Appendix A – Supplemental information, Individual day on-site measurements

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On-site ductwork concentrations from individual sample days

During onsite ductwork sampling many VOCs were measured but only a portion are reported out. The concentrations are reported out for seven VOCs, methanethiol, dimethyl sulfide, dimethyl disulfide, acetaldehyde and monoterpenes (as α-pinene) are all directly calibrated from permeation tubes using the DynaCal, while acetone and acetic acid are reported out in concentration using the PTR-ToF-MS onboard IoniToF software which reports out calibrations which have typically been found within 20% of direct calibration and uses reaction parameters with the H_3O^+ ion, measured internally with the mass spectrometer. Data is displayed in boxplots to visualize all data and has accompanying tables with median concentrations.

Table 1 List of compounds displayed in following data from WWTPs ductwork, m/z's and odour detection thresholds.

m/z of protonated molecule	Chemical formula of molecule	Concentrations reported as	Odour detection threshold (ppb_v)*
49.01	CH_4S	Methanethiol	0.02
63.02	C_2H_6S	Dimethyl sulfide (DMS)	1
94.99	$C_2H_6S_2$	Dimethyl disulfide (DMDS)	0.03
45.02	C_2H_4O	Acetaldehyde	0.1
59.04	C_2H_6O	Acetone	> 20,000
61.02	$C_2H_4O_2$	Acetic Acid	> 1000
137.13	$C_{10}H_{16}$	Monoterpenes measured as α-pinene	100

WWTP1 – French creek pollution control centre from 2023-2024

Individual sampling days select VOCs are reported in this appendix, with accompanying tables.

The sample locations are from throughout the pollution control centre and can be found in figure 1 below.

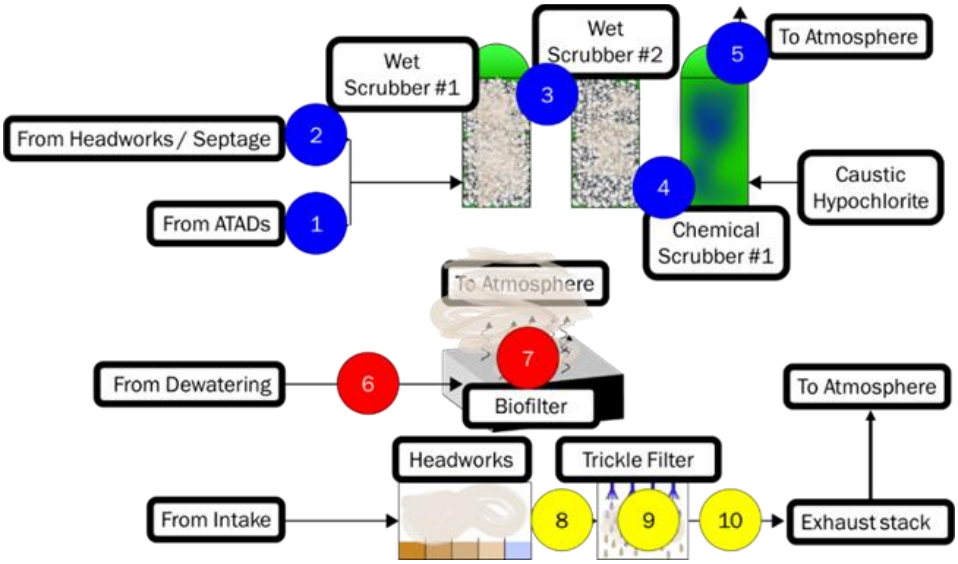


Figure 1 Sample point locations for WWTP1

Table 2 Sampling information from on-site sampling done at WWTP1.

Sampling Date	Sampling Location	Sampling Time
August 02, 2022	On-site duct and community drive	08:45-11:45
March 23, 2023	On site duct FCPCC/ Community drive	09:20-11:40
May 24, 2023	Odour Control Pilot study	11:40-14:40
May 25, 2023	Odour Control Pilot study	09:00-11:00
May 29, 2023	On-site duct FCPCC/Odour Control Pilot study	10:15-12:45
June 12, 2023	Odour Control Pilot study	09:30-13:00
September 29, 2023	On-site duct sampling	09:45-13:45
November 6, 2023	On-site duct sampling + TD-GC/MS analysis	11:00-13:15
February 20, 2024	On-site duct sampling	11:45-14:15
Total on-site duct sampling hours (hh:mm)		25:05

March 2023 Ductwork Summary Boxplots

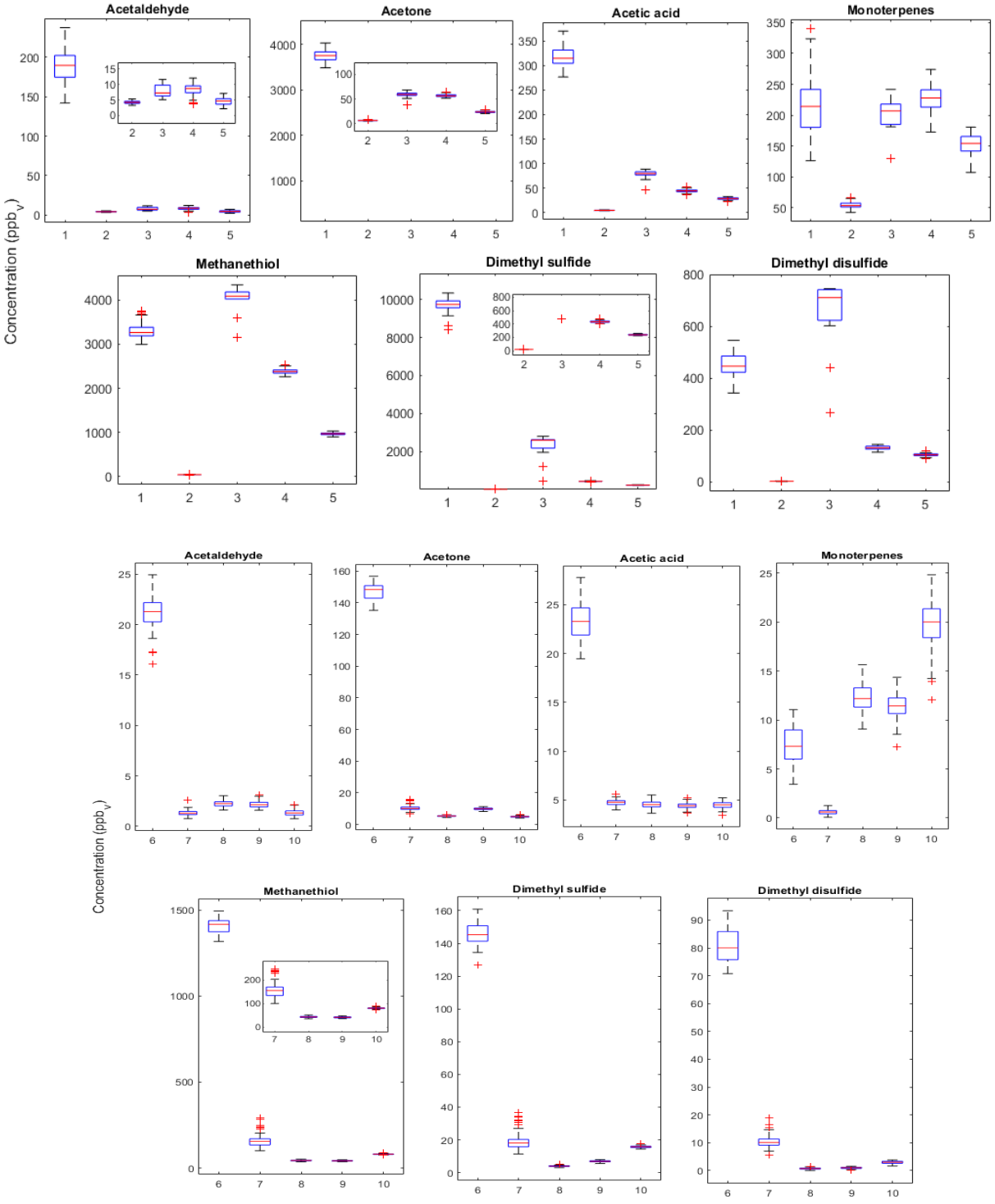
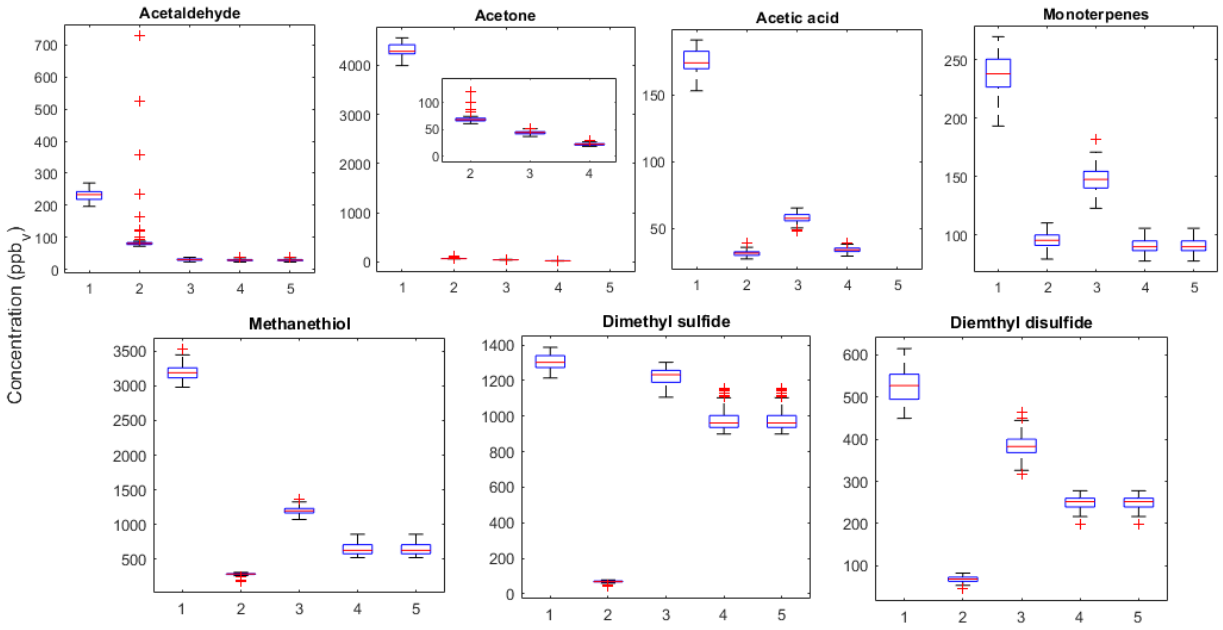


Figure 2 Boxplot summaries from on-site ductwork, Mar 23, 2023

Table 3 Median Concentrations from ductwork on March 23, 2023

3/23/2023	Median Concentration (ppb_v)									
Compound	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Methanethiol	3264	45	4087	2381	973	1416	155	43	41	80
Dimethyl sulfide	9735	18	2598	433	237	145	18	4	7	16
Dimethyl disulfide	446	3	710	131	104	80	10	1	1	3
Acetaldehyde	189	4	7	9	5	21	1	2	2	1
Acetone	3760	7	59	56	24	148	10	6	10	5
Acetic acid	315	4	79	44	28	23	5	5	4	4
Monoterpenes	214	53	207	228	154	7	1	12	11	20

May 29, 2023 Ductwork VOC Boxplot summary



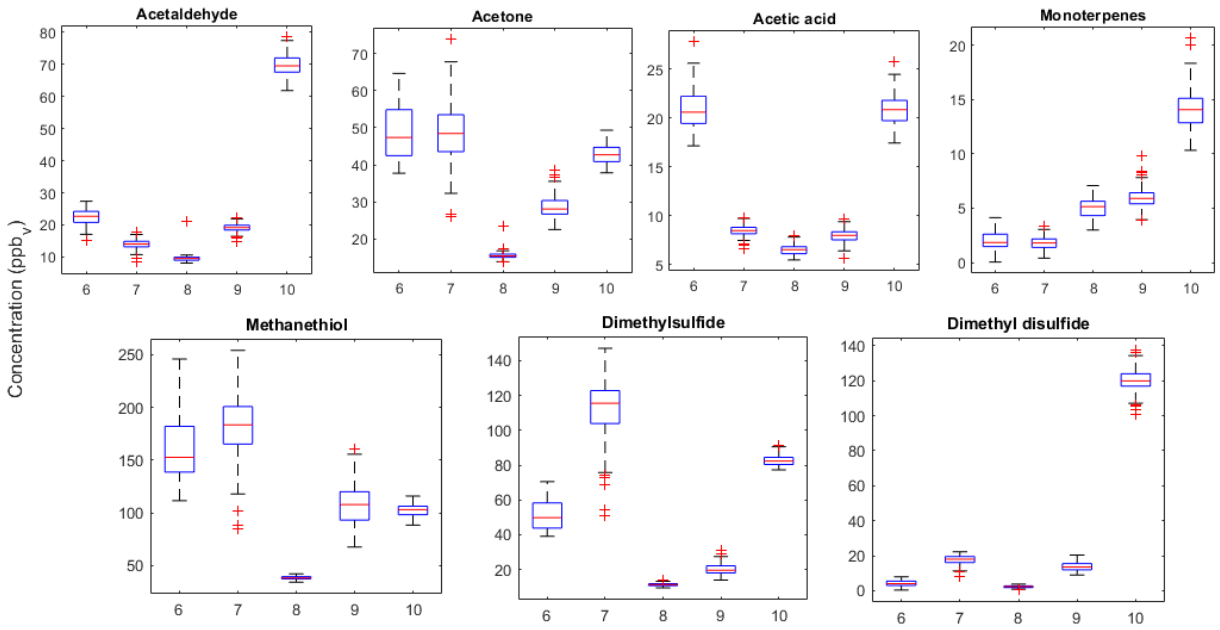


Figure 3 Boxplot summaries from on-site ductwork, May 29, 2023.

Table 4 Median Concentrations from ductwork on May 29, 2023

5/29/2023	Median Concentration (ppb$_v$)									
Compound	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Methanethiol	3188	287	1198	629	629	153	183	38	108	103
Dimethyl sulfide	1302	72	1233	962	962	50	115	12	20	82
Dimethyl disulfide	526	69	382	252	252	4	18	3	14	120
Acetaldehyde	233	81	31	29	29	23	14	10	19	69
Acetone	4287	68	44	22	22	47	48	15	28	42
Acetic acid	174	31	57	33	33	21	8	6	8	21
Monoterpenes	238	95	148	90	90	2	2	5	6	14

September 2023 Ductwork VOC Boxplots

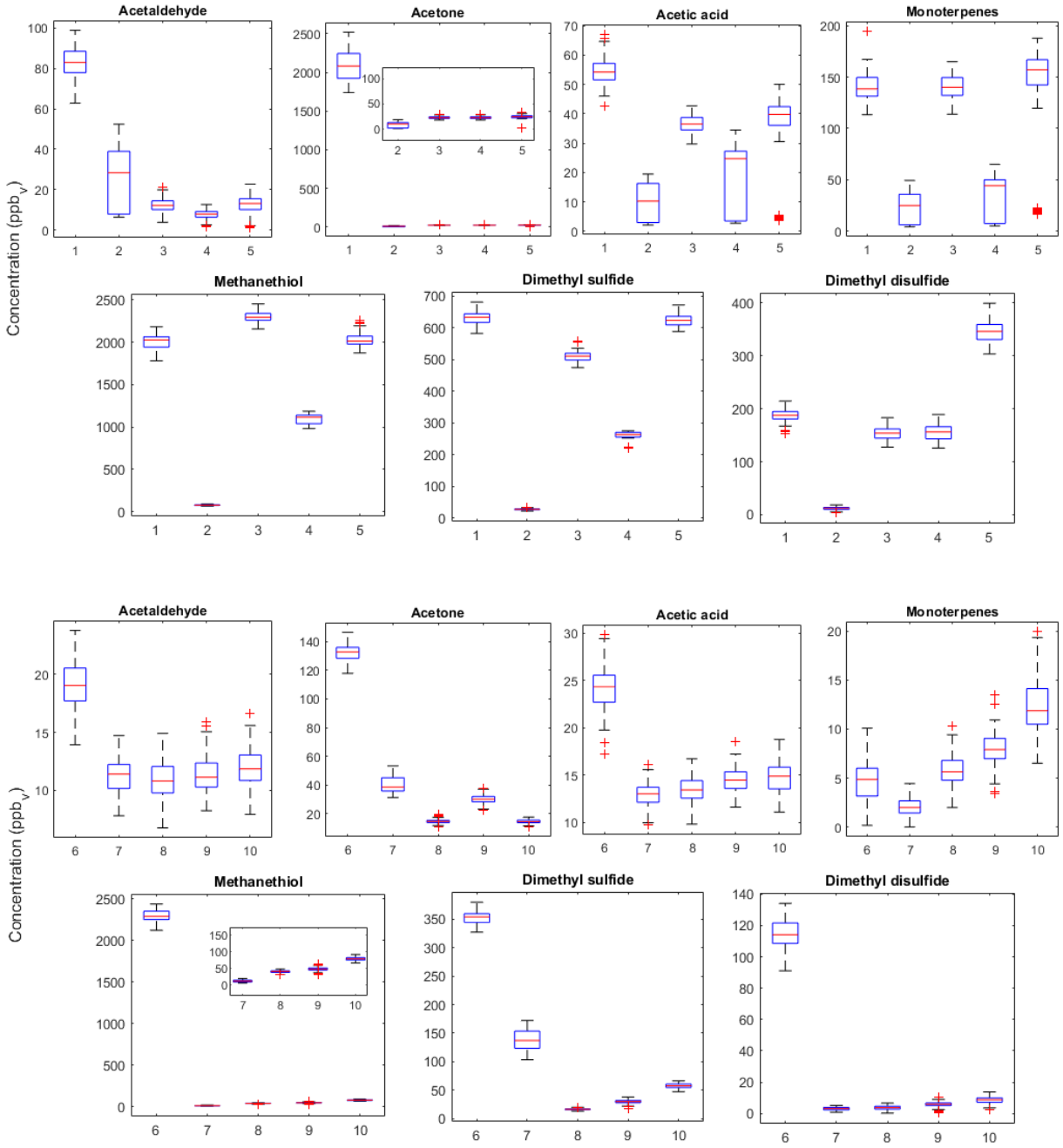


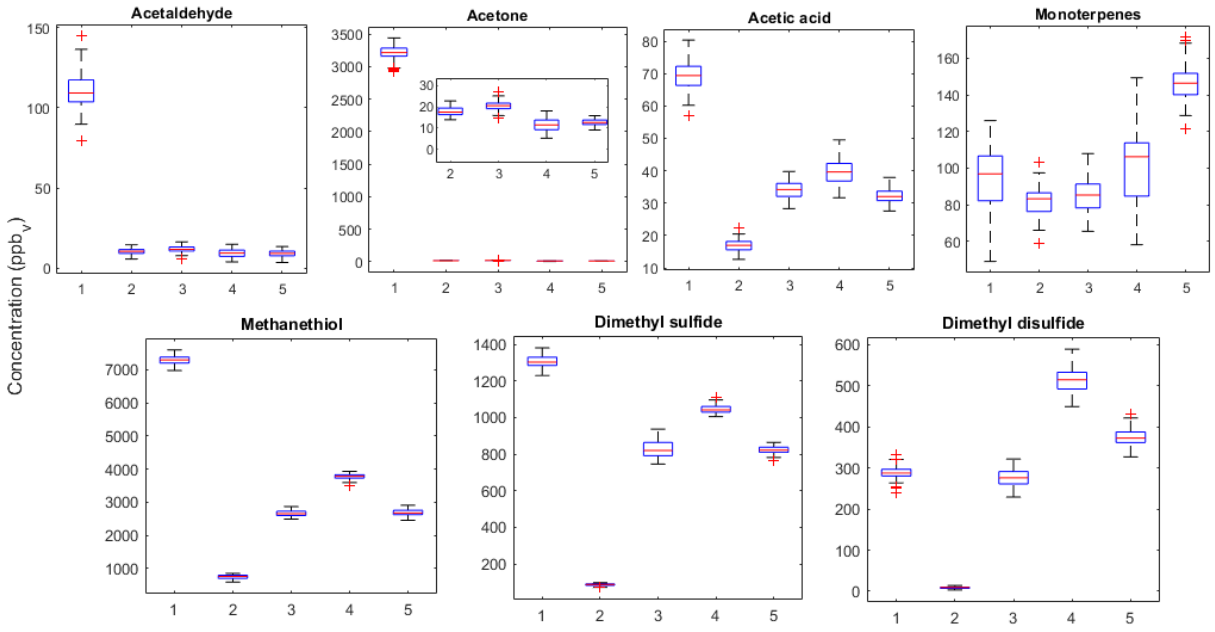
Figure 4 Boxplot summaries from on-site ductwork, Sept 29, 2023.

Table 5 Median concentrations from ductwork on September 29, 2023

9/29/2023	Median Concentration (ppbv)									
Compound	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Methanethiol	2027	79	2294	1115	2013	2289	11	40	48	78

Dimethyl sulfide	633	27	511	263	624	354	137	17	30	58
Dimethyl disulfide	188	13	154	156	347	114	3	4	6	9
Acetaldehyde	83	28	12	8	13	19	11	11	11	12
Acetone	2083	11	23	23	25	133	39	15	30	14
Acetic acid	54	10	37	24	40	24	13	13	15	15
Monoterpenes	138	25	140	44	157	5	2	6	8	12

November 2023, Ductwork Boxplot summary



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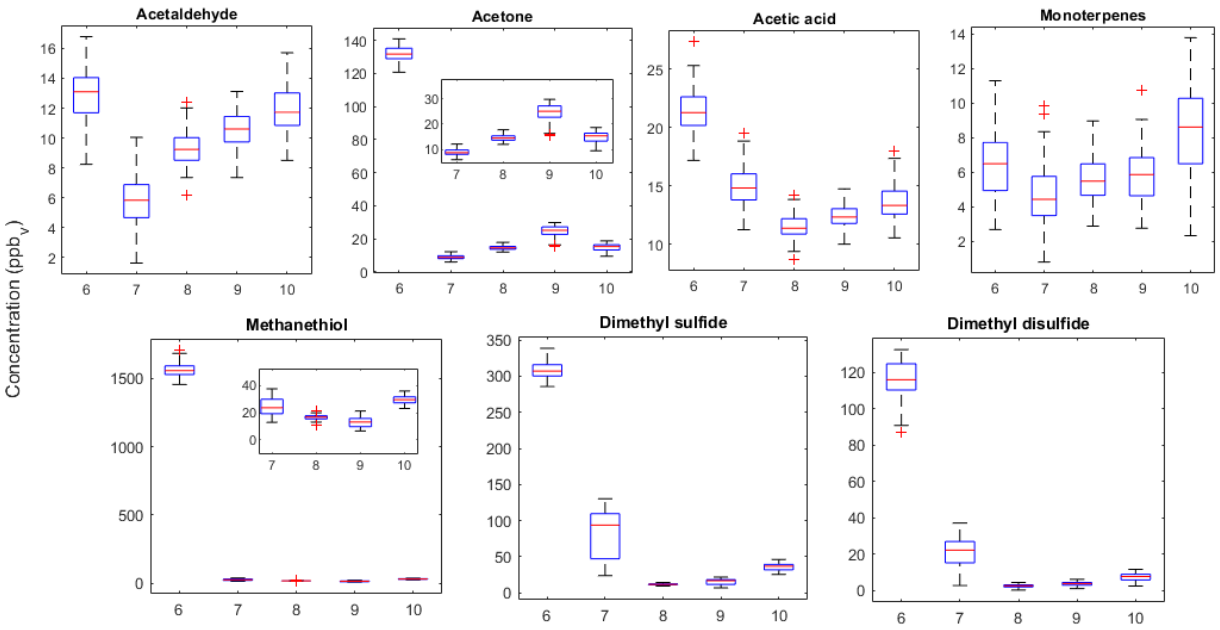


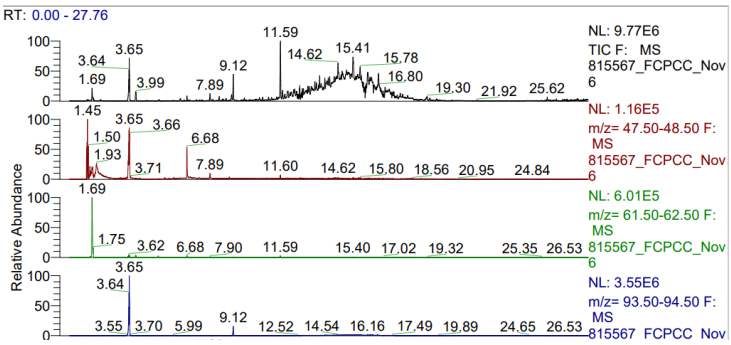
Figure 5 Boxplot summaries from on-site ductwork, Nov 6, 2023.

Table 6 Median Concentrations from ductwork on November 6, 2023

11/6/2023	Median Concentration (ppbv)									
Compound	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Methanethiol	7292	764	2653	3828	2679	1559	24	17	13	30
Dimethyl sulfide	1304	87	821	1042	822	307	94	12	17	37
Dimethyl disulfide	287	7	276	514	372	116	22	3	4	8
Acetaldehyde	109	11	12	9	9	13	6	9	11	12
Acetone	3217	18	21	12	13	132	9	14	25	15
Acetic acid	69	17	34	40	32	21	15	11	12	13
Monoterpenes	97	83	85	106	146	6	4	5	6	9

November 2023, On-site Ductwork TD-GC-MS analysis of S3-5

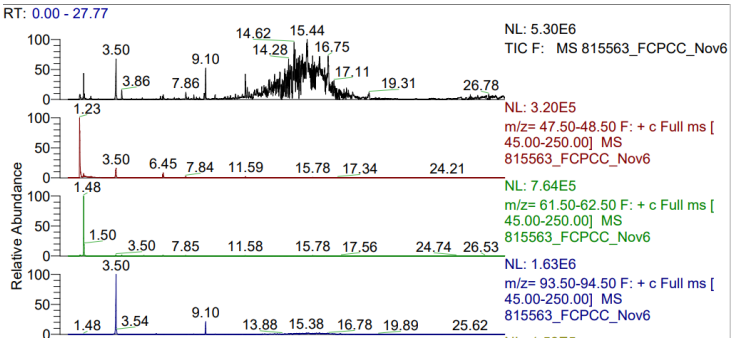
Ion Chromatogram showing sample location 3, with abundances of main ion peaks for Methanethiol (red), DMS (green) and DMDS (blue) shown below.



Sample location 3

Compound	Peak abundance
Methanethiol	$1.16x10^5$
Dimethyl sulfide	$6.01x10^5$
Dimethyl disulfide	$3.55x10^5$

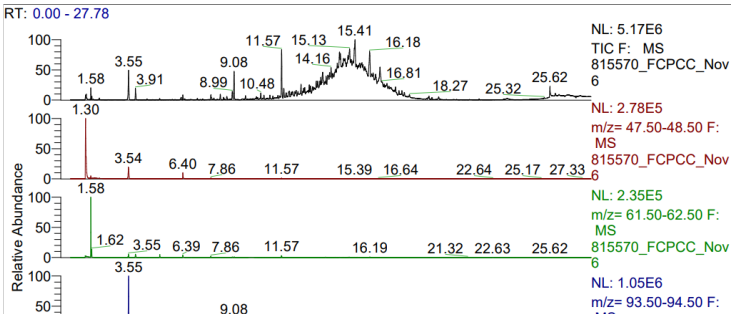
Ion Chromatogram showing sample location 4, with abundances of main ion peaks for Methanethiol (red), DMS (green) and DMDS (blue) shown below.



Sample location 4

Compound	Peak abundance
Methanethiol	$3.20x10^5$
Dimethyl sulfide	$7.64x10^5$
Dimethyl disulfide	$1.63x10^6$

Ion Chromatogram showing sample location 5, with abundances of main ion peaks for Methanethiol (red), DMS (green) and DMDS (blue) shown below.



Sample location 5

Compound	Peak abundance
Methanethiol	$2.78x10^5$
Dimethyl sulfide	$2.35x10^5$
Dimethyl disulfide	$1.05x10^6$

Figure 6 Chromatograms from TD-GC-MS, Sorbent tube analysis at locations 3, 4 and 5 in November 2023. All tubes loaded with same amount of air and desorbed with same method. (8 Min/ 375ml/min)

Compound	Peak height (proportional to concentration)		
	S3	S4	S5
Methanethiol	$1.16x10^5$	$3.20x10^5$	$2.78x10^5$
Dimethyl sulfide	$6.01x10^5$	$7.64x10^5$	$2.35x10^5$
Dimethyl disulfide	$3.55x10^5$	$1.63x10^6$	$1.05x10^6$

Table 7 Results from TD-GC-MS work done at sample points 3, 4 and 5 during Nov 6, 2023 deployment.

The observations in Nov 2023 were confirmed using an independent analytical technique that collected air samples on sulfacarb sorbent tubes and thermally desorbed them followed by chromatographic separation. This approach also confirmed the identify of signal at *m/z* 63.02 as dimethyl sulfide with no appreciable amounts of ethanethiol. In general, the concentrations of these reduced sulfur compounds decreased from S1 to S5 with greater efficiency in Mar than later in the year. Negligible reductions appear to occur within the scrubbing stream as concentrations at S5 were greater then S4 in September suggesting the chemical scrubber may have not been working effectively at that time, also the conc was higher at S4 than S5 in November suggesting that the wet bio-scrubber #2 was ineffective at this time.

*TD Tubes were loaded at 375ml/min for 8 minutes concurrently taken with PTR-TOF-MS measurements

February 20, 2024 , On-site FCPCC sampling

Sample locations for ATADs foul air (1), septage headworks (2), Biotower/trickling filter 1 (3), biotower/tricking filter 2 (4), Chemical scrubber (5), headworks (8), bio-tricking filter room (9), exhaust stack from S8 and 9 (10) are displayed in boxplots below with an accompanying table showing median concentrations. During the February sampling, biotower/trickling filter 2 was not operating properly and was becoming a source of methanethiol ,dimethyl sulfide, dimethyl disulfide and monoterpenes. Concentrations had decreased from the initial concentrations in the ATADs foul air stream post treatment by the wet scrubber towers and chemical scrubber although were being emitted at appreciable levels with MeSH above 1000 ppb_v, DMS >400 ppb_v and DMDS >350 ppb_v.

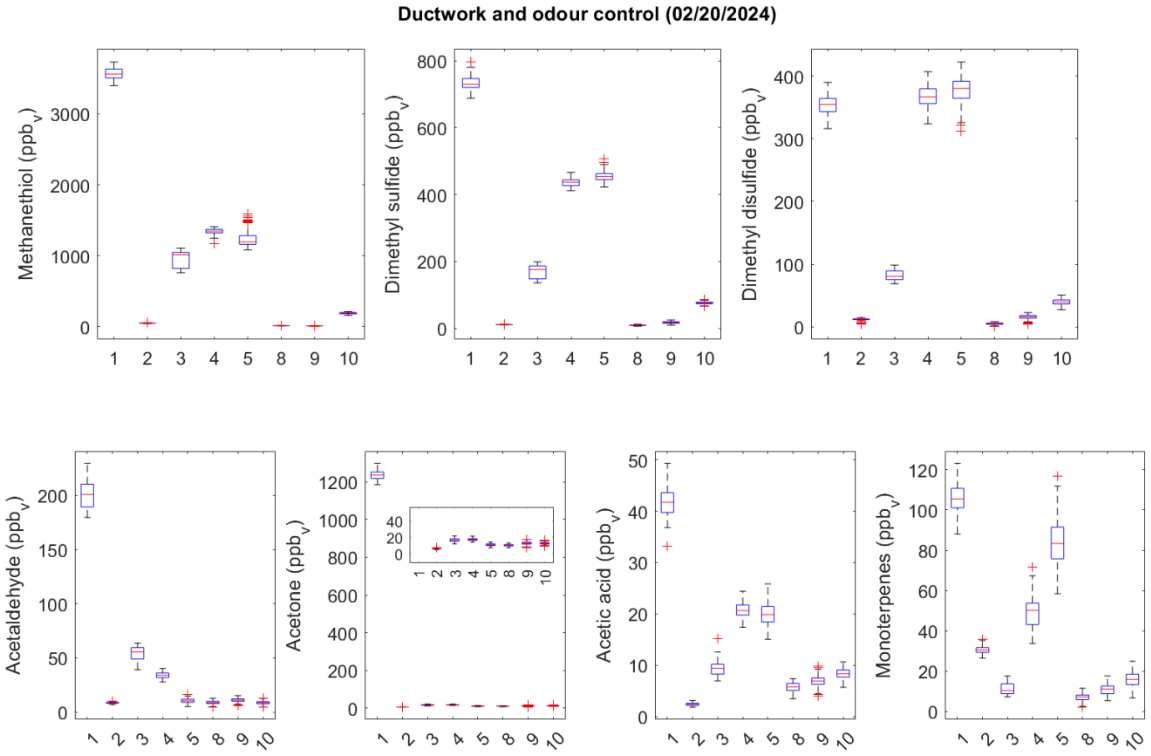


Figure 7 February 20, 2024 , On-site sampling points 1-5,8-10. Boxplots showing select VOCs concentrations.

Table 8 Median concentrations from sample points 1-5,8-10. From Feb 20, 2024.

Median Concentrations (ppb_v)								
Sample ID #	1	2	3	4	5	8	9	10
Methanethiol	3563.1	46.3	1011.5	1347.8	1193.3	11.3	8.7	188.7
Dimethyl sulfide	729.7	11	175.3	436.4	454	9.1	17.5	75.6
Dimethyl disulfide	353.9	12.3	80.4	366.7	380.3	5	16.3	39.7
Acetaldehyde	200.1	8.6	55.4	34.1	10.5	8.9	11.1	8.9
Acetone	1236.5	6	16.8	17.6	10.9	10.3	13.1	13

Acetic acid	41.7	2.5	9.5	20.7	19.9	5.8	7	8.4
Monoterpenes	105.5	30.6	10.4	50.2	83.7	7.2	11.2	16

Sample locations from the centrifuge room (6) and the biofilter bed (7) are shown below, with an accompanying table with median concentrations provided. The biofilter bed was working to decrease the concentration of VOCs from the centrifuge room foul air, except for DMDS which was not decreased. Output concentrations were still relatively high for MeSH, DMS and DMDS, at >500, >150 and >180 ppb_v, respectively.

