JSC TOXICOLOGY AND ENVIRONMENTAL CHEMISTRY GROUP

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SUBJECT: Toxicological Assessment of ISS Air and Water Quality: September 27, 2023 to March 26, 2024 (Increment 70) Including SpaceX-29, Axiom-3, NG-20, and SpaceX-30 Ingresses

SUMMARY: Based on these data, air quality was acceptable on ISS for this period, and potable water remains acceptable for crew consumption.

AIR QUALITY

Fifteen archive air samples were collected in mini grab sample containers (mGSCs) on ISS during Increment 70: 10 routine, 1 contingency, and 4 ingress samples. The contingency sample was collected in Node 3 soon after the docking of 86-P on December 3, 2023 (GMT 337). The crew noticed a "paint thinner type smell" near T2 and believed the source could have been 86-P as the smell was near the ventilation path. A sample was also collected in Crew-8 during its ascent to ISS in March 2024. A summary of the key air quality indicators from the Increment 70 mGSC samples is provided in Table 1A. Additionally, five sets of formaldehyde badges were deployed in the US Lab and the Russian Service Module (SM) during Increment 70. Table 1B includes a summary of the formaldehyde levels measured on ISS during the Increment. Data from three sets of badges are not reportable due to concerns about the validity of control samples.

Data tables containing measured concentrations and corresponding T-values based on appropriate Spacecraft Maximum Allowable Concentrations (SMACs) for compounds present at levels above the laboratory reporting limit are attached to this report. Complete data tables, which include compounds assessed but not detected, are available upon request. Pressure readings for the mGSCs indicate that all samples collected during Increment 70 were within acceptable limits. The mean relative recoveries of the three surrogate standards were all within acceptable limits for the reported samples.

Toxicological Evaluation of ISS Air Quality

Since 2013, ISS air quality monitoring is performed in-flight using the Air Quality Monitors (AQMs). During this Increment, NASA received additional information on trace contaminant levels in ISS from the ESA tech demo, ANITA-2 (Analyzing Interferometer for Ambient Air, a Fourier-transform infrared spectrometer built by Sintef and flown to ISS by the European Space Agency). Archive air samples (mGSCs and formaldehyde badges) are collected during each Increment and returned for analysis in the Environmental Chemistry Laboratory. Data from the ground analyses complement the in-flight data and provide a more complete understanding of air quality on the ISS. Analytical results from the routine mGSC samples that returned on SpX-29 and -30 confirmed that air quality was acceptable during this Increment. **T-values calculated using data from all routine archive samples met the 180-d T-value guideline (T< 1), indicating no concern for crew health.**

Table 1A. Analytical summary of ISS air analyses from mGSCs during Increment 70

Return Flight	Sample Location	Sample Date	Alcohols[a] (mg/m^3)	T-Value[b] (units)
SpaceX-29	US Lab	10/2/2023	4.8	0.1
SpaceX-29	Columbus	10/2/2023	5.0	0.2
SpaceX-29	SpX-29 Ingress	11/11/2023	1.8	0.1 (0.1)
SpaceX-29	US Lab	11/13/2023	3.6	0.1
SpaceX-29	JPM	11/13/2023	3.8	0.1
SpaceX-29	Node-3, near T2 (contingency)	12/3/2023	4.0	0.1
SpaceX-30	US Lab	12/28/2023	6.5	0.2
SpaceX-30	Columbus	12/28/2023	5.4	0.2
Axiom-3	Axiom-3 Ingress	1/20/2024	1.0	0.3 (0.1)
SpaceX-30	NG-20 Ingress	2/1/2024	3.0	1.0 (0.4)
SpaceX-30	US Lab	2/13/2024	4.7	0.1
SpaceX-30	SM	2/13/2024	4.5	0.2
Crew-8	Crew-8 ascent	3/4/2024	0.5	0.1 (<0.1)
SpaceX-30	SpX-30 Ingress	3/23/2024	3.9	0.2 (0.1)
SpaceX-30	US Lab	3/26/2024	5.8	0.1
SpaceX-30	JPM	3/26/2024	5.2	0.4
Guideline			*<5*	*<1*[c]

[a] Includes acetone

[b] Sum of the ratios of the measured concentrations and the corresponding 180-day SMAC for each compound; parenthesis indicate value based on 7-day SMACs and applicable to first ingress

[c] T-value <1 used to evaluate routine monthly sampling; <3 used to evaluate first ingress.

Table 1B: Analytical summary of formaldehyde samples from Increment 70

Return Flight	Sample Location	Sample Date	Formaldehyde ($\mu g/m^3$)
SpaceX-29	US Lab	10/2/2023	29
SpaceX-29	SM	10/2/2023	27
SpaceX-29	US Lab	11/13/2023	28
SpaceX-29	SM	11/13/2023	29
SpaceX-31	US Lab	12/27/2024	NR
SpaceX-31	SM	12/27/2024	NR
SpaceX-31	US Lab	2/13/2024	NR
SpaceX-31	SM	2/13/2024	NR
SpaceX-31	US Lab	3/26/2024	NR
SpaceX-31	SM	3/26/2024	NR
Guideline			*<120*

NR: Not reportable

The average, rounded T-value calculated from the nominal Increment 70 mGSC samples was 0.2 (Figure 1). This value continues Increment 68's trend of lower T-values compared to Increment 65-67 (0.5 - 1.2) which were mostly attributable to periodic detections of acrylonitrile from the ISS atmosphere. The temporary source of acrylonitrile in earlier Increments was not determined despite evaluation of several potential sources; acrylonitrile was detected in the JPM in March 2024 (0.016 mg/m^3), and the T-value of that sample was 0.4.

