

2016
**Membrane
Technology**
CONFERENCE & EXPOSITION



Ceramic Membrane Pilot Testing on Lake Michigan

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America's Authority in Membrane Treatment



Improving America's Waters Through Membrane Treatment and Desalting



American Water Works
Association

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acknowledgements

- METAWATER, Japan
- MPU staff
- Rob Kooijman, PWNT
- Harry Scheerman, PWNT

Interreg
2 Seas Mers Zeeën
DOC2C's



background

- Manitowoc Public Utilities (MPU)
 - two membrane systems
 - 11 mgd cartridge MF
 - 20 mgd submerged MF
 - investigating ceramic membranes for future upgrade



pilot plant

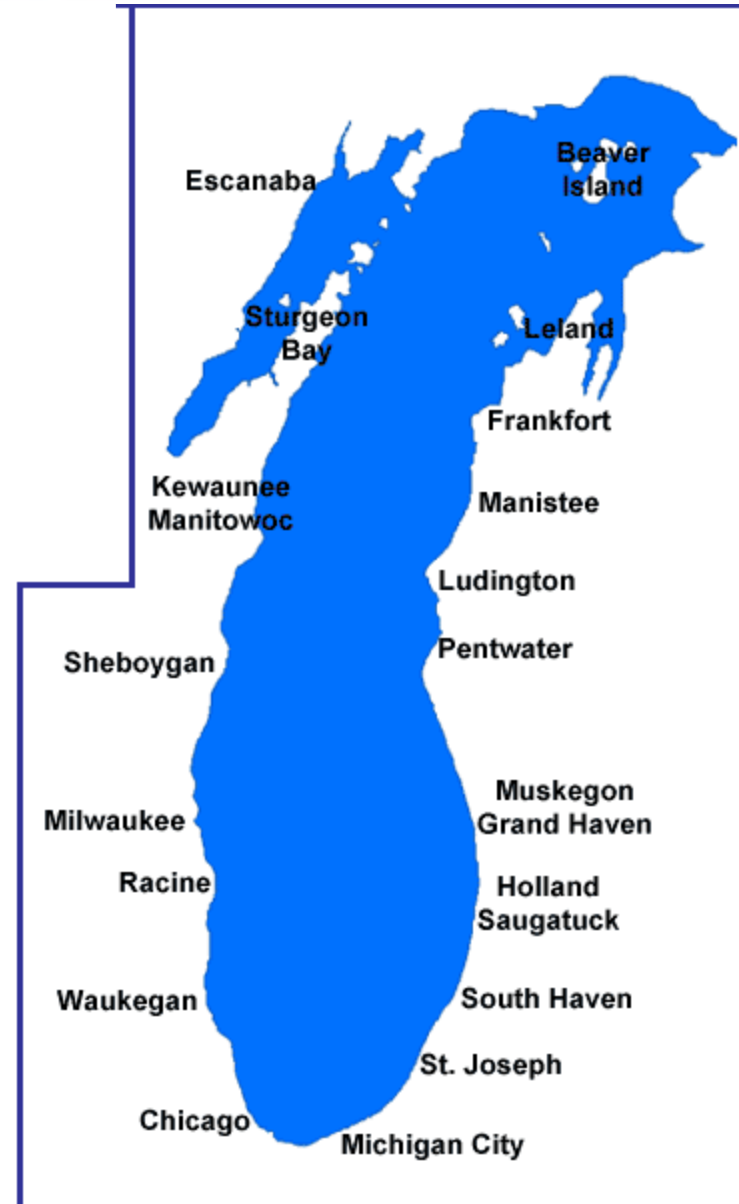
- METAWATER single element pilot
 - pre-sedimentation chamber
 - coagulation/flocculation
 - 25m² ceramic microfilter (0.1 micron)
 - heated CIP
- November 2014 to January 2016
 - critical flux tests (uncoagulated)
 - coagulated trials
 - long-term testing

modular pilot unit



water source

- Lake Michigan
 - low turbidity
 - low DOC
 - low temperature



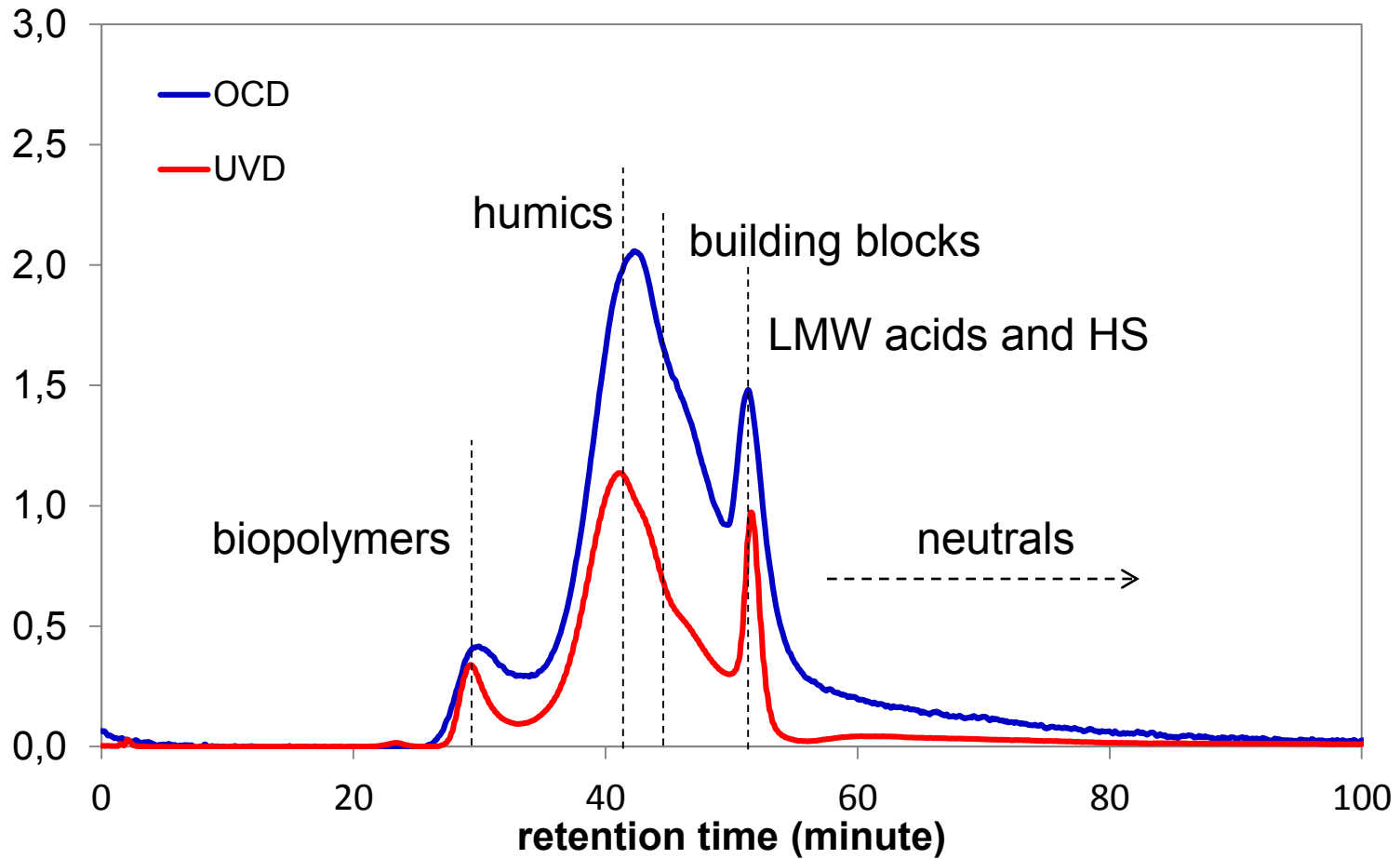
water quality

Parameter	Units	Raw Water	Filtrate
Total aluminum	mg/L	<0.002	<0.002
Dissolved aluminum	mg/L	<0.002	—
Alkalinity	mg/L	102	—
pH	--	8.2	—
turbidity	NTU	<1.0	—
TOC	mg/L	1.87	—
DOC	mg/L	1.74	—
Total iron	mg/L	<0.020	—
Total manganese	mg/L	<0.002	—

Date of sampling: 13-10-2015; Time of sampling: 10:30; Water temperature during sampling: 9.6 Celsius; Pilot coagulant dose: 20 ppm (13.64 ml/min); Pilot flux 175 l/mh or 104 gfd; Timing of sample in BW-EBW cycle: 17/8-1

