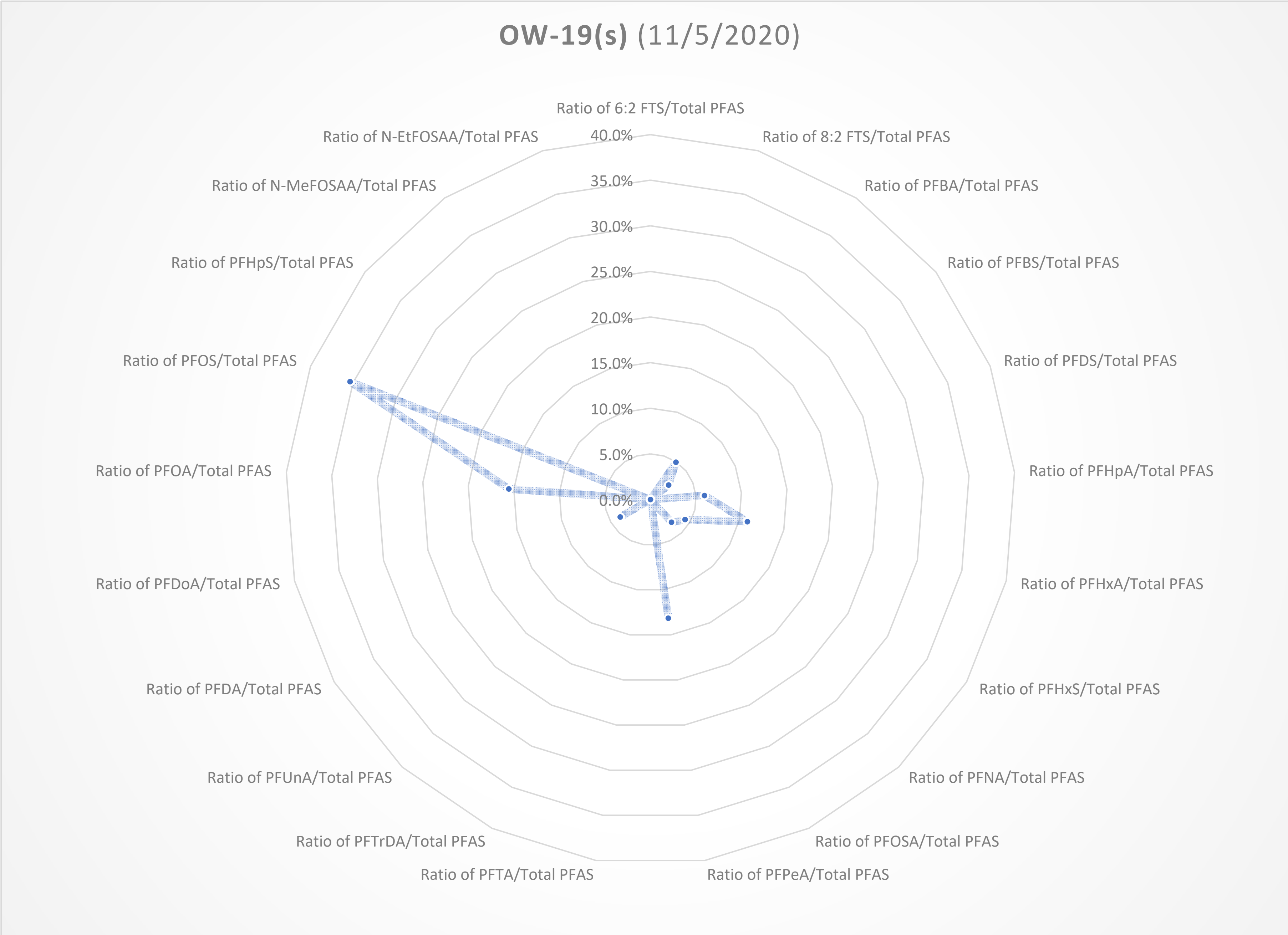
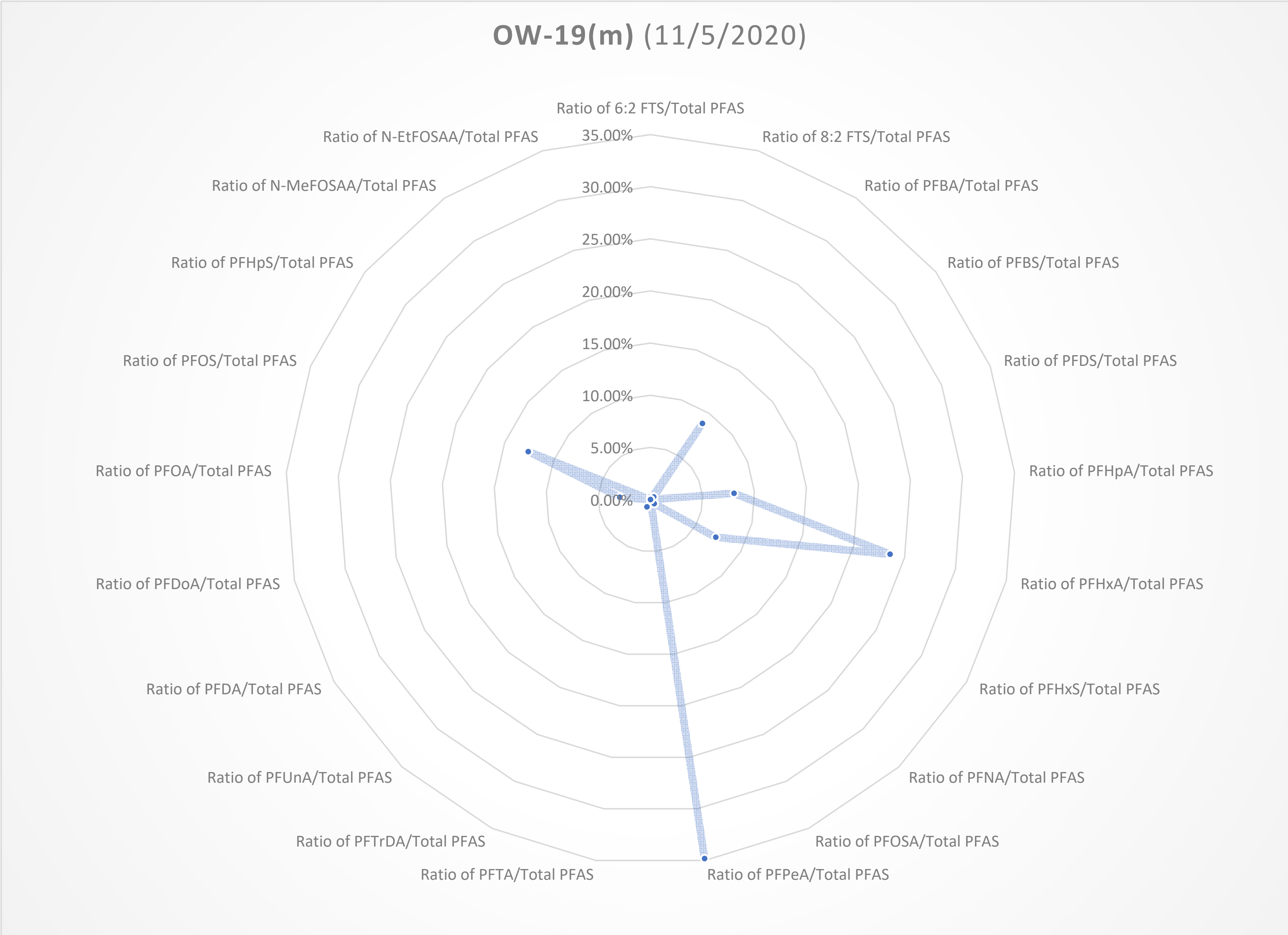
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


OW-19(s) (11/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


OW-19(m) (11/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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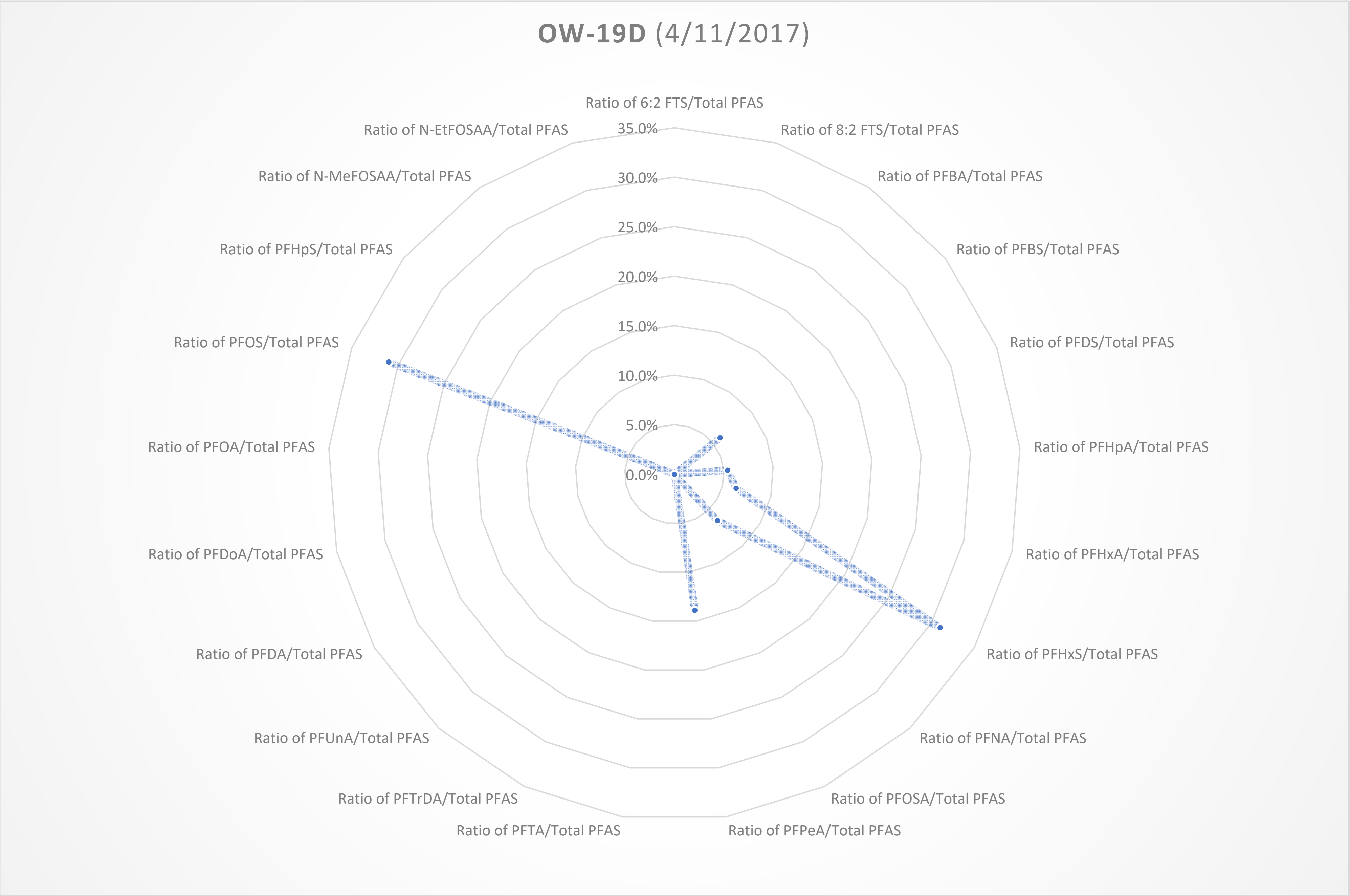
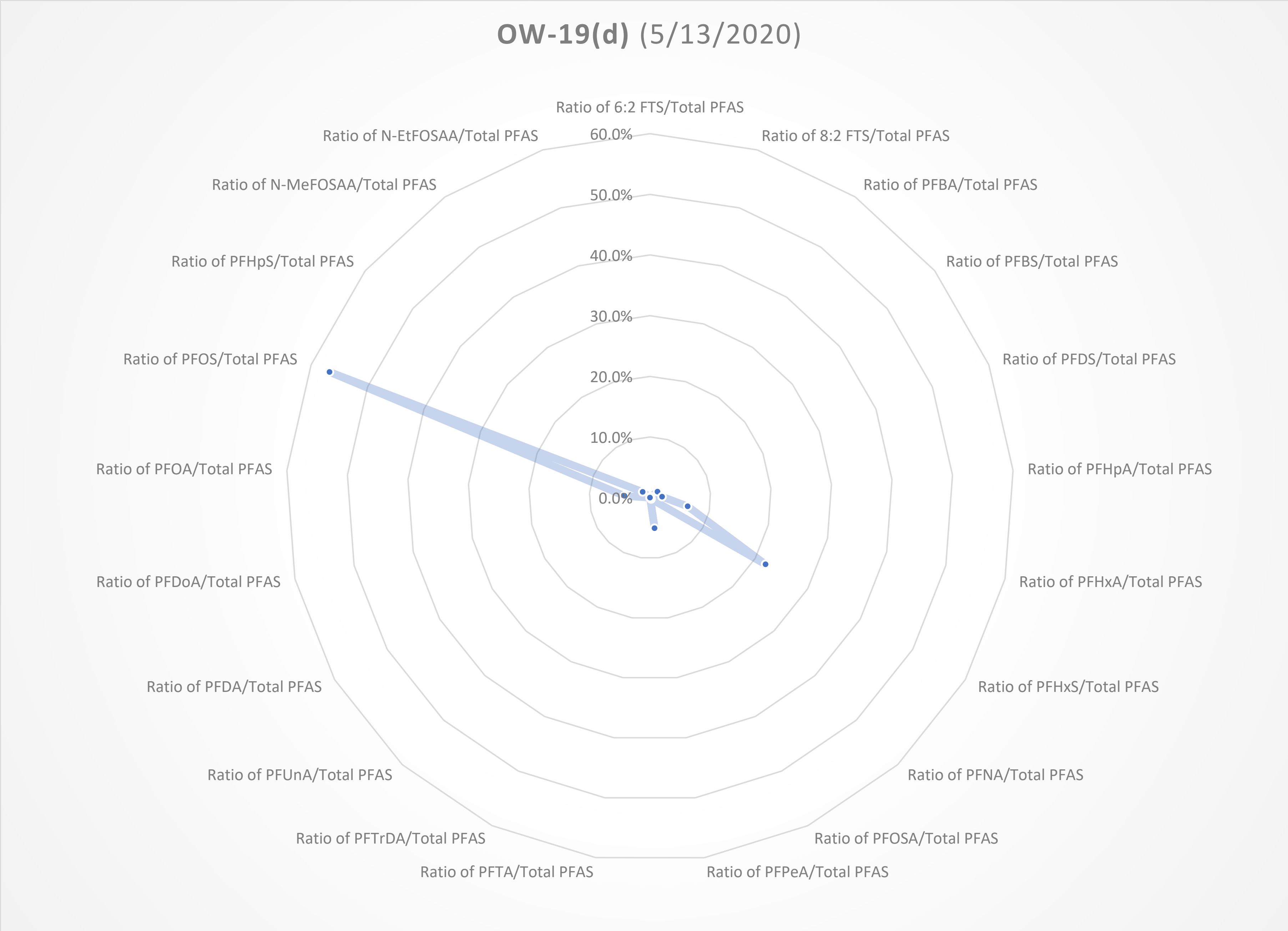
5.00%
0.00%


OW-19D (4/11/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


OW-19(d) (5/13/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
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40.0%
30.0%
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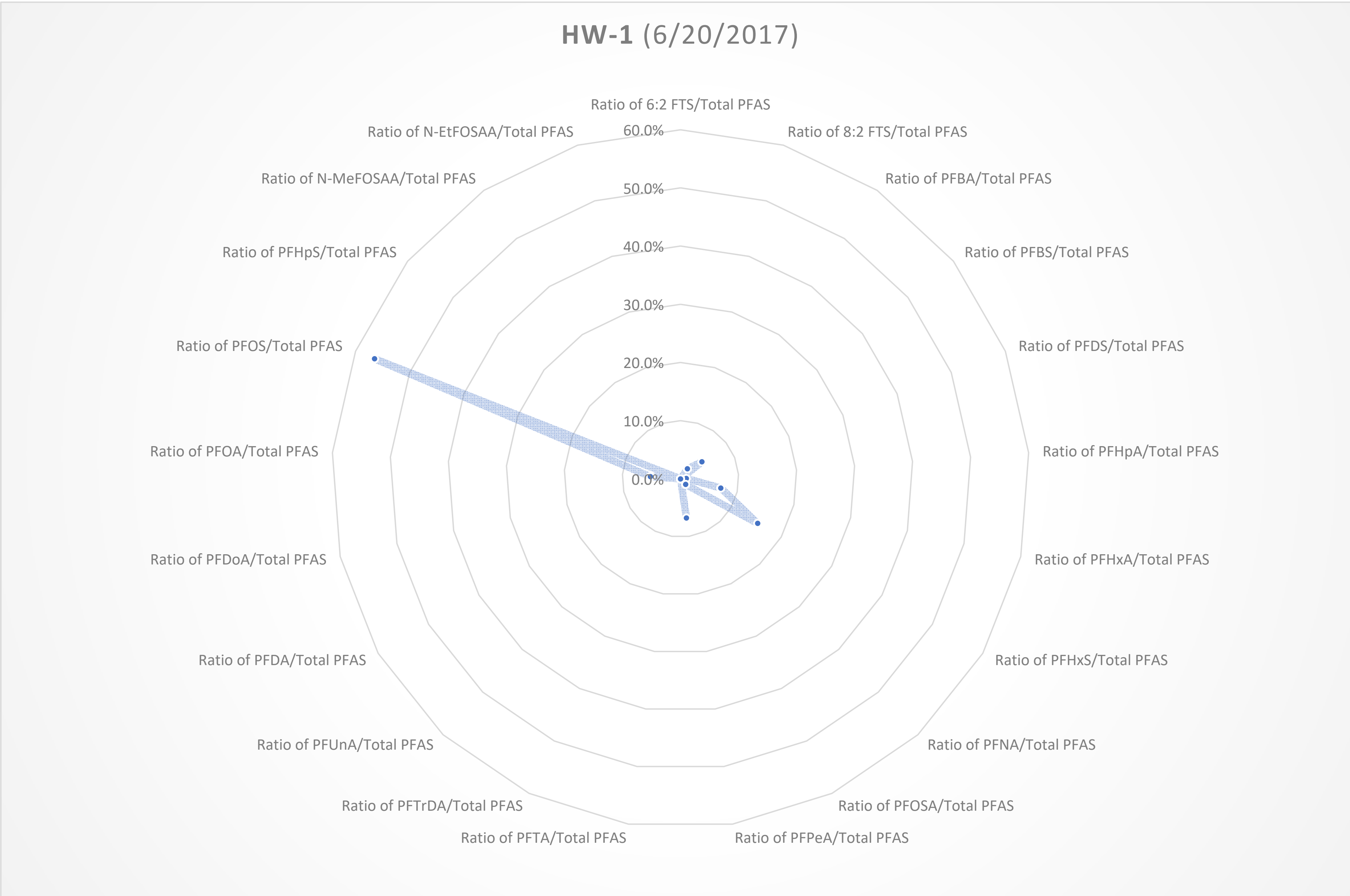
10.0%
0.0%


HW-1 (6/20/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
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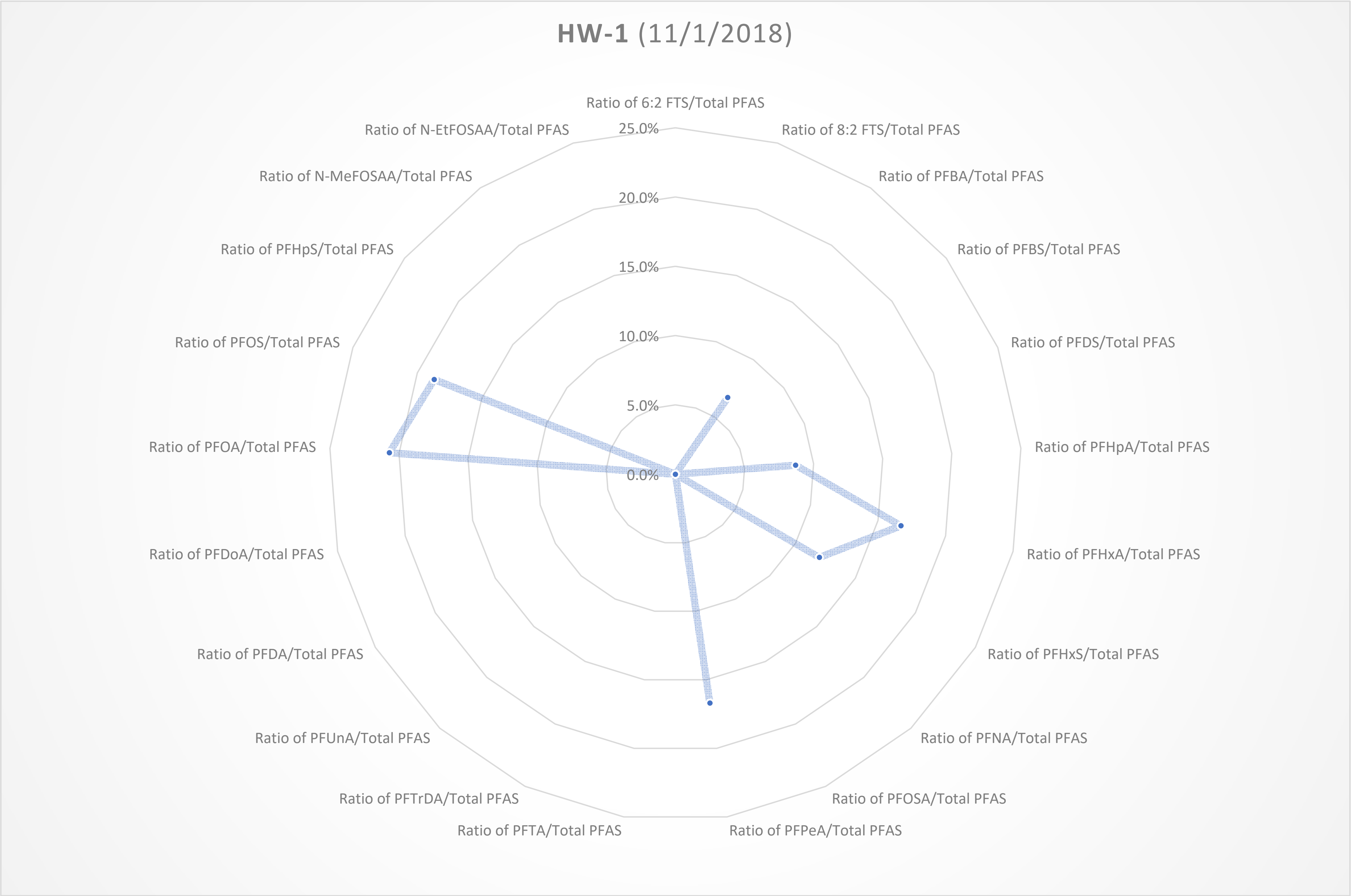
10.0%
0.0%


HW-1 (11/1/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
25.0%
20.0%
15.0%
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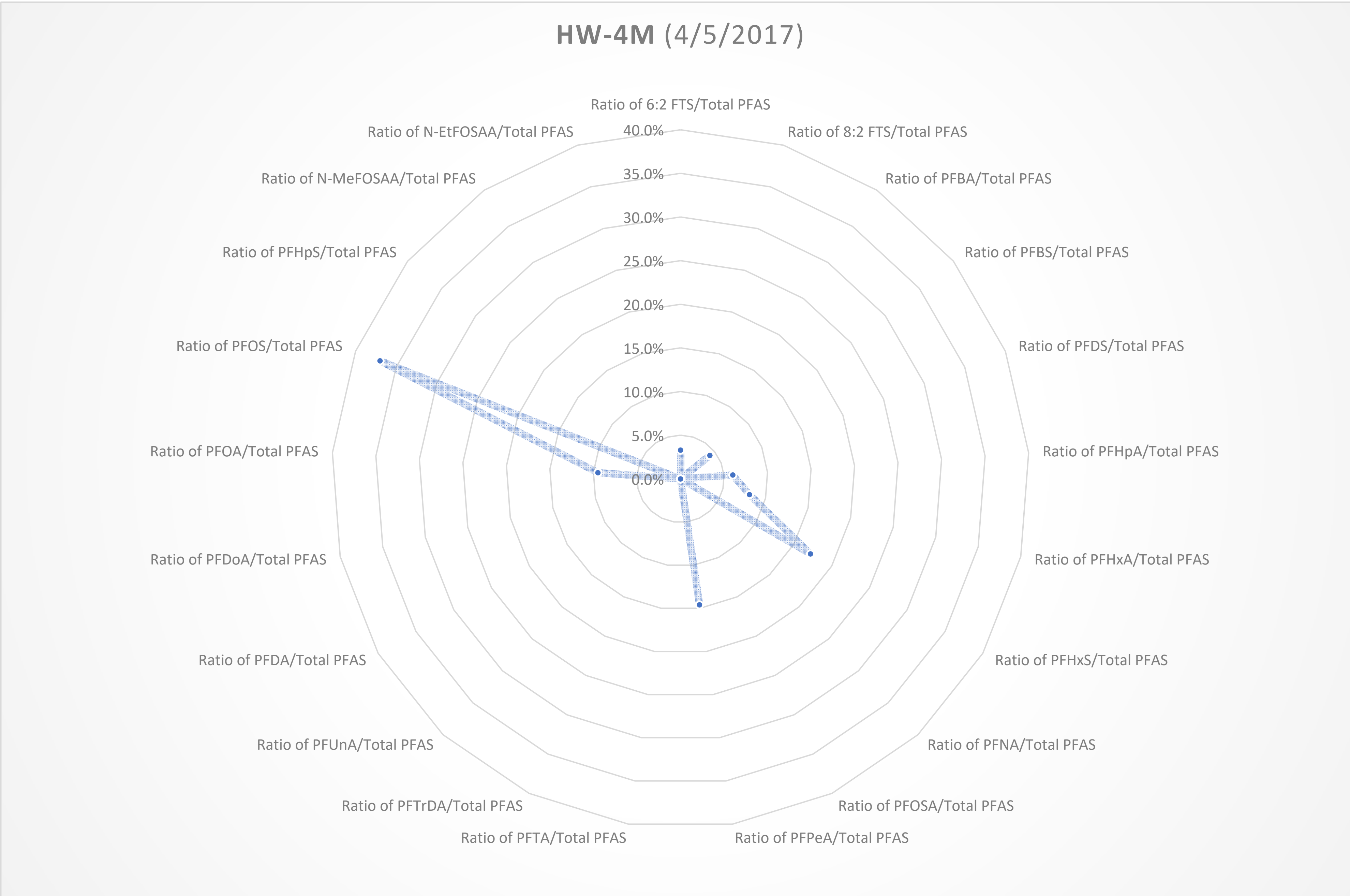
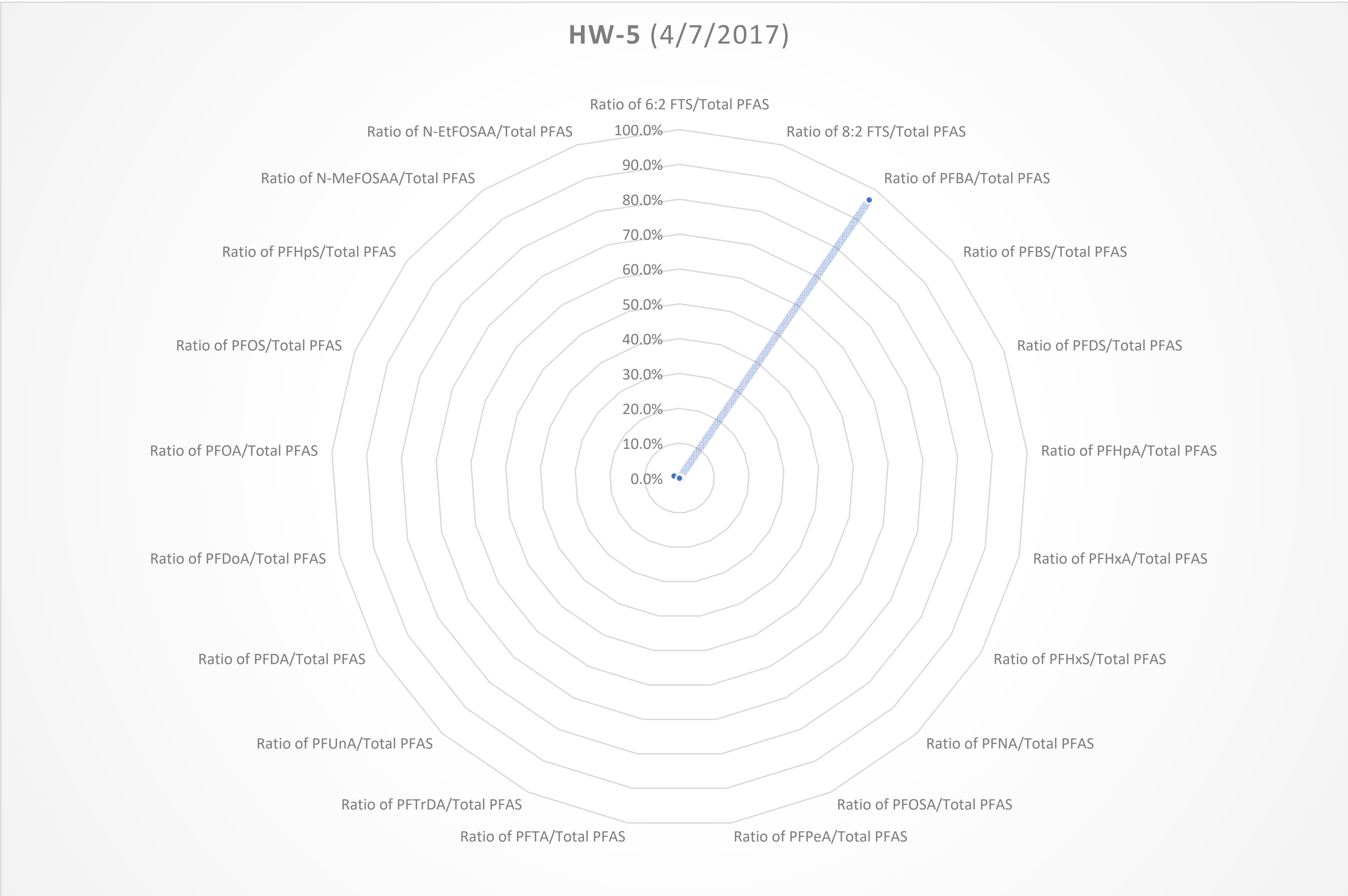
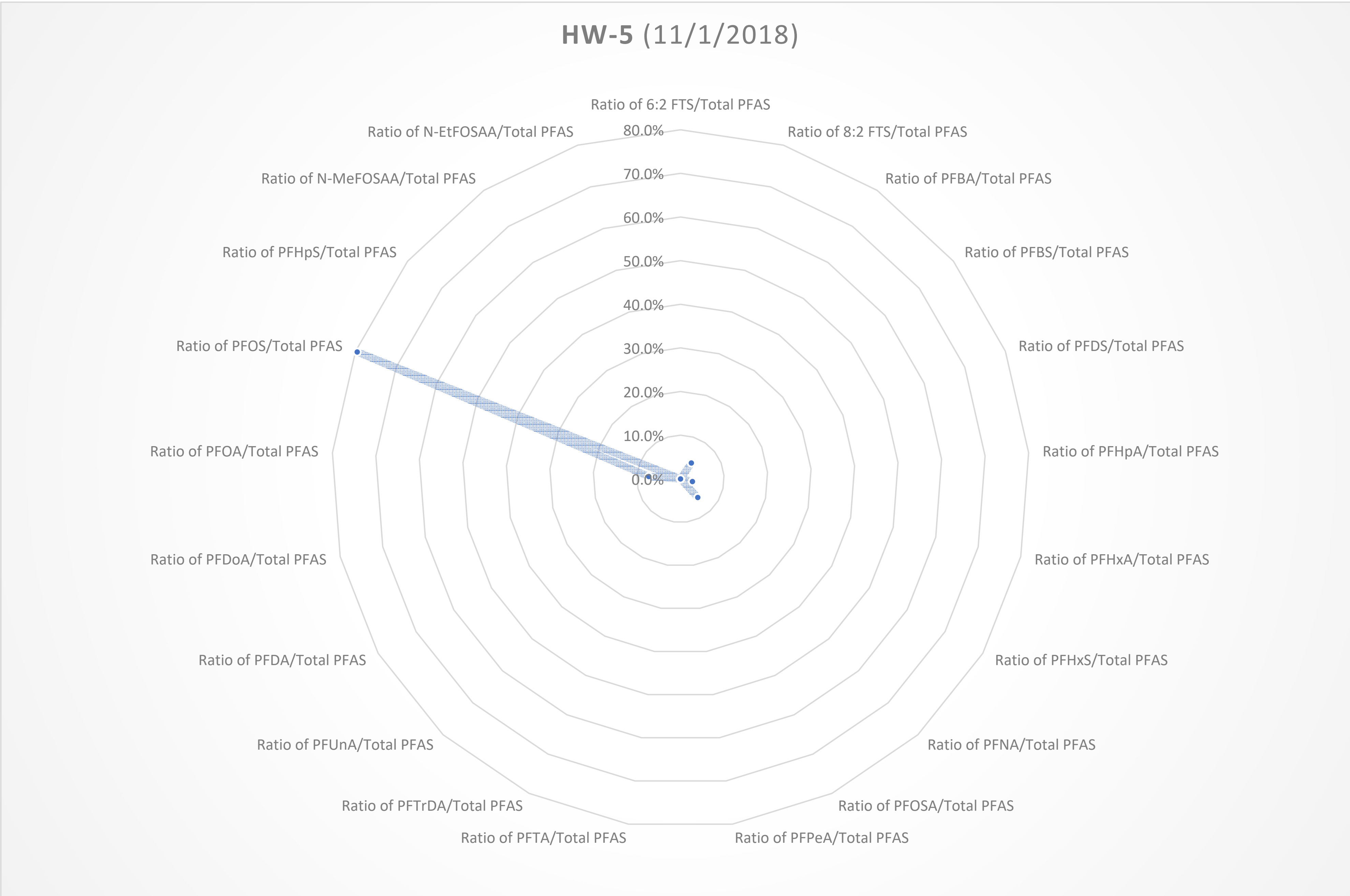


HW-4M (4/5/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



HW-5 (4/7/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



HW-5 (11/1/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
80.0%
70.0%
60.0%
50.0%
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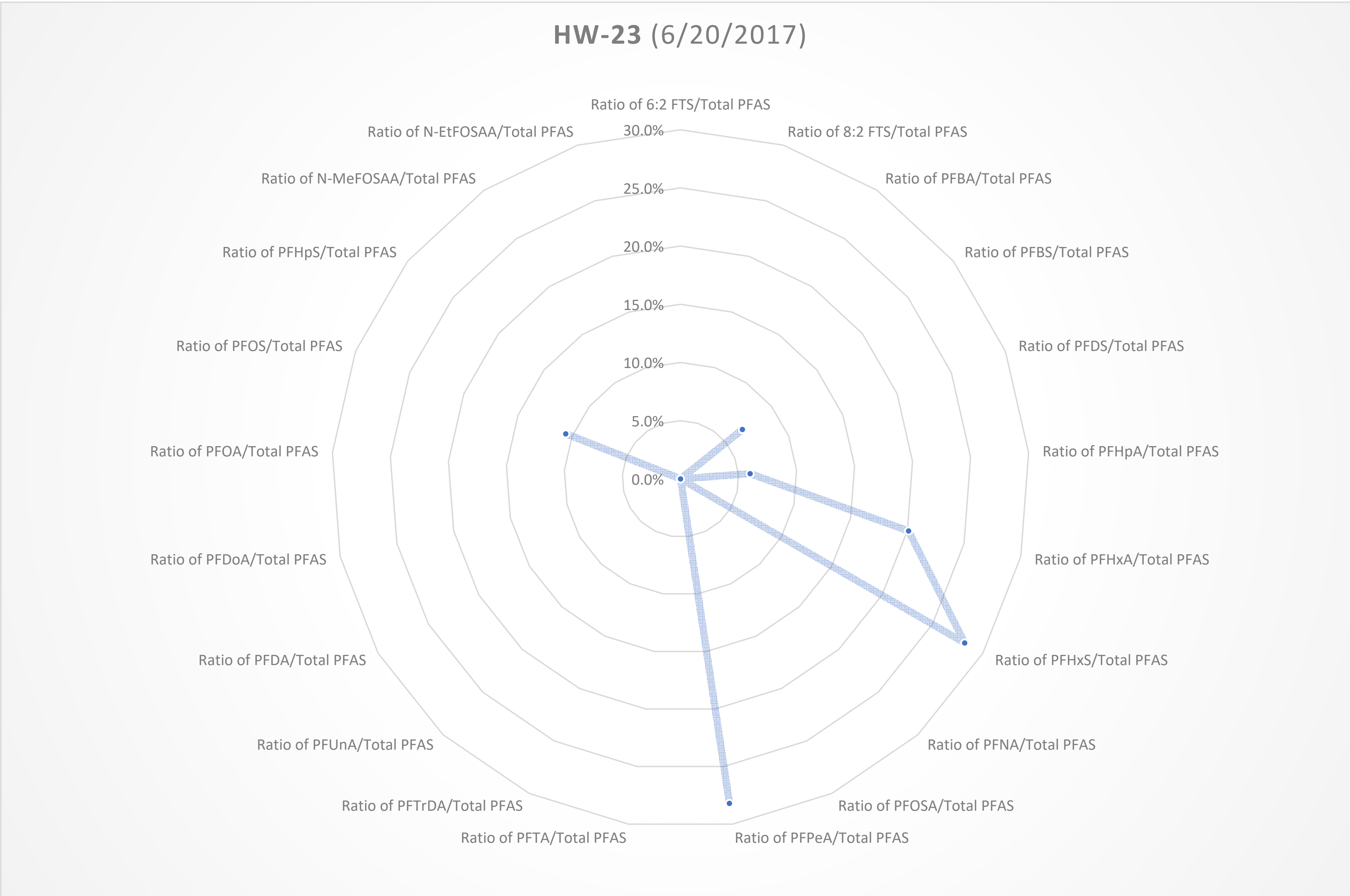
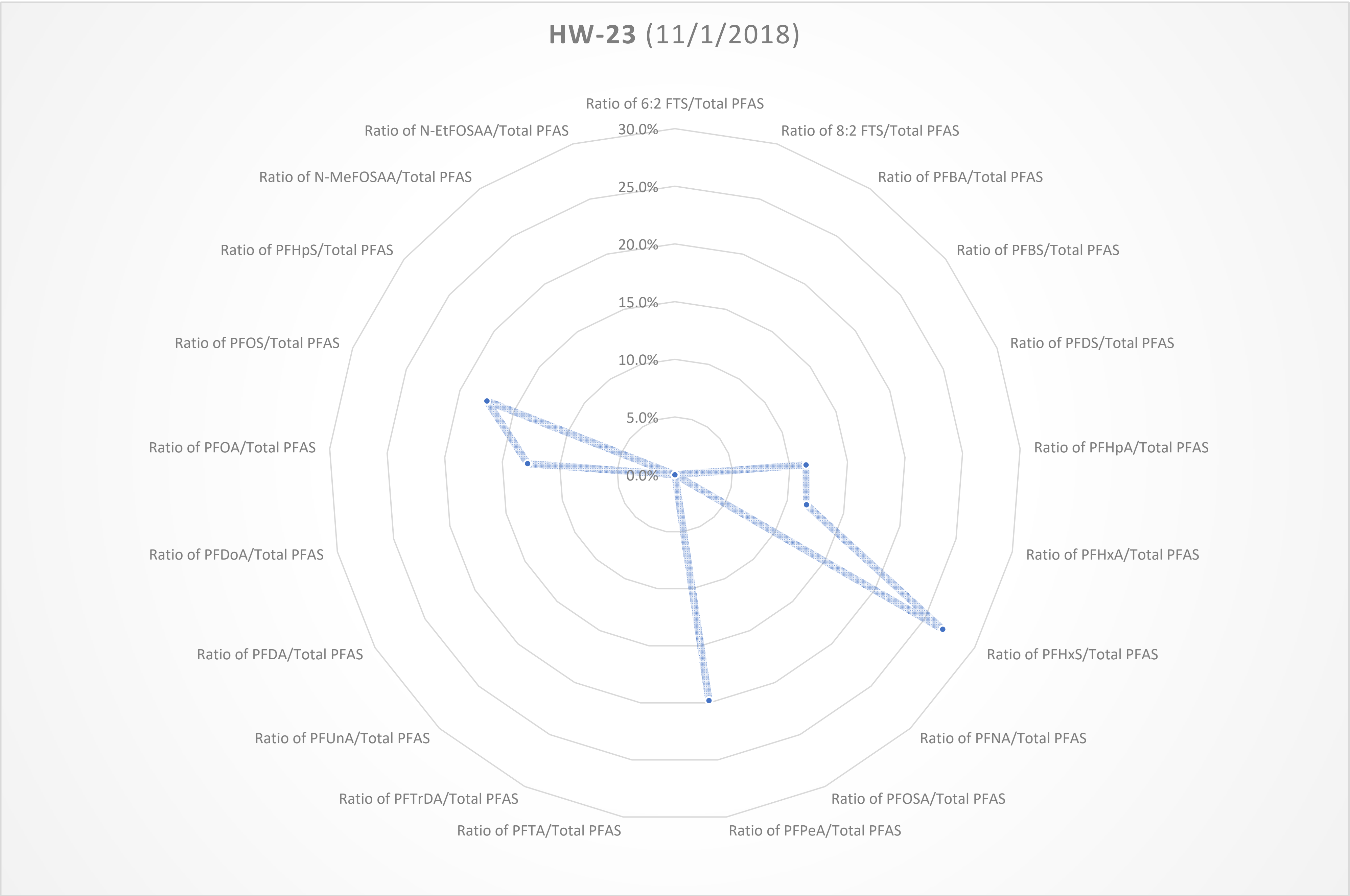
10.0%
0.0%