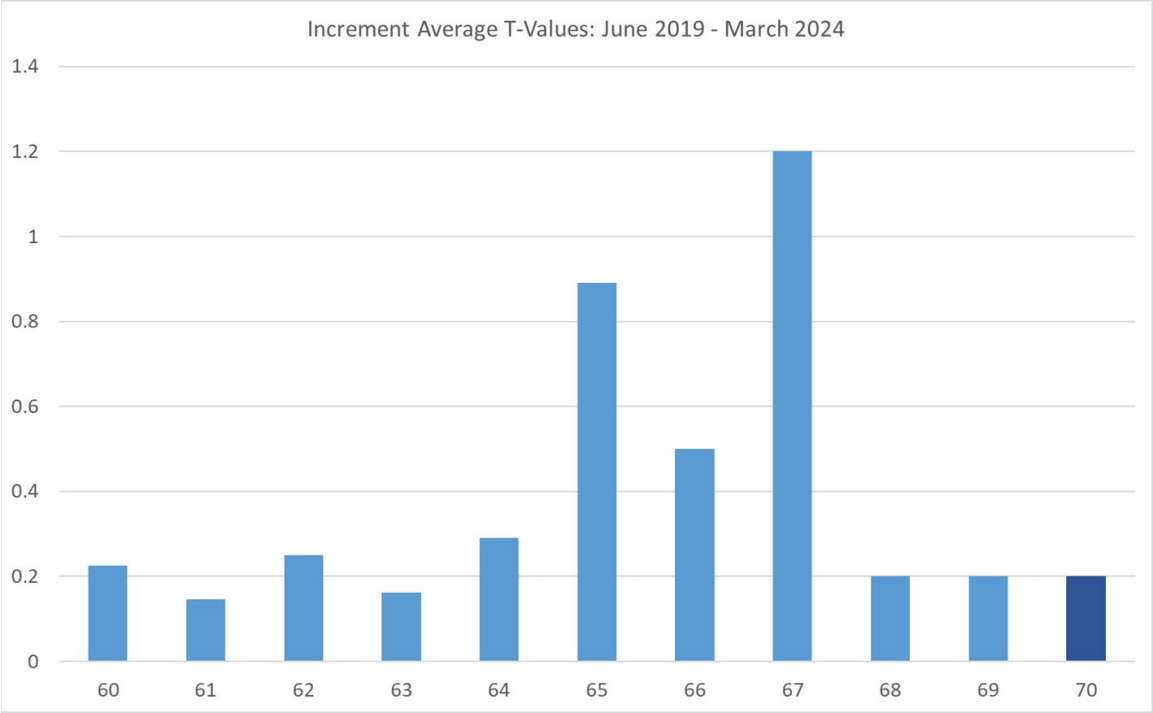


Figure 1. mGSC-Derived T-values for Increments 60-70
(does not include CO_2, first ingress, or contingency samples)

Alcohol values for five of the ten routine mGSC samples returned on SpX-29 and -30 exceeded the ECLS guideline of <5 mg/m^3, and several others were relatively close to the target level. The levels are mostly attributable to ethanol. Measured levels do not present a risk to crew health but are a potential concern for the water recovery system. Data from ANITA-2 indicates that average ethanol levels dropped below 3 mg/m^3 in November, December, and January but rose again in February.

Levels of octafluoropropane (Freon 218) continue to be very low in ISS air compared with historical measurements due to continued operation of a CO_2 removal technology demonstration unit that very efficiently scrubs octafluoropropane from the ISS atmosphere. As a result, octafluoropropane was removed from Table 1. ANITA-2 observed very low average octafluoropropane concentrations across the Increment (0.05-12.8 mg/m^3) (Table 3).

All ten routine mGSC samples collected and analyzed during Increment 70 contained a CO_2 concentration below the limit documented in Flight Note F091532D, which requests that the 24-hour average concentration not exceed 3.0 mmHg (7100 mg/m^3, 4000 ppm) on the US segment. While mGSC CO_2 sampling provides a snapshot of the CO_2 concentration, real-time CO_2 data are available from the Commercial Major Atmospheric Constitutents Sensors (CMACS), from ANITA-2 in Columbus, and intermittently from the Major Constituent Analyzers (MCAs) in Node 3 and the US Lab (daily average CO_2 concentrations are

represented in Figure 2). To preserve the longevity of the instrumentation, MCAs are only activated during EVA activities, crew metabolic characterization, tech demo analysis, anomaly resolution, and when requested by crew surgeons.

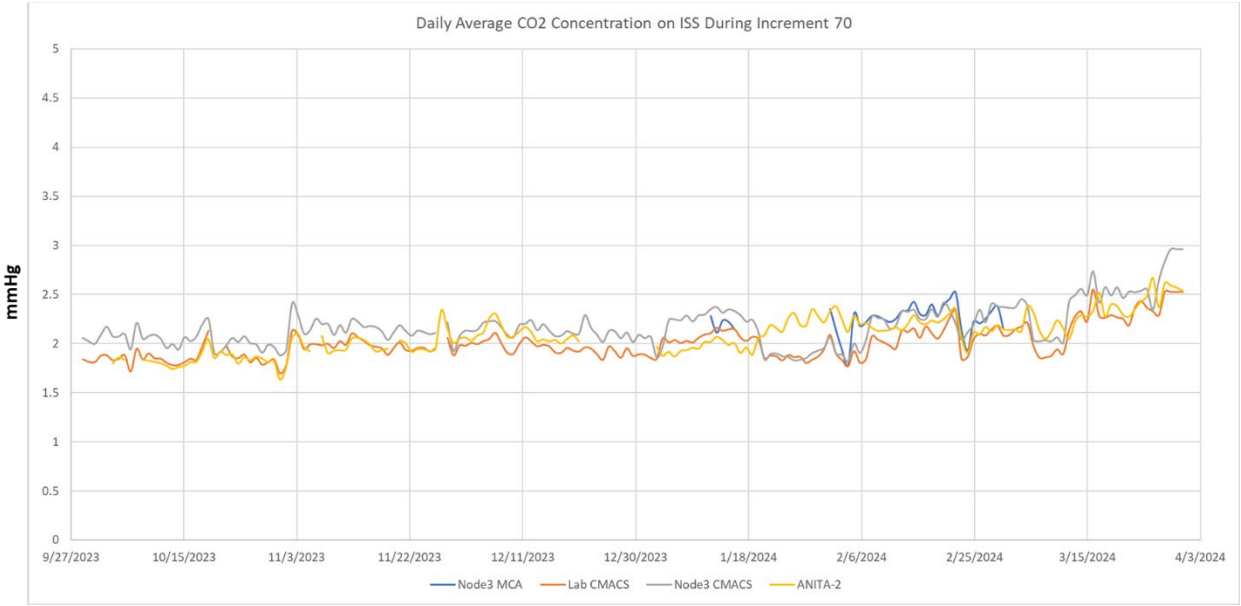
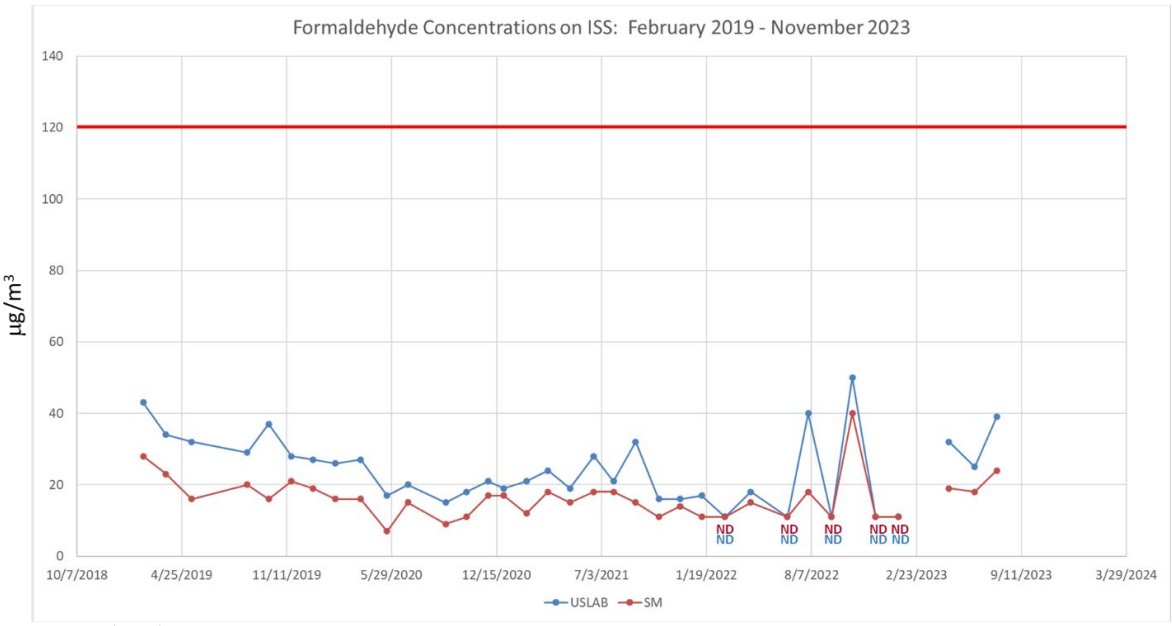