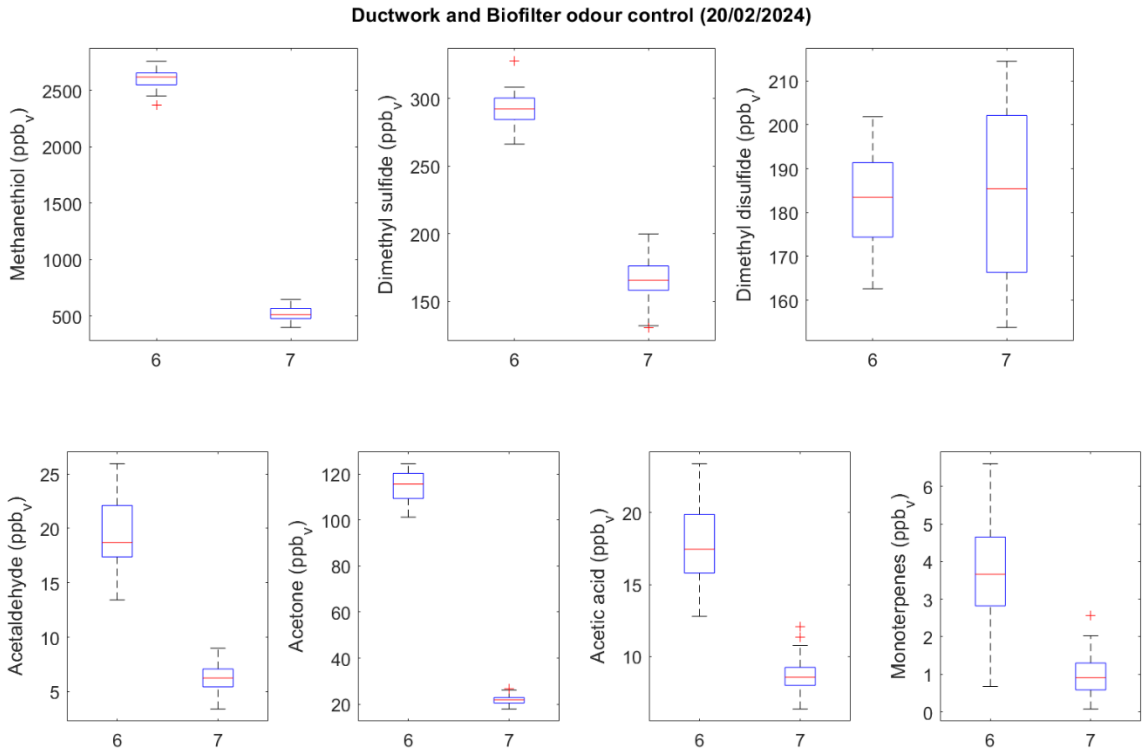


Figure 8 February 20, 2024 , On-site FCPCC sampling points 6,7. Boxplots showing select VOCs concentrations.

Table 9 Median concentrations from sample points 6 and 7 from Feb 20, 2024.

Median Concentrations (ppb_v)		
Sample ID #	6	7
Methanethiol	2616.8	512.9
Dimethyl sulfide	290.6	165.8
Dimethyl disulfide	184.2	187.6
Acetaldehyde	18.8	6.4
Acetone	115.7	21.9
Acetic acid	17.2	8.6
Monoterpenes	3.7	1

Methane concentrations in FCPCC ductwork on February 20, 2024

Methane concentrations from the Los-gatos-fast greenhouse gas analyzer are provided below in a bar graph from each of the sampling locations. Sample locations 5, 7 and 10 are directly emitted to the atmosphere, which had concentrations of methane at 1400, 40 and 10 ppm_v, respectively.

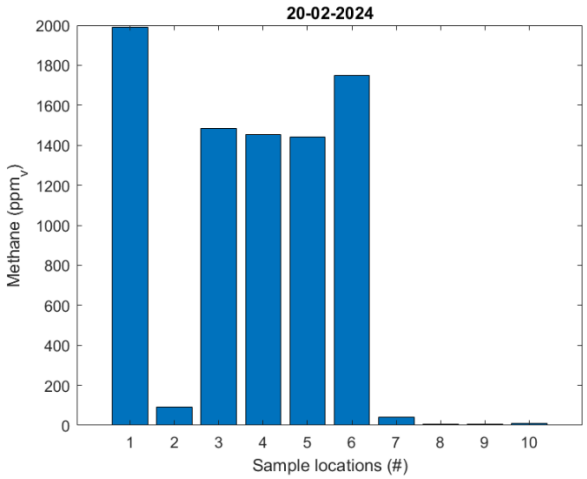


Figure 9 Methane concentrations recorded in ductwork during Feb 20, 2024 sampling. Bar graph of concentrations by GHG analyzer.

June 13, 2024, On-site FCPCC sampling

Sample locations for ATADs foul air (1), septage headworks (2), Biotower/trickling filter 1 (3), biotower/tricking filter 2 (4), Chemical scrubber (5), headworks (8), bio-tricking filter room (9), exhaust stack from S8 and 9 (10) are displayed in boxplots below with an accompanying table showing median concentrations. During the June sampling the biotower/trickling filters were working to decrease the methanethiol at each step by ~50%, except BST2 (4) had increased concentration of DMDS and after chemical scrubber treatment concentrations were lowered for MeSH (output at 630 ppb_v) and elevated for DMS (output at 450 ppb_v) and DMDS (output at 720ppb_v).

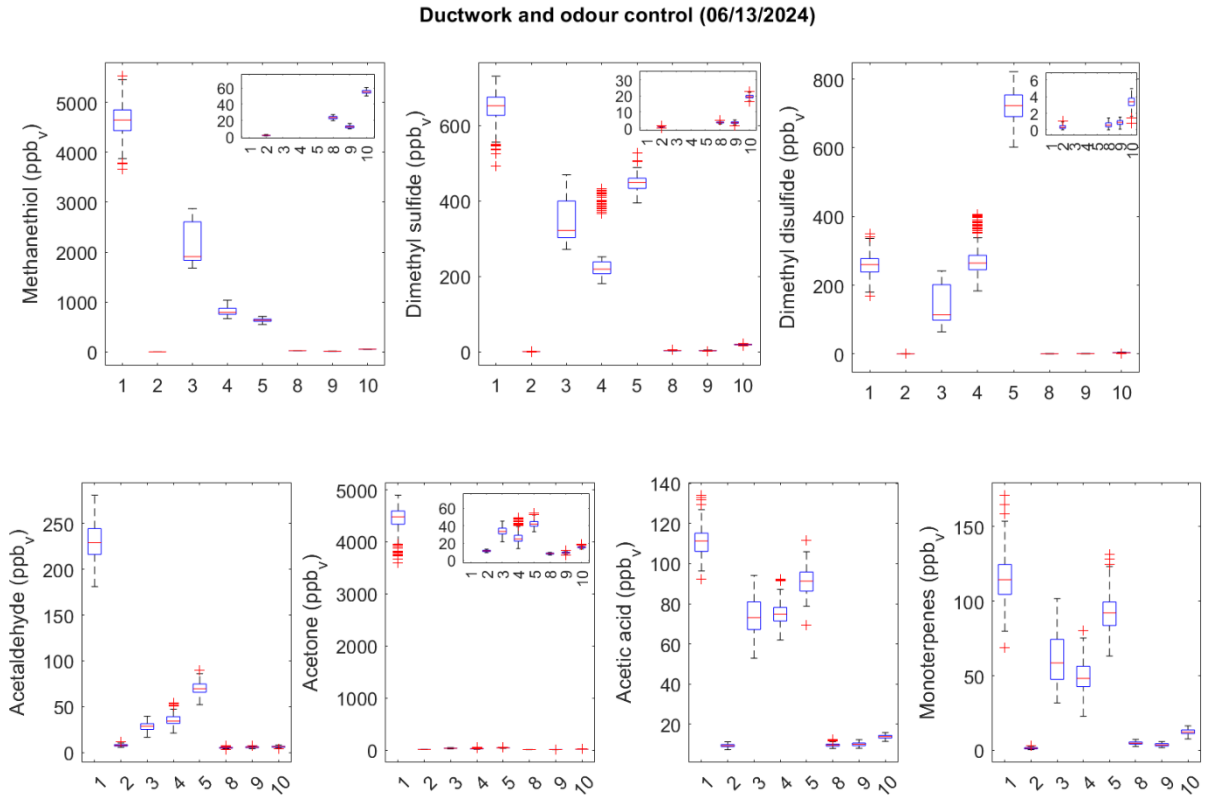


Figure 10 June 13, 2024, On-site sampling points 1-5, 8-10. Boxplots of select VOCs concentrations.

Table 10 Median concentrations from sample points 1-5, 8-10, June 13, 2024

Median Concentrations (ppb_v)								
Sample ID #	1	2	3	4	5	8	9	10
Methanethiol	4647.5	1.6	1909.3	792.2	635.7	23.6	12.2	55.4
Dimethyl sulfide	653	1	322.1	219.6	449.4	3.6	3.4	19.6
Dimethyl disulfide	259.8	0.4	113.8	264.5	722.7	0.6	1	3.4
Acetaldehyde	229.2	7.7	28.6	34.3	69.7	5.1	5.7	6.4
Acetone	4480.1	11.1	33.4	24.8	41.8	8.1	8.8	15.6
Acetic acid	111.3	9.4	73.1	74.8	91.4	9.7	10.1	13.9
Monoterpenes	114.5	1.4	58.6	48.3	92.3	4.9	3.7	16

Sample locations from the centrifuge room (6) and the biofilter bed (7) are shown below, with an accompanying table with median concentrations provided. Concentrations of VOCs were substantially decreased by biofilter bed treatment.

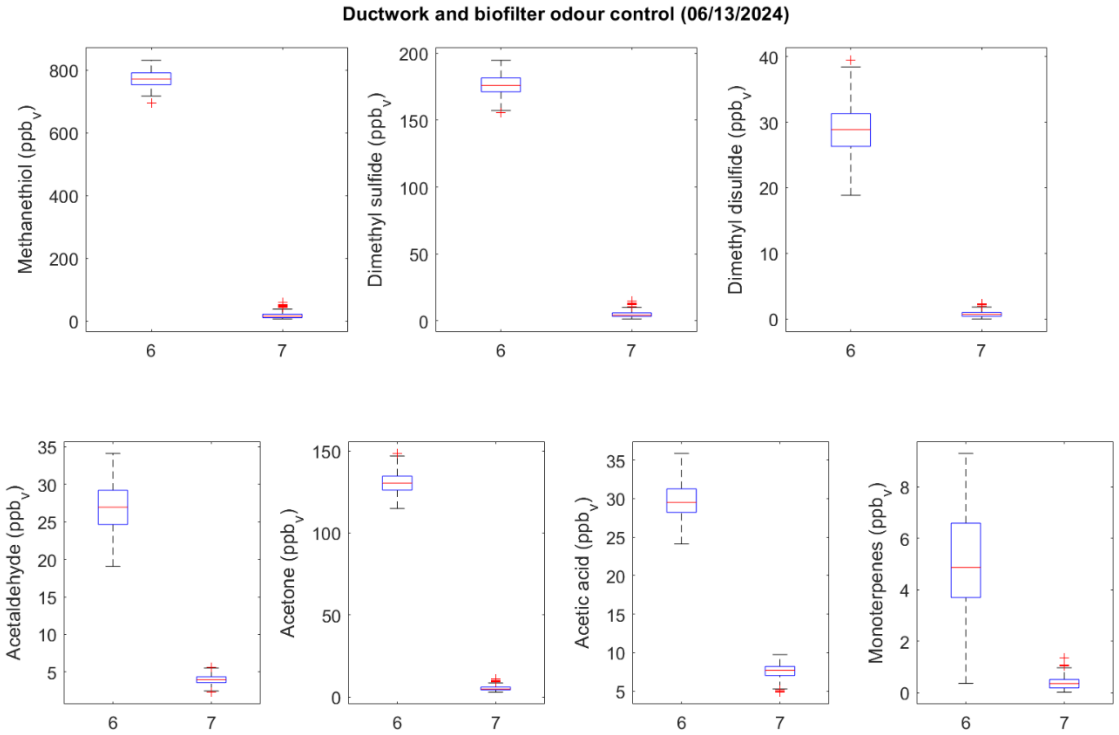


Figure 11 June 13, 2024, On-site FCPCC sampling points 6,7. Boxplots of select VOCs concentrations.

Table 11 Median concentrations from sample points 6 and 7, June 13, 2024

Median Concentrations (ppb_v)		
Sample ID #	6	7
Methanethiol	771.2	16
Dimethyl sulfide	176.1	4.4
Dimethyl disulfide	28.9	0.8
Acetaldehyde	27	4.1
Acetone	130.4	5.2
Acetic acid	29.6	7.4
Monoterpenes	4.9	0.4

Methane concentrations from FCPCC sample points 3,4,5, Bio-tower trickling filter and chemical scrubber on June 13, 2024.

Methane concentrations from the LG-FGGA are displayed below in a bar graph for sampling locations 3-5, with sample location 5 being exhausted to the atmosphere at 1650 ppm_v of methane.

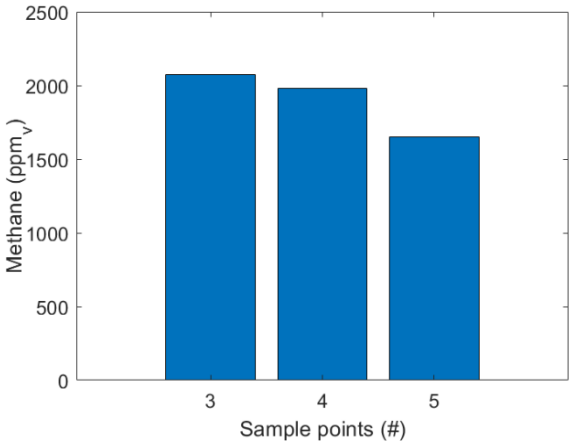


Figure 12 Methane concentrations from sample points 3,4,5, Bio-tower trickling filters and chemical scrubber on June 13, 2024. Bar graph showing concentration of methane by GHG analyzer.

The average methane concentration was 1500 ppm_v at sample location 5, which exhausts to the atmosphere, the average flux is 984049.08 $\mu g/m^3$ at an average flow rate of 3050 m^3/hr is 3.001 kg/hr or 26,260 kg/year of methane.

Results of trial odour control system test at FCPCC

The PTR-ToF-MS allows for continuous monitoring of VOCs with low detection limits (<1 ppb_v) and high temporal frequency (1 Hz). Figure 13 shows a timeseries of measurements collected on June 12, 2023 annotated to indicate which process of the waste treatment stream was being analyzed. Samples collected prior to the odour control unit, in the main exhaust duct pre-biofilter, the post-biofilter exhaust, and the centrifuge room air were diluted 4.5 times with clean air before analysis resulting in observed concentrations higher than those shown on the timeseries. Concentration off all the compounds depicted are decreased significantly through treatment with the odour control unit, and importantly thee observed concentrations are lower than those observed post-biofilter with the current treatment process. A summary of the concentrations before and after the odour treatment unit are described below.

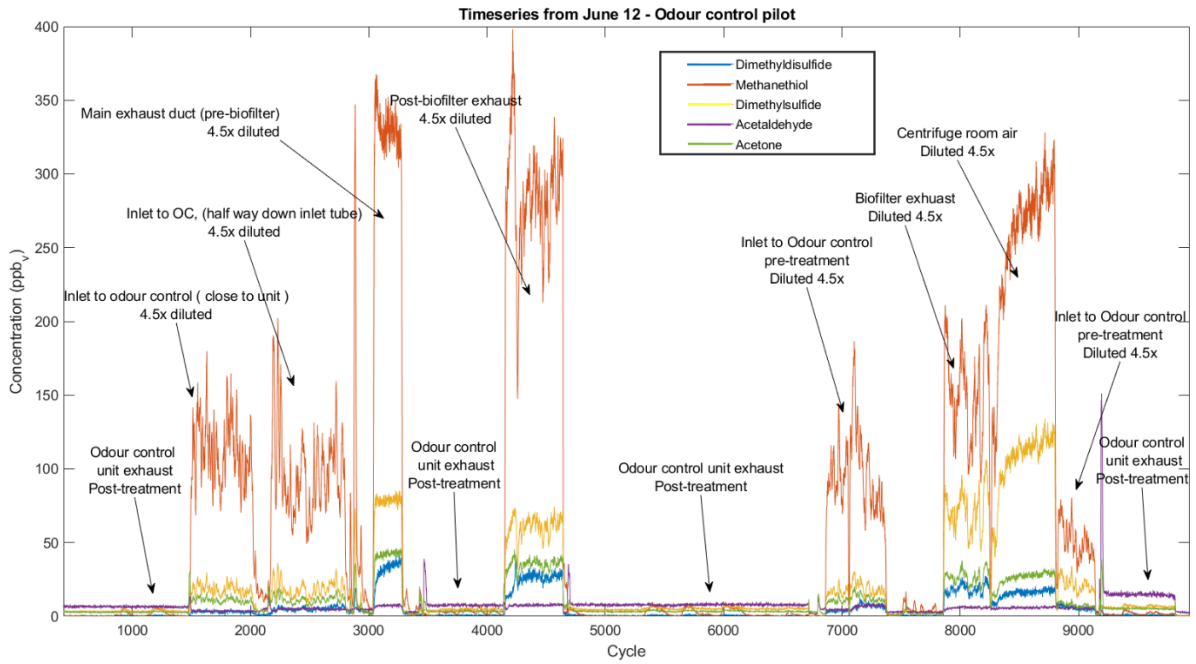


Figure 13: Timeseries of the concentration of methanethiol, DMS, DMDS, acetaldehyde and acetone measured on June 12, 2023. The timeseries has been annotated to indicate where each measurement was collected and if the observed concentrations were of dilute air streams.

Malodorous VOCs from AOP odour control unit study

The concentration of malodorous VOCs observed in the foul air stream pre- and post-odour treatment during each day of the sampling campaign and summarized in the boxplots shown in Figures 14 and 15. The vertical dimension of the box indicates the concentration range that captures the data between the 25th and 75th percentiles of the distribution. The horizontal line inside the box is the median concentration. The top and bottom whiskers are a statistical measure of the difference between the 25th and 75th percentiles. The crosses represent statistical 'outliers', which are extreme observations. All values have been corrected for dilution ratios (typically 4.5:1).

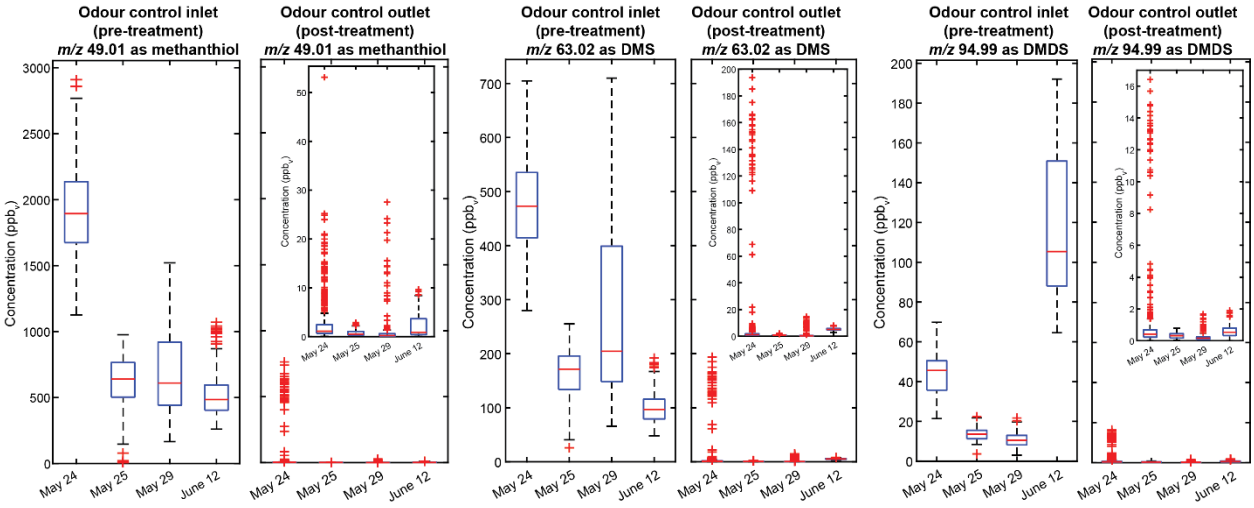


Figure 14: Boxplot of reduced sulfur concentrations before and after odour control treatment. Significant decreases in the reduced sulfur concentrations (>98%) were observed through the treatment process.

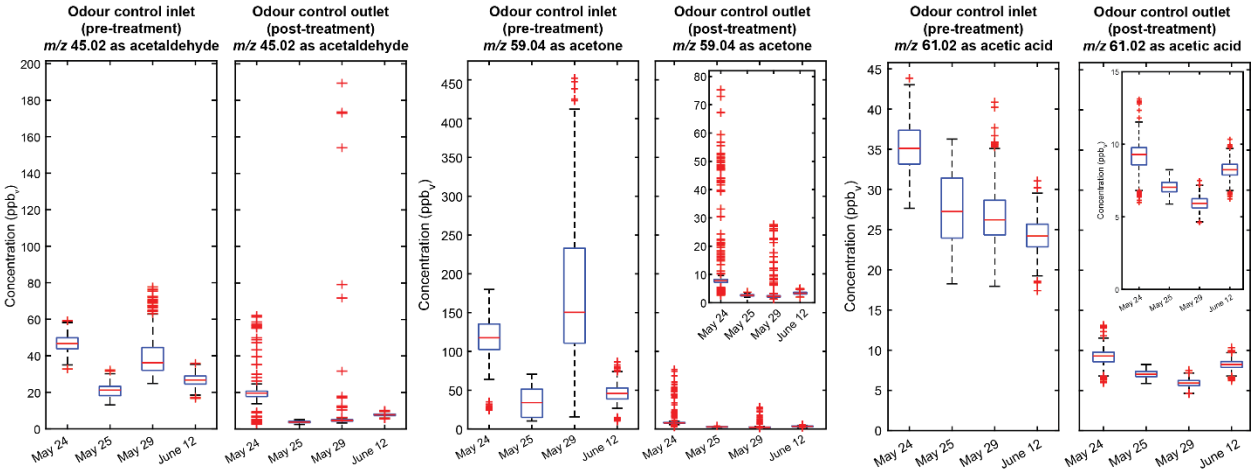


Figure 15: Boxplot of selected oxygenated compound concentrations before and after odour control treatment. Significant decreases in the acetone concentrations (94%, center) were observed through the treatment process, with 72-75% of acetaldehyde and acetic acid being removed in the treatment process.

Concentrations of malodorous VOCs to the inlet of the odour control unit were high and very variable from day-to-day. Median values ranged from 485 – 1894 ppb_v for *m/z* 49.01 (quantified as methanethiol), 97 – 473 ppb_v for *m/z* 63.02 (quantified as DMS), 11 – 106 ppb_v for *m/z* 94.99 (quantified as DMDS), 21 – 47 ppb_v for *m/z* 45.02 (quantified as acetaldehyde), 34 – 140 ppb_v for *m/z* 59.04 (quantified as acetone), and 24 – 35 ppb_v for *m/z* 61.02 (quantified as acetic acid). A significant decrease in concentrations were observed post odour treatment unit for the reduced sulfur compounds with % knockdown in the median concentrations of 98.5% - 99.9%. The removal efficiency for the oxygenated compounds was lower, with a % knockdown of 74.4% for acetaldehyde, 94.2% for acetone, and 72.7% for acetic acid. Table 12 summarizes the observed concentrations of each of these compounds before an after treatment, as well as the % knockdown achieved through the treatment process.

Table 12: Summary of select malodorous VOC concentrations measured at the inlet and outlet of the odour control unit throughout the sampling campaign. The inlet and outlet were measured for 5 minutes twice per day.

Chemical compound		May 24, 2023	May 25, 2023	May 29, 2023	June 12, 2023	Average
m/z 49.01, CH_4S (Quantified as methanethiol)	Median Inlet conc. (ppb_v)	1894 (1674-2136)[1]	640 (503-766)	610 (442-919)	485 (405-595)	907
	Median Outlet conc. (ppb_v)	1.1 (0.7-2.4)	0.5 (0.3-1.1)	0.2 (0.1-0.6)	0.9 (0.4-3.6)	0.7
	% knockdown	99.9	99.9	99.97	99.8	99.9
m/z 63.02, C_2H_6S (Quantified as DMS)	Median Inlet conc. (ppb_v)	473 (414-535)	171 (134-196)	204 (148-399)	97 (79-116)	236
	Median Outlet conc. (ppb_v)	1.1 (0.8-1.9)	0.8 (0.6-1.0)	0.4 (0.2-0.6)	5.1 (4.6-5.8)	1.9
	% knockdown	99.8	99.5	99.8	94.7	98.5
m/z 94.99, $C_2H_6S_2$ (Quantified as DMDS)	Median Inlet conc. (ppb_v)	46 (36-50)	14 (11-16)	11 (8.1-13)	106 (88-151)	44
	Median Outlet conc. (ppb_v)	0.3 (0.2-0.7)	0.2 (0.2-0.4)	0.1 (0.1-0.2)	0.4 (0.3-0.8)	0.3
	% knockdown	99.3	98.6	99.1	99.6	99.2
m/z 45.02, C_2H_4O (Quantified as acetaldehyde)	Median Inlet conc. (ppb_v)	47 (44-50)	21 (18-23)	36 (32-44)	27 (25-29)	33
	Median Outlet conc. (ppb_v)	20 (18-21)	3.8 (3.4-4.2)	4.7 (4.3-5.1)	7.8 (7.3-8.2)	9.1
	% knockdown	57.4	81.9	86.9	71.1	74.4
m/z 59.04, C_3H_6O (Quantified as acetone)	Median Inlet conc. (ppb_v)	118 (102-135)	34 (15-51)	150 (111-233)	46 (39-53)	87
	Median Outlet conc. (ppb_v)	7.8 (7.2-8.3)	2.7 (2.4-2.8)	2.2 (2.0-2.5)	3.3 (3.1-3.7)	4.0
	% knockdown	93.4	92.1	98.5	92.8	94.2
m/z 61.02, $C_2H_4O_2$ (Quantified as acetic acid)	Median Inlet conc. (ppb_v)	35 (33-37)	27 (24-31)	26 (24-29)	24 (23-26)	28
	Median Outlet conc. (ppb_v)	9.3 (8.6-9.8)	7.0 (6.7-7.4)	5.9 (5.6-6.2)	8.2 (7.9-8.6)	7.6
	% knockdown	73.4	74.1	77.3	65.8	72.7

[1]The concentration range of the 25th – 75th percentile measurements are shown in brackets

In addition to pre- and post-odour treatment unit, measurements were made in the centrifuge room air, the main exhaust duct, and in the bio-filter exhaust on June 12, 2023. A summary of the observed methanethiol concentrations in the different areas is shown in Figure 16. The highest concentrations were observed in the main exhaust, while the odour treatment unit resulted in lower concentrations than the exhaust from the bio-filter.

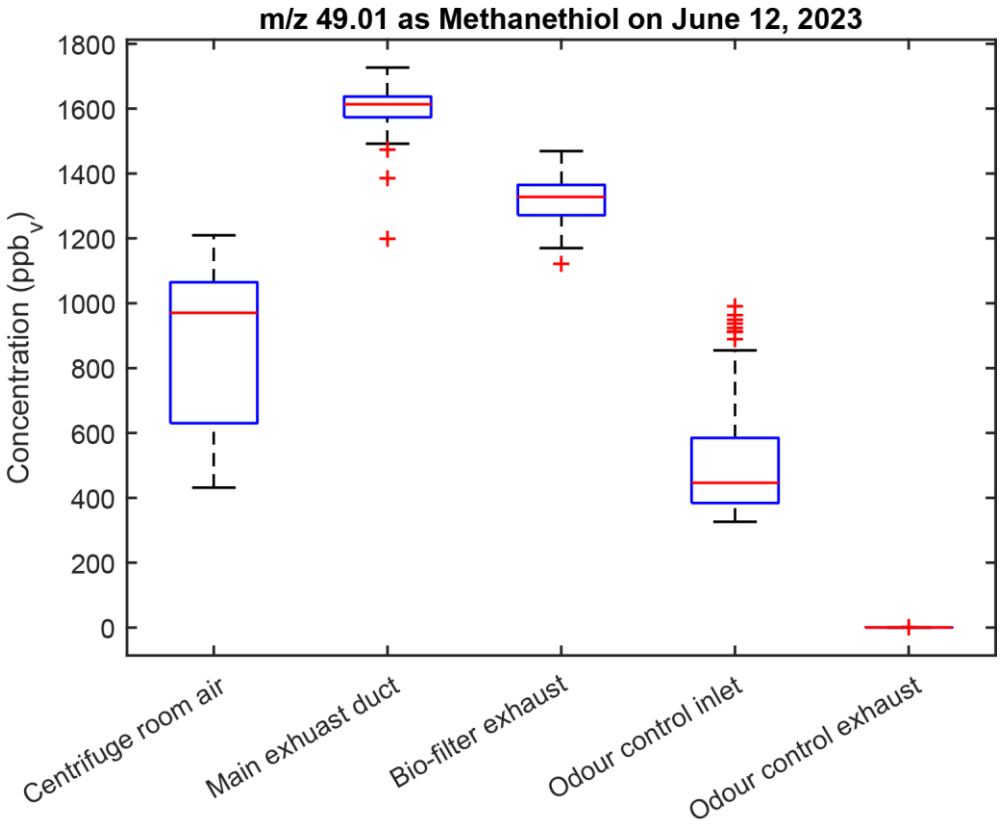


Figure 16: Concentration of methanethiol observed at different points in the treatment process on June 12, 2023.

Methane and ozone concentrations are summarized in Figure 17 and Table 13. Methane concentrations were relatively unchanged by treatment, although the concentrations were less variable in the air stream post-odour control unit. In contrast, ozone concentrations were greatly elevated in the post-treatment air stream, with median concentrations approaching 900 ppb_v being observed and an average increase in concentration of 1600% being observed.

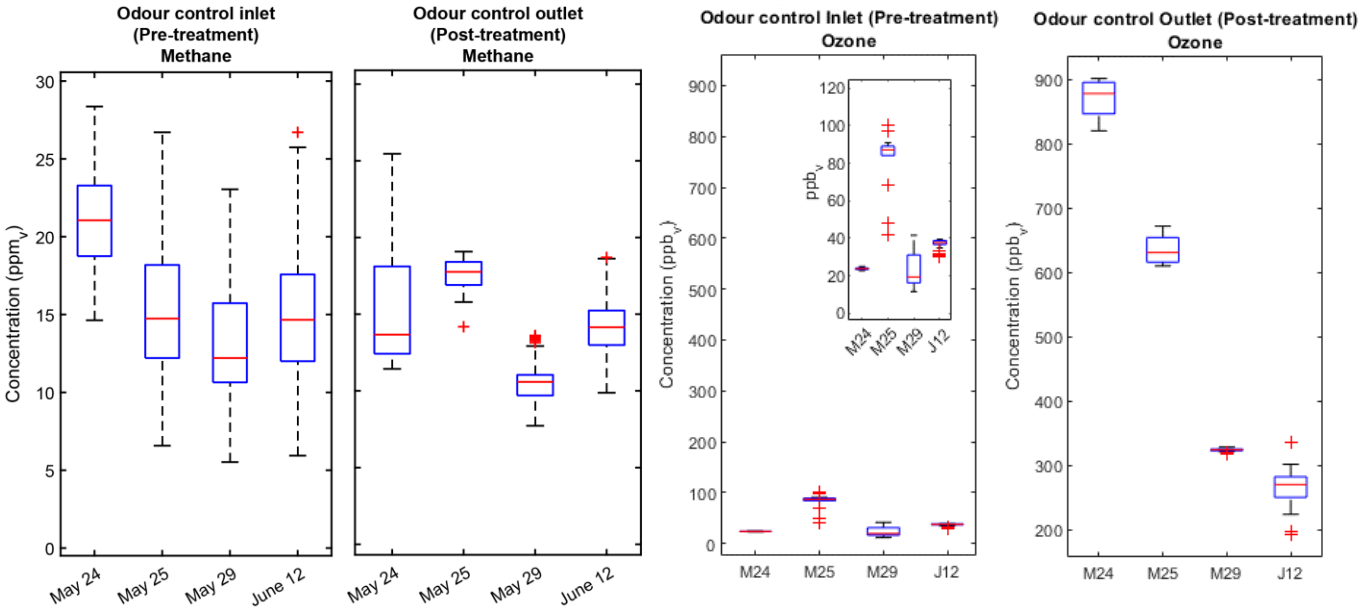


Figure 17: Boxplot of methane and ozone concentrations before and after odour control treatment. Methane concentrations were relatively unchanged by the treatment process, while ozone concentrations were significantly increased in the air stream post-treatment.

Table 13: Summary of methane and ozone concentrations measured at the inlet and outlet of the odour control unit throughout the sampling campaign. The inlet and outlet were measured for 5 minutes twice per day.

Chemical compound		May 24, 2023	May 25, 2023	May 29, 2023	June 12, 2023	Average
Methane	Median Inlet conc. (ppm_v)	21 (19-23)	15 (12-18)	12 (11-16)	15 (12-18)	15.8
	Median Outlet conc. (ppm_v)	14 (12-18)	18 (17-19)	11 (10-11)	14 (13-15)	14.3
	% knockdown	33	-20	8.3	6.7	7.1
Ozone	Median Inlet conc. (ppb_v)	24 (23-24)	87 (84-89)	19 (16-31)	38 (37-39)	42
	Median Outlet conc. (ppb_v)	878 (846-895)	631 (616-654)	324 (686-774)	270 (107-130)	525
	% knockdown	-3560	-625	-1605	-610	-1600

WWTP2 Greater Nanaimo Pollution control centre on-site ductwork 2023-2024

On-site treatment process sampling overview

On-site air sampling at the GNPCC included sampling from ductwork along the foul air stream at 9 locations. Sampling locations capture the treatment process from the raw sewage foul air to the post-biofilter treated air and before and after any odour control. The Sample ID number and description of each sample location is shown in Table 14. The sample sites have been subdivided into groups with Samples 1-4 capturing the primary treatment process, Samples 5-7 capturing the secondary treatment process, Samples 8-9 capturing the tertiary treatment process, and Samples A1-A3 capturing ambient air at three locations on-site. The sampling locations are identified on a map of the GNPCC in Figure 3. On-site sampling was done with the MMSL, with measurements generally made with the PTR-ToF-MS and greenhouse gas (GHG) analyzer to detect VOCs and GHGs in the air stream respectively. At each sampling location 5-10 minutes of data were collected and an average concentration was calculated from the observed 'steady-state' signal intensity. Some locations require dilution prior to sampling to reduce the concentrations into an allowable range for the instrumentation. To dilute air samples, clean charcoal scrubbed air is supplemented at a 5:1 mixing ratio. All data shown has been corrected for any dilutions unless otherwise noted.

Table 14: Sample numbers for on-site sample locations at the GNPCC.

