



Accelerated Deployment and Startup of Ion Exchange Groundwater Treatment System Addresses PFAS Contamination at Australian Air Base

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- This map illustrates the strategic distribution of the Australian Defence Force across the continent. Key locations include:
- Perth:** RAAF Base Leeming, NAVCOMMS TA Harold E Holt (Eremauth), Campbell Barracks (Swanbourne), RAAF Base Pearce (Bullfinch), HMAS Stirling (Rockingham), Lancelin Training Area.
 - South Australia:** Joint Defence Facility, Pine Gap (Alice Springs), Liquefied Natural Gas Plant (Dampier), Defence Establishment (Woomera), Cullina Training Area.
 - Adelaide:** RAAF Base (Edinburgh), Puckapunyal Military Base (Puckapunyal), RAAF Base Williams (Laverton), HMAS Cerberus (Crib Point).
 - Canberra:** Army Aviation Centre (Oakley), Bonree Barracks (Darling Downs), RAAF Base (Richmond), Blarney Barracks (Kapooka), RAAF Base (Wagga Wagga).
 - Sydney:** RAAF Base (Amberley), Gellipool Barracks (Enggore), Lone Pine Barracks (Singleton), RAAF Base Williamtown (Newcastle), Holsworthy Barracks (Holsworthy), Garden Island (Potts Point), HMAS Albatross (Nowra).
 - Melbourne:** RAAF Base (East Sale), Angelsea Barracks (Hobart).
 - Other locations:** Christmas Island, Ashmore and Cartier Islands, East Timor, Sunrise Oil & Gas Fields, Bayu/Undan Oil & Gas, North West Shelf Area Oil & Gas, Gorgon Oil & Gas Fields, RAAF Base (Leeming), NAVCOMMS TA Harold E Holt (Eremauth), Australian Defence Satellite Communications Station (Geraldton), Defence Establishment (Woomera), Cullina Training Area, RAAF Base (Edinburgh), Puckapunyal Military Base (Puckapunyal), RAAF Base Williams (Laverton), HMAS Cerberus (Crib Point), RAAF Base (Richmond), Blarney Barracks (Kapooka), RAAF Base (Wagga Wagga), RAAF Base (Amberley), Gellipool Barracks (Enggore), Lone Pine Barracks (Singleton), RAAF Base Williamtown (Newcastle), Holsworthy Barracks (Holsworthy), Garden Island (Potts Point), HMAS Albatross (Nowra), RAAF Base (East Sale), Angelsea Barracks (Hobart).

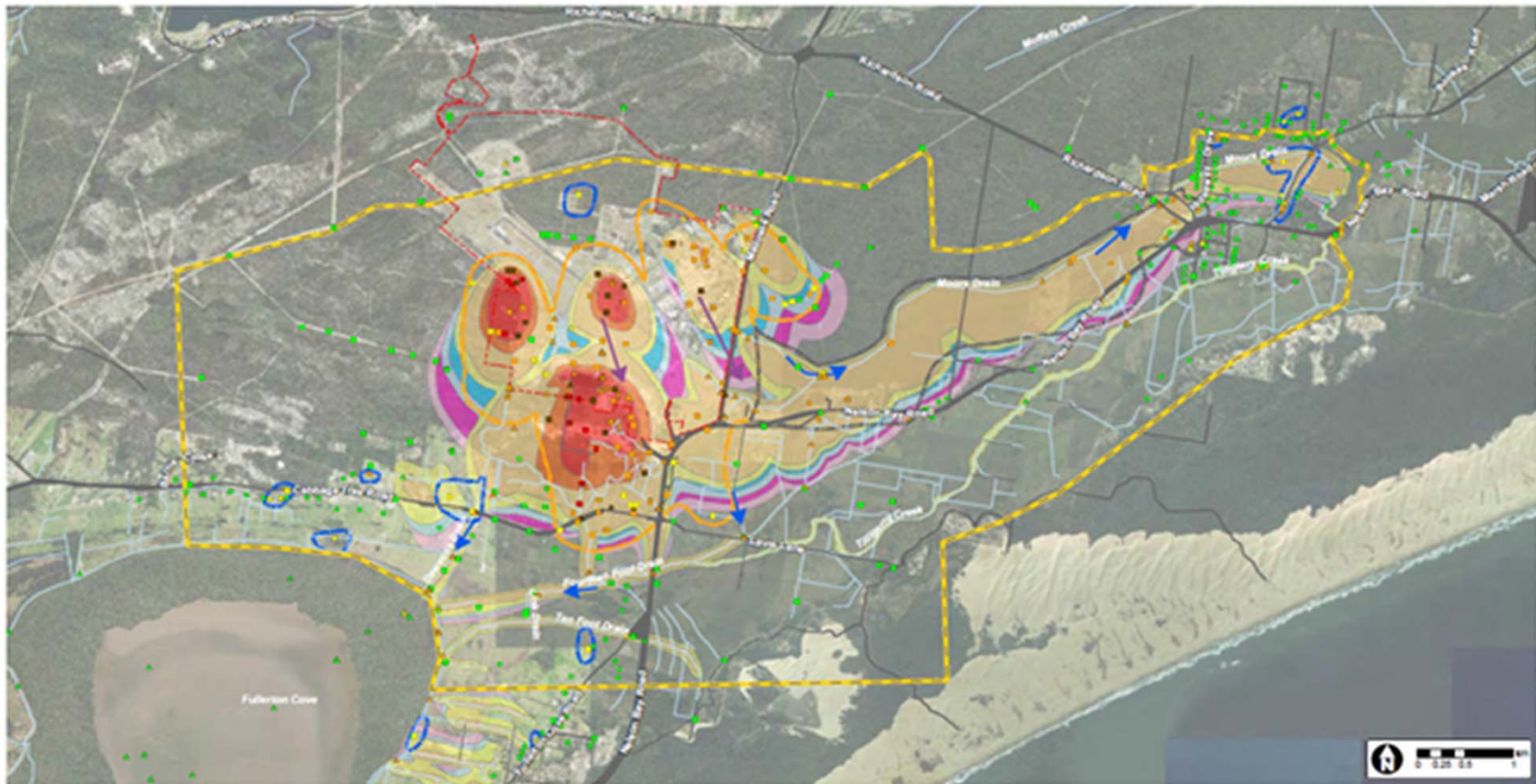
Significant Australian Defence Force Bases