Figure 2. Environmental ppCO$_2$ Concentrations on ISS During Increment 70 (mmHg)

Five sets of passive formaldehyde badges were deployed on ISS during Increment 70. Results from analysis of the remaining badges indicated that formaldehyde remains at or below the historical range observed on ISS, and concentrations are well below the SMAC of 120 µg/m^3 (Figure 3). Data from badges deployed on ISS in December 2023 and February and March of 2024 were considered non-reportable due to analytical issues with the controls. ANITA-2 has the capability to measure formaldehyde at levels on the order of 80 µg/m^3, but this instrument did not report any detections of formaldehyde during Increment 70.

On-orbit, the Air Quality Monitors (AQMs) nominally collect and analyze samples every 73 hours, which results in 2-3 sampling sessions per unit per week. However, both AQMs failed during Increment 69 and were replaced during Increment 70. Monthly average concentrations for compounds measured on the AQMs are presented in Table 2. As a result of concerns about the age of the AQM fleet and difficulties in resupply for consumables, AQMs will be decommissioned in 2025 and will no longer be operational on ISS.

ANITA-2 began operations on ISS as a technological demonstration unit in March 2022 and provides data on up to 48 analytes every 6-10 minutes. Initially, ANITA-2 was installed in the US Lab but has since been relocated to the Columbus module. Recently (early 2025), NASA has selected ANITA-2 as its primary trace contaminants monitor for ISS after a review of its performance against archive samples and AQM readings. Monthly average readings for several of ANITA-2's target compounds are presented in Table 3. Detailed information about the ANITA-2 hardware is available upon request.



ND: not detected

Figure 3: Formaldehyde Concentrations from February 2019 to November 2023

Table 2. Average monthly concentrations (mg/m^3) of AQM target compounds (Increment 70)

Compound	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Increment Average
2-Butanone				ND	ND	ND	ND	ND
2-Propanol							0.2	0.2
Acetaldehyde								
Acetone							0.1	0.1
Acrolein							ND	ND
Benzene							MI	MI
1,2-Dichloroethane							ND	ND
Dichloromethane				ND	ND	ND	ND	ND
Decamethylcyclopentasiloxane#				ND	ND	ND	ND	ND
Ethanol					3.0	2.9	3.0	3.0
Ethyl Acetate				ND	ND	ND	ND	ND
Hexanal				ND	ND	ND	ND	ND
Hexane				ND	ND	ND	ND	ND
Hexamethycyclotrisiloxane#				ND	ND	ND	ND	ND
Methanol							0.1	0.1
m,p-Xylenes#				ND	ND	ND	ND	ND
n-Butanol				ND	ND	ND	ND	ND
Octamethylcylcotetrasiloxane#				ND	ND	ND	ND	ND
o-Xylene#				ND	ND	ND	ND	ND
Toluene#				ND	ND	ND	ND	ND
Trimethylsilanol							0.05	0.05

ND: Not detected; <MDL (Minimum Detection Limit)
MI: Matrix Interference
Black cells indicate AQM failures during the Increment, during which no analysis was performed.

Table 3: Monthly average concentrations (mg/m^3) of ANITA-2 target compounds (Increment 70)

Compound	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Increment Average
Methanol	0.37	0.39	0.50	0.51	0.39	0.36	0.42	0.42
Ethanol	3.92	3.44	2.93	2.78	2.81	3.12	3.52	3.22
2-Propanol	0.54	0.56	0.55	0.60	0.52	0.48	0.44	0.53
PFP	0.53	0.14	0.07	0.05	12.80	0.18	0.14	1.99
R134a	0.09	0.09	0.09	ND	ND	ND	0.11	0.09
DMCPS	0.03	ND	0.05	0.04	0.44	0.92	1.02	0.42
SF_6	0.24	0.13	0.05	0.04	0.01	0.04	0.04	0.08
Ammonia	0.02	0.02	0.02	ND	0.02	0.02	ND	0.02
CO	1.83	1.57	1.47	1.72	1.79	1.47	1.68	1.65
Methane	178	127	76.5	62.7	54.1	60.9	60.7	88.6
CO_2	2.08	1.84	1.97	2.09	2.06	2.19	2.32	2.08
Isobutane	ND	ND	ND	ND	ND	ND	0.43	0.43
N_2O	ND	ND	ND	ND	0.15	ND	0.18	0.17
CF_4	0.13	0.11	0.09	0.09	0.11	0.14	0.13	0.11

ND: Not detected
PFP: perfluoropropane, octafluoropropane, Freon 218
R134a: R-134a, 1,1,1,2-tetrafluoroethane
DMCPS: Decamethylcyclopentasiloxane

SpaceX-29 Ingress
An mGSC sample was collected upon ingress on SpX-29 on November 11, 2023. The hatch was opened at 11:48, and the sample was taken 5 minutes thereafter. Analytical results from the sample indicate a lower level of methane (14 mg/m^3) than found on ISS (~160 mg/m^3), which indicates low levels of mixing between the visiting vehicle and the full ISS volume. Levels of ethanol were also markedly lower. The vehicle also had levels of the coolant R-134A (0.42 mg/m^3) higher than expected on ISS (~0.05 mg/m^3). **The T-value for this sample was 0.1, well below levels of concern for crew health**.

Node 3 Contingency
On December 3, 2023, crew collected a contingency mGSC near T2 (15:55), after they reported a "paint" smell after the hatch opening for 86-P (15:13). The only interesting finding in this mGSC is the presence of ethyl acetate (0.42 mg/m^3); this compound is occasionally detected after docking for visiting vehicles. However, its odor threshold is on the order of 15 mg/m^3 and the odor is usually described as "sweet." ANITA-2 did not detect any changes in the ISS atmosphere during this period, either. As is often the case, the source of the odor remains unknown.

Axiom-3 Ingress
An ingress sample was collected in Axiom-3, a private astronaut mission using a SpaceX vehicle, on January 20, 2024, at 12:20 GMT. The hatch was opened at 12:13 GMT. Methane, ethanol, and CO_2 levels in the visiting vehicle were both markedly lower than expected in the ISS volume, consistent with a low extent of atmospheric mixing at the time the sample was collected. As with SpX-29, R-134a was detected in the Ax-3 atmosphere (0.18 mg/m^3) at levels slightly higher than would be expected on ISS (~0.07 mg/m^3). **The T-value for this sample was 0.1, well below levels of concern for crew health.**

NG-20 Ingress
An ingress sample was collected in NG-20 on February 1, 2024 at 16:54, approximately 7 minutes after hatch opening. Concentrations of ethanol, CO_2, and methane were all markedly lower than expected on ISS, indicating a low level of mixing with ISS air. **The T-value for this sample was 0.4, well below levels of concern for crew health.** The primary contributor to the T-value was trimethylsilanol (0.18). C-11 alkanes were also detected in this sample (7.1 mg/m^3) but contributed very little to the T-value.