	Sample ID	Description
	1	Foul air incoming raw sewage
	2	Coarse screening foul air carbon filter inlet
	3	Coarse screening foul air exhaust
	4	Primary treatment foul air
	5	Incoming influent to secondary treatment/ primary treatment outflow
	6	Desludge foul air carbon inlet
	7	Desludge foul air carbon exhaust
	8	Foul air pre-biofilter/post wetter
	9	Foul air post-biofilter, treated air exhaust
Ambient site	A1	Ambient air by primary treatment
	A2	Ambient air by clarifiers
	A3	Ambient air by digestor

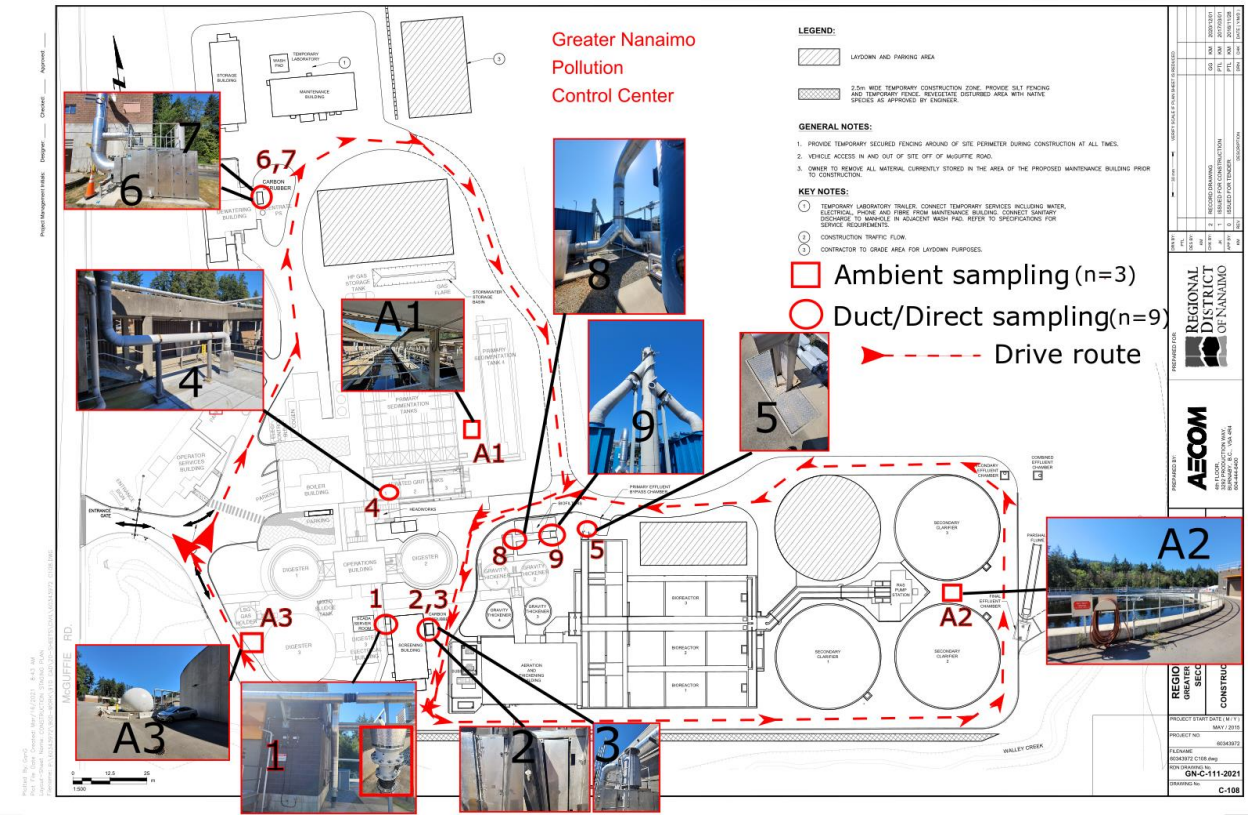


Figure 18: On-site GNPCC air sampling locations.

Table 15 Sampling information from on-site ductwork at WWTP2 sampling campaign.

Sample date	Sampling Location	Time period of sampling
August 23,2022	On-site duct sampling	09:00-12:00
November 16, 2022	On-site duct sampling	10:30 – 12:30
January 25, 2023	On-site duct sampling	12:00-14:00
April 04, 2023	On-site duct sampling	11:40-13:40
June 23, 2023	On-site duct sampling	11:25-13:45
Sept 22, 2023	On-site duct sampling	9:45-11:45
November 7, 2023	On-site duct sampling	10:15-11:30
February 26, 2024	On-site duct sampling	11:00-13:30
Total on-site ductwork sampling hours (hh:mm)		17:05

Data and results from on-site duct sampling

This section summarizes the observed concentrations of VOCs in the on-site duct sampling on April 3 and June 23, 2023. The concentration data of the individual VOCs for each day are summarized as boxplots, where the box captures the 25th – 75th percentiles with the median value marked by a red line, the whiskers indicate the highest and lowest values that are not statistical outliers, and the red crosses represent outliers. The median values for the selected VOCs are also tabulated for clarity. In general, a trend of lowered concentration of malodourous compounds in the treatment exhaust stream was observed.

For each day, the data is first presented in three different groups to better highlight the changes in the concentration observed throughout each part of the treatment process, and a combined summary of all nine sample locations follows. Data from sample locations 1-3 associated with raw influent, screening and foul air treatment from screening room is presented first. Next, data from sample locations 6 and 7 before and after foul air treatment from the desludging process, respectively, is presented. Finally, data from sample locations 4, 5, 8, and 9 are presented. Sample locations 4 and 5 are the foul air stream from primary treatment and a headspace sample over the primary treatment outflow before secondary treatment. Sample locations 8 and 9 are before and after the biofilter, with sample location 8 being an aggregate of all foul air needing treatment before release, and sample location 9 capturing the exhaust stream exhausted to the atmosphere at top of stack.

January 25, 2023 Sampling day summary

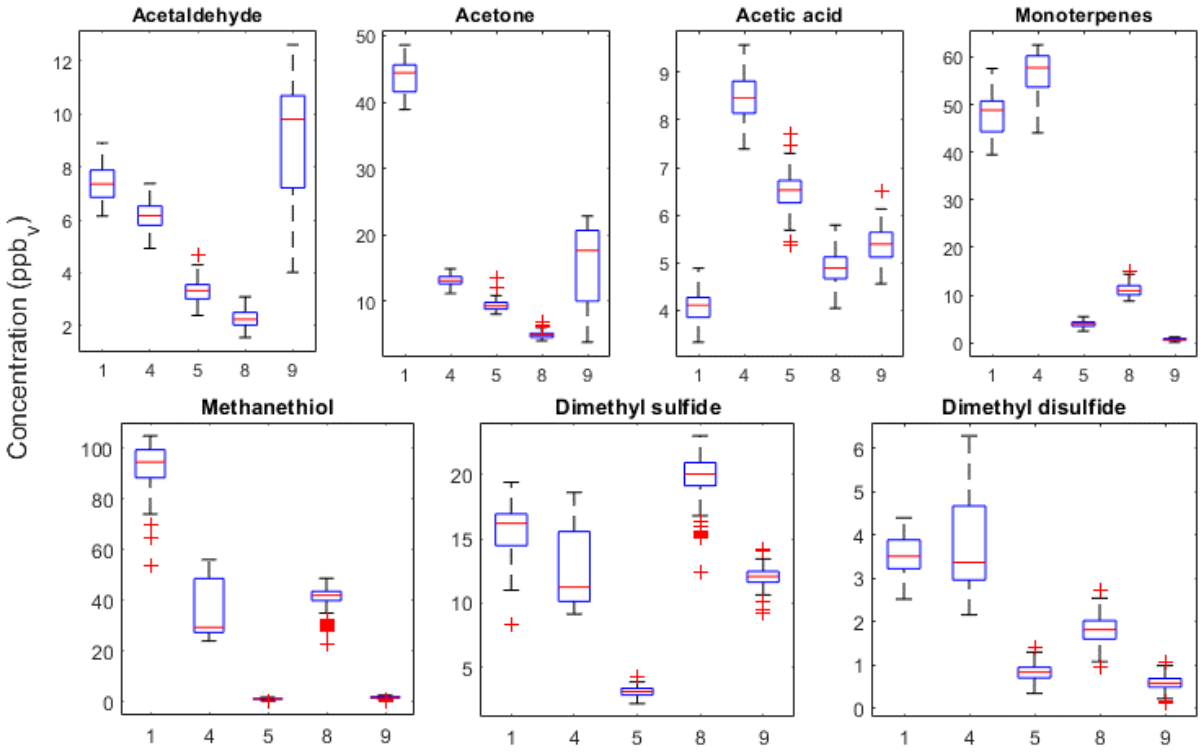


Figure 19 Jan 25 Duct boxplots 1,4,5,8,9

Summary of Duct sampling from Jan 25, 2023, showing selected VOCs including three reduced sulfur compounds MeSH, DMS and DMDS throughout the treatment process, from raw influent (1), Primary sedimentation foul air (4), Primary treatment outfall to secondary (5), odour collection network pre-biofilter (8), Post biofilter (9). The biofilter performance for lowering the concentrations of RSCs is illustrated above showing a good reduction of MeSH and small decrease on DMS and DMDS, which DMS is emitted higher than its odour threshold of ~ 1 ppb_v, in the final exhaust stack.

Table 16 Jan 25 Duct sampling summary 1,4,5,8,9

Sample Locations	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
1- Raw sewage inflow foul air	95	16	3.5	7.4	44.5	4	49
4 - primary treatment foul air	30	11	3.4	6	13	8.5	58
5 - primary treatment outflow	1.3	3	0.8	3	9	6.5	4
8 - pre-biofilter foul air stream	42	20	2	2	5	5	11
9 - post-biofilter exhaust	2	12	0.5	10	17.5	5.5	0.5

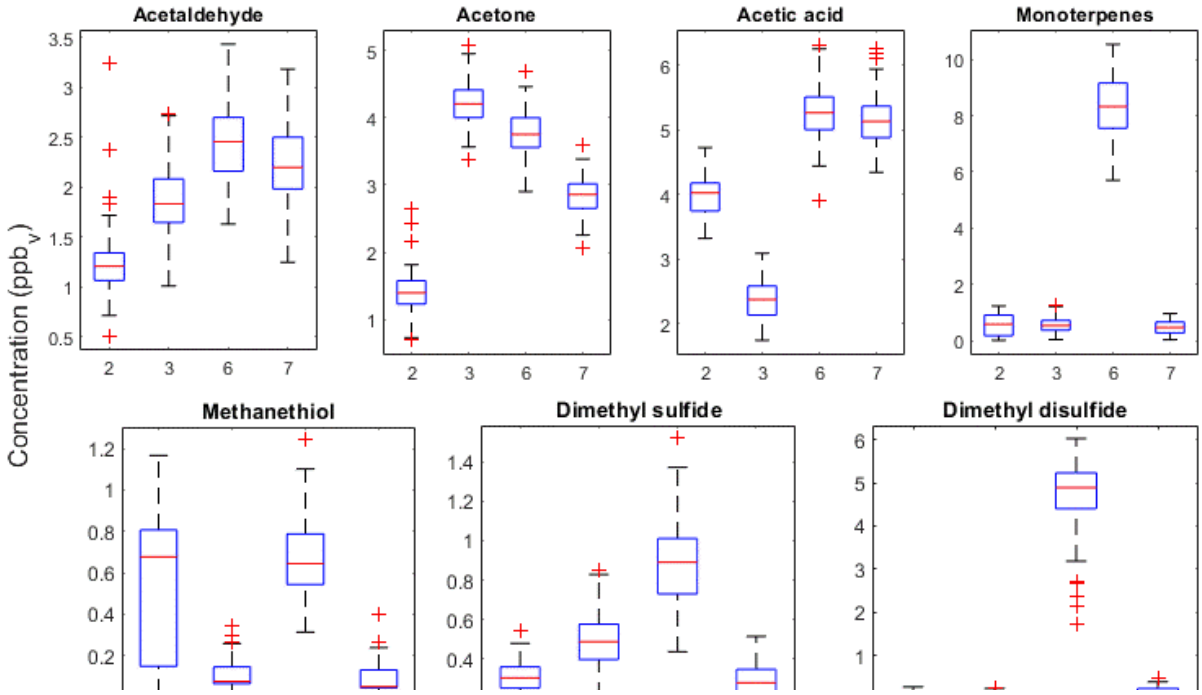


Figure 20 Jan 25 Duct sampling Boxplots 2,3,6,7

Boxplots above show the effects of the odour control technology employed on-site at the screening room foul air (2)inlet, (3)exhaust, and the centrifuge de-watering room foul air (6)inlet, (7)outlet. The concentrations are at or close to the odour threshold for each of the RSCs shown in the boxplots.

Table 17 Jan 25 Duct Sampling summary 2,3,6,7

Sample Location	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
2 - screening room air	0.7	0.3	0.1	1.2	1.4	4	0.6
3 - odour treated screening room air	0.1	0.5	0.1	1.8	4.2	2.4	0.5
6 - centrifuge room foul air	0.6	0.9	5	2.5	3.8	5.3	8.3
7 - treated centrifuge room foul air	0.1	0.3	0.2	2.2	3	5.1	0.5

April 4, 2023 summary of VOC concentrations

Boxplots of the measured concentrations of several odourous VOCs at sample locations 1-3 are shown in Figure 21, with the median concentration observed at each location shown in Table 18. The raw sewage foul air (1) contained high levels of malodourous compounds, particularly methanethiol which had a median concentration of 178 ppb_v. Concentrations of these compounds dropped significantly between sample locations 1 and 2 (the screening room foul air), but the concentrations of the three reduced sulfur compounds were still present above odour thresholds. Sample 3 is measurement of the screening room air post-odour control. Concentrations of methanethiol and monoterpenes (quantified as α-pinene) decreased after odour control, while the concentrations of the other compounds were relatively constant between locations 2 and 3, with the exception of acetone, which increased. The odour control system appears to be working well to reduce odorous methanethiol from the screening room foul air.

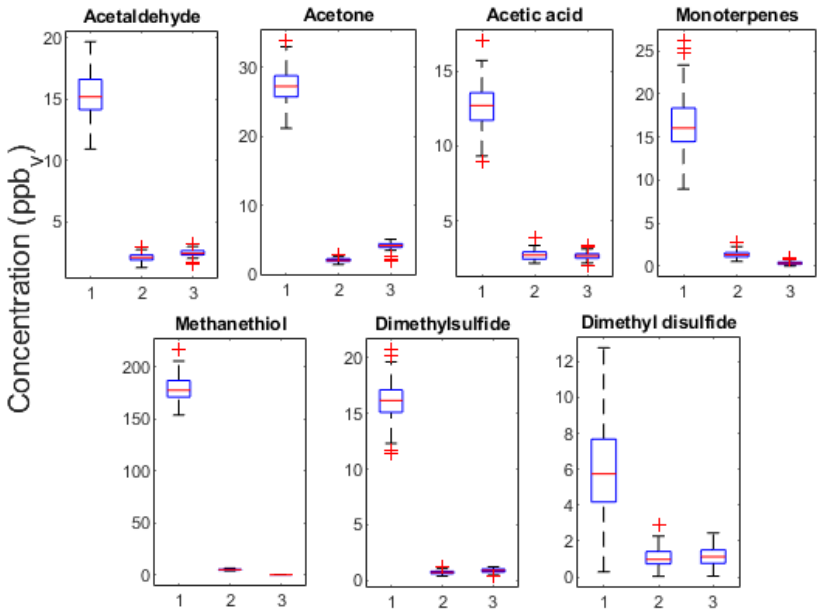


Figure 21: Boxplot summaries of the concentration of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 1 (raw influent foul air), 2 (screening room air), and 3 (odour treated screening room air) on April 4, 2023.

Table 18: Median concentrations of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 1-3.

Sample Location	Median Concentration (ppb$_v$)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
1 - raw influent foul air	178	16	6	15	27	13	16
2 - screening room air	5	1	1	2	2	3	1
3 - odour treated screening room air	0	1	1	2	4	3	0

Boxplot summaries of the concentrations of seven VOCs measured at sampling locations 6 and 7 are shown in Figure 22 with the median concentrations summarized in Table 6. The sample locations measure the foul air in the centrifuge room before (6) and after (7) foul air odour treatment with a carbon filter. Concentrations were generally low (<3 ppb$_v$ for most compounds) pre- and post-odour treatment at these sample locations, with concentrations of reduced sulfur compounds and monoterpenes decreasing after the desludging process. Only minor amounts of VOCs were detected at the inlet and outlet, this process is not always running and can be intermittent.

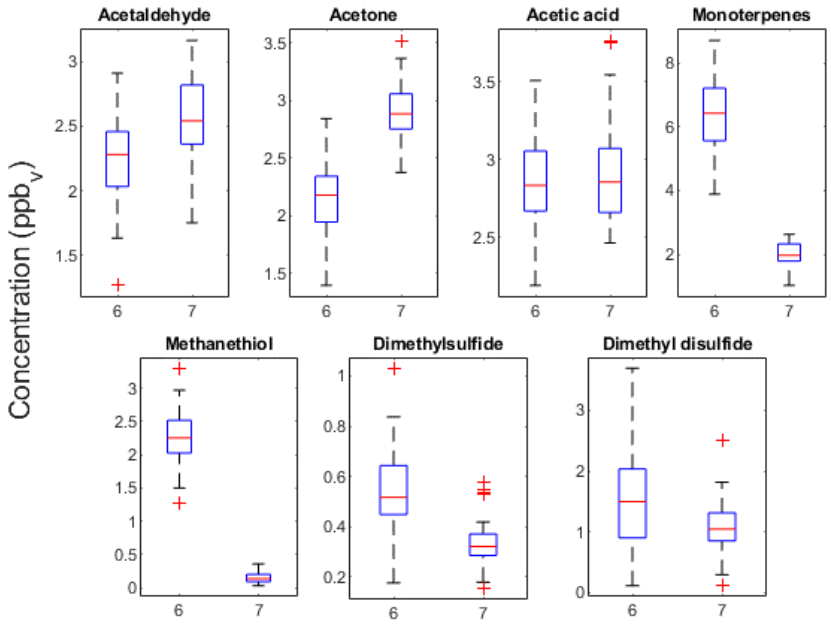


Figure 22: Boxplot summaries of the concentration of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 6 (centrifuge room foul air) and 7 (treated centrifuge room foul air). on April 4, 2023.

Table 19: Median concentrations of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 6 and 7.

Sample Location	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
6 - centrifuge room foul air	2	1	2	2	2	3	6
7 - treated centrifuge room foul air	0	0	1	3	3	3	2

Boxplot summaries of the concentrations of seven VOCs measured at sampling locations 4, 5, 8, and 9 are shown in Figure 23 with the median concentrations summarized in Table 20. Sample location 4, which is the primary treatment foul air stream, contains high levels of VOCs, with median concentrations from 16 – 192 ppb_v for the VOCs depicted. As with sample location 1, the observed concentrations of methanethiol were an order of magnitude higher than the concentrations of the other VOCs. Sample location 5 is a headspace sample of the foul air over the outfall of the water that has passed through primary treatment and is enroute to the secondary treatment network. This headspace sample may be more diffuse and diluted then direct duct sampling which would result in lower observed concentrations. Lower levels of VOCs were detected at sample location 5 compared to sample location 4, although malodourous reduced sulfur compounds were detected above their odour thresholds in both samples.

At sample location 8, the foul air stream from any part of the plant that does not have independent foul air treatment systems is combined. This includes the foul air from sample location 4. Sample location 8 contained the highest levels of malodourous reduced sulfur compounds (methanethiol, DMS and DMDS) of all other sampling locations on-site. This air stream was sampled after the air was humidified (Biorem tower), which could potentially bias methanethiol to have a lower signal intensity. Sample location 9 is measured after the biofilter air treatment at the exhaust stack to the atmosphere. The concentration of most VOCs decreases between locations 8 and 9, with the concentration of methanethiol seeing an 85 % reduction. However, at the point of release to the atmosphere the reduced sulfur compounds have observe concentrations above their odour thresholds, but they are subject to further dilution once mixed with the ambient atmosphere.

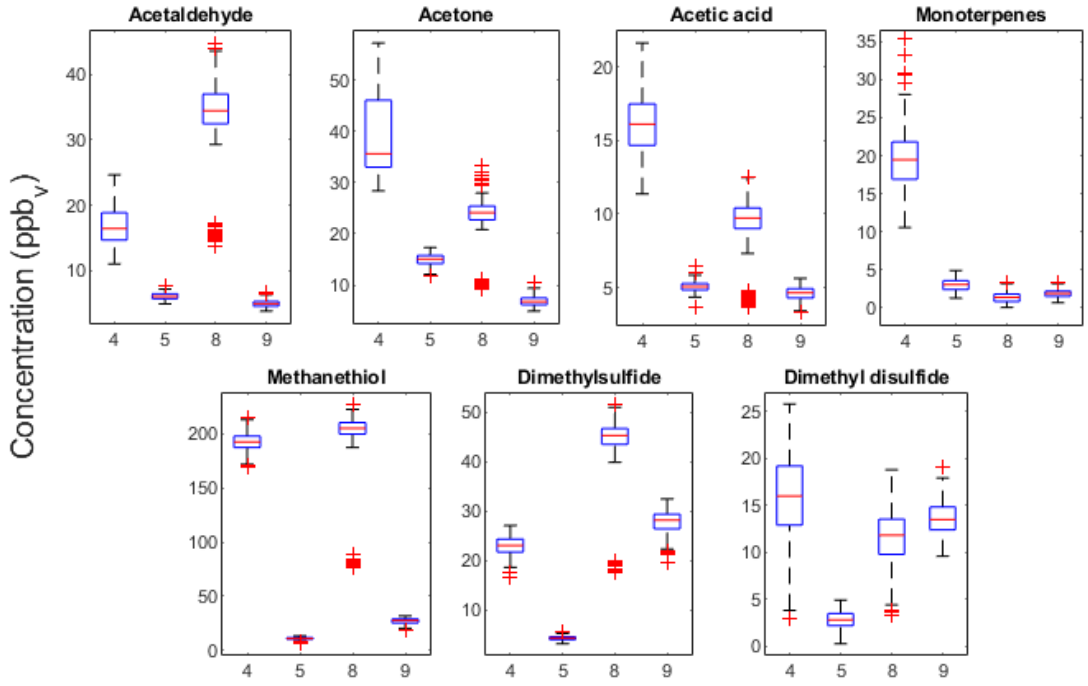


Figure 23: Boxplot summaries of the concentration of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 4 (primary treatment foul air), 5 (outfall to secondary treatment from primary treatment), 8 (main foul air stream pre-biofilter), and 9 (biofilter treated exhaust stream) on April 4, 2023.

Table 20: Median concentrations of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 4, 5, 8, and 9.

Sample Locations	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
4 - primary treatment foul air	192	23	16	16	36	16	20
5 - primary treatment outflow	11	4	3	6	15	5	3

8 - pre-biofilter foul air stream	205	45	12	34	24	10	2
9 - post-biofilter exhaust to atmosphere	28	28	14	5	7	5	2

June 23, 2023 summary of VOC concentrations

The concentrations of VOCs observed in the on-site duct-work samples on June 23 are summarized here in the same sample groups described above. Measurements at sample locations 1-3 are summarized in Figure 24 with Table 21 showing the median concentrations of the seven VOCs presented. The concentrations followed similar trends on the June 23 sampling campaign as were measured in April, but with different median concentrations. Concentrations found in the foul air stream from the raw influent (1) contained higher levels of VOCs, including the reduced sulfur compounds, compared to sample locations 2 and 3. Methanethiol concentrations were very high, with a median value of 974 ppbv, in the raw sewage inflow. The foul air from the screening room (2) contained detectable levels of VOCs with the reduced sulfur compounds still present above their odour threshold, but concentrations were much lower than at sample location 1. In the treated foul air stream (3) the concentration of some VOCs were further reduced (e.g., methanethiol, DMS), while others (e.g., DMDS, acetaldehyde) were unchanged before and after treatment. The low concentrations of reduced sulfur compounds emitted from sample point 3(treated foul air), once diluted further through mixing with ambient air in the atmosphere, should be under odour detection thresholds. The odour control system appears to be working well to reduce nuisance odours in the foul air stream.

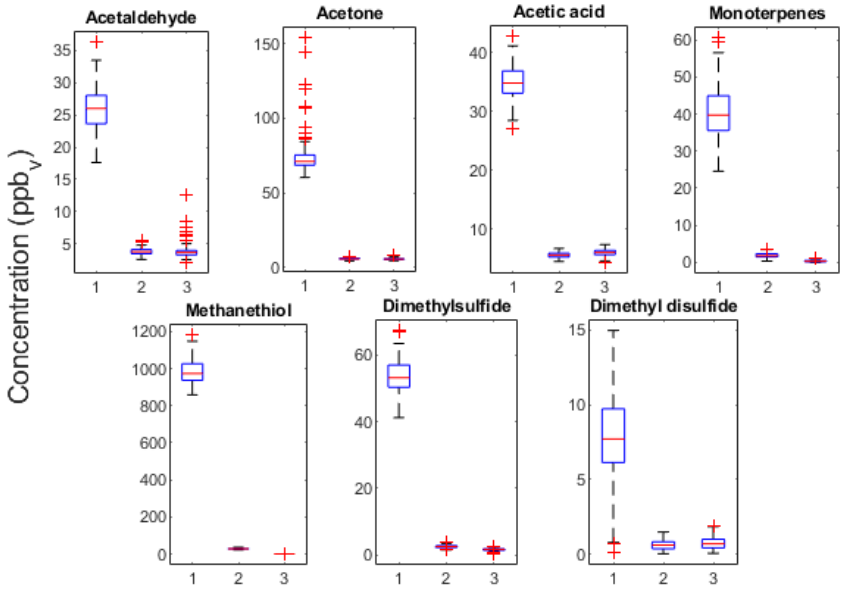


Figure 24: Boxplot summaries of the concentration of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 1 (raw influent foul air), 2 (screening room air), and 3 (odour treated screening room air) on June 23, 2023.

Table 21: Median concentrations of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 1-3.

Sample Location	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
1 - raw influent foul air	974	53	8	26	71	35	40
2 - screening room air	28	3	1	4	6	6	2
3 - odour treated screening room air	0	2	1	4	6	6	0

Concentrations measured at sample locations 6 and 7, pre- and post-odour treatment in the de-watering room, are summarized in Figure 25 and Table 22. Concentrations were generally low, although the operations can be intermittent and can be influenced by operations and influent load of the plant. On this day, the odour control system treated air at sample location 7 had observed concentrations of reduced sulfur compounds of ~1 ppbv, which is close to the odour detection limits. These concentrations will be subject to further dilution when mixed with the ambient atmosphere upon release.

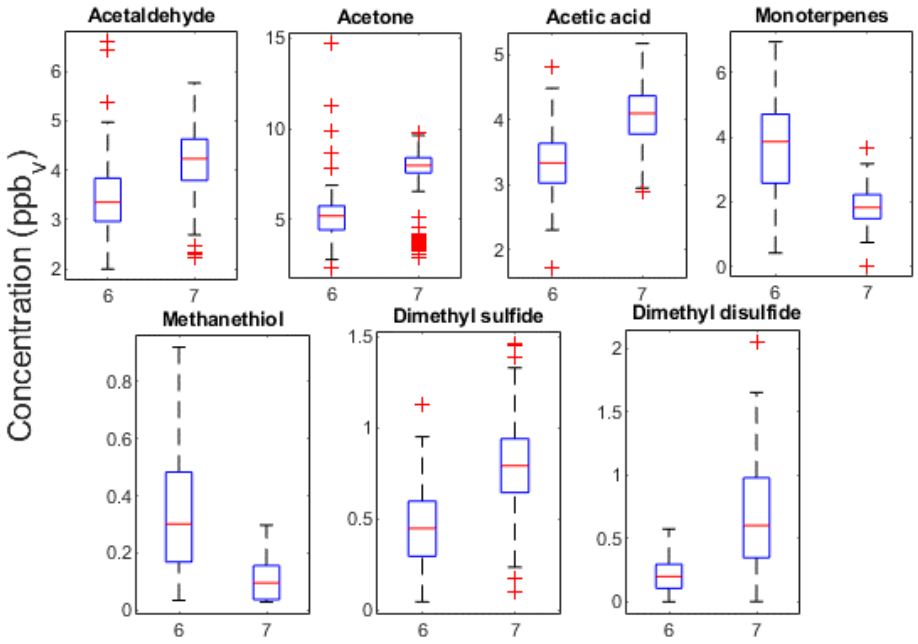


Figure 25: Boxplot summaries of the concentration of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 6 (centrifuge room foul air) and 7 (treated centrifuge room foul air). on June 23, 2023.

Table 22: Median concentrations of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 6 and 7.

Sample Location	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
6 - centrifuge room foul air	0	0	0	3	5	3	4
7 - treated centrifuge room foul air	0	1	1	4	8	4	2

The summary of concentrations observed at sample locations 4, 5, 8, and 9 are shown in Figure 26 and Table 23. Concentrations measured from the primary treatment foul air stream (4) contained the highest levels of methanethiol, with the exception of the raw sewage intake (1) , in the plant and a general high concentration of all the select VOCs. Between sample location 4 and 5, most of the VOCs have been extracted via the foul air network at the primary treatment location and only minimal amounts of VOCs are going to the secondary treatment (5). The pre- and post-biofilter concentrations (sample locations 8 and 9) of the selected VOCs trend downward, with the exception of DMDS, indicating a good performance by the biofilter. However, concentrations of DMS are still high (>140 ppb_v) in the output stream. Post-biofilter the concentrations of

methanethiol, DMS and DMDS were all significantly above odour detection thresholds (19, 141, and 12 ppb_v respectively).

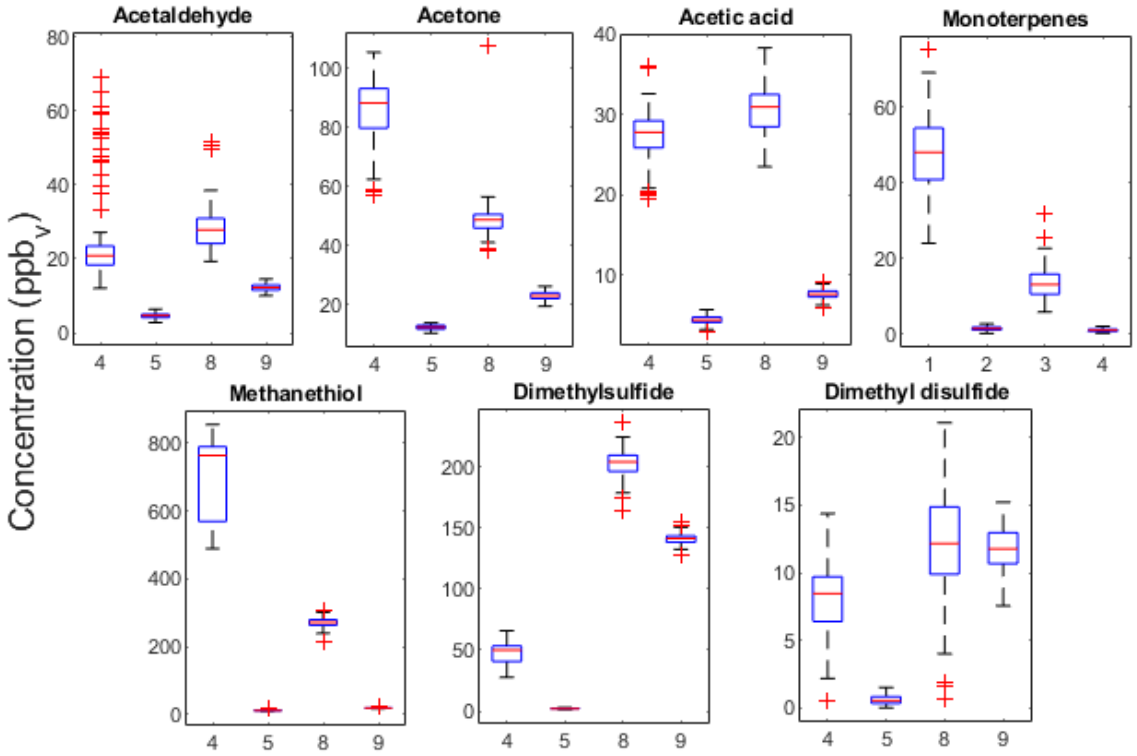


Figure 26: Boxplot summaries of the concentration of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 4 (primary treatment foul air), 5 (outfall to secondary treatment from primary treatment), 8 (main foul air stream pre-biofilter), and 9 (biofilter treated exhaust stream) on June 23, 2023.

Table 23: Median concentrations of acetaldehyde, acetone, acetic acid, monoterpenes (quantified as α-pinene), methanethiol, DMS, and DMDS observed at sample locations 4, 5, 8, and 9.

Sample Locations	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
4 - primary treatment foul air	764	50	9	21	88	28	48
5 - primary treatment outflow	11	2	1	5	12	4	1
8 - pre-biofilter foul air stream	271	204	12	28	49	31	13
9 - post-biofilter exhaust to atmosphere	19	141	12	12	23	8	1

September 22, 2023 Sampling Summary

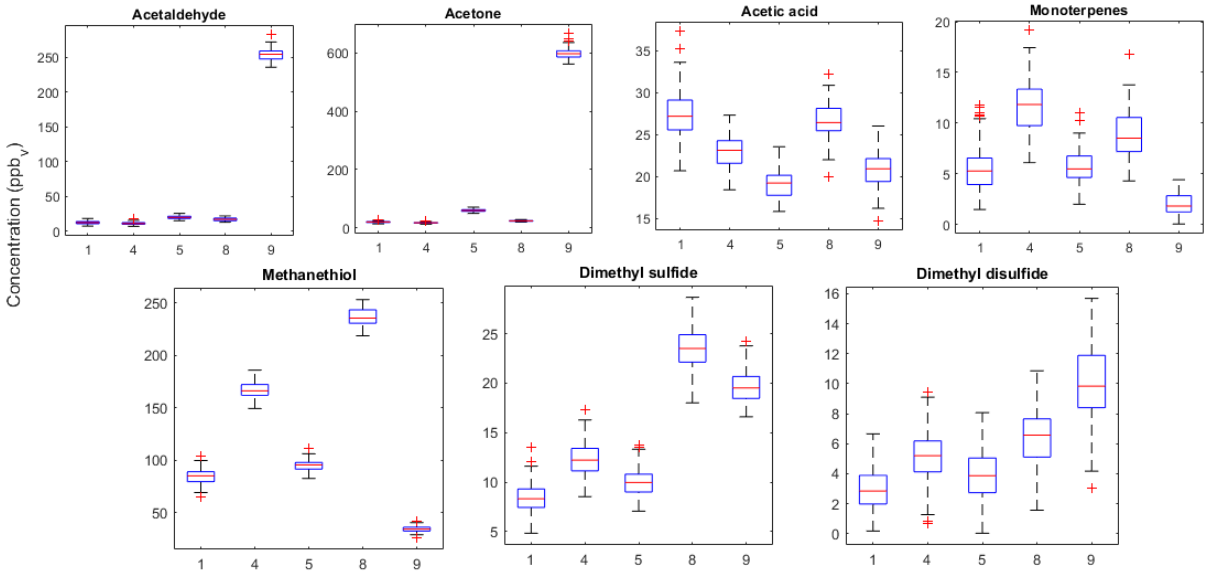


Figure 27 Ductwork Boxplot summary Sept 22 1,4,5,8,9

Summary of Duct sampling from Sept 22, 2023, showing three reduced sulfur compounds MeSH, DMS and DMDS throughout the treatment process, from raw influent (1), Primary sedimentation foul air (4), Primary treatment outfall to secondary (5), odour collection network pre-biofilter (8), Post biofilter (9). The biofilter performance for lowering the concentrations of RSCs is illustrated above showing a good reduction of MeSH and minimal effects on DMS and DMDS, which DMS is emitted higher than its odour threshold of ~ 1 ppb_v, in the final exhaust stack (Figure 27).