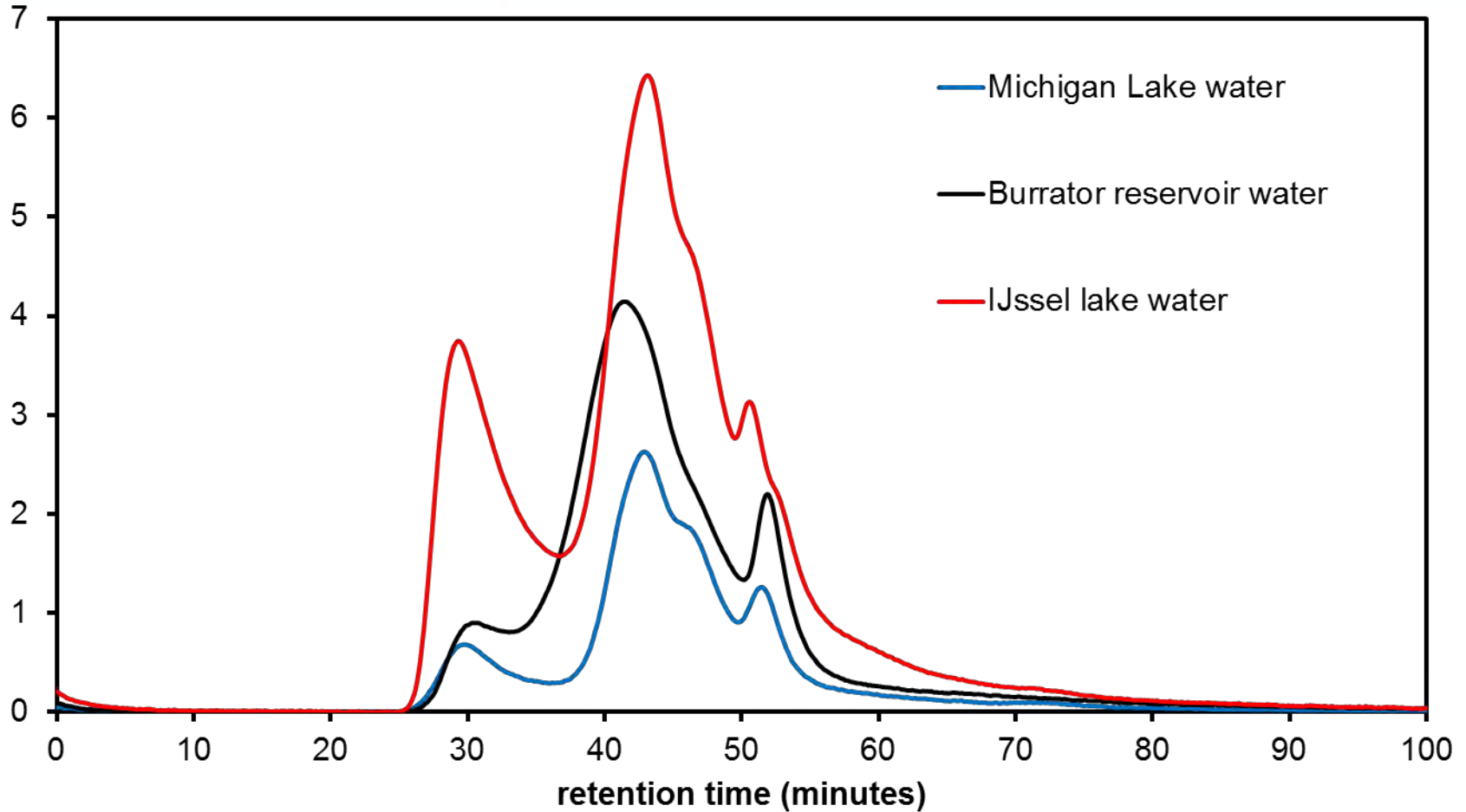
LC-OCD analysis (example)

signal (-)

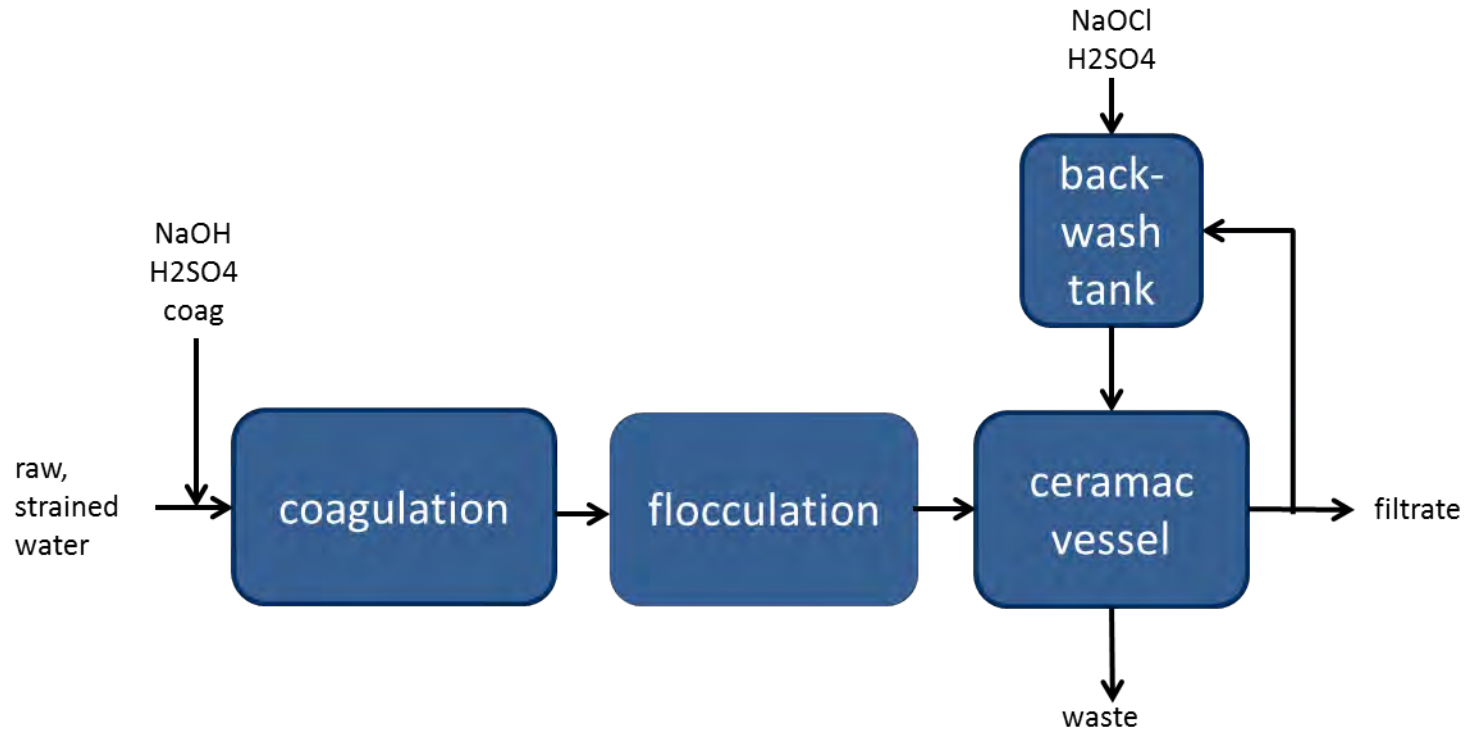


LC-OCD comparison

OCD detector signal (-)



flow diagram

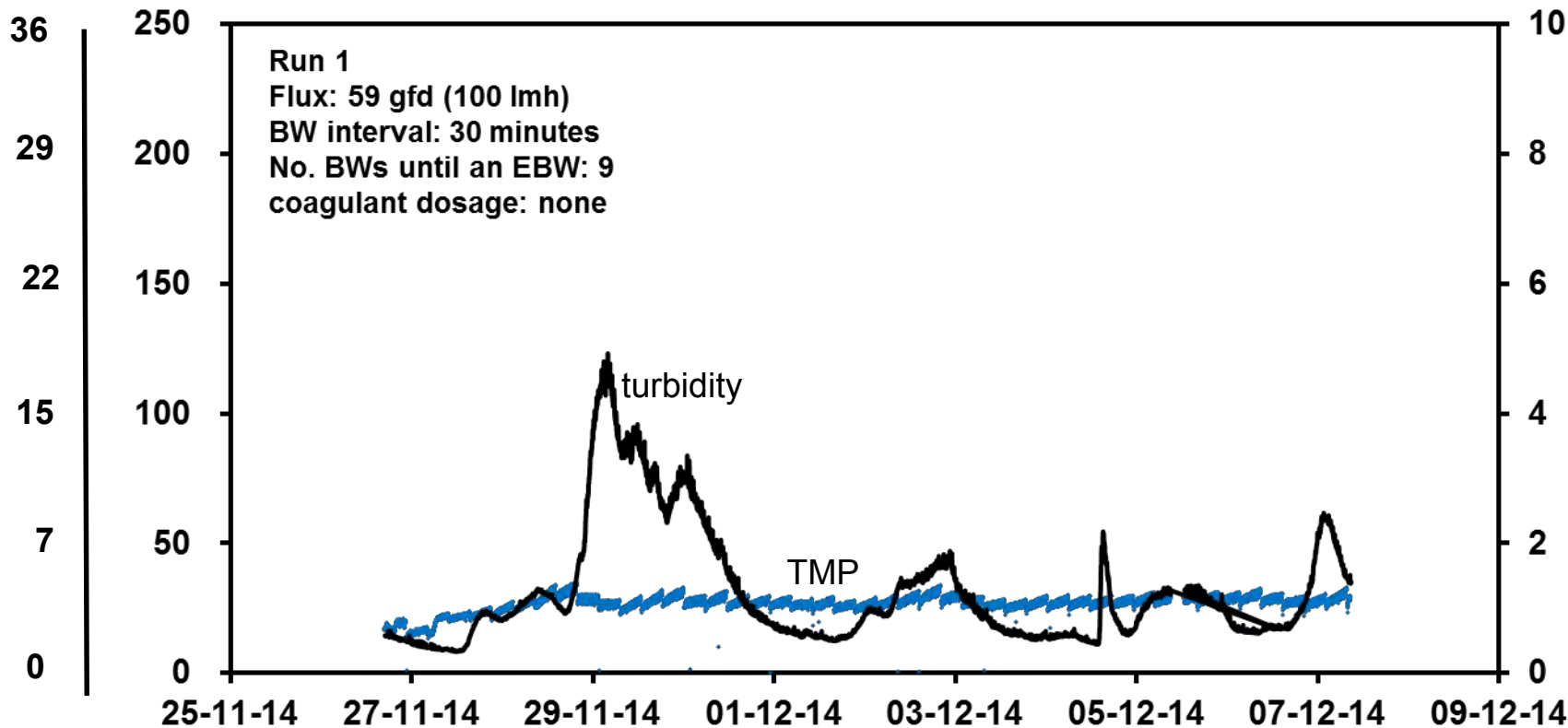


TMP profile

TMP (10 °C)

(psi) (kPa)

turbidity (NTU)

