SANGB - ISWTS – Corrective Action Report
PFOS/PFOA Detection in Effluent
Event Period: 8 to 17 February 2021
Corrective Action Report Date: 15 March 2021

PART 1 - ISWTS BACKGROUND

The Interim Storm Water Treatment System (ISWTS) has been operating consistently since 13 July 2020 when it was put back into operation with the enhanced pretreatment system. Between July 2020 and February 2021, three alternative regimes were tested to confirm the PFAS removal effectiveness in order to determine the most cost-effective treatment approach, while also considering other external factors such as environmental considerations. The ISWTS consists of four treatment trains with three treatment vessels per train. The three configuration regimes tested are each briefly discussed as follows:

Regime 1 - 13 July to 16 September: This PFAS treatment regime consisted of one Granular Activated Carbon (GAC) vessel using reactivated carbon followed by two ion-exchange resin vessels using Purolite PFA-694 series resin. This regime was able to successfully treat approximately 21 Million Gallons (MG) and 10,000 Bed Volumes (BVs); however, the media required a premature exchange due to biofouling issues which resulted in breakthrough of PFOS/PFOA in the secondary resin before the life of the media was exhausted. The maximum detected combined PFOS and PFOA never exceeded 4.1 parts per trillion (ppt) in the effluent. Good PFAS removal was observed in the GAC unit, therefore, it was decided to utilize the GAC further as it is less susceptible to fouling and easier to maintain.

Regime 2 – 24 September to 5 November: The PFAS treatment regime was revised to consist of two GAC vessels also using reactivated GAC and one vessel of ion-exchange resin. All media vessels were replaced with new media. Performance data confirmed that the reactivated carbon performance was not as effective as Regime 1 and breakthrough of PFOS/PFOA in the secondary GAC column exceeded 50% of the lifetime Health Advisory (HA) of 35 ppt on 15 October after 7.5 MG and 3,580 BVs. However, the resin performance was efficient and the highest effluent concentration of combined PFOS/PFOA detected was 1.4 ppt. Overall, this regime treated approximately 16.6 MG or 8,000 BVs. Based on the results obtained during this regime, it was concluded that reactivated GAC was not as effective on a consistent basis as observed in Regime 1. However, the resin condition was good, and only the GAC was replaced.

Regime 3 – 6 November to 17 February: The reactivated carbon was replaced with Calgon F400 virgin carbon because it has demonstrated excellent PFAS removal at other sites. The GAC performance was substantially improved here as well. During the latter stages of Regime 3, the maximum detection of combined PFOS/PFOA in the primary GAC was 54 ppt and the secondary GAC was 1.1 ppt. However, the resin performance was degrading. Higher PFOS and PFOA detections were detected in the final effluent, suggesting that the resin was saturated and now desorbing PFAS compounds; therefore, it is likely that the increased concentrations in the effluent can be attributed to the loading that occurred during Regime 2. The Table below summarizes the PFOS/PFOA results of the final 4 weeks of Regime 3 before media change out occurred. As of 4 February 2021, the GAC had treated over 44 MG or 21,000 BVs, while the resin had treated over 60 MG or 29,000 BVs. This regime clearly demonstrated the best performance when comparing the volume treated.

Combined PFOS/PFOA Results Summary (Prior to Exceedance) ppt					
Date	Influent	Primary GAC	Secondary GAC	Resin Effluent	Overall Combined Effluent
1/25/21	351	54	1.1	14.2	8.1
1/28/21	434	28	ND	12.6	10.9
2/1/21	325	2.3	0.5	18.2	6.1
2/4/21	285	3.4	0.5	35.0	12.2

Results are based on 2A validated data and are still preliminary

PART 2 - ISWTS MEDIA EXCHANGE AND DETECTION OF PFOS/PFOA ABOVE HA IN EFFLUENT

During middle to late January 2021, the BERS Weston team started to plan for the next media change. A complete media replacement was recommended and approved with the same arrangement as Regime 3. A targeted date for the media exchange was set for 1 February; however, weather conditions delayed the work until 8 February. Based on the results summarized above and the observed continued degradation of resin media performance the resin was taken off-line when the media exchange began. This decision was based on the excellent performance of the primary and secondary GAC to date. In addition, because media exchange activities would be taking trains on/off-line and replaced with new media, only the influent and effluent of the system would be monitored by sampling, and not intra-process performance.