Background



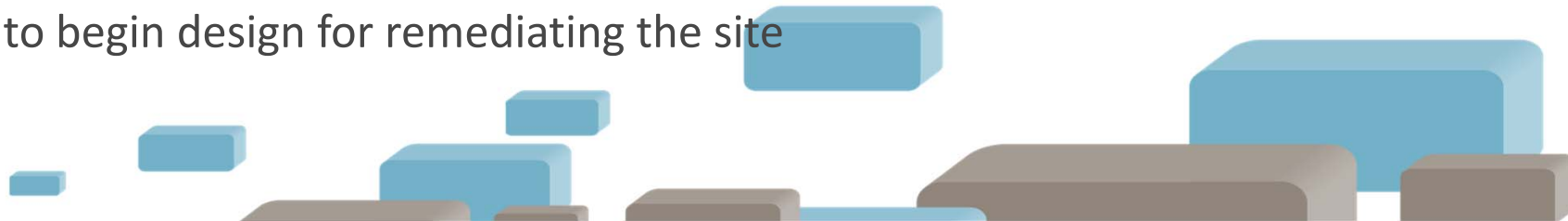
- RAAF Base Williamtown: historical AFFF use
- Resulted in PFAS contamination
 - Groundwater
 - Stormwater
- Both migrate off base
- Defence has defined nature and extent of PFAS contamination

PFAS contamination

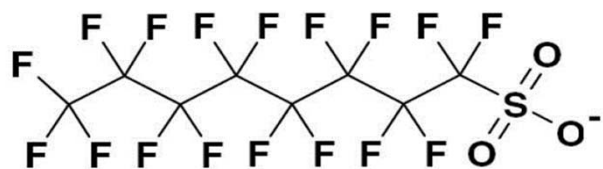


Objectives

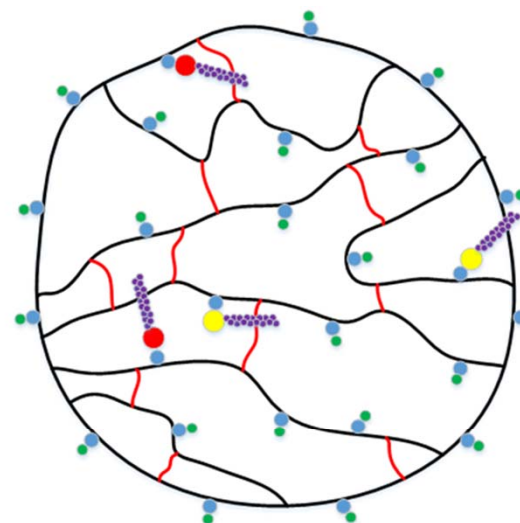
- Phased approach to manage PFAS contamination
 - Phase 1: Moors Drain stormwater
 - Phase 2: Groundwater flowing off base to the south
- Expedited approach
 - Design
 - Fabrication
 - Overseas transport
 - Startup & commissioning
- Defence retained Emerging Compounds Treatment Technologies (ECT2) in March 2017 to begin design for remediating the site