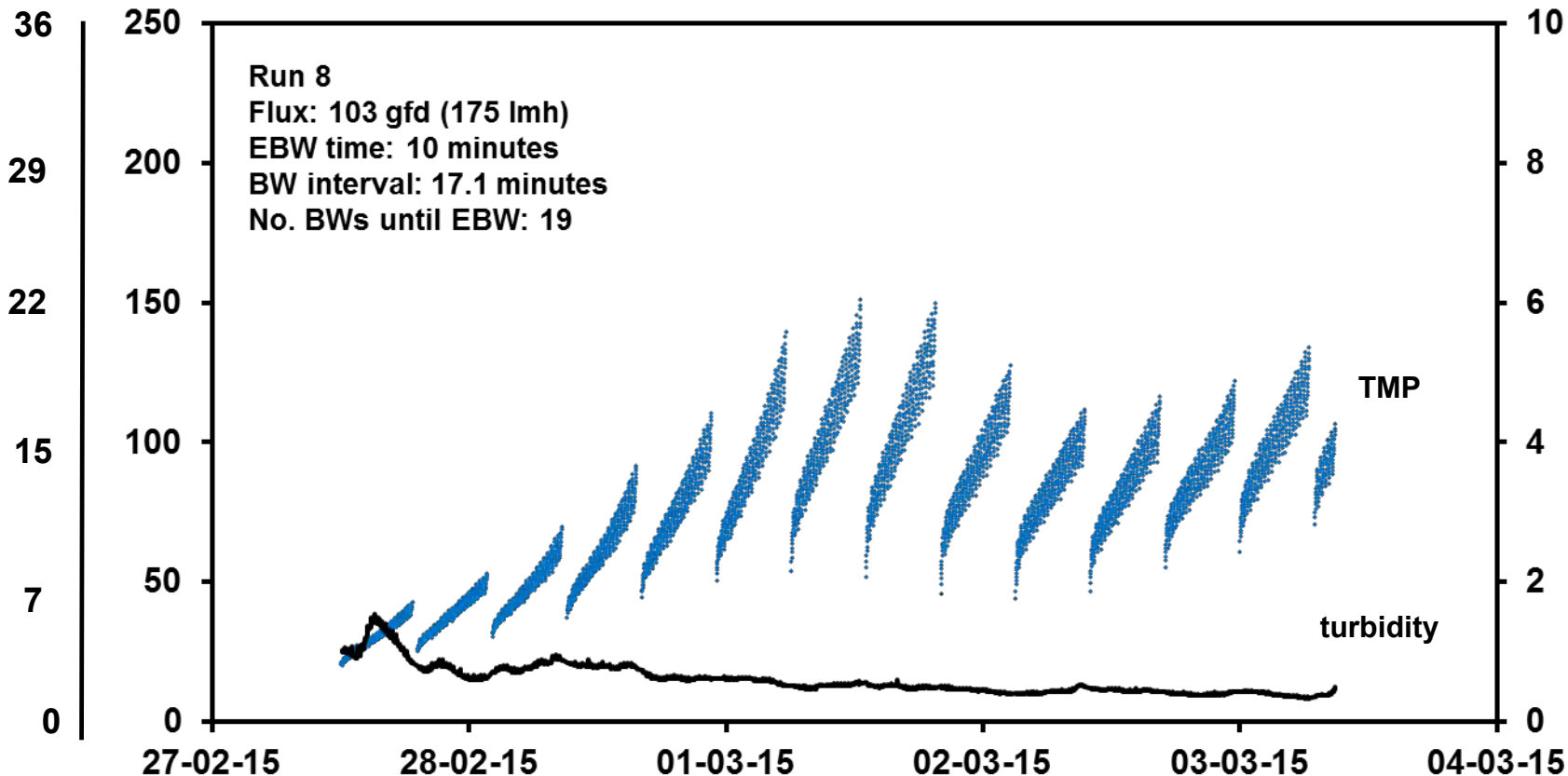


TMP profile

TMP (10 °C)

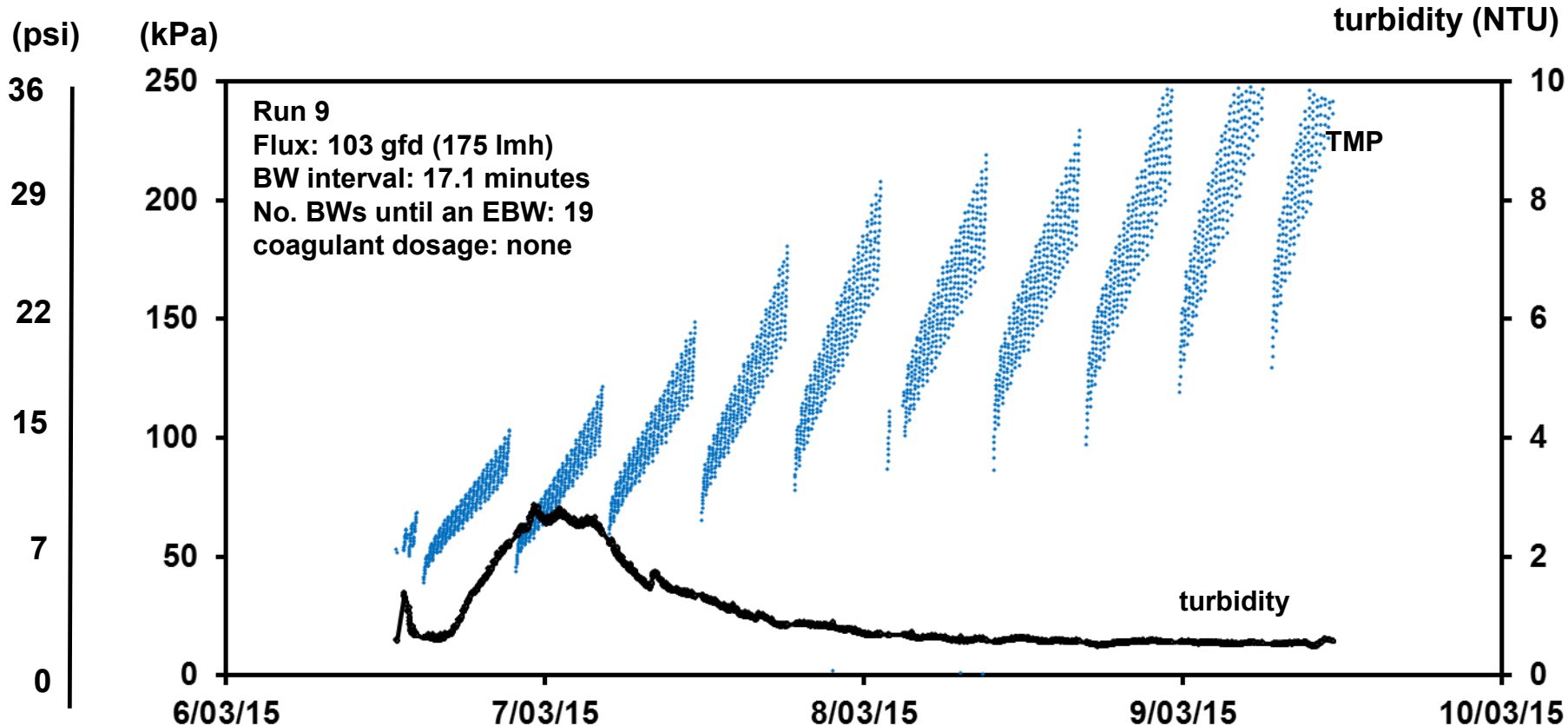
(psi) (kPa)

turbidity (NTU)

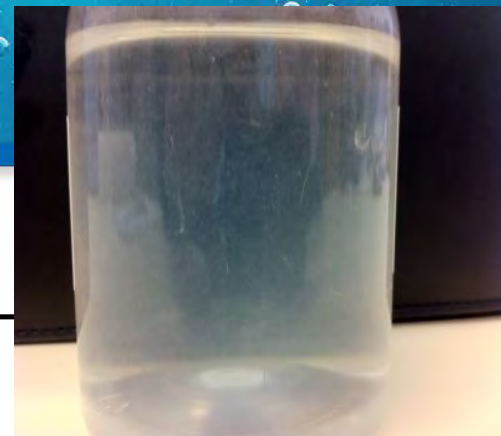


TMP profile

TMP (10 °C)

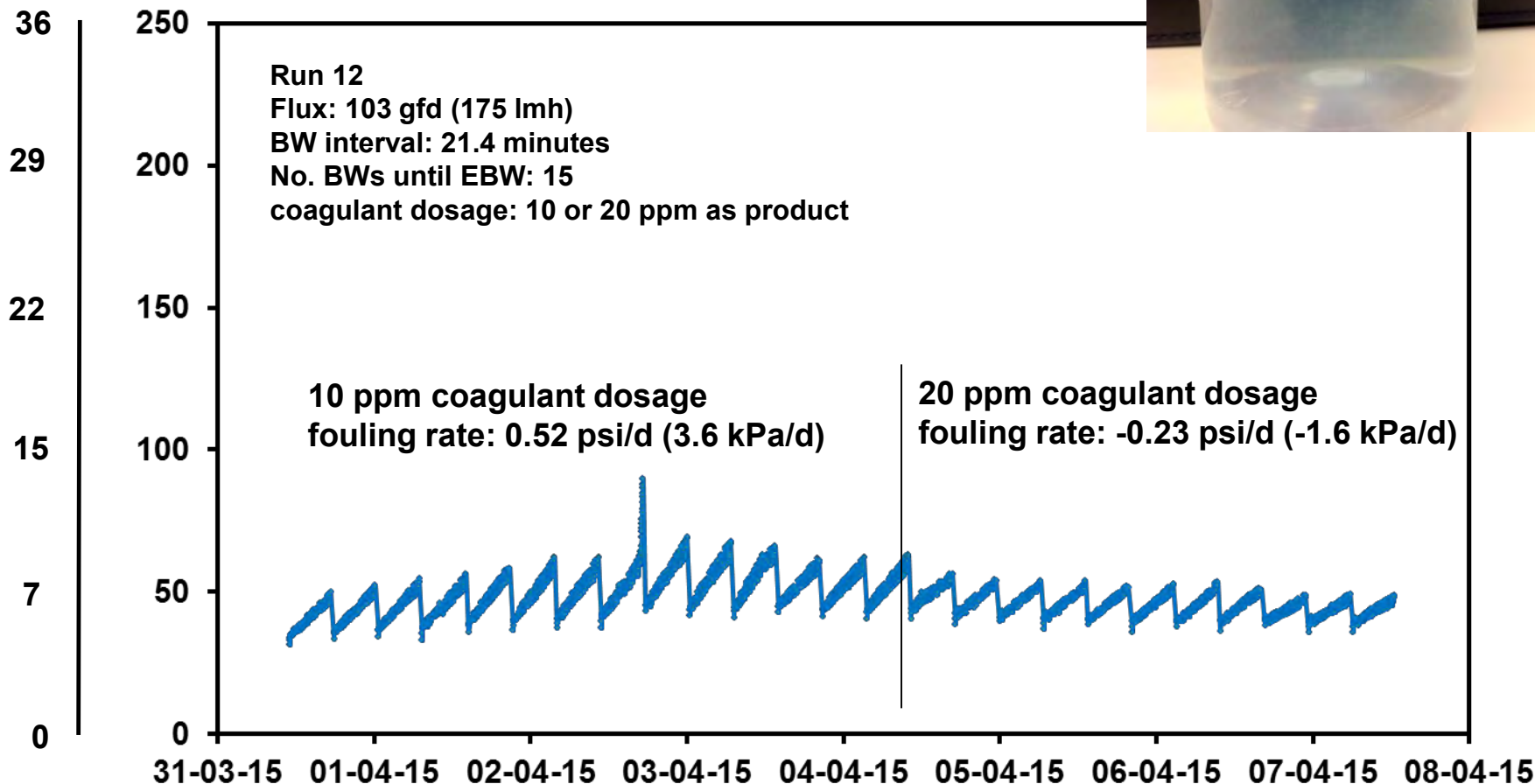


TMP profile



TMP (10 °C)