The media exchange process began on 8 February 2021. During media exchange activities influent and effluent samples were collected on 9, 11 and 15 February to document performance. On 17 February 2021, the results from 9 February were received indicating that a combined concentration of PFOS/PFOA was detected in the effluent at 139 ppt. Upon receipt of this information, BERS Weston notified USACE and ANG/NGB of the lifetime HA exceedance and subsequently diverted effluent to recirculation back to the pond and not over the outfall weir. A prompt evaluation of potential causes of the exceedance was initiated. All PFOS/PFOA results that were collected during the media exchange are summarized below.

Combined PFOS/PFOA Summary (During Media Exchange) ppt		
Date	Influent	Effluent
2/9/21	295	139
2/11/21	337	195
2/15/21	305	55

Results are based on 2A validated data and are still preliminary

The media exchange work was completed on 17 February 2021. On 18 February 2021 after all media trains were placed back in service with new media, normal compliance and intra-process monitoring resumed. The effluent continued to be diverted to the recreation pond until sampling results confirmed

acceptable performance. On 24 February 2021, the 18 February 2021 PFAS results were received that demonstrated acceptable system performance. These results are summarized below. On 24 February 2021, normal operations resumed and treated effluent was discharged over the outfall weir.

Combined PFOS/PFOA Summary (After Exceedance) ppt					
Date	Influent	Primary GAC	Secondary GAC	Resin Effluent	Overall Effluent
2/18/21	229	ND	ND	ND	ND

Results are based on 2A validated data and are still preliminary

PART 3 – EVALUATON OF POTENTIAL CAUSES AND CORRECTIVE ACTION RECOMENDATIONS.

After BERS Weston was notified of the increased PFOS/PFOA in the ISWTS effluent during the media exchange an evaluation of the potential causes and corrective actions was initiated. A complete summary of these results are included in Table 1 (attached). To confirm if some of the potential causes contributed to the elevated PFOS/PFOA detections in the effluent, additional quality control samples were also collected during the 18 February 2021 sampling event. These additional samples included equipment blanks and a comparison of various sample collection techniques used at the effluent when weather conditions resulted in frozen valves and the use of a heat gun was required to thaw (open up) sample ports. Results of these samples indicated that sample collection techniques were not related to the increase of PFOS/PFOA observed in the effluent samples.

As noted in Table 1, the primary lesson learned is that despite intra-process media results indicating great performance, all three treatment columns should remain in operation during the media change-out process. When BERS Weston took the resin off-line, only two GAC columns were in service. It is believed that when the resin was taken off line, this caused preferential flow and possibly short circuiting that resulted in reduced GAC contact time leading to elevated PFOS/PFOA levels in the effluent. Going forward all three media trains will remain in service including during media exchanges. The other recommendations are to continue with our current quality control practices and increase sample port flushing on both the influent and effluent sample ports consistent with the other intra-process monitoring locations.

System shut down or diverting effluent to recirculate to the recreation pond during future media exchange events is not recommended at this time, because the other treatment objective is to contain and treat all stormwater to the maximum practical extent. Both system shut down and effluent recirculation prohibits pond water-level drawdown and increases the likelihood of PFOS/PFOA-impacted water to flow over the weir. During changeout, maintaining and operating all three media vessels in each treatment train while individual trains are changed out, is the current recommendation. However, if future conditions present uncertainty in ensuring effluent compliance, then system shut down or recirculation will be considered.