Dual mechanism of removal: ion exchange (IX) and adsorption



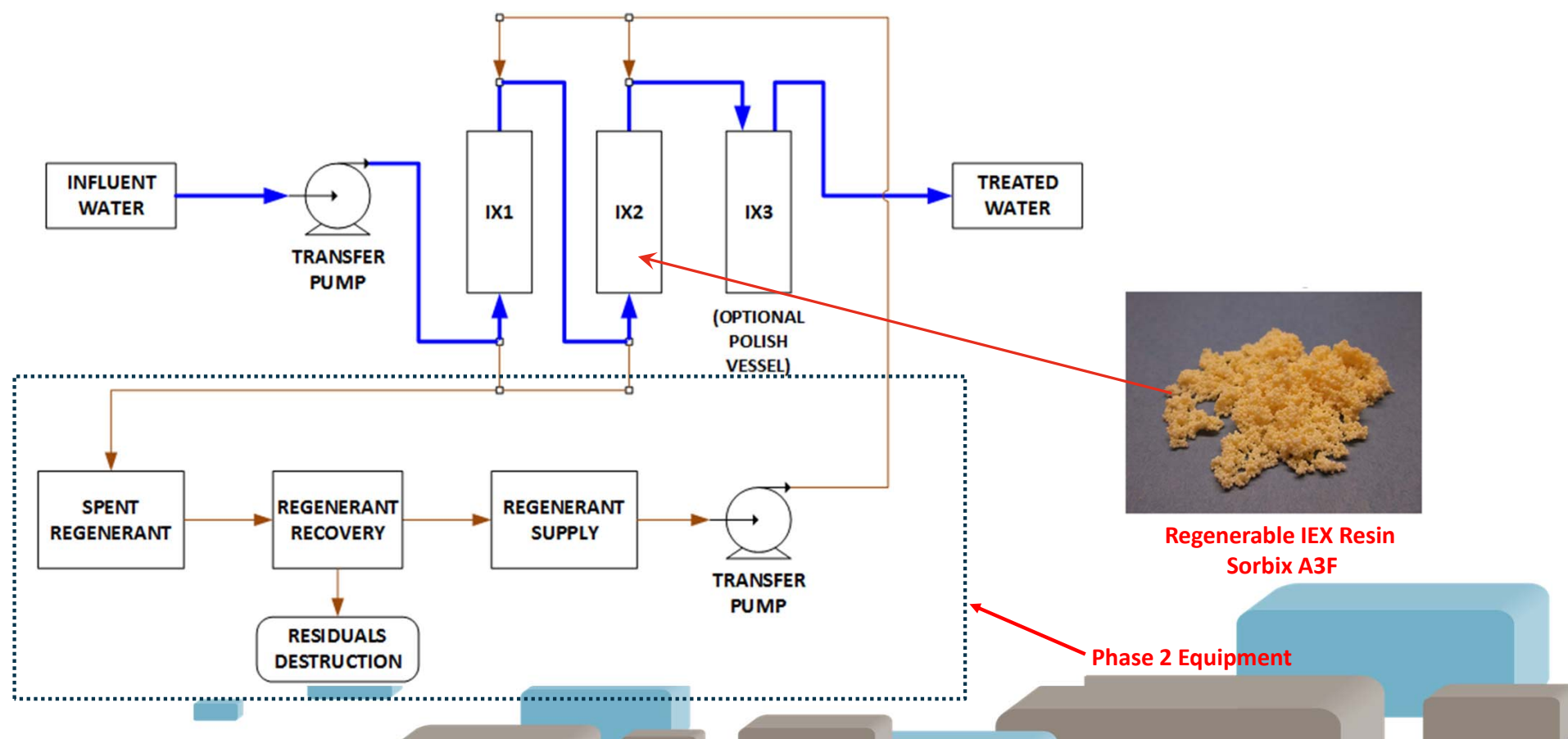
PFOS Molecule



Simplified Resin Bead

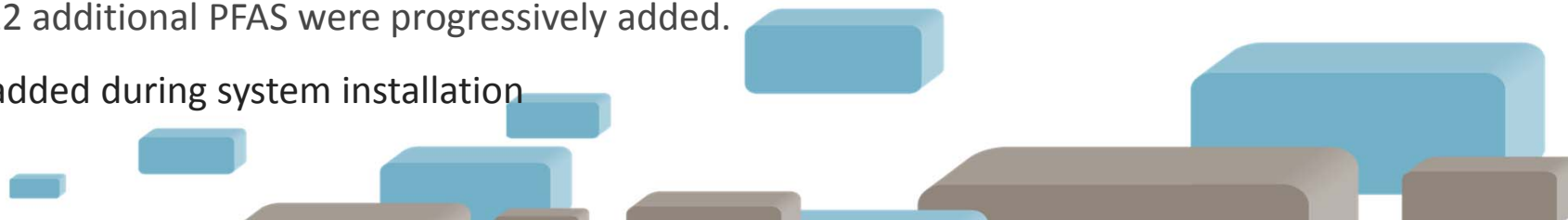
-  Polystyrene polymer chain
-  Divinylbenzene crosslink
-  Fixed ion exchange group, e.g., quaternary ammonium, $-\text{N}^+$, for anion IEX
-  Exchangeable counter ion, e.g., chloride ion, Cl^- , for anion IEX
-  Sulfonate group, $-\text{SO}_3^-$, of PFAS (e.g., PFOS), replacing exchangeable counter ion
-  Carboxylate group, $-\text{CO}_2^-$, of PFAS (e.g., PFOA), replacing exchangeable counter ion
-  PFAS carbon-fluorine tail adsorbing to polystyrene polymer chain or divinylbenzene crosslink via Van der Waals forces

How does IX resin remove PFAS?



