ISS Expeditions 16 thru 20: Chemical Analysis Results for Potable Water

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Presentation

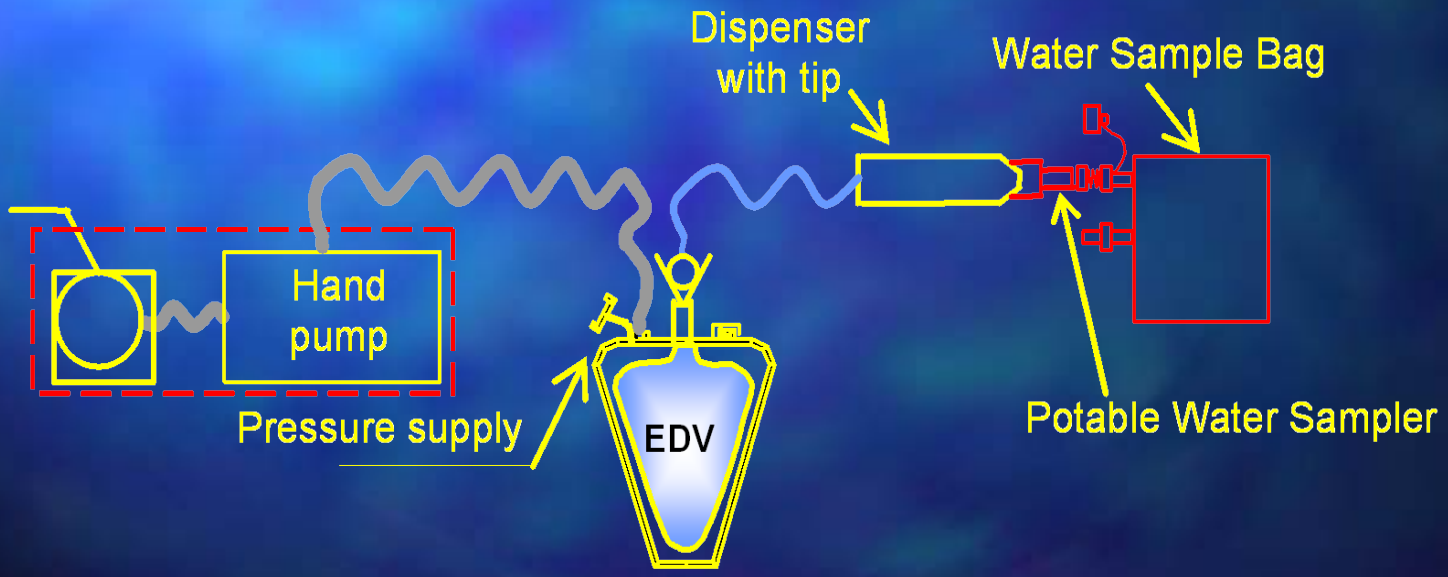
- Background:
  - ISS Potable Water Systems
  - Water Quality Requirements
- Expeditions 16 through 20:
  - Returned Sample Summary
  - Sample Handling & Analysis
  - SRV-K Samples Analytical Results
  - SVO-ZV Samples Analytical Results
  - WPA and PWD Samples Analytical Results
- Conclusion
- Recommendations

Russian Segment Potable Water Systems

- Stored potable water system (SVO-ZV) provides crew access to following sources:
  - Russian ground-supplied potable water
    - → Launched on Progress in Rodnik tanks (210-liter)
  - Shuttle-transferred potable water
    - → Fuel cell water is first deiodinated
    - → Mineralized with formate salts (Ca & Mg)
    - → Transferred to ISS in contingency water containers (CWC's)

SVO-ZV Stored Potable Water System

- Rodnik or CWC potable water is transferred to a 22-liter EDV tank
- Hand pump provides pressure to EDV bladder
- Crews can access water at ambient temperature from the SVO-ZV dispenser

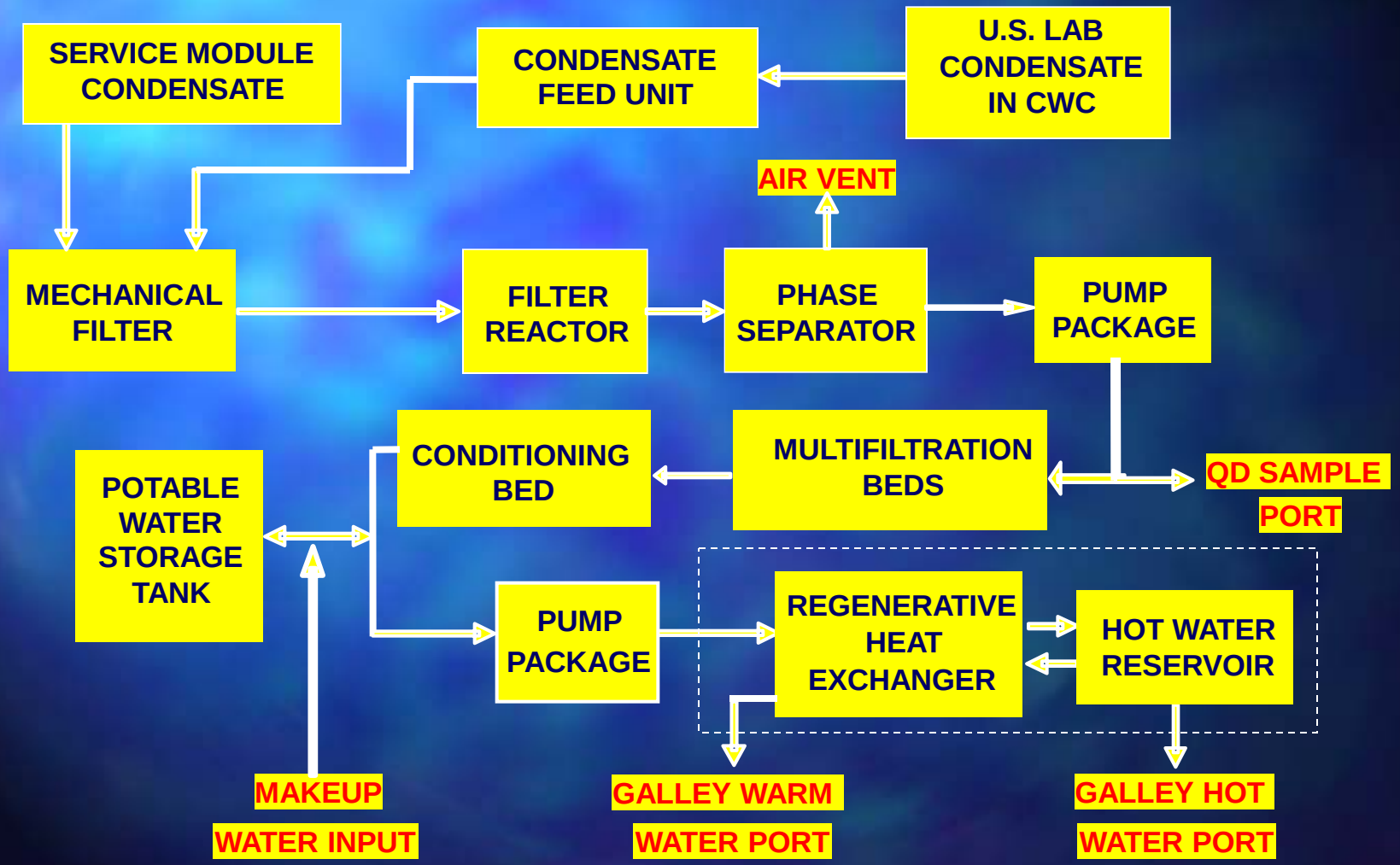


Water Sampling from SVO-ZV

Russian Segment Potable Water Systems

- Condensate H_2O recovery system (SRV-K):
  - Processes humidity condensate direct from Russian Service Module air conditioning unit
  - U.S. Lab condensate in CWC can be processed using Condensate Feed Unit (CFU)
  - Container of Rodnik or CWC potable water can be hooked for use as makeup water to supplement product water