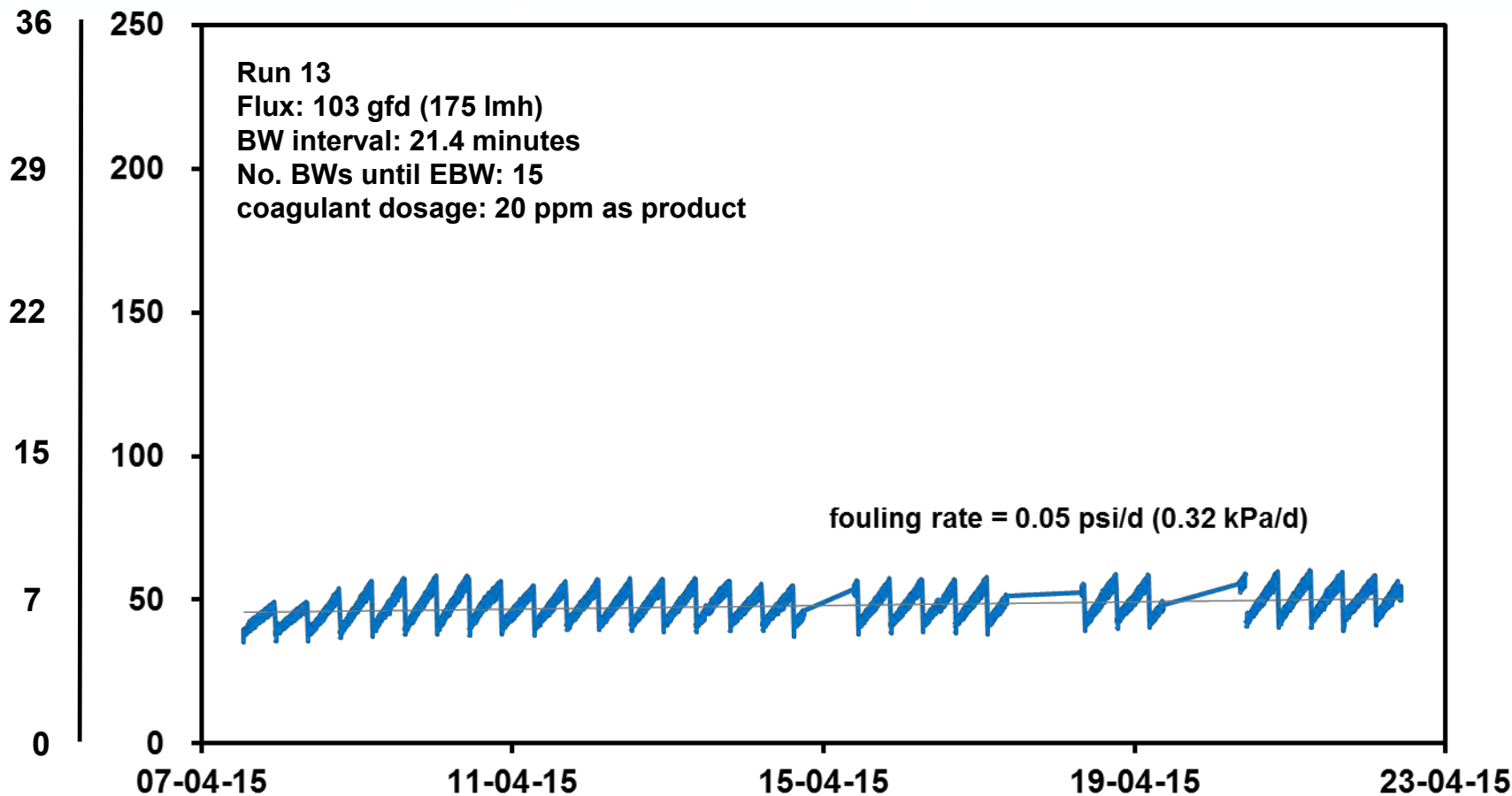
(psi) (kPa)



TMP profile

TMP (10 °C)

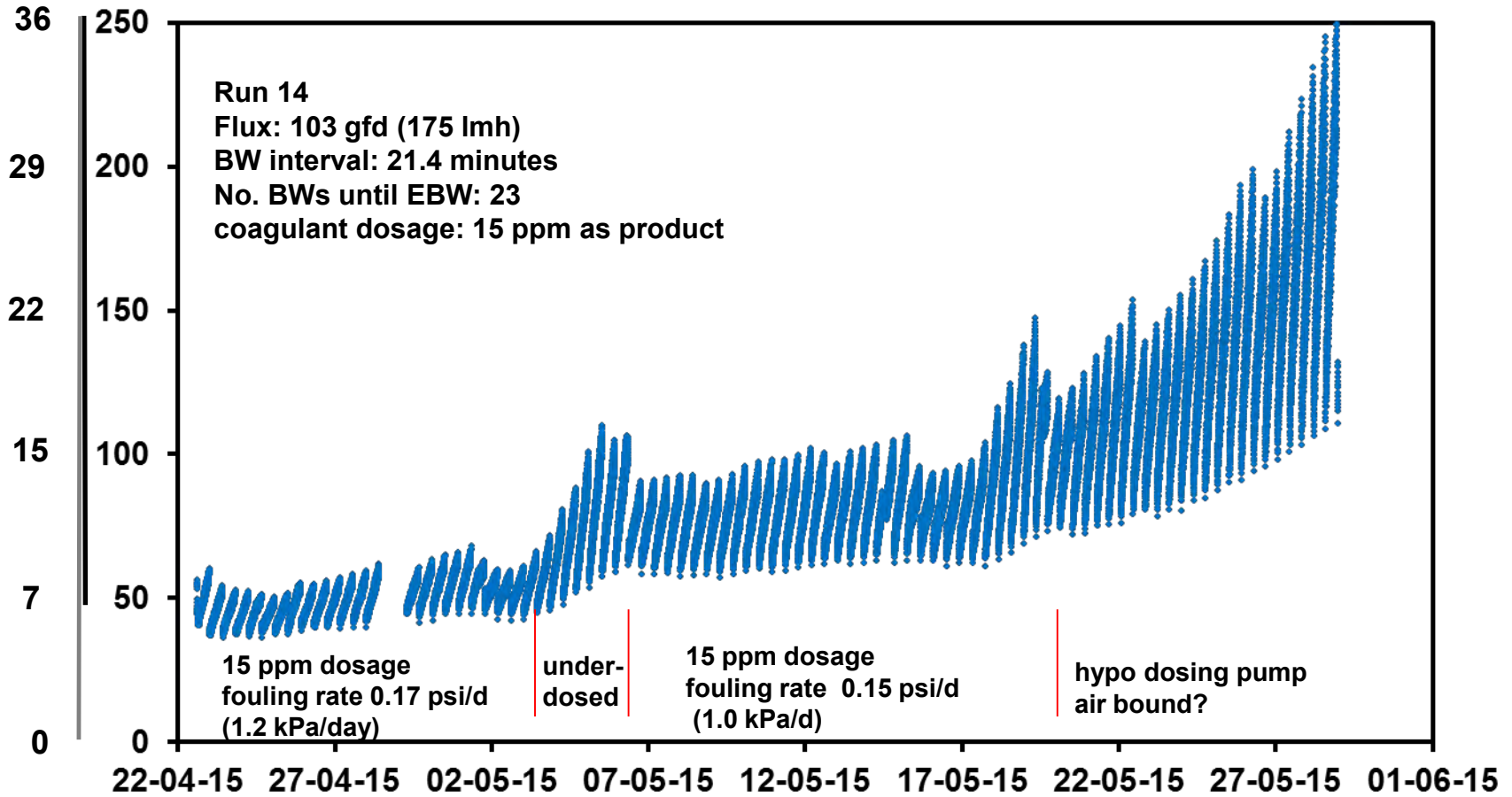
(psi) (kPa)