Evolving regulations and treatment goals

- Influent PFAS concentration around 7 µg/l
- Effluent goal became a moving target
- Original PFAS limits for treatment system design:
 - PFOS + PFHxS < 0.5 µg/l
 - PFOA < 5.0 µg/l
- During system fabrication, Australia/New Zealand drinking water guidelines dropped limits to:
 - PFOS + PFHxS < 0.07 µg/l
 - PFOA < 0.56 µg/l
- Defence asked ECT if we could demonstrate < **Limit of Reporting (LOR)** for all 22 monitored PFAS compounds. 12 additional PFAS were progressively added.
- Polish vessels added during system installation



Expedited overseas transport



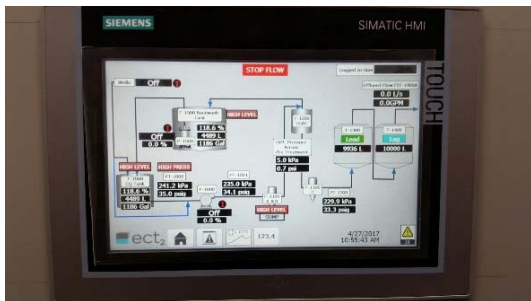
Quick path to on-site commissioning

2017

- **March 4:** Contract signed
- **May 12 :** System fabrication complete
- **May 25 :** Loaded onto C-17 transport plane in Chicopee, Massachusetts
- **May 31:** Unit set in place at RAAF Base Williamtown
- **June 26:** Operation commences
- **July 17:** Commissioning complete



Inside the box



LOR Values for individual PFAS (ppb)

Perfluoroalkyl carboxylic acids		
PFCA	Standard	Ultra Trace
PFBA	0.05	0.005
PFPeA	0.01	0.001
PFHxA	0.01	0.001
PFHpA	0.01	0.001
PFOA	0.01	0.001
PFNA	0.01	0.001
PFDA	0.01	0.001
PFUnA	0.01	0.001
PFDoA	0.01	0.001
PFTTrDA	0.01	0.001
PFTeDA	0.01	0.001

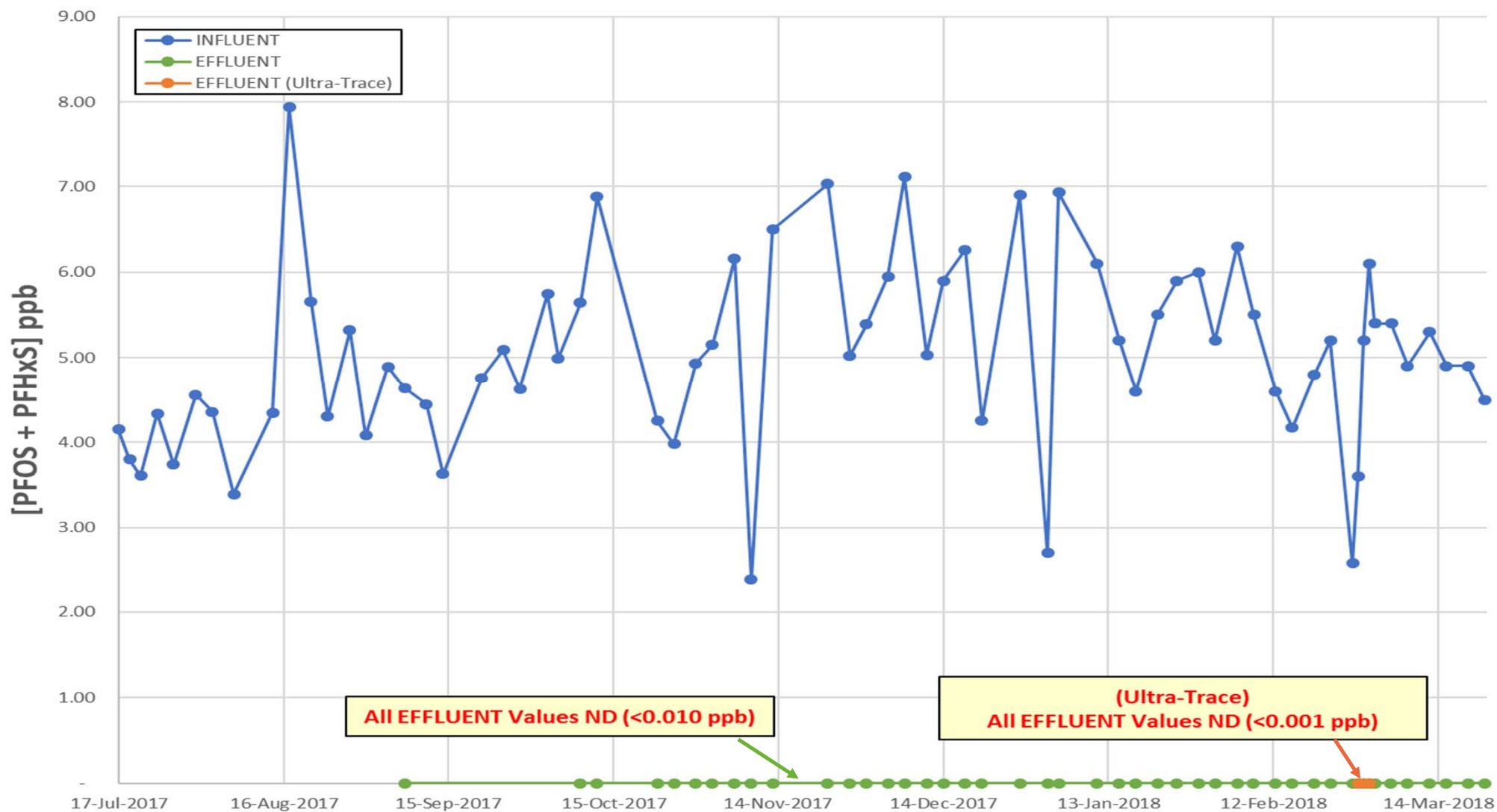
Perfluoroalkane sulfonamides		
PFASA	Standard	Ultra Trace
FOSA	0.05	0.005
N-MeFOSA	0.05	0.005
N-EtFOSA	0.05	0.005
N-MeFOSE	0.05	0.005
N-EtFOSE	0.05	0.005
N-EtFOSAA	0.05	0.005
N-MeFOSAA	0.05	0.005