HW-23 (6/20/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-23 (11/1/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
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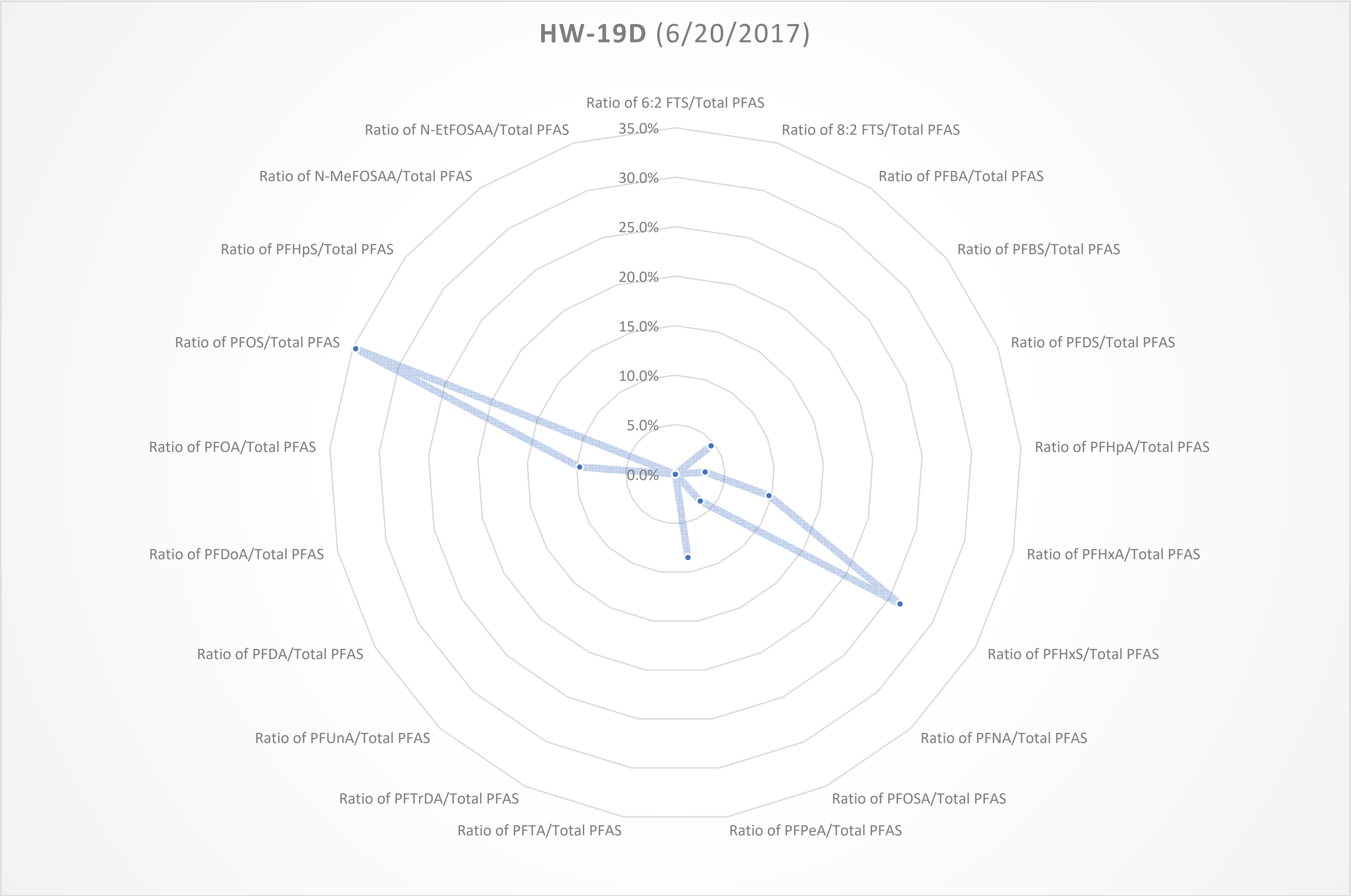
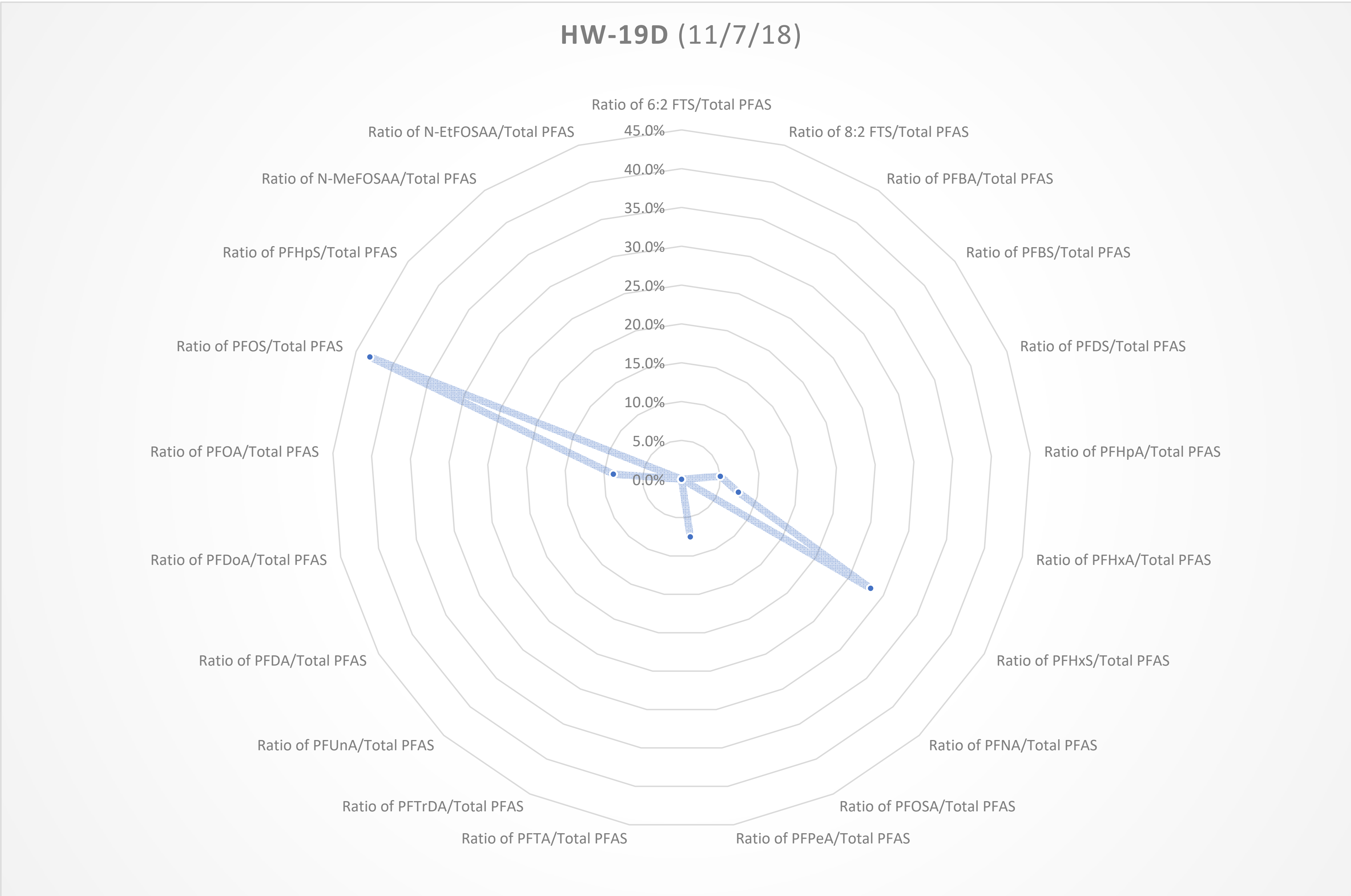
5.0%
0.0%


HW-19D (6/20/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-19D (11/7/18)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
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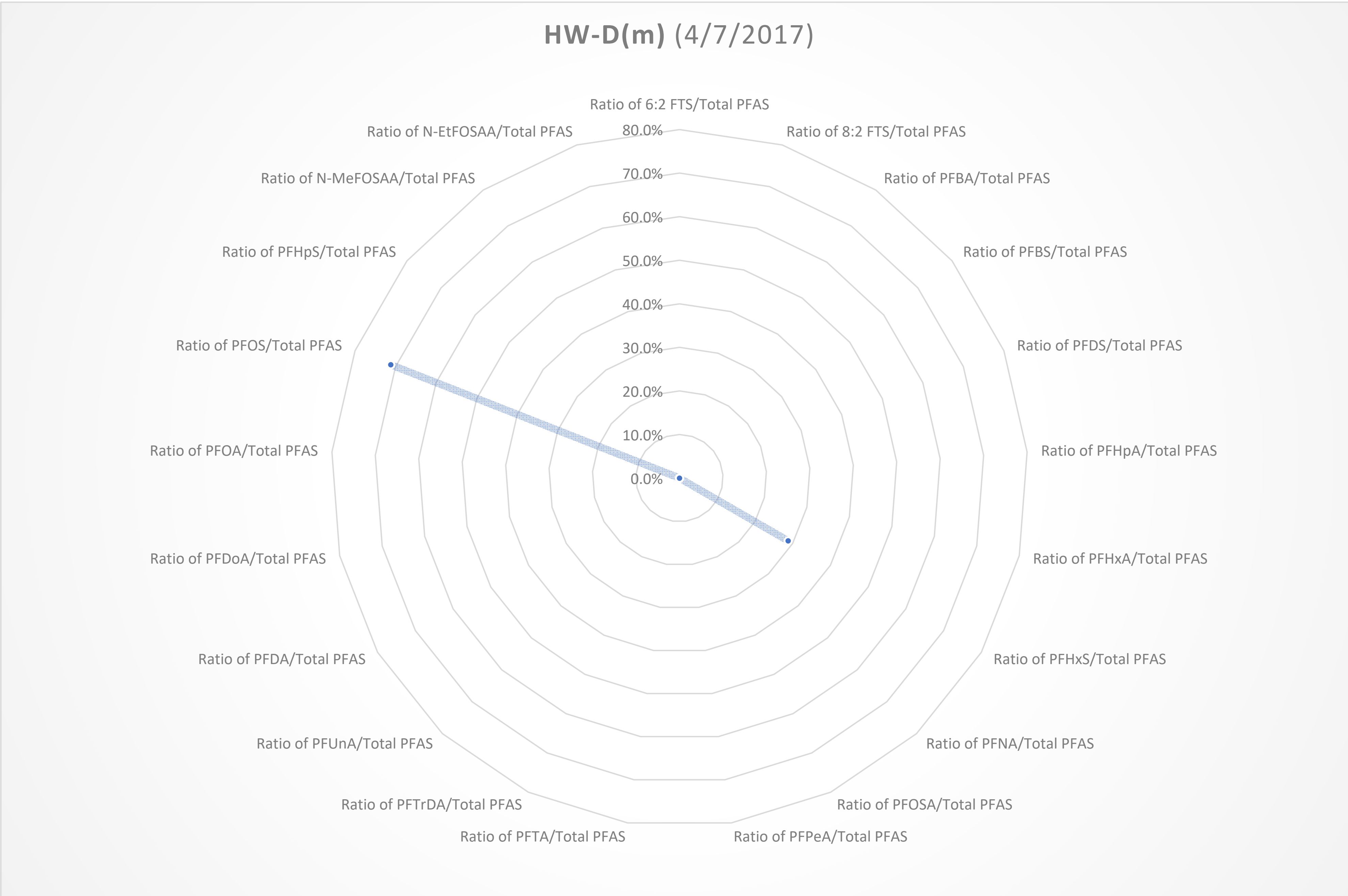
HW-D(m) (4/7/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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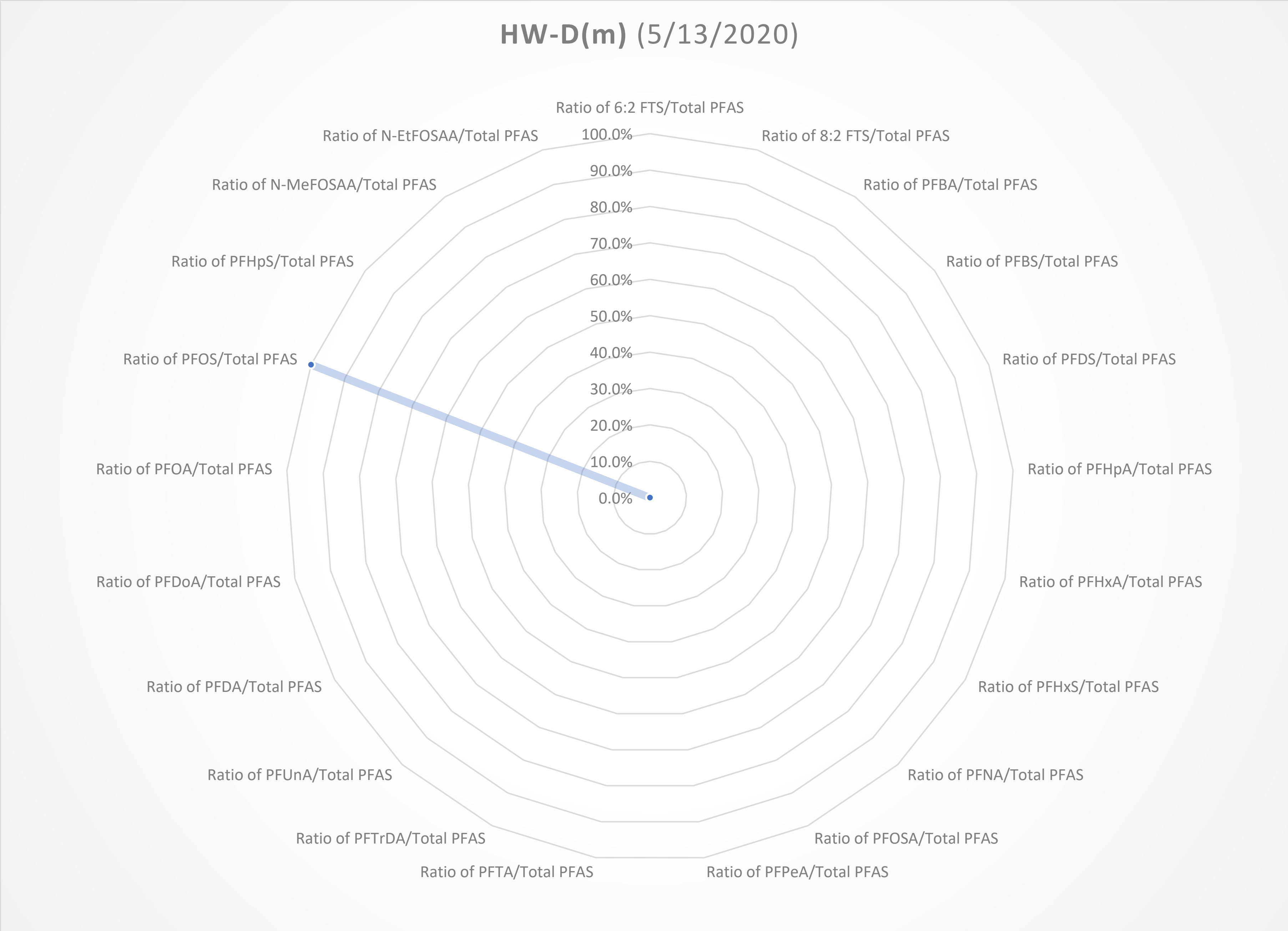
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


HW-D(m) (5/13/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
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10.0%
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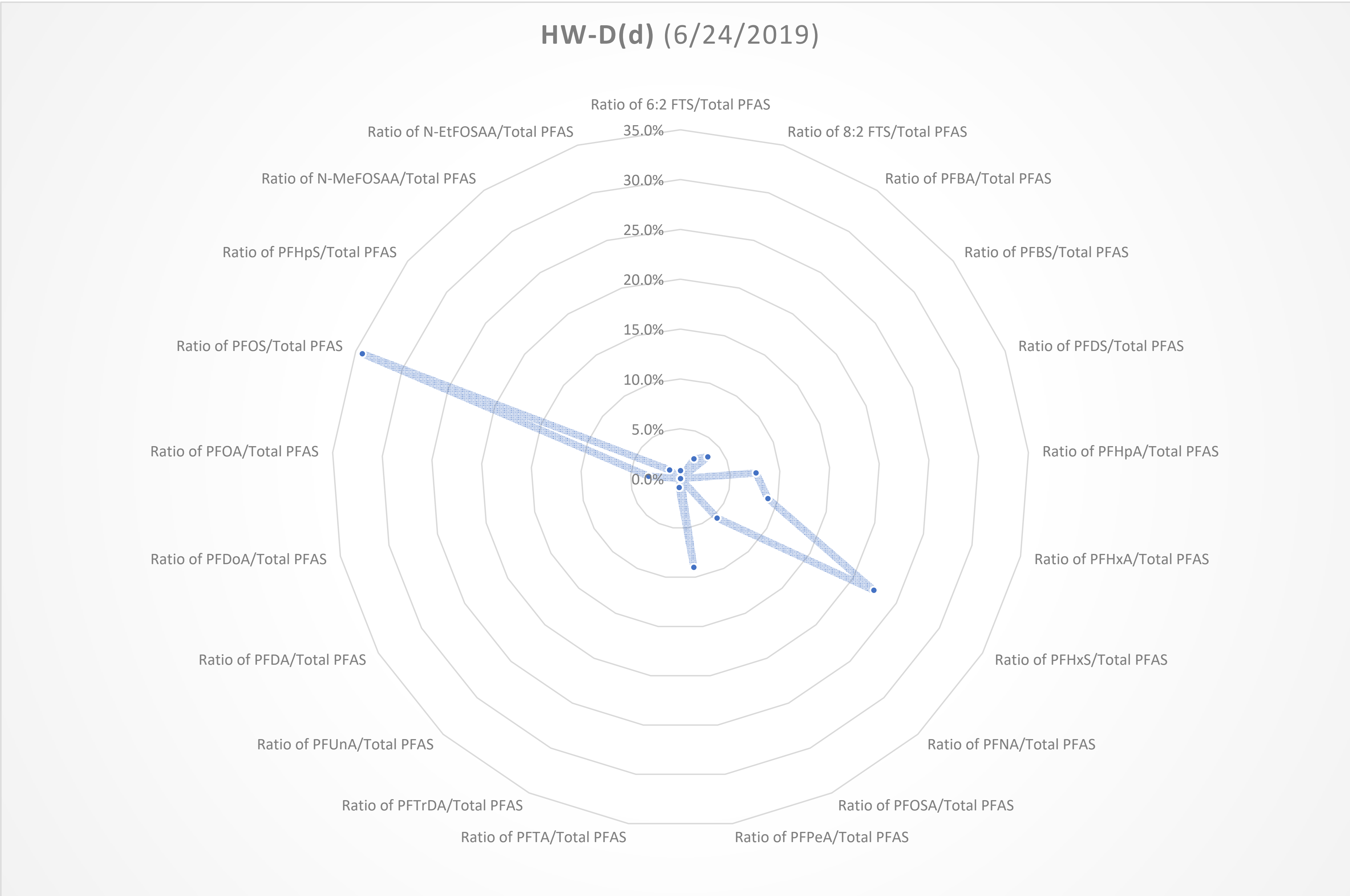
HW-D(d) (6/24/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
15.0%
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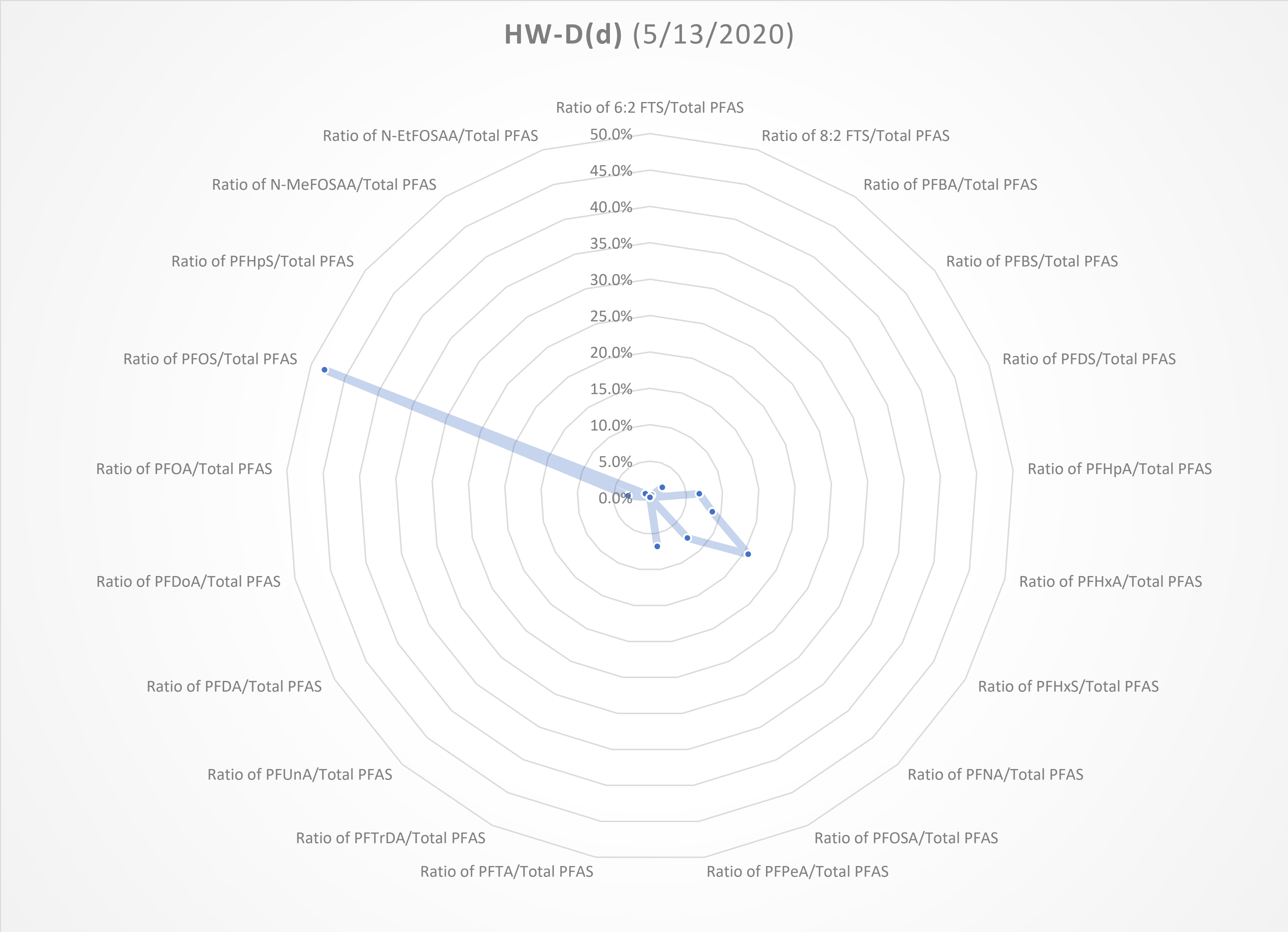
HW-D(d) (5/13/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
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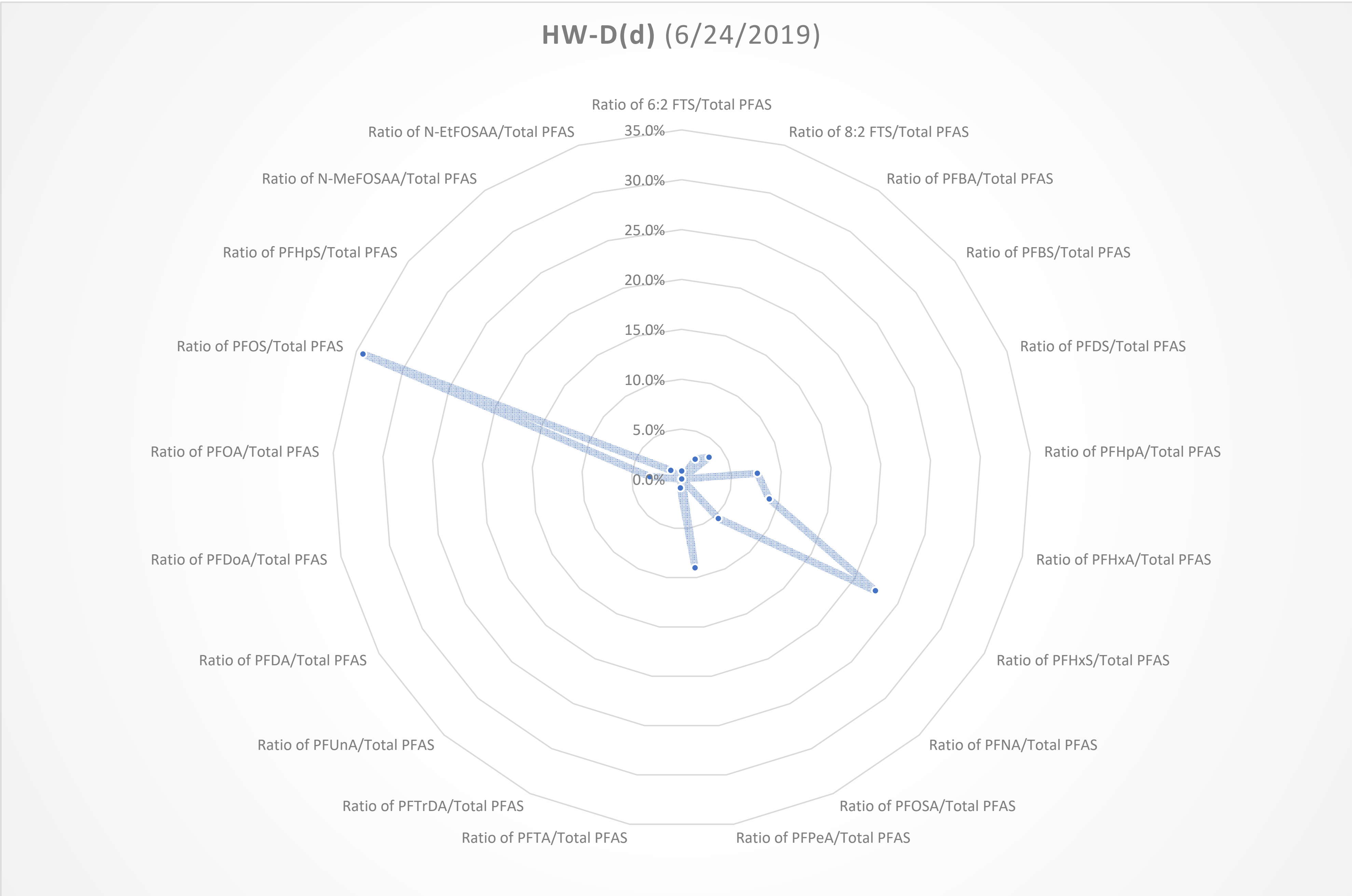
5.0%
0.0%


HW-D(d) (6/24/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
15.0%
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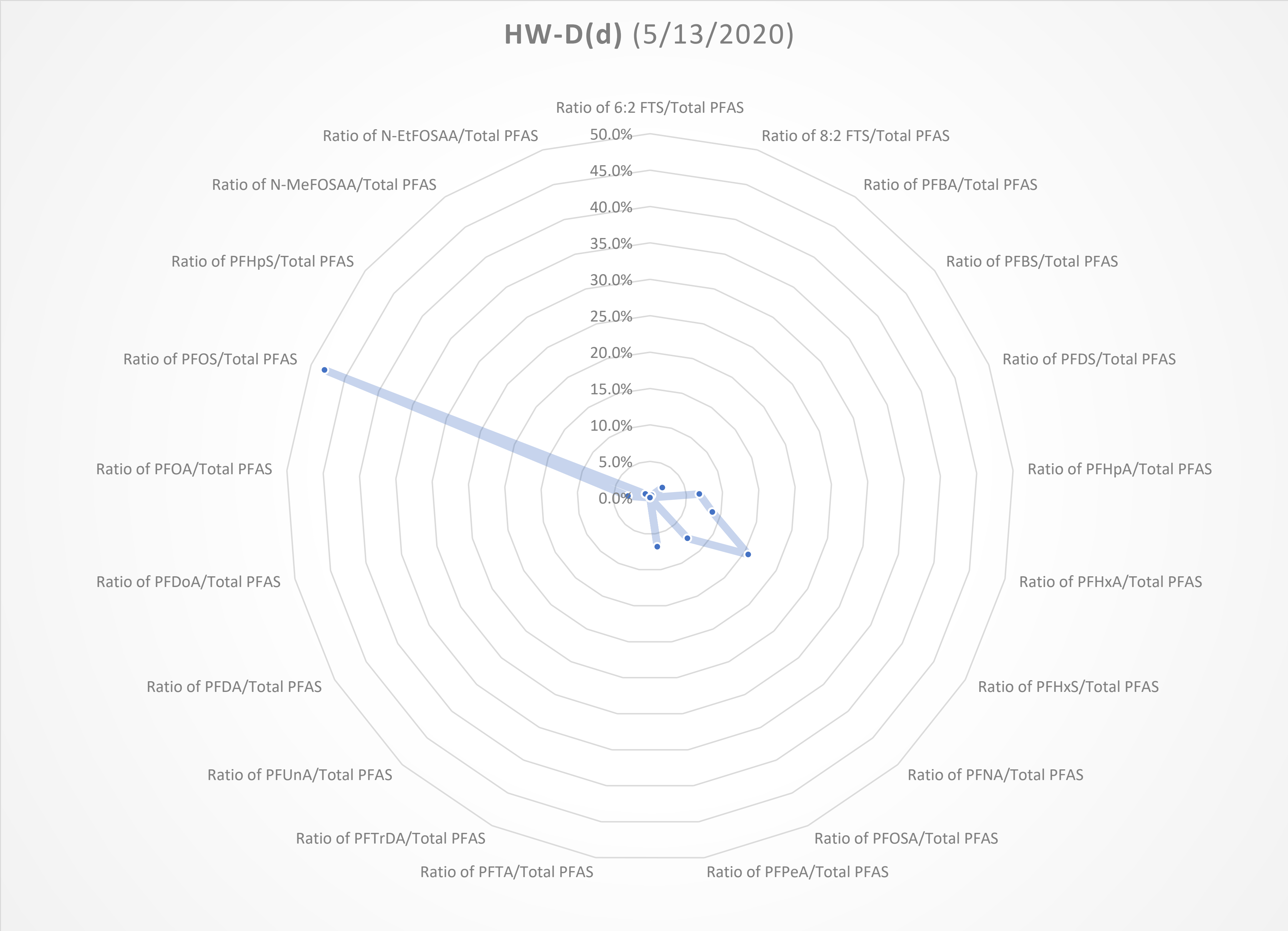
5.0%
0.0%



HW-D(d) (5/13/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
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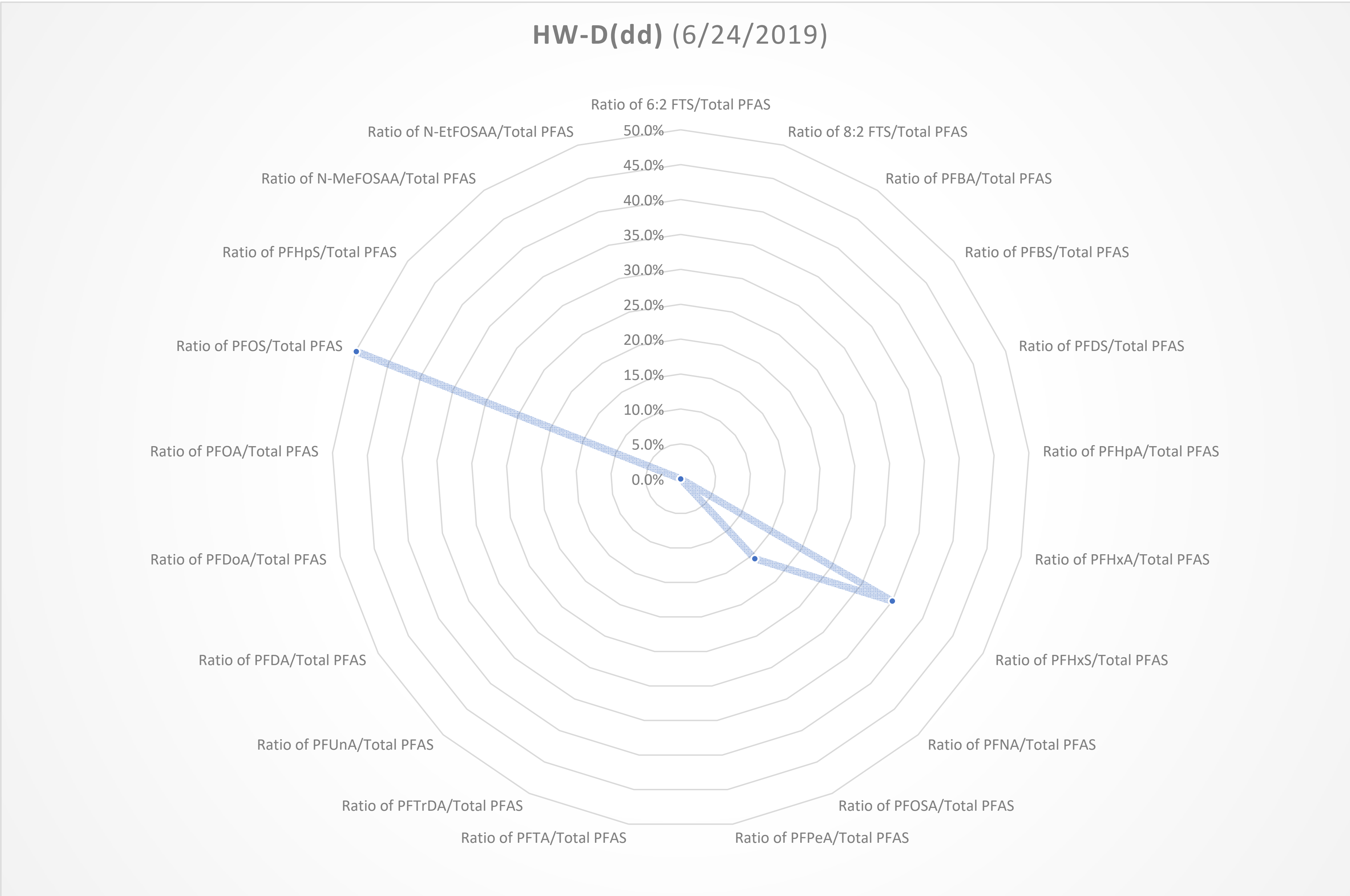
HW-D(dd) (6/24/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.0%
45.0%
40.0%
35.0%
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25.0%
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15.0%
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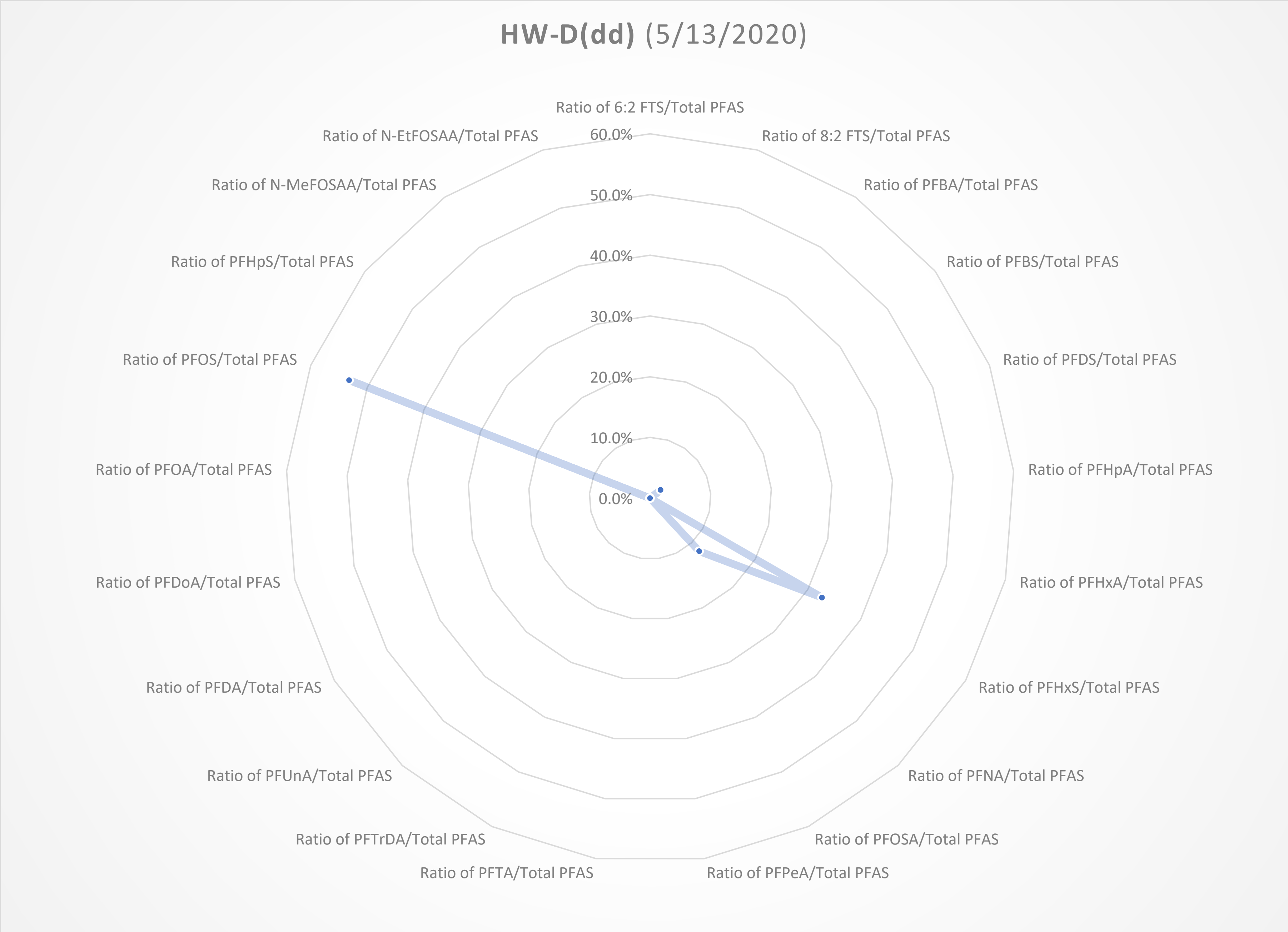
HW-D(dd) (5/13/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
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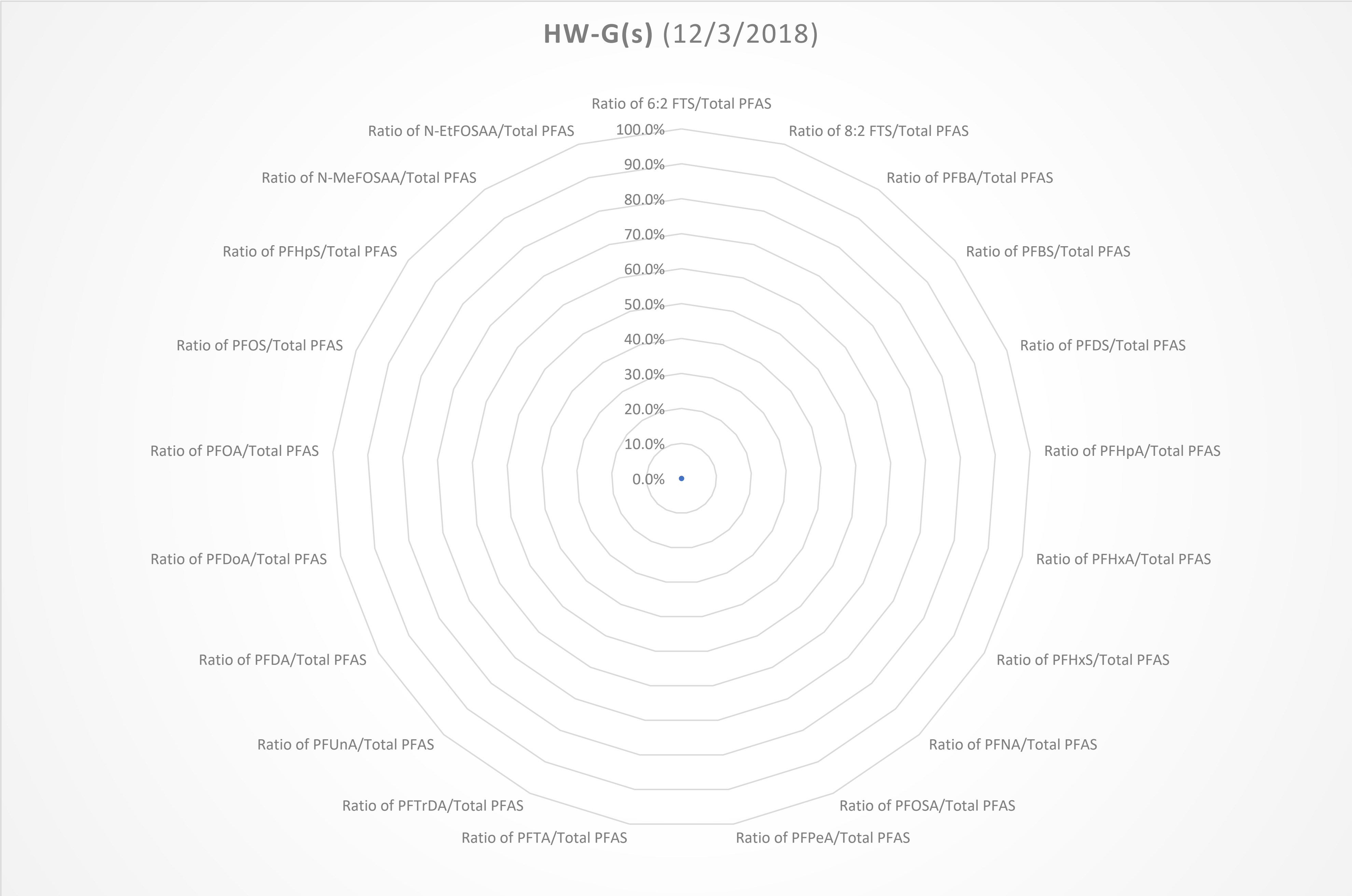
0.0%


