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Effect of Calcium and Bicarbonate on Iron Removal During Groundwater Treatment

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The Netherlands

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Where is the Netherlands

Drinking water in the Netherlands

Key figures

- Population 17 mil
- Total production volume 1,126 mil m^3
- Network length 119,000 km
- Annual investments €431 mil.
- NRW 5.5 %
- Connected 99.9 %

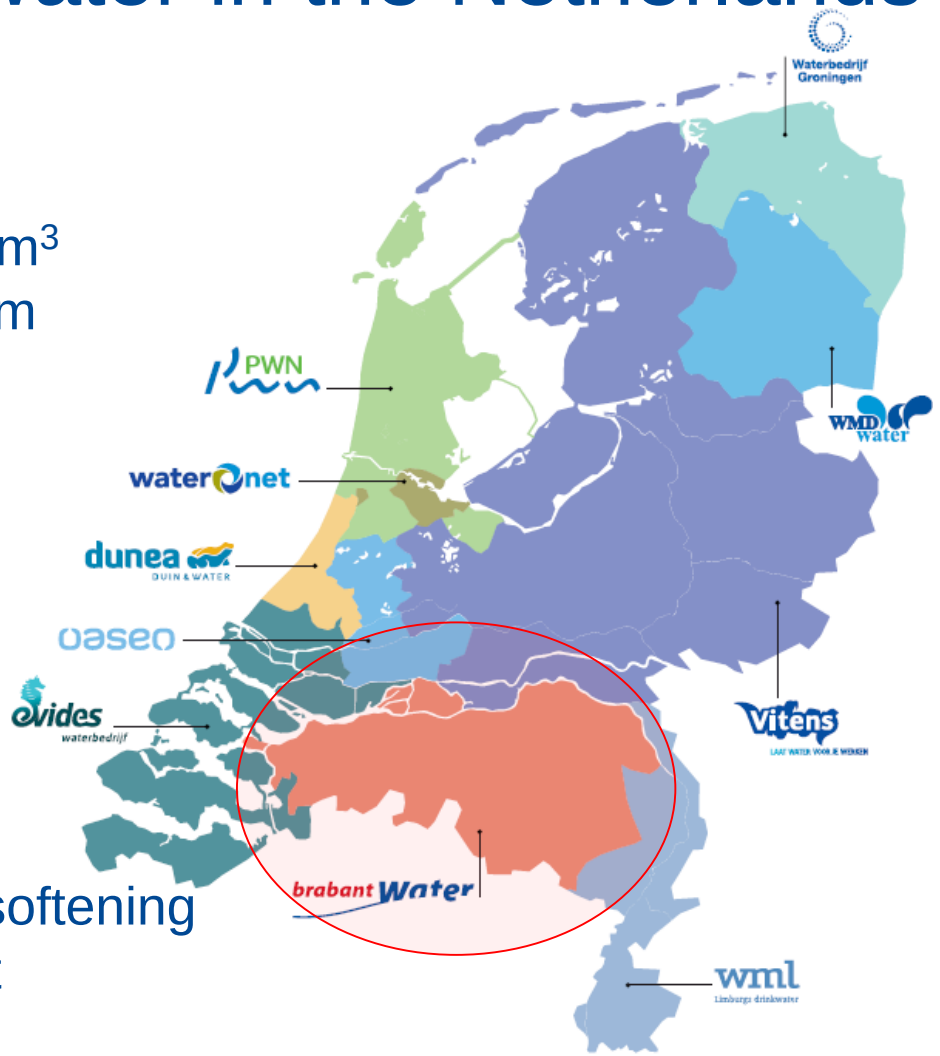
Sources

Ground water 2/3
Surface water 1/3

Treatment

Ground water: Aeration, filtration, softening
Surface water: Extensive treatment

Distribution No Chlorine

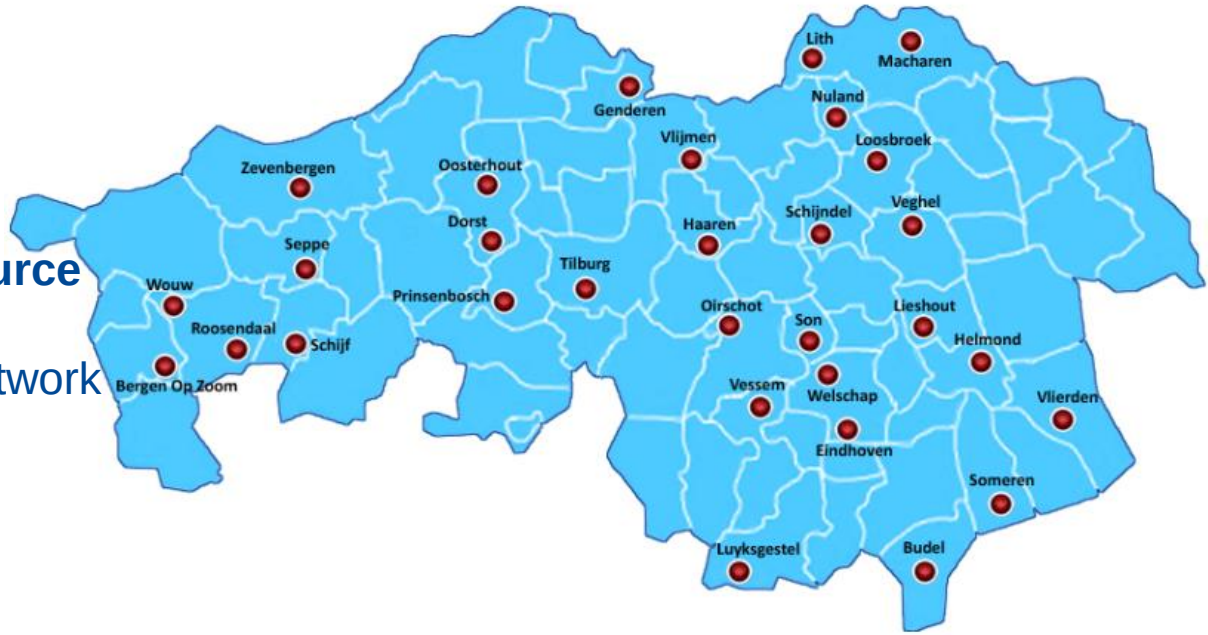


Drinking water company Brabant Water

BRABANT WATER N.V.

- 2.5 mil. inhabitants
- 1.1 mil. connections
- 180,000 regional industries
- Annual production 176 mil. m^3
- 30 treatment plants
- **Groundwater as the main source**
- **No chlorine**
- 18,000 km main distribution network
- Non Revenue Water 2.5%
- 800 Staff
- Annual turnover €200 míl.