Perfluoroalkane sulfonic acids		
PFSA	Standard	Ultra Trace
PFBS	0.01	0.001
PFPeS	0.01	0.001
PFHxS	0.01	0.001
PFHpS	0.01	0.001
PFOS	0.01	0.0001
PFDS	0.01	0.001

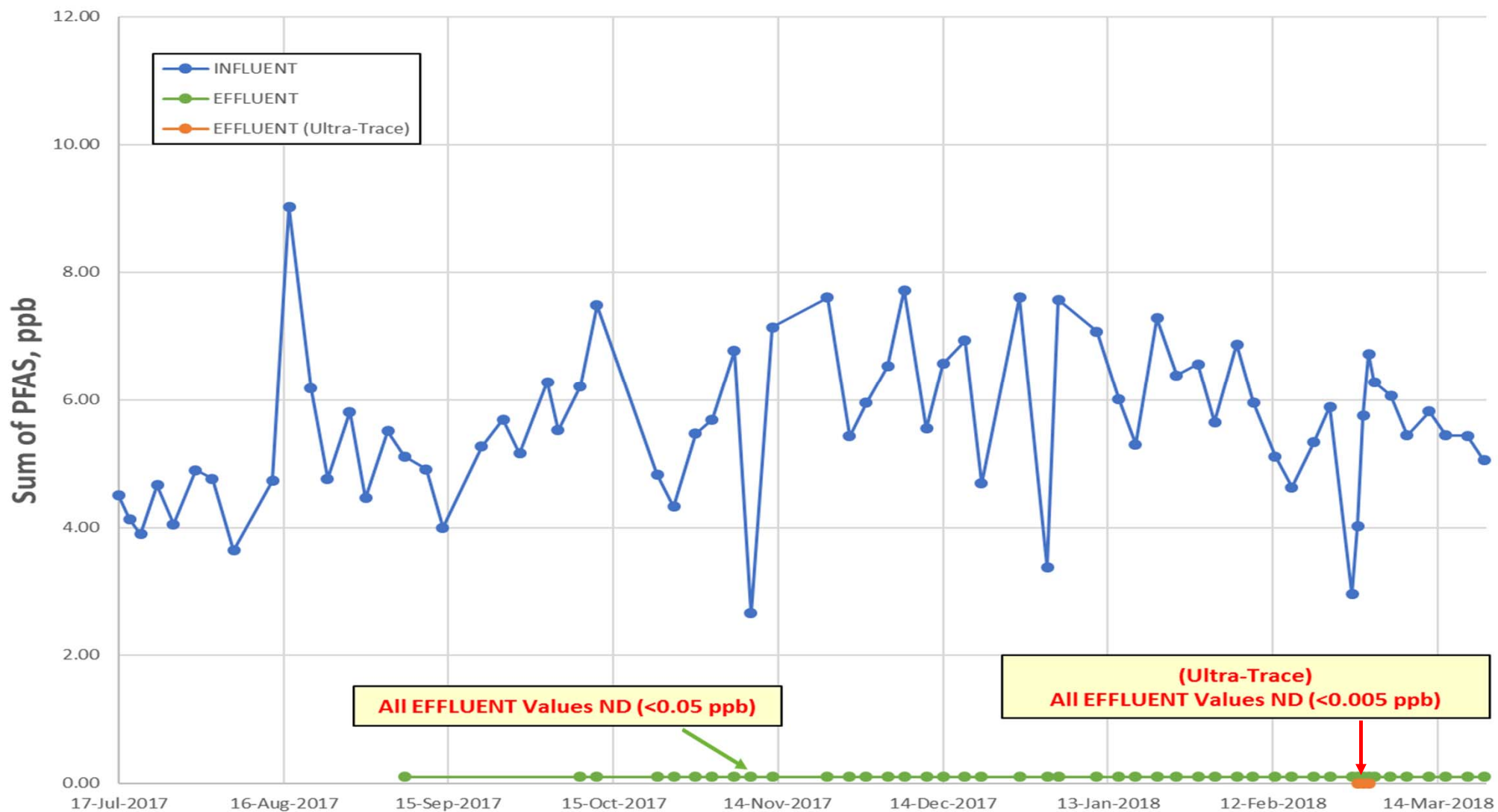
n:2 Fluorotelomer sulfonic acids		
n:2 FTS	Standard	Ultra Trace
4:2 FTS	0.01	0.001
6:2 FTS	0.05	0.005
8:2 FTS	0.01	0.001
10:2 FTS	0.01	0.001