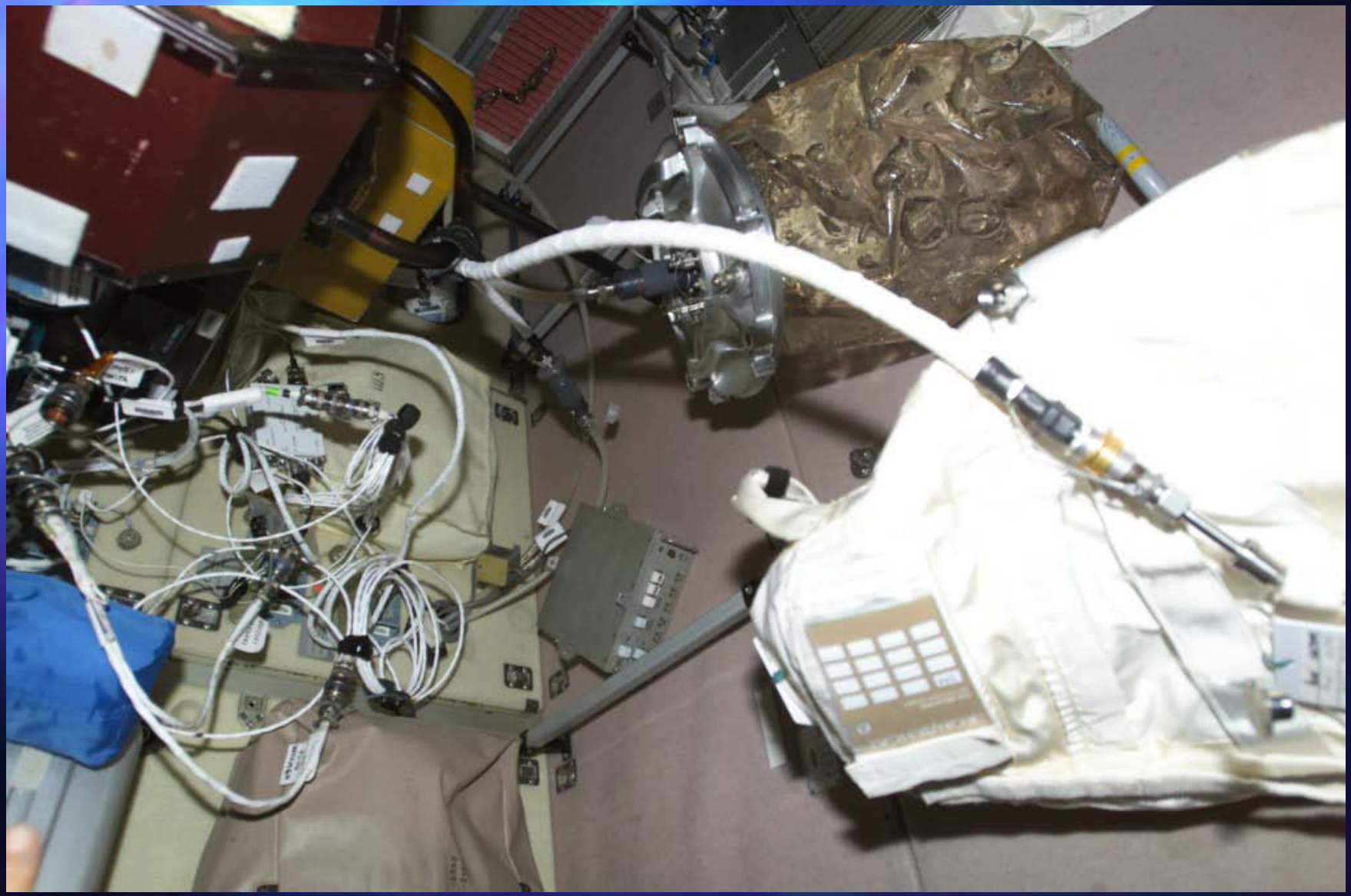
SRV-K Condensate H_2O Recovery System



SRV-K Process Description

- Receives humidity condensate direct from Service Module cabin air heat exchanger
- Condensate Feed Unit (CFU) for processing US Lab condensate from CWC
- Filter reactor:
  - Oxidizes alcohols, glycols, polar organics to organic acids and CO_2 using 2-phase flow to supply oxygen
- Gas/liquid separator
- Multifiltration treatment beds:
  - Ion exchange resins and activated carbon
- Conditioning bed:
  - Adds biocidal silver & minerals (Ca, Mg, & F) for taste
- 10-liter storage tank (КЛВ) upstream of galley
- Galley:
  - Pasteurizing tank (525 mL)
  - Hot and warm dispensing ports