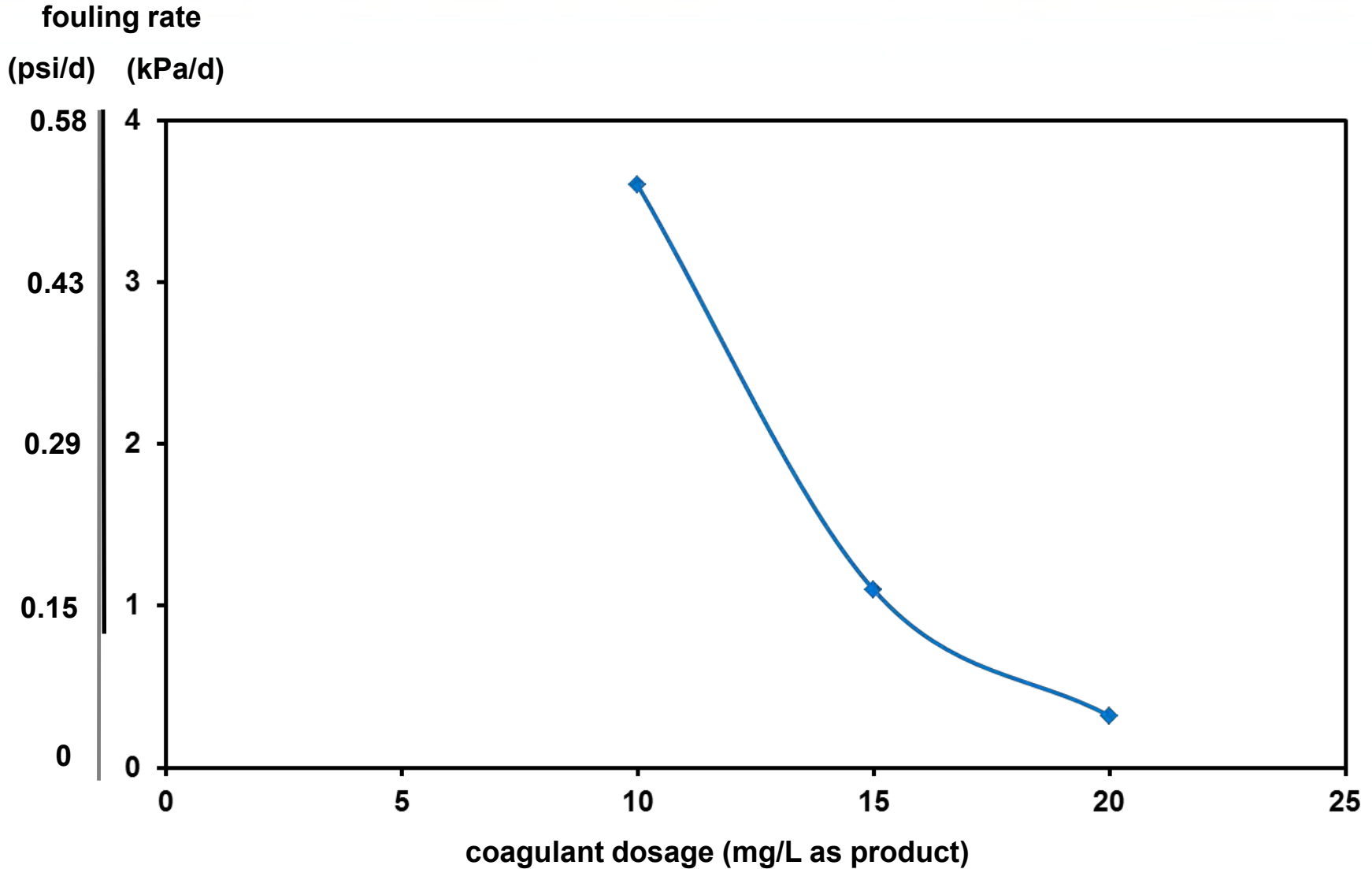
TMP profile

TMP (10 °C)

(psi) (kPa)



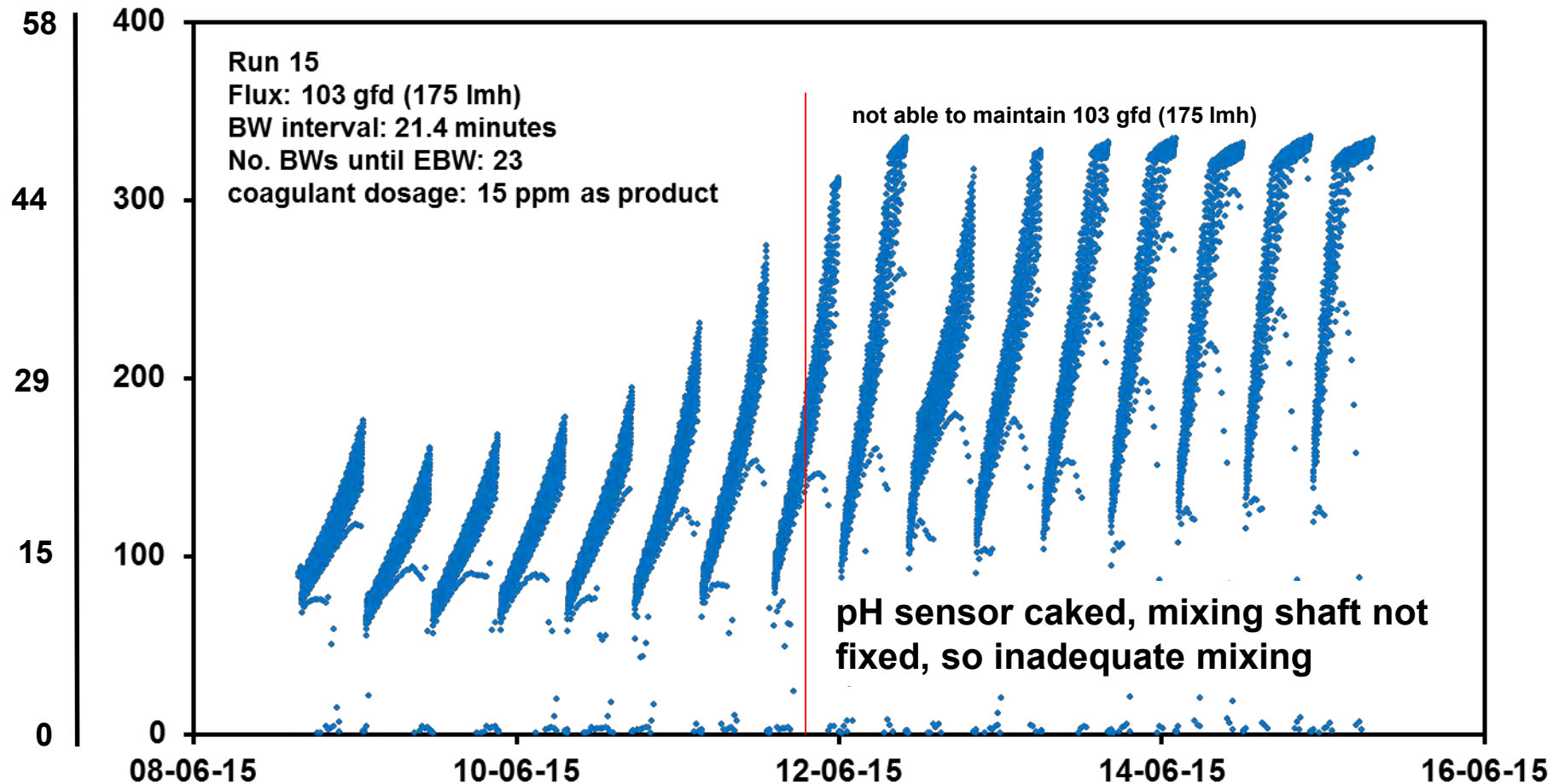
fouling rate comparison



TMP profile

TMP (10 °C)

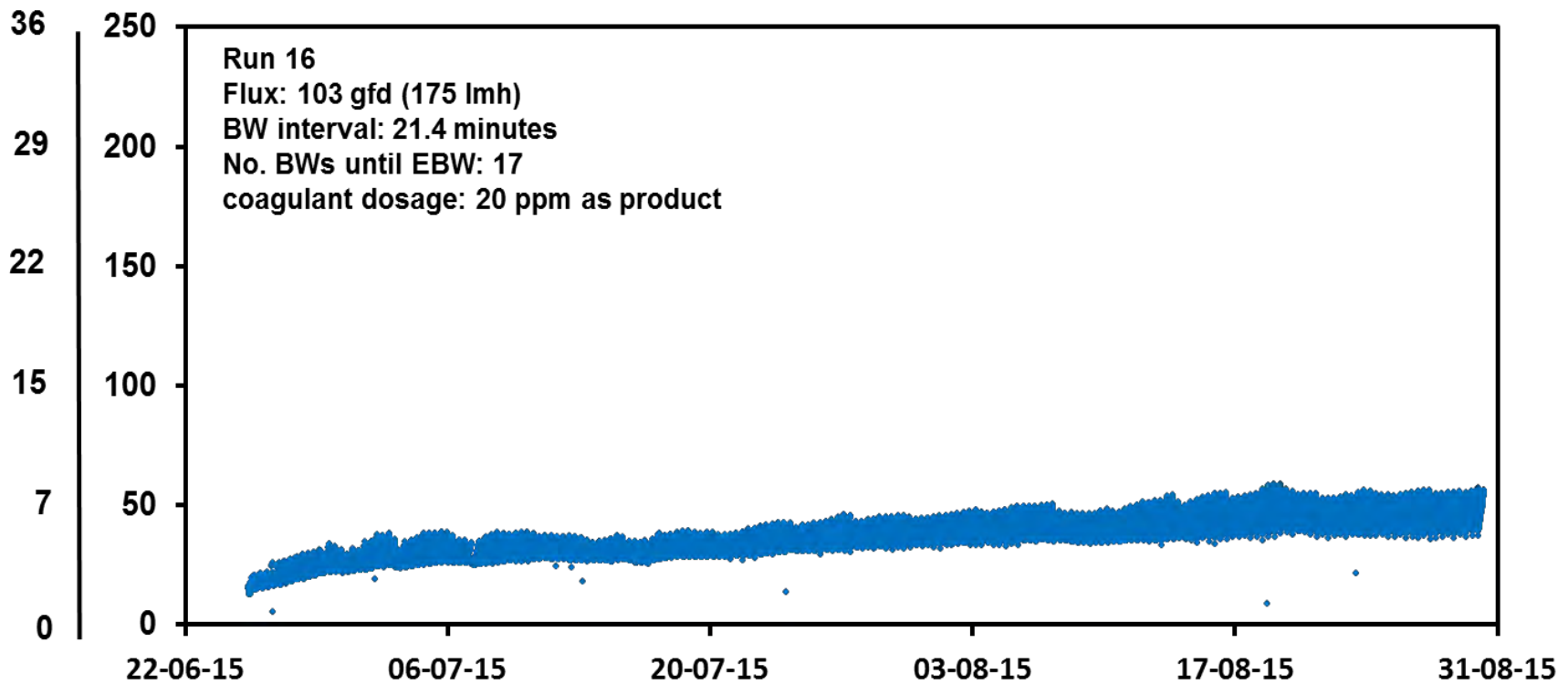
(psi) (kPa)



TMP profile

TMP (10 °C)