Table 24 Median Concentrations from Ductwork 1,4,5,8,9, Sept 22

Sample Locations	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
1- Raw sewage inflow foul air	85	8	3	13	20	27	5
4 - primary treatment foul air	165	12	5	11	17	23	12
5 - primary treatment outflow	95	10	4	20	60	19	5
8 - pre-biofilter foul air stream	235	23	6	17	22	26	8
9 - post-biofilter exhaust to atmosphere	34	19	10	255	595	21	2

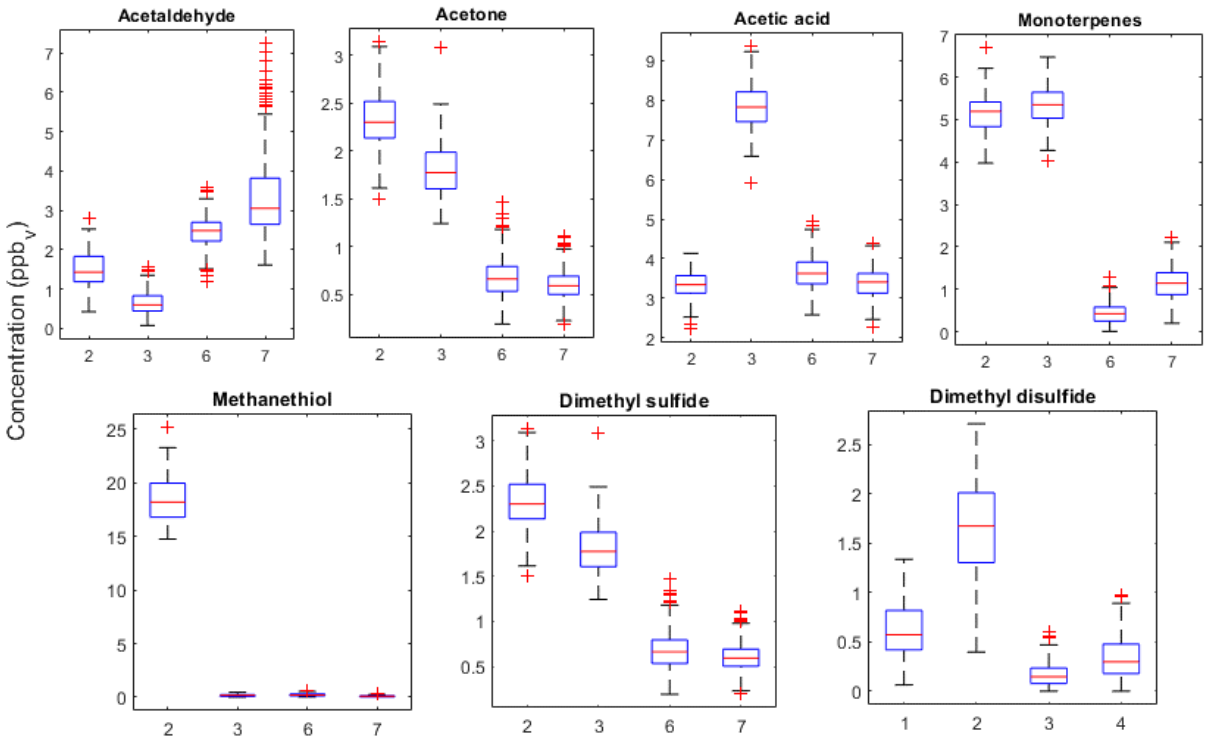


Figure 28 Ductwork Boxplot summary Sept 22, 2,3,6,7

Boxplots above show the effects of the odour control technology employed on-site at the screening room foul air (2)inlet, (3)exhaust, and the centrifuge de-watering room foul air (6)inlet, (7)outlet (Figure 28). The concentrations are at or close to the odour threshold for each of the RSCs shown in the boxplots.

Table 25 Median Concentrations from Ductwork 2,3,6,7, Sept 22

Sample Location	Median Concentration (ppb$_v$)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
2 - screening room air	18	2.5	0.5	1.5	2.2	3	5
3 - odour treated screening room air	0.2	1.5	1.5	0.5	1.7	8	5
6 - centrifuge room foul air	0.2	0.5	0.2	2.5	0.5	3.5	0.5
7 - treated centrifuge	0.2	0.5	0.3	3	0.5	3	1

room foul air							

November 7, 2023 Sampling summary

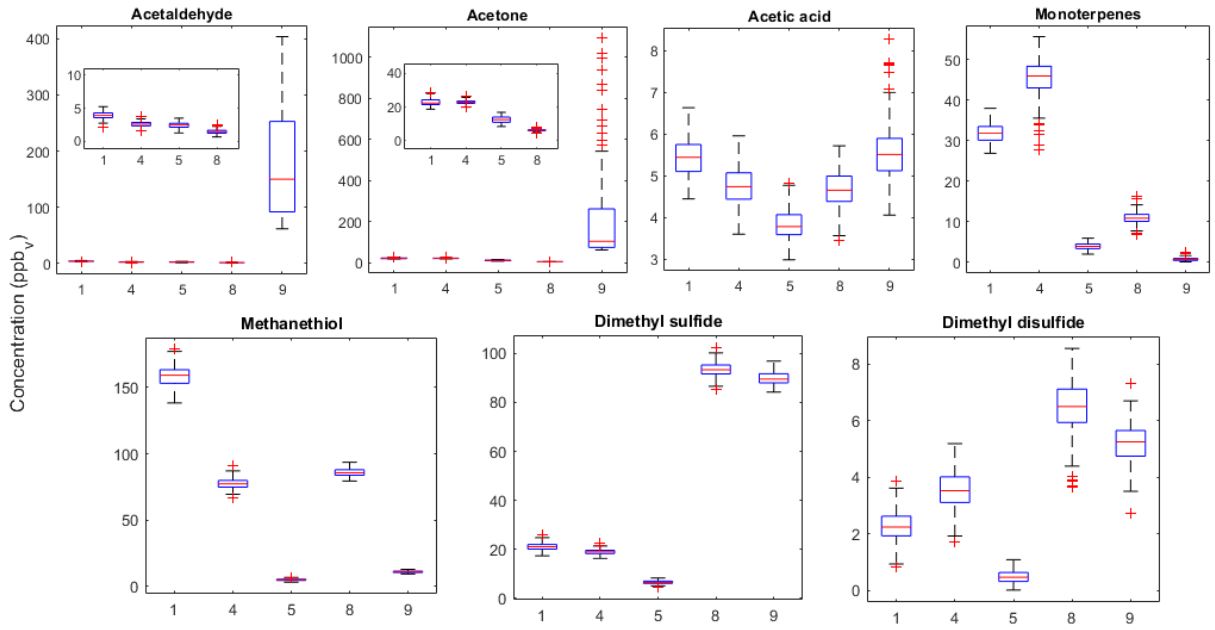


Figure 29 Ductwork Boxplot summary 1,4,5,8,9, Nov 7

Summary of Duct sampling from Nov 7, 2023, showing three reduced sulfur compounds MeSH, DMS and DMDS throughout the treatment process, from raw influent (1), Primary sedimentation foul air (4), Primary treatment outfall to secondary (5), odour collection network pre-biofilter (8), Post biofilter (9). The biofilter performance for lowering the concentrations of RSCs is illustrated above showing a good reduction of MeSH and minimal effects on DMS and DMDS, which DMS is emitted much higher than its odour threshold of ~ 1 ppb_v, in the final exhaust stack (Figure 29).

Table 26 Median Concentrations from Ductwork 1,4,5,8,9, Nov 7

Sample Locations	Median Concentration (ppb_v)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
1- Raw sewage inflow foul air	159	21	2	4	22.5	5.5	32
4 - primary treatment foul air	77	19	3.5	2.5	23	4.5	46
5 - primary treatment outflow	5	6.5	0.5	2.5	12.5	3.5	4

8 - pre-biofilter foul air stream	85	93	6.5	1.4	6	4.5	11
9 - post-biofilter exhaust	11	89	5	150	105	5.5	1

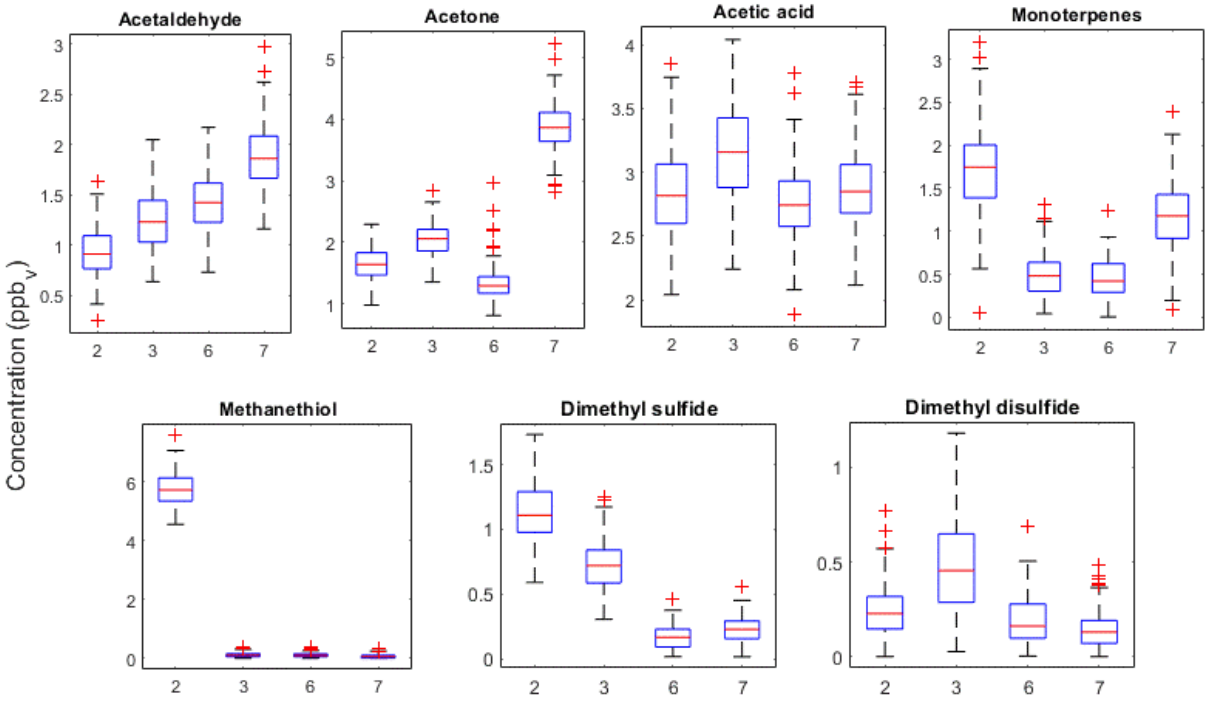


Figure 30 Ductwork Boxplot summary 2,3,6,7, Nov 7

Boxplots above show the effects of the odour control technology employed on-site at the screening room foul air (2)inlet, (3)exhaust, and the centrifuge de-watering room foul air (6)inlet, (7)outlet (Figure 30). The concentrations are at or close to the odour threshold for each of the RSCs shown in the boxplots.

Table 27 Median Concentrations from Ductwork 2,3,6,7, Nov 7

Sample Location	Median Concentration (ppb$_v$)						
	m/z 49.01 as methanethiol $(CH_4S)H^+$	*m/z* 63.02 as dimethyl sulfide $(C_2H_6S)H^+$	*m/z* 94.99 as dimethyl disulfide $(C_2H_6S_2)H^+$	*m/z* 45.02 as acetaldehyde $(C_2H_4O)H^+$	*m/z* 59.04 as acetone $(C_2H_6O)H^+$	*m/z* 61.02 as acetic acid $(C_2H_4O_2)H^+$	*m/z* 137.13 as α-pinene $(C_{10}H_{16})H^+$
2 - screening room air	5.5	1	0.2	1	1.5	2.8	1.7
3 - odour treated screening room air	0.1	0.5	0.5	1.2	2	3.2	0.5
6 - centrifuge room foul air	0.1	0.2	0.2	1.4	1	2.7	0.4

7 - treated centrifuge room foul air	0.1	0.2	0.1	1.9	4	2.8	1.2

TD-GC-MS Confirmation of RSCs at Biofilter inlet (8) and Exhaust (9)

Samples were taken at locations 8 and 9, sampled for 10 minutes at 500 ml/min directly onto Sorbent tube, then analyzed next day at VIU.

Peak heights were evaluated, and retention times were check for accuracy and to confirm PTR-MS measurements taken of the RSCs.

Table 28 GC-MS Reduced sulfur compound summary chromatogram, Nov 7, 2023

	Peak Height		% Change
Compound	8 – Inlet to biofilter	9 – Exhaust stack	
Methanethiol	10,600	8,400	- 20%
Dimethyl sulfide	34,700	543,000	+1400%
Dimethyl disulfide	82,600	164,000	+100%

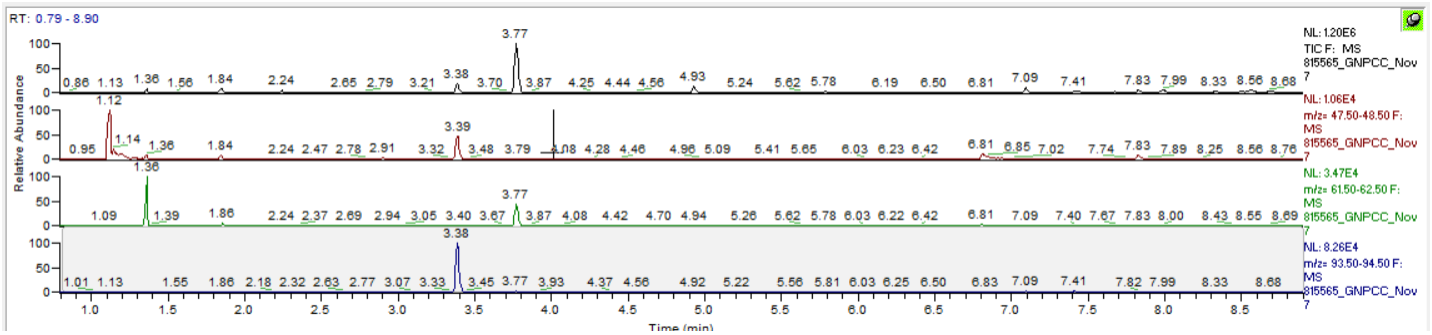


Figure 31 Chromatogram from Nov 7, Biofilter inlet, showing Methanethiol, DMS and DMDS.

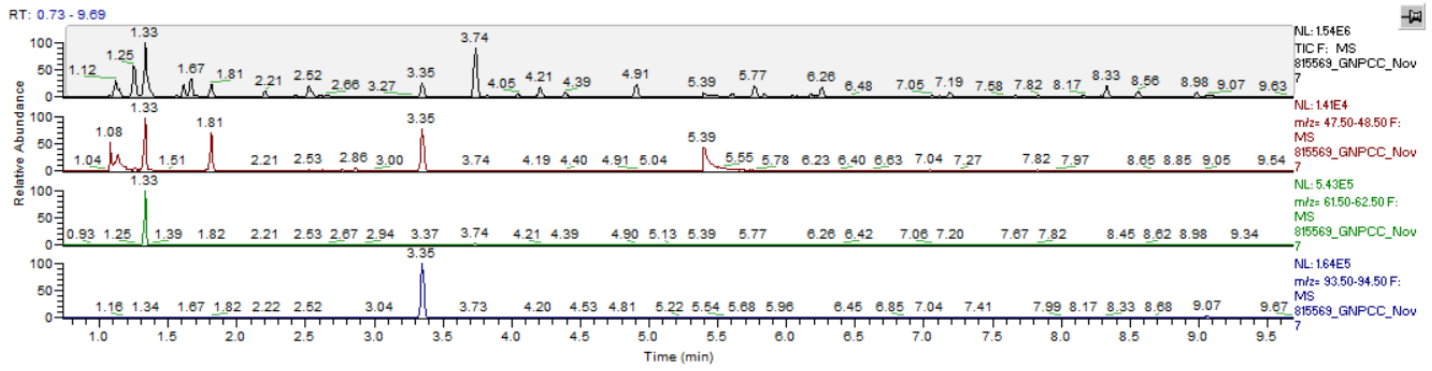


Figure 32 Chromatogram from Nov 7, Biofilter exhaust, showing MeSH, DMS and DMDS.

Chromatograms showing total ion intensity in black, Ion intensity for m/z 47-48 for Methanethiol, confirmed in lab at RT 1.08-1.12 (Red), ion intensity for m/z 61-62 with RT at 1.33 confirmed in lab for Dimethyl sulfide (Green), and ion intensity for m/z 93-94 for Dimethyl disulfide confirmed in lab at RT 3.35 (Blue) (Figure 32). Top chromatogram is showing the results from the Pre-biofilter sorbent tube GC analysis. The bottom group of chromatograms is showing the results from the post-biofilter sorbent tube GC analysis, focused on the three reduced sulfur compounds, MeSH, DMS, and DMDS which are reported by PTR-TOF-MS in the previous Figure 29 . This work was done to confirm the detection of these compounds and to get a relative proportion of the signal intensities for each location.

February 26, 2024 On-site sampling

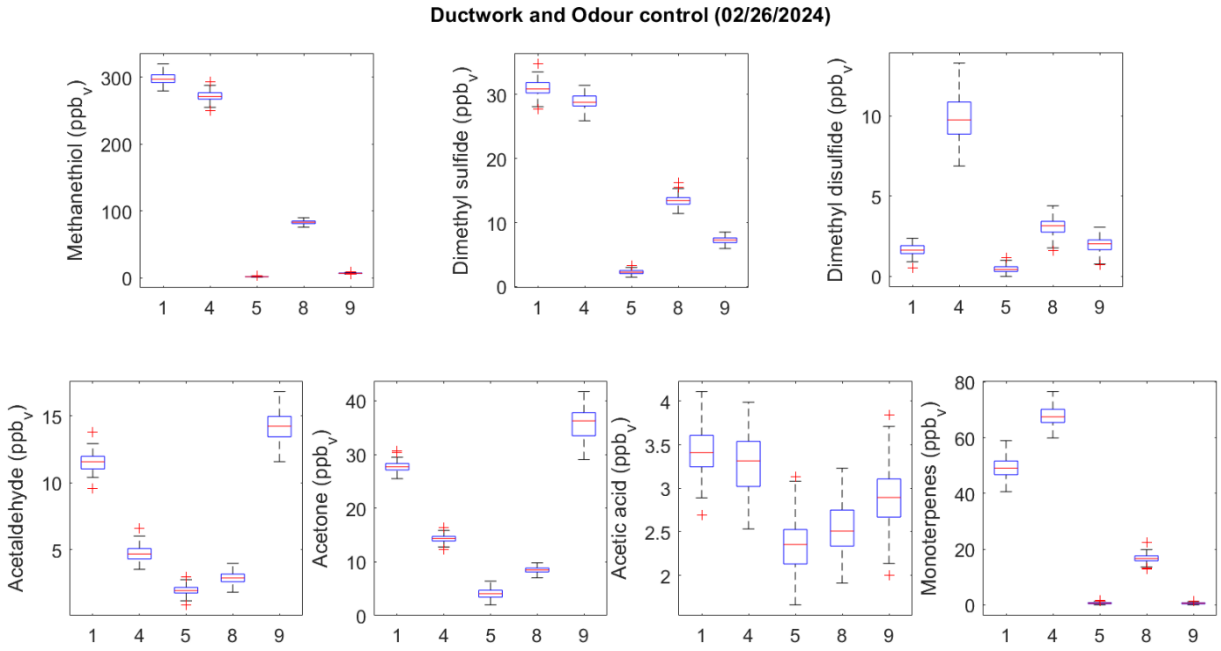


Figure 33 February 26, 2024 On-site sampling points 1,4,5,8,9, showing boxplots of select VOCs concentrations

Table 29 Median concentrations from sample points 1,4,5,8,9, from Feb 26, 2024.

Median Concentrations (ppb_v)					
Sample ID #	1	4	5	8	9
Methanethiol	297.4	271.5	1.8	83.2	6.9
Dimethyl sulfide	30.9	28.8	2.3	13.5	7.3
Dimethyl disulfide	1.7	9.8	0.5	3.2	2.1
Acetaldehyde	11.6	4.7	2	2.9	14.3
Acetone	27.8	14.4	3.9	8.5	36.3
Acetic acid	3.5	3.4	2.4	2.6	2.9

Monoterpenes	49.2	67.6	0.6	16.7	0.6

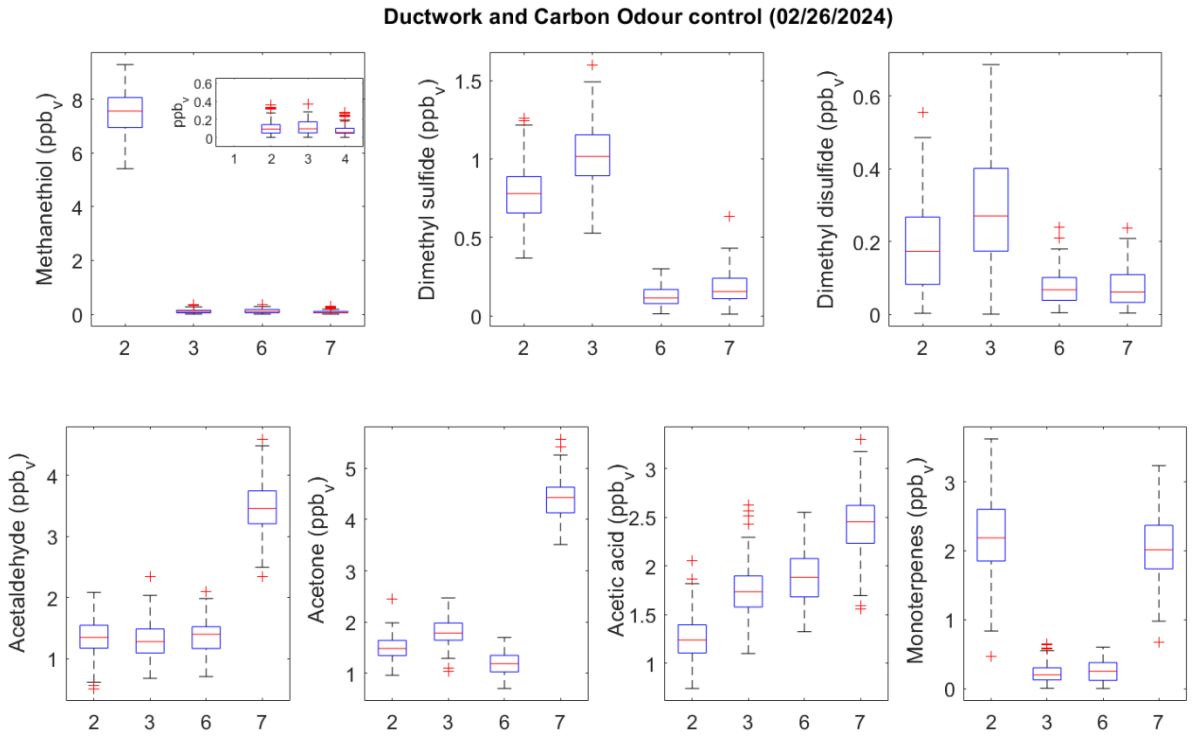


Figure 34 February 26, 2024 On-site GNPCC sampling locations 2,3,6,7, showing boxplots of select VOCs concentration, blower was offline for sample points 6 and 7 and only static air was flowing through the system.

Table 30 Median concentrations from sample points 2,3,6,7, from Feb 26, 2024.

Median Concentrations (ppb_v)				
Sample ID #	2	3	6	7
Methanethiol	7.6	0.1	0.1	0.1
Dimethyl sulfide	0.8	1.1	0.2	0.2
Dimethyl disulfide	0.2	0.3	0.1	0.1
Acetaldehyde	1.4	1.3	1.5	3.5
Acetone	1.5	1.8	1.2	4.5
Acetic acid	1.3	1.8	1.9	2.5
Monoterpenes	2.2	0.3	0.3	2.1

June 11, 2024 On-site GNPCC sampling

Ductwork samples are shown below for locations 1,4,5,8 and 9, the raw sewage (1), primary settling pond foul air (4), outflow to secondary bioreactors (5), post rain tower/pre-odour control bioreactor (8), post bioreactor odour control (9). Boxplots showing the ranges of concentrations in the ductwork are displayed below, with an accompanying table with median values.

During June 11th concentrations at sample point 9 for MeSH and DMS were decreased by >80% (outlet at 26 ppb_v) and 6% (outlet at 59 ppb_v), respectively. DMDS was slightly elevated from the inlet concentration, exhausting out at 9 ppb_v. Methanethiol and dimethyl sulfide were higher than the February sampling and could be a source of odours off-site (Figure 35). The three oxygenated VOCs reported out were all greatly increased after bioreactor treatment, with concentrations of acetaldehyde, acetone and acetic acid at 135, 760 and 16 ppb_v, respectively.

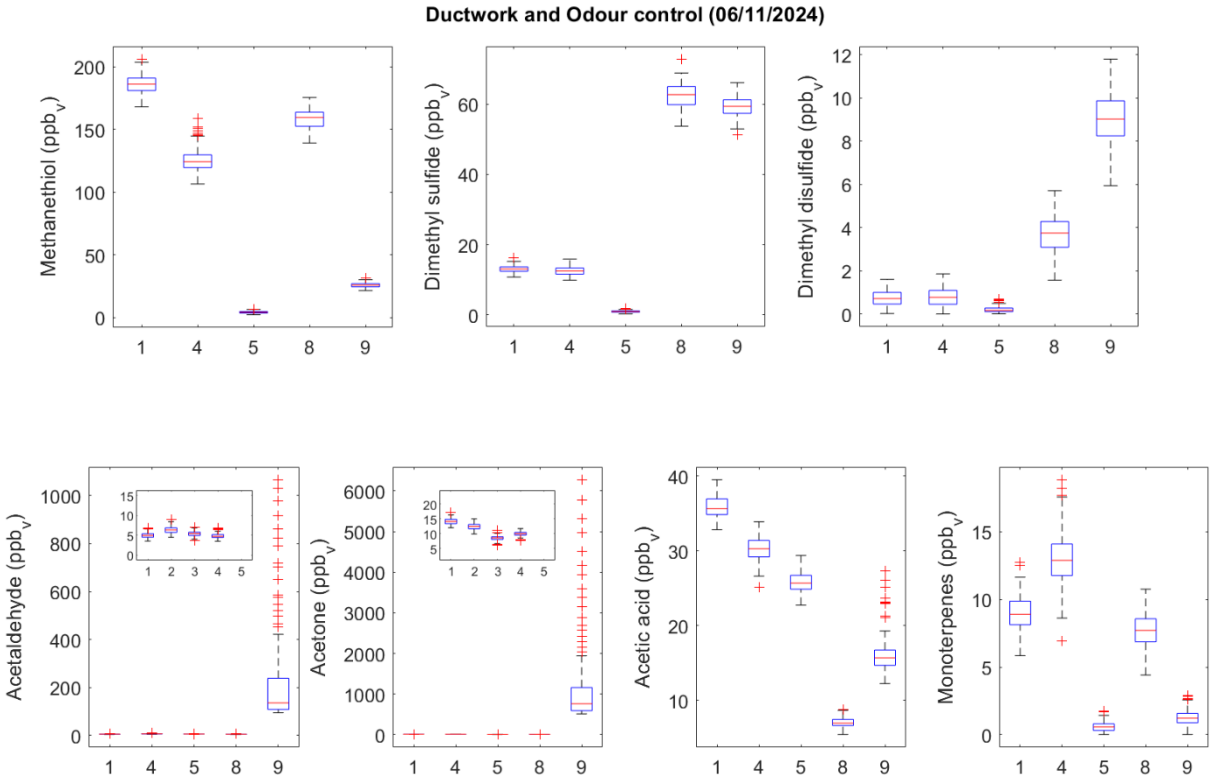


Figure 35 June 11, 2024 On-site sampling locations 1,4,5,8,9, showing boxplots of select VOCs concentrations

Table 31 Median concentrations from sample points 1,4,5,8,9, from June 11, 2024.

Median Concentrations (ppb_v)					
Sample ID #	1	4	5	8	9
Methanethiol	186.3	123.4	4.2	159.7	25.8
Dimethyl sulfide	13.1	12.4	1	62.8	59.4
Dimethyl disulfide	0.8	0.8	0.2	3.8	9.1

Acetaldehyde	5	6.4	5.5	4.8	135.7
Acetone	14.2	12.5	8.6	10	762.9
Acetic acid	35.7	30.2	25.7	7	15.7
Monoterpenes	9	12.8	0.6	7.8	1.3

Ductwork samples are shown below from the module carbon scrubbers, screening room foul air (2), post carbon scrubber from screening room (3), centrifuge room foul air (6) and post carbon scrubber from centrifuge room (7). Boxplots show concentration ranges recorded and an accompanying table with median values is provided below (Figure 36, Table 32).

June 11th concentrations for methanethiol (MeSH) were decreased by 95% at carbon scrubber (3), with outlet concentration at 0.3 ppb_v, and slightly lowered at carbon scrubber (7) exhausting at 0.2 ppb_v , DMS and DMDS were negligibly treated by the carbon scrubbers but were overall under 1ppb_v at the exhaust.

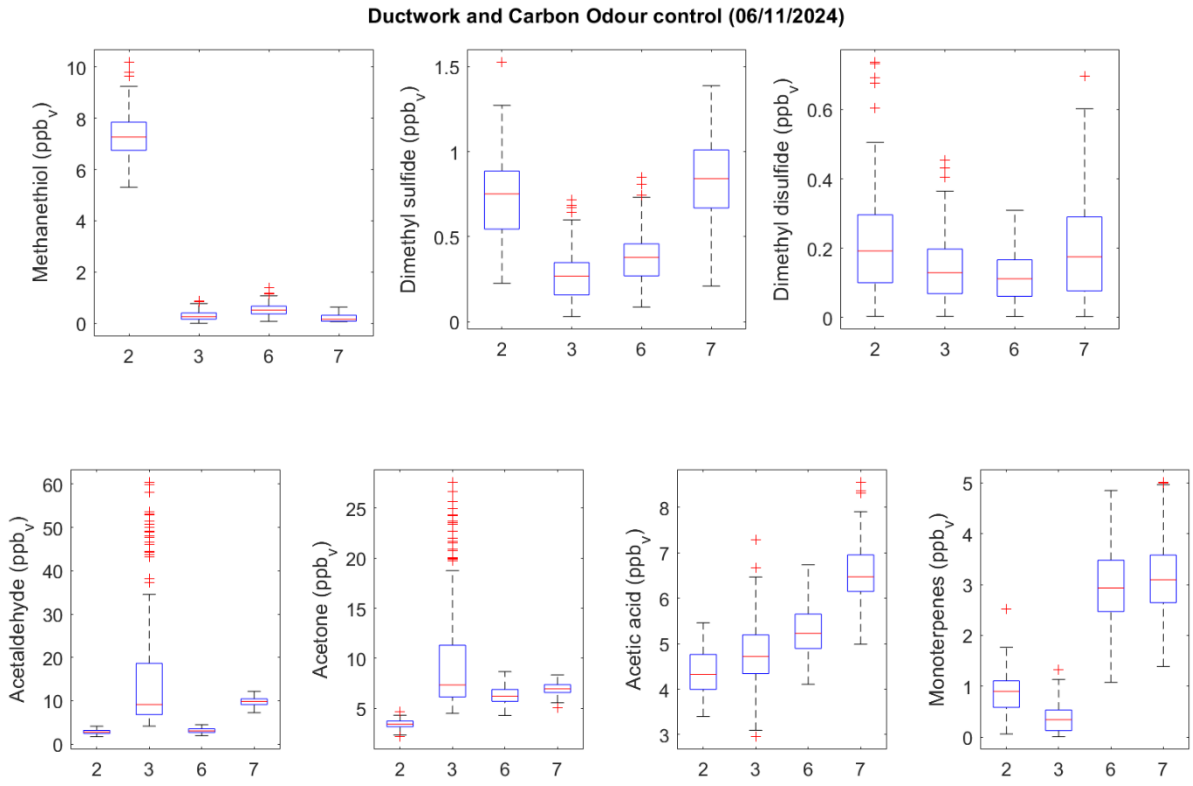


Figure 36 June 11, 2024 On-site GNPCC sampling locations 2,3,6,7, showing boxplots of select VOCs concentrations

Table 32 Median concentrations from sample points 2,3,6,7, from June 11, 2024.

Median Concentrations (ppb_v)				
Sample ID #	2	3	6	7
Methanethiol	7.3	0.3	0.6	0.2
Dimethyl sulfide	0.8	0.3	0.4	0.9
Dimethyl disulfide	0.2	0.2	0.2	0.2
Acetaldehyde	2.8	9.2	3.1	9.9

Acetone	3.5	7.5	6.3	7
Acetic acid	4.4	4.8	5.3	6.5
Monoterpenes	0.9	0.4	3	3.1

WWTP3 – Mcloughlin Point Wastewater Treatment Plant

Table 33 Sample dates and times of ductwork sampling at WWTP3

Date	Comments	Time Sampling
April 21, 2022	On-site ductwork sampling	11:00-17:30
November 24, 2022	On-site ductwork sampling	09:00-12:30
November 25, 2022	On-site ductwork sampling	08:45-10:00/12:00-13:00
February 10, 2023	On-site ductwork sampling	8:45-13:00
April 12, 2023	On-site ductwork sampling	13:00-16:00
May 30, 2023	On-site ductwork sampling	13:00-16:30
July 27, 2023	On-site ductwork sampling	09:00-12:00
August 22, 2023	On-site ductwork sampling	9:00-15:30
October 19, 2023	On-site ductwork sampling	12:00-16:00
November 10, 2023	On-site ductwork sampling	14:30-17:00
February 22, 2024	On-site ductwork sampling	8:30-12:30
TOTAL (hh:mm)		43:00

Table 34 MPWWTP zones and description of air samples.