Province North-Brabant



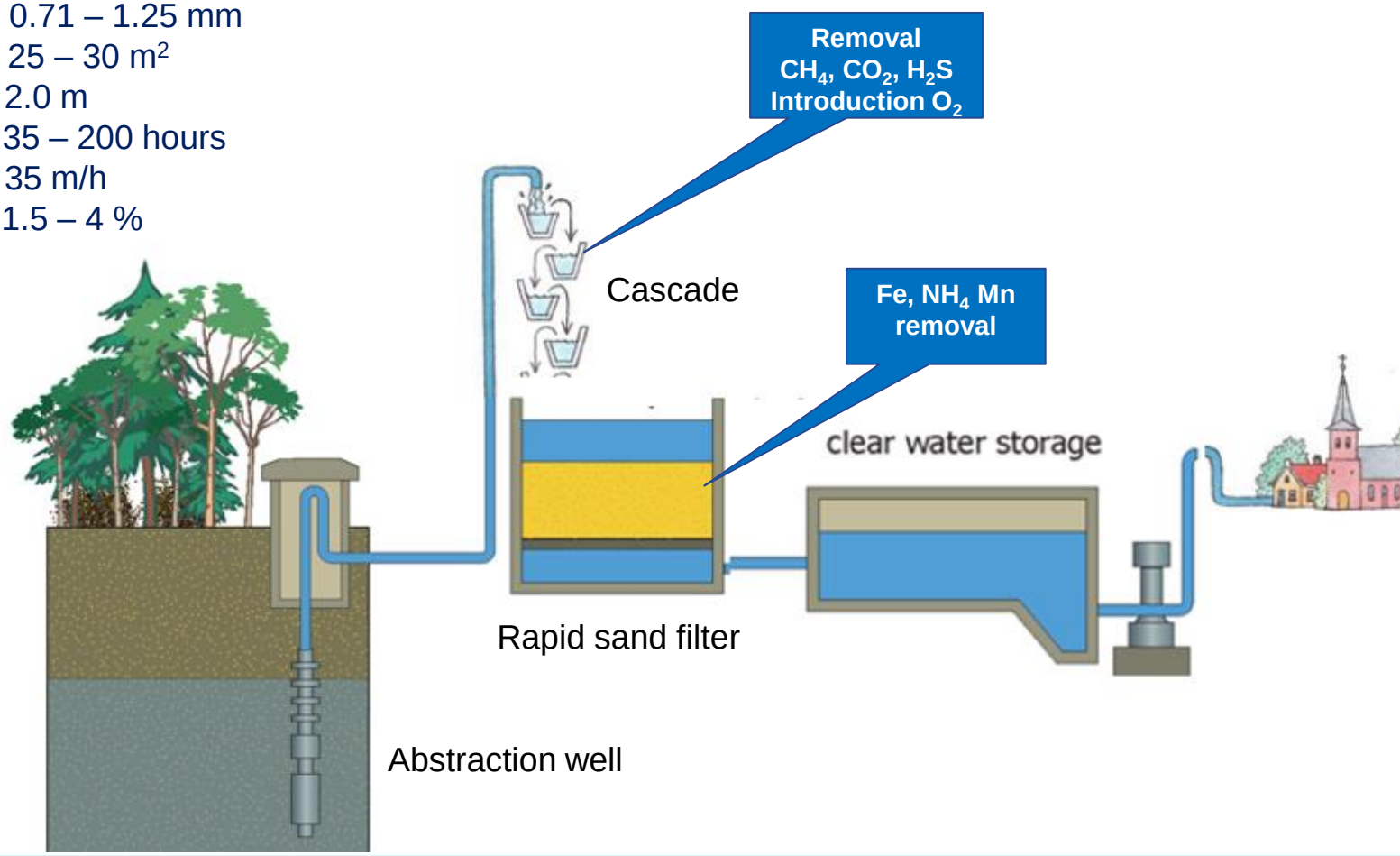
Water use 31.7 USgal (120 l) per person per day

Typical treatment schematic

General design rapid sand filtration

- Filtration rate 3 – 14 m/h
- Filter media 0.71 – 1.25 mm
- Surface area 25 – 30 m^2
- Bed height 2.0 m
- Running times 35 – 200 hours
- Backwash speed 35 m/h
- Water loss 1.5 – 4 %

Ground water treatment



The city of Eindhoven

Province North-Brabant

The city of Eindhoven

Treatment plant Eindhoven

Figures

- Founded 1904
- Inhabitants 420,000
- Annual production 19 mil m^3 / year
- Max production 25 mil m^3 / year
- Production capacity 4000 m^3 / hour
- Distribution capacity 8200 m^3 / hour
- Storage 27,000 m^3