SRV-K Condensate Feed & Makeup Water

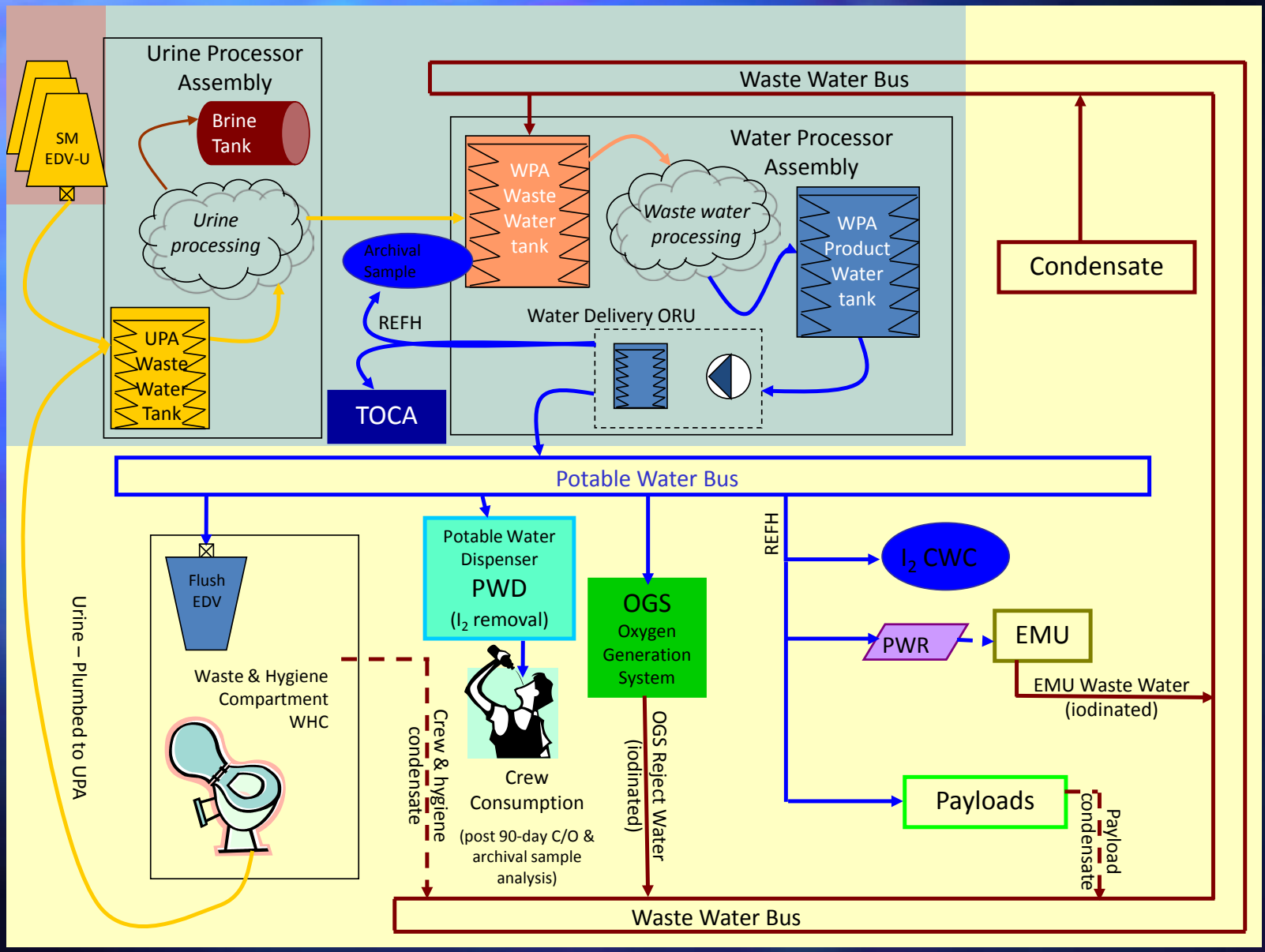


Water Sampling from SRV-K Galley

US Segment Potable Water System

- **Water Recovery System (WRS):**
  - Urine Processor Assembly (UPA) processes pretreated urine by distillation and delivers distillate to a wastewater tank where it is combined with humidity condensate.
  - Water Processor Assembly (WPA) processes the combined wastewater to potable water using multifiltration and thermal catalytic oxidation, adds iodine biocide, and stores product water for delivery to the potable water bus.
  - The Potable Water Dispenser (PWD) receives WPA product water direct from the bus and dispenses either hot or ambient water after removing iodine at the point of use.
  - The UPA, WPA, PWD, and Total Organic Carbon Analyzer (TOCA) were delivered in November 2008 and a 90-day checkout of the integrated water system was completed before approval for consumption was given in May 2009.

US Segment Potable Water System



Sampling at Potable Water Dispenser (PWD)

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ISS Water Quality Requirements

- The ISS Program has established a water quality and monitoring program for regenerated and stored potable water
- System Specification for ISS, SSP 41000, specifies water quality requirements for US potable water
- ISS Medical Operations Requirements Document (MORD) specifies:
  - Water quality requirements for RS potable water sources and Shuttle-transferred water
  - Archival water sampling schedules:
    - → Monthly from SRV-K port (alternating Hot & Warm)
    - → Monthly from SVO-ZV port
    - → Monthly from PWD ports (alternating Hot & Ambient)

Expeditions 16-20 Returned Samples

- **Expedition 16:** *7 samples*
  - SRV-K hot: 2/26/08
  - SRV-K warm: 11/30/07, 1/8/08, 2/4/08
  - SVO-ZV: 11/30/07, 1/8/08, 2/26/08

  →5 returned on STS-122/1E; 2 on STS-123/1JA

- **Expedition 17:** *10 samples*
  - SRV-K hot: 4/16/08, 5/30/08, 8/27/08
  - SRV-K warm: 4/13/08, 4/16/08, 8/27/08
  - SVO-ZV: 4/13/08, 4/16/08, 5/30/08, 10/21/08

  →3 returned on Soyuz 15; 4 on STS-124/1J; 3 on Soyuz 16

Expeditions 16-20 Returned Samples

- **Expedition 18:** *42 samples*
  - SRV-K hot: 7/25/08, 10/8/08, 12/16/08, 2/19/09
  - SRV-K warm: 7/2/08, 9/1/08, 11/11/08, 1/12/09
  - SVO-ZV: 7/2/08, 7/25/08, 9/1/08, 10/8/08, 11/11/08, 12/16/08, 1/12/09, 2/19/09, 4/5/09
  - PWD Aux: 11/26/08, 3/25/09
  - PWD Ambient: 1/2/09, 1/14/09, 1/21/09, 1/30/09, 3/18/09, 3/25/09, 4/2/09
  - PWD Hot: 12/12/08, 12/19/08, 12/29/08, 1/30/09, 3/23/09
  - WPA RIP: 11/22/08, 11/25/08, 11/26/08 (2), 12/8/08, 2/9/09, 2/27/09, 3/10/09, 3/25/09 (2), 4/2/09

  →15 returned on STS-126/ULF2; 24 on STS-119/15A; 3 on Soyuz 17

Expeditions 16-20 Returned Samples

- **Expedition 20:** ***21 samples***
  - SRV-K hot: 5/4/09, 7/22/09
  - SRV-K warm: 4/9/09, 7/7/09, 8/4/09
  - SVO-ZV: 4/9/09, 5/4/09, 7/7/09, 7/22/09, 8/4/09, 9/22/09
  - PWD Ambient: 4/15/09, 5/4/09, 6/16/09, 7/24/09, 8/4/09, 9/22/09
  - PWD Hot: 6/16/09, 7/24/09, 8/4/09, 9/22/09

  →14 returned on STS-127/2JA; 4 on STS-128/17A; 3 on Soyuz 18

Sample Handling & Analysis

- Samples returned on Soyuz were received by the Russian side and the U.S. portions flown back to Houston on a NASA jet using coolers with ice packs.
- Samples returned on Shuttle were received by a Water and Food Analytical Laboratory (WAFAL) representative after the Shuttle landed, placed into coolers with ice packs, and hand-carried back to Houston on commercial airliners.
- Chemical analyses were performed at Johnson Space Center's WAFAL using a combination of standard and custom analytical methods