Zone	Sample Id	Description
Primary	1A	Primary foul air inlet (BTF Inlet)
	1B	Primary foul air carbon filter inlet
	1C	Primary foul air exhaust
Secondary	2A	Secondary foul air inlet
	2B	Secondary foul air exhaust
	2Bbkf	Secondary foul air exhaust backflush
Tertiary	3A	Disk filter 1 (slide gate)

	3B	Disk filter 2 (level sensor)
	3C	Disk filter bypass channel level sensor
	3D	Outfall chamber vent
Holding Tanks	4	Sludge holding tank
	5	Dirty backwash tank
	6	Plant drain tank

February 10, 2023 Ductwork summary

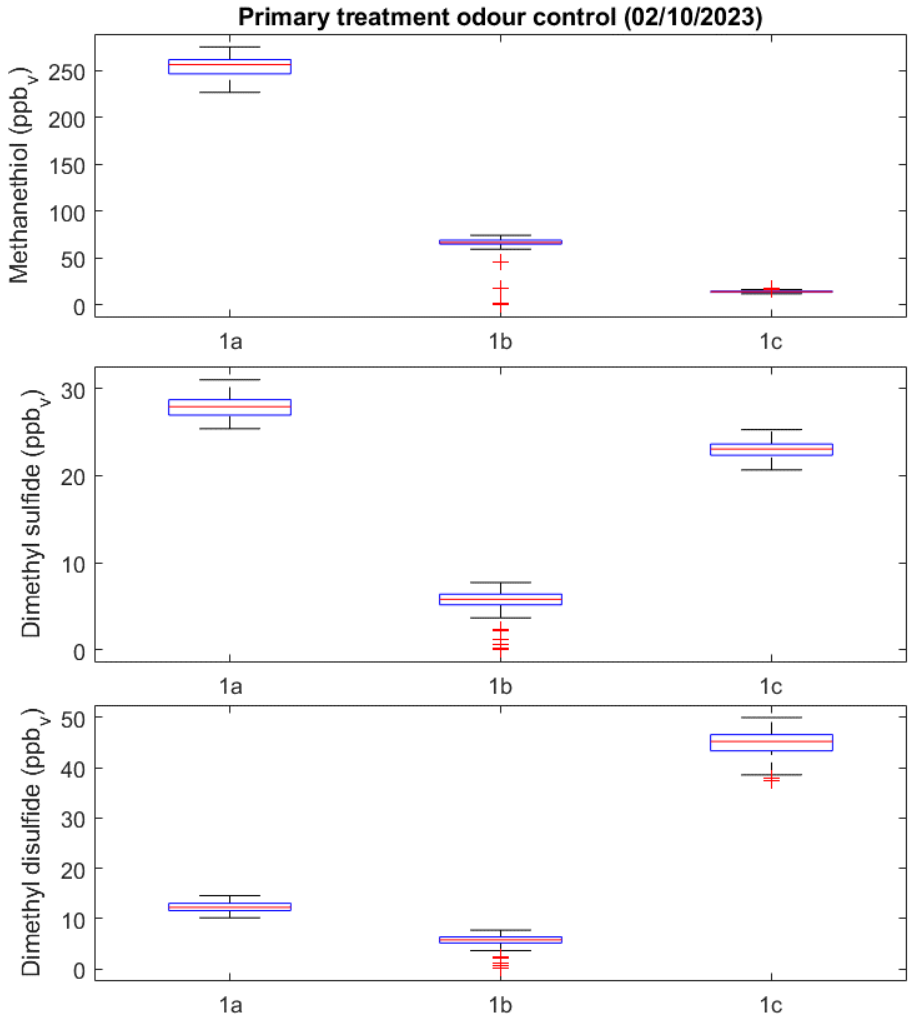


Figure 37 Primary wastewater treatment odour controls, 1a, 1b, 1c, for methanethiol, dimethyl sulfide and dimethyl disulfide. (02/10/2023)

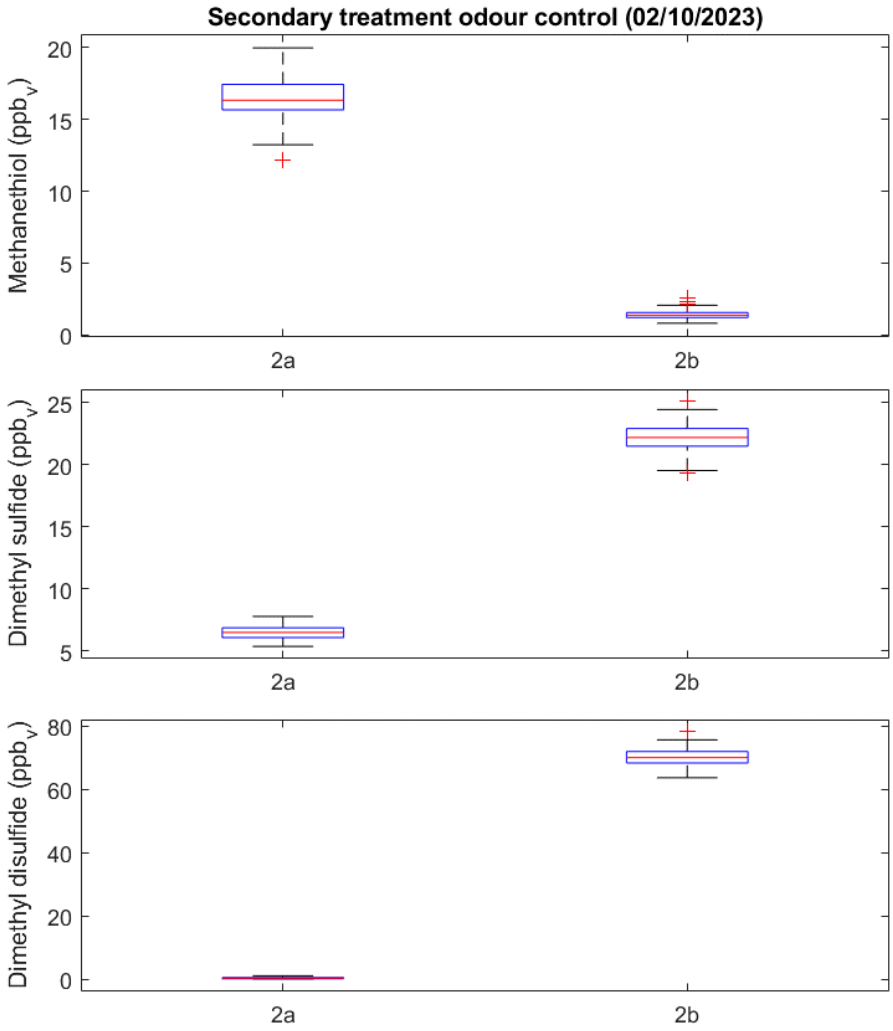


Figure 38 Secondary wastewater treatment odour controls, 2a and 2b for methanethiol, dimethyl sulfide and dimethyl disulfide. (02/10/2023)

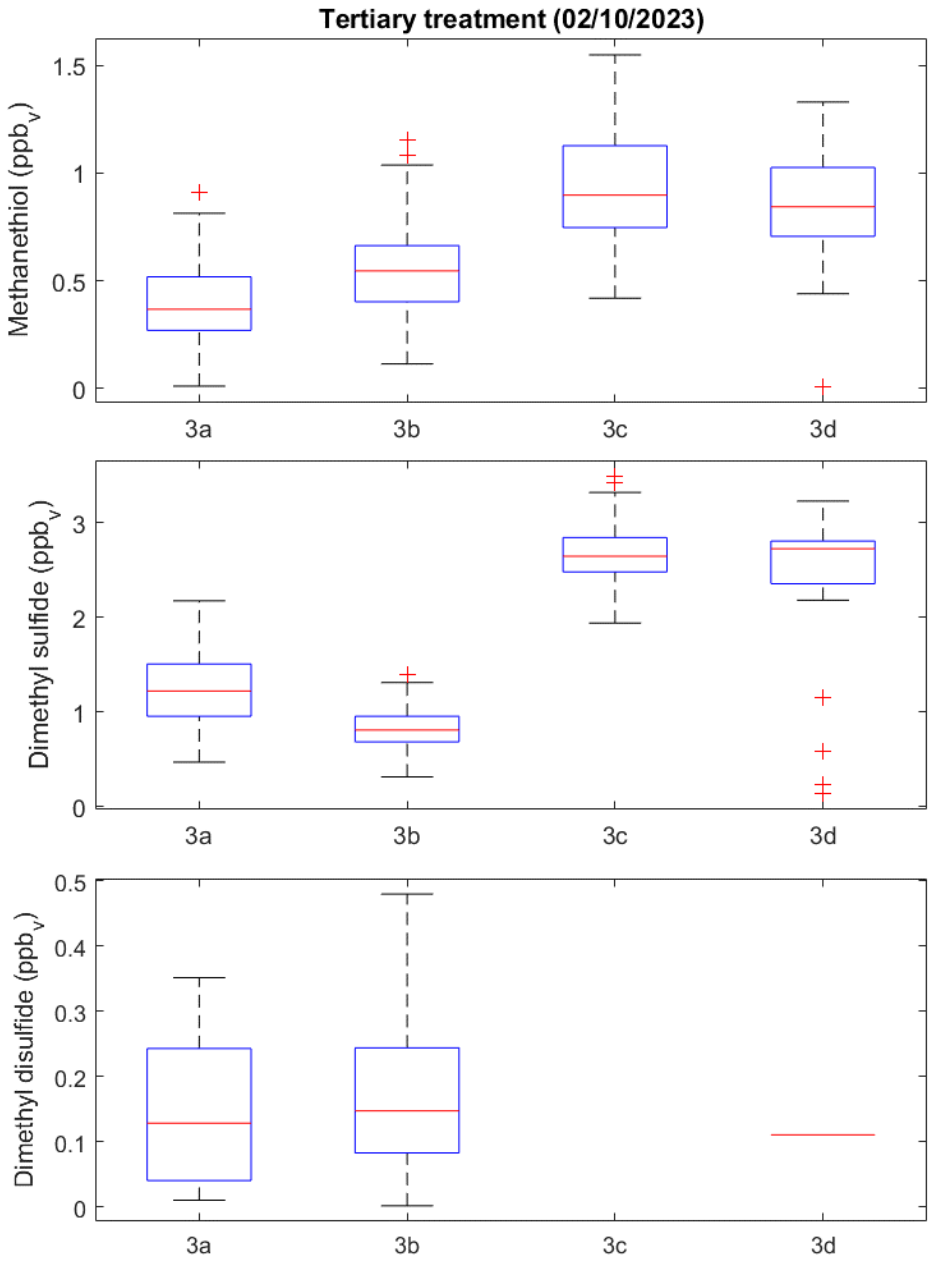


Figure 39 Tertiary wastewater treatment odour controls, 3a, 3b, 3c and 3d for methanethiol, dimethyl sulfide and dimethyl disulfide. (02/10/2023)

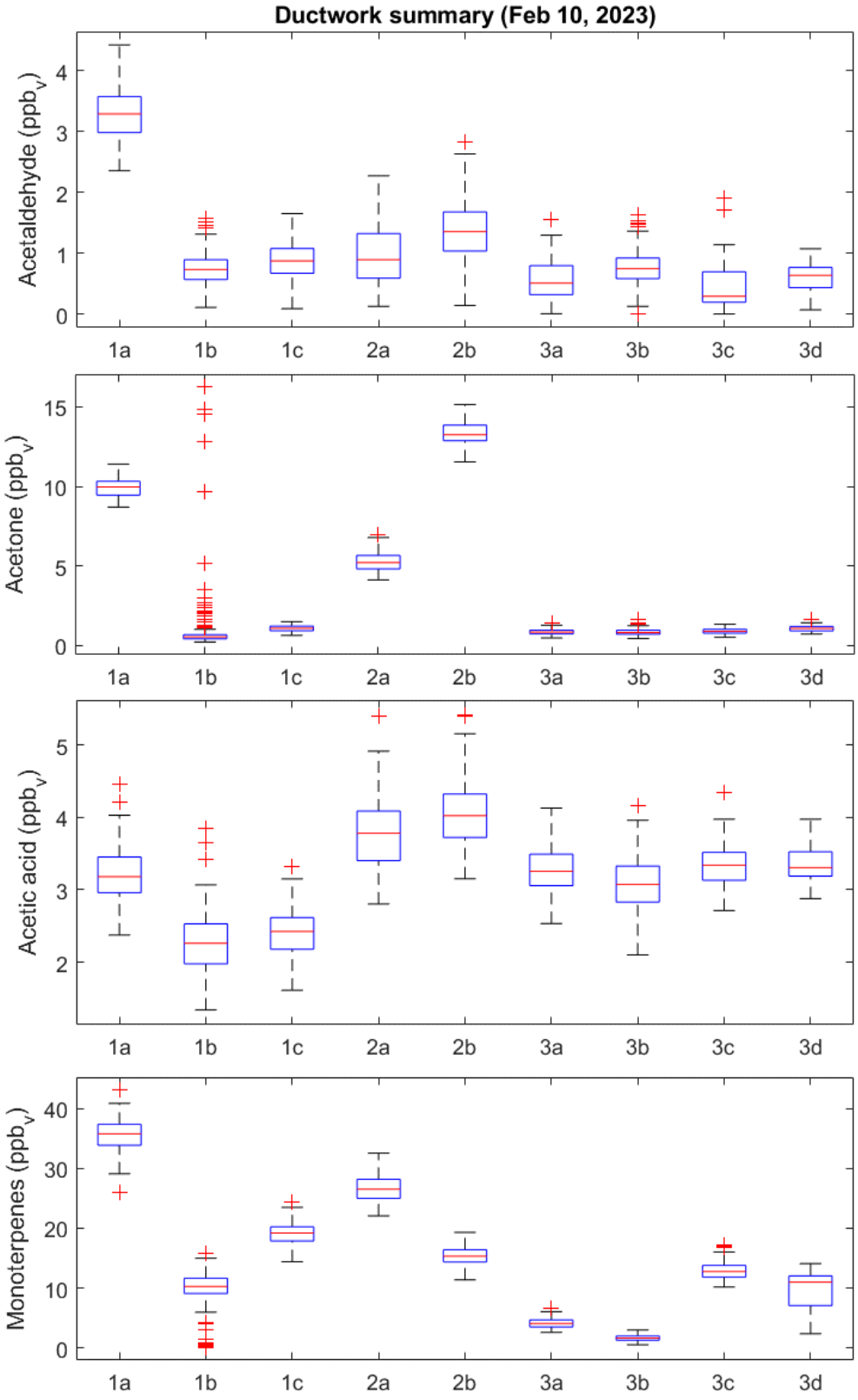


Figure 40 Ductwork summary of acetaldehyde, acetone, acetic acid and monoterpenes for all sample points (02/10/2023)

April 12, 2023, MPWWTP Odour Monitoring summary, Duct sampling.

Boxplot summaries of odourous VOCs from Primary treatment odour control,

A- Inlet, B- Blower, C- Outlet/Exhaust

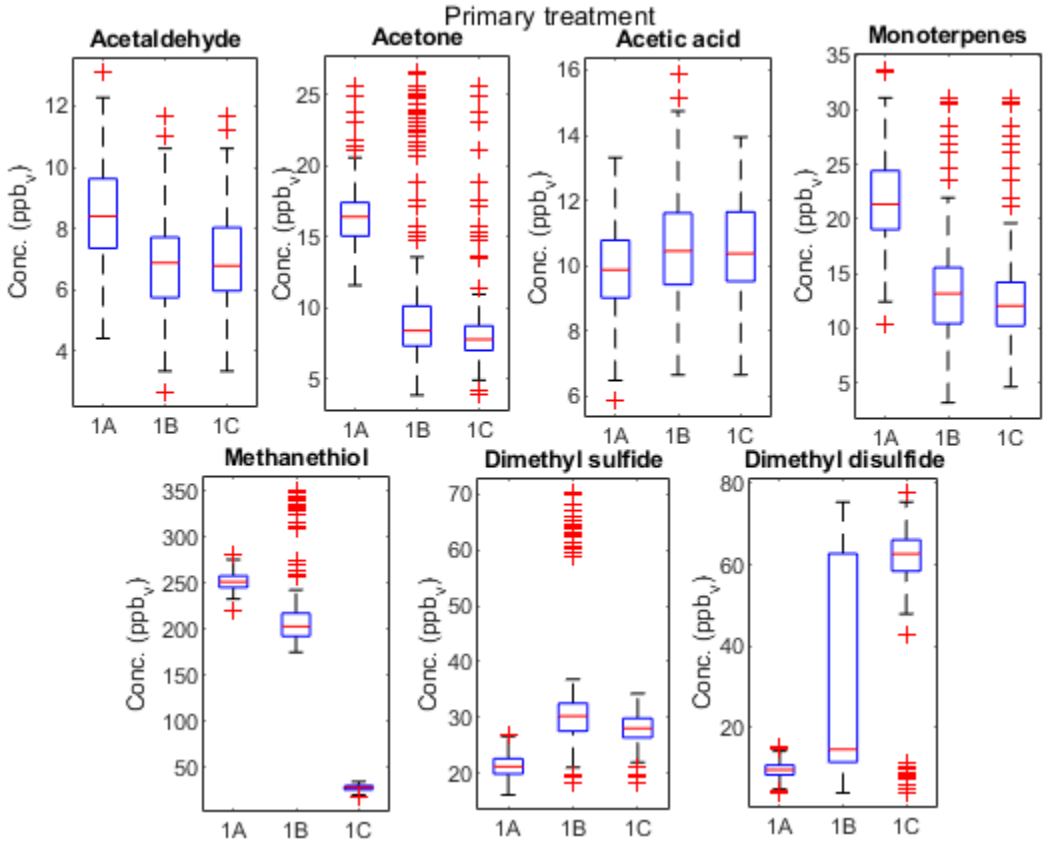


Figure 41 Primary wastewater treatment odour controls, 1a, 1b, 1c, for methanethiol, dimethyl sulfide and dimethyl disulfide. (04/12/2023)

Boxplot summaries of odourous VOCs from Secondary foul air treatment,

A- Inlet , B- Outlet/Exhaust

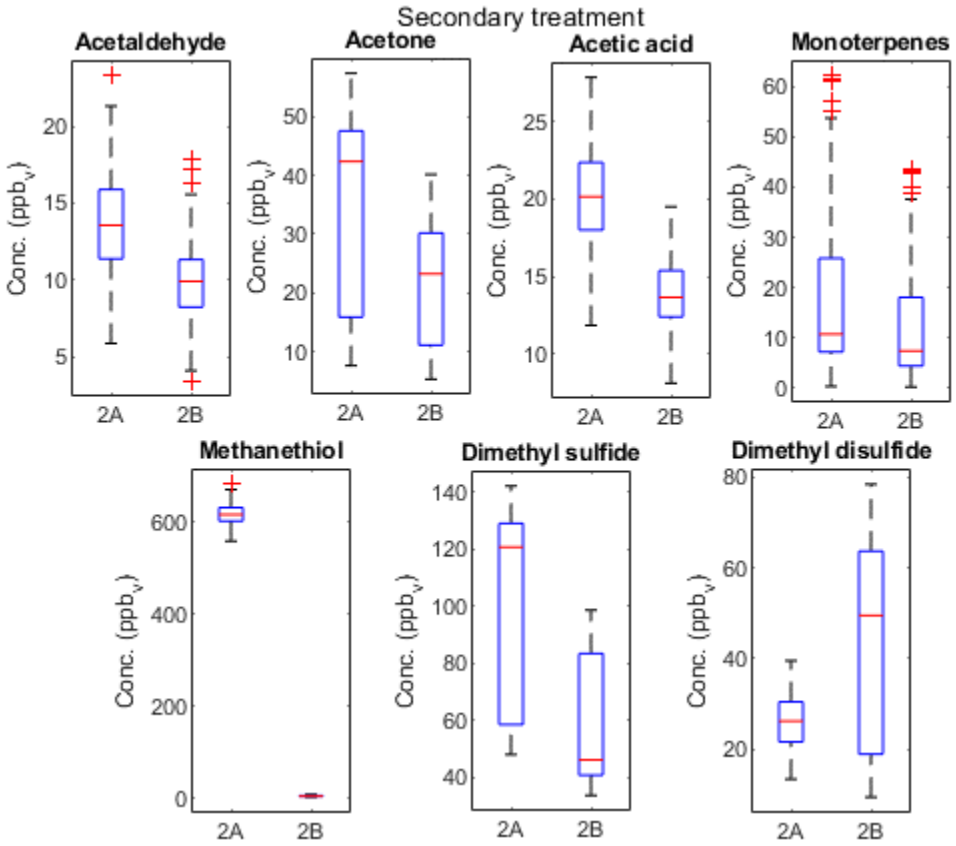


Figure 42 Secondary wastewater treatment odour controls, 2a and 2b for 7 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (04/12/2023)

Boxplot summaries from Tertiary treatment,

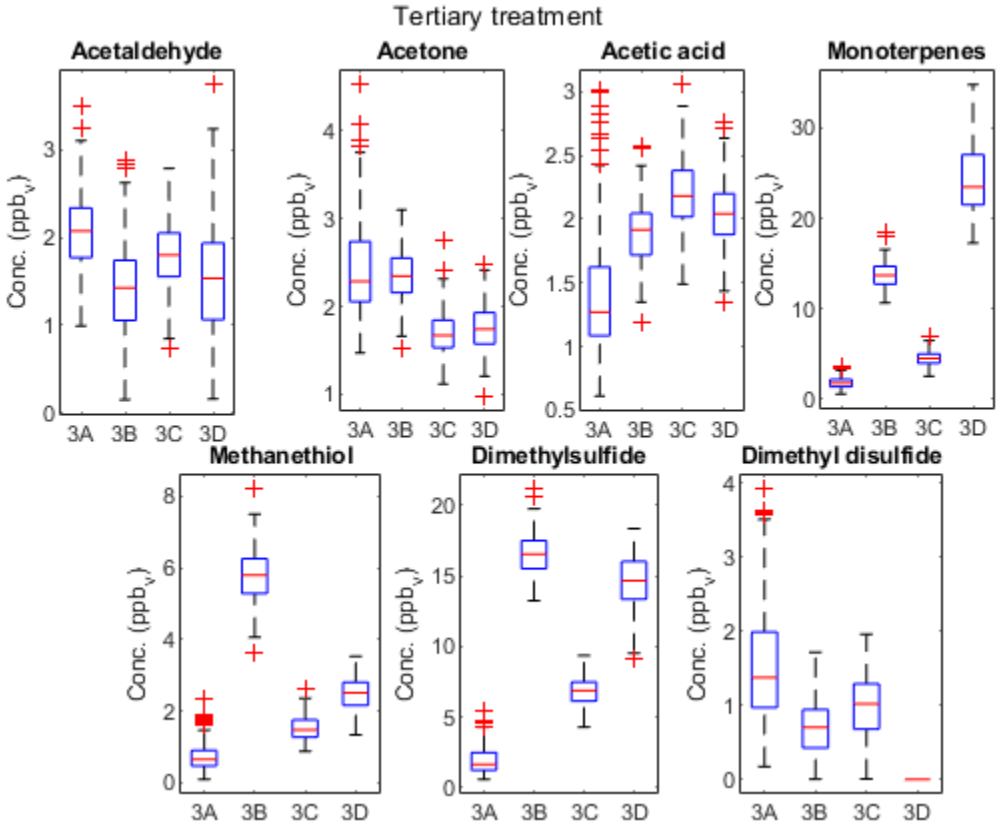


Figure 43 Tertiary wastewater treatment odour controls, 3a, 3b, 3c and 3d for 7 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (04/12/2023)

May 30, 2023, MPWWTP Odour monitoring summary

Boxplot summaries of odourous VOCs from Primary treatment odour control,

A- Inlet, B- Blower, C- Outlet/Exhaust

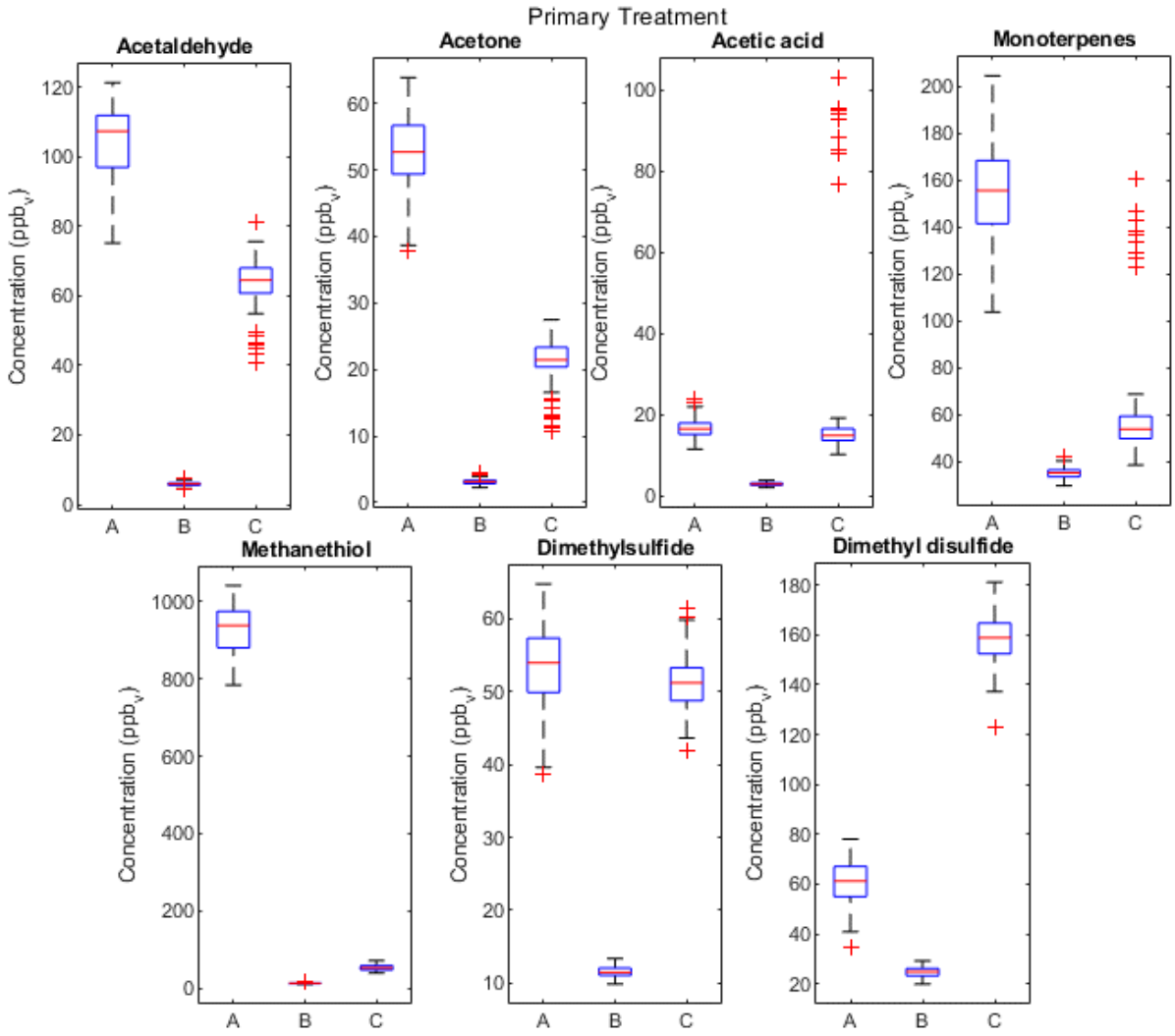


Figure 44 Primary wastewater treatment odour controls, 1a, 1b, 1c, for 7 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (05/30/2023)

Boxplot summaries of odourous VOCs from Secondary foul air treatment,

A- Inlet , B- Outlet/Exhaust

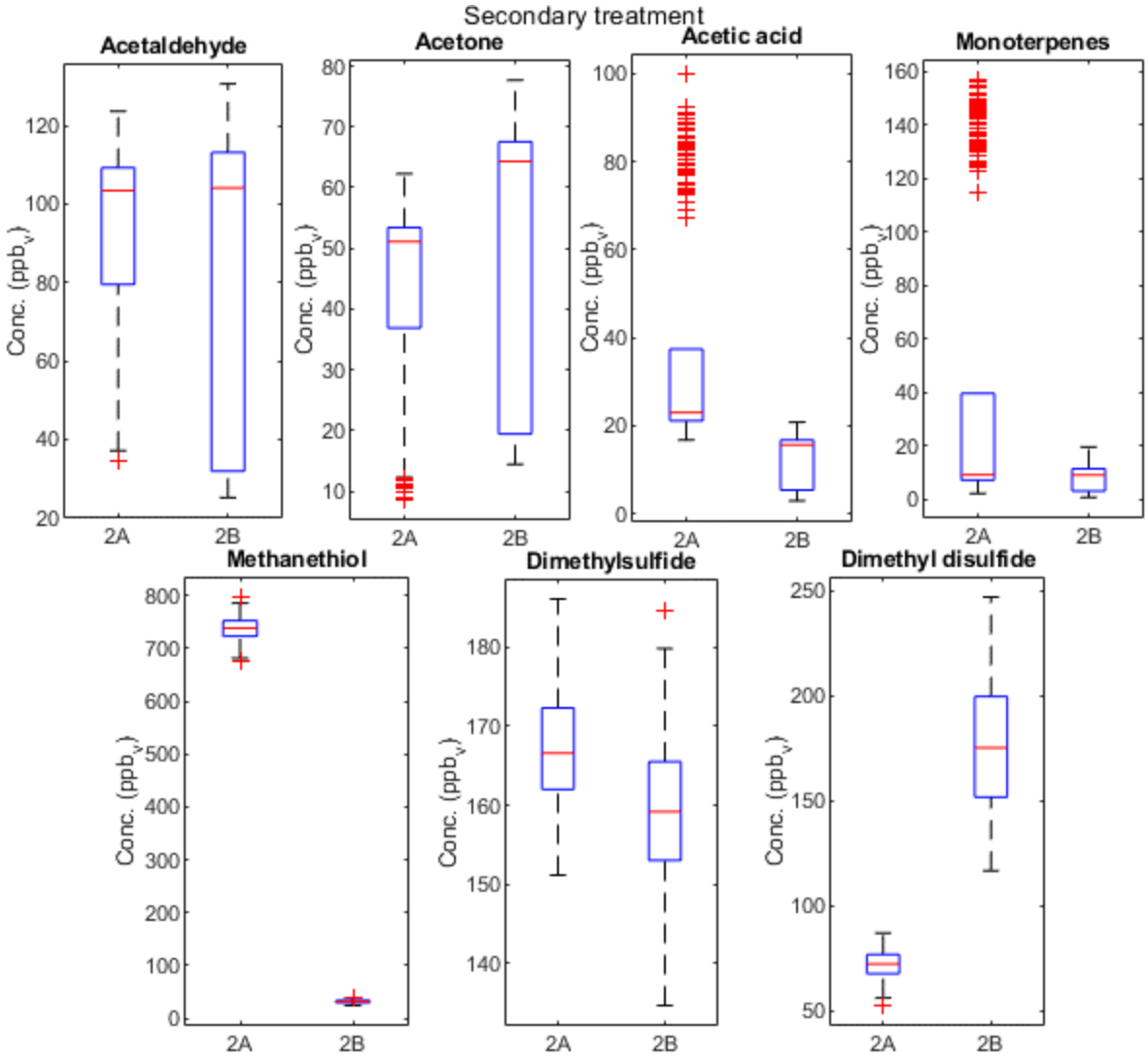


Figure 45 Secondary wastewater treatment odour controls, 2a and 2b for 7 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (05/30/2023)

Boxplot summaries from Tertiary treatment,

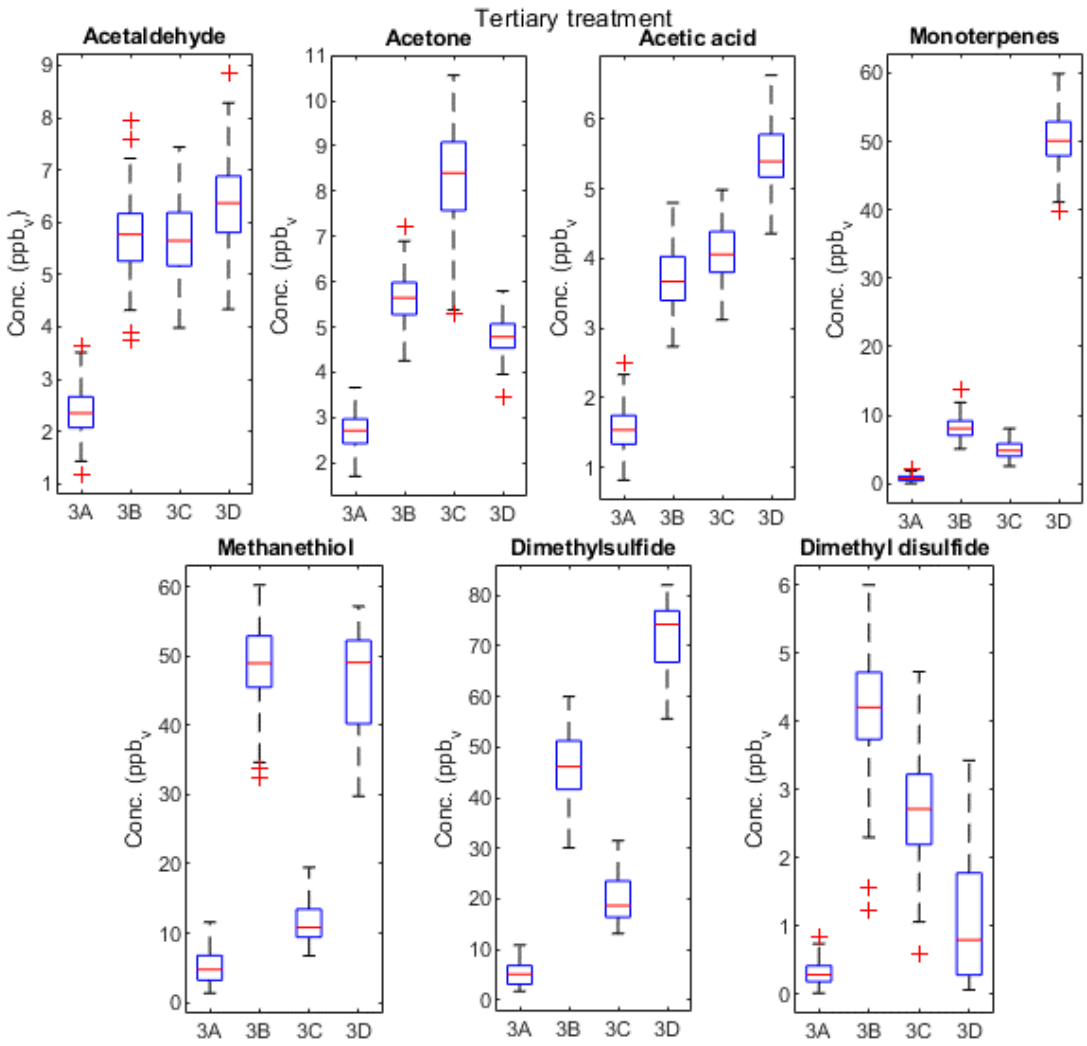


Figure 46 Tertiary wastewater treatment odour controls, 3a, 3b, 3c and 3d for 7 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (05/30/2023)

MPWWTP – Update – July 26-28, 2023

July 26, 2023 – On-site VOC evaluation of biological aerated filters,Bath 2 and 6 headspaces.

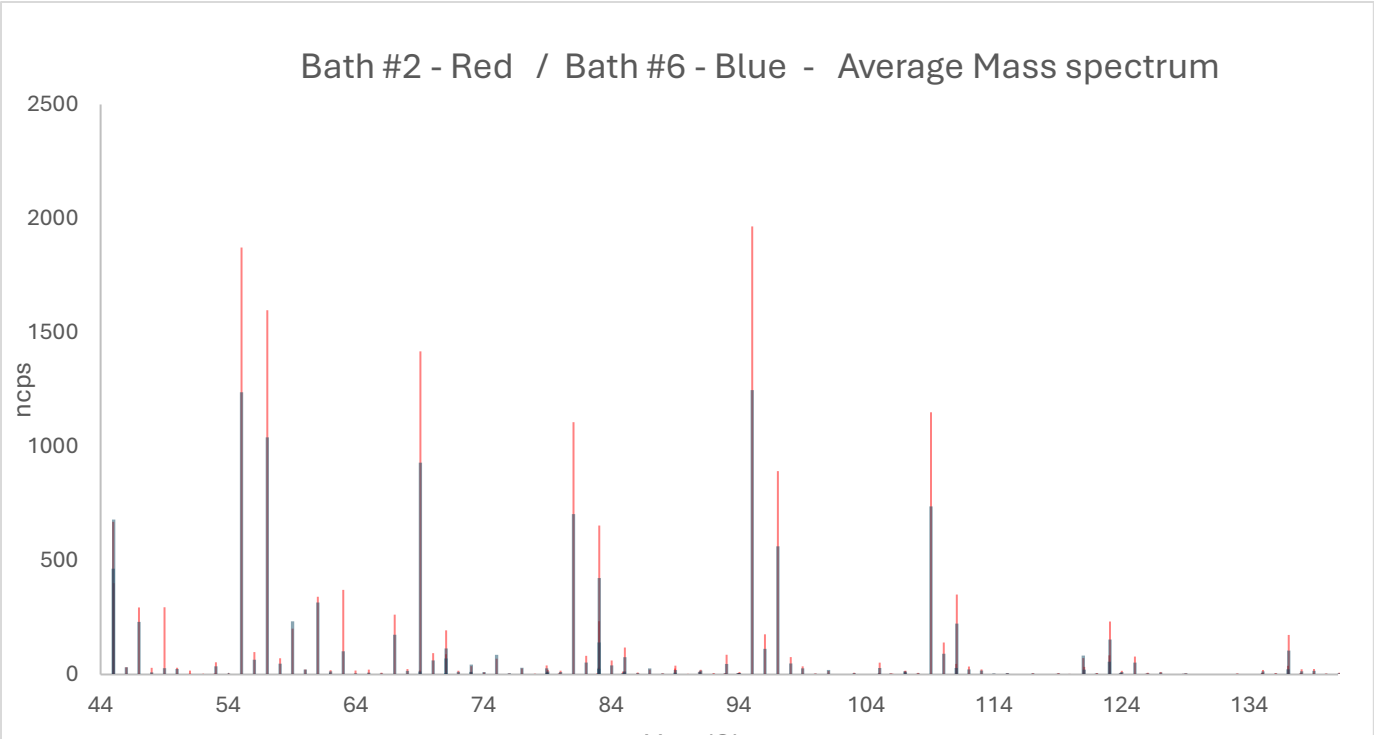


Figure 47 Mass spectrum collected on July 26, 2023, Headspace VOCs from BAF Bath cycle at 15:39-16:16 (bath 6), at 16:27-16:58 (bath 2) (07/26/2023).