Eindhoven Water tower

Build: 1970

Architect: W.G. Quist

Height: 30 – 43 m

Volume: 3 x 500 m^3

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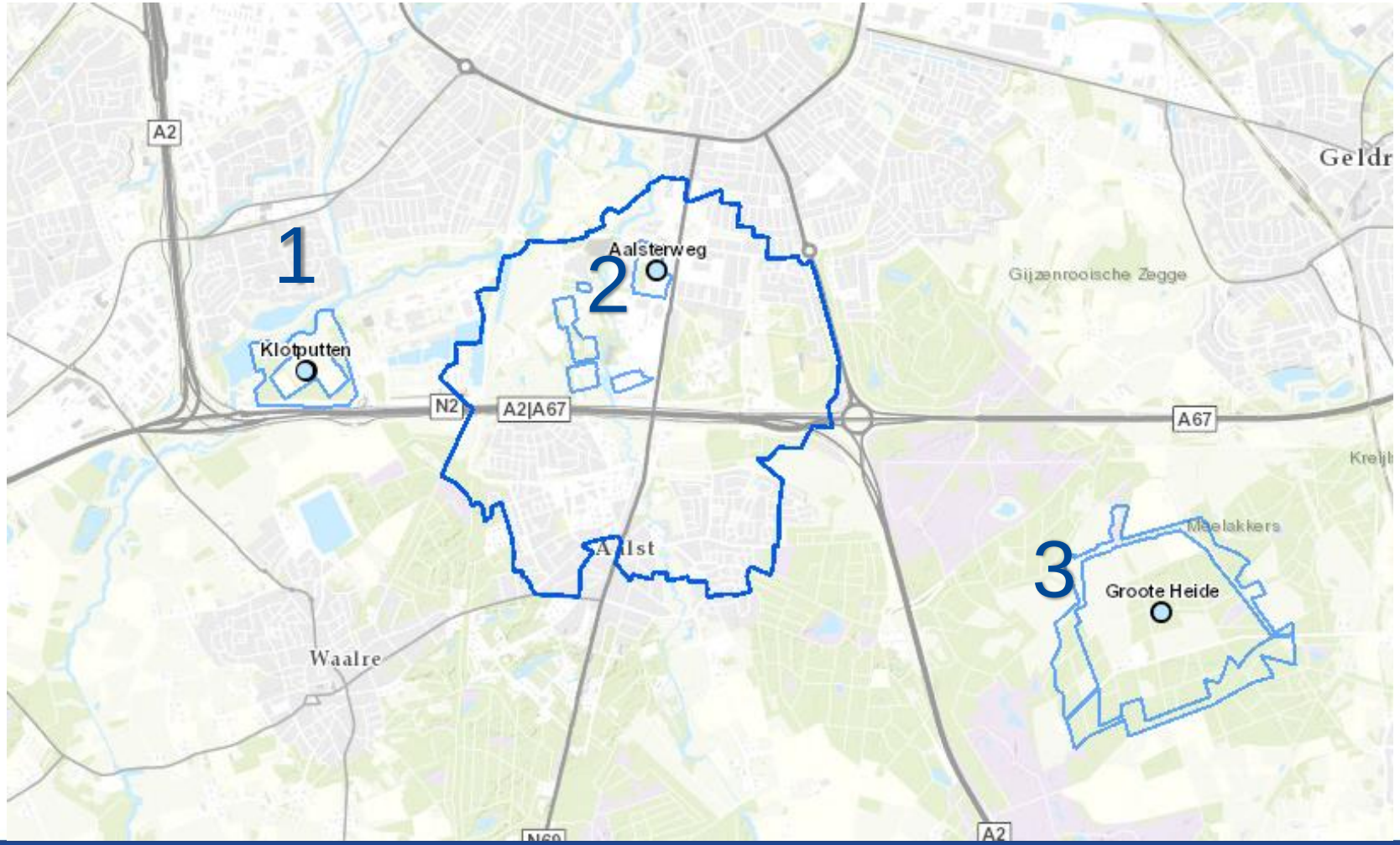
Three ground water borehole fields