Analytical Methods for Inorganics

Parameter	Method
pH & conductivity	Potentiometric
Total Dissolved Solids	Gravimetric
Turbidity	Nephelometric
Iodine & iodide	Leuco crystal violet (LCV)
Fluoride	Ion selective electrode (ISE)
Inorganic anions & cations	Ion chromatography (IC)
Metals/Minerals	Inductively coupled plasma-mass spectrometry (ICP/MS)

Analytical Methods for Organics

Parameter	Method
Total organic carbon (TOC)	Ultraviolet or heated persulfate oxidation
Alcohols & glycols	Direct Injection gas chromatography /mass spectrometry (GC/MS)
Volatile organics	GC/MS with purge & trap concentrator (EPA method 524.2)
Semi-volatile organics	GC/MS after liquid/liquid extraction (modified EPA method 625)
Organic acids & amines	Capillary electrophoresis (CE)
Urea/Caprolactam	Liquid chromatography (LC) with UV diode array detector
Formaldehyde	GC/MS after derivatization & extraction

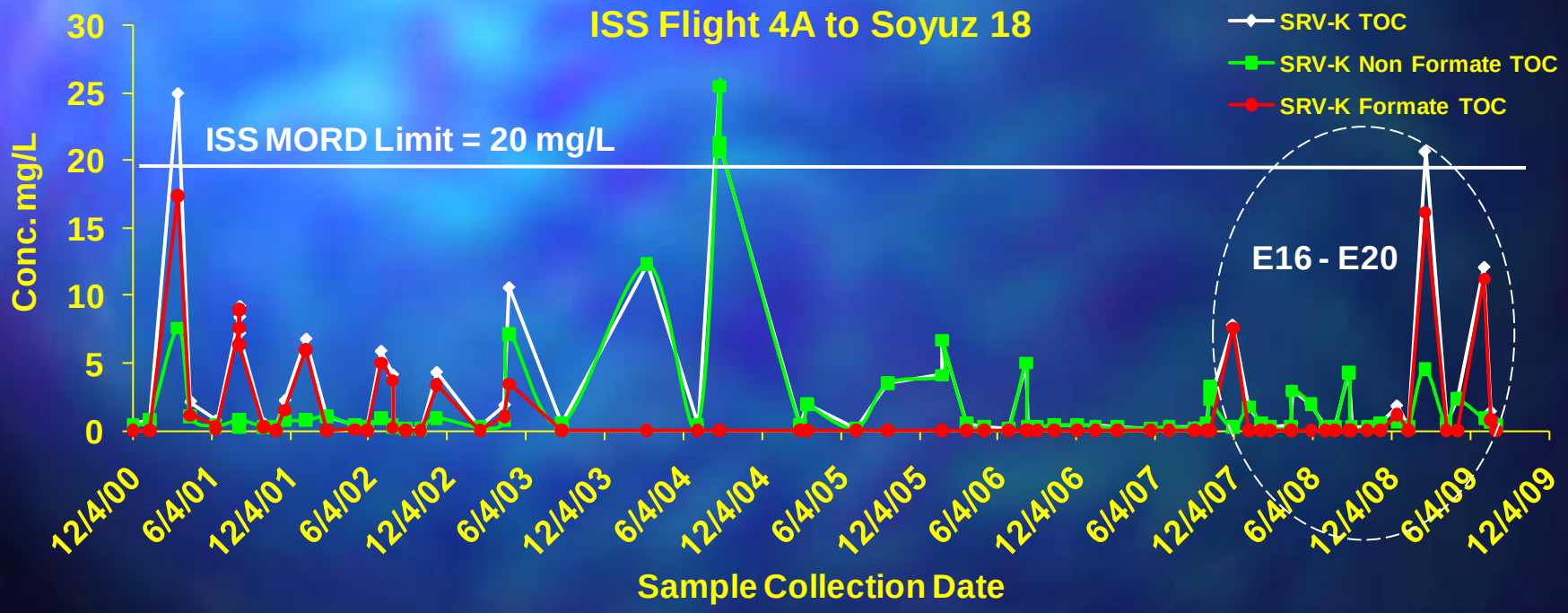
Expeditions 16-20 SRV-K Sample Results
(23 Samples)

Met all ISS MORD requirements except for manganese & total silver:

- **Manganese: <1 to 139 µg/L *(50 µg/L MORD)***
  - ***Well below 1000-d SWEG of 300 µg/L***
- **Total silver: 7 – 895 µg/L *(500 µg/L MORD)***
  - ***High level in 1 sample is likely Rodnik water***
- **TOC: 0.25 to 20.7 mg/L *(20 mg/L MORD limit)***
  - ***All non-formate TOC levels below MORD***
- **Formate: 4.36 to 61.8 mg/L *(5 samples)***
  - ***Shuttle water used as makeup***
- **Nickel: 8 to 101 µg/L *(100 µg/L MORD)***

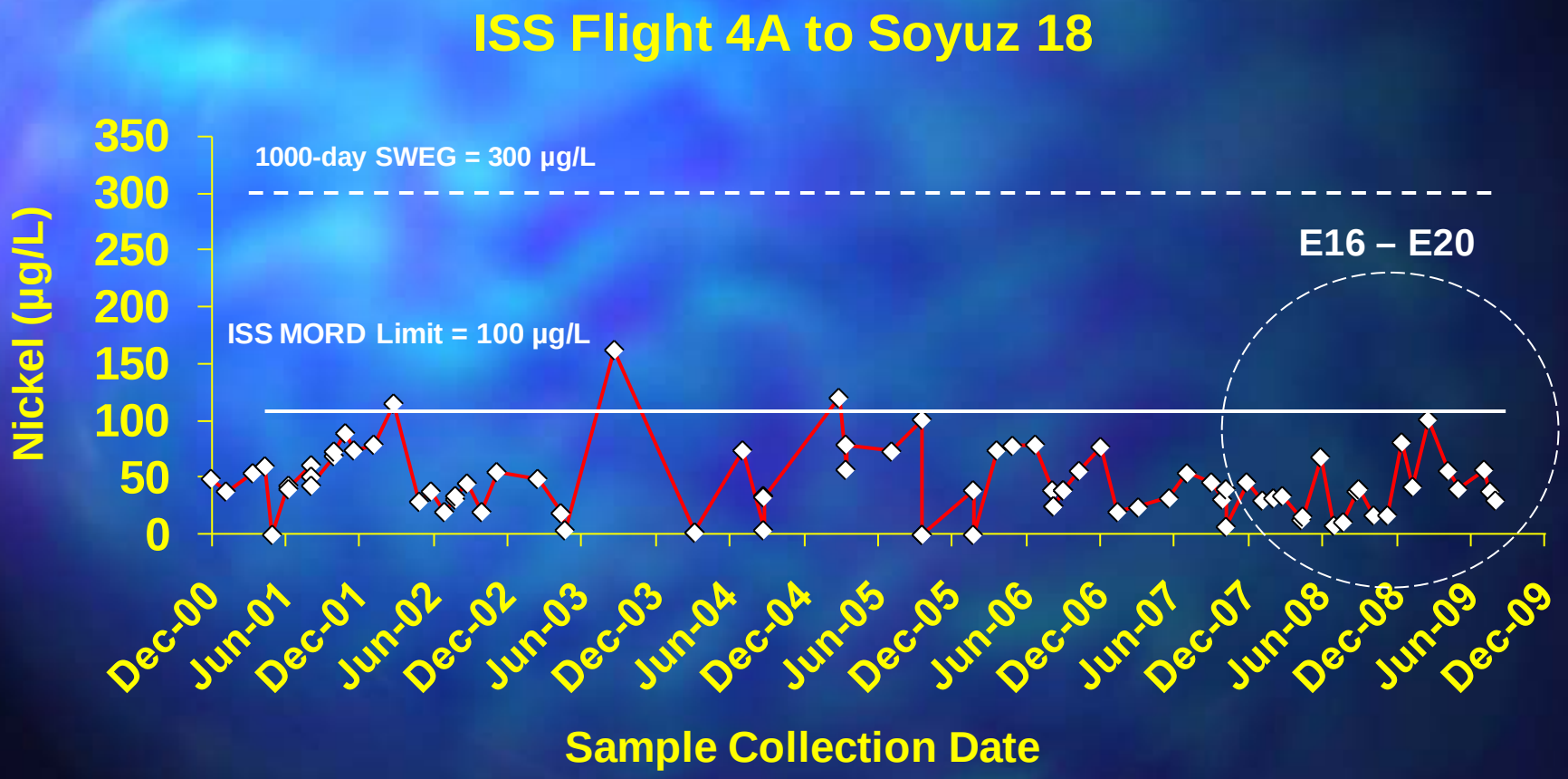
Total & Non-Formate Organic Carbon in SRV-K Water Samples