Crew-8 Ascent
A sample was taken in Crew-8 during ascent to ISS on March 4, 2024. The T-value of this sample is 0.1, indicative of excellent air quality.

SpaceX-30 Ingress
An ingress sample was collected in SpX-30 on March 23, 2024 at 13:16, two minutes after hatch opening. R-134a was detected at 1.5 mg/m^3. Other analytes indicate a low level of mixing with ISS atmosphere prior to sampling. **The T-value for this sample was 0.1, well below levels of concern for crew health**.

WATER QUALITY

In total, six water samples were collected from the US Segment during Increment 70 and returned on SpX-29, -30, and Crew-7. Three of these were ambient and hot potable water samples collected from the US Potable Water Dispenser (PWD) and the Exploration Potable Water Dispenser (xPWD), which fall under the ISS Crew Health Care System (CHeCS). The remaining three samples were non-potable water, including one wastewater and one condensate samples as well as a sample collected from the PWD Auxiliary Port (ECLS). Summaries of select analytical results from the Increment 70 samples are provided in Tables 4A and 4B.

Table 4A. Analytical Summary of ISS Water Analyses for CHeCS Samples (Increment 70)

Return Mission	Sample Location	Sample Date	TOC (mg/L)	DMSD (mg/L)	Methyl Sulfone (mg/L)	Conductivity (µS/cm)	Total Iodine (mg/L)
SpX-29	xPWD Hot	11/7/2023	0.8	<1	0.07	2	<0.05
SpX-29	PWD Ambient	11/27/2023	0.4	<1	0.11	<1	<0.05
SpX-30	PWD Ambient	4/2/2024	0.7	<1	0.15	<1	0.05

Table 4B. Analytical Summary of ISS Water Analyses for ECLS Samples (Increment 70)

Return Mission	Sample Location	Sample Date	TOC (mg/L)	DMSD (mg/L)	Methyl Sulfone (mg/L)	Conductivity (µS/cm)	Total Iodine (mg/L)
Crew-7	Condensate	11/29/2023	20.8	1.4	<0.02	118	NA
SpX-29	PWD Aux Port	12/1/2023	0.4	<1	0.07	<1	2.1
Crew-7	Wastewater	12/1/2023	4.5	1.1	0.02	90	NA

NA: not analyzed

Toxicological Evaluation of ISS Water Quality

Routine water quality monitoring is performed in-flight using the total organic carbon analyzer (TOCA). Results from these analyses provide a general indication of overall water quality. Typically, archive water

samples are also collected during each Increment and returned for comprehensive analysis in ground laboratories (Table 3A, 3B). Data from the ground analyses complement the in-flight data and provide a more complete understanding of water quality on the ISS.

Potable Water

Concentrations of all chemicals detected in the potable water samples met the requirements listed in SSP 41000, *System Specification for the International Space Station* and JSC 63414, *Spacecraft Water Exposure Guidelines (SWEGs)*. Total organic carbon (TOC) concentrations from in-flight (PWD TOC and WPA TOC) and ground analyses (Archive TOC) performed between March 2023 and March 2024 are shown in Figure 4. The TOC concentrations in the five potable samples continued to be low and were well below both the specification for the US segment (<3 mg/L) and the 100-day SWEG (5 mg/L). Methyl sulfone was detected in all potable water samples at levels well below the SWEG of 1,500 mg/L. Silicon was also detected in all potable samples (0.2 – 1 mg/L).

Iodine is a biocide used on the US Segment. It is added to the water produced by the WPA but removed prior to crew consumption to avoid potential thyroid dysfunction. The total iodine level in two of the three potable samples collected from the PWD were below the reporting limit and the third was at the reporting limit (0.05 mg/L), indicating effective removal of iodine in water intended for consumption. For additional information regarding microbial analyses, see the Increment 70 post-flight report generated by the JSC Environmental Microbiology Laboratory.

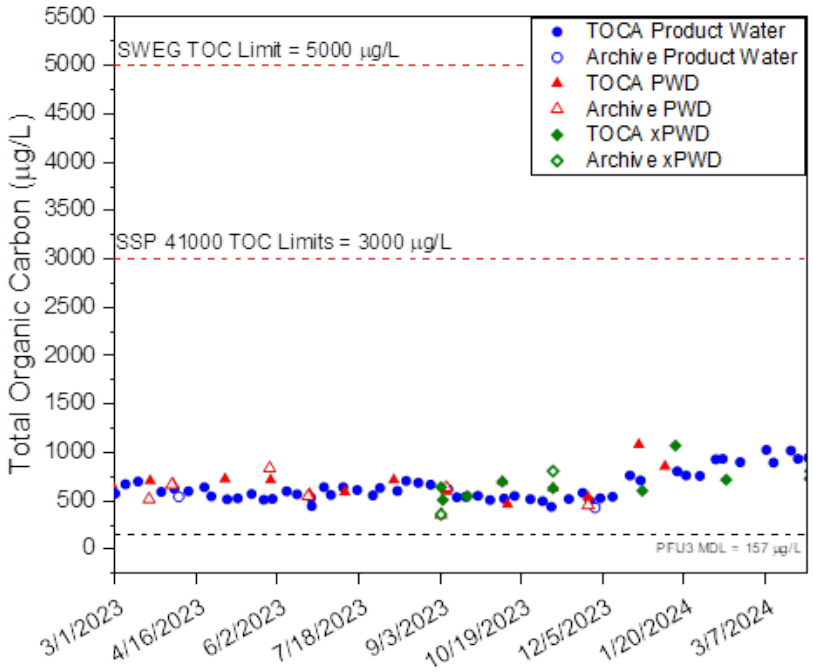


Figure 4. Total Organic Carbon (TOC) trending in US Potable Water from Archive Water Samples and On-Orbit TOCA (PFU3) for March 2023 to March 2024

Condensate (November 29, 2023)

The condensate sample collected on November 29, 2023, contained TOC levels of 20.8 mg/L, well below the historical average of 147 mg/L. Organic compounds detected at or above 1 mg/L are listed in Table 5. Zinc was the only metal detected above 0.1 mg/L (1.83 mg/L). The concentration of ammonium was 15.1 mg/L.

Table 5: Organic Compounds Detected >1 mg/L in US Condensate Sampled on November 29, 2023

Compound	Condensate (mg/L) November 29, 2023	Historical average (mg/L)
Ethanol	27	49
Methanol	7.9	4.9
Acetone	5.9	2.0
2-propanol (isopropanol)	1.6	1.4
Dimethylsilanediol (DMSD)	1.4	34.3

WPA Product Water (PWD Aux Port)
The sample from the PWD Aux Port on December 1, 2023, contained TOC levels of 0.42 mg/L, below the historical average. Methyl sulfone was detected at levels well below the SWEG of 1500 mg/L. The total iodine level of this sample was 2.1 mg/L, but otherwise the chemical results from this sample were consistent with potable water.