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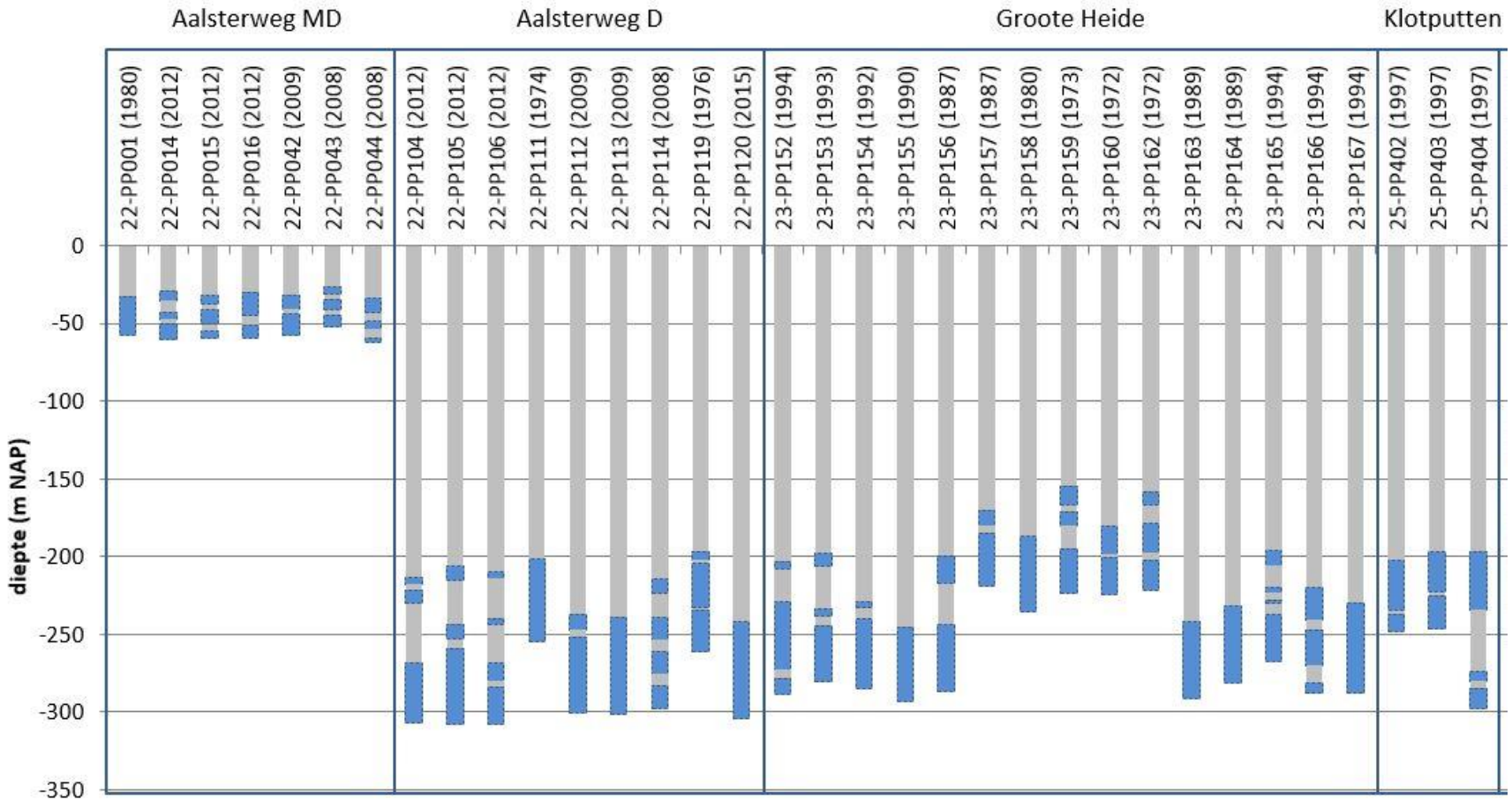
Abstraction depths