- TOC below MORD limit for Expeditions 16 through 20



Nickel Levels in SRV-K Water Samples

- Nickel levels for E16 - E20 all below ISS MORD limit



Expeditions 16-20 SVO-ZV Sample Results

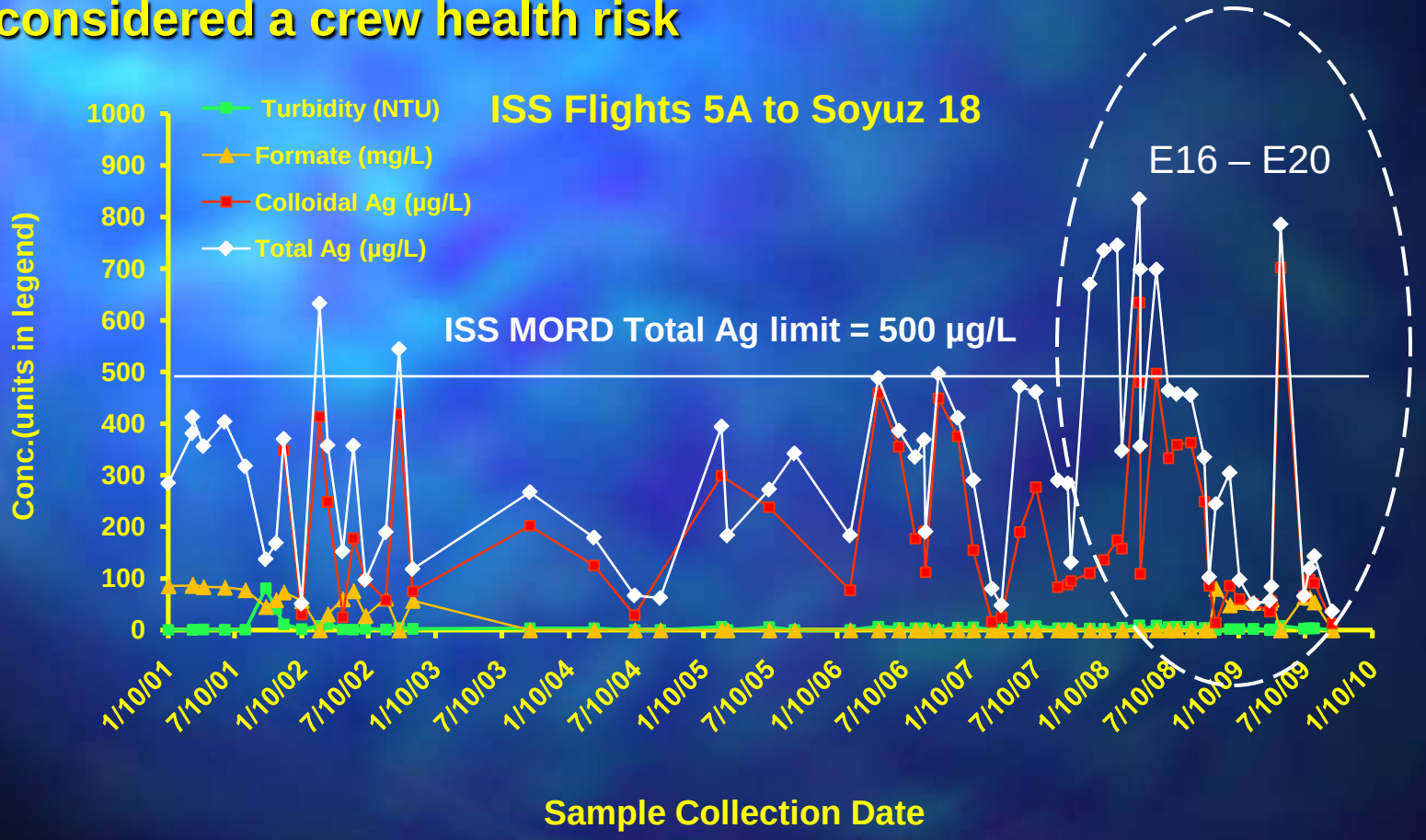
(22 Samples)

Met all ISS MORD quality requirements except for turbidity, manganese, and total silver:

- **Turbidity: 0.2 to 9.5 NTU *(1.5 NTU MORD)***
  - ***Elevated turbidity not a direct crew health risk***
- **Manganese: 2 to 148 µg/L *(50 µg/L MORD)***
  - ***Well below 1000-d SWEG of 300 µg/L***
- **Total silver: 36 to 834 µg/L *(500 µg/L MORD)***
  - ***High levels likely from Rodnik water as source***
- **TOC: 0.32 – 22.9 mg/L *(20 mg/L MORD limit)***
  - ***All non-formate TOC levels below MORD***
- **Formate: 48.6 to 80.6 mg/L *(9 samples)***
  - ***Shuttle water used as makeup***