HW-G(s) (12/3/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
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30.0%
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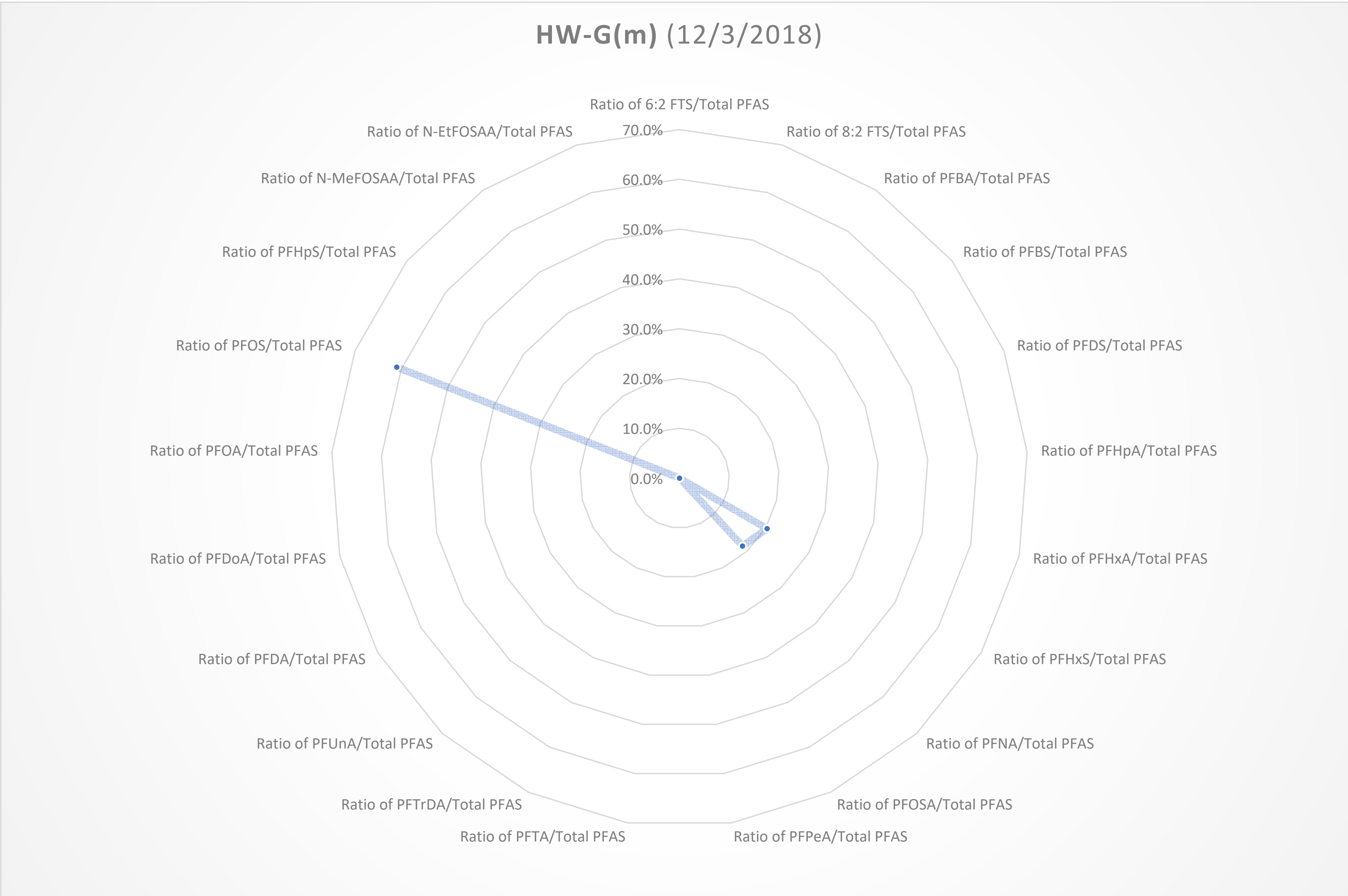
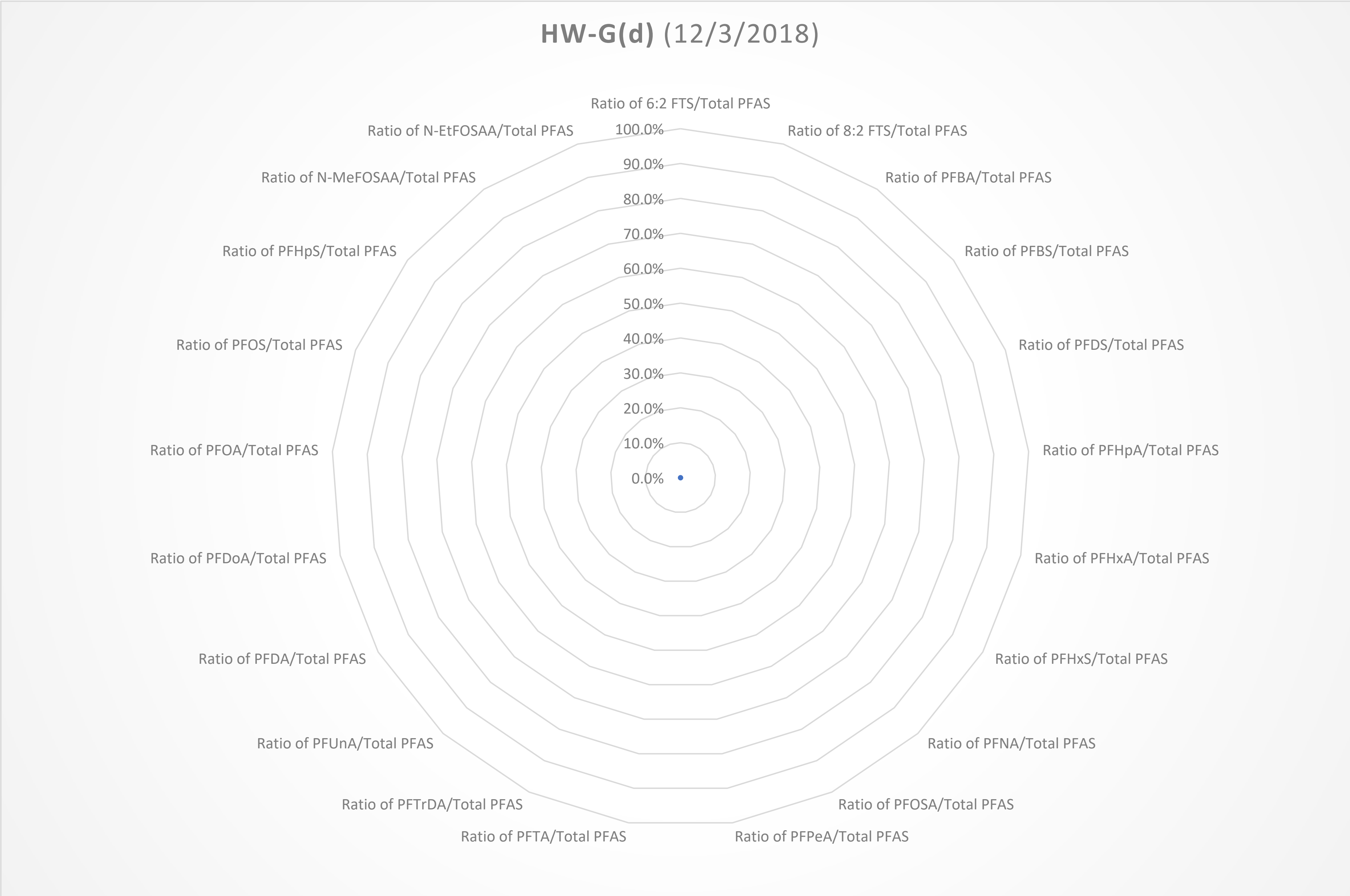
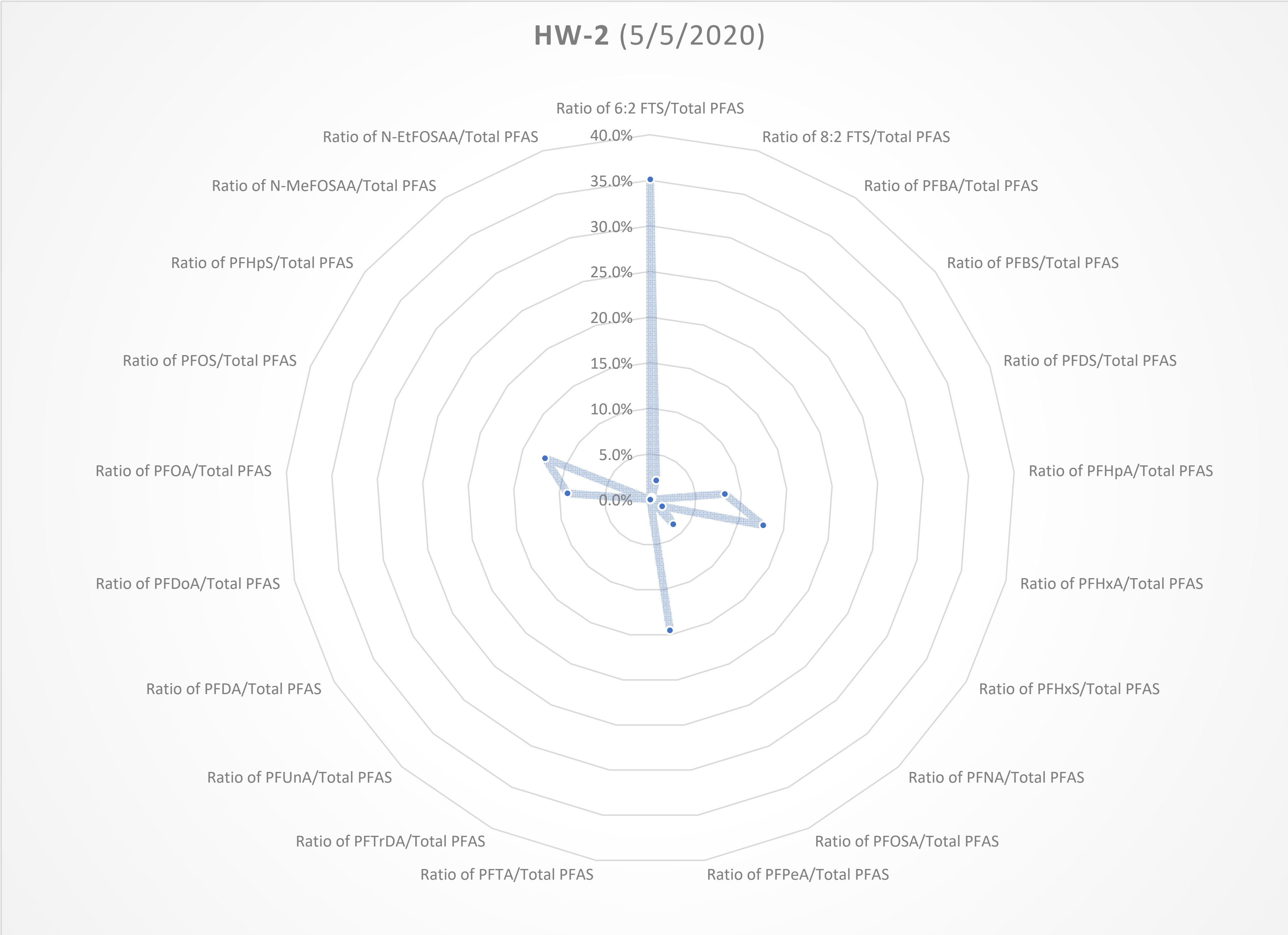


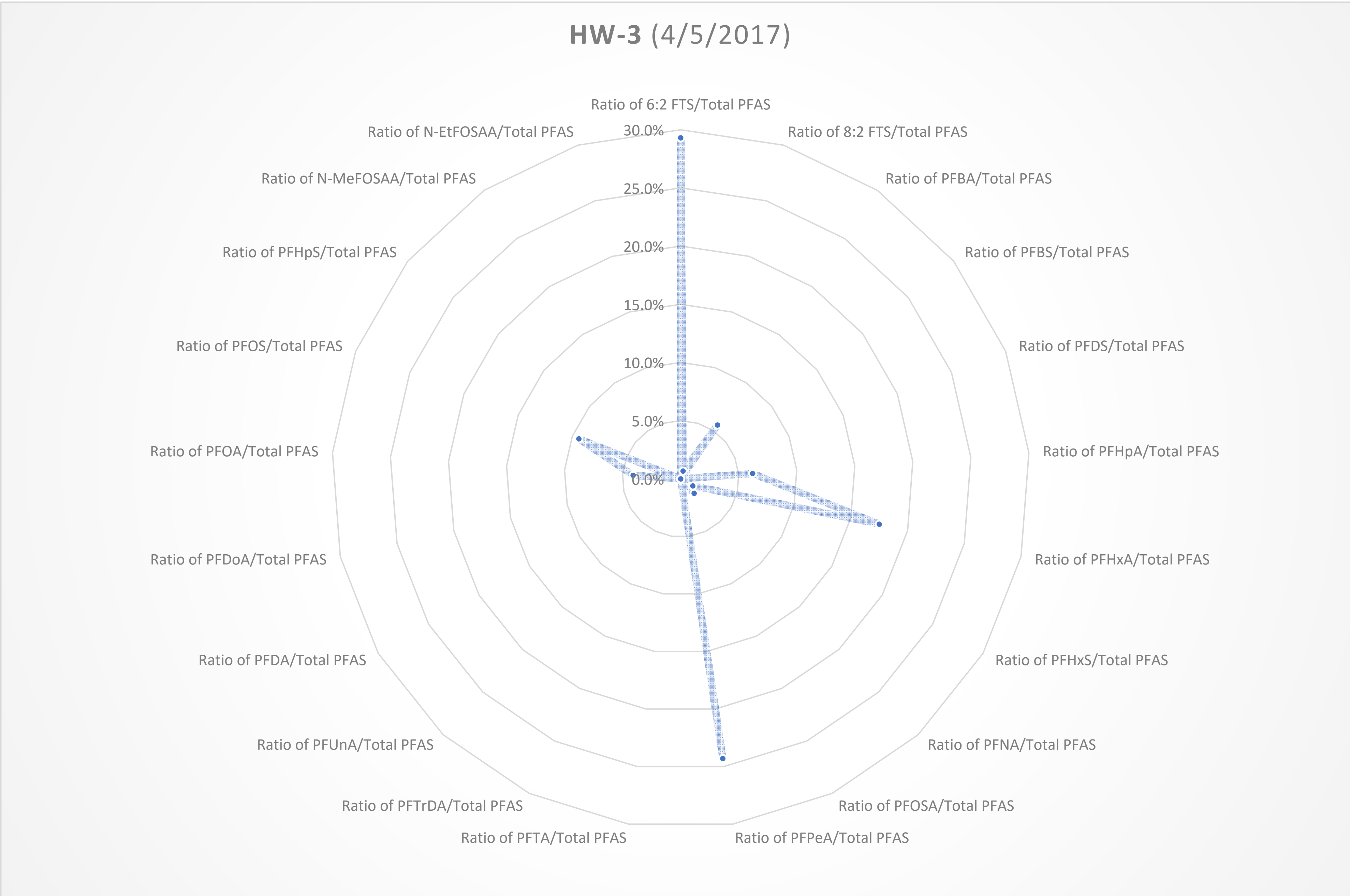
HW-G(m) (12/3/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



HW-G(d) (12/3/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



HW-2 (5/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



HW-3 (4/5/2017)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
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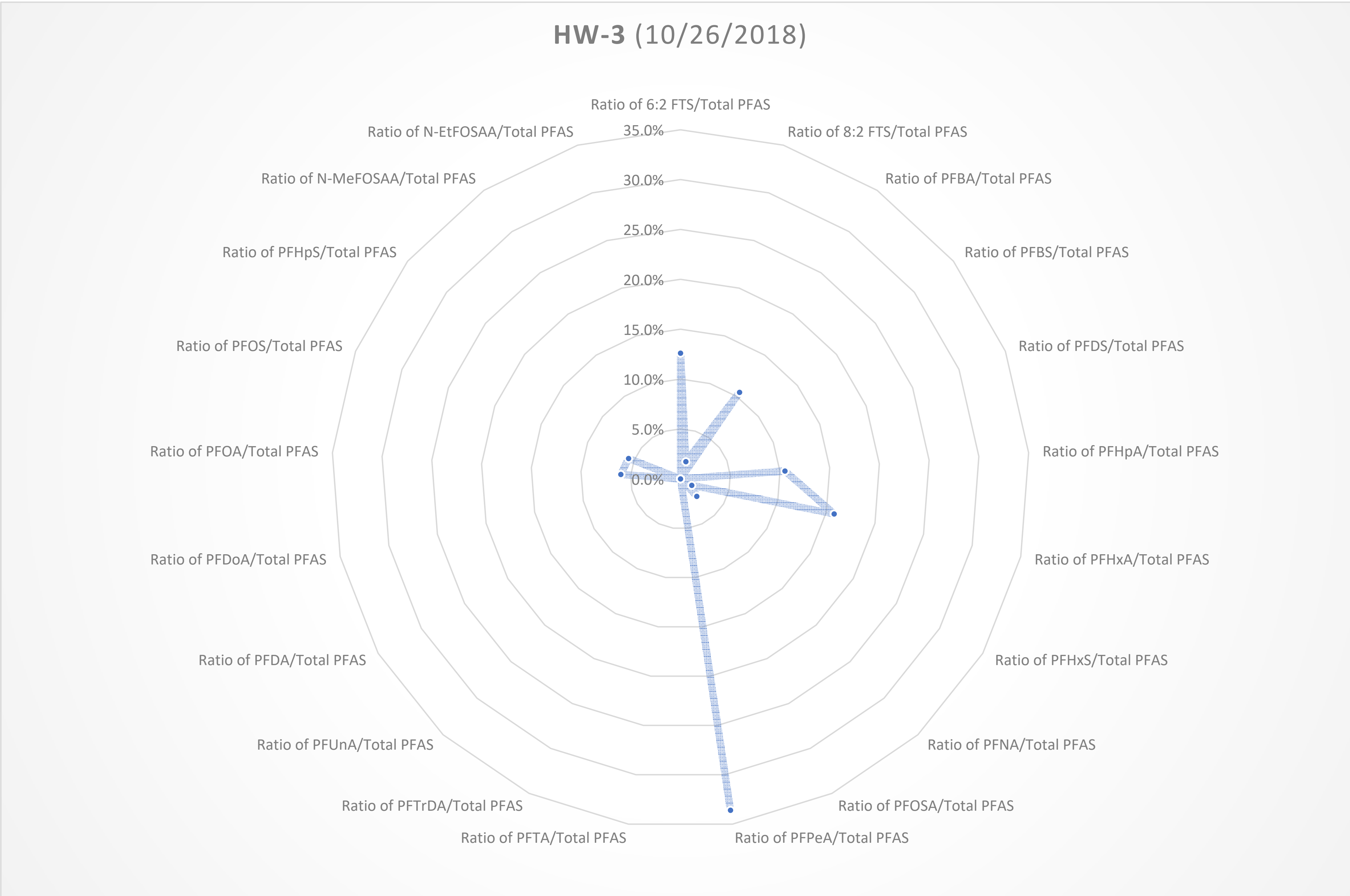
5.0%
0.0%


HW-3 (10/26/2018)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
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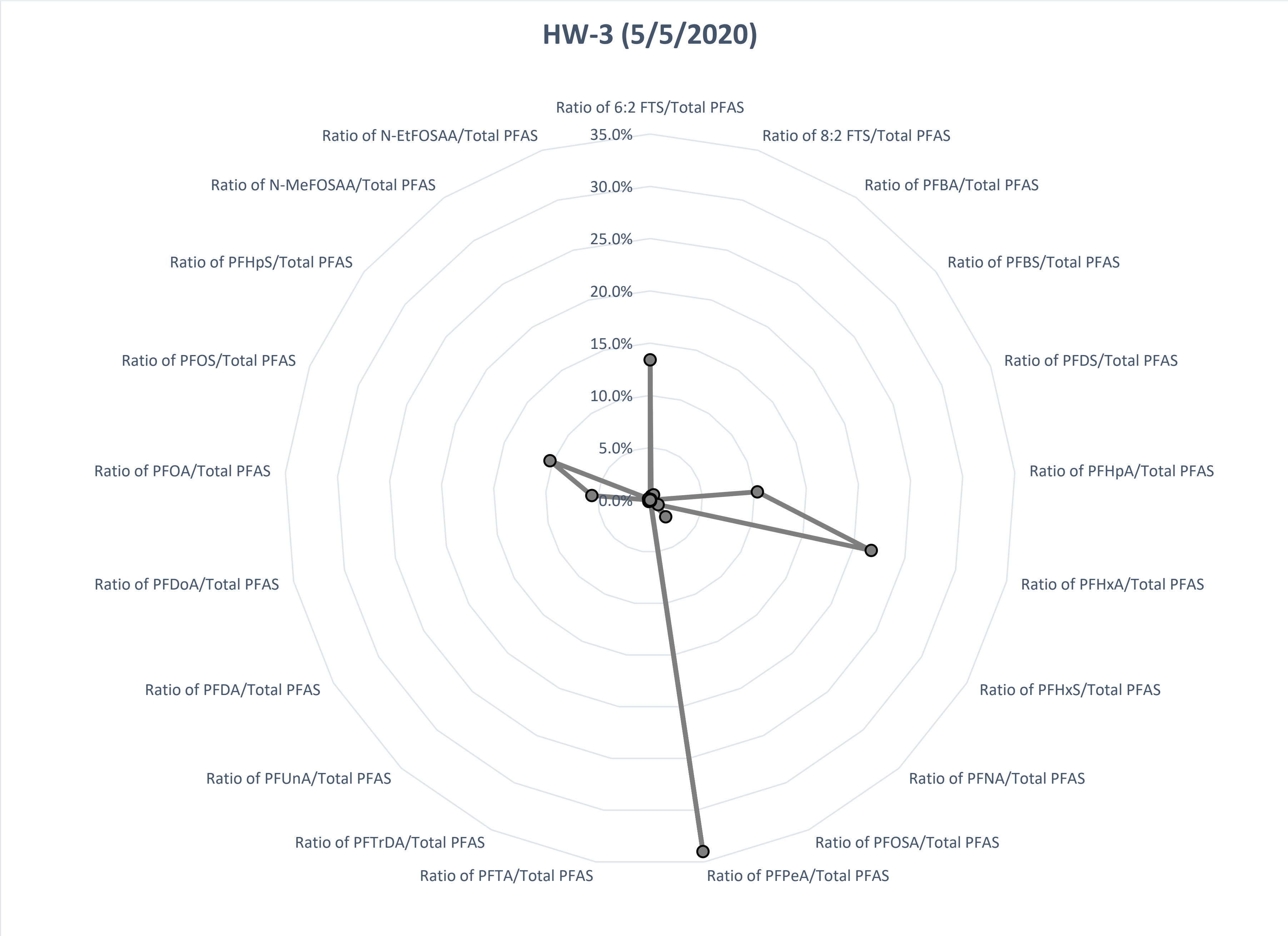
5.0%
0.0%



HW-3 (5/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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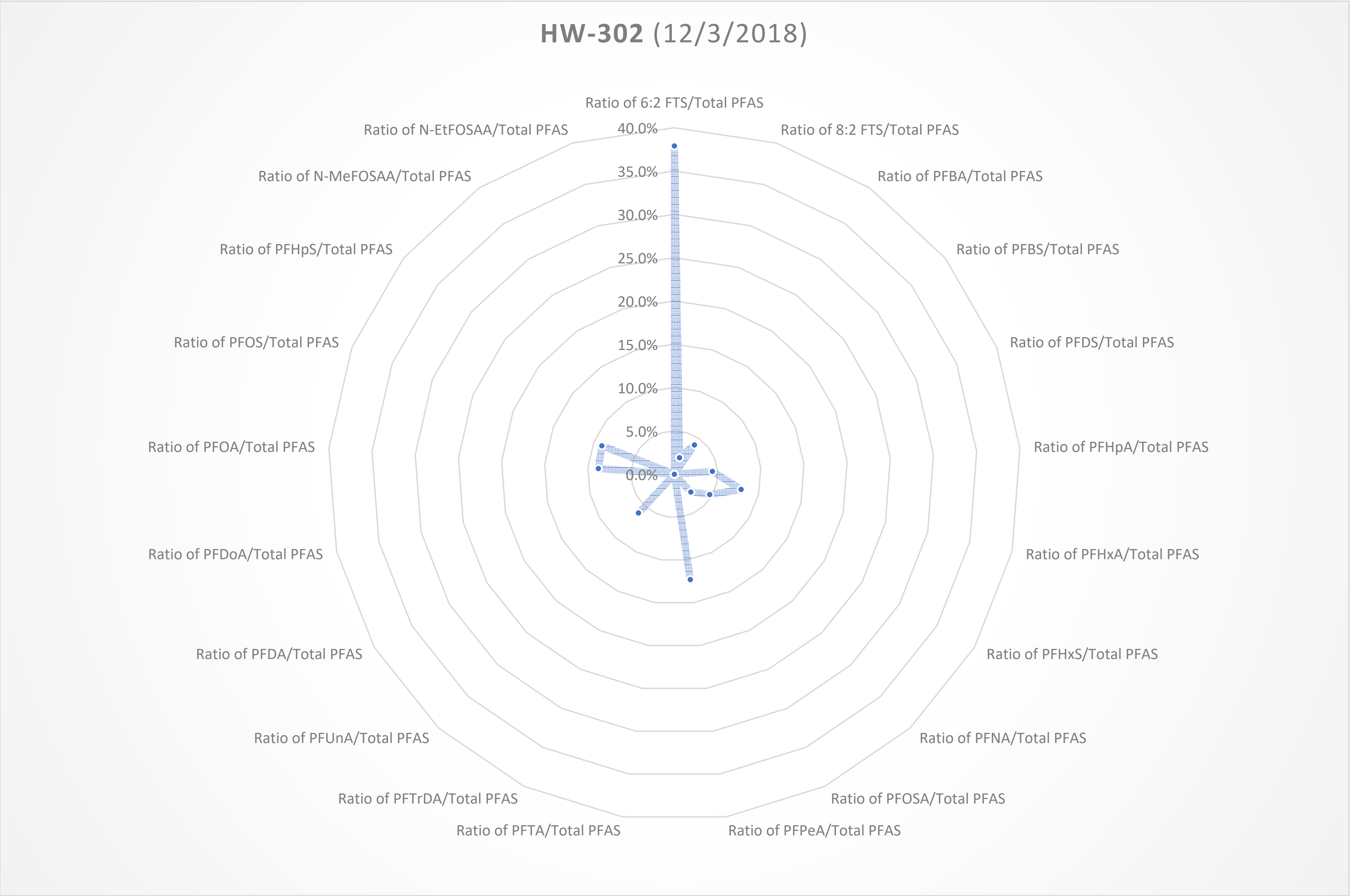
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%


HW-302 (12/3/2018)
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Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
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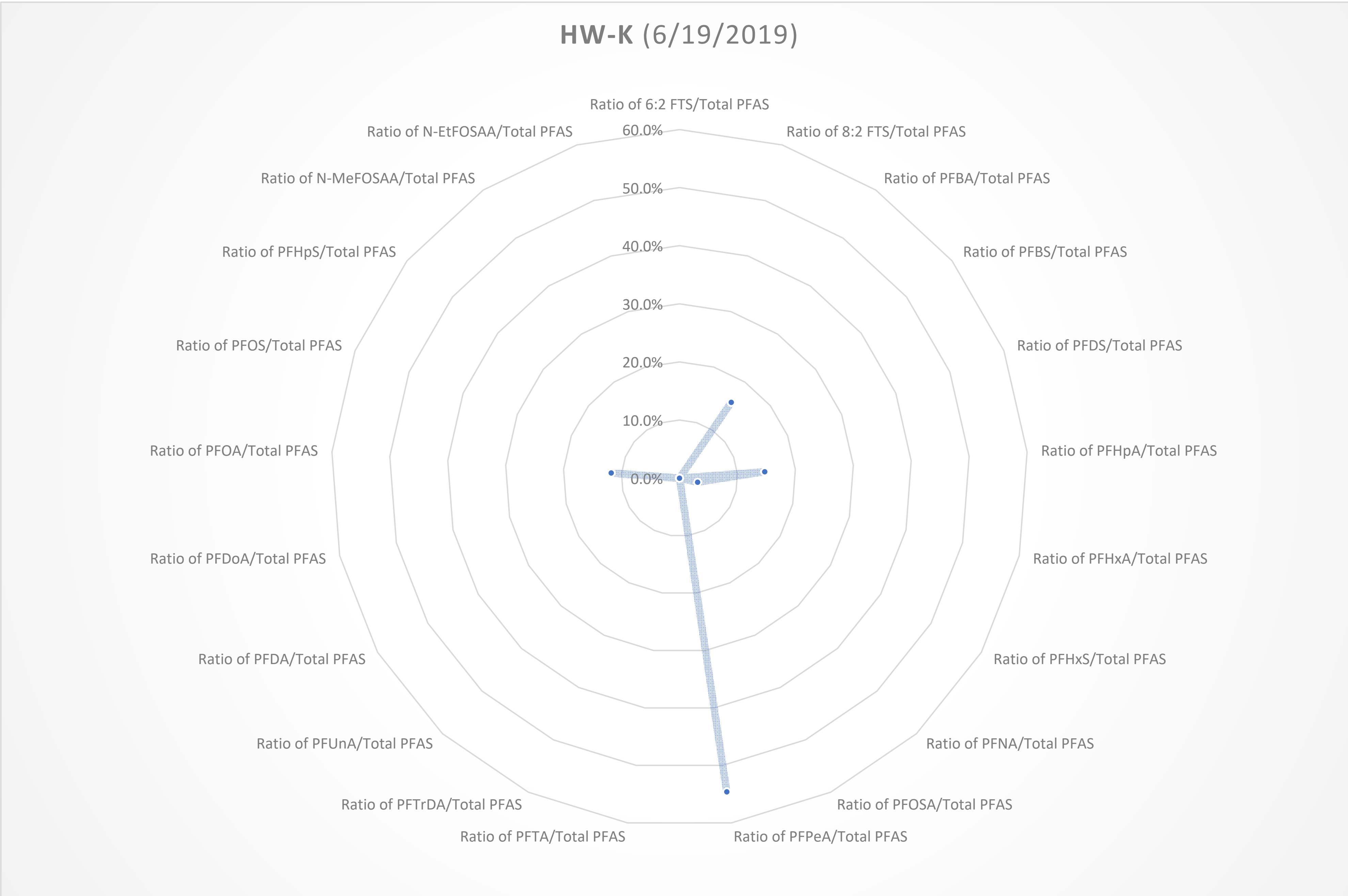
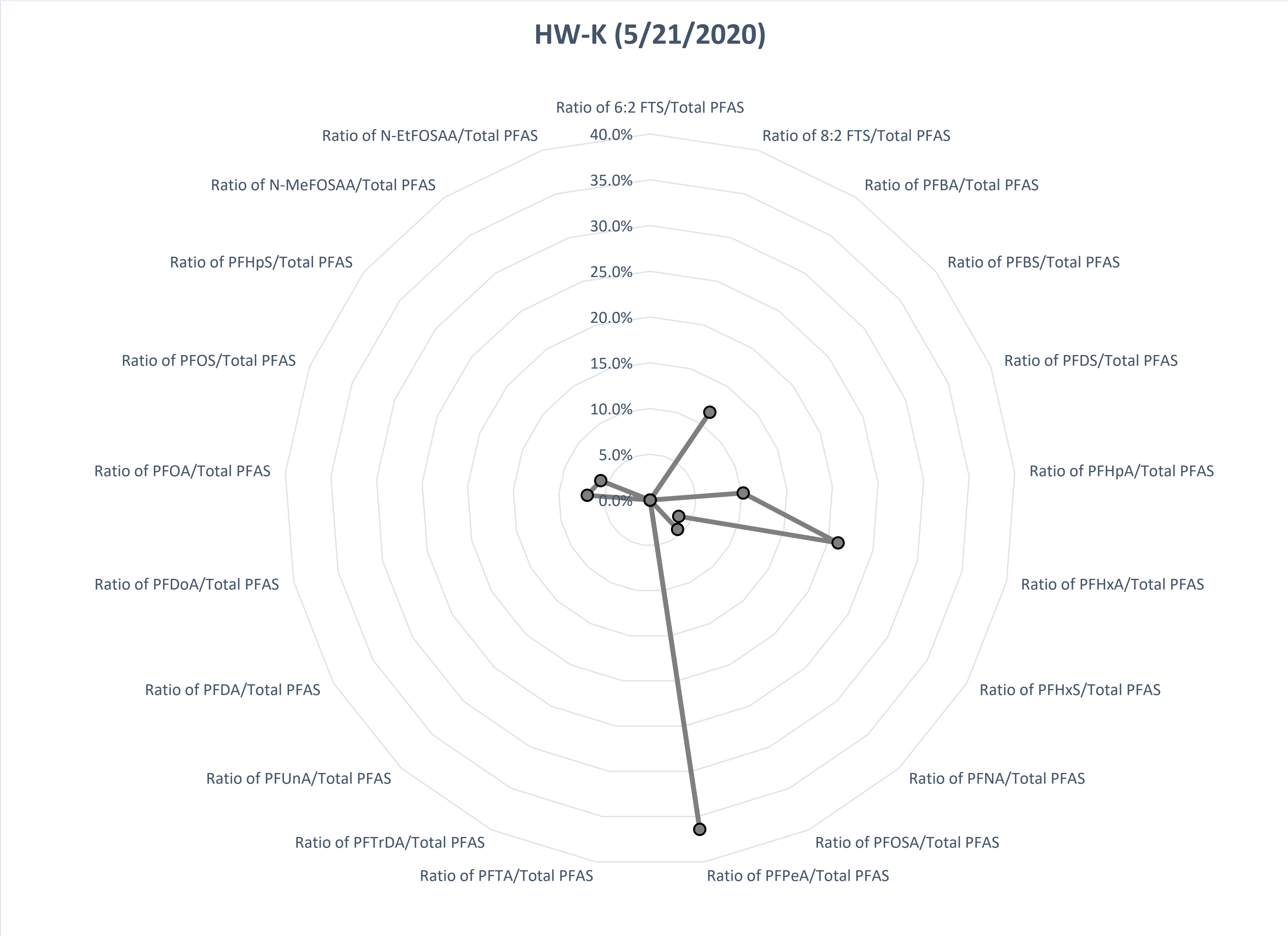
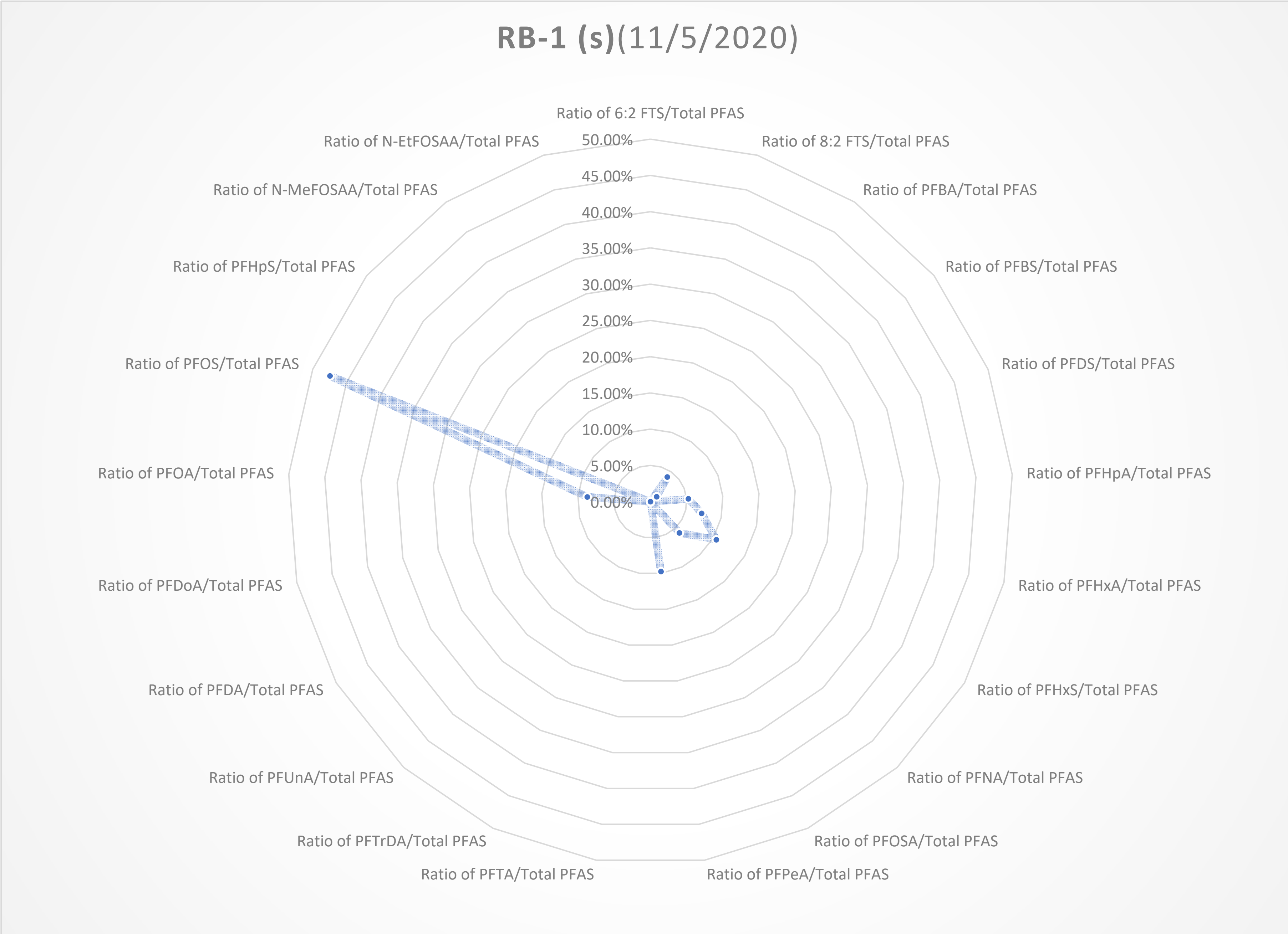
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