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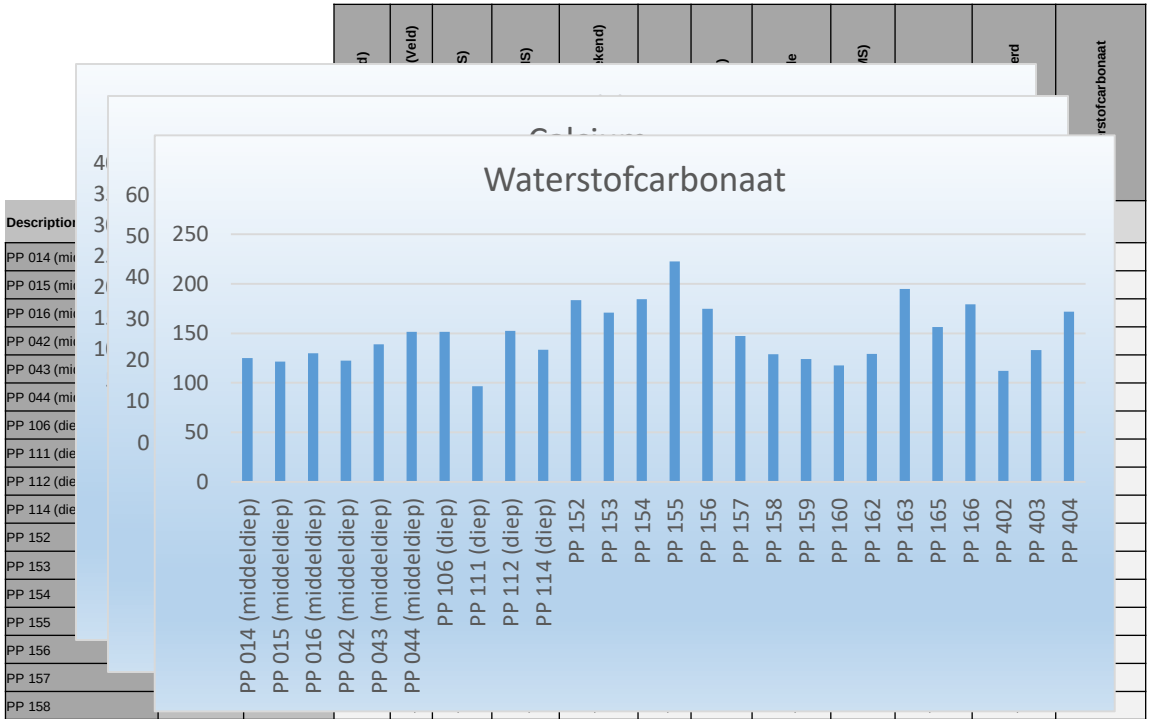
Variation in raw water quality