Boxplot summary from BAF, Bath 2 and 6 headspace VOCs, July 26,2023

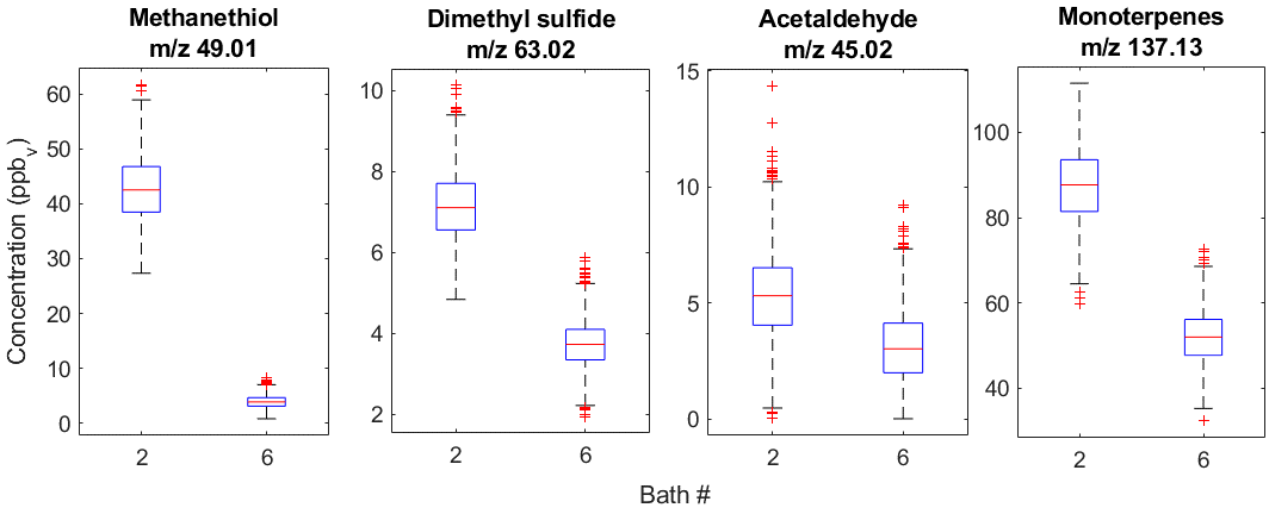


Figure 48 Boxplot summary collected on July 26, 2023, Headspace VOCs from Bath cycle at 15:39-16:16 (bath 6), at 16:27-16:58 (bath 2). (07/26/2023)

July 27, 2023 – On-site duct samples, Summary Boxplots

Primary Treatment foul air

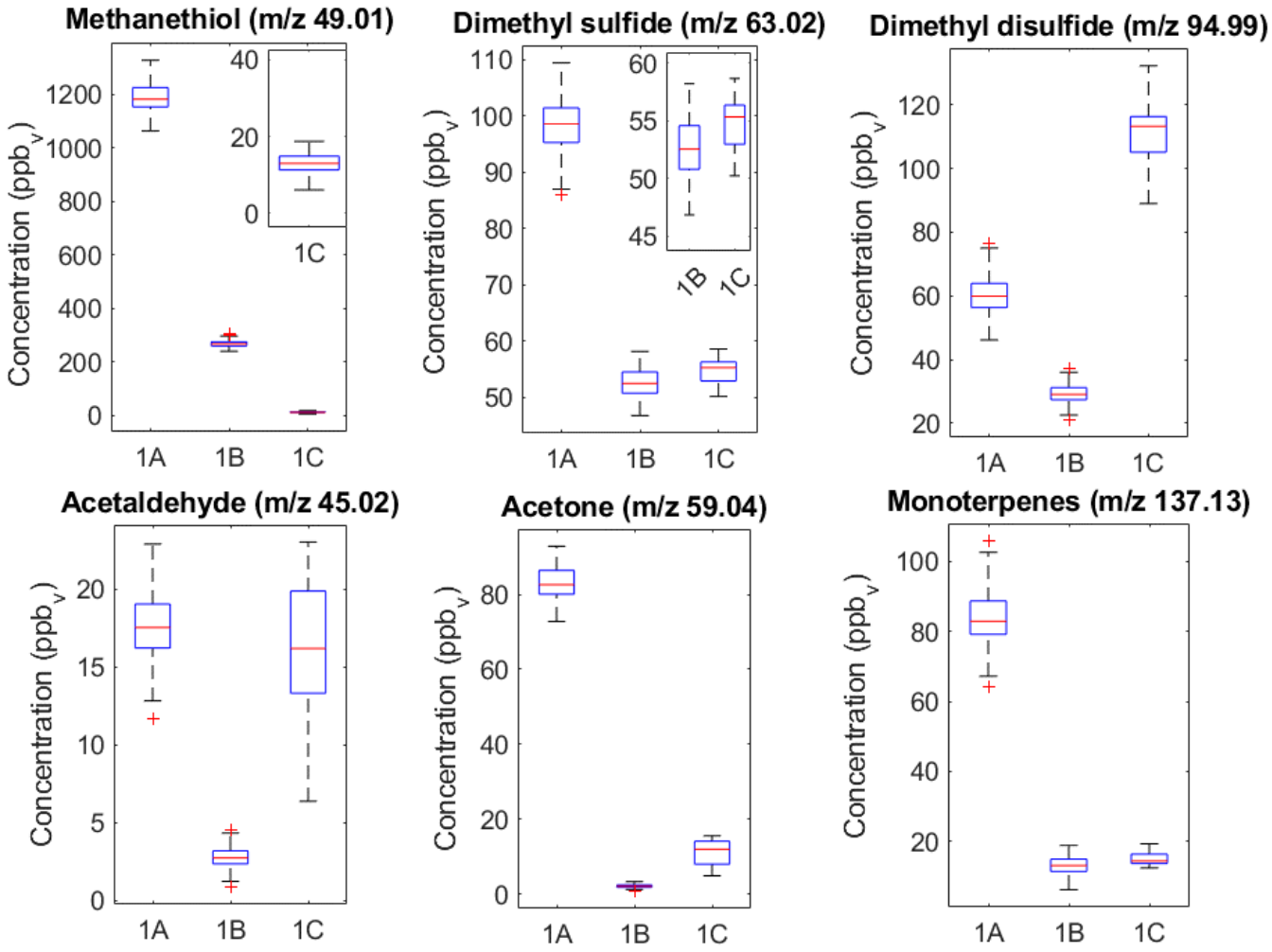


Figure 49 Primary wastewater treatment odour controls, 1a, 1b, 1c, for 7 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (07/27/2023)

Secondary Treatment foul air

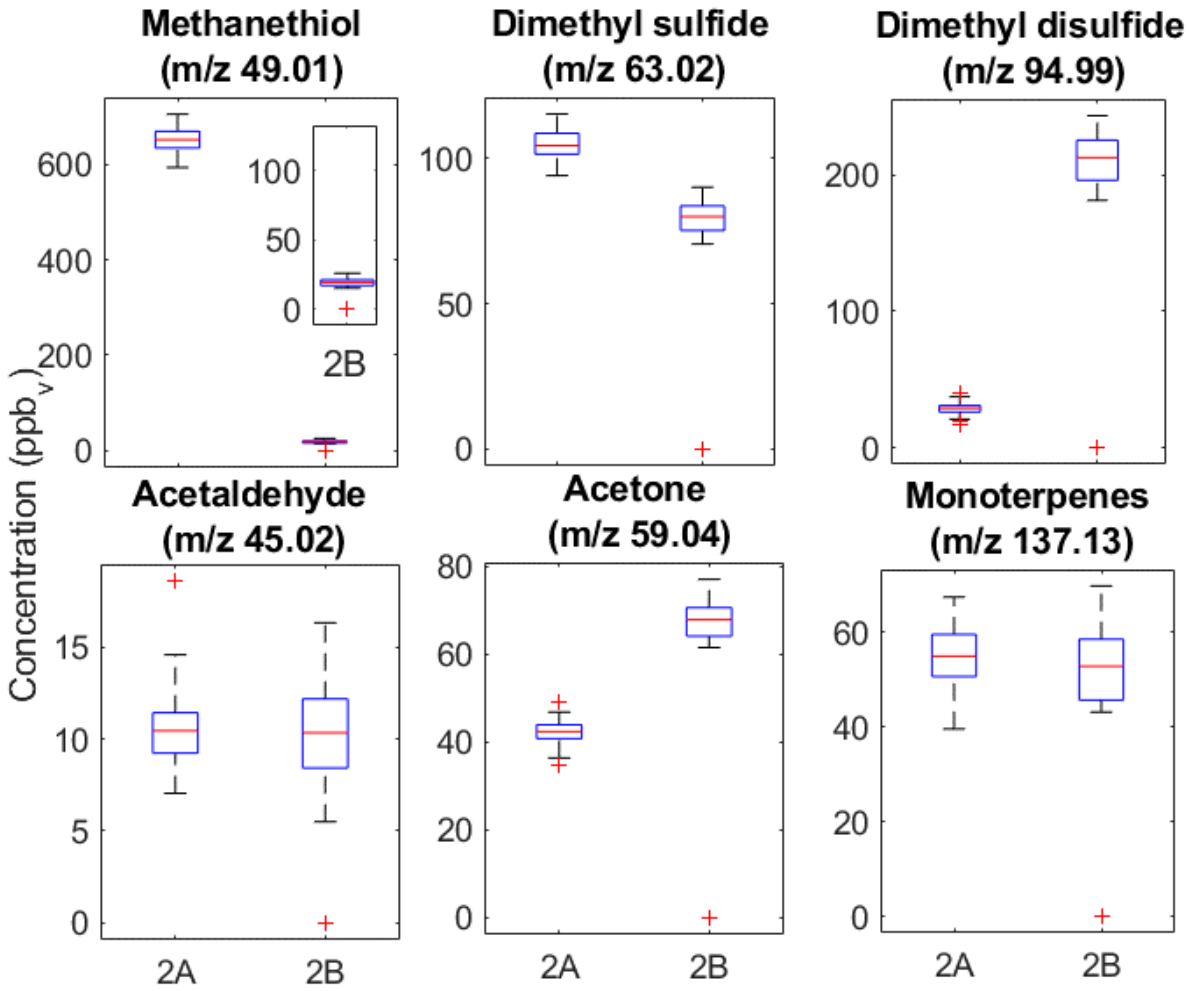


Figure 50 Secondary wastewater treatment odour controls, 2a and 2b for 7 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (07/27/2023)

SHT, DBK, PDT tanks foul air

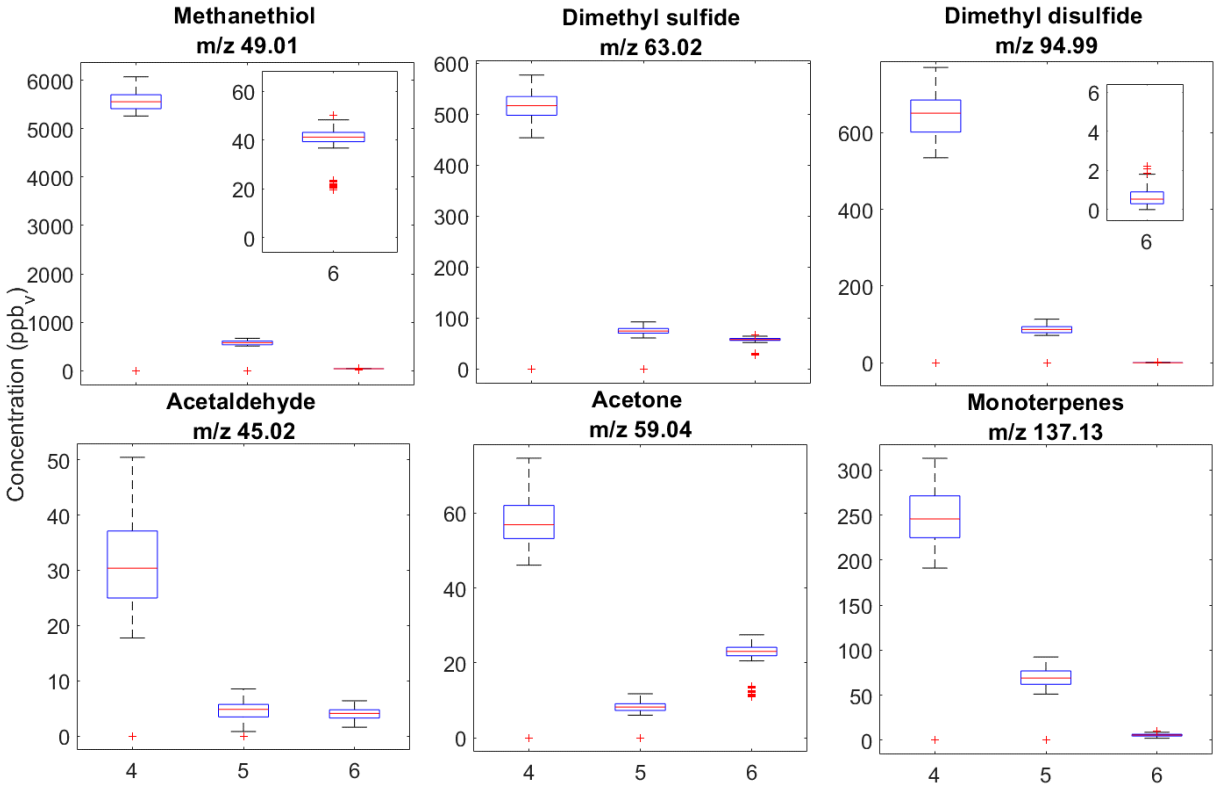


Figure 51 Holding tanks boxplots for 6 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (07/27/2023)

Tertiary treatment foul air

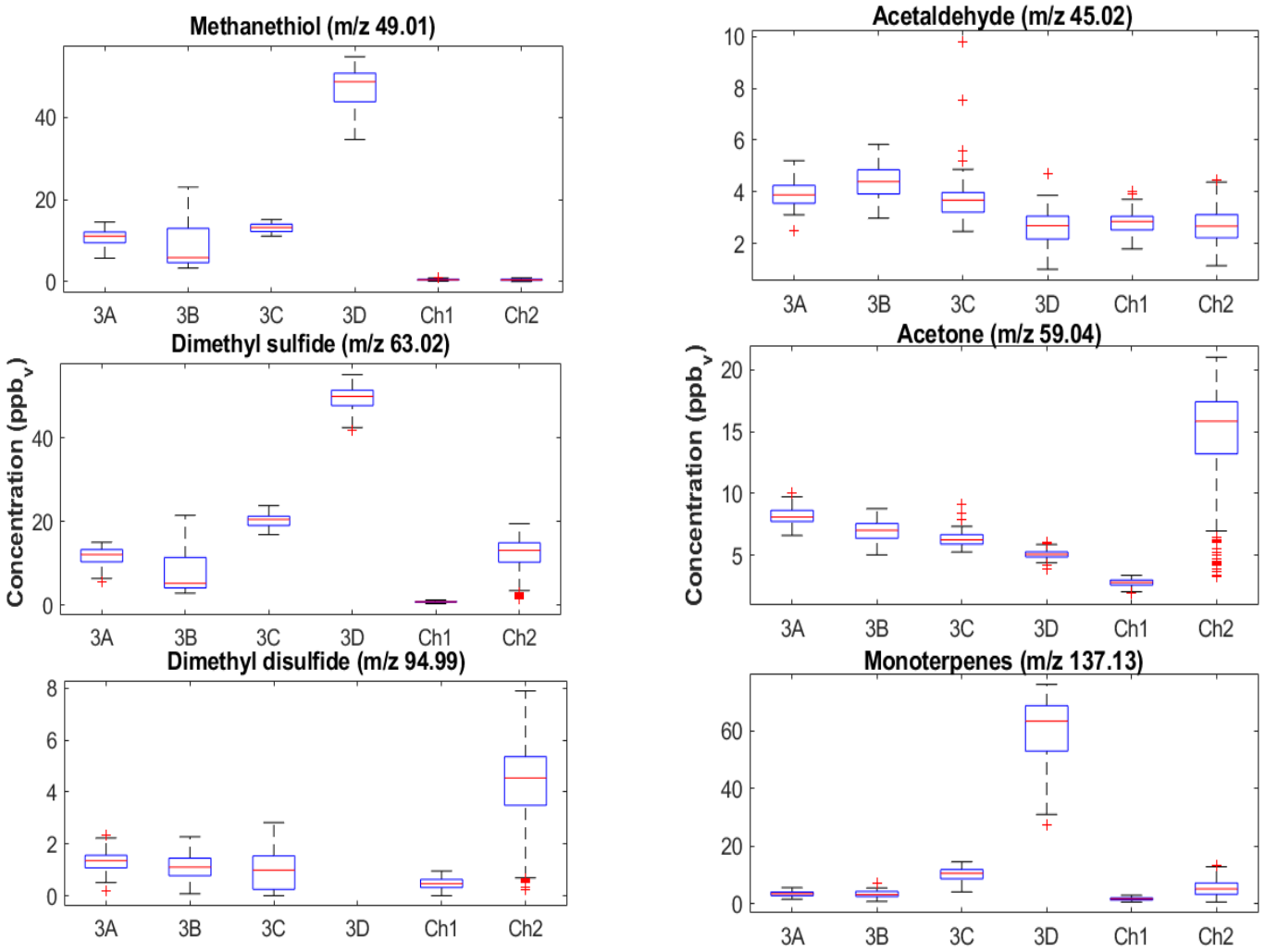


Figure 52 Tertiary wastewater treatment odour controls, 3a, 3b, 3c and 3d for 6 VOCs including methanethiol, dimethyl sulfide and dimethyl disulfide. (07/27/2023)

August 22, 2023 On-site sampling

Primary treatment odour control

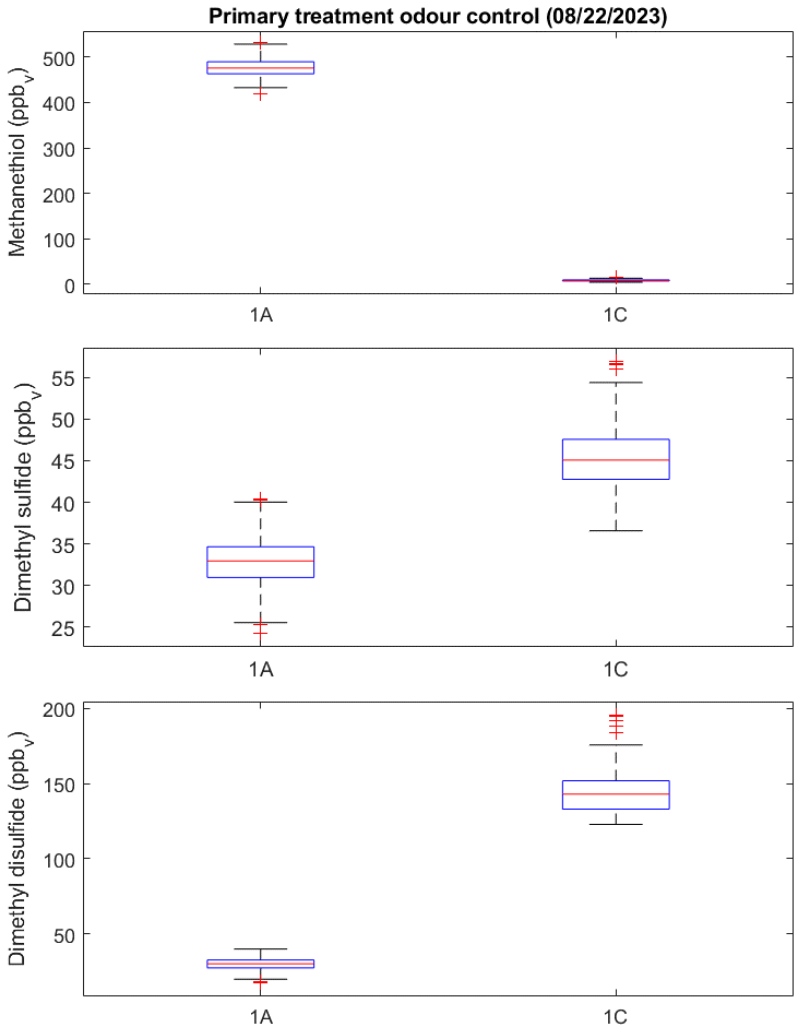


Figure 53 Primary wastewater treatment odour controls, 1a, 1b, 1c, for methanethiol, dimethyl sulfide and dimethyl disulfide. (08/22/2023)

Secondary treatment odour control

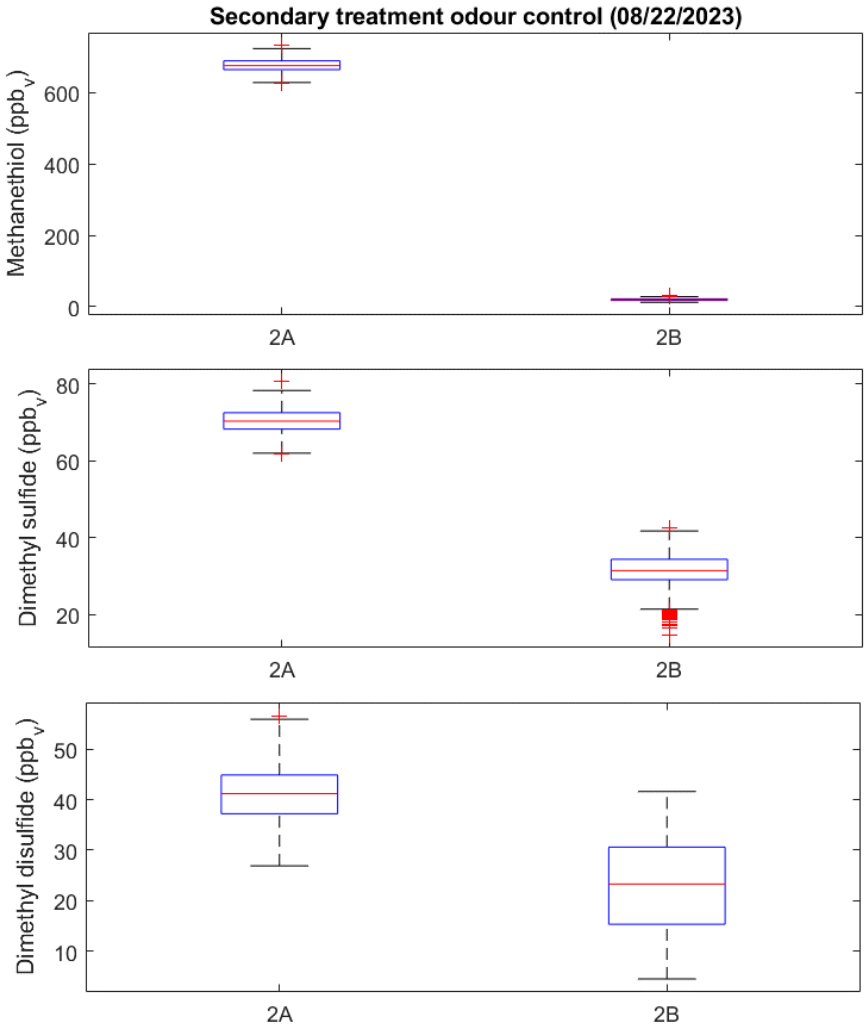


Figure 54 Secondary wastewater treatment odour controls, 2a and 2b for methanethiol, dimethyl sulfide and dimethyl disulfide. (08/22/2023)

Additional VOCs reported

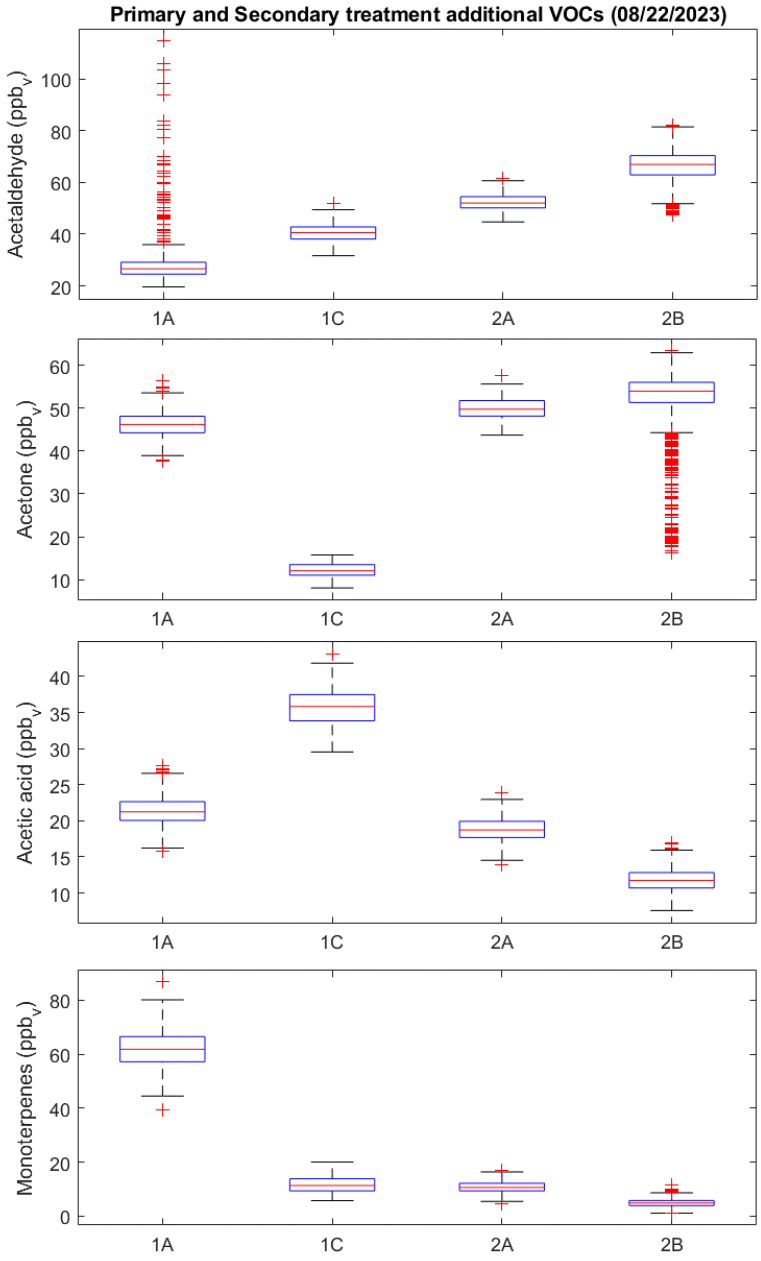


Figure 55 Boxplots for primary and secondary wastewater treatment odour controls for acetaldehyde, acetone, acetic acid and monoterpenes. (08/22/2023)

October 19. 2023 On-site sampling

Primary treatment odour control

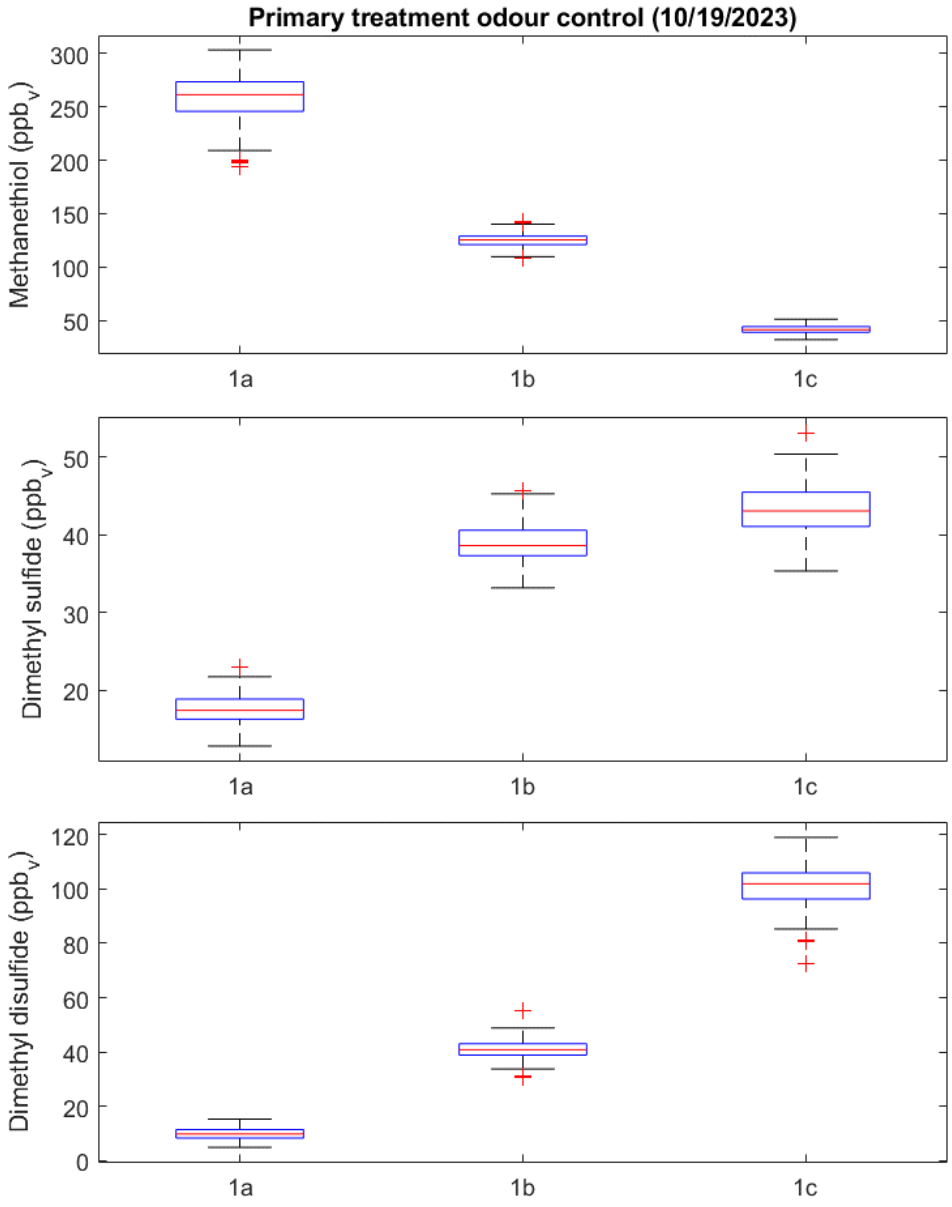


Figure 56 Primary wastewater treatment odour controls, 1a, 1b, 1c, for methanethiol, dimethyl sulfide and dimethyl disulfide. (10/19/2023)

Secondary treatment odour control

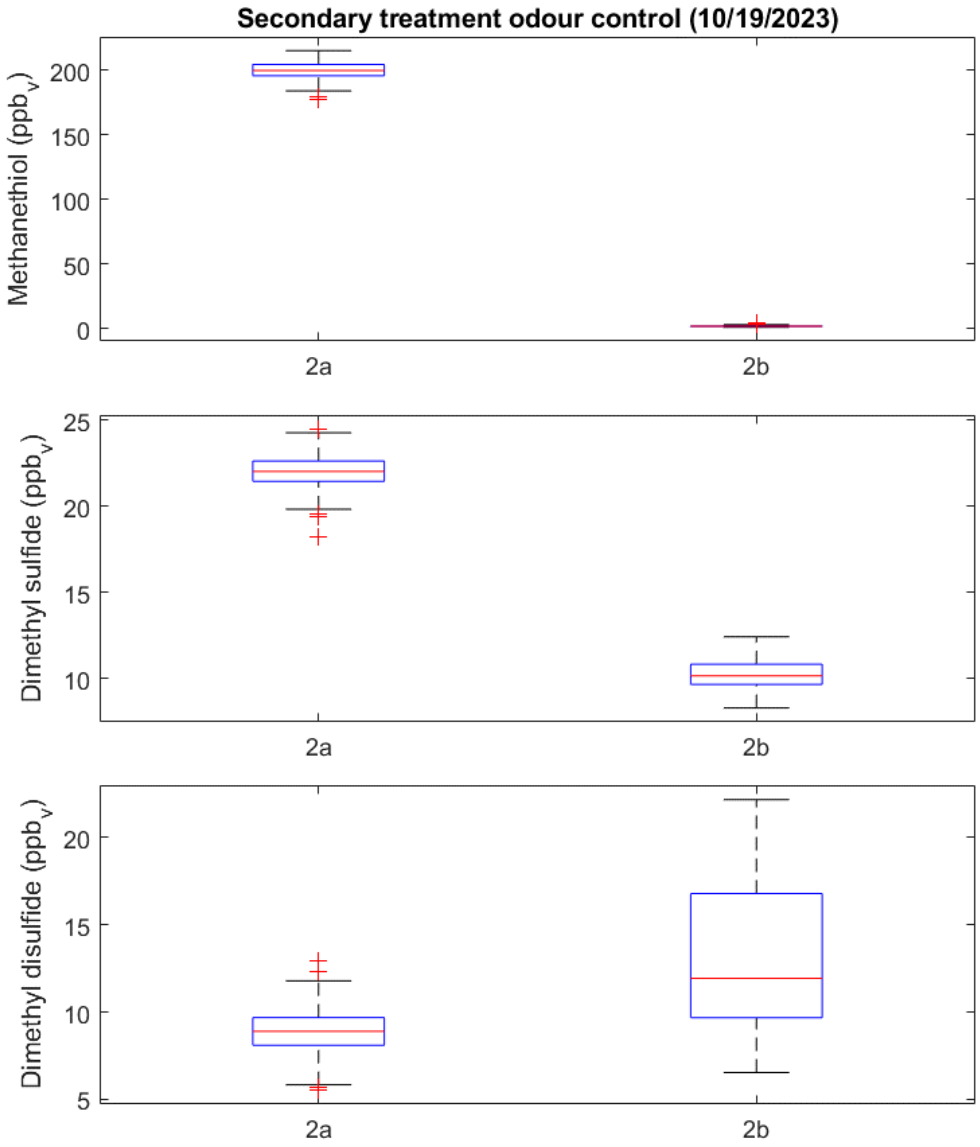


Figure 57 Secondary wastewater treatment odour controls, 2a and 2b for methanethiol, dimethyl sulfide and dimethyl disulfide. (10/19/2023)