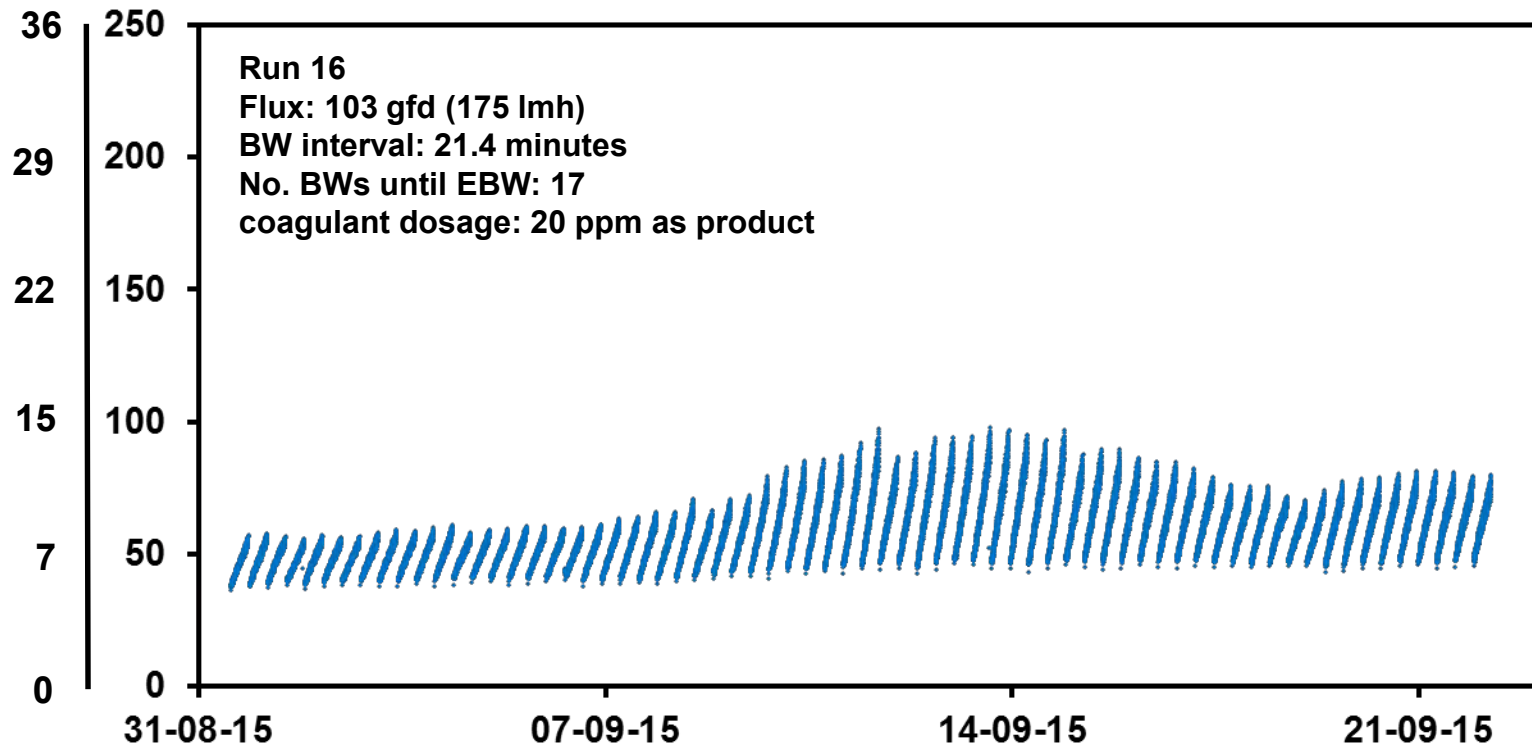
(psi) (kPa)



TMP profile

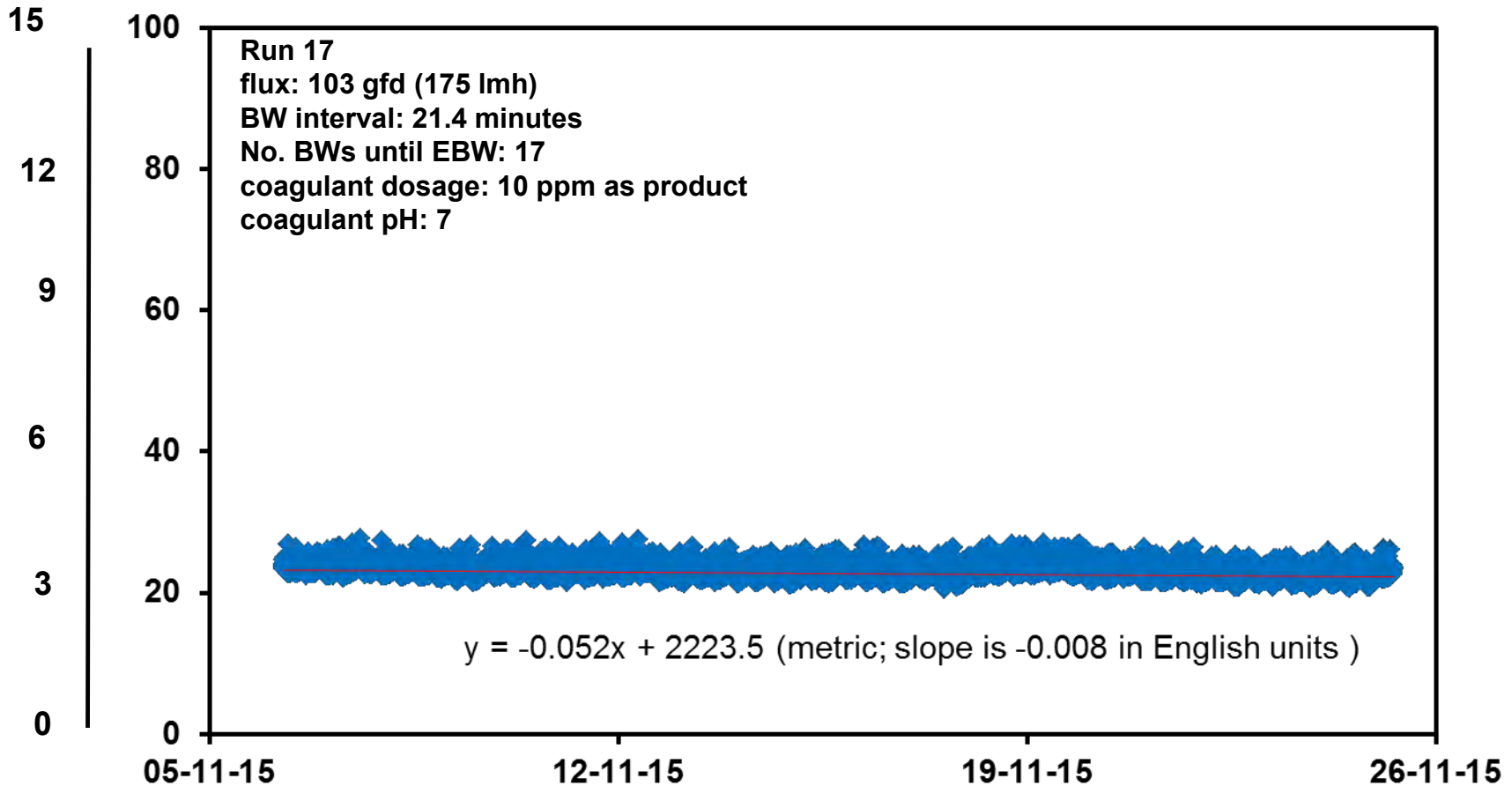
TMP (10 °C)

(psi) (kPa)



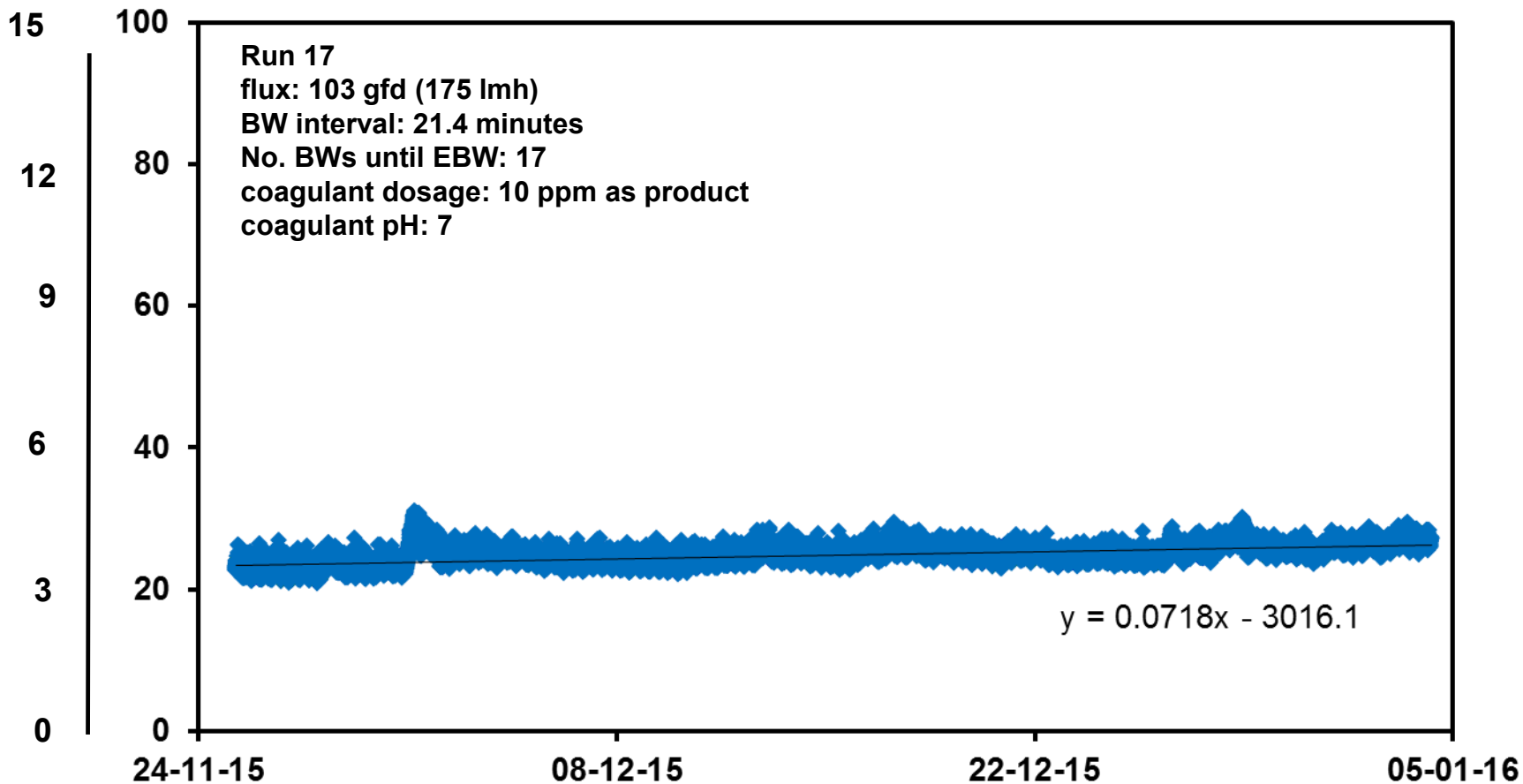
TMP profile

TMP (10 °C)
(psi) (kPa)