Influent and Effluent PFOS + PFHxS



Influent and Effluent Total PFAS



Lessons learned: control of fouling



Influent water



Influent bag filter



Influent pipe

Solutions



- Installed self-cleaning screen and hydrocyclone
- Replaced pretreatment GAC media with Sorbix A3F (TOC & iron removal)
- Installed gravel in bottom of resin vessels

ECT's first drinking water system goes online

SEPTEMBER 26 2017 - 3:24PM

New water treatment plant jets in



Chris McLennan

News



Picture: Sid Mitchell, Aviation Spotters Online.

An aviation website is reporting the arrival of Katherine's new water treatment plant from the US at Darwin Airport.

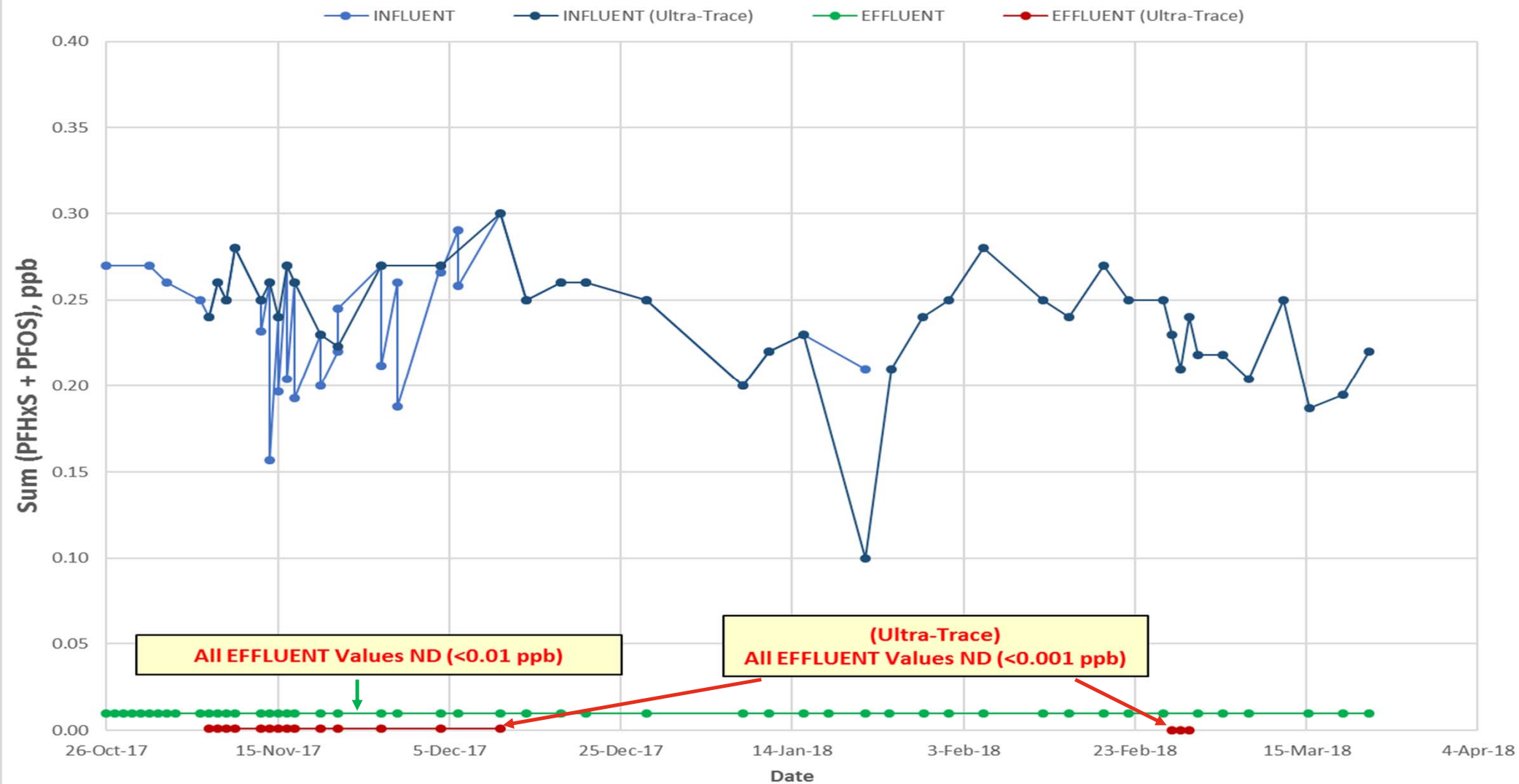


On September 22, 2017 Australian DoD hires Antonov Airlines to transport an ECT resin system to Katherine, AU to treat PFC-contaminated Drinking water