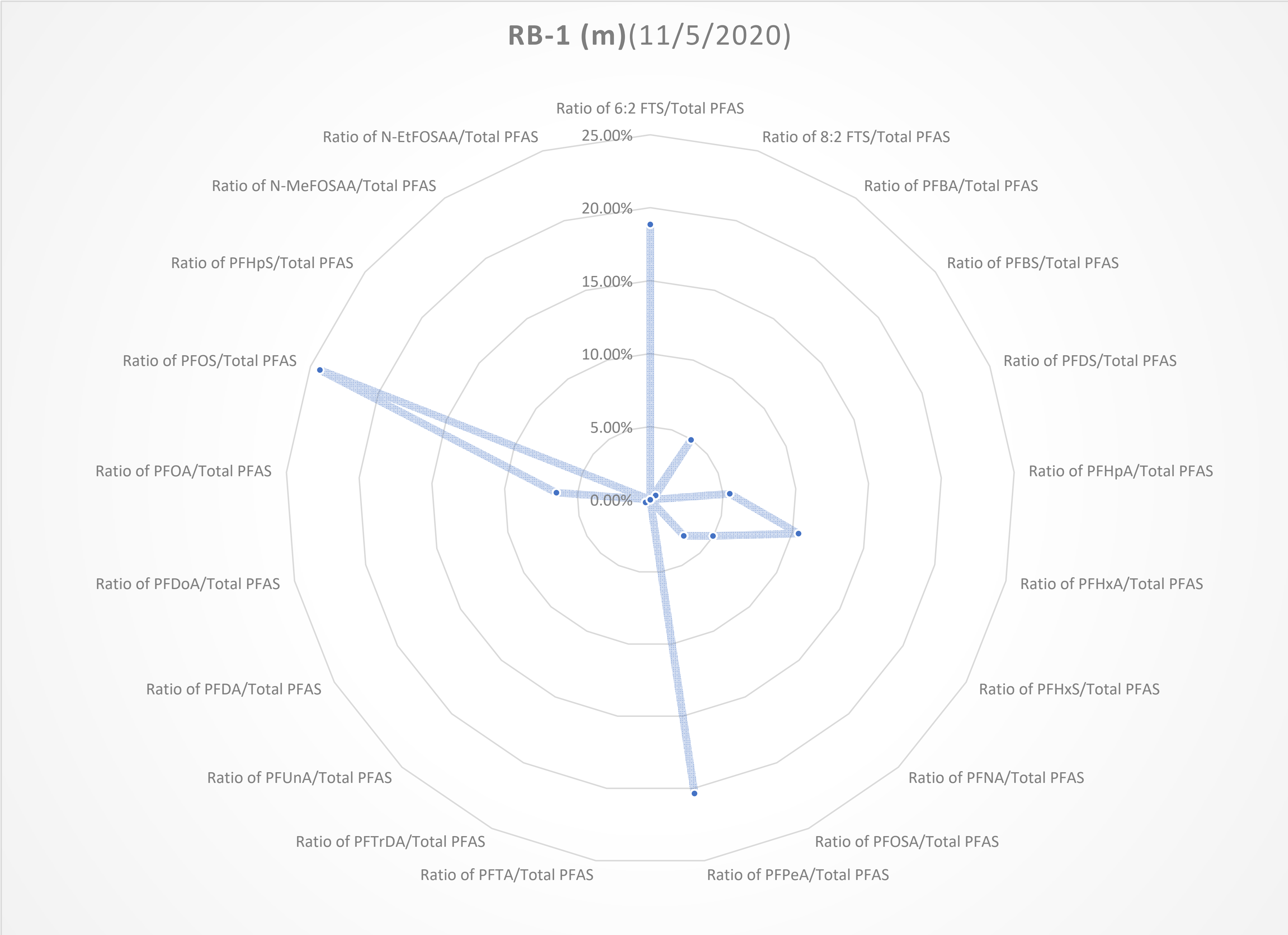


HW-K (6/19/2019)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%


HW-K (5/21/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



RB-1 (s)(11/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%


RB-1 (m)(11/5/2020)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
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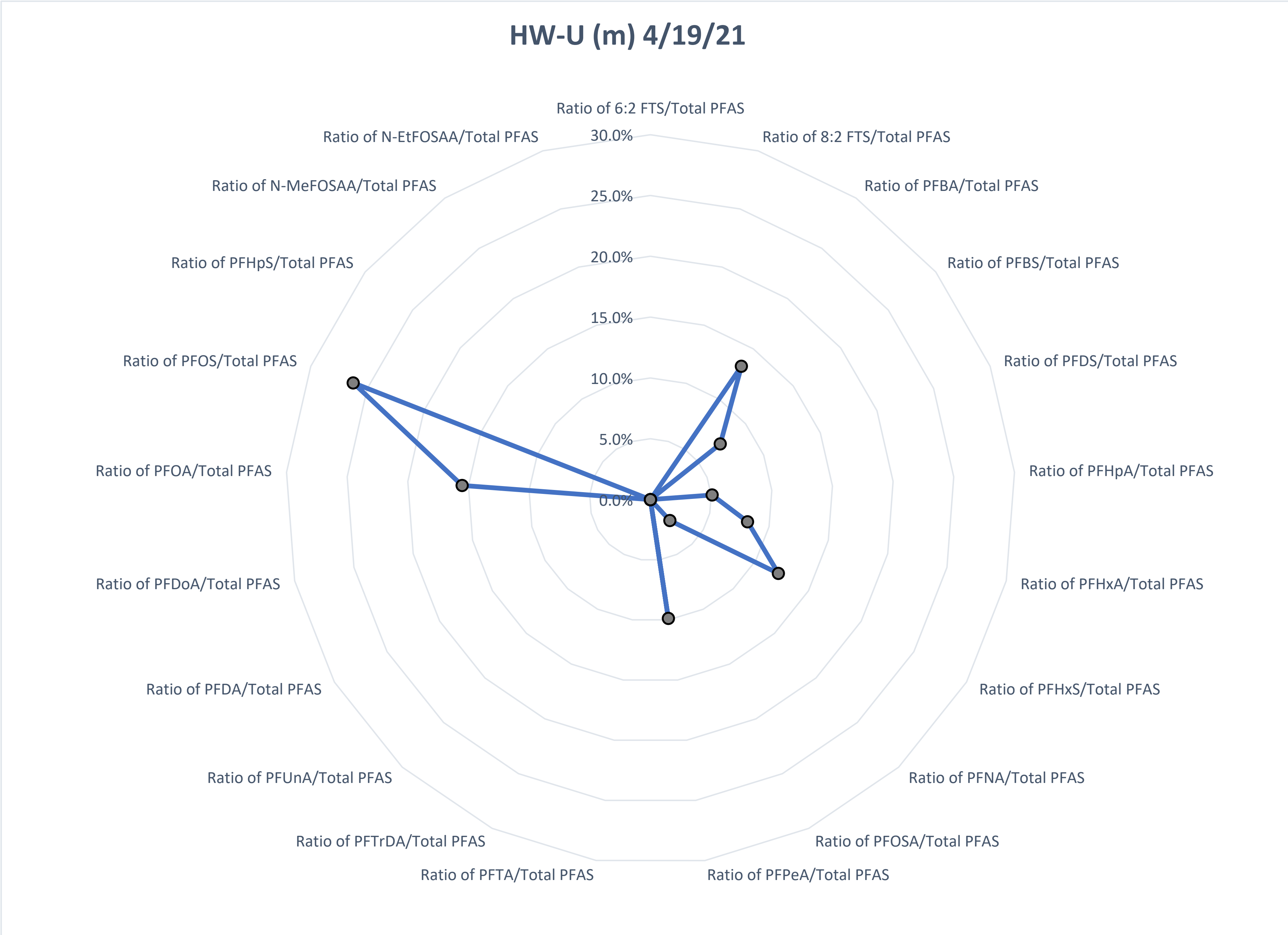
5.00%
0.00%


HW-U (m) 4/19/21
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
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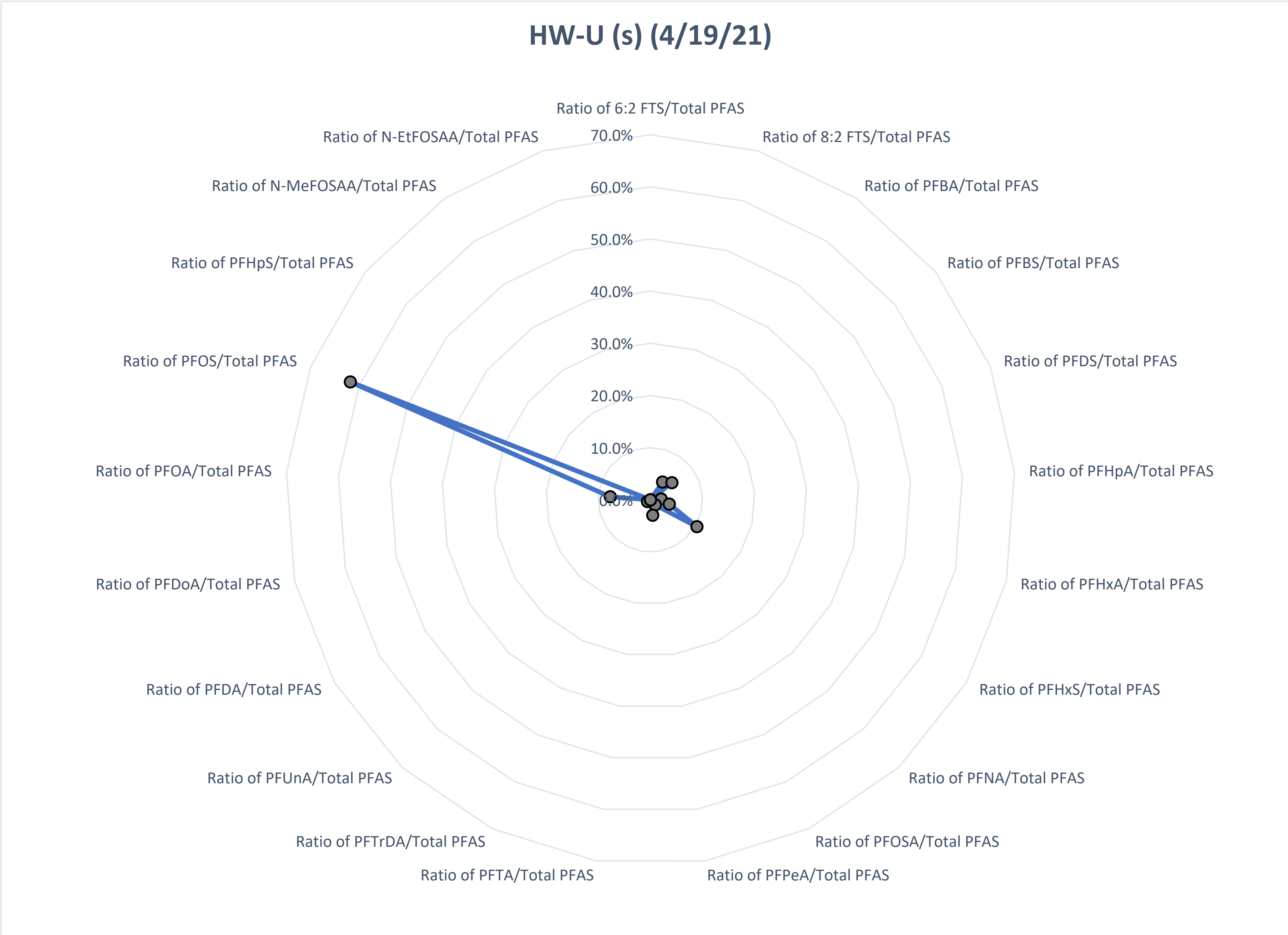
HW-U (s) (4/19/21)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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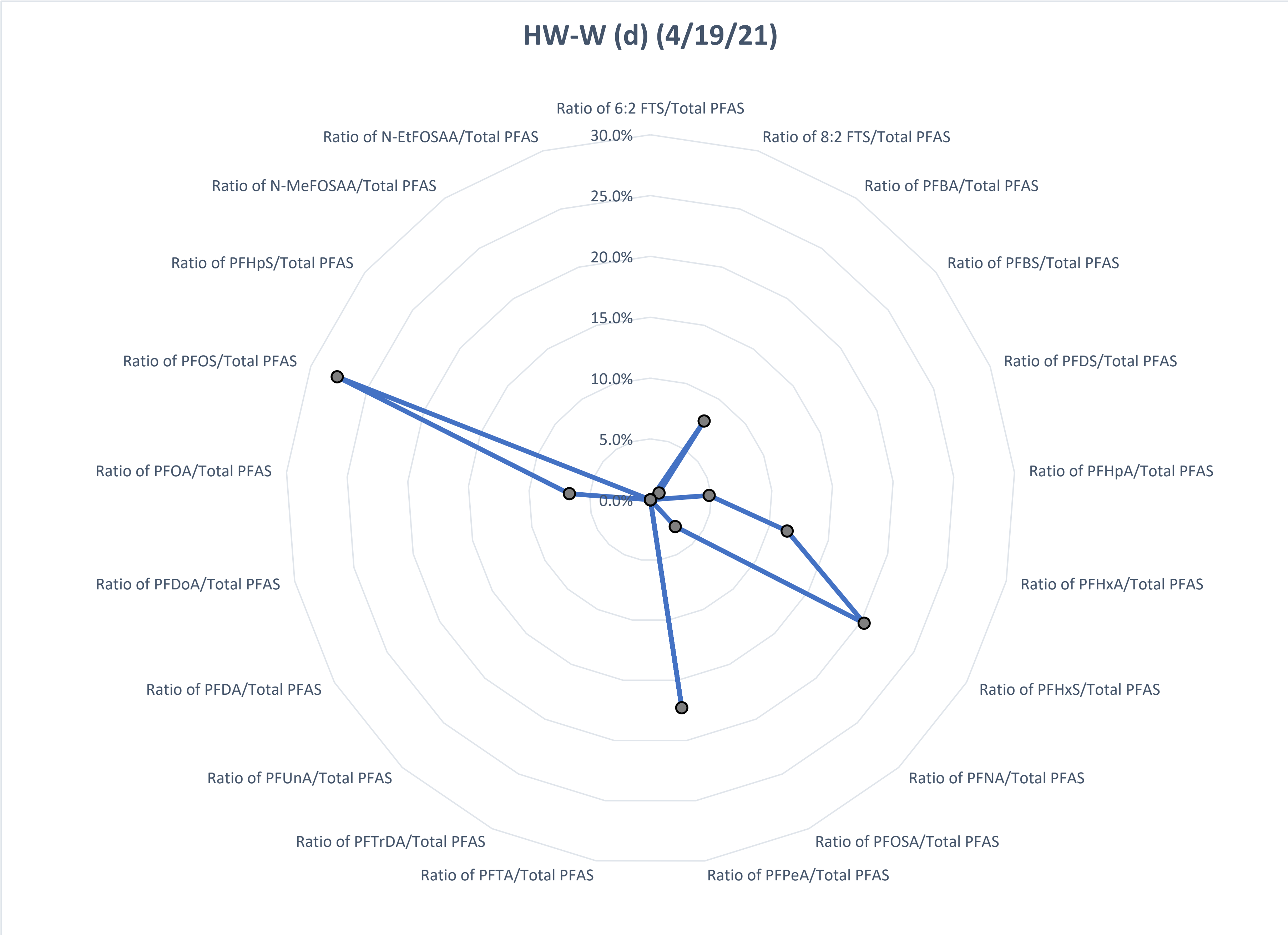
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%



HW-W (d) (4/19/21)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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25.0%
20.0%
15.0%
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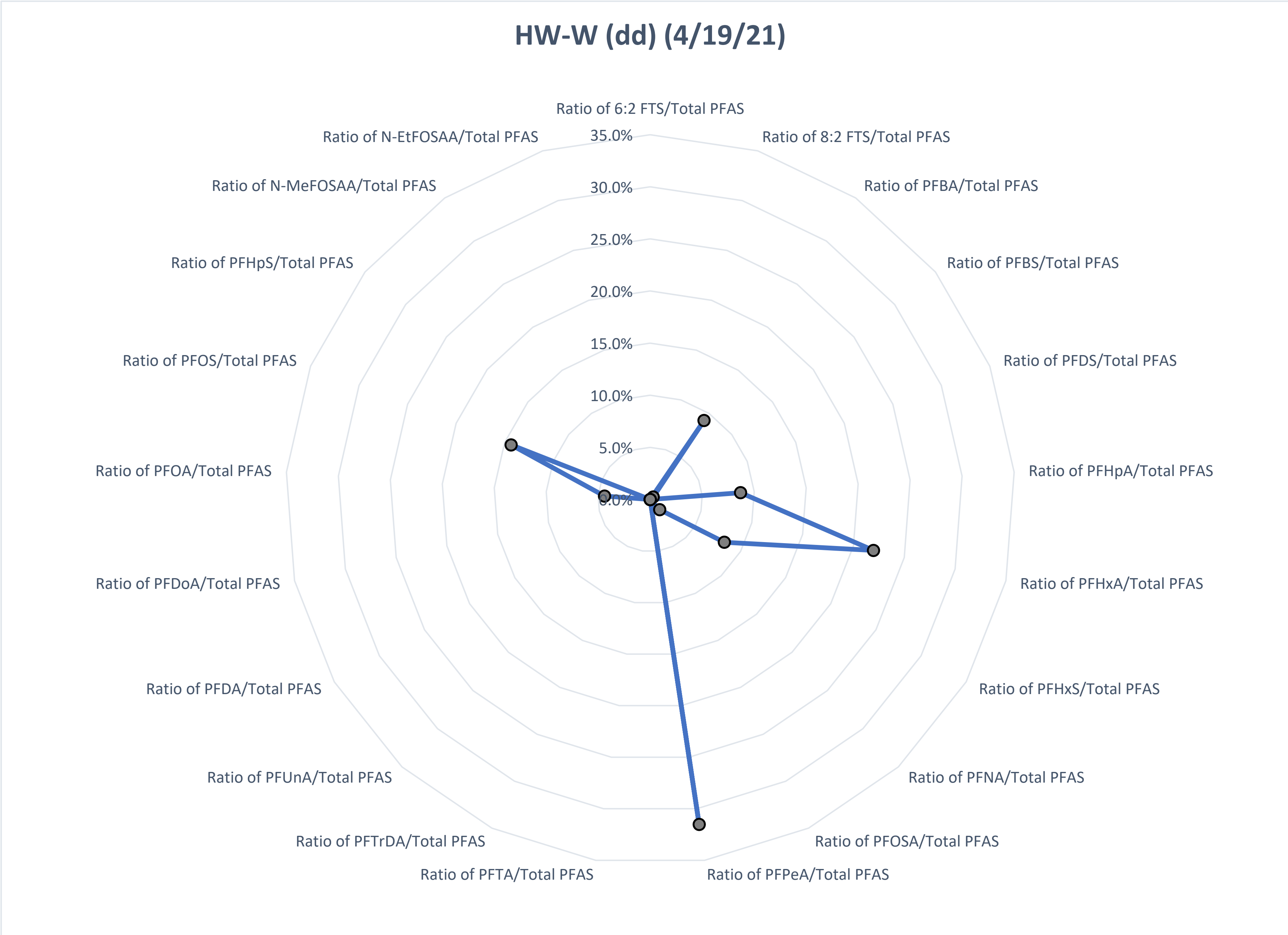
HW-W (dd) (4/19/21)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
35.0%
30.0%
25.0%
20.0%
15.0%
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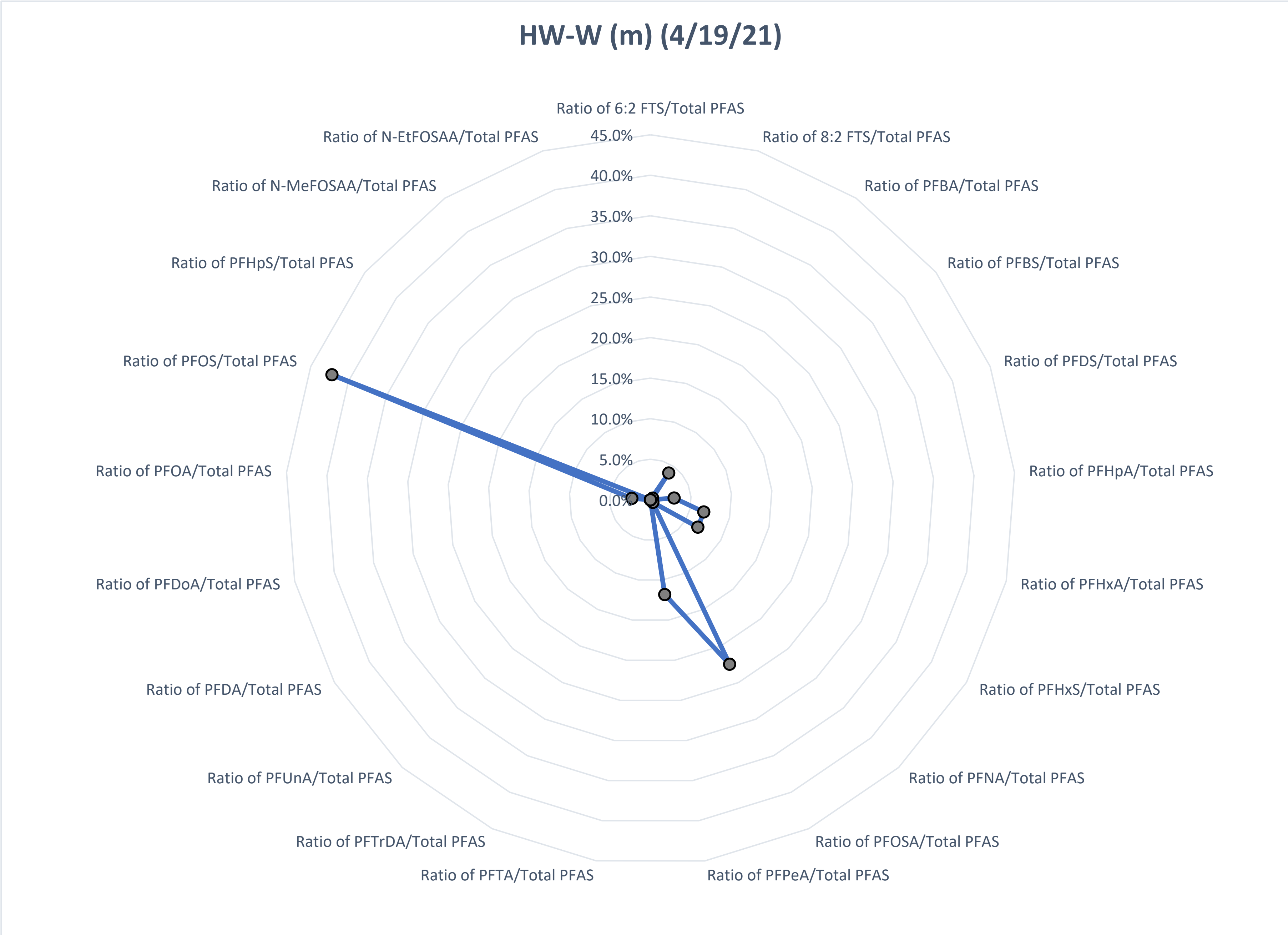
5.0%
0.0%



HW-W (m) (4/19/21)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
30.0%
25.0%
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15.0%
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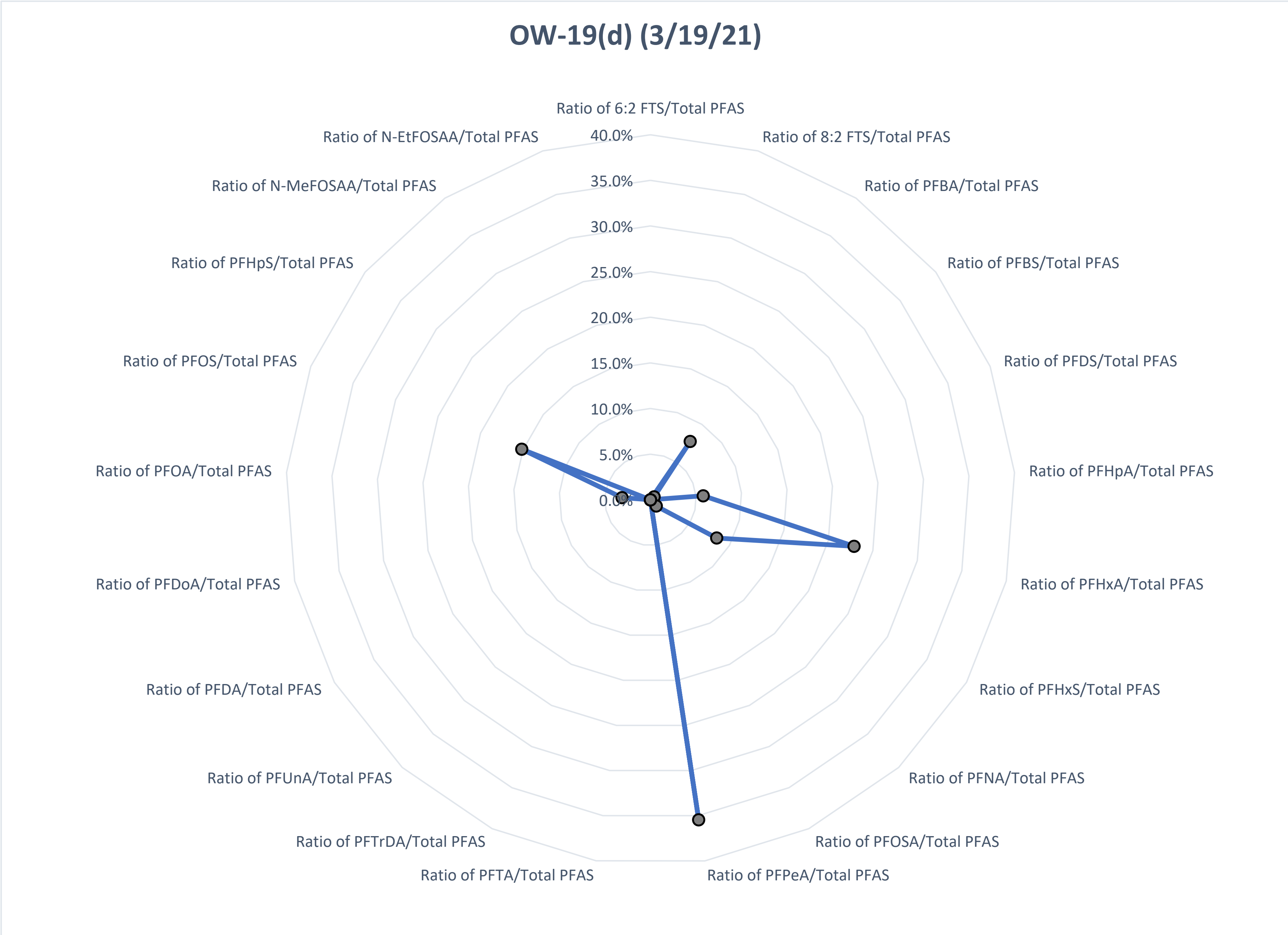
OW-19(d) (3/19/21)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
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25.0%
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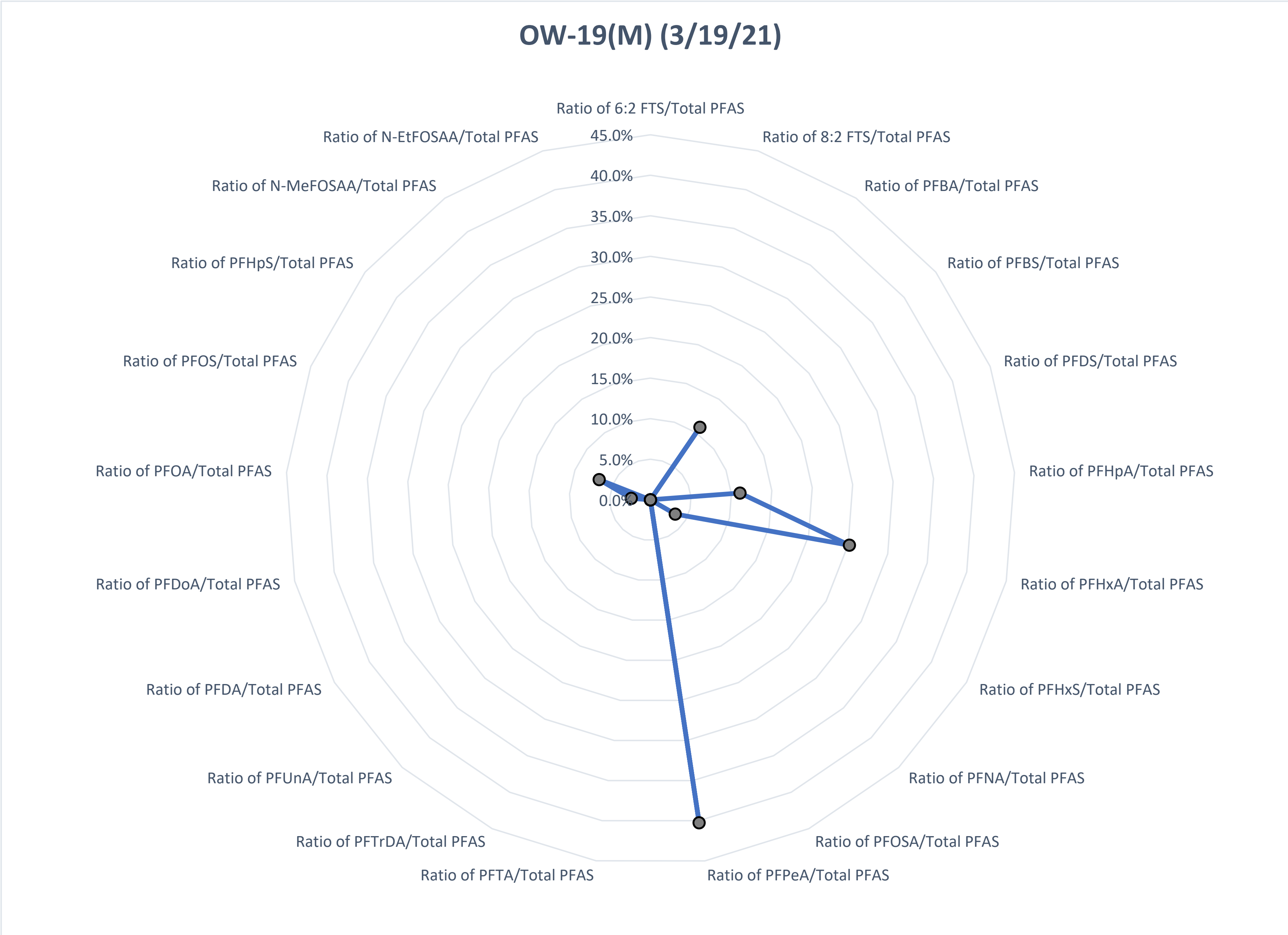
OW-19(M) (3/19/21)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
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Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
45.0%
40.0%
35.0%
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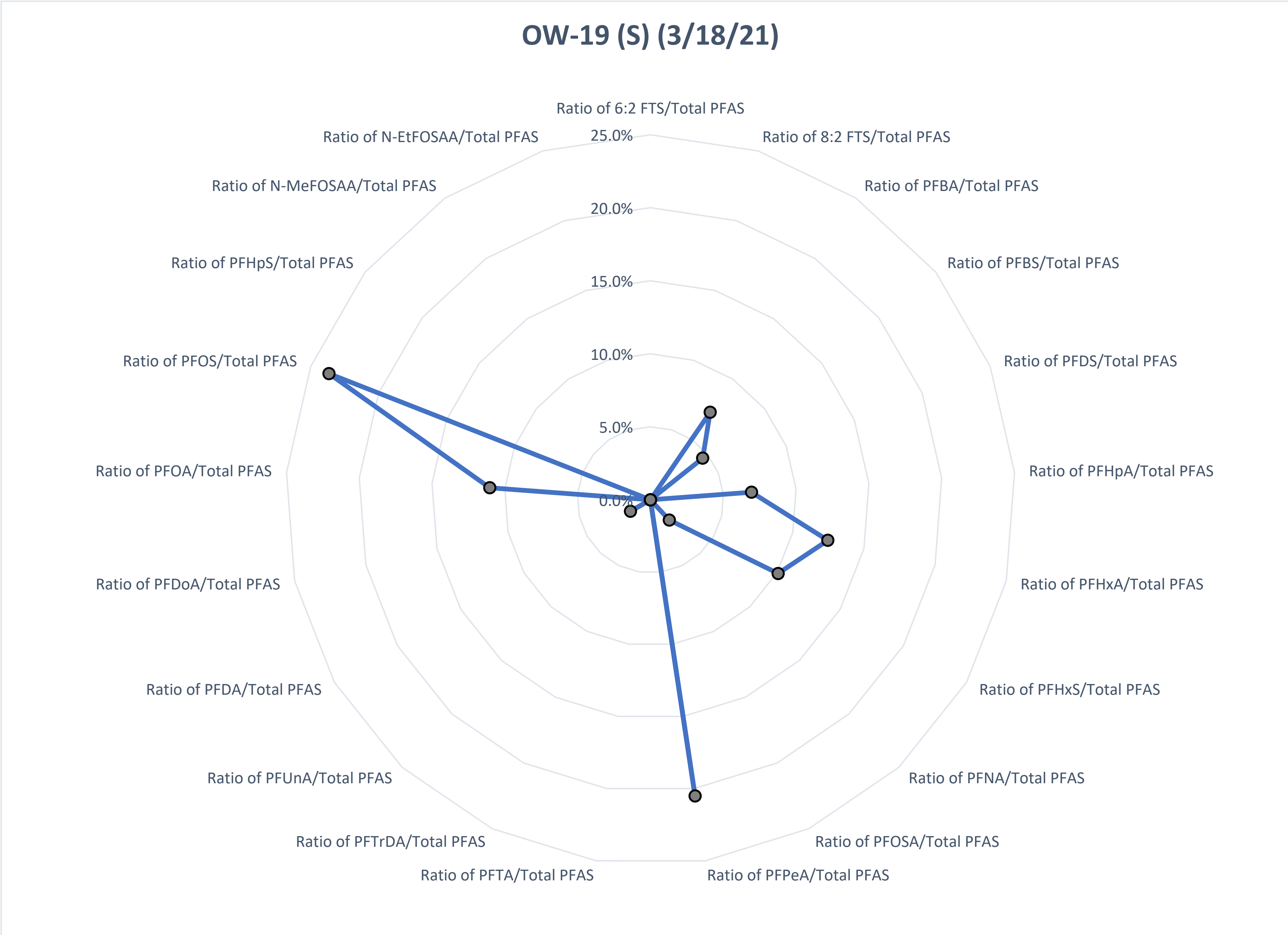
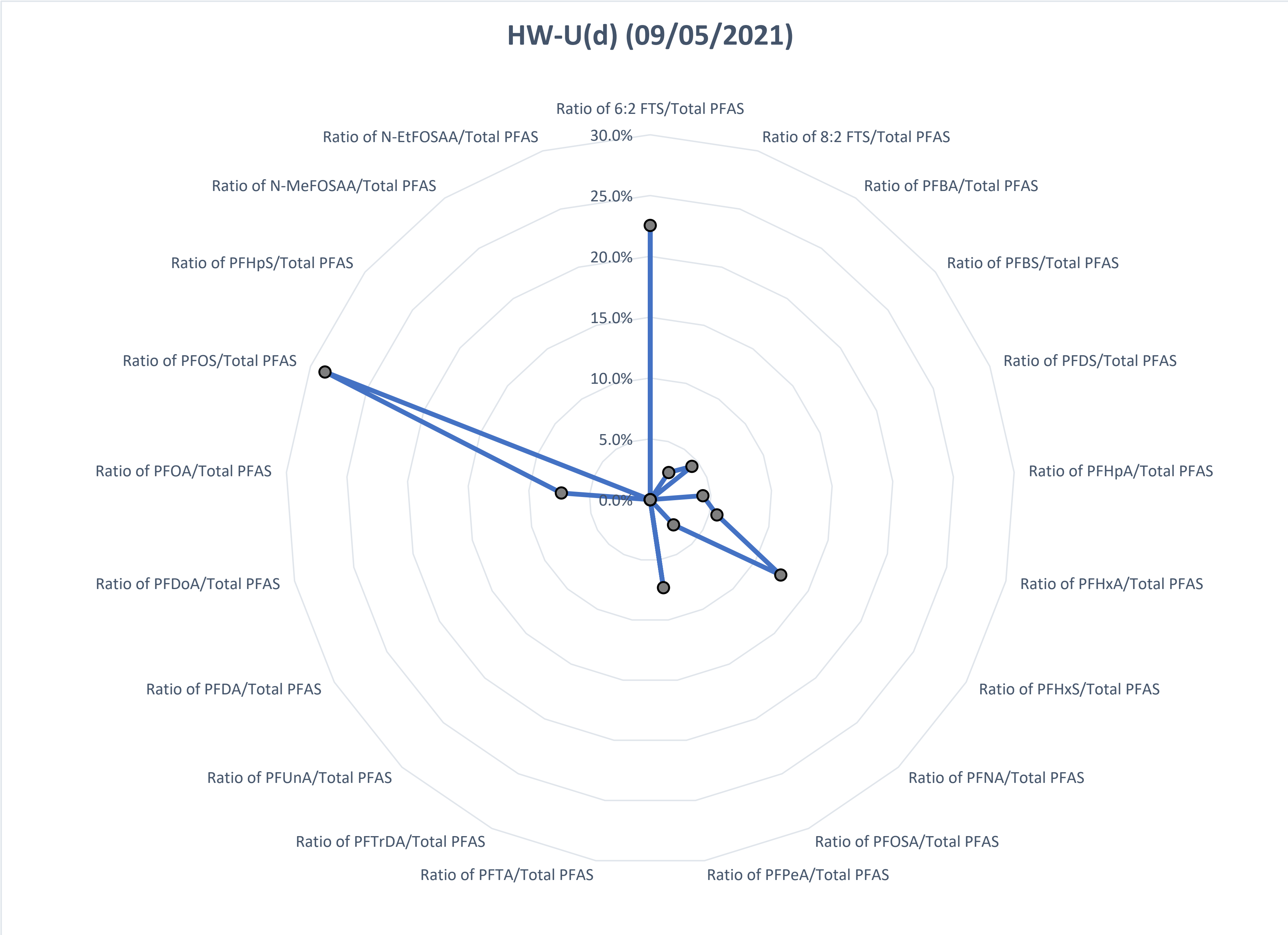

OW-19 (S) (3/18/21)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%



HW-U(d) (09/05/2021)
Ratio of 6:2 FTS/Total PFAS
Ratio of 8:2 FTS/Total PFAS
Ratio of PFBA/Total PFAS
Ratio of PFBS/Total PFAS
Ratio of PFDS/Total PFAS
Ratio of PFHpA/Total PFAS
Ratio of PFHxA/Total PFAS
Ratio of PFHxS/Total PFAS
Ratio of PFNA/Total PFAS
Ratio of PFOSA/Total PFAS
Ratio of PFPeA/Total PFAS
Ratio of PFTA/Total PFAS
Ratio of PFTrDA/Total PFAS
Ratio of PFUnA/Total PFAS
Ratio of PFDA/Total PFAS
Ratio of PFDoA/Total PFAS
Ratio of PFOA/Total PFAS
Ratio of PFOS/Total PFAS
Ratio of PFHpS/Total PFAS
Ratio of N-MeFOSAA/Total PFAS
Ratio of N-EtFOSAA/Total PFAS
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%

APPENDIX E

SAFETY DATA SHEETS

CHEMGUARD C306-MS 3% AFFF Concentrate

Description

CHEMGUARD C306-MS 3% AFFF (Aqueous Film-Forming Foam) Concentrate combines fluoro- and hydrocarbon-surfactant technology to provide superior fire and vapor suppression for Class B hydrocarbon fuel fires. This synthetic foam concentrate is intended for firefighting applications at 3% solution in fresh, salt, or hard water.

CHEMGUARD C306-MS foam solution utilizes three suppression mechanisms for rapid fire knockdown and enhanced burnback resistance:

- The foam blanket blocks oxygen supply to the fuel.
- Liquid drains from the foam blanket and forms an aqueous film that suppresses fuel vapor and seals the fuel surface.
- The water content of the foam solution produces a cooling effect for additional fire suppression.

TYPICAL PHYSIOCHEMICAL PROPERTIES AT 77 °F (25 °C)

Appearance	Pale yellow liquid
Density	1.02 ± 0.02 g/ml
pH	7.0 – 8.5
Refractive Index	1.3655 ± 0.0020
Viscosity	3.25 ± 1.0 cSt*
Spreading Coefficient	3.0 minimum at 3%
Pour Point	27 °F (-3 °C)
Freeze Point	27 °F (-3 °C)

*Cannon-Fenske viscometer at 25 °C

Application

CHEMGUARD C306-MS 3% AFFF Concentrate is intended for use on Class B hydrocarbon fuel fires having low water solubility such as crude oils, gasolines, diesel fuels, and aviation fuels. It is not suitable for use on polar fuels having appreciable water solubility, such as methyl and ethyl alcohol, acetone, and methyl ethyl ketone.

The concentrate has excellent wetting properties that can effectively combat Class A fires as well. It may also be used in conjunction with dry chemical agents to provide even greater fire suppression performance.

CHEMGUARD C306-MS Concentrate is ideal for fixed and emergency response firefighting systems designed to protect naval and aviation assets. Typical applications include:

- Military and civilian aircraft facilities
- Crash fire rescue (per US DOT FAA AC No. 150/5210-6D)
- On-board marine/naval fire suppression systems
- Storage tanks
- Docks/marine tankers

009787

Approvals, Listings, and Standards

CHEMGUARD C306-MS 3% AFFF Concentrate is approved, listed, qualified under, or meets the requirements of the following specifications and standards:

- US Department of Defense Military Specification
  - MIL-F-24385F: Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF) Liquid Concentrate for Fresh and Sea Water.
- Underwriters Laboratories Inc. (UL)
  - UL Standard 162, Foam Liquid Concentrates
  - Fresh and Sea Water
- National Fire Protection Association (NFPA)
  - NFPA 403, Standard for Aircraft Rescue and Fire-Fighting Services at Airports
  - NFPA 409, Standard on Aircraft Hangars
  - NFPA 412, Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Fire Equipment
  - NFPA 414, Standard for Aircraft Rescue and Fire-Fighting Vehicles
  - NFPA 418, Standard for Heliports

Please contact Tyco Fire Protection Products Technical Services and/or refer to listing agency for current product and compatible hardware listings.

The environmentally-mindful CHEMGUARD C306-MS Concentrate formulation contains short-chain, C-6 fluorochemicals manufactured using a telomer-based process. The telomer process produces no PFOS, and these C-6 materials do not breakdown to yield PFOA. The fluorochemicals used in the concentrate meet the goals of the U.S. Environmental Protection Agency 2010/15 PFOA Stewardship Program.

ENVIRO-MINDED FORMULA C6

Foaming Properties

CHEMGUARD C306-MS 3% AFFF Concentrate may be effectively applied using most conventional foam discharge equipment at 3% dilution with fresh, salt, or hard water. For optimum performance, water hardness should not exceed 500 ppm expressed as calcium and magnesium.

Because of the low energy required to create foam with CHEMGUARD C306-MS Concentrate, the foam solution may be applied with aspirating and non-aspirating discharge devices. Aspirating discharge devices typically produce expansion ratios from 3.5:1 to 10:1, depending on the type of device and the flow rate. Non-aspirating devices, such as handline water fog/stream nozzles or standard sprinkler heads, typically produce expansion ratios from 2:1 to 4:1. Medium-expansion discharge devices typically produce expansion ratios from 20:1 to 60:1.

TYPICAL FOAM CHARACTERISTICS (Fresh and Sea Water)**

Proportioning Rate	3%
Expansion Ratio LE	9.5
25% Drain Time (min:sec)	3:30
50% Drain Time (min:sec)	5:45

**per EN 1568-3, 2008 protocol

Proportioning

CHEMGUARD C306-MS 3% AFFF Concentrate can be correctly proportioned using most conventional, properly calibrated, in-line proportioning equipment such as:

- Balanced and in-line balanced pressure pump proportioners
- Balanced pressure bladder tanks and ratio flow controllers
- Around-the-pump type proportioners
- Fixed or portable in-line venturi type proportioners
- Handline nozzles with fixed eductor/pick-up tubes

For immediate use: The concentrate may also be diluted with fresh or sea water to a 3% pre-mix solution.

For delayed use: Consult Technical Services for guidance regarding suitability of a pre-mix solution (fresh water only).

Materials of Construction Compatibility

CHEMGUARD C306-MS Concentrate compatibility with HDPE has been successfully evaluated using ASTM D1693-70 protocol under UL-162 standard. Concentrate corrosion studies with cold-rolled carbon steel (UNS G10100), 90-10 copper-nickel (UNS C70600), 70-30 nickel-copper (UNC N04400), bronze (UNS C90500), and CRES steel (UNS S30400) have been successfully completed per ASTM E527 protocol under MIL-F-24385F specification.