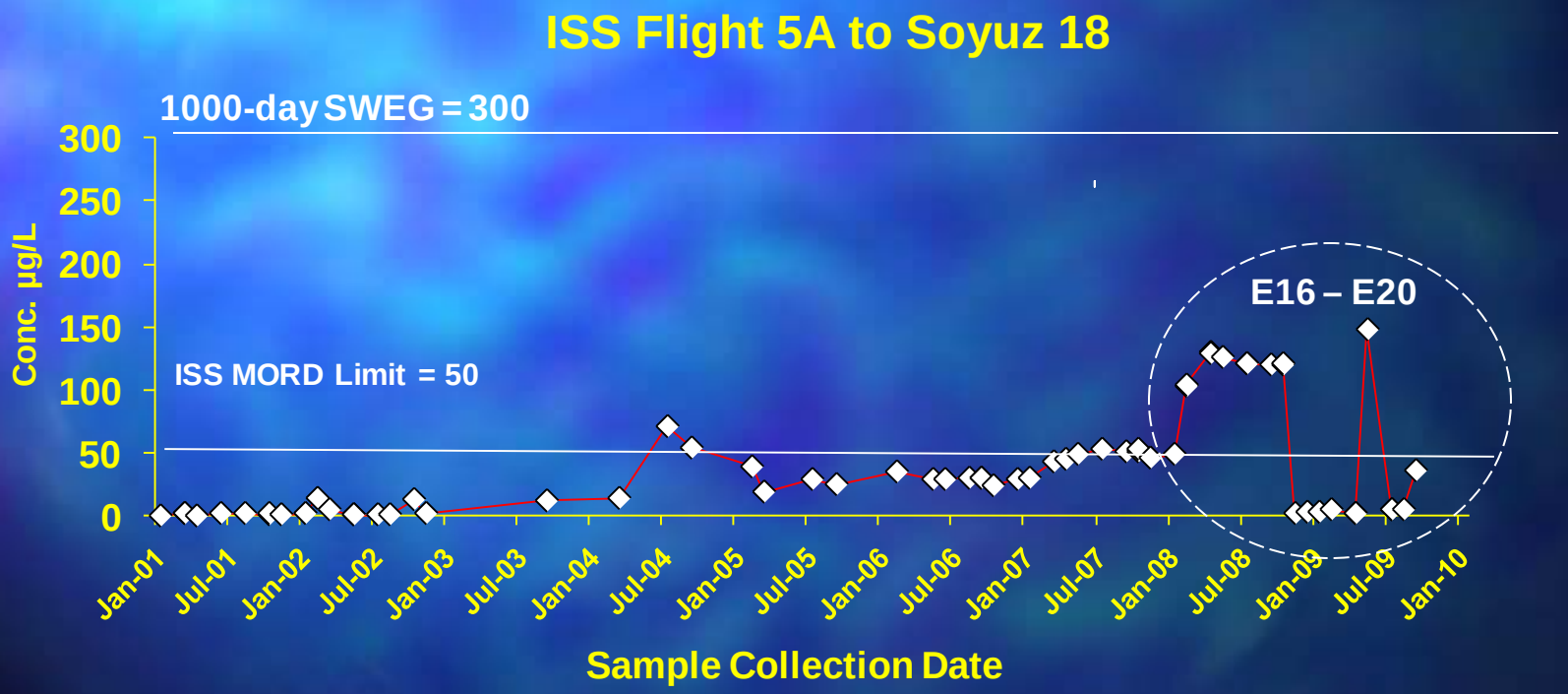
Turbidity, Formate, and Silver in SVO-ZV Water Samples

- Some E16 - E20 results exceeded the ISS MORD Total Ag limit
- Many results continued to exceed ISS turbidity limit but not considered a crew health risk



Manganese in SVO-ZV Water Samples

- Many E16 – E20 samples exceeded ISS MORD limit
- Not a crew health risk since well below 300 µg/L SWEG



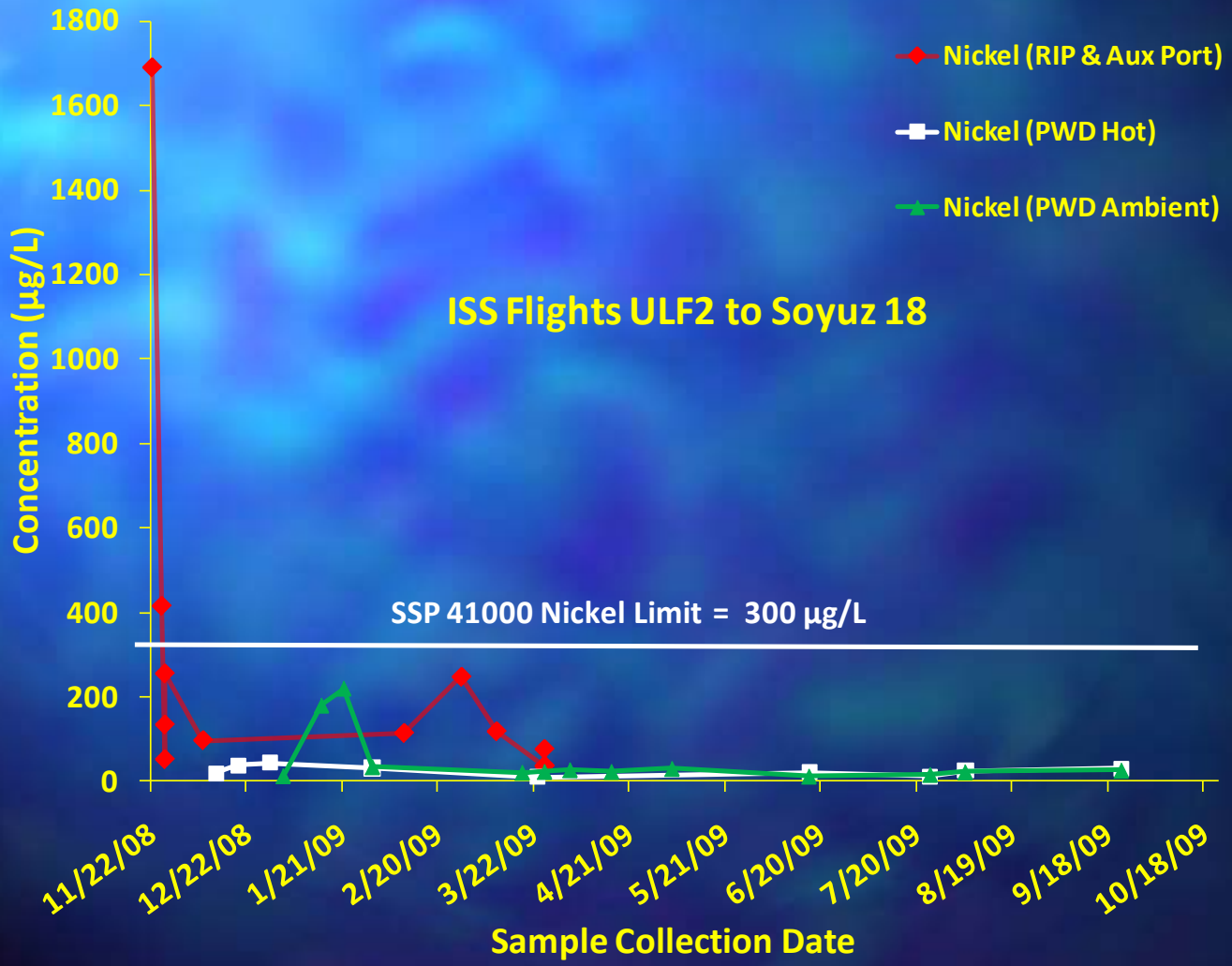
Expeditions 18-20 US Potable Water Samples
(35 samples)