TMP profile

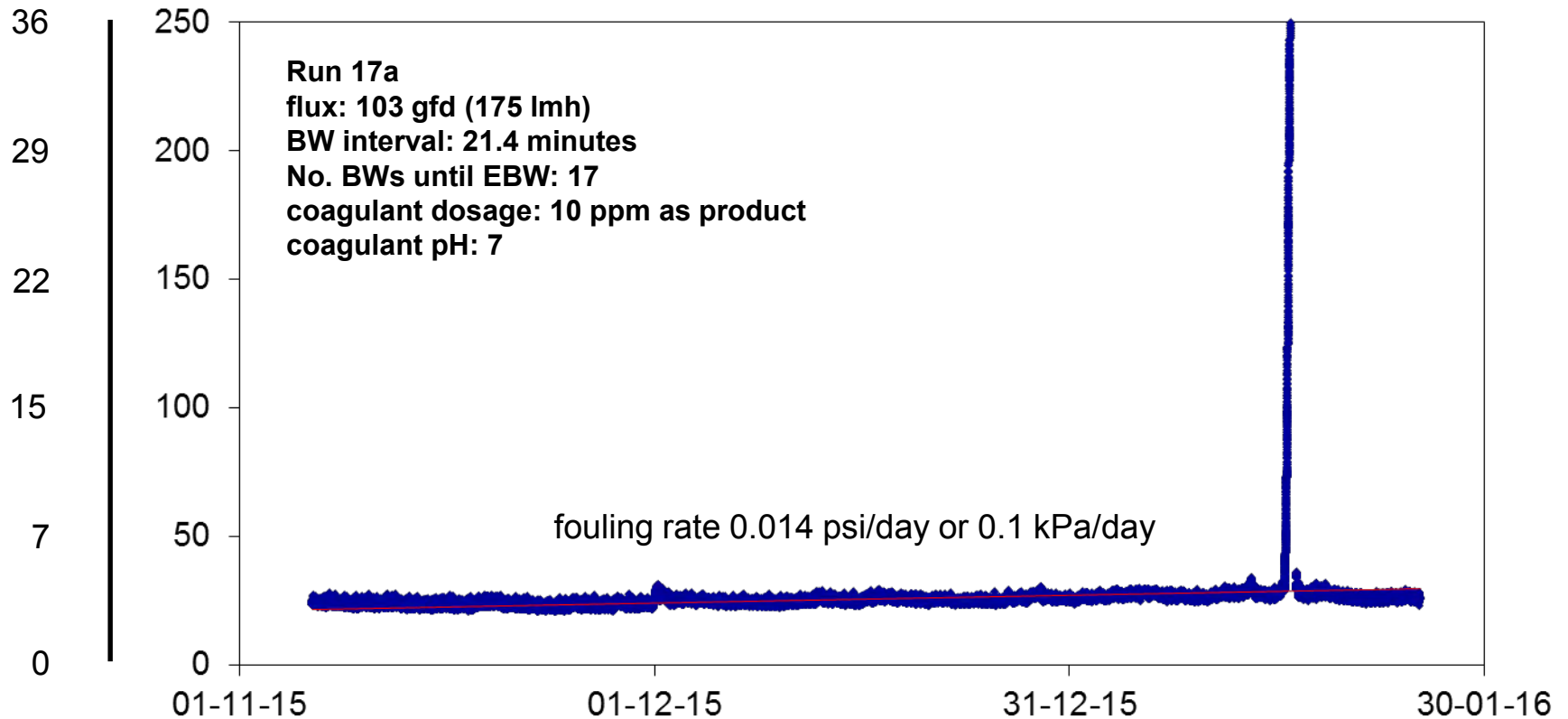
TMP (10 °C)
(psi) (kPa)



TMP profile

TMP (50 °F / 10 °C)

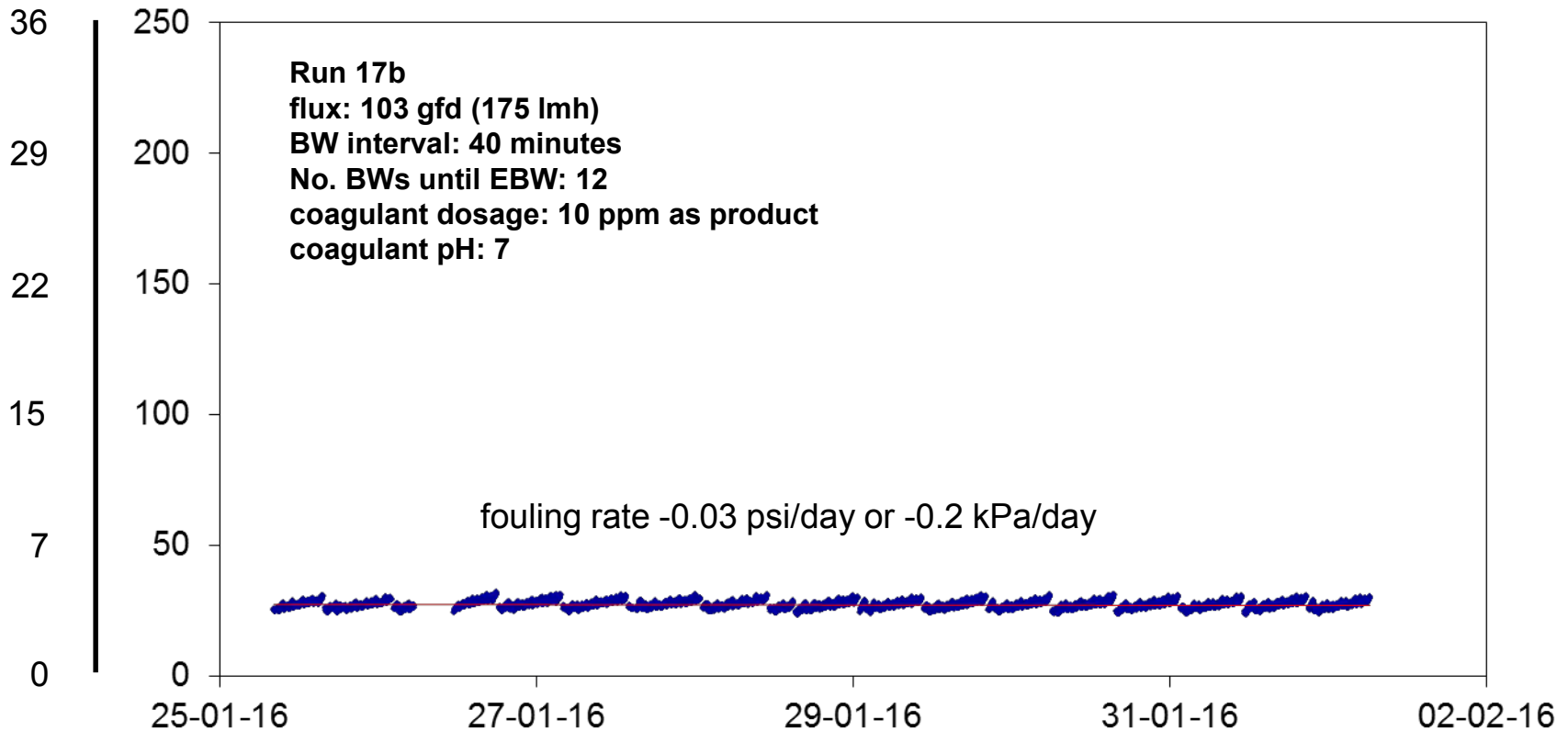
psi kPa



TMP profile

TMP (50 °F / 10 °C)