Wastewater (December 1, 2023)
The wastewater sample collected on December 1, 2023, contained TOC levels of 4.5 mg/L, below the historical average of 40 mg/L. The only organic compound detected above 1 mg/L was DMSD (1.1 mg/L). Nickel was present at 0.1 mg/L, and zinc was detected at 1.4 mg/L. No other metals were detected at levels above 0.1 mg/L. Ammonium was present at a concentration of 11.4 mg/L.

Given the results from wastewater and condensate, the cleanliness of potable water dispensed from the PWD and xPWD provide strong evidence that the Water Recovery System is performing well on ISS. Expanded summary tables containing organic carbon recoveries and results for all analytes present at concentrations above reporting limits are included as attachments to this report.

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Enclosures
- Table S-1: Analytical concentrations of compounds quantified in mGSCs collected in and returned on SpaceX-29, SpaceX-30, Crew-8, and Axiom-3
- Table S-2A: T-values corresponding to concentrations for routine mGSC samples returned on SpaceX-29, SpaceX-30, Crew-8, and Axiom-3
- Table S-2B: T-values corresponding to concentrations for SpaceX-29, Axiom-3, NG-20, and SpaceX-30 ingress air samples, based on 7-day and 180-day SMACs
- Table S-3A: Analytical concentrations of compounds quantified in hot and ambient water samples returned on SpaceX-29 and SpaceX-30
- Table S-3B: Analytical concentrations of compounds quantified in US condensate, wastewater, and PWD Aux Port water samples returned on SpaceX-29 and Crew-7

TABLE S-1: ANALYTICAL RESULTS FOR SPACEX-29, AXIOM-3, SPACEX-30, AND CREW-8

Increment	70															
Mission	SpX-29					SpX-30						Crew-8	SpX-29	Axiom-3	SpX-30	
Sample Location	Lab	Columbus Module	US Lab Center	JPM	Node 3, T2	Lab	Columbus Module	Lab	Service Module	Lab	JPM	Dragon Module	Dragon Module	Dragon Module	NG-20	Dragon
Sample Description	Nominal air sample, S/N 2074	Nominal air sample, S/N 2072	Nominal air sample, S/N 2106	Nominal air sample, S/N 2108	Contingency air sample, S/N 2104	Nominal air sample, S/N 2101	Nominal air sample, S/N 2105	Nominal air sample, S/N 2067	Nominal air sample, S/N 2010	Nominal air sample, S/N 2047	Nominal air sample, S/N 2044	Crew 8 Ascent, S/N 2076	Ingress air sample, SpX-29 S/N 2107	Ingress Air Sample, Ax-3, S/N 2087	Ingress air sample, S/N 2109	Ingress air sample, SpX-30, S/N 2034
Sample Date	10/2/2023	10/2/2023	11/13/2023	11/13/2023	12/3/2023	12/28/2023	12/28/2023	2/13/2024	2/13/2024	3/26/2024	3/26/2024	3/4/2024	11/11/2023	1/20/2024	2/1/2024	3/23/2024
Sample Time	12:49	12:53	19:06	19:08	15:00	13:34	13:37	13:45	13:48	14:43	14:45	10:36	11:53	12:20	16:55	13:16
Analysis/Sample ID	**AQ240112**	**AQ240113**	**AQ240115**	**AQ240116**	**AQ240117**	**AQ240431**	**AQ240432**	**AQ240437**	**AQ240438**	**AQ240443**	**AQ240444**	**AQ250059**	**AQ240114**	**AQ240180**	**AQ240436**	**AQ240441**
Volatiles Targets GCMS (TO-15 mod)	mg/m3															
1,1,1,2-Tetrafluoroethane	0.052	0.064	<0.19	<0.21	0.074	0.080	0.072	0.078	0.073	0.092	0.086	0.066	0.42	0.18	<0.046	1.5
1-Butanol	<0.0091	0.027	<0.081	<0.089	<0.018	<0.020	<0.026	<0.020	<0.020	<0.021	<0.022	<0.019	<0.018	<0.018	0.040	<0.024
1-Propanol	0.011	0.013	<0.066	<0.073	0.018	0.023	0.031	0.021	0.020	0.020	0.033	<0.016	<0.015	<0.015	0.022	<0.019
2-Butanone (Methyl ethyl ketone)	<0.0088	<0.0097	<0.078	<0.086	<0.018	<0.019	<0.026	<0.019	<0.019	<0.020	<0.021	<0.018	<0.018	<0.018	0.022	<0.023
2-Methyl-1-propene	<0.0069	<0.0076	<0.061	<0.068	<0.014	<0.015	<0.020	<0.015	<0.015	<0.016	<0.017	<0.014	<0.014	<0.014	0.055	<0.018
2-Propanol (Isopropanol)	See GC-FID	See GC-FID	0.51	0.54	See GC-FID	See GC-FID	0.74	0.50	0.52	0.42	0.53	0.13	See GC-FID	0.57	See GC-FID	See GC-FID
Acetaldehyde	0.078	0.14	0.12	0.16	0.10	0.15	0.098	0.13	0.12	0.13	0.12	0.020	0.050	0.023	0.18	0.072
Acetone	0.20	0.24	0.32	0.32	0.19	0.28	0.22	0.24	0.30	0.22	0.25	0.15	0.11	0.094	0.25	0.14
Acetonitrile	<0.0050	0.0074	<0.045	<0.049	<0.010	<0.011	<0.014	<0.011	<0.011	<0.011	<0.012	<0.011	<0.010	0.016	<0.011	<0.013
Acrylonitrile	<0.0065	<0.0072	<0.058	<0.064	<0.013	<0.014	<0.019	<0.014	<0.014	<0.015	0.016	<0.014	<0.013	<0.013	<0.014	<0.017
Carbon disulfide	0.010	0.012	<0.083	<0.091	<0.019	<0.020	<0.027	<0.020	<0.020	<0.021	<0.022	<0.020	<0.019	<0.019	0.045	<0.024
Carbonyl sulfide (Carbon oxide sulfide)	<0.0074	<0.0081	<0.066	<0.073	<0.015	<0.016	<0.021	<0.016	<0.016	<0.017	<0.018	<0.016	<0.015	<0.015	0.020	<0.019
Ethanol	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	0.079	See GC-FID	0.20	See GC-FID	See GC-FID
Ethyl acetate	<0.011	<0.012	<0.098	<0.11	0.042	<0.024	<0.032	<0.024	<0.024	<0.025	<0.026	<0.023	<0.022	<0.022	<0.024	<0.029
Hexamethylcyclotrisiloxane (HMCTS)	<0.091	0.036	<0.81	<0.89	0.056	0.12	<0.26	<0.20	<0.20	<0.21	<0.22	<0.19	<0.18	<0.18	0.11	<0.24
Isobutane	0.036	0.037	<0.063	<0.070	0.043	0.048	0.045	0.042	0.039	0.049	0.048	0.037	0.027	0.19	0.77	0.52
Isoprene (2-Methyl-1,3-butadiene)	<0.0084	0.0097	<0.075	<0.082	<0.017	<0.018	<0.024	<0.018	0.021	<0.019	<0.020	<0.018	<0.017	<0.017	<0.018	<0.022
Methanol	See GC-FID	See GC-FID	0.85	0.82	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	0.15	See GC-FID	0.15	0.23	0.28
Methylene chloride (Dichloromethane)	<0.010	0.012	<0.089	<0.098	<0.020	<0.022	<0.029	<0.022	<0.022	<0.023	<0.024	<0.021	<0.020	<0.020	0.061	<0.026
Pentane	<0.0089	<0.0098	<0.079	<0.087	<0.018	0.16	0.14	0.097	0.10	<0.020	<0.021	0.024	<0.018	<0.018	0.19	0.32
Perfluoro(2-methylpentane)	<0.041	0.10	<0.36	<0.40	<0.082	<0.090	<0.12	<0.090	<0.090	<0.094	<0.098	<0.086	<0.082	<0.082	<0.090	<0.11
Propanal (Propionaldehyde)	<0.0071	<0.0078	<0.063	<0.070	<0.014	0.061	0.050	0.057	0.068	0.060	0.067	<0.015	<0.014	<0.014	0.059	0.056
Propane	<0.0054	<0.0059	<0.048	<0.053	<0.011	<0.012	<0.016	<0.012	<0.012	0.040	<0.013	<0.011	0.012	0.017	<0.012	<0.014
Styrene (Ethenylbenzene)	<0.013	<0.014	<0.12	<0.13	<0.026	<0.029	<0.038	<0.029	<0.029	<0.030	<0.031	<0.027	<0.026	<0.026	0.051	<0.034
Toluene	<0.011	<0.012	<0.098	<0.11	<0.022	<0.024	<0.032	<0.024	<0.024	<0.025	<0.026	<0.023	<0.022	<0.022	0.30	<0.029
Trimethylsilanol	0.015	0.018	<0.098	<0.11	0.023	0.025	<0.032	<0.024	<0.024	<0.025	0.054	<0.023	0.023	<0.022	0.70	<0.029
Volatiles Non-Targets GCMS (estimated conc.)																
1,1-Difluoroethane	not found	not found	not found	not found	not found	not found	not found	not found	not found	not found	not found	not found	not found	not found	<0.016	0.12
C11-Alkanes	not found	not found	not found	not found	not found	not found	not found	not found	0.11	<0.038	<0.038	not found	not found	not found	7.1	0.18
Volatiles Targets GCFID																
2-Propanol (Isopropanol)	0.61	0.56	NR	NR	0.55	1.1	NR	NR	NR	NR	NR	NR	0.69	NR	0.94	1.8
Ethanol	3.6	3.8	1.9	2.1	2.8	4.5	3.9	3.6	3.4	4.6	3.9	NR	0.71	NR	1.5	1.7
Methanol	0.37	0.35	NR	NR	0.41	0.55	0.49	0.32	0.30	0.51	0.52	NR	0.27	NR	NR	NR
Octafluoropropane (Perfluoropropane)	<1.5	<1.6	<6.9	<7.5	<1.5	<1.7	<2.2	<1.7	<1.7	<1.8	<1.8	<1.6	<1.5	7.0	<1.7	<2.0
Volatiles Targets TGA																
Carbon dioxide	4,000	4,900	4,400	4,300	4,500	5,000	4,100	4,000	6,400	5,600	6,000	1,900	5,700	1,900	2,700	1,300
Carbon monoxide	1.3	1.4	<2.0	<2.3	<0.46	1.6	1.8	1.2	1.2	1.4	1.4	1.8	1.4	5.5	1.1	1.8
Hydrogen	7.2	7.6	4.9	4.7	6.4	6.3	6.4	7.0	7.0	7.0	6.8	2.2	1.2	18	3.0	1.8
Methane	160	160	59	57	65	54	55	58	58	61	59	<2.7	14	32	21	10
	GMT 275	GMT 275	GMT 317	GMT 317	GMT 337	GMT 362	GMT362	GMT 044	GMT 044	GMT 086	GMT 086	GMT 064	GMT 315	GMT 020	GMT 032	GMT 083