All ISS quality requirements met except for nickel, total iodine, and turbidity:

- **Nickel: 11 to 1690 µg/L *(300 µg/L SSP 41000)***
  - ***High levels in 2 early RIP samples from stagnant pre-launch water***
- **Total I (at PWD needle): <0.05 to 10.9 µg/L *(0.2 mg/L SSP 41000)***
  - ***High levels from iodine flushing needed to recover microbial control***
- **Turbidity: <0.1 to 1.3 NTU *(1.0 NTU limit SSP 41000)***
  - ***Elevated turbidity not a direct health risk***
- **TOC: 0.07 to 1.2 mg/L *(3 mg/L SSP 41000)***
- **Iron: <5 to 261 µg/L *(300 µg/L SSP 41000)***

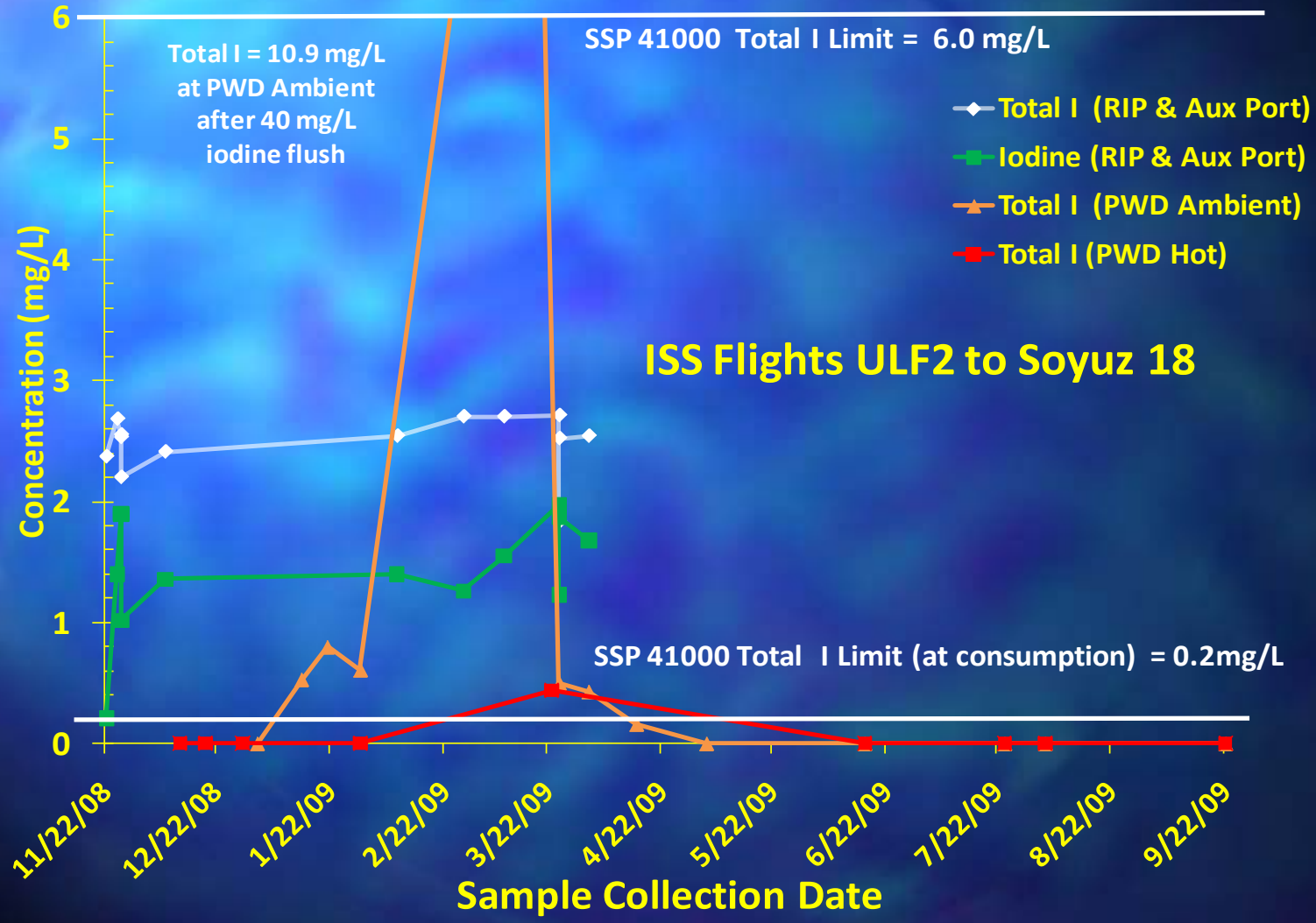
Nickel in US Potable Water Samples

- PWD Nickel levels for E16 - 20 all below SSP 41000 limit
- High Ni in early RIP samples from stagnant pre-launch H_2O