To avoid corrosion, galvanized pipe and fittings should never be used in contact with undiluted concentrate. Please refer to Technical Bulletin No. 59 for recommendations and guidance regarding compatibility of CHEMGUARD concentrates with common materials of construction in the firefighting foam industry.

Storage and Handling

CHEMGUARD C306-MS 3% AFFF Concentrate should be stored in the original supplied package (HDPE totes, drums, or pails) or in the foam system equipment recommended by Technical Services. The product should be maintained within the recommended 35 °F to 120 °F (2 °C to 49 °C) operational temperature range. If the concentrate freezes during transport or storage, full product serviceability can be restored upon thaw with gentle re-mixing.

Factors affecting the foam concentrate long-term effectiveness include temperature exposure and cycling, storage container, air exposure, evaporation, dilution, and contamination. The effective life of CHEMGUARD C306-MS Concentrate can be maximized through optimal storage conditions and proper handling.

CHEMGUARD foam concentrates have demonstrated effective firefighting performance with contents stored in the original package under proper conditions for more than 10 years.

CHEMGUARD C306-MS 3% AFFF Concentrate has been successfully evaluated by the US Naval Sea Systems Command for prolonged compatibility with other 3% AFFF concentrates qualified under MIL-F-24385F specification.

- Mixing with foam concentrates not vetted by MIL-F-24385F is not recommended.
- For immediate incident response, it is appropriate to use the concentrate in conjunction with comparable 3% AFFF products.

Inspection

CHEMGUARD C306-MS 3% AFFF Concentrate should be inspected periodically per NFPA 11 “Standard for Low-, Medium-, and High-Expansion Foam,” EN 13565-2 “Foam System Standard,” or other relevant standard. A representative concentrate sample should be sent to Tyco Fire Protection Products Foam Analytical Services or other qualified laboratory for quality analysis per the applicable standard. An annual inspection and sample analysis is typically sufficient, unless the product has been exposed to unusual conditions.

Ordering Information

Concentrate is available in commercial packaging only under CHEMGUARD C306-MS-C product designation and is not available for direct, contract government acquisition (per MIL-F-24385F packaging provision). Concentrate is available in pails, drums, totes or bulk shipment, with pail and drum containers being UL-162 compliant.

Part No.	Description	Shipping Weight	Cube
770809	Pail 5 gal (19 L)	45 lb (20.4 kg)	1.25 ft^3 (0.0353 m^3)
770810	Drum 55 gal (208 L)	495 lb (224.5 kg)	11.83 ft^3 (0.3350 m^3)
770811	Tote 265 gal (1000 L)	2463 lb (1117 kg)	50.05 ft^3 (1.42 m^3)

Safety Data Sheet (SDS) available at www.chemguard.com

Note: The converted metric values in this document are provided for dimensional reference only and do not reflect an actual measurement.

Chemguard Specialty Chemical and Fire Suppression Products

An Environmental Statement

Fluorine-containing organic surfactants, or fluorosurfactants, are used in everyday consumer and industrial products such as paints, waxes, cleaners, polishes, adhesives, inks and, notably, fire-fighting foams. There are no known substitutes that have the same functionality and outstanding performance characteristics. Often, fluorosurfactant products are misunderstood to be made from perfluorooctanoic acid (PFOA) or perfluorooctane sulfonate (PFOS), when in fact there are a large number of different types of fluorosurfactants in use.

Chemguard Specialty Chemical and Fire Suppression Products contain no significant levels of PFOA or PFOS. Neither PFOA nor PFOS is an intentional ingredient in any Chemguard products.

Over the past decade or so, there has been increasing concern about products that contain PFOA or PFOS. Both are thought to be persistent in the environment, bioaccumulative, and potentially toxic. The US Environmental Protection Agency became aware in the late 1990's that PFOS was found at very low levels in blood samples representing the general population.[1] However, studies show that blood levels have been declining in the past decades.[2] PFOA and PFOS are produced by the electrochemical fluorination (ECF) process practiced by several companies within the US and abroad, although, this production process is in decline. As a business decision based on precaution, 3M ceased commercial production of PFOS in 2002.[3]

However, given the scientific uncertainties regarding exposure routes and human health effects, the EPA does not believe there is any reason for consumers to stop using any consumer or industrial related products because of concerns about PFOA.[1] The limited, but still existing, stocks of such products are still allowed for use until supplies are exhausted.[4] Despite the low risks, the precautionary principle (i.e., caution due to uncertainty) requires that action be taken to further minimize any potential adverse effects these substances may pose. In 2006, the EPA initiated its "2010/15 PFOA Stewardship Program" in which industrial participants agree, in summary, to (1) reduce by 95% the product content and emissions of PFOA and precursor materials by 2010, and (2) eliminate such by 2015.

To distinguish PFOA and PFOS from fluorosurfactants that are in common use, it is necessary to have a sense of the chemical structures involved. Both PFOA and PFOS molecules contain a chain of 8 carbon atoms in which all the typical hydrogen atoms bonded to the carbons are substituted with fluorine atoms.[5] This chemical group is generally referred to as a "C8 perfluoroalkyl chain," or simply as "C8". The fluorine-carbon bond, also found in Teflon®[6]

products, is very strong, making the molecule resistant to degradation and adhesion. The C8 chain length has been preferred for fluorosurfactants because it gives optimum performance to a large number of product properties. Due to its common use, it has also received the most scrutiny, as mentioned above. The response by manufacturers, driven by EPA and other such regulatory authorities, has been to shift production to C6-based substances, which cannot degrade to C8. The EPA's 2010/15 PFOA Stewardship Program applies to all potential PFOA precursors, which includes C8 and longer chain lengths.

Furthermore, fluorosurfactants today are based on an entirely different production process, known as telomerization, as opposed to the ECF process mentioned above. Telomerization chemistry does not use or produce PFOS, however trace levels of PFOA may result as a byproduct. As a class, however, telomerization products have been shown in EPA studies to be neither toxic nor bioaccumulative.[7] Fluorosurfactants based on C6 telomerization chemistry cannot degrade into PFOA or PFOS.[8]

All Chemguard fluorosurfactants are derived from the telomerization process and are therefore substantially free of both PFOA and PFOS. Only trace levels of PFOA are present, and these originate as minor impurities in the raw materials that Chemguard relies on, as mentioned. At present, Chemguard Specialty Chemical products typically contain less than 5 ppm PFOA. As a practice, fluorosurfactant use in Fire Suppression foams is minimized by synergistic formulation with non-fluorinated surfactants and other components to provide maximum effectiveness. Therefore, Chemguard Fire Suppression foams typically contain less than 1 ppm PFOA. Chemguard is a participant in the EPA 2010/15 PFOA Stewardship Program and dedicated to ultimately eliminating C8 and longer chain chemistry from all products. As our conversion proceeds toward C6 chemistry, the PFOA level in our products is expected to fall well below 1 ppm, approaching the lower ppb level.

Chemguard is a conscientious and technology-driven company with a dedication to safety and product stewardship. We share the environmental concerns expressed by our customers and support the progressing regulatory environment in which we operate. We have the research, production and sales capabilities to respond with superior products that meet or exceed both our customers' expectations and our environmental responsibilities.

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1 Source: www.epa.gov/oppt/pfoa/pubs/pfoainfo.htm.
2 (a) Environmental Health Perspectives, v. 113, n. 5, May 2005,
(b) Source: www.cdc.gov/exposurereport/perfluorinated_compounds2.htm.
3 Source: solutions.3m.com/wps/portal/3M/en_US/PFOS/PFOA/Information/Action.
4 EU and Canada regulations specify deadlines for use.
5 PFOA contains a 7 carbon perfluoroalkyl group, with the organic acid functionality representing the 8^{th} carbon.
6 Registered trademark of DuPont.
7 Industrial Fire Journal, Sept. 2007, p. 26.
8 International Fire Protection, August 2008, p. 29.

Material Safety Data Sheet
The Dow Chemical Company

Product Name: UCAR(TM) PG Aircraft Deicing Fluid Concentrate

Issue Date: 10/19/2009
Print Date: 03 Jan 2011

The Dow Chemical Company encourages and expects you to read and understand the entire (M)SDS, as there is important information throughout the document. We expect you to follow the precautions identified in this document unless your use conditions would necessitate other appropriate methods or actions.

1. Product and Company Identification

Product Name

UCAR(TM) PG Aircraft Deicing Fluid Concentrate

COMPANY IDENTIFICATION

The Dow Chemical Company
2030 Willard H. Dow Center
Midland, MI 48674
USA

Customer Information Number: 800-258-2436
SDSQuestion@dow.com

EMERGENCY TELEPHONE NUMBER

24-Hour Emergency Contact: 989-636-4400
Local Emergency Contact: 989-636-4400

2. Hazards Identification

Emergency Overview
Color: Orange
Physical State: Liquid.
Odor: Sweet
Hazards of product:

No significant immediate hazards for emergency response are known.

OSHA Hazard Communication Standard
This product is not a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Potential Health Effects
Eye Contact: May cause slight temporary eye irritation. Corneal injury is unlikely.
Skin Contact: Prolonged contact is essentially nonirritating to skin. Repeated contact may cause flaking and softening of skin. Material may be handled at elevated temperatures; contact with heated material may cause thermal burns.
Skin Absorption: Prolonged skin contact is unlikely to result in absorption of harmful amounts.

Inhalation: At room temperature, exposure to vapor is minimal due to low volatility; vapor from heated material or mist may cause respiratory irritation and other effects.
Ingestion: Very low toxicity if swallowed. Harmful effects not anticipated from swallowing small amounts.
Effects of Repeated Exposure: In rare cases, repeated excessive exposure to propylene glycol may cause central nervous system effects.

3. Composition Information

Component	CAS #	Amount
Propylene glycol	57-55-6	88.0 %
Water	7732-18-5	11.4 %

4. First-aid measures

Eye Contact: Flush eyes thoroughly with water for several minutes. Remove contact lenses after the initial 1-2 minutes and continue flushing for several additional minutes. If effects occur, consult a physician, preferably an ophthalmologist.
Skin Contact: Wash skin with plenty of water.
Inhalation: Move person to fresh air; if effects occur, consult a physician.
Ingestion: No emergency medical treatment necessary.
Notes to Physician: If burn is present, treat as any thermal burn, after decontamination. No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.
Medical Conditions Aggravated by Exposure: Skin contact may aggravate preexisting dermatitis.
Emergency Personnel Protection: First Aid responders should pay attention to self-protection and use the recommended protective clothing (chemical resistant gloves, splash protection). If potential for exposure exists refer to Section 8 for specific personal protective equipment.

5. Fire Fighting Measures

Extinguishing Media: To extinguish combustible residues of this product use water fog, carbon dioxide, dry chemical or foam.
Fire Fighting Procedures: Keep people away. Isolate fire and deny unnecessary entry. Use water spray to cool fire exposed containers and fire affected zone until fire is out and danger of reignition has passed. To extinguish combustible residues of this product use water fog, carbon dioxide, dry chemical or foam.
Special Protective Equipment for Firefighters: Wear positive-pressure self-contained breathing apparatus (SCBA) and protective fire fighting clothing (includes fire fighting helmet, coat, trousers, boots, and gloves). If protective equipment is not available or not used, fight fire from a protected location or safe distance.
Unusual Fire and Explosion Hazards: This material will not burn until the water has evaporated. Residue can burn.
Hazardous Combustion Products: Under fire conditions some components of this product may decompose. The smoke may contain unidentified toxic and/or irritating compounds.

6. Accidental Release Measures

Steps to be Taken if Material is Released or Spilled: Small spills: Absorb with materials such as: Cat litter. Sawdust. Vermiculite. Zorb-all®. Collect in suitable and properly labeled containers. Large spills: Dike area to contain spill. Recover spilled material if possible. Contain spilled material if possible. See Section 13, Disposal Considerations, for additional information.

Personal Precautions: Keep unnecessary and unprotected personnel from entering the area. Use appropriate safety equipment. For additional information, refer to Section 8, Exposure Controls and Personal Protection.
Environmental Precautions: Prevent from entering into soil, ditches, sewers, waterways and/or groundwater. See Section 12, Ecological Information.

7. Handling and Storage

Handling
General Handling: Product shipped/handled hot can cause thermal burns. Spills of these organic materials on hot fibrous insulations may lead to lowering of the autoignition temperatures possibly resulting in spontaneous combustion. See Section 8, EXPOSURE CONTROLS AND PERSONAL PROTECTION.

Storage
Store in accordance with good manufacturing practices.

8. Exposure Controls / Personal Protection

Exposure Limits

Component	List	Type	Value
Propylene glycol	WEEL	TWA Aerosol.	10 mg/m3

Personal Protection
Eye/Face Protection: Use safety glasses (with side shields). When handling hot material: Use chemical goggles. Wear a face-shield which allows use of chemical goggles, or wear a full-face respirator, to protect face and eyes when there is any likelihood of splashes. Eye wash fountain should be located in immediate work area.
Skin Protection: Wear clean, body-covering clothing. When handling hot material, protect skin from thermal burns. Selection of specific items will depend on the operation. When handling hot material, a safety shower should be located in the immediate work area.

Hand protection: Use gloves chemically resistant to this material when prolonged or frequently repeated contact could occur. Use gloves with insulation for thermal protection, when needed. Examples of preferred glove barrier materials include: Butyl rubber. Natural rubber ("latex"). Neoprene. Nitrile/butadiene rubber ("nitrile" or "NBR"). Polyethylene. Ethyl vinyl alcohol laminate ("EVAL"). Polyvinyl chloride ("PVC" or "vinyl"). Avoid gloves made of: Polyvinyl alcohol ("PVA"). NOTICE: The selection of a specific glove for a particular application and duration of use in a workplace should also take into account all relevant workplace factors such as, but not limited to: Other chemicals which may be handled, physical requirements (cut/puncture protection, dexterity, thermal protection), potential body reactions to glove materials, as well as the instructions/specifications provided by the glove supplier.

Respiratory Protection: Atmospheric levels should be maintained below the exposure guideline. When airborne exposure guidelines and/or comfort levels may be exceeded, use an approved air-purifying respirator. The following should be effective types of air-purifying respirators: Organic vapor cartridge with a particulate pre-filter.
Ingestion: Use good personal hygiene. Do not consume or store food in the work area. Wash hands before smoking or eating.

Engineering Controls
Ventilation: Use local exhaust ventilation, or other engineering controls to maintain airborne levels below exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, general ventilation should be sufficient for most operations. Local exhaust ventilation may be necessary for some operations.

9. Physical and Chemical Properties

Physical State	Liquid.
Color	Orange
Odor	Sweet
Flash Point - Closed Cup	*ASTM D93* none to 100°C (212 °F)
Flammable Limits In Air	**Lower**: No test data available **Upper**: No test data available
Autoignition Temperature	No test data available
Vapor Pressure	6.7 mmHg @ 20 °C
Boiling Point (760 mmHg)	125 °C (257 °F) *Literature* .
Vapor Density (air = 1)	1.9 *Literature*
Specific Gravity (H2O = 1)	1.045 *Literature*
Freezing Point	< -30 °C (< -22 °F) *ASTM D1177*
Melting Point	Not applicable to liquids
Solubility in water (by weight)	100 % @ 20 °C
pH	7 - 9 *ASTM E70*
Decomposition Temperature	No test data available
Evaporation Rate (Butyl Acetate = 1)	0.6

10. Stability and Reactivity

Stability/Instability
Thermally stable at recommended temperatures and pressures.
Conditions to Avoid: Some components of this product can decompose at elevated temperatures. Generation of gas during decomposition can cause pressure in closed systems.

Incompatible Materials: Avoid contact with: Strong acids. Strong bases. Strong oxidizers.

Hazardous Polymerization
Will not occur.

Thermal Decomposition
Decomposition products depend upon temperature, air supply and the presence of other materials. Decomposition products can include and are not limited to: Aldehydes. Ethers. Alcohols. Organic acids.

11. Toxicological Information

Acute Toxicity
Ingestion
For component(s) tested. LD50, Rat 20,000 - 34,000 mg/kg
Skin Absorption
For component(s) tested. LD50, Rabbit > 20,000 mg/kg
Inhalation
For component(s) tested. LC50, 8 h, Vapor, Rat > 1,314 ppm
No deaths occurred following exposure to a saturated atmosphere.

Repeated Dose Toxicity
In rare cases, repeated excessive exposure to propylene glycol may cause central nervous system effects.

Chronic Toxicity and Carcinogenicity

Contains component(s) which did not cause cancer in laboratory animals.

Developmental Toxicity

Contains component(s) which did not cause birth defects or any other fetal effects in lab animals.

Reproductive Toxicity

Contains component(s) which did not interfere with reproduction in animal studies. Contains component(s) which did not interfere with fertility in animal studies.

Genetic Toxicology

In vitro genetic toxicity studies were negative for component(s) tested. Genetic toxicity studies in animals were negative for component(s) tested.

12. Ecological Information

ENVIRONMENTAL FATE

Data for Component: **Propylene glycol**

Movement & Partitioning

Bioconcentration potential is low (BCF less than 100 or log Pow less than 3). Potential for mobility in soil is very high (Koc between 0 and 50). Given its very low Henry's constant, volatilization from natural bodies of water or moist soil is not expected to be an important fate process.

Henry's Law Constant (H): 1.2E-08 atm*m3/mole Measured

Partition coefficient, n-octanol/water (log Pow): -0.92 Measured

Partition coefficient, soil organic carbon/water (Koc): < 1 Estimated.

Persistence and Degradability

Material is readily biodegradable. Passes OECD test(s) for ready biodegradability.
Biodegradation may occur under anaerobic conditions (in the absence of oxygen).

Indirect Photodegradation with OH Radicals

Rate Constant	Atmospheric Half-life	Method
1.28E-11 cm3/s	10 h	Estimated.

OECD Biodegradation Tests:

Biodegradation	Exposure Time	Method
81 %	28 d	OECD 301F Test
96 %	64 d	OECD 306 Test

Biological oxygen demand (BOD):

BOD 5	BOD 10	BOD 20	BOD 28
69 %	70 %	86 %	

Chemical Oxygen Demand: 1.53 mg/mg

Theoretical Oxygen Demand: 1.68 mg/mg

ECOTOXICITY

Typical for this family of materials. Material is practically non-toxic to aquatic organisms on an acute basis (LC50/EC50/EL50/LL50 >100 mg/L in the most sensitive species tested).

13. Disposal Considerations

All disposal practices must be in compliance with all Federal, State/Provincial and local laws and regulations. Regulations may vary in different locations. Waste characterizations and compliance with applicable laws are the responsibility solely of the waste generator. AS YOUR SUPPLIER, WE HAVE NO CONTROL OVER THE MANAGEMENT PRACTICES OR MANUFACTURING PROCESSES OF PARTIES HANDLING OR USING THIS MATERIAL. THE INFORMATION PRESENTED HERE PERTAINS ONLY TO THE PRODUCT AS SHIPPED IN ITS INTENDED CONDITION AS DESCRIBED IN MSDS SECTION: Composition Information. FOR UNUSED & UNCONTAMINATED PRODUCT, the preferred options include sending to a licensed, permitted: Reclaimer. Incinerator or other thermal destruction device.

14. Transport Information

DOT Non-Bulk
NOT REGULATED

DOT Bulk
NOT REGULATED

IMDG
NOT REGULATED

ICAO/IATA
NOT REGULATED

This information is not intended to convey all specific regulatory or operational requirements/information relating to this product. Additional transportation system information can be obtained through an authorized sales or customer service representative. It is the responsibility of the transporting organization to follow all applicable laws, regulations and rules relating to the transportation of the material.

15. Regulatory Information

OSHA Hazard Communication Standard

This product is not a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Sections 311 and 312

Immediate (Acute) Health Hazard	No
Delayed (Chronic) Health Hazard	No
Fire Hazard	No
Reactive Hazard	No
Sudden Release of Pressure Hazard	No

Superfund Amendments and Reauthorization Act of 1986 Title III (Emergency Planning and Community Right-to-Know Act of 1986) Section 313
To the best of our knowledge, this product does not contain chemicals at levels which require reporting under this statute.

Pennsylvania (Worker and Community Right-To-Know Act): Pennsylvania Hazardous Substances List and/or Pennsylvania Environmental Hazardous Substance List:
The following product components are cited in the Pennsylvania Hazardous Substance List and/or the Pennsylvania Environmental Substance List, and are present at levels which require reporting.

Component	CAS #	Amount
Propylene glycol	57-55-6	88.0%

Pennsylvania (Worker and Community Right-To-Know Act): Pennsylvania Special Hazardous Substances List:
To the best of our knowledge, this product does not contain chemicals at levels which require reporting under this statute.

California Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986)
WARNING: This product contains a chemical(s) known to the State of California to cause cancer.

Component	CAS #	Amount
Ethylene oxide	75-21-8	<= 0.02 PPM
Acetaldehyde	75-07-0	<= 6.0 PPB

Formaldehyde	50-00-0	<= 4.0 PPB
1,4-Dioxane	123-91-1	<= 5.0 PPB

California Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986)
WARNING: This product contains a chemical(s) known to the State of California to cause birth defects or other reproductive harm.

Component	CAS #	Amount
Ethylene oxide	75-21-8	<= 0.02 PPM

US. Toxic Substances Control Act
All components of this product are on the TSCA Inventory or are exempt from TSCA Inventory requirements under 40 CFR 720.30

CEPA - Domestic Substances List (DSL)
All substances contained in this product are listed on the Canadian Domestic Substances List (DSL) or are not required to be listed.

16. Other Information

Hazard Rating System

NFPA	Health	Fire	Reactivity
	1	1	0

Recommended Uses and Restrictions
Aircraft deicing fluid We recommend that you use this product in a manner consistent with the listed use. If your intended use is not consistent with the stated use, please contact your sales or technical service representative.

Revision
Identification Number: 40431 / 1001 / Issue Date 10/19/2009 / Version: 3.0
Most recent revision(s) are noted by the bold, double bars in left-hand margin throughout this document.

Legend

N/A	Not available
W/W	Weight/Weight
OEL	Occupational Exposure Limit
STEL	Short Term Exposure Limit
TWA	Time Weighted Average
ACGIH	American Conference of Governmental Industrial Hygienists, Inc.
DOW IHG	Dow Industrial Hygiene Guideline
WEEL	Workplace Environmental Exposure Level
HAZ_DES	Hazard Designation
Action Level	A value set by OSHA that is lower than the PEL which will trigger the need for activities such as exposure monitoring and medical surveillance if exceeded.

The Dow Chemical Company urges each customer or recipient of this (M)SDS to study it carefully and consult appropriate expertise, as necessary or appropriate, to become aware of and understand the data contained in this (M)SDS and any hazards associated with the product. The information herein is provided in good faith and believed to be accurate as of the effective date shown above. However, no warranty, express or implied, is given. Regulatory requirements are subject to change and may differ between various locations. It is the buyer's/user's responsibility to ensure that his activities comply with all federal, state, provincial or local laws. The information presented here pertains only to the product as shipped. Since conditions for use of the product are not under the control of the manufacturer, it is the buyer's/user's duty to determine the conditions necessary for the safe use of this product. Due to the proliferation of sources for information such as manufacturer-specific (M)SDSs, we are not and cannot be responsible for (M)SDSs obtained from any source other than ourselves. If you have *obtained an (M)SDS from another source or if you are not sure that the (M)SDS you have is current, please contact us for the most current version.*

APPENDIX F

SOIL BORING/MONITORING WELL LOGS

Cape Cod Test Boring	Project	Boring No. ARFF - 3
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller: Tommy Desmond	Boring location:	
Helper: Sean Morgan	Ground Surface Elevation:	
Inspector: Josephine Ibanez	Date start: 10/9/2018	Date end: 10/9/2018

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)	Direct push steel tooling: 2 3/8" G3 dual tube

Depth	Sample				Sample Description
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"	
+2					
0	1	N/R	0 - 4	N/R	Loamy; F-M-C brown sand and F gravel. Dry.
2					
4	2		4 - 8		F-M-C brown sand and F-M gravel. Dry.
6					
8	3		8 - 12		F-M-C brown sand. Dry.
10					
12					
14					
16					
18					
20					
22					
24					
26					
28					
30					
32					
34					
36					
38					
40					
42					
44					
46					
48					
50					
52					
54					
56					
58					
60					End of probe: 12'
62					End of sample: 12'
64					
66					

Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	■ - CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	■ - SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	▨ - BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		# - SCREEN
		> 30	HARD		▽ - APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. ARFF - 3**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. DL - 11 Sheet 1 of 1

Driller: Tommy Desmond Helper: Sean Morgan Inspector: Josephine Ibanez	Boring location: Ground Surface Elevation: Date start: 10/3/2018 Date end: 10/3/2018
Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)	Direct push steel tooling: 2 3/8" G3 dual tube

Depth	Sample				Sample Description
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"	
	1	24/18	4 - 6		F-M-C brown sand; trace of cobble. Dry.
					Switched to Probe
0	1	N/R	0 - 4	N/R	Loamy material; F-M-C brown sand; trace F-M gravel. Dry.
2					
4	2		4 - 8		F-M-C brown sand; trace F-M gravel. Dry.
6					
8	3		8 - 12		F-M-C brown sand; trace very C brown sand. Dry.
10					
12	4		12 - 16		F-M-C brown sand; trace very C brown sand. Dry.
14					
16					
18					
20					
22					
24					
26					
28					
30					
32					
34					
36					
38					
40					
42					
44					
46					
48					
50					
52					
54					
56					End of probe: 16'
58					End of sample: 16'
60					
62					

Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		- CONCRETE
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- SAND PACK
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	Z - SOIL BACKFILL
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	- BENTONITE
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	# - SCREEN
> 50	V. DENSE	15 - 30	V. STIFF		- APPROX. WATER LEVEL
		> 30	HARD		

Cape Cod Test Boring	Project	Boring No. DL - 14
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller: Tommy Desmond	Boring location:
Helper: Sean Morgan	Ground Surface Elevation:
Inspector: Josephine Ibanez	Date start: Date end:

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)	Direct push steel tooling: 2 3/8" G3 dual tube

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
+2					
0	1	N/R	0 - 4	N/R	Subsurface road material. Loamy; silty sand; F-M-C brown sand;
2					trace F gravel. Dry.
4	2		4 - 8		F-M-C brown sand; some F-M gravel. Dry.
6					
8	3		8 - 12		F-M-C brown sand; trace F gravel. Dry.
10					
12	4		12 - 16		F-M-C brown sand. Dry.
14					
16					
18					
20					
22					
24					
26					
28					
30					
32					
34					
36					
38					
40					
42					
44					
46					
48					
50					
52					
54					
56					
58					
60					End of probe: 16'
62					End of sample: 16'
64					
66					

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used	Well Installation Key
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		# - SCREEN
		> 30	HARD		▽ - APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. DL - 14**

BORING LOG

Boring No. HW-1
Sheet 1 of 1

Project: Barnstable Air Hangar
Client: Barnstable Municipal Airport
Boring Contractor: Desmond Well Drilling, Inc.
Boring Equipment: Hollow Stem Auger
Ground Water: Date: 31-Aug-95 — Depth, ft.: 23 below land surface

Date: 31 August 1995
Completion Depth: 31 feet Below Land Surface
Elevation: N/A
Inspector: Howard Frank

Depth Feet	Description	Sample Number	Penetra./ Recovery	Blow Count	Comments	Depth Feet
0					Locking Road Box	0
2					Cement Seal	2
4						4
6	M-C Br sand, rock frags pebbles in tip to 4"	HW-1.1	13"	9-23-13-12		6
8					Natural Backfill	8
10	VC Br sand and gravel	HW-1.2	14"	8-11-15-12		10
12					21 ft. of 2 inch of sch. 40 PVC riser	12
14						14
16	Br M-C sand, so gravel coarsening up to C-VC sand so. gravel	HW-1.3	15"	8-15-15-14		16
18					2 ft. Bentonite Seal approx. 2 ft above screen	18
20	Beige M-C sand	HW-1.4	16"	6-11-13-19		20
22	Water Table		Water Table		Water Table	22
24					Natural Backfill (coars sand)	24
26	Beige M-C sand	HW-1.5	13"	8-7-6-8		26
28					10 ft. of 2 in. .010 Slot threaded Shc. 40 PVC screen	28
30	Br VC-C sand, so M sand so gravel	HW-1.6	21"	7-7-9-10		30

Well Details:

Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%

Abbreviations:

Brown (Br)	Green = (Gr)	Fine = (F)	Fine to Coarse = F-C
Red (R)	Gray = (Gy)	Medium = (M)	Very = (V)
Orange (Or)	Blue = (Bl)	Coars = (C)	More/Less = (+/-)
Rust (Ru)	Light = (lt)	Dark = (dk)	

H&W, Inc.

BORING LOG

Boring No. HW- 2
Sheet 1 of 1

Project: Steamship Gravel Parking Lot
Client: WHMV + N Steamship Authority
Boring Contractor: Desmond Well Drilling
Boring Equipment: Hollow Stem Auger
Ground Water:

Date	Depth, ft.
2/18/1999	28.5

Date: 2/18/1999
Completion Depth: 35.15
Elevation:
Inspector: JEL

Depth Feet	Description	Sample Number	Penetra./ Recovery	Blow Count	USCS Code	USCS Color	PID (ppm)	Comments	Well Details	Depth Feet
0	grass									0
								Cement Seal		
2										2
	tan m-c SAND, some	S-1	24-Dec	14-19-23-27				Bentonite Seal		
4	m gravel, li f gravel									4
6										6
8	tan m-c SAND, li f gravel	S-2	14/24	5-6-7-10						8
10										10
12	graywacke stuck in spoon									12
	tan f-m SAND	S-3	14/24	6-8-12-16						
14	tan m-c SAND									14
	tan m SAND, so gravel									
16										16
18	tan f-m SAND, so f gravel	S-4	16/24	6-9-9-12						18
20										20
22										22
	tan m-c SAND, tr f gravel	S-5	16/24	5-7-9-12						
24	moist @ 25'									24
26								.010 slot pvc screen		26
28	tan f-m SAND and coarse		24/24	3-4-7-10						28
	sand, some f gravel							Water Table		
30										30
32										32
34										34
36										36

Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
			Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
Rust (Ru)	Black (Blk)		Below Land Surface (BLS)		
			Not Available (N/A)		

H&W, Inc.

BORING LOG

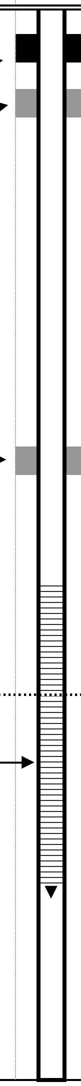
Boring No. HW- 3
Sheet 1 of 1

Project: Steamship Gravel Parking Lot
Client: WHMV + N Steamship Authority
Boring Contractor: Desmond Well Drilling
Boring Equipment: Hollow Stem Auger
Ground Water:

Date	Depth, ft.
4/24/1999	23

Date: 24/24/99
Completion Depth: 37
Elevation:
Inspector: JEL

Depth Feet	Description	Sample Number	Penetra./ Recovery	Blow Count	USCS Code	USCS Color	PID (ppm)	Comments	Well Details	Depth Feet
0										0
								Cement Seal		
2										2
	f-c GRAVEL,	S-1	24/15	12-23-28-26		Br		Bentonite Seal		
4	m-c Sand, tr f Sand									4
6										6
8	f-m SAND, tr c Sand,	S-2	24/15	7-9-10-11		Br				8
	tr f-c Gravel									
10										10
12										12
	f-m SAND, tr c Sand,	S-3	24/15	12-14-12-13		Br				
14	li f-c Gravel									14
								Bentonite Seal		
16										16
18	f-m SAND, tr c Sand,	S-4	24/13	5-9-11-12		Br				18
	tr f Gravel									
20										20
22										22
	f-m SAND, tr c Sand,	S-5	24/15	9-11-10-11		Br		▼		
24	tr f Gravel							Water Table		24
26								.010 slot pvc screen		26
28	f-m SAND, tr c Sand,	S-6	24/14	3-3-5-9		Br				28
	tr f Gravel									
30										30
32										32
34										34
36										36



Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
			Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
Rust (Ru)	Black (Blk)		Below Land Surface (BLS)		
			Not Available (N/A)		

H&W, Inc.

BORING LOG

Boring No. HW-4m
Sheet 1 of 1

Project: UST investigation
Client: Barnstable Airport
Boring Contractor: Desmond Well Drilling
Boring Equipment: Hollow Stem Auger
Ground Water:

Date	Depth, ft.	M.P.
4/23/01	26	pvc

Date: 4/23/01
Completion Depth: 32
Elevation:
Inspector: JEL
Notes: East of Cape Air Hangar next to HW-4s

Depth Feet	Description	Sample Number	Penetra./ Recovery	Blow Count	PID ppm	USCS Color	USGS Angularity	Comments	Well Details	Depth Feet
0										0
								Cement Seal →		
2										2
								Bentonite Seal →		
4	tan m-c SAND and f-m gravel bands of red-brown gray-tan	S-1	24/17	7-17-19-15						4
6										6
8										8
	tan m-c SAND	S-2	24/19	4-8-9-12	0					
10										10
12										12
14	no recovery and fine to med gravel	S-3	24/0	7-6-7-6	0					14
16										16
18										18
	tan m SAND, some fine sand, trace fine gravel	S-4	24/20	1-2-2-2	0					
20										20
22										22
24	tan/grey med SAND, trace fine gravel, trace fine sand bottom 6" wet with petroleum odor	S-5	24/15	1-1-1-1	176					24
26								Water Table ▽		26
28										28
	cuttings are grey m sand with a heavy weathered oil odor							.010 slot pvc screen → 22-32 bgs		
30										30
32										32
34										34
36										36

Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
			Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
Rust (Ru)	Black (Blk)		Below Land Surface (BLS)		
			Not Available (N/A)		

H&W, Inc.

Projects \ HYA \ 11072 (697 Barnstable Airport) \boring logs

BORING LOG

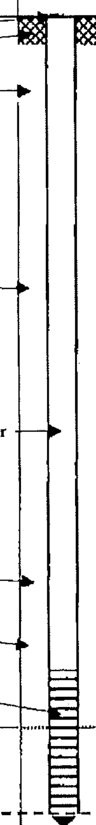
Boring No. HW-5
Sheet 1 of 1

Project: Barnstable Airport
Client: Ben Jones, Manager
Boring Contractor: Desmond Well Drilling, Inc.
Boring Equipment: Hollow Stem Auger
Ground Water: Date / Depth, ft.
6/24/96 — 25' below land surface

Date: 24 June 1996
Completion Depth: 28 feet bls
Elevation: N/A 54.98 *
Inspector: H. Frank

Depth Feet	Description	Sample Number	Penetra./ Recovery	Blow Count	USCS Code	USCS Color	USCS Angularity	Comments	Depth Feet
0								Locking road box; Cement seal	0
2								Bentonite seal	2
4	F-C poorly graded sand w/ >15% gravel, dry, no odor, no cement, 2" Br layer of silt PID: 0.0	HW-5.1	15"/24"	34-28-32-30	SP	Br	rnd-subrnd		4
6									6
8	F-M-C well graded sand w/ <15% gravel, dry, no cement no odor, PID: 0.0	HW-5.2	11.5"/24"	18-18-24-27	SW	Br- lt. Br- Beige	rnd-subrnd	Native backfill	8
10									10
12									12
14	F-VC poorly graded sand w/ >15% gravel, dry, no odor, no cement, PID: 0.0	HW-5.3	15"/24"	14-36-27-47	SP	Br- lt. Br- Beige	rnd-subrnd	23 ft. of sch. 40, threaded PVC riser	14
16									16
18	F-VC poorly graded sand w/ >15% gravel, dry, no odor, no rock frags, Fe stain layer no cement, PID: 0.0	HW-5.4	14"/24"	12-20-24-24	SP	Br - lt. Br- Beige	rnd-subrnd	Bentonite Seal	18
20								Native Backfill	20
22									22
24	F-M-C well graded sand w/ <15% gravel, dry, no odor, no cement, PID: 3.1	HW-5.5	15"/24"	6-8-10-14	SW	lt Br Beige	rnd-subrnd	5 ft. of .010 slot, threaded PVC screen; WATER TABLE	24
26									26
28	F-M-C well graded sand w/ <15% gravel, wet, no cement, strong petroleum odor, PID: 333 ppm	HW-5.6	17"/24"	1-1-1-1	SW	Gy	rnd-subrnd	BOTTOM OF HOLE	28
30									30
32									32
34									34
36									36

Well Details:



Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (F)	Fine to Coarse = F-C
Red (R)	Gray (Gy)	Angular (ang.)	Cement (Cem.)	Medium = (M)	Very = (V)
Light (lt)	Brown (Br)		Well-Graded (W-G)	Coarse = (C)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded (P-G)	Dark = (dk)	
Rust (Ru)	Black (Blk)		Not Available (N/A)		

H&W, Inc.

BORING LOG

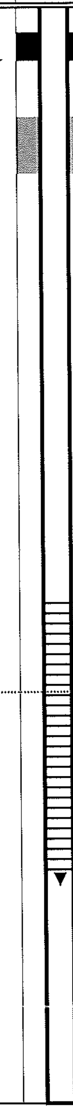
Boring No. HW-23
Sheet 1 of 1

Project: AS/SVE Installation
Client: Barnstable Airport
Boring Contractor: Desmond Well Drilling
Boring Equipment: Hollow Stem Auger
Ground Water:

Date	Depth, ft.	M.P.
5/11/99	23'	pvc

Date: 5/11/99
Completion Depth: 29
Elevation:
Inspector: JEL
Notes: Downgradient of downgradient as fence

Depth Feet	Description	Sample Number	Penetra./ Recovery	Blow Count	PID ppm	USCS Color	USGS Angularity	Comments	Well Details	Depth Feet
0	No samples taken							Cement Seal		0
2								Bentonite Seal		2
4										4
6										6
8										8
10										10
12										12
14										14
16										16
18										18
20										20
22								▽		22
24								Water Table		24
26								.010 slot pvc screen		26
28								19 - 29 bgs		28
30										30
32										32
34										34
36										36



Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color
Blue (Bl) Green (Gr)
Red (R) Gray (Gy)
Light (lt) Brown (Br)
Dark (dk) Orange (Or)
Rust (Ru) Black (Blk)

Angular
Round (rnd.)
Angular (ang.)

Misc.
Fragments (frag.)
Cement (cem.)
Well-Graded Sand (SW)
Poorly-Graded Sand (SP)
Well-Graded Gravel (GW)
Poorly-Graded Gravel (GP)
Below Land Surface (BLS)
Not Available (N/A)

Size
Fine = (f)
Medium = (m)
Coarse = (c)
Dark = (dk)
Fine to Coarse = (f-c)
Very = (v)
More/Less = (+/-)

H&W, Inc.