Tertiary treatment sampling

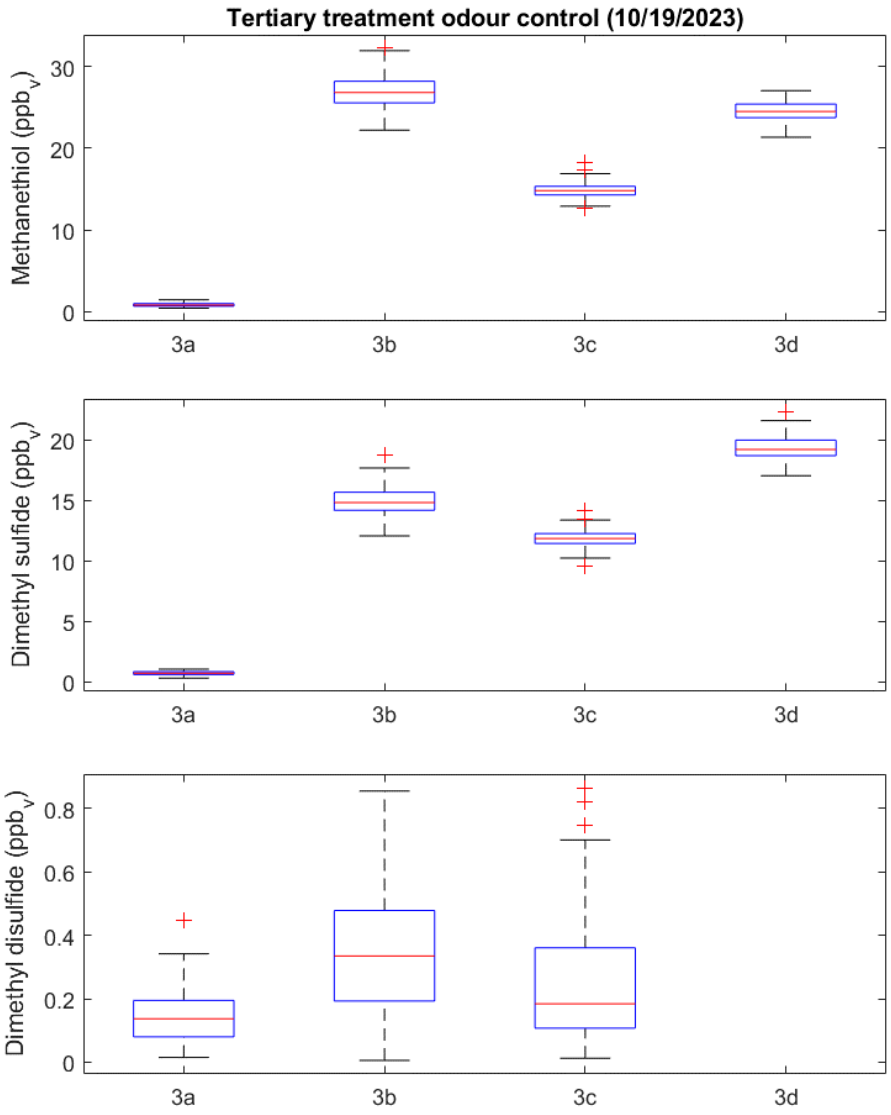


Figure 58 Tertiary wastewater treatment odour controls, 3a, 3b, 3c and 3d for methanethiol, dimethyl sulfide and dimethyl disulfide. (10/19/2023)

Additional VOCs in ductwork

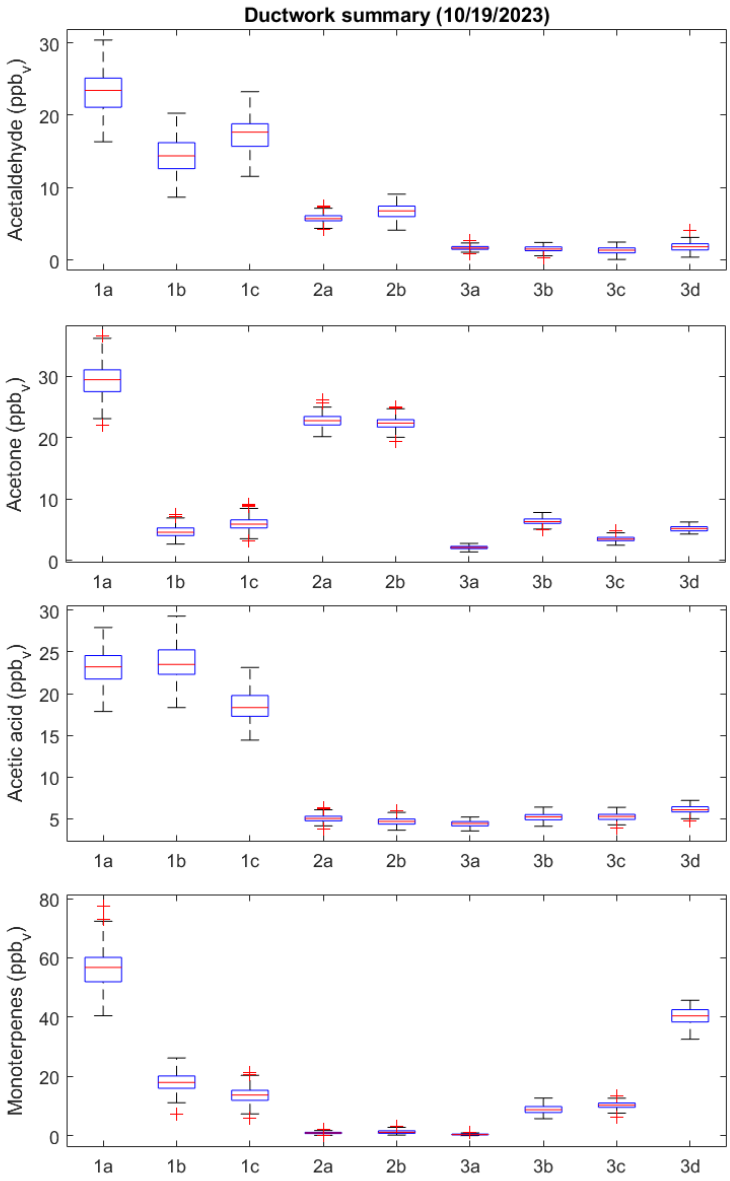


Figure 59 Ductwork summary of acetaldehyde, acetone, acetic acid and monoterpenes for all sample points(10/19/2023)

Ductwork, SHT 4, DBW 5, PDT 6 Summary

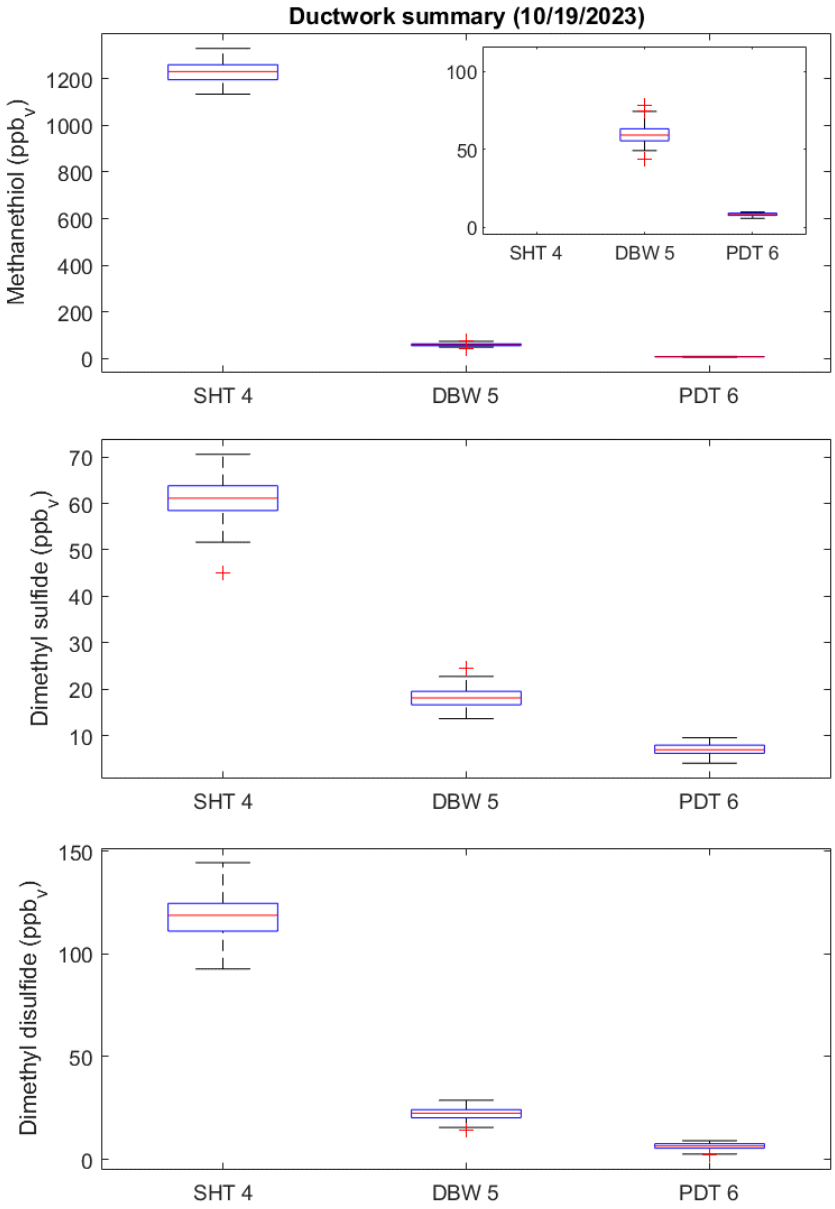


Figure 60 Holding tanks boxplots for methanethiol, dimethyl sulfide and dimethyl disulfide. (10/19/2023)

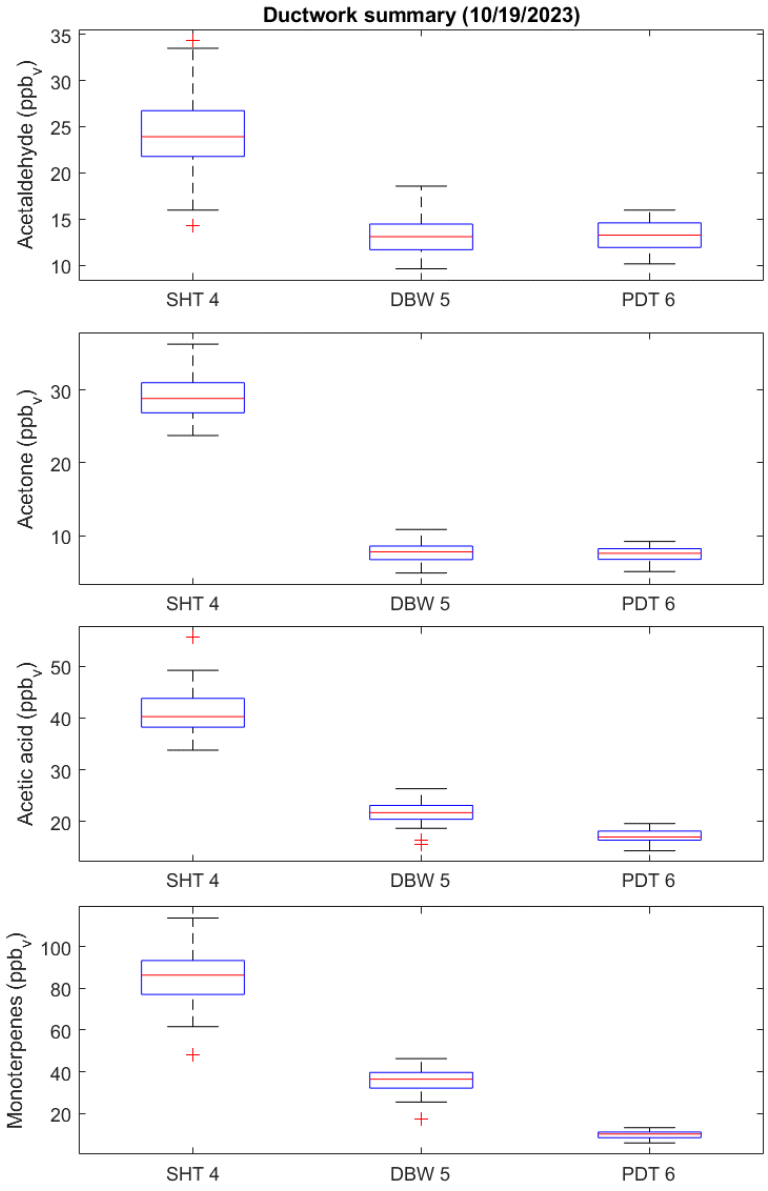


Figure 61 Holding tanks boxplots for 4 additional VOCs, (10/19/2023)

November 10, 2023 on-site sampling

Primary treatment odour control

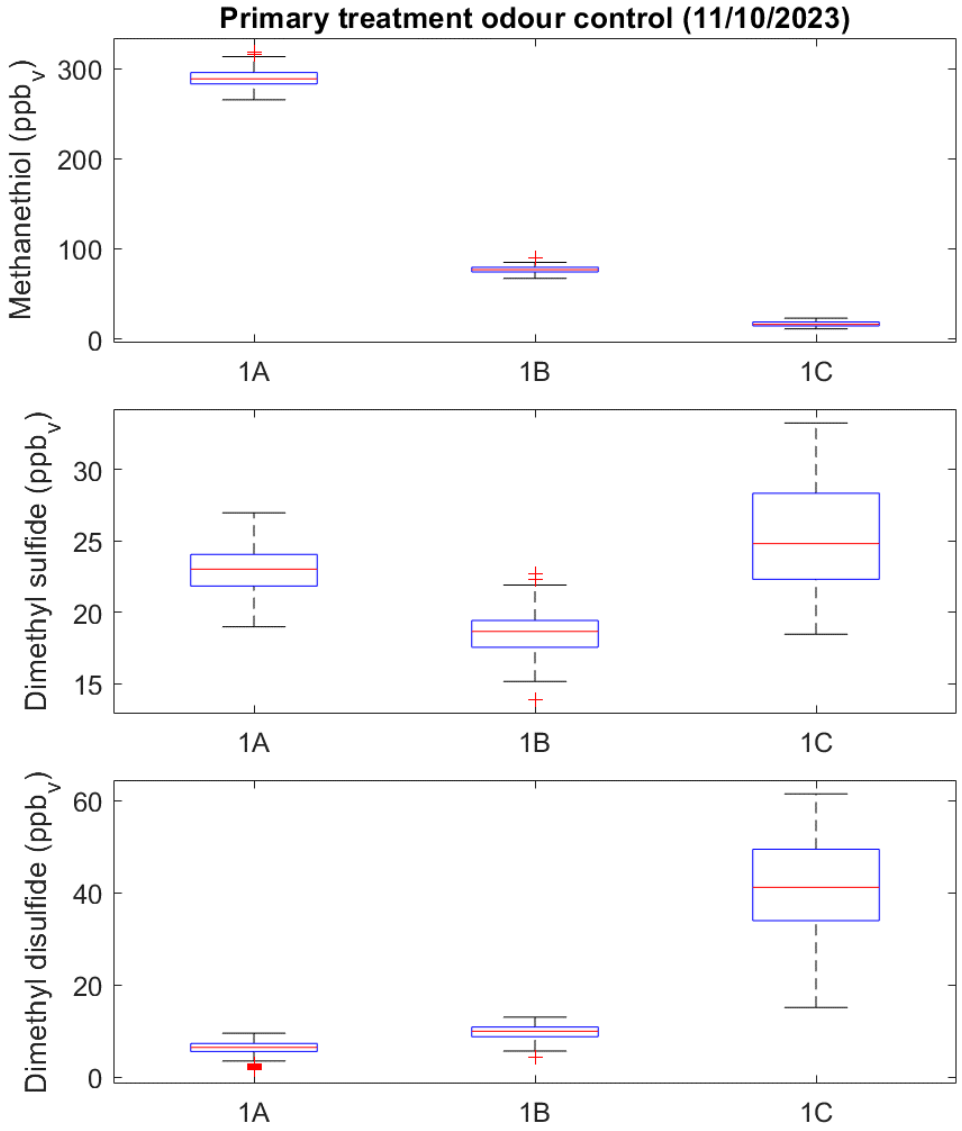


Figure 62 Primary wastewater treatment odour controls, 1a, 1b, 1c, for methanethiol, dimethyl sulfide and dimethyl disulfide. (11/10/2023)

Secondary treatment odour control

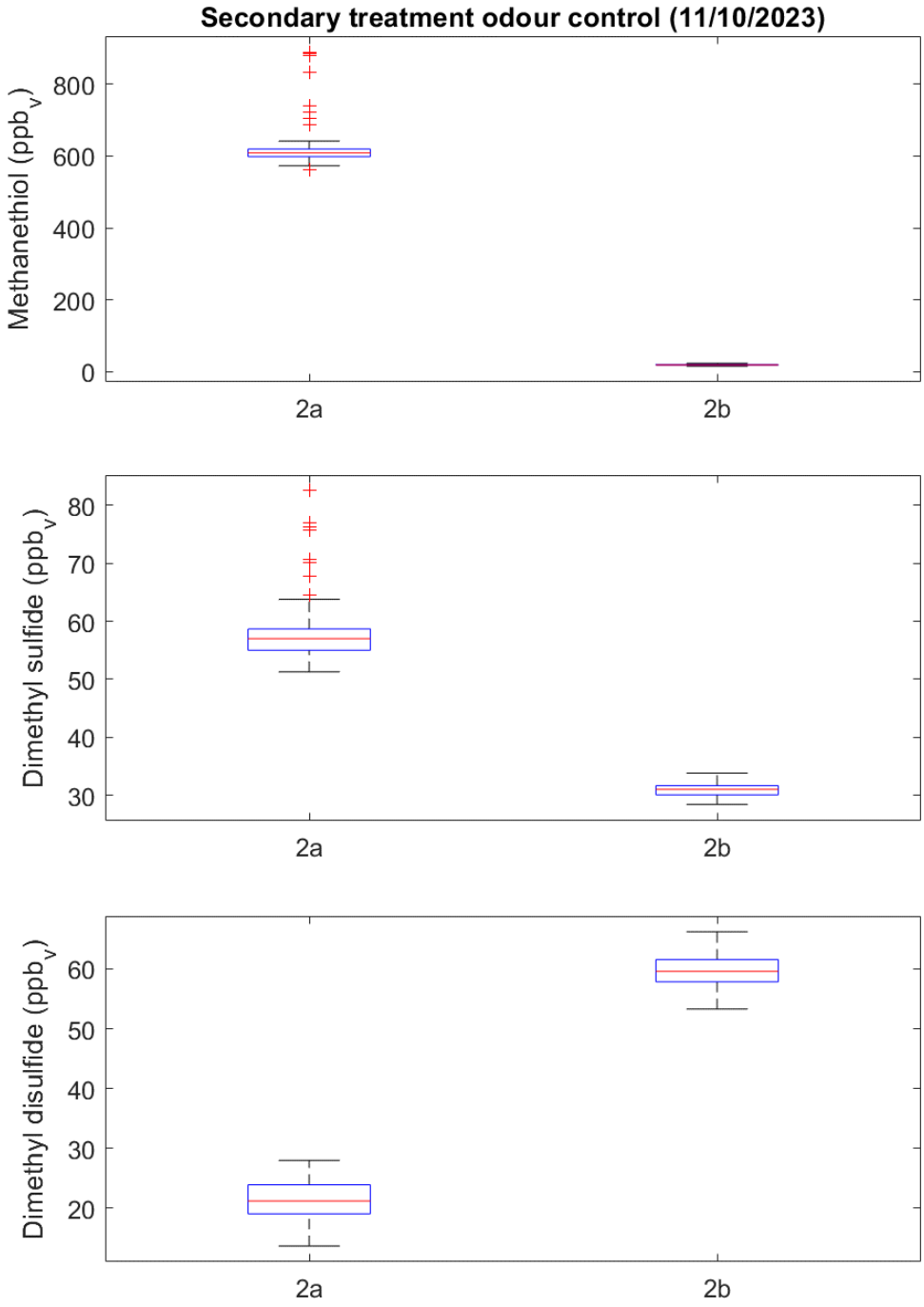


Figure 63 Secondary wastewater treatment odour controls, 2a and 2b for methanethiol, dimethyl sulfide and dimethyl disulfide. (11/10/2023)

Tertiary treatment odour survey

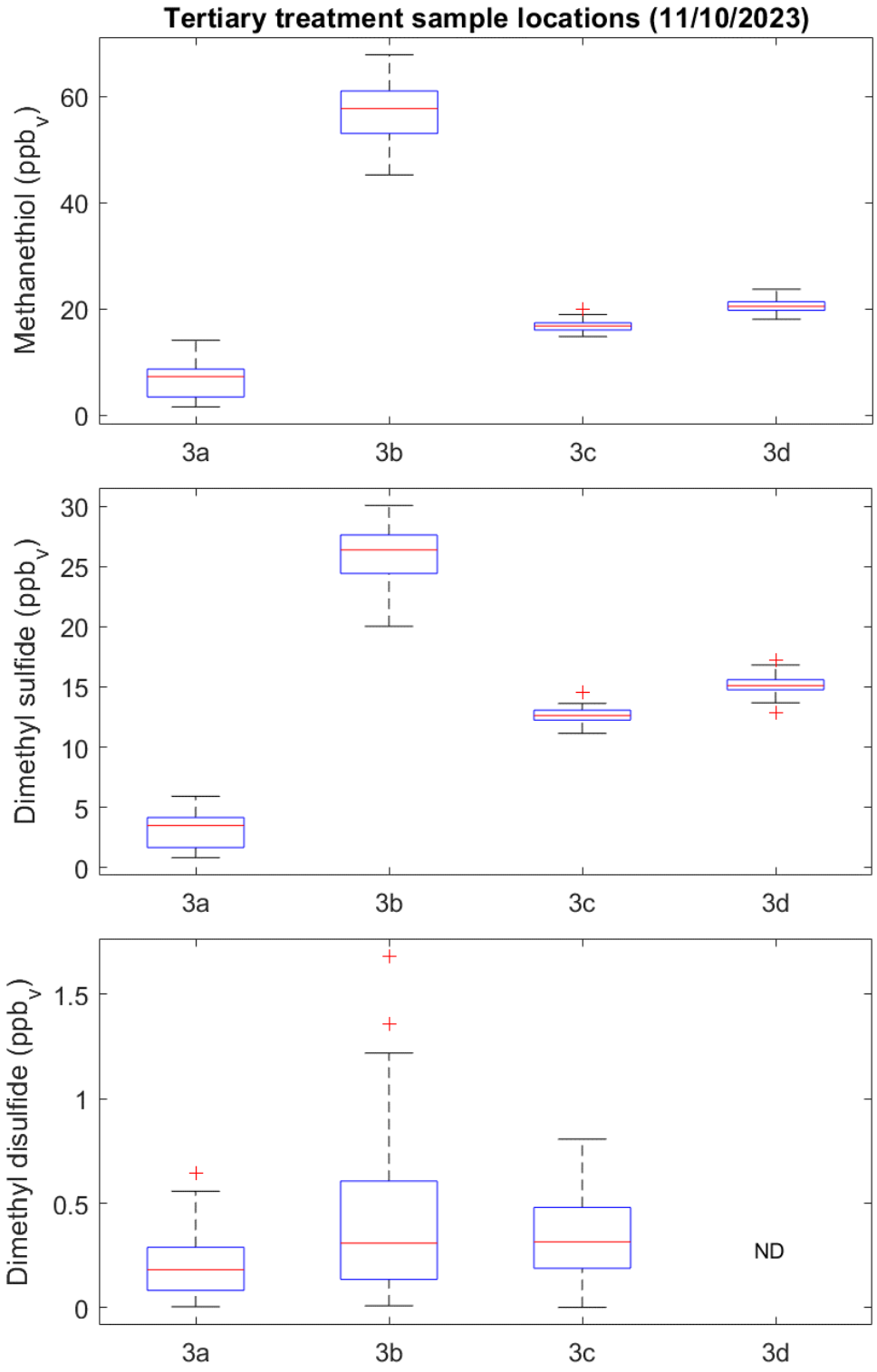


Figure 64 Tertiary wastewater treatment odour controls, 3a, 3b, 3c and 3d for methanethiol, dimethyl sulfide and dimethyl disulfide. (11/10/2023)

Ductwork survey for SHT, DBW, PDT

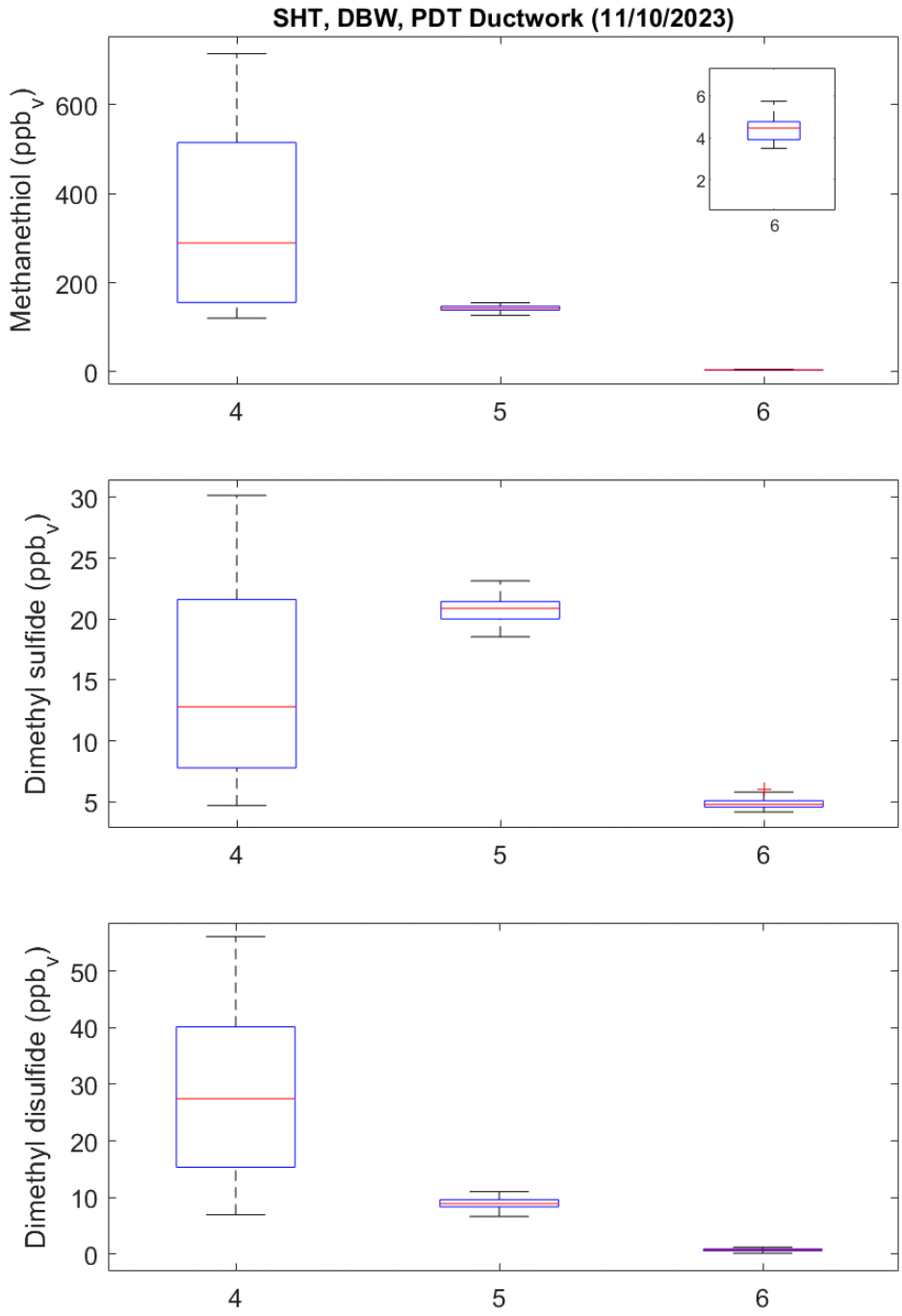


Figure 65 Holding tanks boxplots for methanethiol, dimethyl sulfide and dimethyl disulfide. (11/10/2023)

Ductwork summary for acetaldehyde, acetone, acetic acid and monoterpenes.

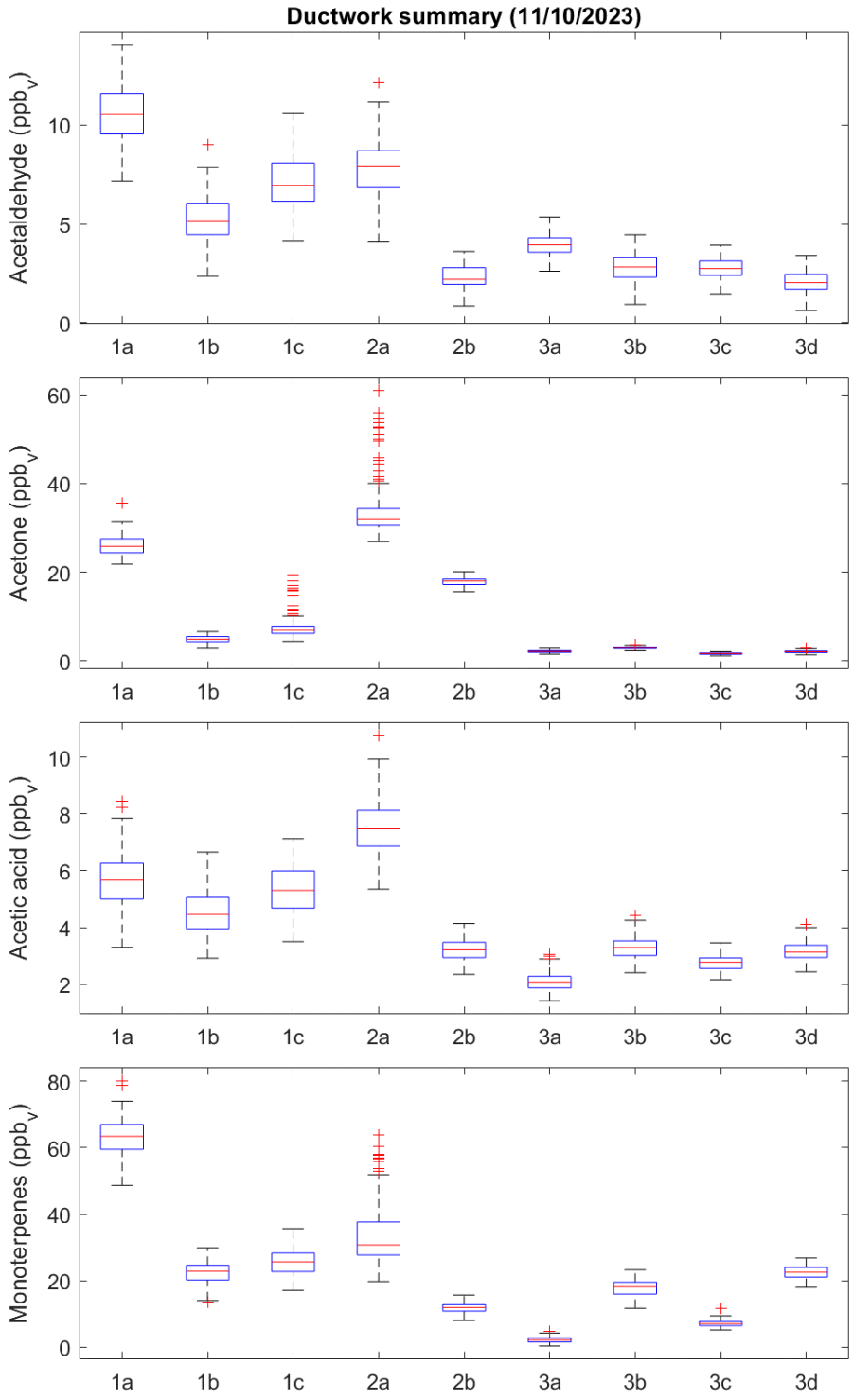


Figure 66 Ductwork summary of acetaldehyde, acetone, acetic acid and monoterpenes for all sample points. (11/10/2023)

February 22, 2024 on-site sampling

Primary treatment odour control

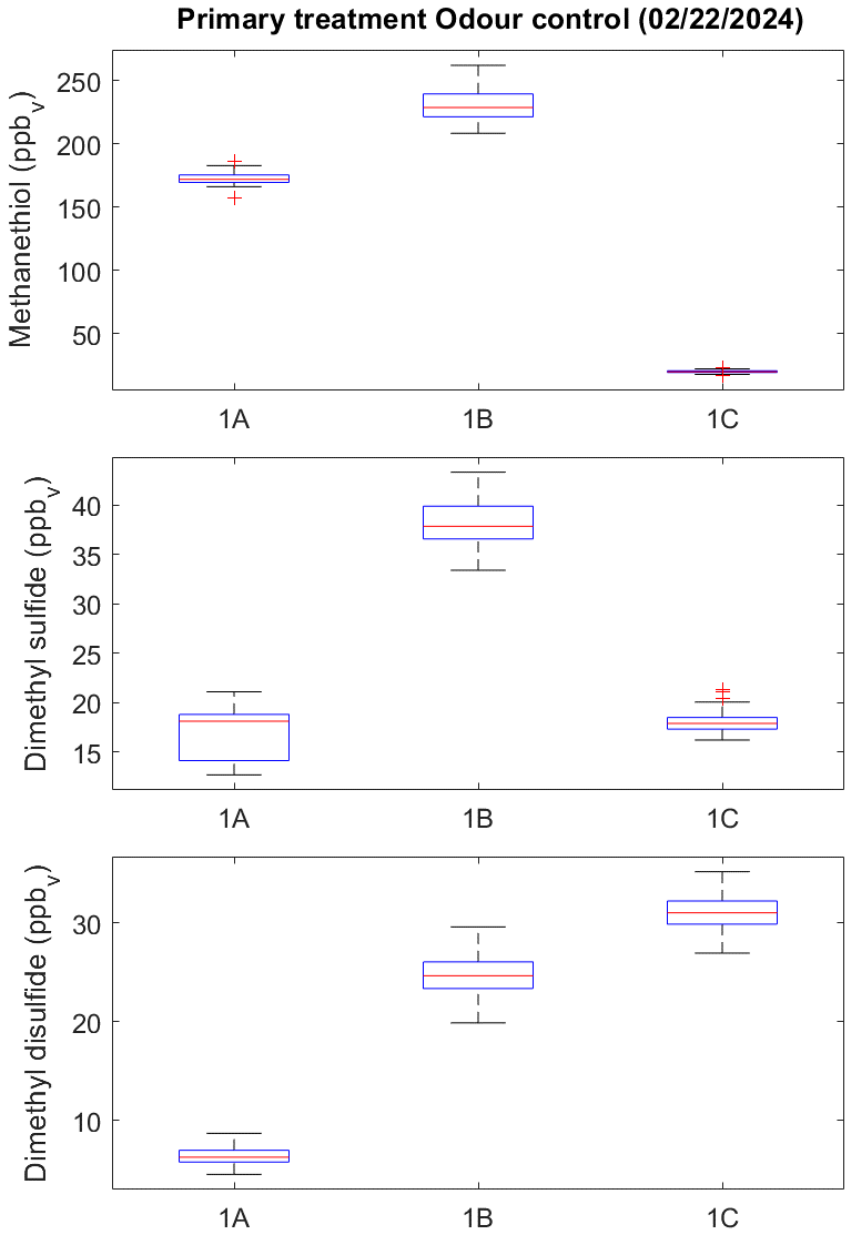


Figure 67 Primary wastewater treatment odour controls, 1a, 1b, 1c, for methanethiol, dimethyl sulfide and dimethyl disulfide. (02/22/2024)

Secondary treatment odour control

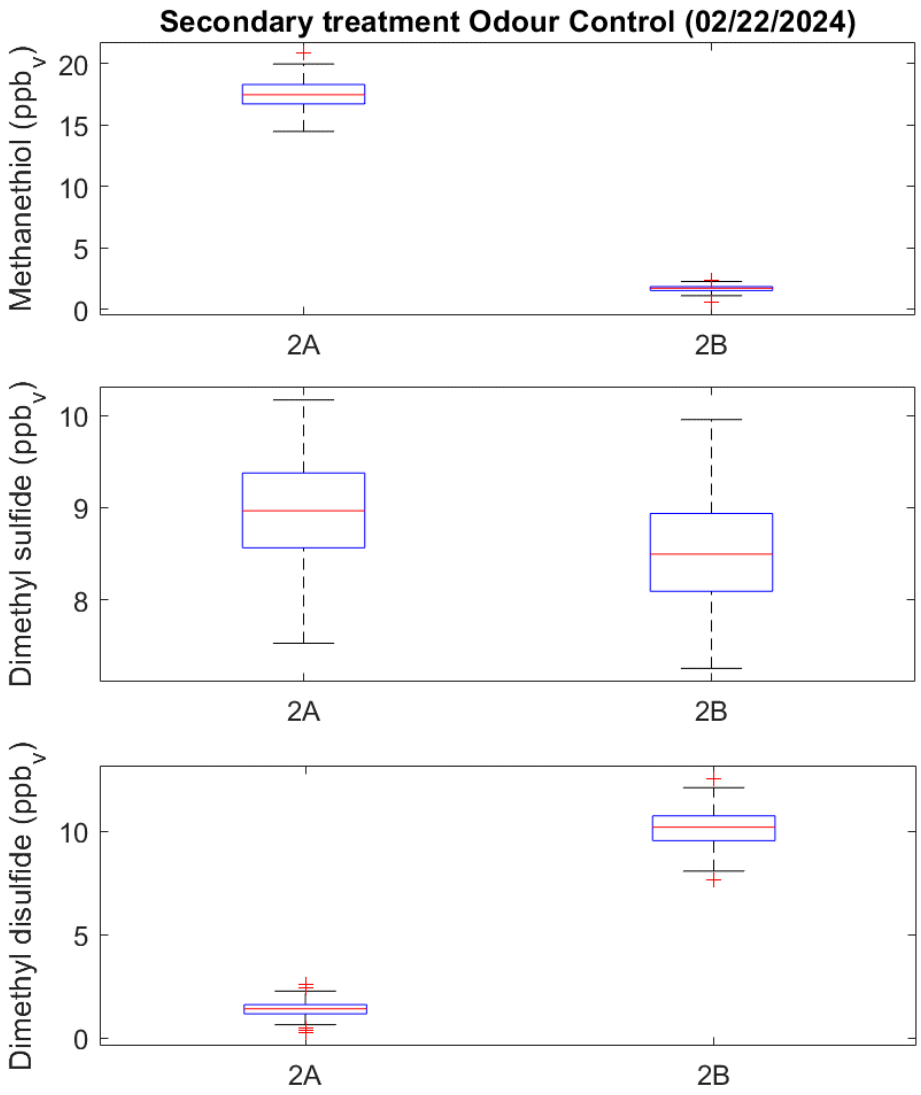


Figure 68 Secondary wastewater treatment odour controls, 2a and 2b for methanethiol, dimethyl sulfide and dimethyl disulfide. (02/22/2024)

Ductwork summary for acetaldehyde, acetone, acetic acid and monoterpenes.