SANGB - ISWTS
High Effluent PFOS/PFOA
Potential Causes/Corrective actions

No.	Potential Cause for Increased PFOS/PFOA in effluent during media exchange	Further Evaluation and Discussion	Recommended Corrective Action
1	**PREFERENTIAL FLOW & REDUCED GAC CONTACT TIME:** The flow through each treatment train is not controlled. The head pressure from each treatment train impacts flow. We suspect that when the resin was taken off line that this could have caused non-equal flow to the trains or on-line trains that reduced contact time in certain GAC trains that resulted in poor treatment performance.	This theory continues to be the most likely cause for the exceedances. Flow metering could be considered on individual trains but we don't believe it is necessary at this time. Instead continue to monitor individual treatment trains to confirm acceptable performance of each train.	For future media exchanges run all three treatment columns whenever the trains are in service and discharging to the outfall.
2	**REDUCED OUTLET PRESSURE/SHORT CIRCUITING:** The outlet pressure of the GAC dropped by approximately 20 PSIG when the Ion Excange resin was taken off line. Possibly the reduced outlet pressure caused short circuiting in the GAC vessesl and reduced performance.	This theory is very similary to Item No. 1 as short circuiting should result in preferential flow. Again, flow metering could be considered on individual trains but we don't believe it is necessary at this time. Instead continue to monitor individual treatment trains to confirm acceptable performance of each train.	See above
3	**GRANULAR ACTIVATED CARBON MEDIA EXHAUSTED:** The media exchange was delayed due to weather. GAC performance could have degraded since previous sample event because PFOS and PFOA saturated the bed.	Based on extensive data colllected on both the primary and secondary carbon we do not think the secondary GAC was exhausted. This potential cause is not likely.	Contiue to monitor intra-process performance to enable evaluation of each media stage.
4	**POOR SAMPLE PORT FLUSHING:** In discussion with samplers, we learned the Influent/Effluent sample ports were not getting the same 5 gallon flush like the GAC/Resin samples because the ports are directly connected to the flow stream. However the sampling was consistent with past practices.	Influent and Effluent sampling during media exchange was consistent with current protocol and hisotric practices.	Implement 5 gallon minimum flush for all PFAS sample ports including Influent and Effluent going forward for consistency.
5	**EFFLUENT TUBING CONTAMINATION:** Effluent tubing has been getting removed due to cold weather/freezing. It is possible it has been contaminated.	Perform tubing equipment blank to confirm if PFAS is detected. Equipment blank collected on 18 February confirmed no contamination. This was determined not to be the cause.	None
6	**EFFLUENT SAMPLE PORT CONTAMINATION FROM HEAT GUN:** A heat gun had been used to thaw sample port during previous cold periods. The heat gun could be a potential cause of contamination. It was only used on the 9th and earlier samples but historical contamination could have been present. The heat gun was not used on the 11th or 15th.	Performed additional equipment blanks with heat gun on effluent sample port with and without tubing to see if PFAS was detected. Equipment blanks collected on 18 February confirmed no contamination. This was determined not to be the cause.	None
7	**SAMPLER ERROR:** Same sampling protocol being followed by two separerate samplers. On the 9th, the pump had to be shut down to replace the influent sample port. Typically the system is running stead state at time of sample collection.	The influent port/pump shutdown is not believed to have impacted the effluent sample results because PFAS was also detected on the two subsequent sample events. The samplers are also completing the PFAS QC checklist and field blanks on every sample event.	Continue to follow PFAS sampling guidelines and complete checklist for each sample event.
8	**CONTAMINATED BOTTLEWARE:** Recently received new sample bottles. Could they have been contaminated?	Field blanks were collected on all sample results and eachwere Non Detect, confirming the bottles are not contaminated.	Continue with performing one Field Blank during each sampling event.
9	**Laboratory Error:** Have Chemist review results with Laboratory.	Chemist reviewed the reports, contacted the laboratory and believes laboratory results are correct. A level 2A data validation has been completed and a level 2B data validation has not yet occurred, no futher QC issues are expected.	Continue with independent Chemist QC as is currently being performed.