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HYA\11072 (697 Barnstable Airport)\ boring logs

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MONITORING WELL BORING LOG

Boring No. HW-A(s) (cape gun works)

Project: 17027- Barnstable On-call #4
Client: Barnstable Minicipal Airport
Boring Contractor: New england Goetech
Boring Equipment: Direct Push, 3" casing

Date: 3/16/2017
Completion Depth: 32' bgs
Elevation:
Inspector: JDB

Proportions Used:

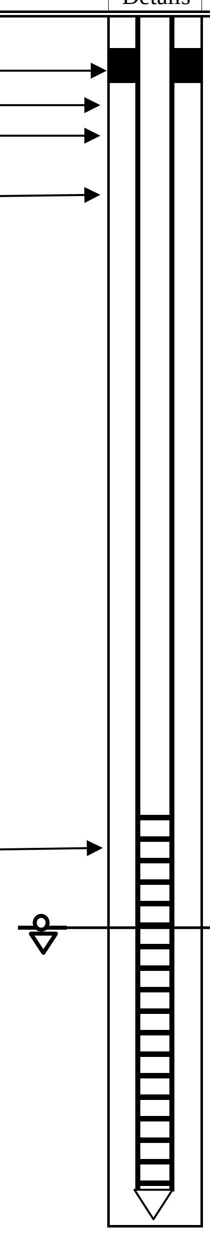
trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
Rust (Ru)	Black (Blk)		Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
			Below Land Surface (BLS)		
			Not Available (N/A)		

Depth Feet	Description		Penetration	Recovery	USCS Code	USCS Color	PID (parts per million)	Comments	Depth Feet
0	0"-4" asphalt							Cement	0
								#2 sand @ 6" bgs	
	0-5' bgs	Light Brown M-C sand, some F sand, little gravel		30"	ang	brn		Bontonite @ 2' bgs	
								#2 sand @ 4' bgs	
5									5
	5-10' bgs	Light Brown M-C sand, some F sand, little gravel; bottom 6" F white sand		43"	ang	brn			
10									10
	10-15' bgs	0-9"- Drk Br, M-C sand; some F sand; 9-32" - Lt Br, F-M sand; 22-26" - Drk Br, M-C sand; 32-48" - Lt Br, F-M sand		48"	ang	brn			
15									15
	15-20' bgs	0-27" - Lt Br, M-C sand, some F sand 27-43" - Drk Br, M-C sand; some F sand		43"	ang	brn			
20									20
	20-25' bgs	0-12" - Lt Br, M-C sand; 12+" - Drk Br, M-C sand, some gravel		48"	ang	brn		0.02 slot screen @ 22-32 ' bgs	
25								Groundwater @ 25.5' bgs	25
	25-30' bgs	0-24" - Lt Br, M-C sand, some F sand; 24+" - Drk Br, M-C sand; some F sand		43"	ang	brn			
30									30
35									
40									
45									
50									
55									

Well Details



Horsley Witten Group
Sustainable Environmental Solutions
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MONITORING WELL BORING LOG

Boring No. HW-B(d)

Project:	17027- Barnstable On-call #4	**Date:**	4/3/2017
Client:	Barnstable Minicipal Airport	**Completion Depth:**	57.2' bgs
Boring Contractor:	New england Goetech	**Elevation:**	
Boring Equipment:	Direct Push, 3" casing	**Inspector:**	JDB

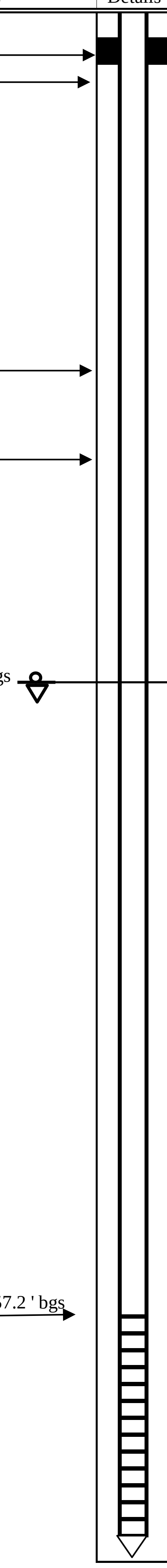
Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
Rust (Ru)	Black (Blk)		Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
			Below Land Surface (BLS)		
			Not Available (N/A)		

Depth Feet	Description		Penetration	Recovery	USCS Code	USCS Color	PID (parts per million)	Comments	Well Details	Depth Feet
0								Cement		0
								#2 sand @ 9" bgs		
5										5
10										10
								Bentonite @ 12' bgs		
15								#2 sand @ 15' bgs		15
20										20
								Groundwater @ 22.75' bgs		
25										25
30										30
	30-35' bgs	0-16" - Lt Br, M sand, some C sand/gravel; 16-19" - Med Br, F sand, little gravel		19"	ang	brn				
35										35
	35-40' bgs	Lt brn, M sand, some C sand/silt.gravel		2"	ang	brn				
40										40
	40-45' bgs	Lt brn, M sand, some C sand/silt.gravel		2"	ang	brn				
45										45
	45-50' bgs	0-9" - Lt Br, M sand, some F/C sand; 9-12" - Lt Br, F sand, some silt, little gravel		12"	ang	brn		0.02 slot screen @ 47.2-57.2 ' bgs		
50										50
	50-55' bgs	NO RECOVERY		0"						
55										55
	55-60' bgs	Lt Br, well graded sand, some gravel		19"	ang	brn				
60										60



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MONITORING WELL BORING LOG

Boring No. HW-B(s)

Project: 17027- Barnstable On-call #4
Client: Barnstable Minicipal Airport
Boring Contractor: New england Goetech
Boring Equipment: Direct Push, 3" casing

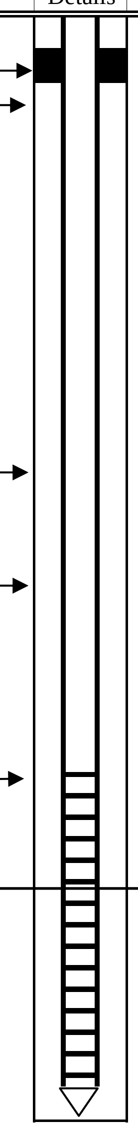
Date: 3/16/2017
Completion Depth: 30.5' bgs
Elevation:
Inspector: JDB

Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
Rust (Ru)	Black (Blk)		Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
			Below Land Surface (BLS) Not Available (N/A)		

Depth Feet	Description		Penetration	Recovery	USCS Code	USCS Color	PID (parts per million)	Comments	Well Details	Depth Feet
0	0"-6" Organic							Cement →		0
	0-5' bgs	0-6" - Lt Br, M-C sand, some F sand; 6-18" - Med Br, M-C sand, some F sand; 18+" - Drk Br, F-M sand, some C sand		50"	ang	brn		#2 sand @ 9" bgs →		
5										5
	5-10' bgs	0-10" - Lt Br, F-M sand, some C sand 10+" - Med Br, M-C sand, some F sand		45"	ang	brn				
10										10
	10-15' bgs	0-12" - Med Br, M-C sand, some F sand/gravel; 12-36" - Lt Br, C sand, some F-M sand, little gravel; 36+" - Drk Br, F-M sand, some C/gravel		52"	ang	brn		Bentonite @ 12' bgs →		
15								#2 sand @ 15' bgs →		15
	15-20' bgs	0-20" - Lt Br, F-M sand; 20+" - F-M sand, some C sand, and large gravel		60"	ang	brn				
20								0.02 slot screen @ 20.5-30.5 ' bgs →		20
	20-25' bgs	0-12" - Med Br, M-C sand, some F sand; 12-16" - Lt Br, F-M sand; 16-22" - Med Br, M-C sand, some F sand; 22+" - Lt Br, F-M sand		48"	ang	brn		Groundwater @ 23.5' bgs		
25										25
	25-30' bgs	M-C sand, some Fsand/gravel		36"	ang	brn				
30										30
35										
40										
45										
50										
55										

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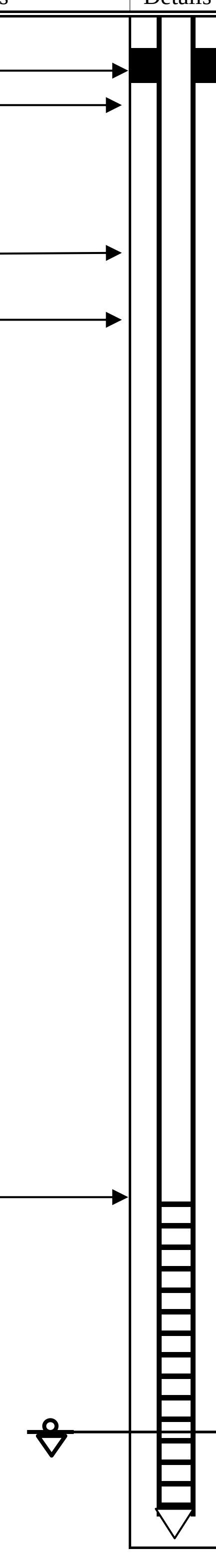
MONITORING WELL BORING LOG

Boring No. HW-C

Project:	17027- Barnstable On-call #4	**Date:**	3/16/2017
Client:	Barnstable Minicipal Airport	**Completion Depth:**	42.5' bgs
Boring Contractor:	New england Goetech	**Elevation:**	
Boring Equipment:	Direct Push, 3" casing	**Inspector:**	JDB

Proportions Used: **Abbreviations:**

Proportions Used		Color		Angular	Misc.	Size	
trace (tr)	0 - 10%	Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
little (li)	10 - 20%	Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
some (so)	20 - 35%	Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
and	35 - 50%	Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
		Rust (Ru)	Black (Blk)		Well-Graded Gravel (GW)		
					Poorly-Graded Gravel (GP)		
					Below Land Surface (BLS)		
					Not Available (N/A)		

Depth Feet	Description		Penetration	Recovery	USCS Code	USCS Color	PID (parts per million)	Comments	Well Details	Depth Feet
0	0"-12" Organic							Cement		0
								#2 sand @ 9" bgs		
	0-5' bgs	0-8" - M-C sand, little gravel; 8-26" - Lt Br, F sand, some silt; 26-32" - Or Br, F-M sand; 32-44 - Organic		44"	ang	brn				
5										5
								Bontonite @ 12' bgs		
	5-10' bgs	0-16" - Drk Br, C sand, some Fsand/gravel; 16-30" - Med Br, M sand, some F sand/gravel; 30-34" - Lt Br, F sand; 34+" - Or Br, M-C sand, little Fsand/silt		44"	ang	brn		#2 sand @ 7' bgs		
10										10
	10-15' bgs	Med Br, M-C sand, some F sand/large gravel (1"+);		45"	ang	brn				
15										15
	15-20' bgs	Med Br, M-C sand, some F sand		53"	ang	brn				
20										20
	20-25' bgs	0-6" - Or Br, M-C sand, some gravel; 6-12" - Lt Br, F-M sand, some gravel; 12-26" - Lt Br, F sand; 26+" - Med Br, M-C sand, little F sand, some gravel		55"	ang	brn				
25										25
	25-30' bgs	0-18" - Lt Br, F-M sand, little C sand; 18+" - Med Br, F sand, some M sand/gravel		36"	ang	brn				
30										30
	30-35' bgs	0-12" - Lt Br, F sand, little C sand; 12+" - Med Br, C sand, some F-M sand, little gravel		48"				0.02 slot screen @ 32.5-42.5 ' bgs		
35										
	35-42" bgs	NO SAMPLE COLLECTED		0"						
40								Groundwater @ 39.3' bgs		
45										
50										
55										

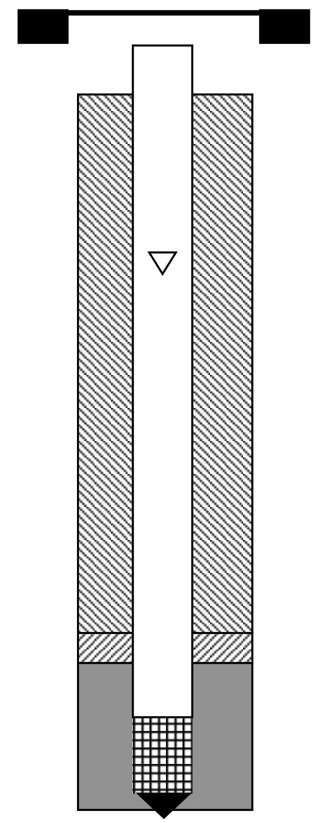
Cape Cod Test Boring	Project	Boring No. HW-D (d)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller: Tommy Desmond	Boring location: Cluster by solar field (41.67230, -70.27519)
Helper: Sean Morgan	Ground Surface Elevation:
Inspector: Josephine Ibanez	Date start: 5/15/2019 Date end: 5/15/2019

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x39.75' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	Sample PEN/REC	Sample DEPTH/FT	Sample Description
2				
0			0 - 15	F-M-C brown sand and gravel. Dry.
-2				
-4				
-6				
-8				
-10				
-12				
-14				
-16			15 - 45	F-M-C brown sand. Wet.
-18				
-20				
-22				
-24				
-26				
-28				
-30				
-32				
-34				
-36				
-38				
-40				
-42				
-44				
-46				
-48				
-50				
-52				
?				
-57				
-62				
-67				
-72				

Well Installation



Not to scale

Well Depth: 44.75'
Static: 18.25'
Well screen: 39.75' to 44.75'
Grout: 3' to 34'
Bentonite seal: 34' to 36'
Sand pack: 36' to 44.75'
End of boring: 45'
End of sample: N/A

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
- GROUT
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-D (d)**

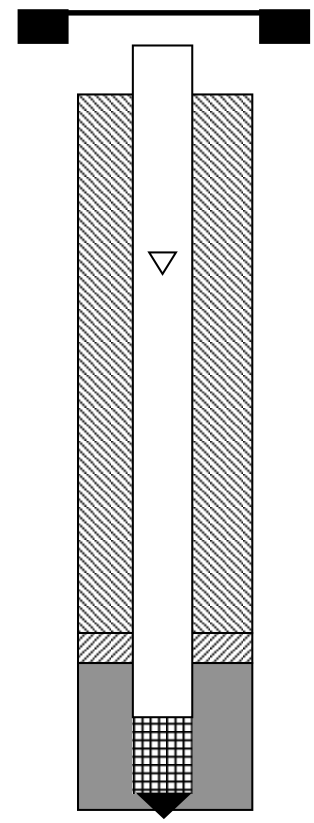
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-D (dd) Sheet 1 of 1

Driller: Tommy Desmond Helper: Sean Morgan Inspector: Josephine Ibanez	Boring location: Cluster by solar field (41.67230, -70.27519) Ground Surface Elevation: Date start: 5/14/2019 Date end: 5/14/2019

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x59.4' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	Sample Description
2				
0				
-2				
-4				
-6				
-8				
-10				
-12				
-14				
-16				
-18				
-20				
-22				
-24				
-26				
-28	1	24/16	27 - 29	F-M-C brown sand; little gravel. Wet.
-30				
-32	2	24/24	32 -34	F-M-C light brown sand; trace gravel. Wet.
-34				
-36				
-38	3	24/0	37 - 39	No recovery.
-40				
-42	4	24/20	42 - 44	F-M-C light gray sand; trace gravel. Wet.
-44				
-46				
-48	5	24/21	47 - 49	F-M-C light gray sand; little clay. Wet.
-50				
-52	6	24/8	52 - 54	F-M-C dark brown silty sand; some clay. Wet.
?				
-57	7	24/17	57 - 59	F-M-C light brown sand; trace gravel. Wet.
-62	8	24/13	62 - 64	F-M-C light brown sand. Wet.
-67	9	24/13	67 - 69	F-M-C red/brown sand and clay. Wet.
-72				

Well Installation



Not to scale

Well Depth: 64.9'
Static: 19.95'
Well screen: 59.9' to 64.9'
Grout: 3' to 55'
Bentonite seal: 55' to 57'
Sand pack: 57' to 64.9'
End of boring: 67'
End of sample: 69'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
- GROUT
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-D (dd)**

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MONITORING WELL BORING LOG

Boring No. HW-D

Project: 17027- Barnstable On-call #4
Client: Barnstable Minicipal Airport
Boring Contractor: New england Goetech
Boring Equipment: Direct Push, 3" casing
Date: 3/17/2017
Completion Depth: 29.5' bgs
Elevation:
Inspector: JDB

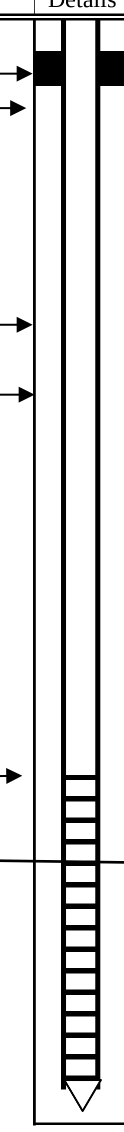
Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
Rust (Ru)	Black (Blk)		Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
			Below Land Surface (BLS)		
			Not Available (N/A)		

Depth Feet	Description		Penetration	Recovery	USCS Code	USCS Color	PID (parts per million)	Comments	Well Details	Depth Feet
0	0"-6" Organic							Cement		0
	0-5' bgs	0-30" - Or Br, M sand, little F/C sand/gravel; 30-42" - F-M sand, some C sand/gravel; 42-48" - Organic		48"	ang	brn		#2 sand @ 1' bgs		
5										5
	5-10' bgs	0-16" - Med Br, C sand, little F-M sand/large gravel; 16-24" - Med Br, M sand, little F sand, some C sand/gravel; 24+" - Med Br, C sand, little F-M sand/large gravel		42"	ang	brn		Bontonite @ 7' bgs #2 sand @ 9' bgs		
10										10
	10-15' bgs	0-20" - Lt Br, M-C sand, some F sand/gravel; 20-43" - Lt Br, C sand, little F sand/gravel, some C sand; 43+" - F-M sand, some C sand/gravel		55"	ang	brn				
15										15
	15-20' bgs	0-15" - Med Br, M sand, some F/C sand/gravel; 15-25" - F-M sand, some C sand; 25+" - Drk Br, F-M sand, some C sand/gravel		40"	ang	brn				
20								0.02 slot screen @ 16.2-26.2 ' bgs		20
	20-25' bgs	0-20" - Lt Br, M sand, some C sand, littleF sand/gravel; 20+" - F-M sand, some C sand/gravel		38'	ang	brn		Groundwater @ 22.6' bgs		
25										25
	25-30' bgs	NO SAMPLE COLLECTED, SOIL SLUFFED OUT OF SLEEVE		0"						
30										30
35										
40										
45										
50										
55										



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MONITORING WELL BORING LOG

Boring No. HW-E

Project: 17027- Barnstable On-call #4
Client: Barnstable Minicipal Airport
Boring Contractor: New england Goetech
Boring Equipment: Direct Push, 3" casing

Date: 3/17/2017
Completion Depth: 26.5' bgs
Elevation:
Inspector: JDB

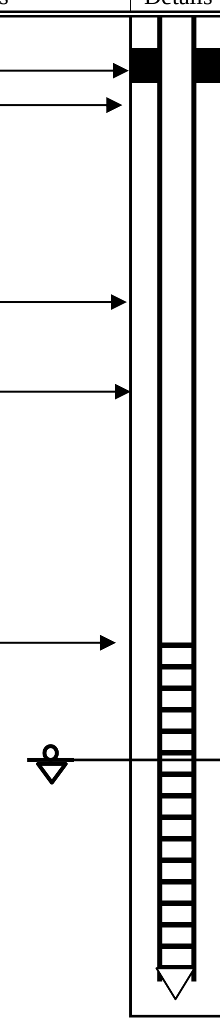
Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
Rust (Ru)	Black (Blk)		Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
			Below Land Surface (BLS)		
			Not Available (N/A)		

Depth Feet	Description			Penetration	Recovery	USCS Code	USCS Color	PID (parts per million)	Comments	Well Details	Depth Feet
0	0"-4" Organic								Cement		0
	0-5' bgs	0-12" - Med Br, M-C sand, some F sand, little gravel; 12-36" - Med Br, C sand, some F-M sand/gravel			40"	ang	brn		#2 sand @ 1' bgs		
5											5
	5-10' bgs	Med Br, C sand, little M-F sand/gravel			36"	ang	brn		Bontonite @ 6.5' bgs		
10									#2 sand @ 9' bgs		10
	10-15' bgs	0-12" - Lt Br, F sand; 12-24" - Lt Br, F-M sand, some C sand/gravel; 24-32" - Lt Br, F-M sand; 32+" - M-C sand, some F sand/gravel			60"	ang	brn				
15											15
	15-20' bgs	0-12" - Med Br, M-C sand, little F sand/gravel; 12-20" - F sand, some silt; 20+" - C sand, some F-M sand/gravel			58"	ang	brn		0.02 slot screen @ 16.2-26.2 ' bgs		
20									Groundwater @ 19.7' bgs		20
	20-25' bgs	Med Br, F sand, Little M-C sand/gravel ROCK IN SHOE			22"	ang	brn				
25											25
	25-30' bgs	Med Br, C sand, some M sand/gravel			24"	ang	brn				
30											30
35											
40											
45											
50											
55											



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MONITORING WELL BORING LOG

Boring No. HW-F

Project: 17027- Barnstable On-call #4
Client: Barnstable Minicipal Airport
Boring Contractor: New england Goetech
Boring Equipment: Direct Push, 3" casing

Date: 3/17/2017
Completion Depth: 27.2' bgs
Elevation:
Inspector: JDB

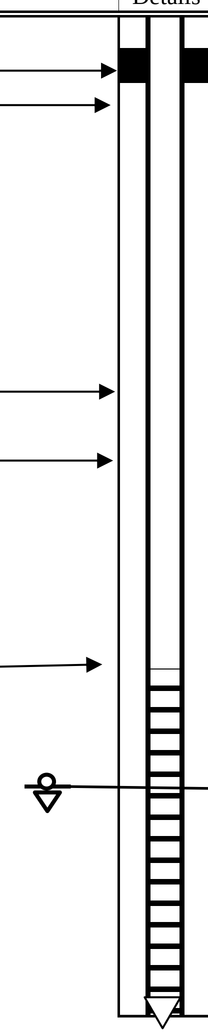
Proportions Used:

trace (tr)	0 - 10%
little (li)	10 - 20%
some (so)	20 - 35%
and	35 - 50%

Abbreviations:

Color		Angular	Misc.	Size	
Blue (Bl)	Green (Gr)	Round (rnd.)	Fragments (frag.)	Fine = (f)	Fine to Coarse = (f-c)
Red (R)	Gray (Gy)	Angular (ang.)	Cement (cem.)	Medium = (m)	Very = (v)
Light (lt)	Brown (Br)		Well-Graded Sand (SW)	Coarse = (c)	More/Less = (+/-)
Dark (dk)	Orange (Or)		Poorly-Graded Sand (SP)	Dark = (dk)	
Rust (Ru)	Black (Blk)		Well-Graded Gravel (GW)		
			Poorly-Graded Gravel (GP)		
			Below Land Surface (BLS)		
			Not Available (N/A)		

Depth Feet	Description	Penetration	Recovery	USCS Code	USCS Color	PID (parts per million)	Comments	Well Details	Depth Feet
0	0"-5" Organic						Cement		0
	0-5' bgs — 0-12" - Med Br, M sand, liitle C sand; 12-32" - Drk Br, C sand, some M sand/gravel; 32-40" - Drk Br, F sand, Some M sand/gravel; 40+" - Organic		45"	ang	brn		#2 sand @ 1' bgs		
5									5
	5-10' bgs — C sand, some F-M sand, tr gravel		52"	ang	brn				
10							Bontonite @ 7' bgs		10
	10-15' bgs — 0-16" - Lt Br, M sand, some C; 16-32" - Lt Br, F-M sand; 32-41" - Med Br, M sand, some C sand/gravel; 41+" F-M sand, tr gravel		56"	ang	brn		#2 sand @ 11' bgs		
15									15
	15-20' bgs — M-C sand, some F-M sand, little gravel		52"	ang	brn		0.02 slot screen @ 17.2-27.2 ' bgs		
20							Groundwater @ 22.6' bgs		20
	20-25' bgs — 0-20" - Lt-Med Br, C sand, some F-M sand, little gravel; 20-28" - Gray, F-M sand, little C sand; 28+" - Drk Br, M-C sand, some Fsand/gravel		38'	ang	brn/gray				
25									25
	25-30' bgs — NO SAMPLE COLLECTED, SOIL SLUFFED OUT OF SLEEVE		0"						
30									30
35									
40									
45									
50									
55									



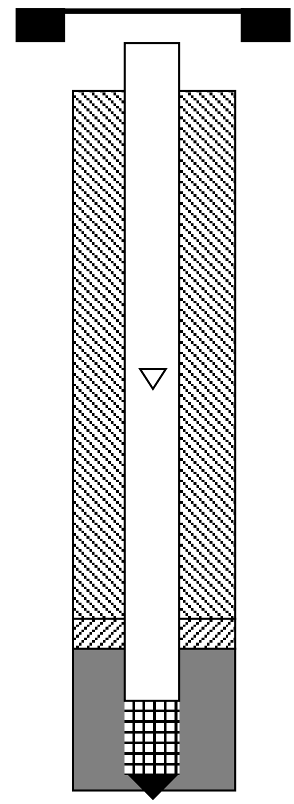
Cape Cod Test Boring	Project	Boring No.	HW-G(d)
02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 10/1/2018	Date end: 10/2/2018

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A	
		Casing Size:	2"x43.3' SCH40 PVC FJT
		Screen Size:	2"x5'X.010 SCH40 PVC FJT

Depth	Sample			Sample Description
(FT)	NO	PEN/REC	DEPTH/FT	
2				
0	1	24/14	0 - 2	Loamy sand. F-M-trace C brown sand. Dry.
-2	2	24/14	2 - 4	F-M-C brown sand; trace gravel. Dry.
-4	3	24/13	4 - 6	F-M-C brown sand; some cobble. Dry.
-6	4	24/15	6 - 8	F-M-C brown sand; trace cobble. Dry.
-8	5	24/14	8 - 10	F-M-C brown sand; some cobble. Dry.
-10	6	24/15	10 - 12	F-M-C brown sand; some cobble. Dry.
-12	7	24/14	12 - 14	F-M-C brown sand; trace cobble. Dry.
-14	8	24/17	14 - 16	F-M-C brown sand; trace gravel. Dry.
-16	9	24/17	16 - 18	F-M-C brown sand; trace gravel. Dry.
-18	10	24/17	18 - 20	F-M-C brown sand; trace gravel. Dry.
-20	11	24/17	20 - 22	F-M-C brown sand; trace gravel. Dry.
-22	12	24/13	22 - 24	F-M-C brown sand. Wet at 24'.
-24	13	24/3	24 - 26	Rock jammed in top of spoon.
-26	14	24/0	26 - 28	No recovery basket broke.
-28	15		28 - 30	F-M-C brown sand; trace gravel. Wet.
-30	16	24/11	30 - 32	F-M-C brown sand; trace gravel. Wet.
-32	17	24/13	32 -34	F-M-C brown sand; trace gravel. Wet.
-34	18	24/10	34 - 36	F-M-C brown sand; trace gravel. Wet.
-36	19	24/0	36 - 38	No recovery.
-38	20	24/12	38 - 40	F-M-C brown sand; trace silt, trace gravel. Wet.
-40	21	24/11	40 - 42	F-M-C brown sand; trace gravel. Wet.
-42	22	24/9	42 - 44	F-M-C brown sand; trace gravel. Wet.
-44	23	24/13	44 - 46	F-M-C light brown sand. Wet.
-46	24	24/12	46 - 48	F-M-C brown sand; trace silt. Wet.
-48	25	24/13	48 - 50	F-M-C brown sand; trace silt; trace clay. Wet.
-50	26	24/19	50 - 52	Blue clay. Wet.
-52				
-54				
-56				
-58				
-60				
-62				
-64				
-66				

Well Installation



Well Depth: 48.30'
Static: 22.30'
Well screen: 43.3' to 48.3'
Grout: 5' to 38'
Bentonite seal: 38' to 40'
Sand pack: 40' to 48.3'
End of boring: 50'
End of sample: 52'

Granular Soils		Cohesive Soils		Proportions Used
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY	
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

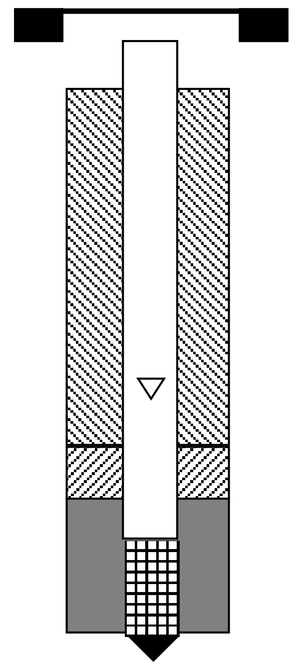
Well Installation Key
- CONCRETE
- SAND PACK
- GROUT
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING | **BORING NO.** | **GW - Deep well**

Cape Cod Test Boring	Project	Boring No.	HW-G(m)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 10/3/2018	Date end: 10/3/2018

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes: Middle	Auger Size: 6 1/4" x 4" H.S.A	
		Casing Size:	2"x33.25' SCH40 PVC FJT
		Screen Size:	2"x5'X.010 SCH40 PVC FJT

Depth	Sample				Sample Description	Well Installation
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"		
2					Drilled straight with H.S.A.	
0			0 - 10		F-M-C brown sand; gravel. Dry.	
-2						
-4						
-6						
-8						
-10			10 - 40		F-M-C brown sand.	
-12					Water encountered at 22.35'.	
-14						
-16						
-18						
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						
-50						
-52						Well Depth: 38.25'
-54						Static: 22.35'
-56						Well screen: 33.25' to 38.25'
-58						Grout: 5' to 27.25'
-60						Bentonite seal: 27.25' to 30.25'
-62						Sand pack: 30.25' to 38.25'
-64						End of boring: 40'
-66						End of sample: n/a

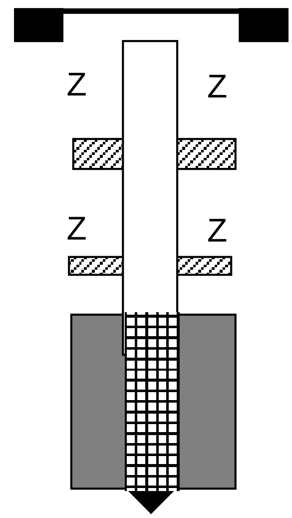
Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		- CONCRETE
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- SAND PACK
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- GROUT
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	- BENTONITE
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- SCREEN
> 50	V. DENSE	15 - 30	V. STIFF		- APPROX. WATER LEVEL
		> 30	HARD		

CAPE COD TEST BORING | **BORING NO. GW - Middle well**

Cape Cod Test Boring	Project	Boring No.	HW-G(s)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 10/3/2018	Date end: 10/3/2018

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes: Shallow	Auger Size:	6 1/4" x 4" H.S.A
		Casing Size:	2"x18.45' SCH40 PVC FJT
		Screen Size:	2"x10'X.010 SCH40 PVC FJT

Depth	Sample				Sample Description	Well Installation
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"		
2					Drilled straight with H.S.A.	
0			0 -10		F-M-C brown sand; Gravel. Dry.	
-2						
-4						
-6						
-8						
-10			10 - 40		F-M-C brown sand.	
-12					Water encountered at 22.29'.	
-14						
-16						
-18						
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						
-50						
-52						Well Depth: 28.45'
-54						Static: 22.29'
-56						Well screen: 18.45' to 28.45'
-58						Bentonite seal: 8' to 10'
-60						Bentonite seal: 15' to 16'
-62						Sand pack: 18.25' to 28.45'
-64						End of boring: 30'
-66						End of sample: n/a

Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		- CONCRETE
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- SAND PACK
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	Z - SOIL BACKFILL
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	- BENTONITE
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- SCREEN
> 50	V. DENSE	15 - 30	V. STIFF		- APPROX. WATER LEVEL
		> 30	HARD		

CAPE COD TEST BORING **BORING NO. GW - Shallow well**

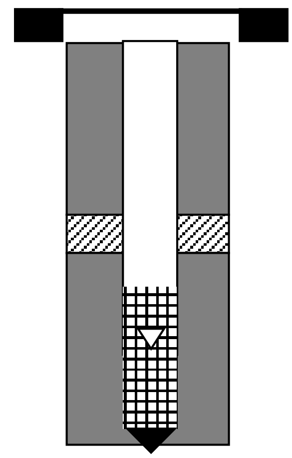
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. Sheet 1 of	HW - H 1

Driller:	Tommy Desmond	Boring location:	
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 10/4/2018	Date end: 10/4/2018

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)	Auger Size: 6 1/4" x 4" H.S.A Casing Size: Screen Size:	 2"x17.11' SCH40 PVC FJT 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0	1	N/R	0 - 4	N/R	Loamy; F-M brown sand; trace silt.
-2					Dry.
-4	2		4 - 8		F-M-C brown sand; little F-M
-6					gravel. Dry.
-8	3		8 - 12		F-M-C brown sand; trace F gravel.
-10					Dry.
-12	4		12 - 16		F-M-C brown sand. Dry.
-14					
-16	5		16 - 20		F-M-C brown sand; trace F gravel.
-18					Dry.
-20	6		20 - 24		F-M-C brown sand. Wet.
-22					
-24	7		24 - 28		F-M-C brown sand. Wet.
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Well Depth: 27.11'
Static: 20.68'
Well screen: 17.11' to 27.11'
Sand pack: 0' to 13'
Bentonite seal: 13' to 15'
Sand pack: 15' to 27.11'
End of boring: 24'
End of sample: 28'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

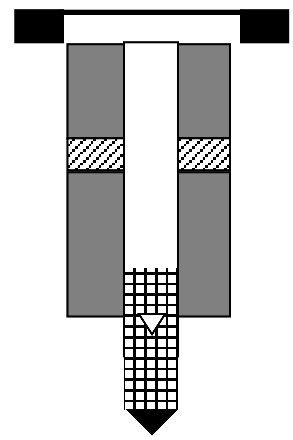
Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING | **BORING NO. HW - H**

Cape Cod Test Boring	Project	Boring No.	HW - I
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 10/4/2018	Date end: 10/4/2018

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)	Auger Size: 6 1/4" x 4" H.S.A	
	Casing Size:	2"x15.1' SCH40 PVC FJT
	Screen Size:	2"x10'X.010 SCH40 PVC FJT

Depth	Sample				Sample Description	Well Installation
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"		
2						
0	1	N/R	0 - 4	N/R	Loamy; silty sand; F-M gravel;	
-2					F-M-C brown sand. Dry.	
-4	2		4 - 8		F-M-C brown sand; trace F gravel.	
-6					Dry.	
-8	3		8 - 12		F-M-C brown sand. Dry.	
-10						
-12	4		12 - 16		F-M-C brown sand. Dry.	
-14						
-16	5		16 - 20		F-M-C brown sand; trace very C	
-18					brown sand; trace F gravel. Wet.	
-20	6		20 - 24		F-M-C brown sand. Wet.	
-22						
-24	7		24 - 28		F-M-C brown sand. Wet.	
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						
-50						
-52						Well Depth: 25.10'
-54						Static: 18.62'
-56						Well screen: 15.1' to 25.1'
-58						Sand pack: 0' to 8'
-60						Bentonite seal: 8' to 10'
-62						Sand pack: 10' to 18.62'
-64						End of boring: 24'
-66						End of sample: 28'

Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		- CONCRETE
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- SAND PACK
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	Z - SOIL BACKFILL
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	- BENTONITE
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- SCREEN
> 50	V. DENSE	15 - 30	V. STIFF		- APPROX. WATER LEVEL
		> 30	HARD		

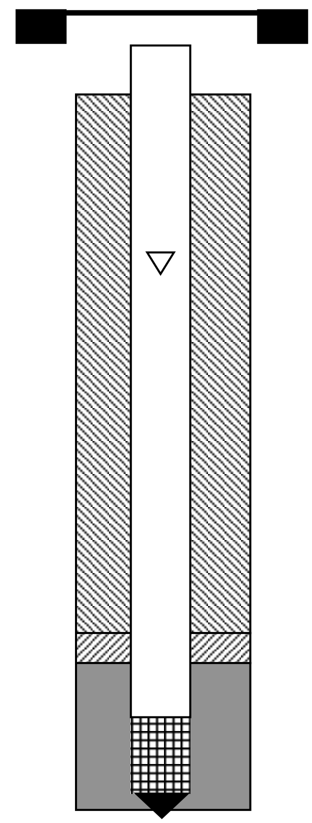
Cape Cod Test Boring	Project	Boring No.	HW-I (d)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	Behind deployment (41.66662, -70.27212)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 5/16/2019	Date end: 5/16/2019

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A	
		Casing Size:	2"x36.5' SCH40 PVC FJT
		Screen Size:	2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	Sample PEN/REC	Sample DEPTH/FT	Sample Description
2				
0				
-2				
-4				
-6				
-8				
-10				
-12				
-14				
-16				
-18				
-20				
-22				
-24				
-26				
-28	1	24/20	27 - 29	F-M-C light brown sand; trace gravel. Wet.
-30				
-32	2	24/24	32 -34	F-M-C light brown sand. Wet.
-34				
-36				
-38	3	24/11	37 - 39	F-M-C light gray sand; trace gravel. Wet.
-40				
-42	4	24/15	42 - 44	F-M-C brown sand; trace red sand; trace clay. Wet.
-44				
-46				
-48				
-50				
-52				
?				
-57				
-62				
-67				
-72				

Well Installation



Not to scale

Well Depth: 41.5'

Static: 15.45'

Well screen: 36.1' to 41.5'

Grout: 3' to 27'

Bentonite seal: 27' to 30'

Sand pack: 30' to 41.5'

End of boring: 42'

End of sample: 44'

Granular Soils BLOWS/FT	Granular Soils DENSITY	Cohesive Soils BLOWS/FT	Cohesive Soils DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
- GROUT
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-I (d)**

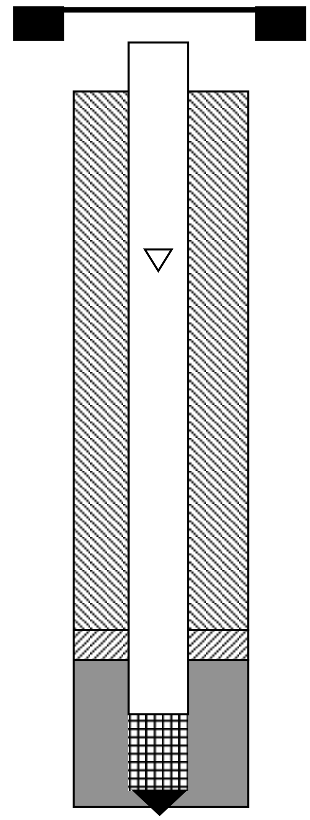
Cape Cod Test Boring	Project	Boring No.	HW-I (m)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	Behind deployment (41.66662, -70.27212)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 5/16/2019	Date end: 5/16/2019

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A	
		Casing Size:	2"x30' SCH40 PVC FJT
		Screen Size:	2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	Sample PEN/REC	Sample DEPTH/FT	Sample Description
2				
0			0 - 35	F-M-C light brown sand; trace gravel.
-2				
-4				
-6				
-8				
-10				
-12				
-14				
-16				
-18				
-20				
-22				
-24				
-26				
-28				
-30				
-32				
-34				
-36				
-38				
-40				
-42				
-44				
-46				
-48				
-50				
-52				
?				
-57				
-62				
-67				
-72				

Well Installation



Not to scale

Well Depth: 35'

Static: 16.4'

Well screen: 30' to 35'

Grout: 3' to 27'

Bentonite seal: 27' to 30'

Sand pack: 30' to 35'

End of boring: N/A

End of sample: N/A

Granular Soils BLOWS/FT	Granular Soils DENSITY	Cohesive Soils BLOWS/FT	Cohesive Soils DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key

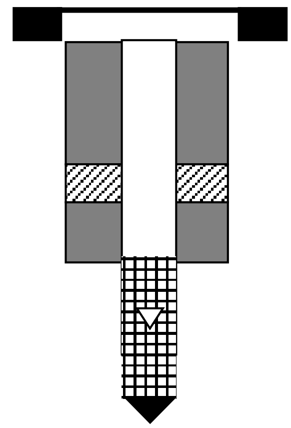
- CONCRETE
- SAND PACK
- GROUT
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO.** **HW-I (m)**

Cape Cod Test Boring	Project	Boring No. HW - J
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 10/4/2018	Date end: 10/4/2018

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x___' SCH40 PVC FJT Screen Size: 2"x___'X.010 SCH40 PVC FJT

Depth	Sample				Sample Description	Well Installation
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"		
2						
0	1	N/R	0 - 4	N/R	Loamy; F-M brown sand; F-M-C	
-2					brown sand; trace F gravel. Dry.	
-4	2		4 - 8		F-M-C brown sand. Dry.	
-6						
-8	3		8 - 12		F-M-C brown sand;	
-10					trace F gravel (lense). Dry.	
-12	4		12 - 16		F-M-C brown sand; trace F-M	
-14					gravel. Dry.	
-16	5		16 - 20		F-M-C brown sand; little F-M	
-18					gravel. Wet.	
-20	6		20 - 24		F-M-C brown sand. Wet.	
-22						
-24	7		24 - 28		F-M-C brown sand. Wet.	
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						
-50						
-52						Well Depth: 24.35'
-54						Static: 19.56'
-56						Well screen: 14.35' to 24.35'
-58						Sand pack: 0' to 10'
-60						Bentonite seal: 10' to 12'
-62						Sand pack: 12' to 14.35'
-64						End of boring: 24'
-66						End of sample: 28'

Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		- CONCRETE
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- SAND PACK
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	Z - SOIL BACKFILL
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	- BENTONITE
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- SCREEN
> 50	V. DENSE	15 - 30	V. STIFF		- APPROX. WATER LEVEL
		> 30	HARD		

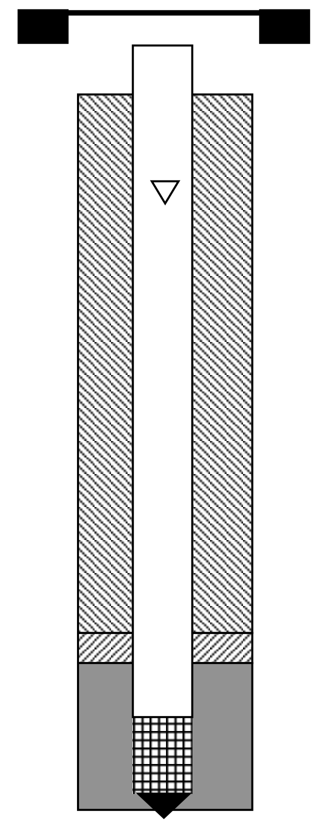
Cape Cod Test Boring	Project	Boring No.	HW-K
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller: Tommy Desmond	Boring location:	Back of parking lot off site (41.66284, -70.27542)	
Helper: Sean Morgan	Ground Surface Elevation:		
Inspector: Josephine Ibanez	Date start: 5/31/2019		Date end: 6/3/2019

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A	
		Casing Size:	2"x39' SCH40 PVC FJT
		Screen Size:	2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	Sample Description
2				
0				
-2				
-4				
-6	1	24/24	5 - 7	F-M-C brown sand; some gravel; some cobble. Dry.
-8	2	24/10	7 - 9	F-M-C brown sand; trace cobble; trace gravel. Dry.
-10				
-12	3	24/15	12 - 14	F-M-C brown sand; trace gravel. Dry.
-14				
-16				
-18	4	24/15	17 - 19	F-M-C light brown sand; trace gravel. Dry.
-20				
-22	5	24/15	22 - 24	F-M brown sand; trace silt. Wet at 22 ft.
-24				
-26				
-28	6	24/8	27 - 29	F-M brown silty sand. Wet.
-30				
-32	7	24/9	32 -34	F-M-C brown sand; trace silt. Wet.
-34				
-36				
-38	8	24/9	37 - 39	F-M-C brown silty sand; trace gravel. Wet.
-40				
-42	9	24/12	42 - 44	F-M-C brown sand; M-C brown/black sand. Wet.
-44				
-46				
-48				
-50				
-52				
?				
-57				
-62				
-67				
-72				

Well Installation



Not to scale
Well Depth: 44'
Static: 19.7'
Well screen: 39' to 44'
Grout: 3' to 34'
Bentonite seal: 34' to 36'
Sand pack: 36' to 44'
End of boring: 44'
End of sample: 44'

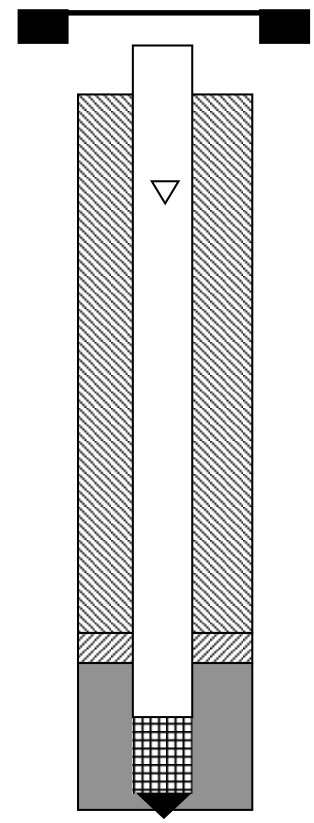
Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
- GROUT
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-3(m)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. Sheet 1 of	HW-L(d) 1