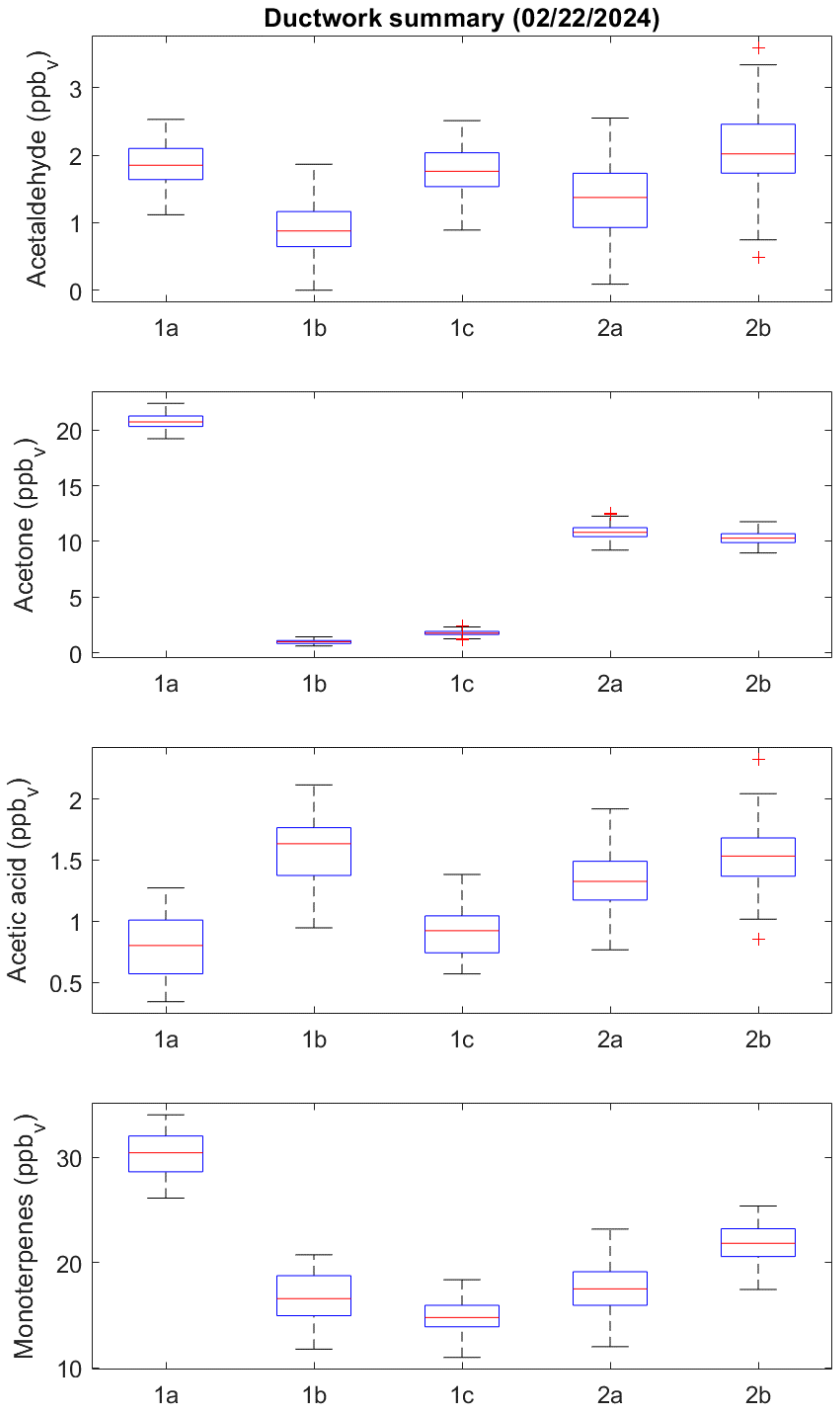


Figure 69 Boxplots for primary and secondary wastewater treatment odour controls for acetaldehyde, acetone, acetic acid and monoterpenes. (02/22/2024)

Tertiary system was under repair during this visit and was not sampled

Ductwork summary for SHT, DBW and PDT

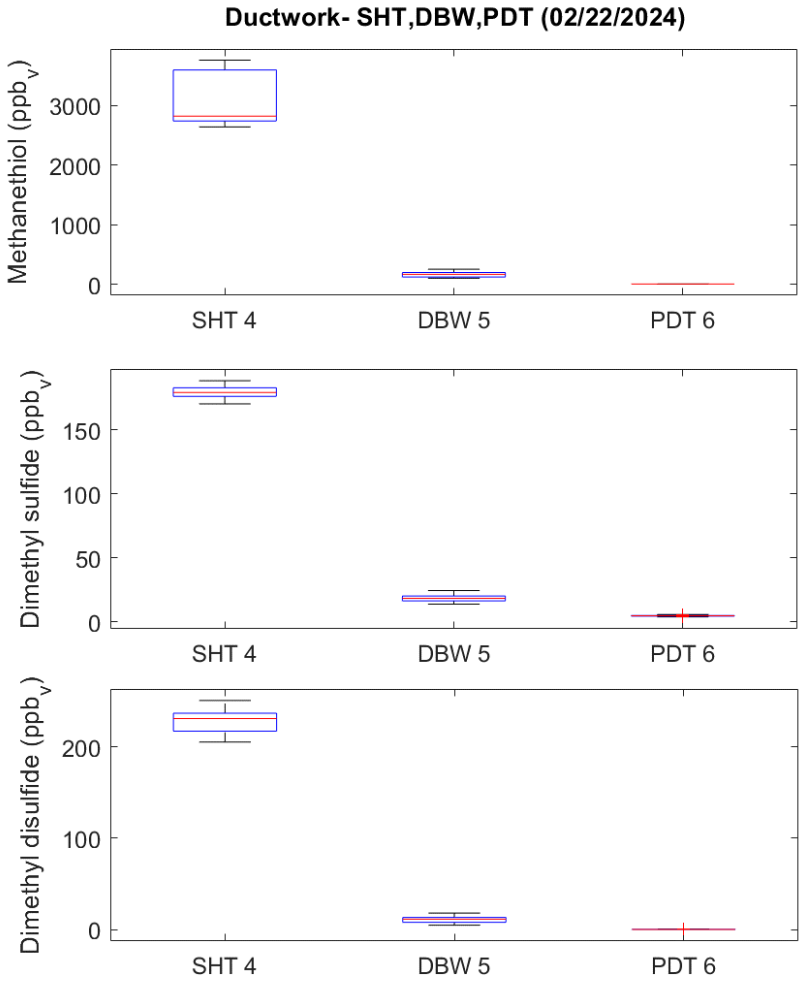


Figure 70 Holding tanks boxplots for methanethiol, dimethyl sulfide and dimethyl disulfide. (02/22/2024)

Ductwork summary for methane concentrations

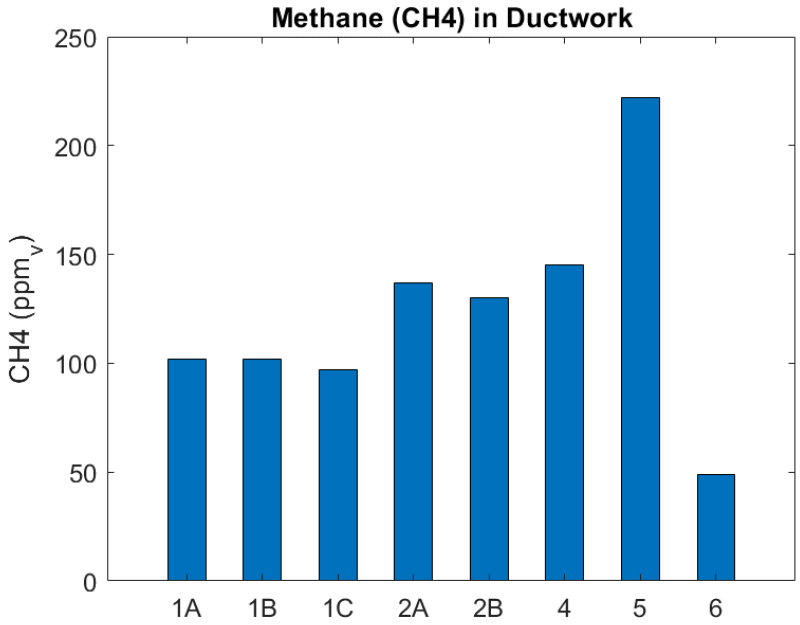


Figure 71 Methane concentrations from primary and secondary wastewater treatment odour controls and 4, 5, 6. (02/22/2024)

June 18, 2024 On-site sampling

Primary odour control summary

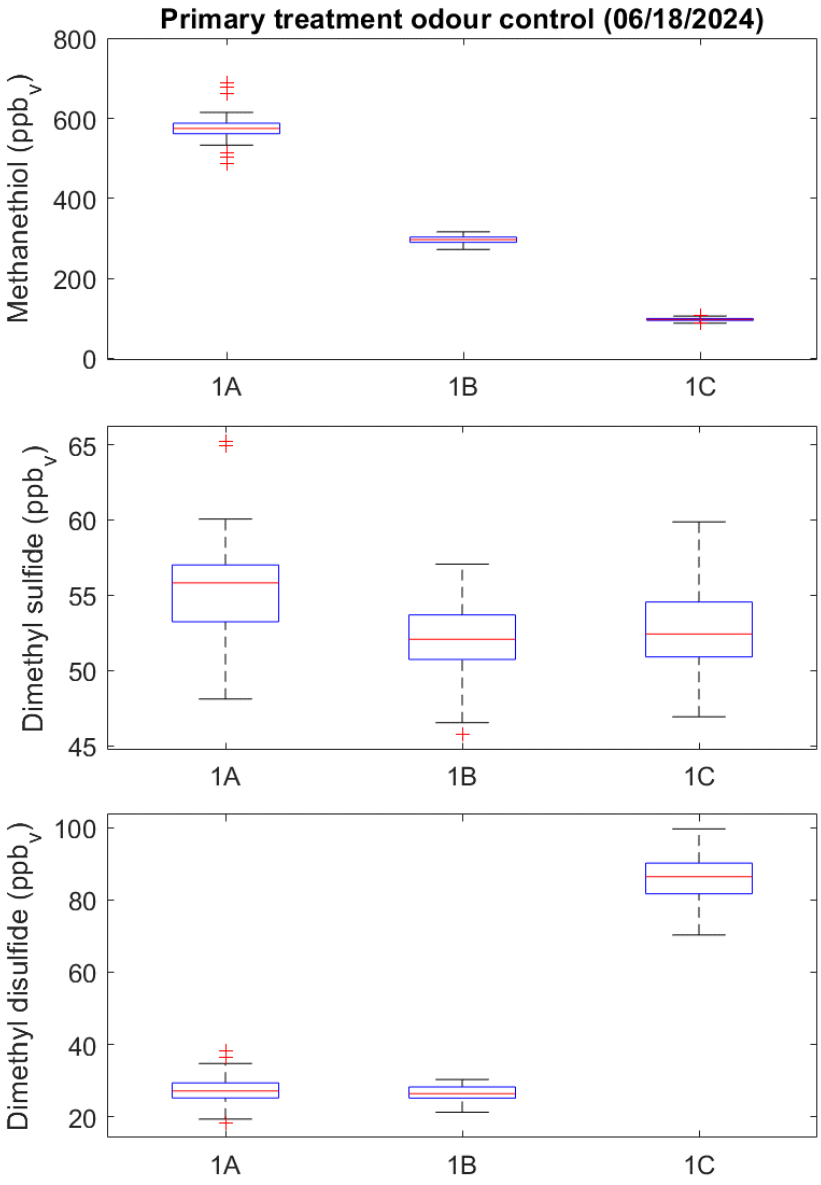


Figure 72 Primary wastewater treatment odour controls, 1a, 1b, 1c, for methanethiol, dimethyl sulfide and dimethyl disulfide. (06/18/2024)

Secondary odour control summary

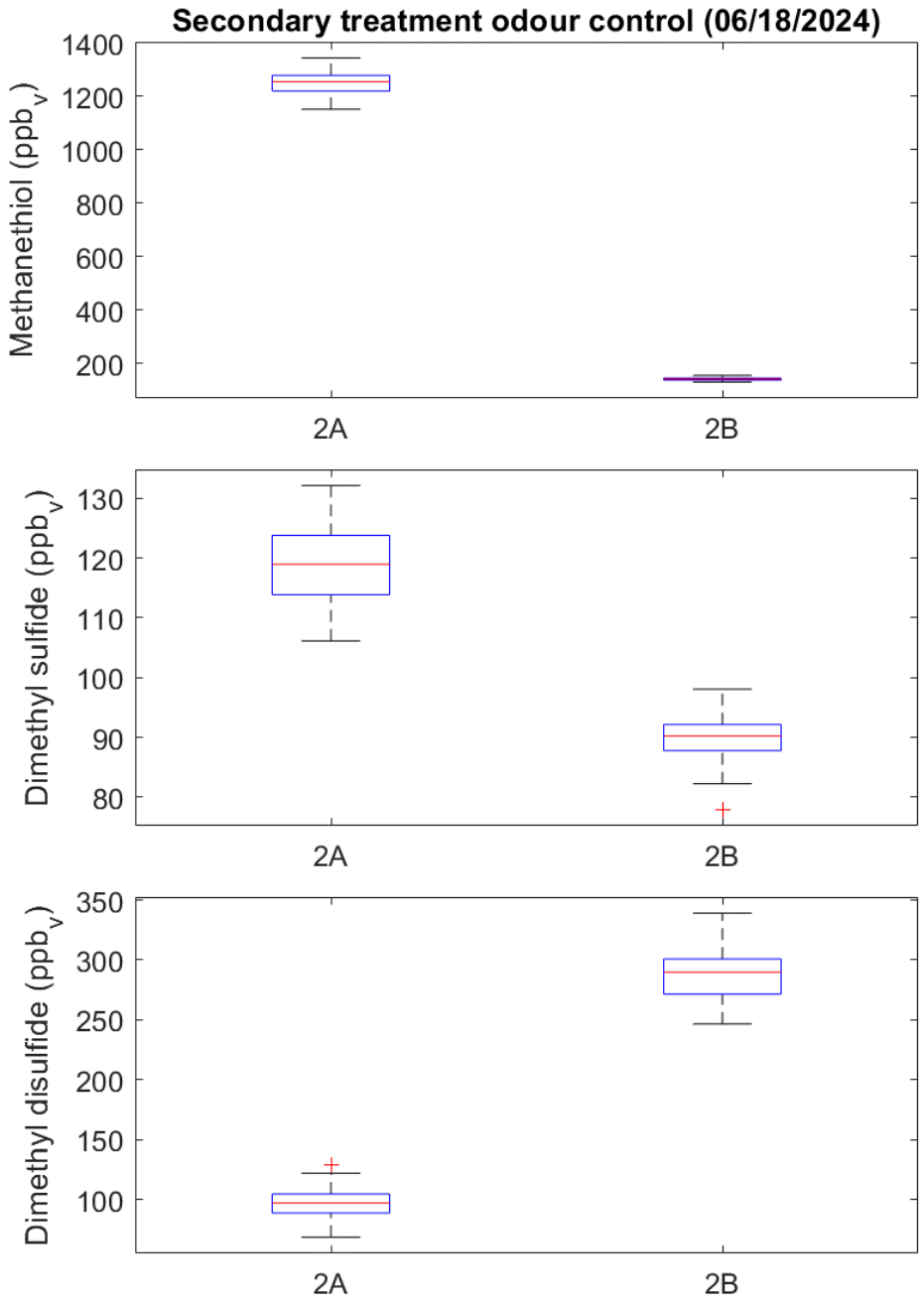


Figure 73 Secondary wastewater treatment odour controls, 2a and 2b for methanethiol, dimethyl sulfide and dimethyl disulfide. (06/18/2024)

Tertiary treatment odour survey

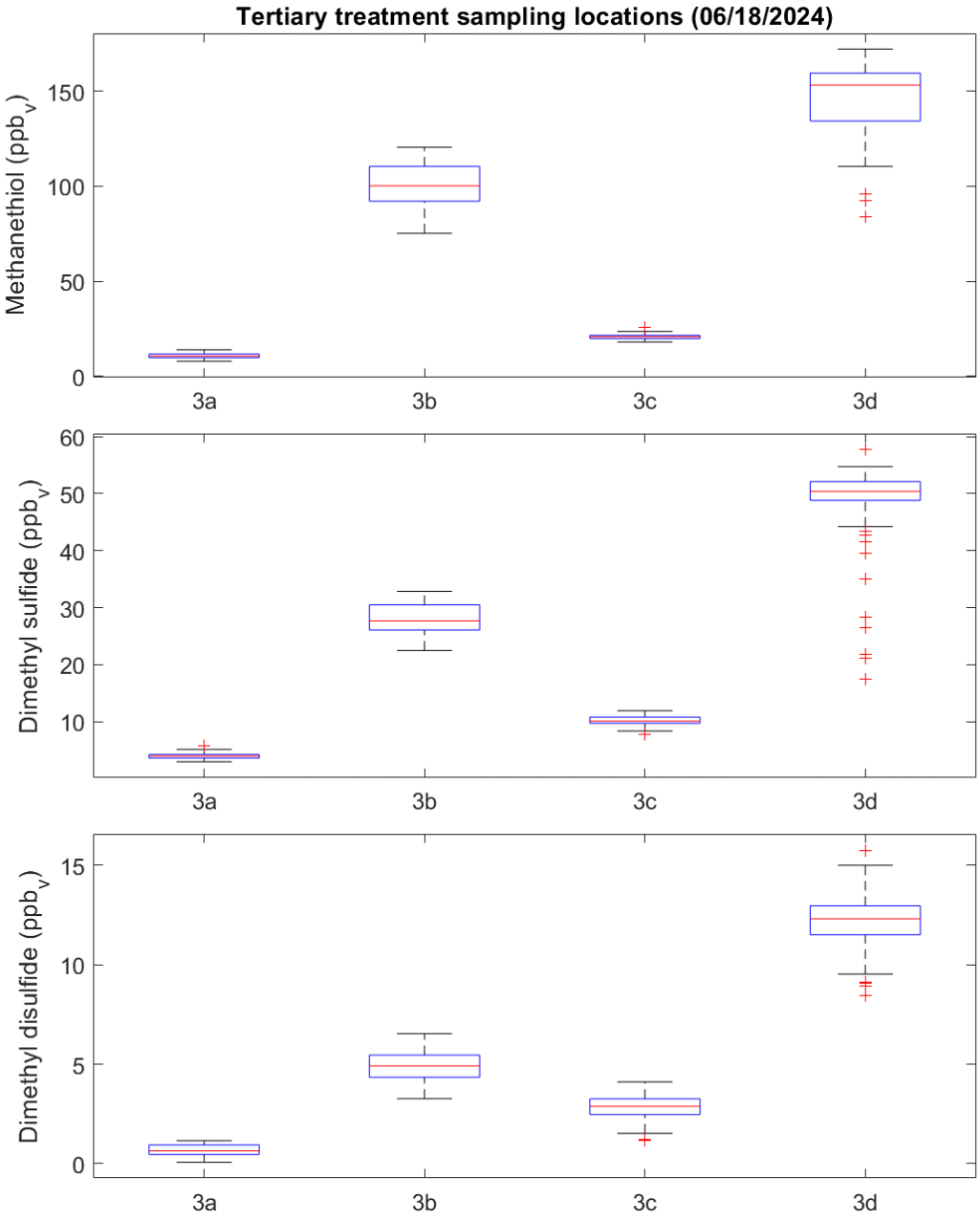


Figure 74 Tertiary wastewater treatment odour controls, 3a, 3b, 3c and 3d for methanethiol, dimethyl sulfide and dimethyl disulfide. (06/18/2024)

Ductwork summary for acetaldehyde, acetone, acetic acid and monoterpenes.

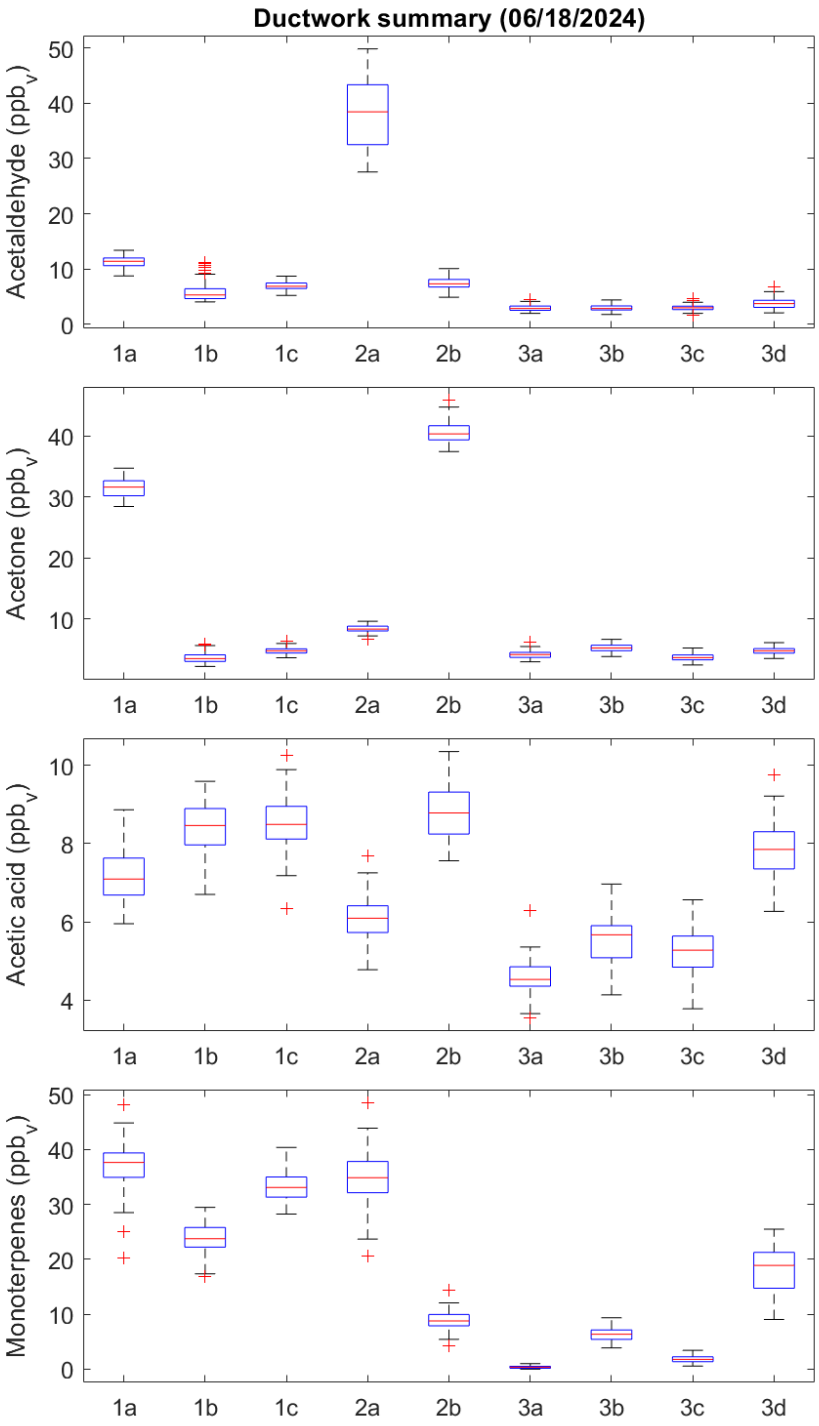


Figure 75 Ductwork summary of acetaldehyde, acetone, acetic acid and monoterpenes for all sample points (06/18/2024)

Charcoal scrubber on tertiary treatment roof.

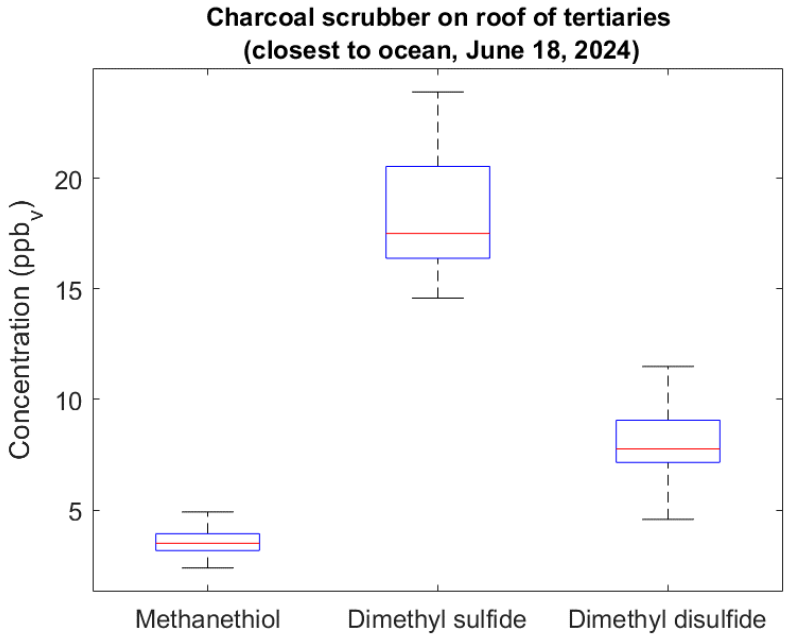


Figure 76 Boxplots for new charcoal scrubbers on tertiary treatment rooftop. For MeSH, DMS, DMDS. (06/18/2024)

Summary of ductwork for SHT, DBW and PDT

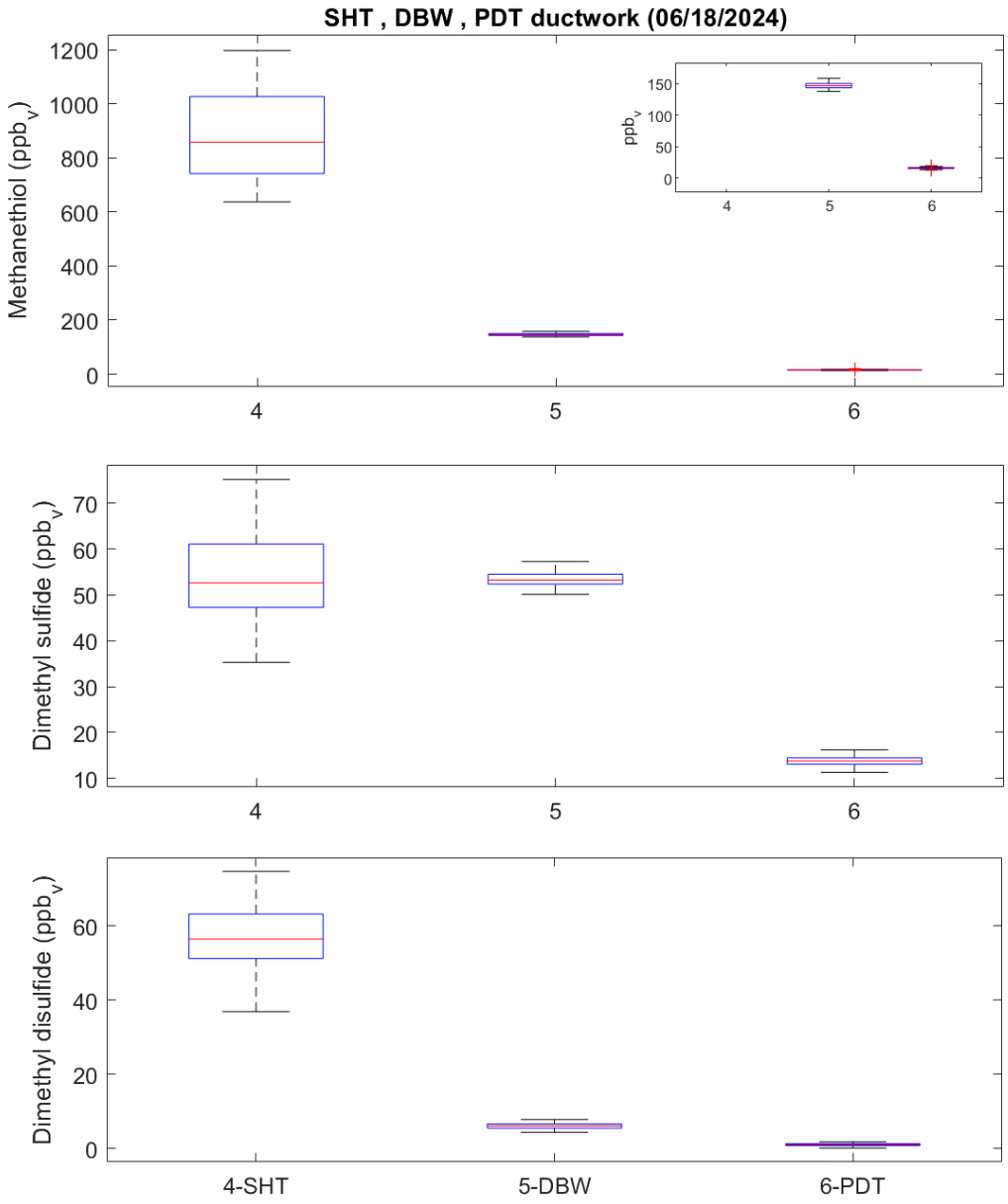


Figure 77 Holding tanks boxplots for methanethiol, dimethyl sulfide and dimethyl disulfide. (06/18/2024)

Exhaust points 1C and 2B summary for methane concentration

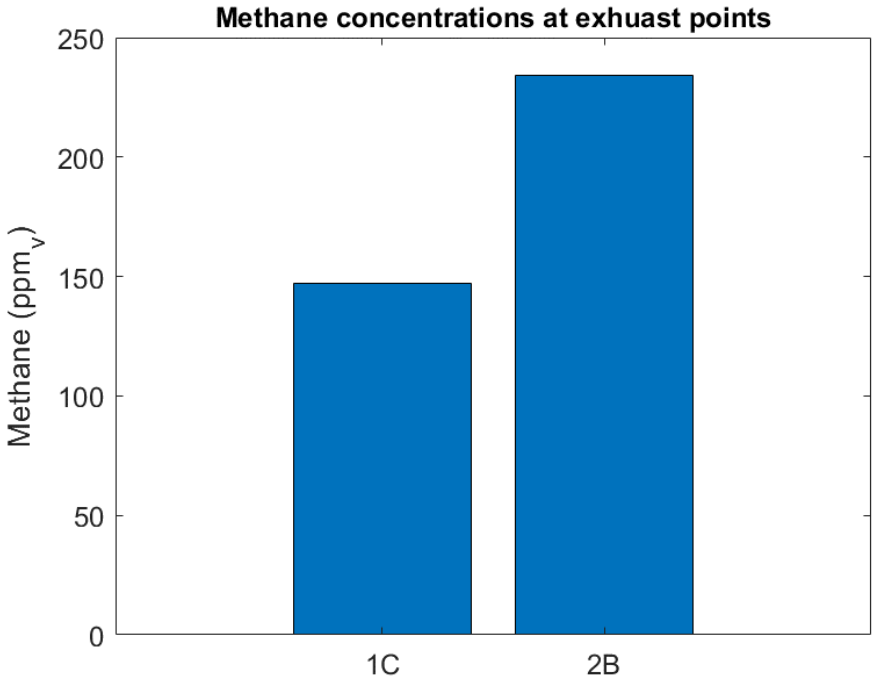


Figure 78 Methane concentrations from 1C and 2B, (06/18/2024)