psi kPa



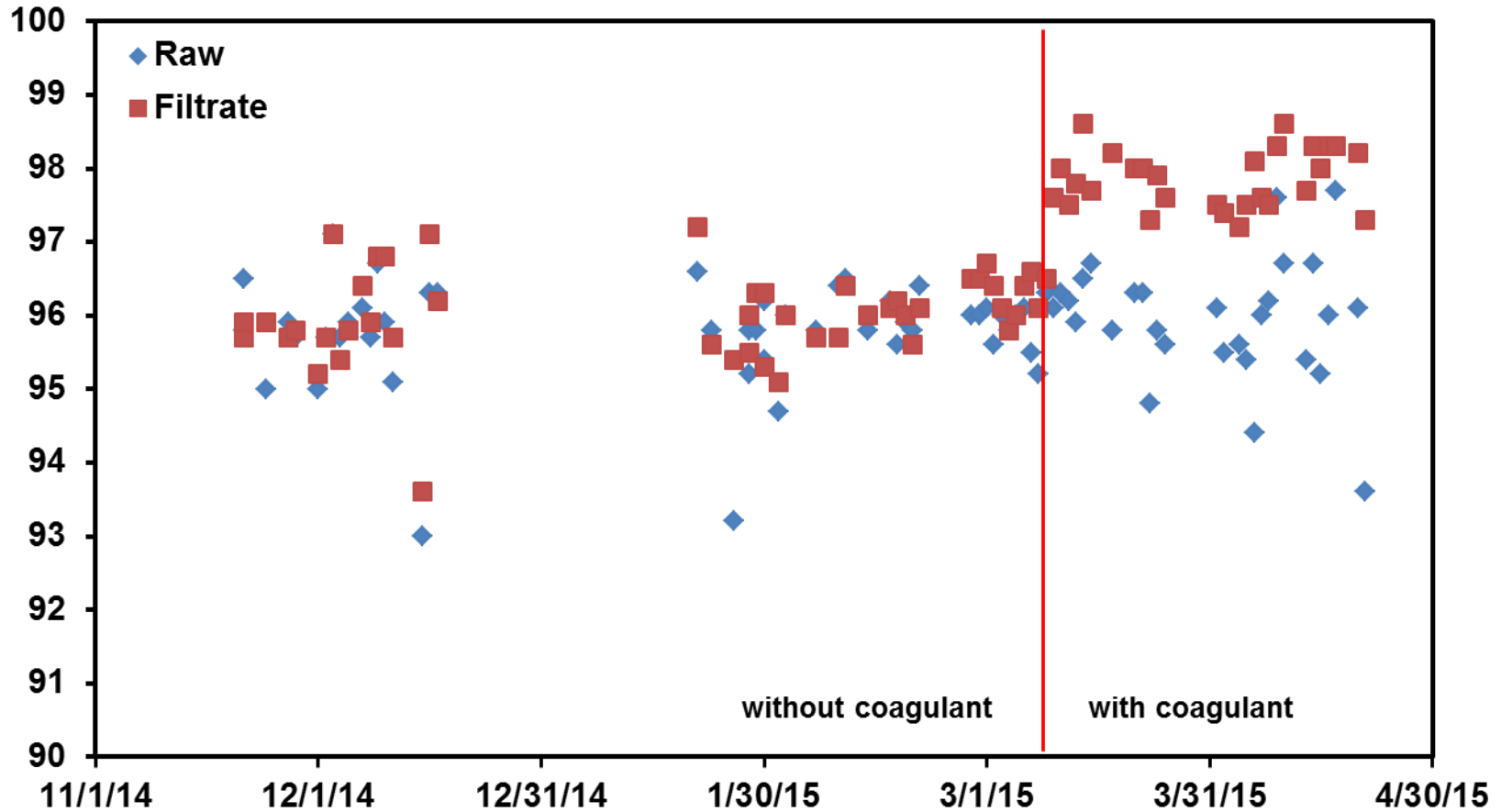
aluminum results

Lab	Sample Date	Time of sample	Water temp (oC)	pH	Total Aluminum (mg/L) (unfiltered)		
					Raw	CeraMac Feed	Filtrate
Eurofins	29 - 10	14:20	9.9	7.06	--	1.5	0.07
Eurofins	29 - 10	14:42	9.9	7.04	--	1.5	0.07
Eurofins	29 - 10	15:05	9.9	7.09	--	1.4	0.067
Eurofins	29 - 10	15:30	9.9	7.11	--	1.4	0.058
Eurofins	29-10	15:55	9.9	7.12	--	1.4	0.052

Note: 10 mg/L coagulant

UVT comparison

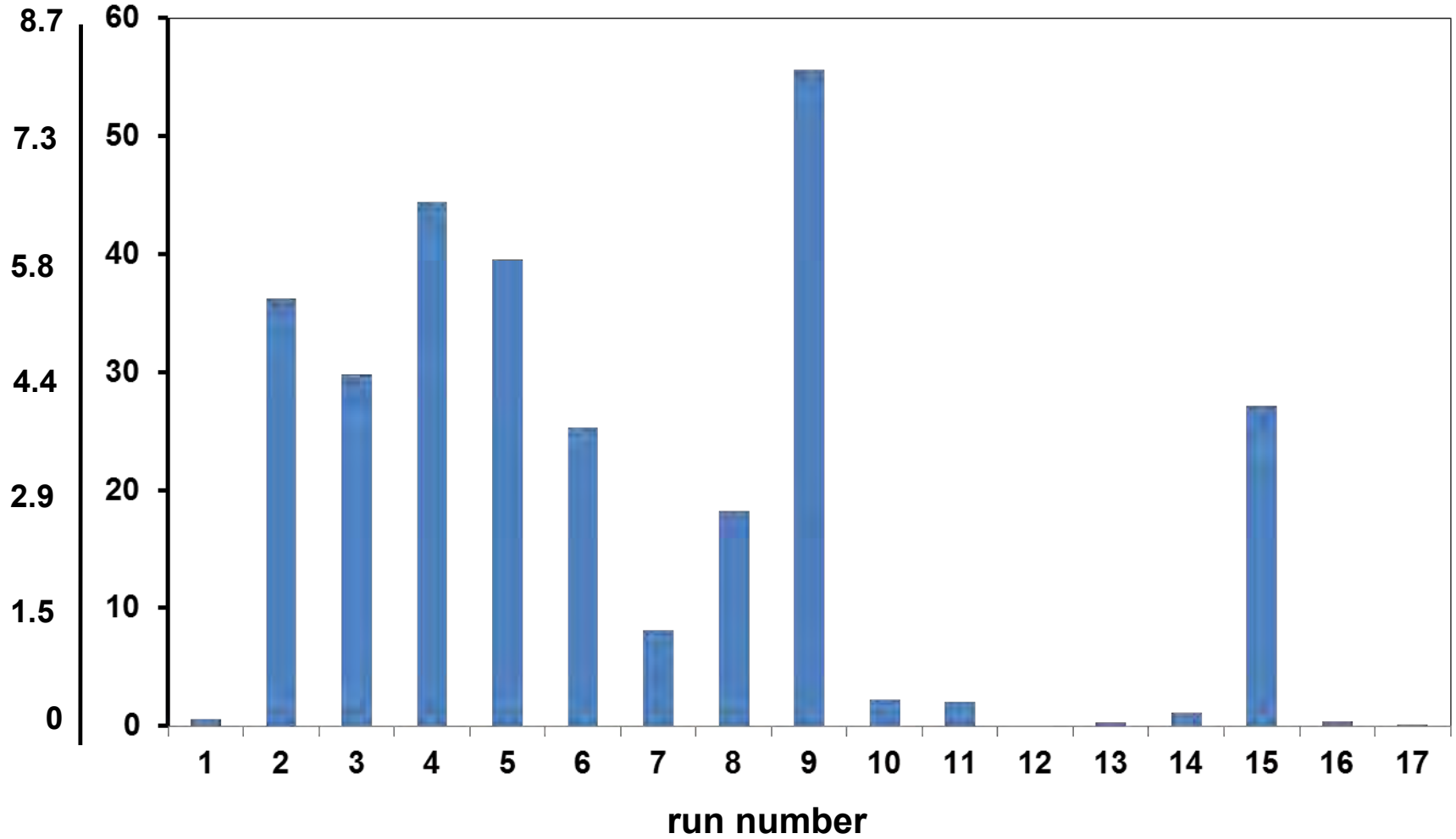
UVT (percent)



fouling rate

fouling rate (10 °C)

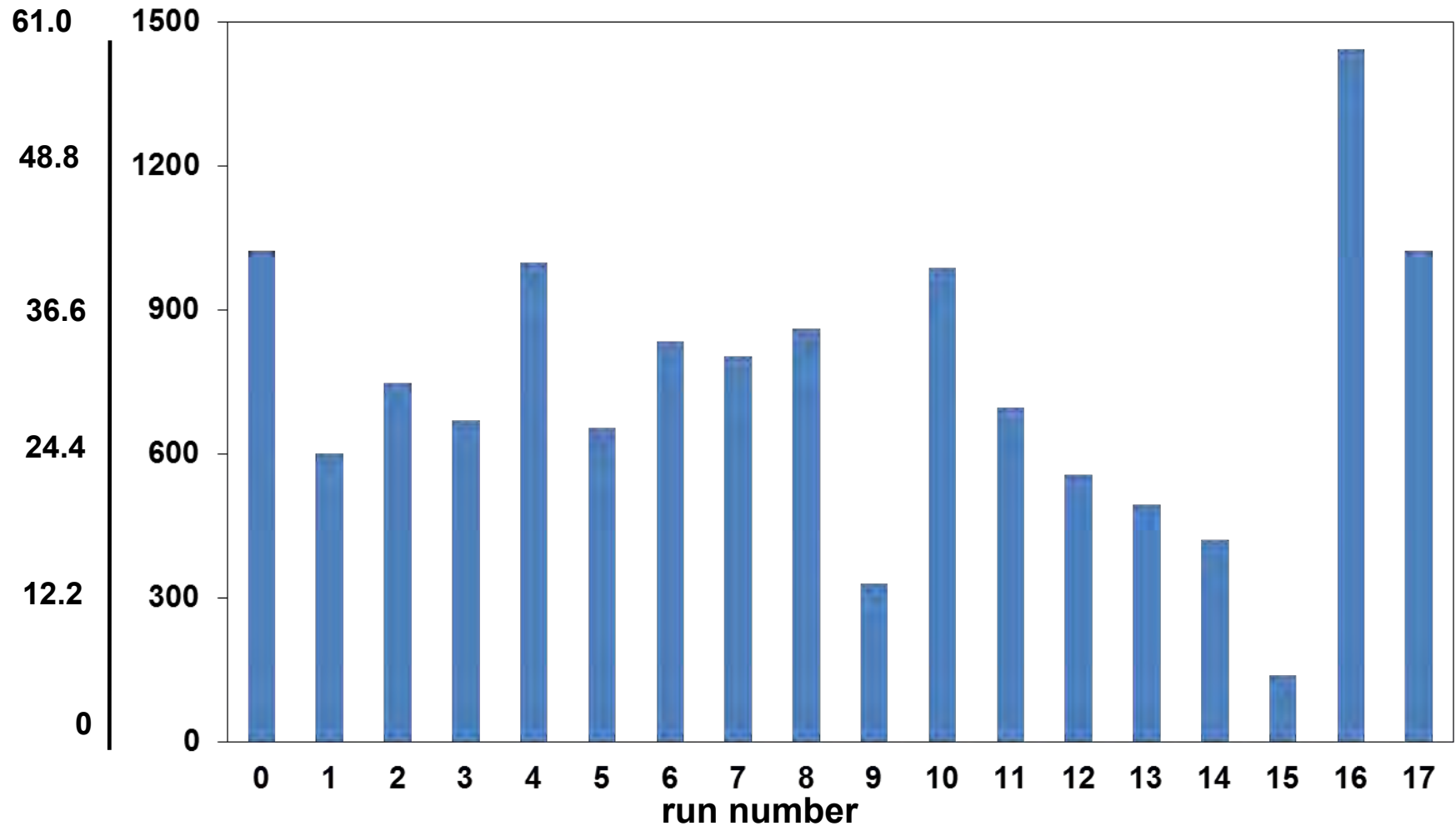
(psi/d) (kPa/d)



initial specific flux

Initial run specific flux (10 °C)

(gfd/psi) (Lmh/bar)



pilot findings

- membrane performance improved with pre-coagulation
- stable operation at 104 gfd (175 l/mh)
 - coagulant at 10 mg/L
 - CIP interval >> 45 days
 - BW interval = 22 minutes (testing 40 min)
 - EBWs after 17 BWs (testing 12 BWs)
- in-line coagulation with good mixing and pH 7 for Sumalchlor 50

pilot findings

- EBW with NaOCl at 100 mg/L
- EBW at pH < 3 with H₂SO₄
- avg TMP = 3.6 psi (24.7 kPa) at 10oC
- organics – low, but present as biopolymers and humics which contribute to fouling



Questions