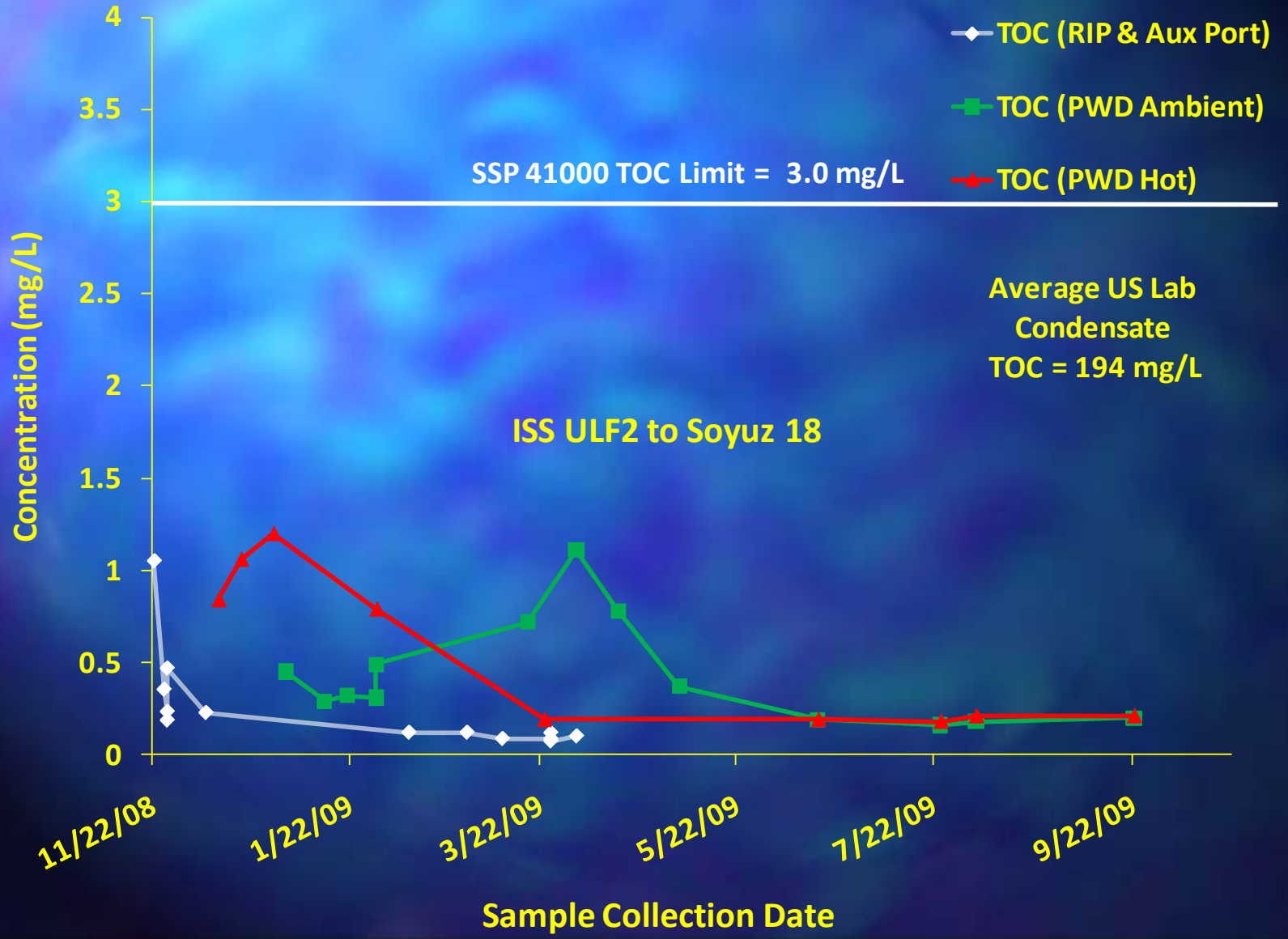
Total I and I_2 in US Potable H_2O Samples

- Performed 40 mg/L iodine flush of PWD lines on 3/17/09



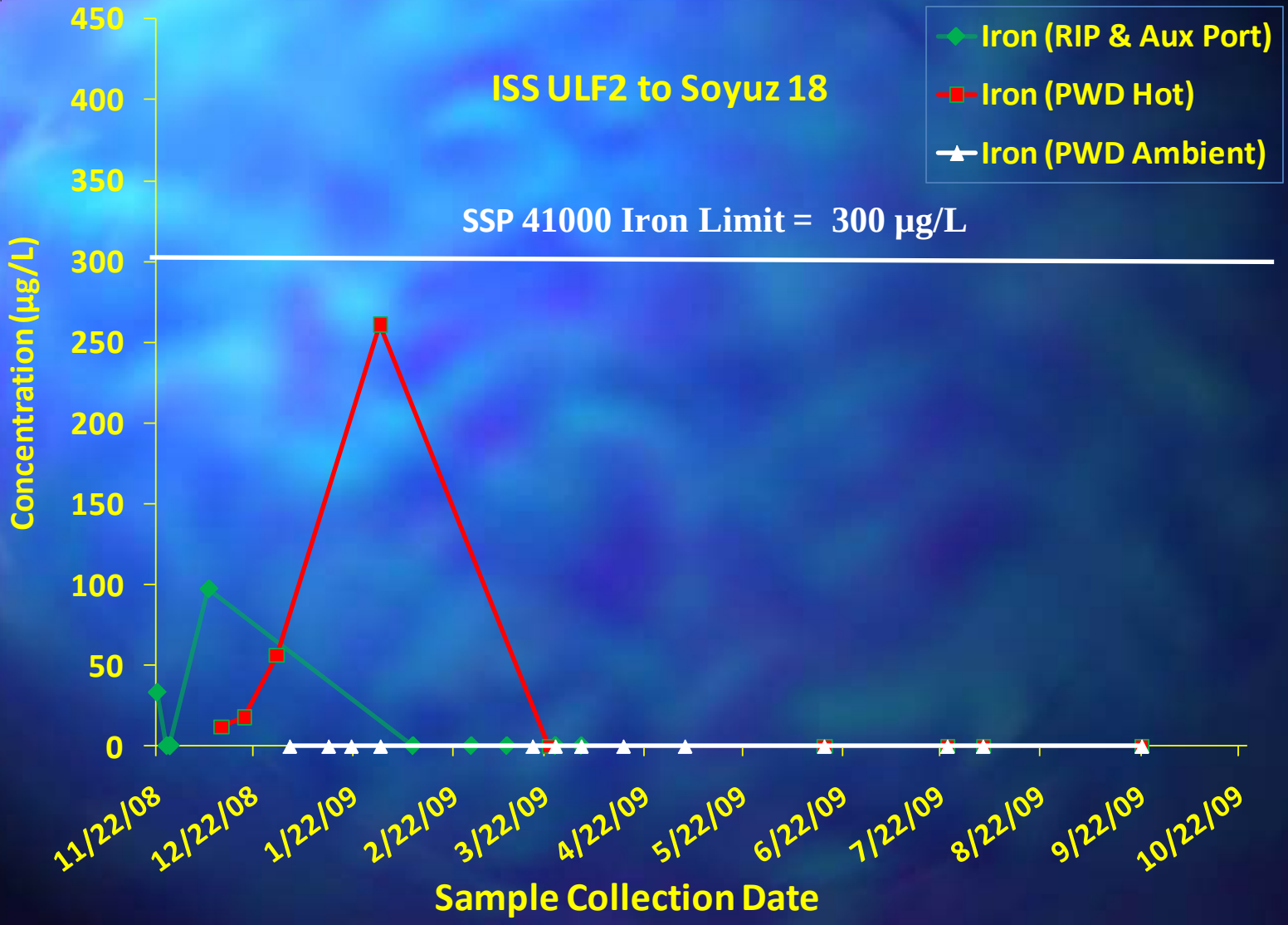
TOC in US Potable H_2O Samples

- TOC levels for E16 - E20 samples were all below ISS limit



Iron in US Potable H_2O Samples

- Iron levels for E16 - E20 samples were all below ISS limit



Conclusion

- Chemical analysis results for Expeditions 16-20 archival water samples collected from SRV-K, SVO-ZV, RIP, and PWD indicate that all of the ISS potable water supplies were acceptable for crew consumption.

Recommendations

- Continue discussions with Russian side to ensure that pre-launch Rodnik water silver levels are no higher than the limit of 500 µg/L
- Continue investigating cause of elevated turbidity in SVO-ZV water
  - Turbidity is a measure of particulates
  - Bacteria can attach to particulates shielding them from disinfectants leading to increased risk of consuming contaminated water
- Continue monitoring manganese, turbidity, total silver, and bacterial count in SVO-ZV, SRV-K, and Rodnik water
- Continue to monitor total iodine, metals, and bacterial count in PWD water

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