Comments: NR= Not Reported
Not Found =No unknown peaks above the threshold limit
AQ240115: Low Pressure: 3.4 psia
AQ240116: Low Pressure: 3.1 psia
AQ240117: Collected after 86P docking

Project Specific SMACs: 1,1-Difluoroethane: 7 and 180d-(2701mg/m^3)
C11-Alkanes: 7d-(383mg/m^3) and 180d-(19mg/m^3)

TABLE S-2A: T-VALUES FOR SPACEX-29, AXIOM-3, SPACEX-30, AND CREW-8

Increment	70										
Mission	SpX-29						SpX-30				
	T-Value (180-day)										
Sample Location	Lab	Columbus Module	US Lab Center	JPM	Node 3, T2	Lab	Columbus Module	Lab	Service Module	Lab	JPM
Sample Description	Nominal air sample, S/N 2074	Nominal air sample, S/N 2072	Nominal air sample, S/N 2106	Nominal air sample, S/N 2108	Contingency air sample, S/N 2104	Nominal air sample, S/N 2101	Nominal air sample, S/N 2105	Nominal air sample, S/N 2067	Nominal air sample, S/N 2010	Nominal air sample, S/N 2047	Nominal air sample, S/N 2044
Sample Date	10/2/2023	10/2/2023	11/13/2023	11/13/2023	12/3/2023	12/28/2023	12/28/2023	2/13/2024	2/13/2024	3/26/2024	3/26/2024
Sample Time	12:49	12:53	19:06	19:08	15:00	13:34	13:37	13:45	13:48	14:43	14:45
Analysis/Sample ID	**AQ240112**	**AQ240113**	**AQ240115**	**AQ240116**	**AQ240117**	**AQ240431**	**AQ240432**	**AQ240437**	**AQ240438**	**AQ240443**	**AQ240444**
Volatiles Targets GCMS (TO-15 mod)											
1,1,1,2-Tetrafluoroethane	0.000	0.000	ND	ND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1-Butanol	ND	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Propanol	0.000	0.000	ND	ND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2-Butanone (Methyl ethyl ketone)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Methyl-1-propene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Propanol (Isopropanol)	See GC-FID	See GC-FID	0.003	0.004	See GC-FID	See GC-FID	0.005	0.003	0.003	0.003	0.004
Acetaldehyde	0.019	0.036	0.030	0.039	0.026	0.039	0.025	0.034	0.029	0.032	0.029
Acetone	0.00	0.005	0.006	0.006	0.004	0.005	0.004	0.005	0.006	0.004	0.005
Acetonitrile	ND	0.000	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.234
Carbon disulfide	0.009	0.011	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbonyl sulfide (Carbon oxide sulfide)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethanol	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID
Ethyl acetate	ND	ND	ND	ND	0.000	ND	ND	ND	ND	ND	ND
Hexamethylcyclotrisiloxane (HMCTS)	ND	0.004	ND	ND	0.006	0.013	ND	ND	ND	ND	ND
Isobutane	0.000	0.000	ND	ND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Isoprene (2-Methyl-1,3-butadiene)	ND	0.003	ND	ND	ND	ND	ND	ND	0.007	ND	ND
Methanol	See GC-FID	See GC-FID	0.033	0.031	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID	See GC-FID
Methylene chloride (Dichloromethane)	ND	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylene	ND	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentane	ND	ND	ND	ND	ND	0.018	0.016	0.011	0.011	ND	ND
Perfluoro(2-methylpentane)	ND	0.000	ND	ND	ND	ND	ND	ND	ND	ND	ND
Propanal (Propionaldehyde)	ND	ND	ND	ND	ND	0.005	0.004	0.005	0.006	0.005	0.006
Styrene (Ethenylbenzene)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trimethylsilanol	0.004	0.004	ND	ND	0.006	0.006	ND	ND	ND	ND	0.013
Volatiles Non-Targets GCMS (estimated conc.)											
1,1-Difluoroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C11-Alkanes	ND	ND	ND	ND	ND	ND	ND	ND	0.006	ND	ND
Tetradecafluorohexane	ND	0.000	ND	ND	ND	ND	ND	ND	ND	ND	ND
Volatiles Targets GCFID											
2-Propanol (Isopropanol)	0.004	0.004	NR	NR	0.004	0.007	NR	NR	NR	NR	NR
Ethanol	0.002	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Methanol	0.014	0.014	NR	NR	0.016	0.021	0.019	0.012	0.012	0.020	0.02
Octafluoropropane (Perfluoropropane)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Volatiles Targets TGA											
Carbon monoxide	0.077	0.084	ND	ND	ND	0.097	0.104	0.072	0.073	0.081	0.084
Total T-Value	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**	**0.4**