Four days later the 2-container treatment system is being transported overland in Australia to Katherine for rapid installation

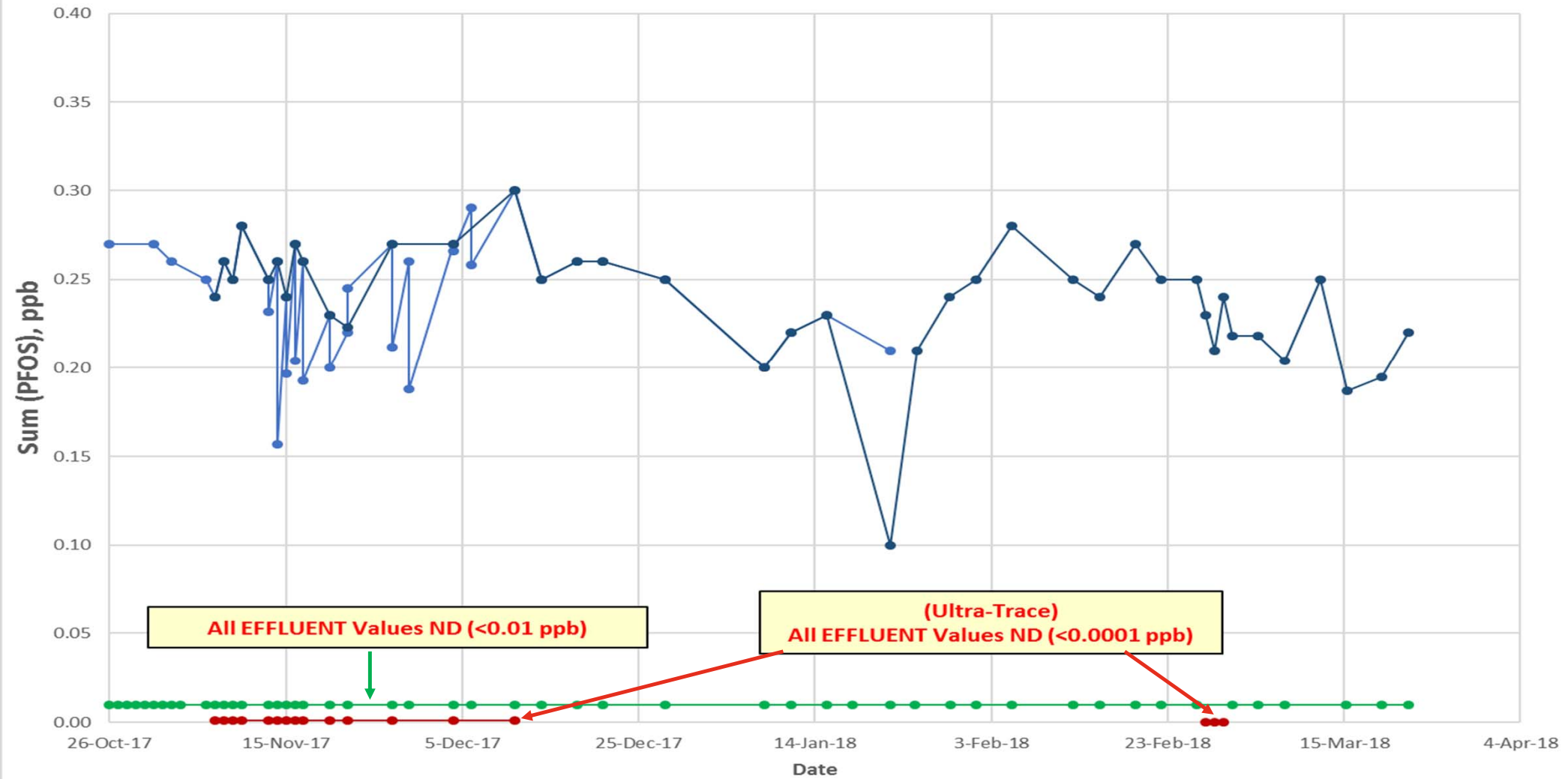
Installation is complete and the system is treating water less than a month after leaving the U.S.