Driller: Tommy Desmond Helper: Sean Morgan Inspector: Josephine Ibanez	Boring location: Ground Surface Elevation: Date start: 5/13/2019	End of runway 33 (41.66329, -70.27865) 	 Date end: 5/13/2019
Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: Screen Size:	 2"x65.4' SCH40 PVC FJT 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	Sample PEN/REC	Sample DEPTH/FT	Sample Description	Well Installation
2					
0	1	24/8	0 - 2	F-M-C brown sand; trace gravel. Dry.	
-2	2	24/13	2 - 4	F-M-C brown sand; trace gravel. Dry.	
-4					
-6					
-8	3	24/12	7 - 9	F-M-C light brown sand; trace gravel. Dry.	
-10					
-12	4	24/8	12 - 14	F-M-C brown sand; some gravel. Dry.	
-14					
-16					
-18	5	24/14	17 - 19	F-M-C light brown sand; trace gravel. Dry.	
-20					
-22	6	24/12	22 - 24	F-M-C light brown sand. Wet.	
-24					
-26					
-28	7	24/15	27 - 29	F-M-C light brown sand; trace gravel. Wet.	
-30					
-32	8	24/19	32 -34	F-M-C light brown sand; trace gravel. Wet.	
-34					
-36					
-38	9	24/24	37 - 39	F-M-C light brown sand; trace gravel. Wet.	
-40					
-42	10	24/19	42 - 44	F-M-C light brown sand; little gravel. Wet.	
-44					
-46					
-48	11	24/15	47 - 49	F-M-C light brown sand; little gravel. Wet.	
-50					*Not to scale*
-52	12	24/24	52 - 54	F-M-C light brown sand; little gravel. Wet.	Well Depth: 70.4'
?					Static: 19'
-57	13	24/12	57 - 59	F-M brown sand. Wet.	Well screen: 65.4' to 70.4'
-62	14	24/15	62 - 64	F-M light brown sand. Wet.	Grout: 3' to 60'
-67	15	24/20	67 - 69	F-M brown sand. Wet.	Bentonite seal: 60' to 62'
-72	16	24/13	72 - 74	F gray clay. Wet.	Sand pack: 62' to 70.4'
					End of boring: 72'
					End of sample: 74'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used	Well Installation Key
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	- GROUT
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-L**

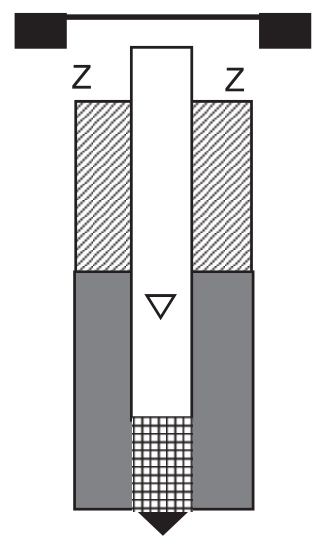
Cape Cod Test Boring	Project	Boring No.	HW-L(M)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	Runway (41.66277, -70.27842)	
Helper:	Sean Morgan	Ground Surface Elevation:		
Inspector:	Sarah Bartlett	Date start: 9/17/2020		Date end: 9/17/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x32.33' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					F-M-C brown sand; some gravel. Dry.
-2					
-4					
-6			5 - 38		F-M-C brown sand; some gravel. Dry.
-8					
-10					Drilled with hollow stem augers to 38'
-12					and set well as directed.
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 37.33'
Static: 21.88'
Well screen: 32.33' to 37.33'
Native backfill: 0' to 5'
Bentonite seal: 5' to 28'
Bentonite grout slow: 28' to 32'
Sand pack: 32' to 37'
End of boring: 38'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

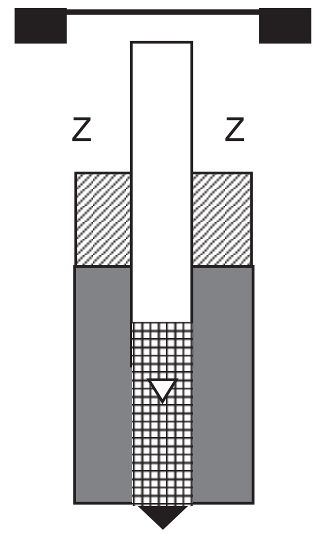
Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-L(M)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-L(S) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Runway (41.66277, -70.27842)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/17/2020	Date end: 9/17/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x17.33' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description	Well Installation
2			0 - 5		Cleared with vacuum truck.	
0					F-M-C brown sand; some gravel. Dry.	
-2						
-4						
-6			5 - 28		F-M-C brown sand. Dry.	
-8						
-10					Drilled with hollow stem augers to 28'	
-12					and set well as directed.	
-14						
-16						
-18						
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						
-50						*Not to scale*
-52						Well Depth: 27.33'
-54						Static: 21.96'
-56						Well screen: 17.33' to 27.33'
-58						Native backfill: 0' to 10'
-60						Bentonite seal: 10' to 14'
-62						Sand pack: 14' to 27'
-64						End of boring: 28'
-66						End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used	Well Installation Key
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

CAPE COD TEST BORING | **BORING NO. HW-L(S)**

Cape Cod Test Boring	Project	Boring No. HW-M
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

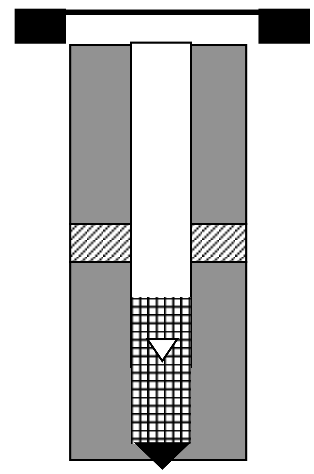
Driller:	Tommy Desmond	Boring location:	Cit Ave and Plant Road (41.67157, -70.29359)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 5/30/2019	Date end: 5/30/2019

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)

Auger Size: 6 1/4" x 4" H.S.A
Casing Size: 2"x16.9' SCH40 PVC FJT
Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth	Sample				Sample Description
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"	
2					
0			0 - 5		Vacuum truck.
-2					
-4	1		5 - 8		F-M-C brown sand and gravel.
-6					Dry.
-8	2		8 - 12		F-M-C brown sand and gravel.
-10					Dry.
-12	3		12 - 16		F-M-C brown sand and gravel.
-14					Dry.
-16	4		16 - 20		F-M-C brown sand and gravel.
-18					Dry.
-20	5		20 - 24		F-M-C brown sand and gravel.
-22					Wet.
-24	6		24 - 28		F-M-C brown sand and gravel.
-26					Wet.
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Well Depth: 26.90'
Static: 20.45'
Well screen: 16.9' to 26.9'
Native: 0' to 11'
Bentonite seal: 11' to 13'
Sand pack: 13' to 20.45'
End of boring: 28'
End of sample: 28'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-M**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-N Sheet 1 of 1

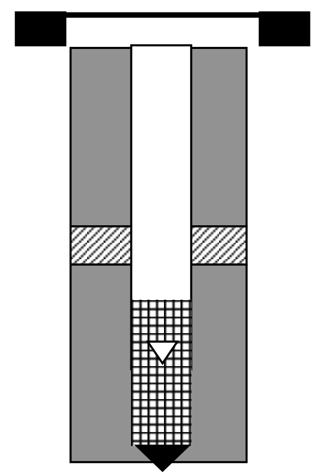
Driller:	Tommy Desmond	Boring location:	Attucks Lane (41.67372, -70.29490)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 5/31/2019	Date end: 5/31/2019

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)

Auger Size: 6 1/4" x 4" H.S.A
Casing Size: 2"x16.9' SCH40 PVC FJT
Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0			0 - 5		Vacuum truck.
-2					
-4	1		5 - 8		F-M-C brown sand and gravel.
-6					Dry.
-8	2		8 - 12		F-M-C brown sand and gravel.
-10					Dry.
-12	3		12 - 16		F-M-C brown sand and gravel.
-14					Wet.
-16	4		16 - 20		F-M-C brown sand and gravel.
-18					Wet.
-20	5		20 - 24		F-M-C brown sand and gravel.
-22					Wet.
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Well Depth: 22.3'
Static: 15.48'
Well screen: 12.3' to 22.3'
Native: 0' to 7'
Bentonite seal: 7' to 9'
Sand pack: 9' to 22.3'
End of boring: 24'
End of sample: 24'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

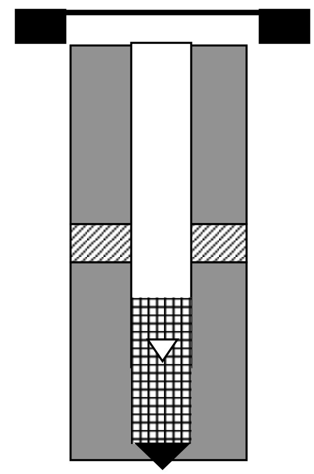
Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-N**

Cape Cod Test Boring	Project	Boring No. HW-O
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Airport Road (41.67054, -70.29819)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Josephine Ibanez	Date start: 5/31/2019	Date end: 5/31/2019

Direct push sampler consists of 4' x 2 3/8" G3 dual tube direct push steel tooling with 4' x 1 1/2" PVC liner with 201 ft lb hydraulic hammer (percussion rate 2200 bpm)	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x16.9' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description	Well Installation
2						
0			0 - 5		Vacuum truck.	
-2						
-4	1		5 - 8		F-M-C brown sand and gravel.	
-6					Wet.	
-8	2		8 - 12		F-M-C brown sand and gravel.	
-10					Wet.	
-12	3		12 - 16		F-M-C brown sand and gravel.	
-14					Wet.	
-16	4		16 - 20		F-M-C brown sand and gravel.	
-18					Wet.	
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						
-50						
-52						Well Depth: 14'
-54						Static: 1.8'
-56						Well screen: 4' to 14'
-58						Native: 0' to 1'
-60						Bentonite seal: 1' to 3'
-62						Sand pack: 3' to 14'
-64						End of boring: 20'
-66						End of sample: 20'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used	Well Installation Key
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

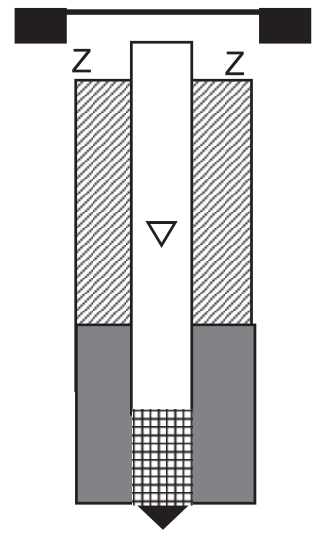
CAPE COD TEST BORING **BORING NO. HW-O**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-P(M) Sheet 1 of 1

Driller: Tommy Desmond Helper: Sean Morgan Inspector: Sarah Bartlett	Boring location: Deployment area (41.66458, -70.27720) Ground Surface Elevation: Date start: 9/18/2020 Date end: 9/18/2020
Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:
Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x33.3' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT	

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0					
-2					
-4	1	24/8	3 - 5	3-1-4-8	Fill; F-M-C brown sand and gravel.
-6					Dry.
-8	2	24/11	8 - 10	6-10-12-12	F-M-C brown sand. Dry.
-10					
-12					
-14	3	24/16	13 - 15	10-13-14-12	F-M-C brown sand and gravel. Dry.
-16					
-18	4	24/18	18 - 20	5-6-10-10	F-M-C brown sand; trace gravel. Dry.
-20					
-22					
-24	5	24/8	23 - 25	4-4-5-5	F-M-C brown sand. Wet.
-26					
-28	6	24/8	28 - 30	12-4-4-4	F-M-C brown sand; silty clay layer. Wet.
-30					
-32					
-34	7	24/15	33 - 35	1-3-4-5	F-M-C brown sand. Wet.
-36					
-38	8	24/22	38 - 40	6-9-11-15	F-M-C brown sand. Wet.
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 38.3'
Static: 22.8'
Well screen: 33.3' to 38.3'
Native: 0' to 5'
Bentonite grout: 5' to 28'
Bentonite grout slow: 28' to 32'
Sand pack: 32' to 38'
End of boring: 38'
End of sample: 40'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

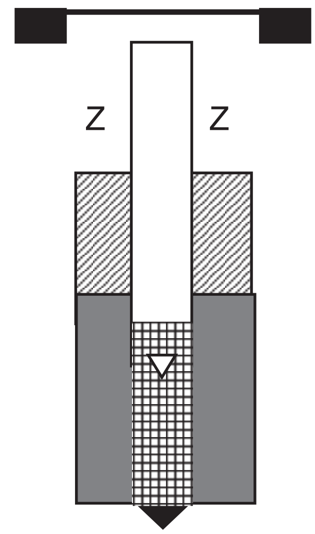
Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-P(M)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-P(S) Sheet 1 of 1
Driller: Tommy Desmond Helper: Sean Morgan Inspector: Sarah Bartlett		Boring location: Deployment area (41.66458, -70.27720) Ground Surface Elevation: Date start: 9/18/2020 Date end: 9/18/2020
Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x17.6' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					F-M-C brown sand; some gravel. Dry.
-2					
-4					Drilled to 29 ft with hollow stem augers
-6					and set well as directed.
-8					
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 27.6
Static: 22.69
Well screen: 17.6' to 27.6'
Native: 0' to 10'
Bentonite grout: 10' to 14'
Bentonite grout slow: n/a
Sand pack: 14' to 27'
End of boring: 29'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-P(S)**

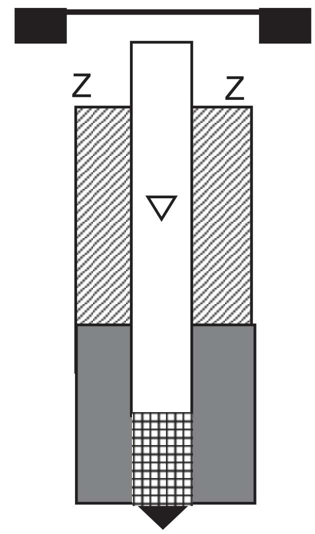
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-Q(M) Sheet 1 of 1

Driller: Tommy Desmond Helper: Sean Morgan Inspector: Sarah Bartlett	Boring location: Parking area - Gate M (41.66508, -70.27440) Ground Surface Elevation: Date start: 9/14/2020 Date end: 9/14/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x31.79' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0			0 - 5		Cleared with vacuum truck.
-2					
-4					
-6	1	24/17	5 - 7	7-12-18-25	F-M-C brown sand and gravel. Dry.
-8	2	24/21	8 - 10	6-7-8-9	F-M-C brown sand; trace gravel. Dry.
-10					
-12					
-14	3	24/20	13 - 15	8-16-21-15	F-M brown sand; F-M-C brown sand;
-16					some gravel. Dry.
-18	4	24/17	18 - 20	5-11-13-12	F-M-C brown sand. Dry.
-20					
-22					
-24	5	24/12	23 - 25	3-4-4-4	F-M-C brown sand; some gravel. Wet.
-26					around 23 to 25 ft.
-28	6	24/13	28 - 30	2-4-6-6	F-M-C silty brown sand; little gravel. Wet.
-30					
-32					
-34	7	24/0	33 - 35	2-6-7-11	No recovery.
-36					
-38	8	24/21	38 - 40	7-13-16-21	F-M brown sand; F-M-C brown sand;
-40					trace gravel. Wet.
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 36.79'
Static: 21.41'
Well screen: 31.79' to 36.79'
Native: 0' to 3'
Bentonite grout: 3' to 24'
Bentonite grout slow: 24' to 27'
Sand pack: 27' to 36'
End of boring: 38'
End of sample: 40'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

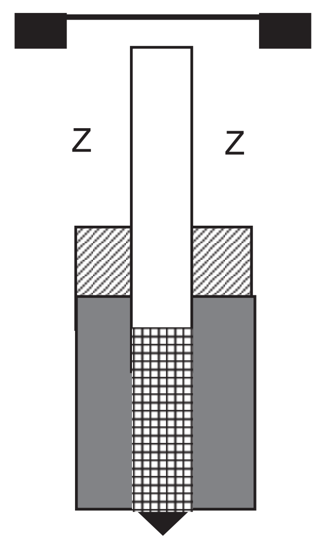
CAPE COD TEST BORING **BORING NO. HW-Q(M)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-Q(S) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Parking area - Gate M (41.66508, -70.27440)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/15/2020	Date end: 9/15/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size:	6 1/4" x 4" H.S.A
		Casing Size:	2"x16.6' SCH40 PVC FJT
		Screen Size:	2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description	Well Installation
2					Drilled with hollow stem augers to 28'	
0					and set well as directed.	
-2						
-4						
-6						
-8						
-10						
-12						
-14						
-16						
-18						
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						*Not to scale*
-50						Well Depth: 26.6'
-52						Static: 21.45'
-54						Well screen: 16.6' to 26.6'
-56						Native: 0' to 10'
-58						Bentonite grout: 10' to 13'
-60						Bentonite grout slow: n/a
-62						Sand pack: 13' to 26'
-64						End of boring: 28'
-66						End of sample: n/a



Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-Q(S)**

Cape Cod Test Boring	Project	Boring No. HW-R(S)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Back road (41.66832, -70.27081)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett/Bryan Massa	Date start: 9/14/2020	Date end: 9/14/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x13.56' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					
-2					
-4	1	24/13	5 - 7	5-6-6-6	F-M brown sand; trace gravel. Dry.
-6					
-8	2	24/17	8 - 10	8-3-4-5	F-M-C brown sand; some gravel. Dry.
-10					
-12					
-14	3	24/15	13 - 15	7-7-9-9	F-M-C brown sand; some gravel. Dry.
-16					
-18	4	24/18	18 - 20	5-10-10-8	F-M-C brown sand; some gravel. Wet.
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
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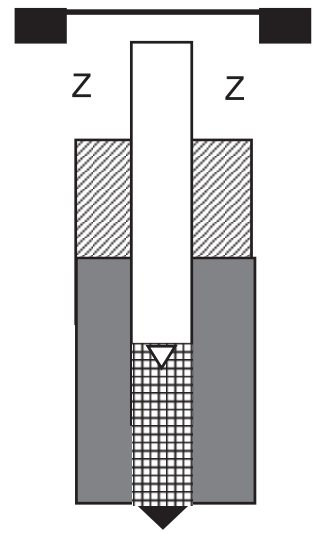
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 23.56'
Static: 18.33'
Well screen: 13.56' to 23.56'
Native: 0' to 5'
Bentonite grout: 5' to 9'
Bentonite grout slow: n/a
Sand pack: 9' to 23.56'
End of boring: 25'
End of sample: 20'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
Z - SOIL BACKFILL
- SAND PACK
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-R(S)**

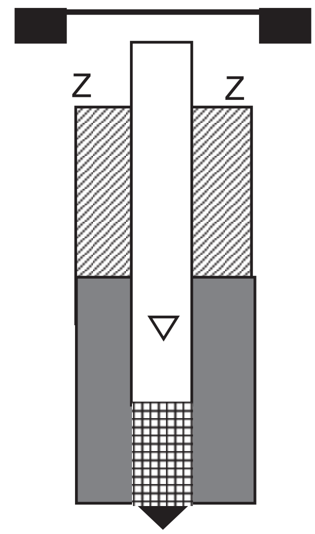
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-S(M) Sheet 1 of 1

Driller: Tommy Desmond		Boring location:	Ferndoc St. & Old Yarmouth Rd. (41.66511, -70.27112)
Helper: Sean Morgan		Ground Surface Elevation:	
Inspector: Sarah Bartlett		Date start: 9/16/2020	Date end: 9/16/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x27.04' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0					
-2					
-4					
-6	1	24/18	5 - 7	7-11-11-11	F-M-C brown sand; little gravel. Dry.
-8	2	24/21	8 - 10	3-5-4-5	F-M-C brown sand. Dry.
-10					
-12					
-14	3	24/16	13 - 15	2-9-6-8	F-M-C brown sand; some gravel. Dry.
-16					
-18	4	24/15	18 - 20	2-4-7-4	F-M-C brown sand; some gravel. Wet.
-20					
-22					
-24	5	24/16	23 - 25	2-3-3-4	F-M-C brown sand; trace gravel. Wet.
-26					
-28	6	24/14	28 - 30	1-3-3-4	F-M-C brown sand. Wet.
-30					
-32					
-34	7	24/18	33 - 35	2-5-4-7	F-M-C brown sand. Wet.
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 32.04'
Static: 17.01'
Well screen: 27.04' to 32.04'
Native: 0' to 3'
Bentonite grout: 3' to 21'
Bentonite grout slow: 21' to 24'
Sand pack: 24' to 32.04'
End of boring: 35'
End of sample: 33'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-S(M)**

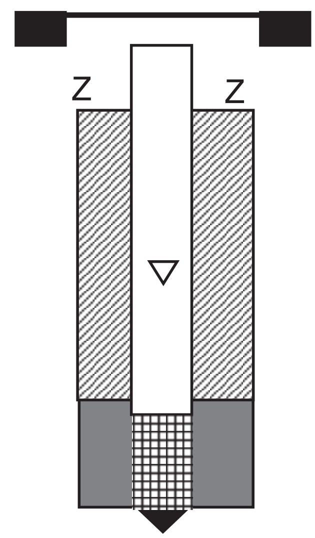
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-B(M) Sheet 1 of 1

Driller: Tommy Desmond	Boring location: Cape Cod Gun Works (41.672148, -70.296514)
Helper: Sean Morgan	Ground Surface Elevation:
Inspector: Sarah Bartlett	Date start: 9/24/2020 Date end: 9/24/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x31.15' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0					
-2					
-4	1	24/5	4 - 6	8-18-16-14	F-M-C brown; some gravel. Dry.
-6					
-8	2	24/12	8 - 10	3-9-6-7	F-M-C brown sand; some gravel. Dry.
-10					
-12					
-14	3	24/15	13 - 15	3-6-12-14	F-M-C brown sand and gravel. Dry.
-16					
-18	4	24/12	18 - 20	5-6-9-7	F-M brown sand. Dry.
-20					
-22					
-24	5	24/0	23 - 25	7-8-8-6	No recovery.
-26					
-28	6	24/6	28 - 30	4-8-12-10	F-M-C brown sand. Wet.
-30					
-32					
-34	7	24/12	33 - 35	2-4-5-5	F-M brown sand; F-M-C brown sand. Wet.
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 36.15'
Static: 22.9'
Well screen: 31.15' to 36.15'
Native: 0' to 6'
Bentonite grout: 2' to 27'
Bentonite grout slow: 27' to 30'
Sand pack: 30' to 36'
End of boring: 36'
End of sample: 35'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-B(M)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-L(S) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Runway (41.66277, -70.27842)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/17/2020	Date end: 9/17/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x17.33' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					F-M-C brown sand; some gravel. Dry.
-2					
-4					
-6			5 - 28		F-M-C brown sand. Dry.
-8					
-10					Drilled with hollow stem augers to 28'
-12					and set well as directed.
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
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-52					
-54					
-56					
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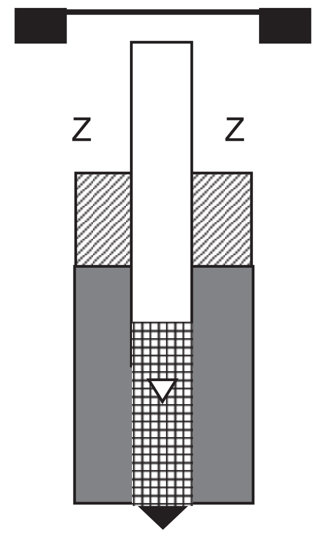
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 27.33'
Static: 21.96'
Well screen: 17.33' to 27.33'
Native backfill: 0' to 10'
Bentonite seal: 10' to 14'
Sand pack: 14' to 27'
End of boring: 28'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

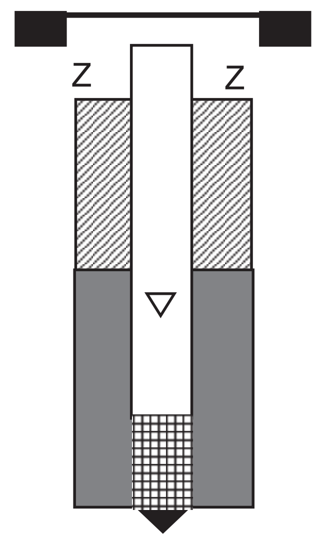
Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-L(S)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-L(M) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Runway (41.66277, -70.27842)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/17/2020	Date end: 9/17/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x32.33' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth	Sample				Sample Description	Well Installation
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"		
2			0 - 5		Cleared with vacuum truck.	
0					F-M-C brown sand; some gravel. Dry.	
-2						
-4						
-6			5 - 38		F-M-C brown sand; some gravel. Dry.	
-8						
-10					Drilled with hollow stem augers to 38'	
-12					and set well as directed.	
-14						
-16						
-18						
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						*Not to scale*
-50						Well Depth: 37.33'
-52						Static: 21.88'
-54						Well screen: 32.33' to 37.33'
-56						Native backfill: 0' to 5'
-58						Bentonite seal: 5' to 28'
-60						Bentonite grout slow: 28' to 32'
-62						Sand pack: 32' to 37'
-64						End of boring: 38'
-66						End of sample: n/a

Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-L(M)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-P(S) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Deployment area (41.66458, -70.27720)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/18/2020	Date end: 9/18/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x17.6' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					F-M-C brown sand; some gravel. Dry.
-2					
-4					Drilled to 29 ft with hollow stem augers
-6					and set well as directed.
-8					
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
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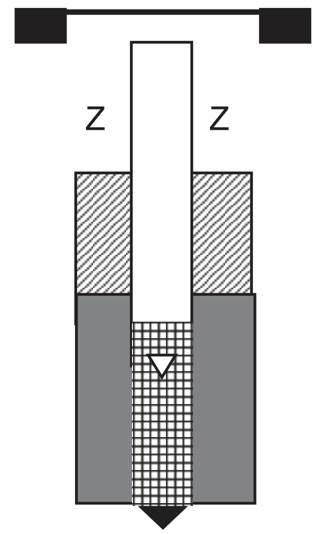
-66					

Well Installation



Not to scale
Well Depth: 27.6
Static: 22.69
Well screen: 17.6' to 27.6'
Native: 0' to 10'
Bentonite grout: 10' to 14'
Bentonite grout slow: n/a
Sand pack: 14' to 27'
End of boring: 29'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

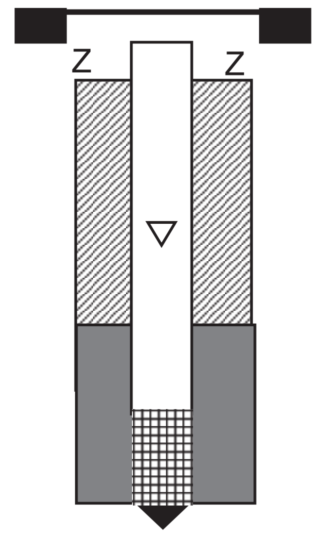
Cape Cod Test Boring	Project	Boring No. HW-P(M)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Deployment area (41.66458, -70.27720)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/18/2020	Date end: 9/18/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x33.3' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0					
-2					
-4	1	24/8	3 - 5	3-1-4-8	Fill; F-M-C brown sand and gravel.
-6					Dry.
-8	2	24/11	8 - 10	6-10-12-12	F-M-C brown sand. Dry.
-10					
-12					
-14	3	24/16	13 - 15	10-13-14-12	F-M-C brown sand and gravel. Dry.
-16					
-18	4	24/18	18 - 20	5-6-10-10	F-M-C brown sand; trace gravel. Dry.
-20					
-22					
-24	5	24/8	23 - 25	4-4-5-5	F-M-C brown sand. Wet.
-26					
-28	6	24/8	28 - 30	12-4-4-4	F-M-C brown sand; silty clay layer. Wet.
-30					
-32					
-34	7	24/15	33 - 35	1-3-4-5	F-M-C brown sand. Wet.
-36					
-38	8	24/22	38 - 40	6-9-11-15	F-M-C brown sand. Wet.
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



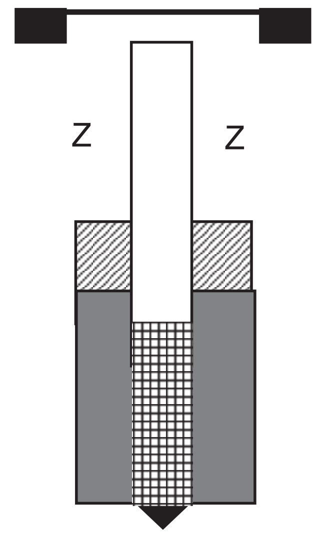
Not to scale
Well Depth: 38.3'
Static: 22.8'
Well screen: 33.3' to 38.3'
Native: 0' to 5'
Bentonite grout: 5' to 28'
Bentonite grout slow: 28' to 32'
Sand pack: 32' to 38'
End of boring: 38'
End of sample: 40'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING | **BORING NO. HW-P(M)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-Q(S) Sheet 1 of 1
Driller: Tommy Desmond Helper: Sean Morgan Inspector: Sarah Bartlett		Boring location: Parking area - Gate M (41.66508, -70.27440) Ground Surface Elevation: Date start: 9/15/2020 Date end: 9/15/2020
Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x16.6' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth	Sample				Sample Description	Well Installation
(FT)	NO	PEN/REC	DEPTH/FT	BLOWS 6"		
2					Drilled with hollow stem augers to 28'	
0					and set well as directed.	
-2						
-4						
-6						
-8						
-10						
-12						
-14						
-16						
-18						
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						*Not to scale*
-50						Well Depth: 26.6'
-52						Static: 21.45'
-54						Well screen: 16.6' to 26.6'
-56						Native: 0' to 10'
-58						Bentonite grout: 10' to 13'
-60						Bentonite grout slow: n/a
-62						Sand pack: 13' to 26'
-64						End of boring: 28'
-66						End of sample: n/a

Granular Soils		Cohesive Soils		Proportions Used	Well Installation Key
BLOWS/FT	DENSITY	BLOWS/FT	DENSITY		
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

CAPE COD TEST BORING | **BORING NO. HW-Q(S)**

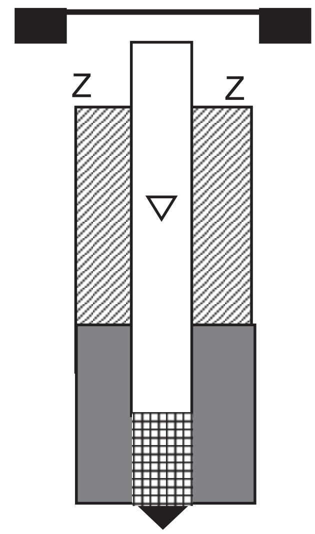
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-Q(M) Sheet 1 of 1

Driller: Tommy Desmond	Boring location: Parking area - Gate M (41.66508, -70.27440)
Helper: Sean Morgan	Ground Surface Elevation:
Inspector: Sarah Bartlett	Date start: 9/14/2020 Date end: 9/14/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x31.79' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0			0 - 5		Cleared with vacuum truck.
-2					
-4					
-6	1	24/17	5 - 7	7-12-18-25	F-M-C brown sand and gravel. Dry.
-8	2	24/21	8 - 10	6-7-8-9	F-M-C brown sand; trace gravel. Dry.
-10					
-12					
-14	3	24/20	13 - 15	8-16-21-15	F-M brown sand; F-M-C brown sand;
-16					some gravel. Dry.
-18	4	24/17	18 - 20	5-11-13-12	F-M-C brown sand. Dry.
-20					
-22					
-24	5	24/12	23 - 25	3-4-4-4	F-M-C brown sand; some gravel. Wet.
-26					around 23 to 25 ft.
-28	6	24/13	28 - 30	2-4-6-6	F-M-C silty brown sand; little gravel. Wet.
-30					
-32					
-34	7	24/0	33 - 35	2-6-7-11	No recovery.
-36					
-38	8	24/21	38 - 40	7-13-16-21	F-M brown sand; F-M-C brown sand;
-40					trace gravel. Wet.
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 36.79'
Static: 21.41'
Well screen: 31.79' to 36.79'
Native: 0' to 3'
Bentonite grout: 3' to 24'
Bentonite grout slow: 24' to 27'
Sand pack: 27' to 36'
End of boring: 38'
End of sample: 40'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-Q(M)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No.	HW-R(S)
		Sheet 1 of	1

Driller:	Tommy Desmond	Boring location:	Back road (41.66832, -70.27081)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett/Bryan Massa	Date start: 9/14/2020	Date end: 9/14/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size:	6 1/4" x 4" H.S.A
		Casing Size:	2"x13.56' SCH40 PVC FJT
		Screen Size:	2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					
-2					
-4	1	24/13	5 - 7	5-6-6-6	F-M brown sand; trace gravel. Dry.
-6					
-8	2	24/17	8 - 10	8-3-4-5	F-M-C brown sand; some gravel. Dry.
-10					
-12					
-14	3	24/15	13 - 15	7-7-9-9	F-M-C brown sand; some gravel. Dry.
-16					
-18	4	24/18	18 - 20	5-10-10-8	F-M-C brown sand; some gravel. Wet.
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
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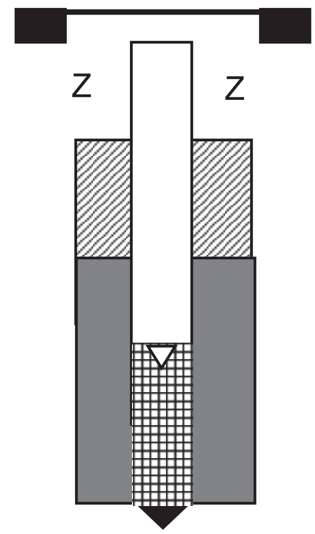
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 23.56'
Static: 18.33'
Well screen: 13.56' to 23.56'
Native: 0' to 5'
Bentonite grout: 5' to 9'
Bentonite grout slow: n/a
Sand pack: 9' to 23.56'
End of boring: 25'
End of sample: 20'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-R(S)**

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-S(S) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Ferndoc St. & Old Yarmouth Rd. (41.66511, -70.27112)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/16/2020	Date end: 9/16/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x12.1' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					Drilled with hollow stem augers to 23'
0					and set well as directed.
-2					
-4					
-6					
-8					
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
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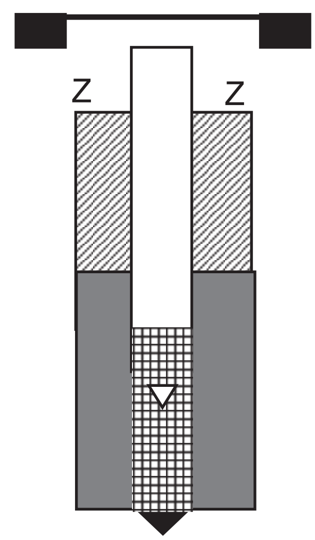
-64					
-66					

Well Installation



Not to scale
Well Depth: 22.1'
Static: 16.88
Well screen: 12.1' to 22.1'
Native: 0' to 6'
Bentonite grout: 6' to 9'
Bentonite grout slow: n/a
Sand pack: 9' to 22'
End of boring: 23'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-S(S)**

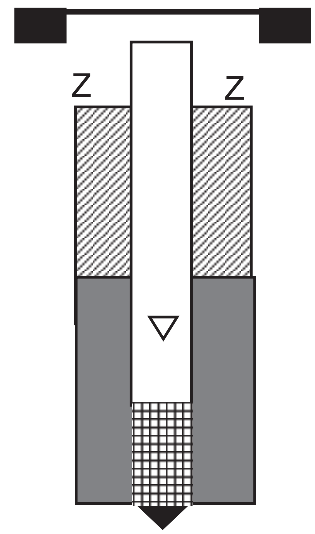
Cape Cod Test Boring	Project	Boring No. HW-S(M)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Ferndoc St. & Old Yarmouth Rd. (41.66511, -70.27112)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/16/2020	Date end: 9/16/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x27.04' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0					
-2					
-4					
-6	1	24/18	5 - 7	7-11-11-11	F-M-C brown sand; little gravel. Dry.
-8	2	24/21	8 - 10	3-5-4-5	F-M-C brown sand. Dry.
-10					
-12					
-14	3	24/16	13 - 15	2-9-6-8	F-M-C brown sand; some gravel. Dry.
-16					
-18	4	24/15	18 - 20	2-4-7-4	F-M-C brown sand; some gravel. Wet.
-20					
-22					
-24	5	24/16	23 - 25	2-3-3-4	F-M-C brown sand; trace gravel. Wet.
-26					
-28	6	24/14	28 - 30	1-3-3-4	F-M-C brown sand. Wet.
-30					
-32					
-34	7	24/18	33 - 35	2-5-4-7	F-M-C brown sand. Wet.
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 32.04'
Static: 17.01'
Well screen: 27.04' to 32.04'
Native: 0' to 3'
Bentonite grout: 3' to 21'
Bentonite grout slow: 21' to 24'
Sand pack: 24' to 32.04'
End of boring: 35'
End of sample: 33'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-S(M)**

Cape Cod Test Boring	Project	Boring No. HW-T(S)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller: Tommy Desmond	Boring location: Across from 6 Joaquim Road (41.66648, -70.269207)
Helper: Sean Morgan	Ground Surface Elevation:
Inspector: Sarah Bartlett	Date start: 9/21/2020 Date end: 9/21/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x8.54' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					Drilled with hollow stem augers to 20'
-2					and set well as directed.
-4					
-6					
-8					
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
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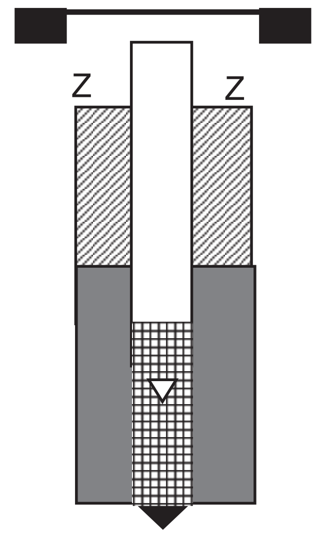
Well Installation



Not to scale
Well Depth: 18.54'
Static: 13.41'
Well screen: 8.54' to 18.54'
Native backfill: 0' to 1'
Bentonite seal: 1' to 5'
Sand pack: 5' to 18'
End of boring: 20'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-T(S)**

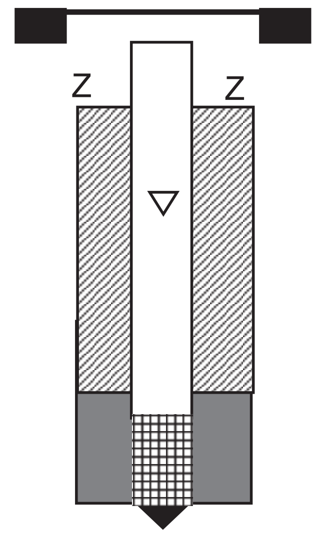
Cape Cod Test Boring	Project	Boring No. HW-T(M)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Across from Joaquim Rd. (41.66653, -70.26913)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/21/2020	Date end: 9/21/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x23.96' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 4		Cleared with vacuum truck.
0					
-2					
-4	1	24/15	4 - 6	1-10-18-20	F-M-C brown sand; some gravel. Dry.
-6					
-8	2	24/15	8 - 10	4-8-8-9	F-M-C brown sand; some gravel. Dry.
-10					
-12					
-14	3	24/16	13 - 15	4-5-8-9	F-M-C brown sand; some gravel. Wet.
-16					
-18	4	24/14	18 - 20	5-8-7-6	F-M-C brown sand; some gravel. Wet.
-20					
-22					
-24	5	24/14	23 - 25	2-4-5-7	F-M brown sand; F-M-C brown sand;
-26					trace gravel. Wet.
-28	6	24/15	28 - 30	3-5-8-6	F-M brown sand; F-M-C brown sand;
-30					trace gravel. Wet.
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 28.96'
Static: 13.58'
Well screen: 23.96' to 28.96'
Native: 0' to 5'
Bentonite grout: 5' to 13'
Bentonite grout slow: 13' to 20'
Sand pack: 20' to 28.96'
End of boring: 28'
End of sample: 30'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

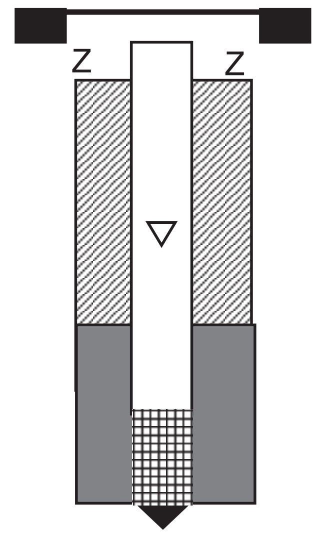
CAPE COD TEST BORING **BORING NO. HW-T(M)**

Cape Cod Test Boring	Project	Boring No. HW-U(D)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Wendy's (41.66568, -70.207908)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/22/2020	Date end: 9/22/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x57.3' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description	Well Installation
2						
0						
-2						
-4						
-6	1	24/12	5 - 7	3-3-4-4	F-M-C brown sand; trace gravel. Dry.	
-8	2	24/24	8 - 10	6-14-13-14	F-M-C brown sand and gravel. Dry.	
-10						
-12						
-14	3	24/17	13 - 15	7-15-23-17	F-M-C brown sand and gravel. Dry.	
-16						
-18	4	24/18	18 - 20	5-10-16-16	F-M-C brown sand and gravel. Dry.	
-20						
-22						
-24	5	24/14	23 - 25	5-6-8-8	F-M-C brown sand; some gravel. Wet.	
-26						
-28	6	24/7	28 - 30	4-5-5-5	F-M-C brown sand; trace gravel. Wet.	
-30						
-32						
-34	7	24/14	33 - 35	3-5-5-5	F-M gray sand; F-M-C gray sand. Wet.	
-36						
-38	8	24/5	38 - 40	3-4-5-5	F-M-C brown sand. Wet.	
-40						
-42	9	24/15	43 - 45	5-5-9-10	F-M-C brown sand; trace gravel. Wet.	
-44						
-46	10	24/16	48 - 50	3-3-6-8	F-M-C brown sand; trace gravel. Wet.	
-48						*Not to scale*
-50						Well Depth: 62.3'
-52						Static: 24.66'
-54	11	24/13	53 - 55	3-5-5-8	F-M gray sand; F-M-C gray sand. Wet.	Well screen: 57.3' to 62.3'
-56						Native: 0' to 5'
-58	12	24/15	58 - 60	3-5-9-11	F-M-C brown sand; trace gravel. Wet.	Bentonite grout: 5' to 48'
-60						Bentonite grout slow: 48' to 52'
-62						Sand pack: 52' to 62'
-64	13	24/16	63 - 65	4-7-10-12	F-M-C brown sand; trace gravel. Wet.	End of boring: 63'
-66						End of sample: 65'



Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

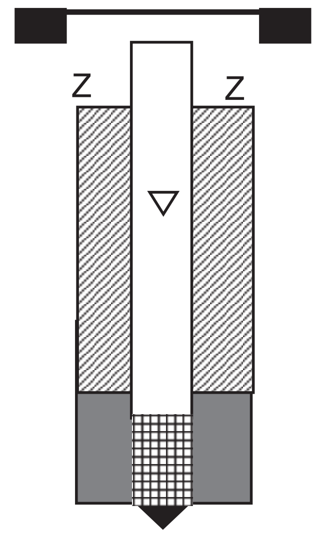
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-T(M) Sheet 1 of 1

Driller: Tommy Desmond		Boring location:	Across from Joaquim Rd. (41.66653, -70.26913)
Helper: Sean Morgan		Ground Surface Elevation:	
Inspector: Sarah Bartlett		Date start: 9/21/2020	Date end: 9/21/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x23.96' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 4		Cleared with vacuum truck.
0					
-2					
-4	1	24/15	4 - 6	1-10-18-20	F-M-C brown sand; some gravel. Dry.
-6					
-8	2	24/15	8 - 10	4-8-8-9	F-M-C brown sand; some gravel. Dry.
-10					
-12					
-14	3	24/16	13 - 15	4-5-8-9	F-M-C brown sand; some gravel. Wet.
-16					
-18	4	24/14	18 - 20	5-8-7-6	F-M-C brown sand; some gravel. Wet.
-20					
-22					
-24	5	24/14	23 - 25	2-4-5-7	F-M brown sand; F-M-C brown sand;
-26					trace gravel. Wet.
-28	6	24/15	28 - 30	3-5-8-6	F-M brown sand; F-M-C brown sand;
-30					trace gravel. Wet.
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 28.96'
Static: 13.58'
Well screen: 23.96' to 28.96'
Native: 0' to 5'
Bentonite grout: 5' to 13'
Bentonite grout slow: 13' to 20'
Sand pack: 20' to 28.96'
End of boring: 28'
End of sample: 30'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-T(M)**

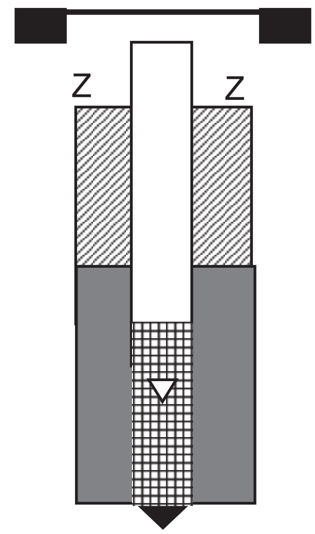
Cape Cod Test Boring	Project	Boring No. HW-T(S)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Across from 6 Joaquim Road (41.66648, -70.269207)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/21/2020	Date end: 9/21/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x8.54' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2			0 - 5		Cleared with vacuum truck.
0					Drilled with hollow stem augers to 20'
-2					and set well as directed.
-4					
-6					
-8					
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 18.54'
Static: 13.41'
Well screen: 8.54' to 18.54'
Native backfill: 0' to 1'
Bentonite seal: 1' to 5'
Sand pack: 5' to 18'
End of boring: 20'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

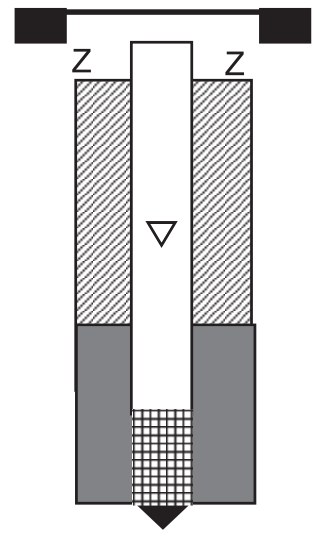
Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING | **BORING NO. HW-T(S)**

Cape Cod Test Boring	Project	Boring No. HW-U(D)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Wendy's (41.66568, -70.207908)
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 9/22/2020	Date end: 9/22/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x57.3' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT



Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description	Well Installation
2						
0						
-2						
-4						
-6	1	24/12	5 - 7	3-3-4-4	F-M-C brown sand; trace gravel. Dry.	
-8	2	24/24	8 - 10	6-14-13-14	F-M-C brown sand and gravel. Dry.	
-10						
-12						
-14	3	24/17	13 - 15	7-15-23-17	F-M-C brown sand and gravel. Dry.	
-16						
-18	4	24/18	18 - 20	5-10-16-16	F-M-C brown sand and gravel. Dry.	
-20						
-22						
-24	5	24/14	23 - 25	5-6-8-8	F-M-C brown sand; some gravel. Wet.	
-26						
-28	6	24/7	28 - 30	4-5-5-5	F-M-C brown sand; trace gravel. Wet.	
-30						
-32						
-34	7	24/14	33 - 35	3-5-5-5	F-M gray sand; F-M-C gray sand. Wet.	
-36						
-38	8	24/5	38 - 40	3-4-5-5	F-M-C brown sand. Wet.	
-40						
-42	9	24/15	43 - 45	5-5-9-10	F-M-C brown sand; trace gravel. Wet.	
-44						
-46	10	24/16	48 - 50	3-3-6-8	F-M-C brown sand; trace gravel. Wet.	
-48						*Not to scale*
-50						Well Depth: 62.3'
-52						Static: 24.66'
-54	11	24/13	53 - 55	3-5-5-8	F-M gray sand; F-M-C gray sand. Wet.	Well screen: 57.3' to 62.3'
-56						Native: 0' to 5'
-58	12	24/15	58 - 60	3-5-9-11	F-M-C brown sand; trace gravel. Wet.	Bentonite grout: 5' to 48'
-60						Bentonite grout slow: 48' to 52'
-62						Sand pack: 52' to 62'
-64	13	24/16	63 - 65	4-7-10-12	F-M-C brown sand; trace gravel. Wet.	End of boring: 63'
-66						End of sample: 65'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used	Well Installation Key
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

CAPE COD TEST BORING | **BORING NO. HW-U(D)**

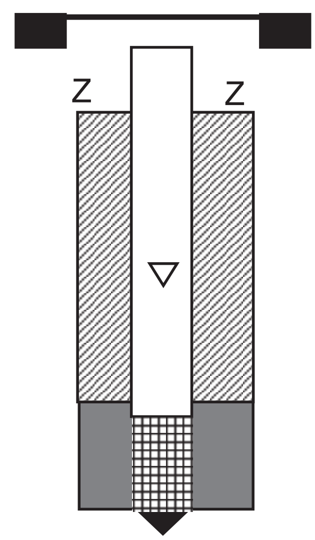
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-V (M) Sheet 1 of 1

Driller: Tommy Desmond Helper: Sean Morgan Inspector: Sarah Bartlett	Boring location: Cape Cod Gun Works (41.672148, -70.296514) Ground Surface Elevation: Date start: 9/24/2020 Date end: 9/24/2020

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x31.15' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0					
-2					
-4	1	24/5	4 - 6	8-18-16-14	F-M-C brown; some gravel. Dry.
-6					
-8	2	24/12	8 - 10	3-9-6-7	F-M-C brown sand; some gravel. Dry.
-10					
-12					
-14	3	24/15	13 - 15	3-6-12-14	F-M-C brown sand and gravel. Dry.
-16					
-18	4	24/12	18 - 20	5-6-9-7	F-M brown sand. Dry.
-20					
-22					
-24	5	24/0	23 - 25	7-8-8-6	No recovery.
-26					
-28	6	24/6	28 - 30	4-8-12-10	F-M-C brown sand. Wet.
-30					
-32					
-34	7	24/12	33 - 35	2-4-5-5	F-M brown sand; F-M-C brown sand. Wet.
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 36.15'
Static: 22.9'
Well screen: 31.15' to 36.15'
Native: 0' to 6'
Bentonite grout: 2' to 27'
Bentonite grout slow: 27' to 30'
Sand pack: 30' to 36'
End of boring: 36'
End of sample: 35'

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-B(M)**

IEP Inc. BORING LOG

BORING NO. OW-9

SHEET 1 **OF** 2

PROJECT Barnstable Water Company

PROJECT

LOCATION Rte 28 + Yarmouth Road

ELEVATION AND DATUM 24.55(?), 24.76(m), 24.82(d), 24.86(dd)(?)

BORING CONTRACTOR Desmond Well Drilling

DATE 21 July 87

COMPLETION DEPTH 95'

BORING EQUIPMENT Hollow Stem Auger

OBSERVED WATER LEVEL DATA ~18'

ELEV.	DESCRIPTION	DEPTH SCALE	WELL DETAILS	SAMPLE NO.	REMARKS
	0-10' vf/m+ SAND and f/m+ gravel	5'			OW-9dd installed 18 Aug 87 — cemented water boxes w/ clay seals — 2" diameter PVC risers
	brown m/c+ SAND, trace f gravel	10'		SS-1	3-4-6, R=12"
	~12-14' layer of m/c+ gravel; 14' back into dk brn m/c+ sand	15'			gravel up to 4" diameter
	f/c+ SAND, trace f gravel	20'		SS-2	8-5-7, R=16"
		25'			10', 0.010 slot, sch. 40, flush joint + threaded PVC screen w/ point
	brown m/c+ SAND, some f gravel	30'		SS-3	4-8-8
		35'			
	brown f/c+ SAND, some f/m gravel	40'		SS-4	6-5-4 HNU (head space in sample jar) 2ppm
	f/c+ SAND; some f gravel	45'		SS-5	4-7-13, R=1/2" (first attempt, 10-5-6, empty)
	NO recovery	50'		SS-6	4-6-11 R=0"; no change on auger flights
	brown f/c+ SAND, some f gravel	55'		SS-7	17-15-15, R=18"; HNU 0 ppm red brown Fe staining,
	brown m/c+ SAND, some f gravel	60'		SS-8	2-8-9
	red brown m/c+ SAND, some f gravel	65'		SS-9	15-11-8

INSPECTOR: M. Nelson

IEP inc. BORING LOG

BORING NO. OW-9

SHEET 2 **OF** 2

PROJECT Barnstable Water Company	**PROJECT**
LOCATION Rte 28 + Yarmouth Road	**ELEVATION AND DATUM** msl 24.55(s), 24.76(m), 24.82(d), 24.84(dd)
BORING CONTRACTOR Desmond Well Drilling	**DATE** 21 July 87 / **COMPLETION DEPTH** 95'
BORING EQUIPMENT Hollow Stem Auger	**OBSERVED WATER LEVEL DATA** ~18'

ELEV.	DESCRIPTION	DEPTH SCALE	WELL DETAILS	SAMPLE NO.	REMARKS
		70'			
	F/C+ SAND, some f gravel	75'		SS-10	21-12-12, R=18", HNU=0 ppm
		80'			
	same, brown	85'		SS-11	15-15-19 HNU=0 ppm
	pockets of brown and grey CLAY on last flight of auger	90'	screen		10', 0.010 slot, schedule 40, flush joint threaded, PVC screens with point
	BOH 95'	95'			
		100'			
		105'			
		110'			

INSPECTOR: M. Nelson

BORING LOG

Boring No. OW-18
Sheet 1 of 2

Project: Water Quality Investigation
Client: Maher Wellfield Task Force
Boring Contractor: Desmond Well Drilling, Inc.
Boring Equipment: hollow stem auger
Ground Water: Date Depth, ft.

Date: 30 July 1990
Completion Depth: 125.5'
Elevation: 39.27 (s), 39.12 (m), 39.06 (d) msl
Inspector: M. Nelson, R. Lamb

Depth (feet)	Description	Sample Number	Penetra./ Recovery	Blow Count	Comments	Well Details
0	f/c SAND, m gravel				cemented water boxes with clay seals	
5						
10						
15					2" diameter, schedule 40, flush joint threaded, PVC risers	
20						
25	f/m+c SAND, some f/m gravel	ss-1		6-14-14	10', 0.010 slot, schedule 40, flush joint threaded, PVC screen with point set at 34'	
30	f/c SAND, trace gravel	ss-2	18"/6"	3-5-9		
35	f/m+c SAND	ss-3	18"/6"	3-4-8		
40	f/m+c SAND, trace f gravel	ss-4		9-14-25	dark color	
45	f/m+c SAND, some m gravel	ss-5	18"/12"	5-13-30		
50	f/c SAND	ss-6	18"/14"	6-13-28		
55	f/c SAND, trace f gravel	ss-7	18"/2"	5-4-8		
60	f/c+ SAND, trace f gravel	ss-8				
65	f+/m SAND	ss-9			10' heave	
70	f/m SAND; 2" c SAND and f/mgravel	ss-10			Fe stain; 10', 0.010 slot PVC screen (see above) set at 75'	
75	f/c+ SAND	ss-11		10-20-9		
80	f/m+/c SAND, trace m gravel	ss-18	24"/24"		2.5' heave	

Proportions used:

trace (tr)	0-10%
little (li)	10-20%
some (so)	20-35%
and	35-50%

Abbreviations:

f = fine	f/c = fine to coarse
m = medium	v = very
c = coarse	+ = more
f/m = fine to medium	- = less

HWH, Inc.

BORING LOG

Boring No. OW-18
Sheet 2 of 2

Project: Water Quality Investigation
Client: Maher Wellfield Task Force
Boring Contractor: Desmond Well Drilling, Inc.
Boring Equipment: hollow stem auger
Ground Water: Date Depth, ft.

Date: 30 July 1990
Completion Depth: 125.5'
Elevation: 39.27 (s), 39.12 (m), 39.06 (d) msl
Inspector: M. Nelson, R. Lamb

Depth (feet)	Description	Sample Number	Penetra./ Recovery	Blow Count	Comments	Well Details
85	f/m+/c SAND, some f gravel	ss-13		7-4-8	small sample	
90	f/c+ SAND, some f/m gravel	ss-14	18"/18"	6-8-10		
95	f/c SAND	ss-15	18"/12"	4-7-8		
100	same	ss-16		3-7-17		
105	f/m+/c SAND	ss-17				
110	greyish f+/m SAND	ss-18	24"/24"		2.5' heave	
115	f/c SAND, trace blue silty sand	ss-19			1.5' heave	
120	f SAND, trace blue-grey silty sand	ss-20			10', 0.010 slot, schedule 40, flush threaded PVC screen with point set at 125.5'	
125	grey f/m SAND, m gravel, f silty sand, trace clay	ss-21				
130	BOH 125.5'					

Proportions used:

trace (tr)	0-10%
little (li)	10-20%
some (so)	20-35%
and	35-50%

Abbreviations:

f = fine
m = medium
c = coarse
f/m = fine to medium
f/c = fine to coarse
v = very
+ = more
- = less

HWH, Inc.

BORING LOG

Boring No. OW-19
Sheet 1 of 2

Project: Remidial Investigation
Client: Barnstable Water Company
Boring Contractor: Desmond Well Drilling, Inc.
Boring Equipment: hollow stem auger
Ground Water:

Date	Depth, ft.
6 Sept 90	~ 27.5

Date: 6 September 1990
Completion Depth: 111.5'
Elevation: 39.13 (s), 39.12 (m), 39.06 (d) msl
Inspector: Odiaga

Depth (feet)	Description	Sample Number	Penetra./ Recovery	Blow Count	Comments	Well Details
0					cemented water boxes with clay seals	
5	vf/v SAND, some gravel, trace coarse sand					
10	f/m+/c SAND, some to trace fine gravel					
15					2" diameter, schedule 40, flush joint threaded PVC risers	
20						
25	f/m+ SAND, trace f gravel	ss-1	18"/≥12"	7-14-15	10', 0.010 slot, PVC screen with point set at 33'	
30	same	ss-2	18"/≥12"	4-10-9		
35	f/c SAND	ss-3	18"/≥12"	5-12-23		
40	vf/c SAND	ss-4	18"/≥12"	4-6-11		
45	same	ss-5	18"/≥12"	3-5-6	dark brown stain at ~44'	
50	vf/f+/m+/c SAND	ss-6	18"/≥12"	3-7-11		
55	same	ss-7	18"/≥12"	6-13-23		
60	f/m+/c SAND, trace f gravel	ss-8	24"/≥12"	7-9-10-23		
65	f/m+/c SAND	ss-9	24"/3"	5-8-12-16		
70	f/c SAND, trace f gravel	ss-10	18"/≥ 12"	5-13-25		
75	vf/f SAND, tr m sand,f gravel	ss-11	18"/≥12"	12-47-46	10'. 0.010 slot, PVC screen with point set at 77'	
80	vf/f+/m+/c SAND, tr f gravel	ss-12	18"/≥12"	2-4-15		

Proportions used:

trace (tr)	0-10%
little (li)	10-20%
some (so)	20-35%
and	35-50%

Abbreviations:

f = fine
m = medium
c = coarse
f/m = fine to medium
f/c = fine to coarse
v = very
\+ = more
\- = less

HWH, Inc.

BORING LOG

Boring No. OW-19
Sheet 2 of 2

Project: Remidial Investigation
Client: Barnstable Water Company
Boring Contractor: Desmond Well Drilling, Inc.
Boring Equipment: hollow stem auger
Ground Water:

Date	Depth, ft.
6 Sept 90	~ 27.5

Date: 6 September 1990
Completion Depth: 111.5'
Elevation: 39.13 (s), 39.12 (m), 39.06 (d) msl
Inspector: Odiaga

Depth (feet)	Description	Sample Number	Penetra./ Recovery	Blow Count	Comments	Well Details
85	vf/vc SAND, trace f/m gravel	ss-13	18"/>12"	4-5-6		
90	f/c SAND, tr vf sand, vf gravel	ss-14	24"/≥12"	17-10-7-7	may not be a representative sample	
95	{f/vc SAND, tr f/m gravel with a 1/16" lens of SILT, tr f/m gravel}	ss-15	24"/≥12"	4-10-20-43	slight Fe stain 10', 0.010 slot, schedule 40,	
100	no recovery	NR	24"/0"	17-20-23/30	flush joint threadedPVC screenwith point at 110'--	
105	vf/vc SAND and vf/f gravel	ss-16	24"/>12"	∞	approximately 300 blows	
	{f/m+/c SAND, tr f gravel					
110	4" brown CLAY, some silt}	ss-17	24"/>12"	∞	Fe stained; augered down 18"	
	f/m+/c SAND, tr f gravel	ss-18	24"/>12"	∞	some Fe stain	
115	BOH 111.5'					

Proportions used:
trace (tr) 0-10%
little (li) 10-20%
some (so) 20-35%
and 35-50%

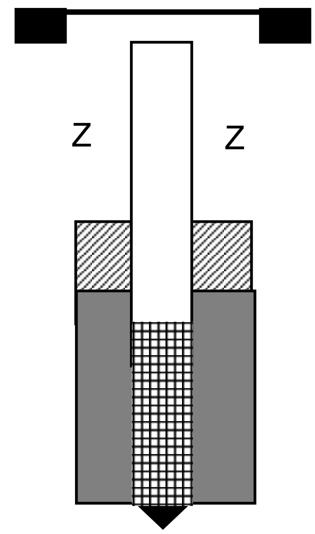
Abbreviations:
f = fine
m = medium
c = coarse
f/m = fine to medium
f/c = fine to coarse
v = very
+ = more
- = less

HWH, Inc.

Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-U(s) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Wendy's
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 4/5/2021	Date end: 4/8/2021

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x20' SCH40 PVC FJT Screen Size: 2"x10'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description	Well Installation
2						
0			0 - 30		F-M-C brown sand.	
-2						
-4						
-6					Drilled with hollow stem augers to 30'	
-8					and set well as directed.	
-10						
-12						
-14						
-16						
-18						
-20						
-22						
-24						
-26						
-28						
-30						
-32						
-34						
-36						
-38						
-40						
-42						
-44						
-46						
-48						*Not to scale*
-50						Well Depth: 28.8'
-52						Static: 23.69'
-54						Well screen: 18.8' to 28.8'
-56						Native: 0' to 13'
-58						Bentonite grout: n/a
-60						Bentonite seal: 13' to 16'
-62						Sand pack: 16' to 28.8'
-64						End of boring: 30'
-66						End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used	Well Installation Key
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-U(s)**

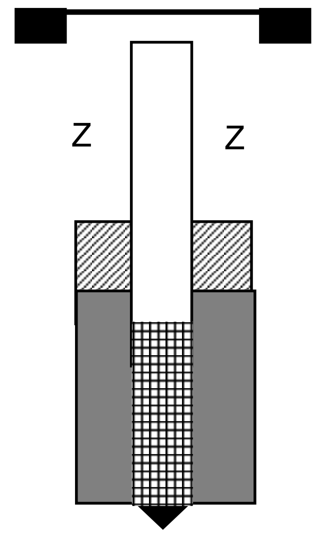
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-U(M) Sheet 1 of 1

Driller: Tommy Desmond	Boring location: Wendy's
Helper: Sean Morgan	Ground Surface Elevation:
Inspector: Sarah Bartlett	Date start: 4/5/2021 Date end: 4/8/2021

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x35' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0			0 - 40		F-M-C brown sand.
-2					
-4					
-6					Drilled with hollow stem augers to 40'
-8					and set well as directed.
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

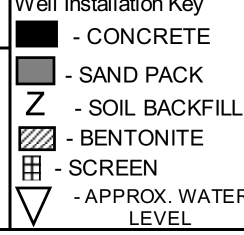
Well Installation



Not to scale
Well Depth: 38.93'
Static: 23.61'
Well screen: 18.61' to 23.61'
Native: 0' to 2'
Bentonite grout: 2' to 25'
Bentonite seal: 25' to 28.93'
Sand pack: 28.93' to 38.93'
End of boring: 40'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key



CAPE COD TEST BORING **BORING NO. HW-U(m)**

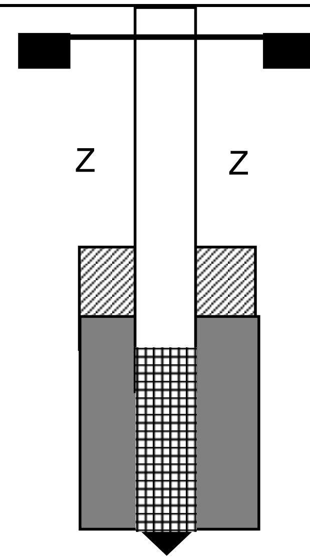
Cape Cod Test Boring	Project	Boring No. HW-W(M)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group	
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of 1
div. Desmond Well Drilling, Inc.	Hyannis, MA	

Driller:	Tommy Desmond	Boring location:	Watershed area
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 4/5/2021	Date end: 4/8/2021

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x45' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0			0 - 50		F-M-C brown sand.
-2					
-4					
-6					Drilled with hollow stem augers to 50'
-8					and set well as directed.
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale
Well Depth: 52.01'
Static: 28.90'
Well screen: 47.01' to 52.01'
Native: 0' to 5'
Bentonite grout: 5' to 39'
Bentonite seal: 39' to 42'
Sand pack: 42' to 52.01'
End of boring: 50'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-W(M)**

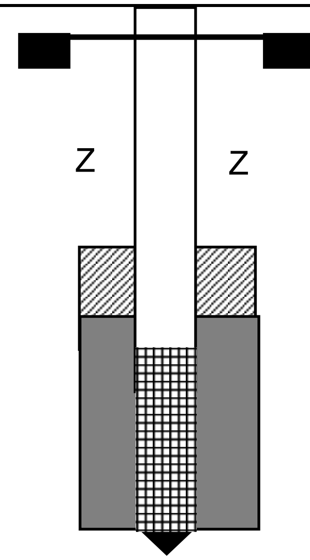
Cape Cod Test Boring 5 Rayber Road, Orleans, MA 02653 (508) 240-1000 div. Desmond Well Drilling, Inc.	Project Horsley Witten Group Barnstable, 480 Barnstable Road Hyannis, MA	Boring No. HW-W(D) Sheet 1 of 1

Driller:	Tommy Desmond	Boring location:	Watershed area
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 4/5/2021	Date end: 4/8/2021

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size: 6 1/4" x 4" H.S.A Casing Size: 2"x55' SCH40 PVC FJT Screen Size: 2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description
2					
0			0 - 60		F-M-C brown sand.
-2					
-4					
-6					Drilled with hollow stem augers to 60'
-8					and set well as directed.
-10					
-12					
-14					
-16					
-18					
-20					
-22					
-24					
-26					
-28					
-30					
-32					
-34					
-36					
-38					
-40					
-42					
-44					
-46					
-48					
-50					
-52					
-54					
-56					
-58					
-60					
-62					
-64					
-66					

Well Installation



Not to scale

Well Depth: 61.77'
Static: 28.67'
Well screen: 56.77' to 61.77'
Native: 0' to 5'
Bentonite grout: 5' to 48'
Bentonite seal: 48' to 51'
Sand pack: 51' to 56.77'
End of boring: 60'
End of sample: n/a

Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%
> 50	V. DENSE	15 - 30	V. STIFF	
		> 30	HARD	

Well Installation Key
- CONCRETE
- SAND PACK
Z - SOIL BACKFILL
- BENTONITE
- SCREEN
- APPROX. WATER LEVEL

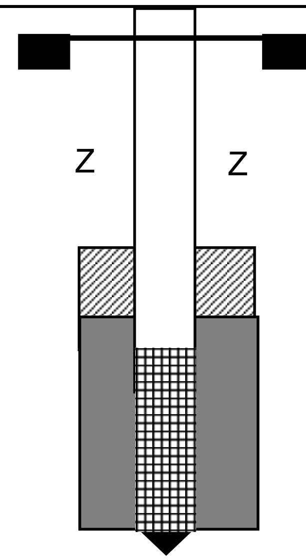
CAPE COD TEST BORING | **BORING NO. HW-W(D)**

Cape Cod Test Boring	Project	Boring No.	HW-W(DD)
5 Rayber Road, Orleans, MA 02653	Horsley Witten Group		
(508) 240-1000	Barnstable, 480 Barnstable Road	Sheet 1 of	1
div. Desmond Well Drilling, Inc.	Hyannis, MA		

Driller:	Tommy Desmond	Boring location:	Watershed area
Helper:	Sean Morgan	Ground Surface Elevation:	
Inspector:	Sarah Bartlett	Date start: 4/5/2021	Date end: 4/8/2021

Sampler consists of a two inch split spoon driven using a 140 lb. hammer falling thirty inches	Notes:	Auger Size:	6 1/4" x 4" H.S.A
		Casing Size:	2"x67' SCH40 PVC FJT
		Screen Size:	2"x5'X.010 SCH40 PVC FJT

Depth (FT)	Sample NO	PEN/REC	DEPTH/FT	BLOWS 6"	Sample Description	Well Installation
2						
0						
-2						
-4	1	24/19	3 - 5	7-8-8-14	F-M-C brown sand; trace gravel. Dry.	
-6						
-8	2	24/16	8 - 10	2-5-7-7	F-M brown sand. Dry.	
-10						
-12						
-14	3	24/8	13 - 15	4-4-8-7	F-M-C brown sand; little gravel. Dry.	
-16						
-18	4	24/13	18 - 20	3-5-7-9	F-M-C brown sand; some gravel. Dry.	
-20						
-22						
-24	5	24/16	23 - 25	4-5-6-4	F-M brown sand. Dry.	
-26						
-28	6	24/10	28 - 30	1-4-4-6	F-M-C brown sand. Wet.	
-30						
-32						
-34	7	24/12	33 - 35	2-3-3-4	F-M-C brown sand. Wet.	
-36						
-38	8	DHH	38 - 40	DHH	F-M-C brown sand. Wet.	
-40						
-42						
-44	9	DHH	43 - 45	DHH	F-M-C brown sand. Wet.	
-46						
-48	10	DHH	48 - 50	DHH	F-M-C brown sand; M-C brown sand.	*Not to scale*
-50					Wet.	Well Depth: 72.05'
-52						Static: 28.59'
-54	11	DHH	53 - 55	DHH	F-M brown sand; M-C brown sand; some	Well screen: 67.05' to 72.05'
-56					gravel. Wet.	Native: 0' to 5'
-58	12	DHH	58 - 60	DHH	F-M-C brown sand. Wet.	Bentonite grout: 5' to 59'
-60						Bentonite seal: 59' to 62'
-62						Sand pack: 62' to 72.05'
-64	13	DHH	63 - 65	DHH	F-M brown sand. Wet.	End of boring: 70'
-66	14	DHH	68 - 70	DHH	No sample. Set well.	End of sample: 70'



Granular Soils BLOWS/FT	DENSITY	Cohesive Soils BLOWS/FT	DENSITY	Proportions Used	Well Installation Key
0 - 4	V. LOOSE	> 2	V. SOFT	Trace 0 - 10%	- CONCRETE
4 - 10	LOOSE	2 - 4	SOFT	Little 10 - 20%	- SAND PACK
10 - 30	M. DENSE	4 - 8	M. STIFF	Some 20 - 35%	Z - SOIL BACKFILL
30 - 50	DENSE	8 - 15	STIFF	And 35 - 50%	- BENTONITE
> 50	V. DENSE	15 - 30	V. STIFF		- SCREEN
		> 30	HARD		- APPROX. WATER LEVEL

CAPE COD TEST BORING **BORING NO. HW-W(DD)**

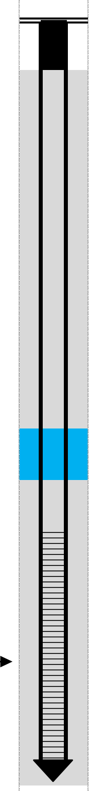
Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

BORING LOG: HW-X(s)

Project: 21084	**Date:** 9/7/2021
Client: Cape Cod Gateway Airport	**Completion Depth:** 30.00'
Drilling Contractor: New England Geotech.	**Elevation:** N/A
Drilling Equipment: Direct Push	**Inspector:** VA
Drilling Location: North Ramp, Adjacent to Former ARFFF/SRE Building	**Depth to Water:** 24.80 BGS

Proportions		**Color**	**USCS Code**		**Size**	**Misc.**
trace (trc)	0 - 10%	Blue (Bl)	Well-Graded Gravel (GW)	Inorganic Clays of High Plasticity, Fat	Fine = (f)	Fragments (frag.)
little (li)	10 - 20%	Red (R)	Poorly-Graded Gravel (GP)	Clays, Sandy Clays of High Plasticity (CH)	Medium = (m)	Cement (cem.)
some (so)	20 - 35%	Light (lt)	Silty Gravels, Gravel-Sand-Silt Mixtures (GM)	Organic Silts and Clays of Low to Medium	Coarse = (c)	Below Ground Surface (BGS)
and	35 - 50%	Dark (dk)	Clayey Gravels, Gravel-Sand-Clay Mixtures (GC)	Plasticity, Sandy Organic Silts, and Clays (OL)	Dark = (dk)	Total Organic Vapors (TOV)
		Rust (Ru)	Well-Graded Sand (SW)	Organic Silts and Clays of High Plasticity,	Fine to Coarse = (f-c)	Parts per million (PPM)
		Brown (Br)	Poorly-Graded Sand (SP)	Sandy Organic Silts and Clays (OH)	Very = (v)	Not Available (N/A)
		Orange (Or)	Silty Sands, Sand Silt Mixtures (SM)	Peat (PT)	More/Less = (+/-)	Depth to Water (DTW)
		Black (Blk)	Clayey Sands, Sand-Clay Mixtures (SC)			
		Angular	Inorganic Silts, Clayey Silts of Low to Medium Plasticity (ML)			
		Round (rnd.)	Inorganic Silts, Micaceous, or Diatomaceous Silty Soils, Elastic Silts (MH)			
		Angular (ang.)	Inorganic Clays of Low to Medium Plasticity, Gravely, Sandy, and Silty Clays (CL)			

Depth Feet	Description	TOV (PPM)	Recovery	USCS Code	Color	Comments	Well Details	Depth Feet
0-2	0-8" asphalt followed by dry, tan fine sand and gravel	<0.1	54/62	SP	lt			0-2' feet concrete collar and road box
2-4	Dry, tan fine sand and gravel	<0.1						
4-6	Dry, fine to medium tan sand with trace gravel	<0.1	62/62	SP	lt			
6-8	Dry, fine to medium tan sand with trace gravel	<0.1						
8-10	Dry, fine to medium tan sand with trace gravel	<0.1	62/62	SP	lt			
10-12	Dry, fine to medium tan sand with trace gravel	<0.1						Sand pack 2'-16'
12-14	Dry, fine to medium tan sand with trace gravel	<0.1	62/62	SP	lt			
14-16	Dry, fine to medium tan sand with trace gravel	<0.1						
16-18	Dry, fine to medium tan sand with trace gravel	<0.1	62/62	SP	lt			Bentonite pack 16'-18'
18-20	Moist, fine to medium tan sand with trace gravel	<0.1						
20-22	NA					Hole collapse at 20'. Hammer casing to 30' and set well.		Sand pack 18'-30'
22-24	NA							
24-26	NA					DTW: 24.80'		
26-28	NA					2-inch 0.010 slot PVC screen Screen Interval: 25'-30' BGS		
28-30	NA							



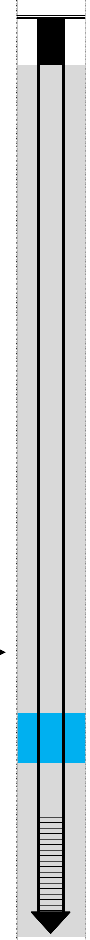
Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Sandwich, MA • 02563
Tel: 508-833-6600 • Fax: 508-833-3150 • www.horsleywitten.com

BORING LOG: HW-X(m)

Project: 21084	**Date:** 9/7/2021
Client: Cape Cod Gateway Airport	**Completion Depth:** 37.00'
Drilling Contractor: New England Geotech.	**Elevation:** N/A
Drilling Equipment: Direct Push	**Inspector:** VA
Drilling Location: North Ramp, Adjacent to Former ARFFF/SRE Building	**Depth to Water:** 25.15 BGS

Proportions		Color	USCS Code		Size	Misc.
trace (trc)	0 - 10%	Blue (Bl)	Well-Graded Gravel (GW)	Inorganic Clays of High Plasticity, Fat	Fine = (f)	Fragments (frag.)
little (li)	10 - 20%	Red (R)	Poorly-Graded Gravel (GP)	Clays, Sandy Clays of High Plasticity (CH)	Medium = (m)	Cement (cem.)
some (so)	20 - 35%	Light (lt)	Silty Gravels, Gravel-Sand-Silt Mixtures (GM)	Organic Silts and Clays of Low to Medium	Coarse = (c)	Below Ground Surface (BGS)
and	35 - 50%	Dark (dk)	Clayey Gravels, Gravel-Sand-Clay Mixtures (GC)	Plasticity, Sandy Organic Silts, and Clays (OL)	Dark = (dk)	Total Organic Vapors (TOV)
		Rust (Ru)	Well-Graded Sand (SW)	Organic Silts and Clays of High Plasticity,	Fine to Coarse = (f-c)	Parts per million (PPM)
		Brown (Br)	Poorly-Graded Sand (SP)	Sandy Organic Silts and Clays (OH)	Very = (v)	Not Available (N/A)
		Orange (Or)	Silty Sands, Sand Silt Mixtures (SM)	Peat (PT)	More/Less = (+/-)	Depth to Water (DTW)
		Black (Blk)	Clayey Sands, Sand-Clay Mixtures (SC)			
		Angular	Inorganic Silts, Clayey Silts of Low to Medium Plasticity (ML)			
		Round (rnd.)	Inorganic Silts, Micaceous, or Diatomaceous Silty Soils, Elastic Silts (MH)			
		Angular (ang.)	Inorganic Clays of Low to Medium Plasticity, Gravely, Sandy, and Silty Clays (CL)			

Depth Feet	Description	TOV (PPM)	Recovery	USCS Code	Color	Comments	Well Details	Depth Feet
0-2	NA					Installed adjacent to HW-X(s). 1.5" prepacked stainless steel screen with PVC Riser.		0-2' feet concrete collar and road box
2-4	NA							
4-6	NA							
6-8	NA							
8-10	NA							
10-12	NA							Sand pack 2'-28'
12-14	NA							
14-16	NA							
16-18	NA							
18-20	NA							
20-22	NA							
22-24	NA							
24-26	NA					DTW: 25.15'		
26-28	NA							
28-30	NA							Bentonite pack 28-30'
30-32	NA							
32-34	NA							Sand pack 30'-37'
34-36	NA					1.5-inch 0.010 slot stainless steel screen Screen Interval: 32'-37' BGS		
36-37	NA							



APPENDIX G

HYDRAULIC CONDUCITIVITY WORKSHEETS

HW-F

Low Flow Single Well Pumping Test Analysis (Robbins, 2009)

$$K = \frac{Q * 2.303 * \log(Re/R)}{2\Pi LeH}$$

- Steady State Radial Flow Equation

K = hydraulic conductivity
Q = flow rate
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
H = Steady State drawdown
R = Borehole intake radius (includes sand pack)
Re = Radius of influence in aquifer (calculated separately)
ln = natural log
Units must be consistent

$$Re = R * \exp\left[\left(\frac{1.1}{\ln(Lw/R)}\right) + \left(\frac{C}{Le/R}\right) \right]^{-1}$$

- Bouwer and Rice, 1976

Re = Radius of influence in aquifer
R = Borehole intake radius (includes sand pack)
Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)
C = Dimensionl ess constant (from graph)
Lw = Distance from static watertable down to bottom of well screen
Units must be consistent

Flow Rate:

Vol=	40	gal
Time=	1296.00	s
Flow=	0.25	cf/min

Input Factors:

Total Well Depth=	26.82	ft
Initital Depth to Water=	20.242	ft
Initial Water Column=	6.578	ft
Final Depth to Water =	20.483	ft
Final Water Column=	6.337	ft
Screen Length=	10	ft
Screen Diameter =	2	in
Borehole Diameter =	6.25	in
K_h / $K/_v$ =		

Initial Calculations:

Lw=	6.578	ft
Le=	6.337	ft
H=	0.241	ft
R=	0.26	ft
Le/R=	24.33	
C=	3.00	

Final Calculations:

Re = 5.54807 ft

K_h = 0.079 ft/min -or- 113.7 ft/day

HW-I(s)

Low Flow Single Well Pumping Test Analysis (Robbins, 2009)

$$K = \frac{Q * 2.303 * \log(Re / R)}{2\Pi LeH}$$

- Steady State Radial Flow Equation

K = hydraulic conductivity

Q = flow rate

Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)

H = Steady State drawdown

R = Borehole intake radius (includes sand pack)

Re = Radius of influence in aquifer (calculated separately)

ln = natural log

Units must be consistent

$$Re = R * \exp\left[\left(\frac{1.1}{\ln(Lw / R)}\right) + \left(\frac{C}{Le / R}\right) \right]^{-1}$$

- Bouwer and Rice, 1976

Re = Radius of influence in aquifer

R = Borehole intake radius (includes sand pack)

Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)

C = Dimensionl ess constant (from graph)

Lw = Distance from static watertable down to bottom of well screen

Units must be consistent

Flow Rate:

Vol=	75	gal
Time=	1800.00	s
Flow=	0.33	cf/min

Input Factors:

Total Well Depth=	25.09	ft
Initital Depth to Water=	18.416	ft
Initial Water Column=	6.674	ft
Final Depth to Water =	18.732	ft
Final Water Column=	6.358	ft
Screen Length=	6.358	ft
Screen Diameter =	2	in
Borehole Diameter =	6.25	in
K_h / K_v =		

Initial Calculations:

Lw=	6.674	ft
Le=	6.358	ft
H=	0.316	ft
R=	0.26	ft
Le/R=	24.41	
C=	3.00	

Final Calculations:

Re = 5.61934 ft

K_h = 0.081 ft/min -or- 117.1 ft/day

OW-19(m)

Low Flow Single Well Pumping Test Analysis (Robbins, 2009)

$$K = \frac{Q * 2.303 * \log(\mathrm{Re}/R)}{2\Pi LeH}$$

- Steady State Radial Flow Equation

K = hydraulic conductivity

Q = flow rate

Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)

H = Steady State drawdown

R = Borehole intake radius (includes sand pack)

Re = Radius of influence in aquifer (calculated separately)

ln = natural log

Units must be consistent

$$\mathrm{Re} = R * \exp\left[\left(\frac{1.1}{\ln(Lw/R)}\right) + \left(\frac{C}{Le/R}\right) \right]^{-1}$$

- Bouwer and Rice, 1976

Re = Radius of influence in aquifer

R = Borehole intake radius (includes sand pack)

Le = Screen intake length (if water level at end of test is lower than the top of the screen, then L equals the distance from the final water level to the bottom of the screen)

C = Dimensionless constant (from graph)

Lw = Distance from static watertable down to bottom of well screen

Units must be consistent

Flow Rate:

Vol=	75	gal
Time=	1800.00	s
Flow=	0.33	cf/min

Input Factors:

Total Well Depth=	76.14	ft
Initital Depth to Water=	26.942	ft
Initial Water Column=	49.198	ft
Final Depth to Water =	27.417	ft
Final Water Column=	48.723	ft
Screen Length=	10	ft
Screen Diameter =	2	in
Borehole Diameter =	6.25	in
K_h / $K/_v$ =		

Initial Calculations:

Lw=	49.198	ft
Le=	10	ft
H=	0.475	ft
R=	0.26	ft
Le/R=	38.40	
C=	3.00	

Final Calculations:

Re = 33.03256 ft

K_h = 0.054 ft/min -or- 78.1 ft/day