Comments: ND= Value is less than the laboratory reporting limit.
NR= Not Reported
AQ240115: Low Pressure: 3.4 psia
AQ240116: Low Pressure: 3.1 psia
AQ240117: Collected after 86P docking

Project Specific SMACS: 1,1-Difluoroethane: 7 and 180d-(2701mg/m3)
C11-Alkanes: 7d-(383mg/m3) and 180d-(19mg/m3)

TABLE S-2B: T-VALUES FOR SPACEX-29, AXIOM-3, AND SPACEX-30

Increment	70							
Mission	SpX-29		Axiom-3		SpX-30			
	T-Value (7-Day)	T-Value (180-day)	T-Value (7-day)	T-Value (180-day)	T-Value (7-Day)	T-Value (180 day)	T-Value (7-Day)	T-Value (180 day)
Sample Location	Dragon Module	Dragon Module	Dragon Module	Dragon Module	NG-20	NG-20	Dragon	Dragon
Sample Description	Ingress air sample, SpX-29 S/N 2107	Ingress air sample, SpX-29 S/N 2107	Ingress Air Sample, Ax-3, S/N 2087	Ingress Air Sample, Ax-3, S/N 2087	Ingress air sample, S/N 2109	Ingress air sample, S/N 2109	Ingress air sample, SpX-30, S/N 2034	Ingress air sample, SpX-30, S/N 2034
Sample Date	11/11/2023	11/11/2023	1/20/2024	1/20/2024	2/1/2024	2/1/2024	3/23/2024	3/23/2024
Sample Time	11:53	11:53	12:20	12:20	16:55	16:55	13:16	13:16
Analysis/Sample ID	**AQ240114**	**AQ240114**	**AQ240180**	**AQ240180**	**AQ240436**	**AQ240436**	**AQ240441**	**AQ240441**
Volatiles Targets GCMS (TO-15 mod)								
1,1,1,2-Tetrafluoroethane	0.000	0.000	0.000	0.000	ND	ND	0.000	0.000
1-Butanol	ND	ND	ND	ND	0.001	0.001	ND	ND
1-Propanol	ND	ND	ND	ND	0.000	0.000	ND	ND
2-Butanone (Methyl ethyl ketone)	ND	ND	ND	ND	0.001	0.001	ND	ND
2-Methyl-1-propene	ND	ND	ND	ND	0.000	0.000	ND	ND
2-Propanol (Isopropanol)	See GC-FID	See GC-FID	0.004	0.004	See GC-FID	See GC-FID	See GC-FID	See GC-FID
Acetaldehyde	0.013	0.013	0.006	0.006	0.046	0.046	0.018	0.018
Acetone	0.002	0.002	0.002	0.002	0.005	0.005	0.003	0.003
Acetonitrile	ND	ND	0.000	0.001	ND	ND	ND	ND
Carbon disulfide	ND	ND	ND	ND	0.041	0.041	ND	ND
Carbonyl sulfide (Carbon oxide sulfide)	ND	ND	ND	ND	0.000	0.001	ND	ND
Ethanol	See GC-FID	See GC-FID	0.000	0.000	See GC-FID	See GC-FID	See GC-FID	See GC-FID
Hexamethylcyclotrisiloxane (HMCTS)	ND	ND	ND	ND	0.001	0.013	ND	ND
Isobutane	0.000	0.000	0.001	0.001	0.004	0.004	0.003	0.003
Methanol	See GC-FID	See GC-FID	0.006	0.006	0.009	0.009	0.011	0.011
Methylene chloride (Dichloromethane)	ND	ND	ND	ND	0.001	0.006	ND	ND
Pentane	ND	ND	ND	ND	0.001	0.021	0.002	0.036
Propanal (Propionaldehyde)	ND	ND	ND	ND	0.005	0.005	0.005	0.005
Styrene (Ethenylbenzene)	ND	ND	ND	ND	0.007	0.169	ND	ND
Toluene	ND	ND	ND	ND	0.020	0.020	ND	ND
Trimethylsilanol	0.006	0.006	ND	ND	0.176	0.176	ND	ND
Volatiles Non-Targets GCMS (estimated conc.)								
1,1-Difluoroethane	ND	ND	ND	ND	ND	ND	0.000	0.000
C11-Alkanes	ND	ND	ND	ND	0.019	0.373	0.000	0.009
Volatiles Targets GCFID								
2-Propanol (Isopropanol)	0.005	0.005	NR	NR	0.006	0.006	0.012	0.012
Ethanol	0.000	0.000	NR	NR	0.001	0.001	0.001	0.001
Methanol	0.010	0.010	NR	NR	NR	NR	NR	NR
Octafluoropropane (Perfluoropropane)	ND	ND	0.000	0.000	ND	ND	ND	ND
Volatiles Targets TGA								
Carbon monoxide	0.022	0.082	0.088	0.325	0.018	0.067	0.028	0.104
Total T-Value	**0.1**	**0.1**	**0.1**	**0.3**	**0.4**	**1.0**	**0.1**	**0.2**

Comments: ND= Value is less than the laboratory reporting limit.
NR= Not Reported
AQ240115: Low Pressure: 3.4 psia
AQ240116: Low Pressure: 3.1 psia
AQ240117: Collected after 86P docking

Project Specific SMACs: 1,1-Difluoroethane: 7 and 180d-(2701mg/m3)
C11-Alkanes: 7d-(383mg/m3) and 180d-(19mg/m3)

TABLE S-3A: ANALYTICAL CONCENTRATIONS OF COMPOUNDS QUANTIFIED IN HOT AND AMBIENT POTABLE WATER RETURNED ON SPACEX-29 AND SPACEX-30