Influent and effluent PFOS + PFHxS

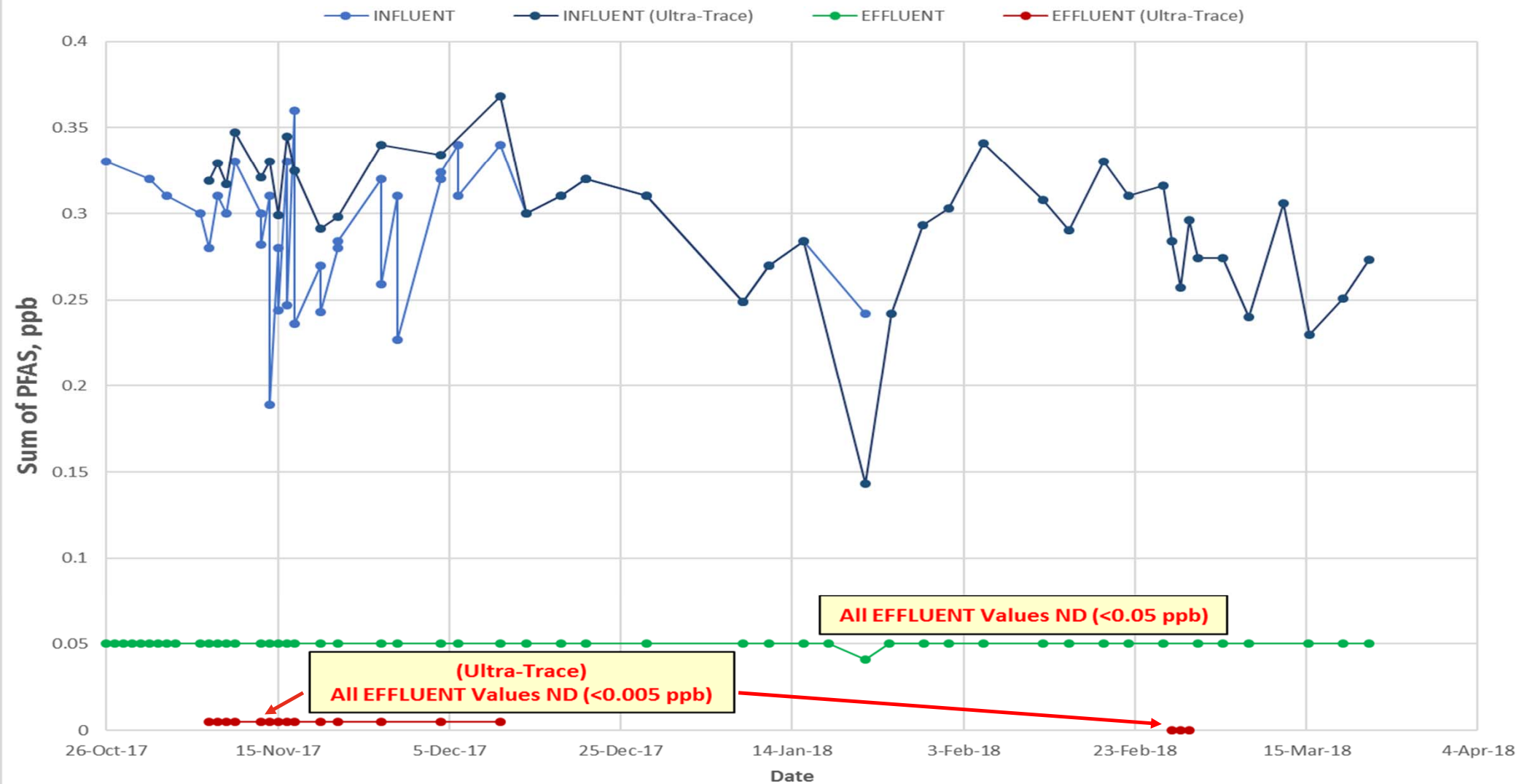


Influent and Effluent PFOS

INFLUENT INFLUENT (Ultra-Trace) EFFLUENT EFFLUENT (Ultra-Trace)

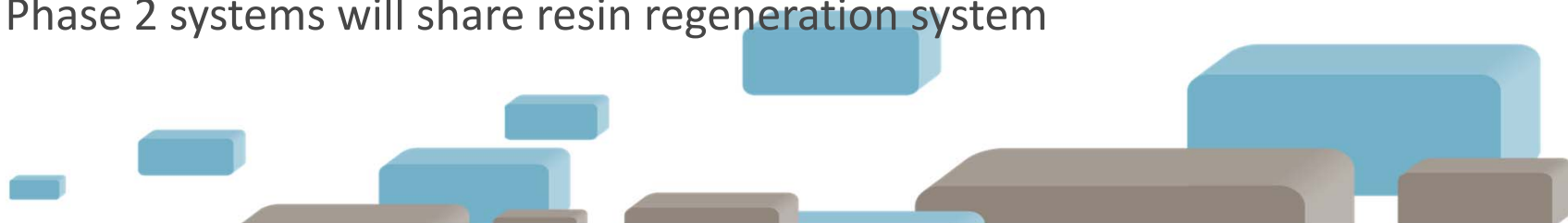


Influent and effluent Total PFAS



Summary

- IX resin can consistently remove PFAS to non-detect, even at ultratrace levels
- Treatment systems can be installed in storage containers for ease of transport and deployment
- Flexible – can add polish resin to remove short chains and precursors
- High capacity for PFAS – no resin changeouts since startup in June
- Work well in potable water supply applications
- Phase 2 system will be set in place in April
- Phase 1 and Phase 2 systems will share resin regeneration system



Thank you!



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