Increment					70		
Mission					SpX-29		SpX-30
Sample Location					WPA xPWD Hot	WPA PWD Ambient	WPA PWD Ambient
Sample Description		Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	Potable Water	Potable Water	Potable Water
Sample Date / Analysis/Sample ID	Units				11/7/2023 WQ240009	11/27/2023 WQ240010	4/2/2024 WQ240196
Physical Characteristics							
Conductivity	µS/cm	U.S.			2	< 1	< 1
pH	pH units	U.S.	4.5-8.5	41000	5.35	5.52	5.83
Iodine LCV							
Iodine	mg/L	U.S.	1.0-4.0	41000 (residual iodine in product water)	< 0.05	< 0.05	0.05
Total I	mg/L	U.S.	6/0.2	41000 (tl I max in product water/tl I at pt of consumption)	< 0.05	< 0.05	0.05
Minerals ICPMS							
Calcium	mg/L	U.S.	30	41000	0.06	0.01	0.02
Trace Metals ICPMS							
Boron	µg/L	U.S.			4	< 1	10
Chromium	µg/L	U.S.	230	41000	5	< 1	< 1
Copper	µg/L	U.S.	1,000	41000	5	< 1	< 1
Iron	µg/L	U.S.	300	41000	61	< 5	< 5
Manganese	µg/L	U.S.	300	SWEG&41000	40	< 1	< 1
Nickel	µg/L	U.S.	300	SWEG&41000	17	2	7
Zinc	µg/L	U.S.	2,000	SWEG&41000	1	< 1	< 1
Silicon ICPMS							
Silicon	µg/L	U.S.			239	424	1,050
Total Organic Carbon-Sievers							
Total Inorganic Carbon (TIC)	mg/L	U.S.			0.654	0.895	0.835
Total Organic Carbon (TOC)	mg/L	U.S.	5 / 3	SWEG / 41000	0.799	0.446	0.721
Semi-volatile Organics-Targets							
bis-(2-Ethylhexyl)adipate	µg/L	U.S.	400	EPA	116	75	< 20
Methyl sulfone	µg/L	U.S.	1,500,000	interim SWEG (06-2017)	69	111	149
Base and Neutral Extractables-EPA 625 List GCMS							
bis-(2-Ethylhexyl)phthalate	µg/L	U.S.	20,000/6	SWEG/EPA	1,690	< 40	< 20
Silanols LCRI (Semi-Quantitative-NIST traceable standard not available)							
Monomethylsilanetriol (MMST)	µg/L	U.S.	110,000	SWEG	< 1000	1,500	3,300
Aldehydes GCMS							
Formaldehyde (Methanal)	µg/L	U.S.	12,000	SWEG	34	< 10	< 10
Organic Carbon Recovery	percent	U.S.			173	61.1	63.7
Unaccounted Organic Carbon	mg/L	U.S.			0.00	0.170	0.260

Comments: NR= Not Reported NA=Not Analyzed

Data Qualifiers: **WQ240009&10-Data Qualifier-Nitrobenzene and Freon 12 (Dichlorodifluoromethane) - Possible low bias in volatiles analysis**

NA=Not analyzed
MI=Matrix Interference
N/A=Not applicable
#previously identified as bis(2-Chloroisopropyl) ether

TABLE S-3B: ANALYTICAL CONCENTRATIONS OF COMPOUNDS QUANTIFIED IN WASTEWATER AND US CONDENSATE WATER SAMPLES RETURNED ON SPACEX-29 AND CREW-7

Increment					70		
Mission					SpX-29	Crew-7	
Sample Location					WPA PWD Aux Port	WPA Wastewater ORU	WPA Condensate Sample Port
Sample Description					WPA Product Water	WPA Wastewater	US Condensate
Sample Date					12/1/2023	12/1/2023	11/29/2023
Analysis/Sample ID	Units	Test Conducted by	Potable Water Maximum Contaminant Level (MCL)	Maximum Contaminant Level Source	WQ240011	WQ240126	WQ240127
Physical Characteristics							
Conductivity	µS/cm	U.S.			< 1	90	118
pH	pH units	U.S.	4.5-8.5	41000	5.55	7.45	7.51
Iodine ICPMS							
Total I	mg/L	U.S.			NA	0.085	0.027
Iodine LCV							
Iodide	mg/L	U.S.			0.240	NA	NA
Iodine	mg/L	U.S.	1.0-4.0	41000 (residual iodine in product water)	1.83	NA	NA
Total I	mg/L	U.S.	6/0.2	41000 (tl I max in product water/tl I at pt of consumption)	2.07	NA	NA
Cations IC							
Ammonium (as N)	mg/L	U.S.	1	SWEG&41000	< 0.25	11.4	15.1
Minerals ICPMS							
Calcium	mg/L	U.S.	30	41000	0.01	0.03	0.02
Magnesium	mg/L	U.S.	50	41000	< 0.01	0.01	< 0.01
Phosphate (as P)	mg/L	U.S.			< 0.01	0.32	< 0.01
Potassium	mg/L	U.S.	340	41000	< 0.01	0.19	< 0.01
Sodium	mg/L	U.S.			< 0.01	0.20	< 0.01
Trace Metals ICPMS							
Aluminum	µg/L	U.S.			< 1	4	3
Boron	µg/L	U.S.			< 1	6	6
Chromium	µg/L	U.S.	230	41000	< 1	45	< 1
Manganese	µg/L	U.S.	300	SWEG&41000	< 1	< 1	1
Nickel	µg/L	U.S.	300	SWEG&41000	35	118	99
Silver	µg/L	U.S.	400	SWEG&41000	< 1	2	2
Zinc	µg/L	U.S.	2,000	SWEG&41000	< 1	1,440	1,830
Silicon ICPMS							
Silicon	µg/L	U.S.			619	510	659
Total Organic Carbon-Sievers							
Total Inorganic Carbon (TIC)	mg/L	U.S.			0.689	11.8	13.9
Total Organic Carbon (TOC)	mg/L	U.S.	5 / 3	SWEG / 41000	0.420	4.51	20.8
Volatile Organics-Targets							
Semi-volatile Organics-Targets							
Methyl sulfone	µg/L	U.S.	1,500,000	interim SWEG (06-2017)	76	20	< 20
Base and Neutral Extractables-EPA 625 List GCMS							
Alcohols & Acetone GCMS							
2-Propanol (Isopropanol)	µg/L	U.S.			< 400	< 400	1,610
Acetone	µg/L	U.S.	15,000	SWEG	See Volatiles	See Volatiles	5,930
Ethanol	µg/L	U.S.			< 400	< 400	27,200
Methanol	µg/L	U.S.	40,000	SWEG	< 400	< 400	7,880
Silanols LCRI (Semi-Quantitative-NIST traceable standard not available)							
Dimethylsilanediol (DMSD)	µg/L	U.S.	35,000	SWEG	< 1000	1,100	1,400
Monomethylsilanetriol (MMST)	µg/L	U.S.	110,000	SWEG	2,500	< 1000	< 1000
Aldehydes GCMS							
Formaldehyde (Methanal)	µg/L	U.S.	12,000	SWEG	< 10	< 10	24
Organic Carbon Recovery	percent	U.S.			80.5	6.47	107
Unaccounted Organic Carbon	mg/L	U.S.			0.080	4.22	0.00

Comments: NR= Not Reported NA=Not Analyzed **WQ240011 is noted to have a slight leak in the bag.**

Data Qualifiers: WQ240011-Data Qualifier-Nitrobenzene and Freon 12 (Dichlorodifluoromethane) - Possible low bias in volatiles analysis

WQ240126-Matrix Interference: Possible low bias of all B/N analytes