Description															
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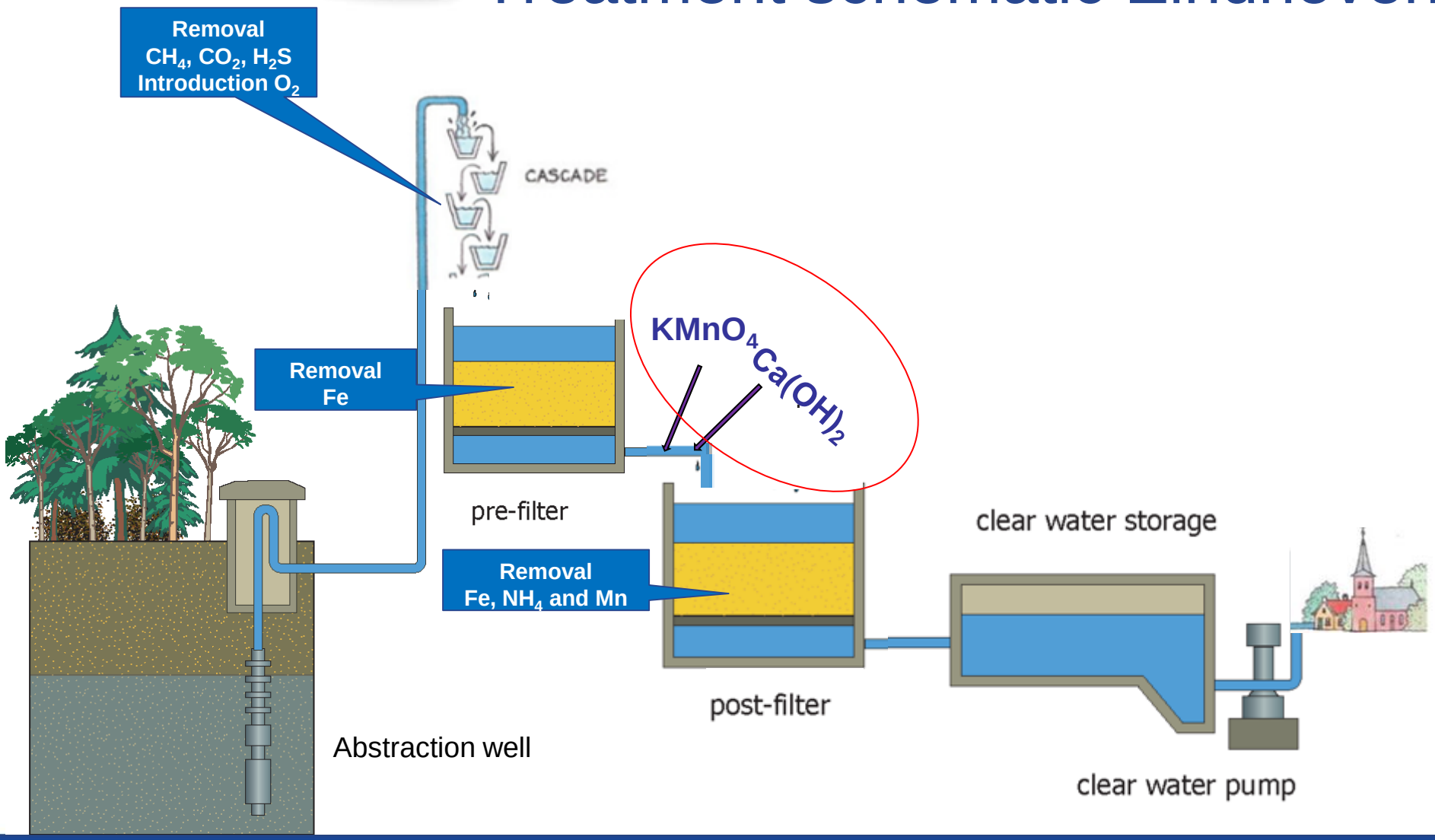
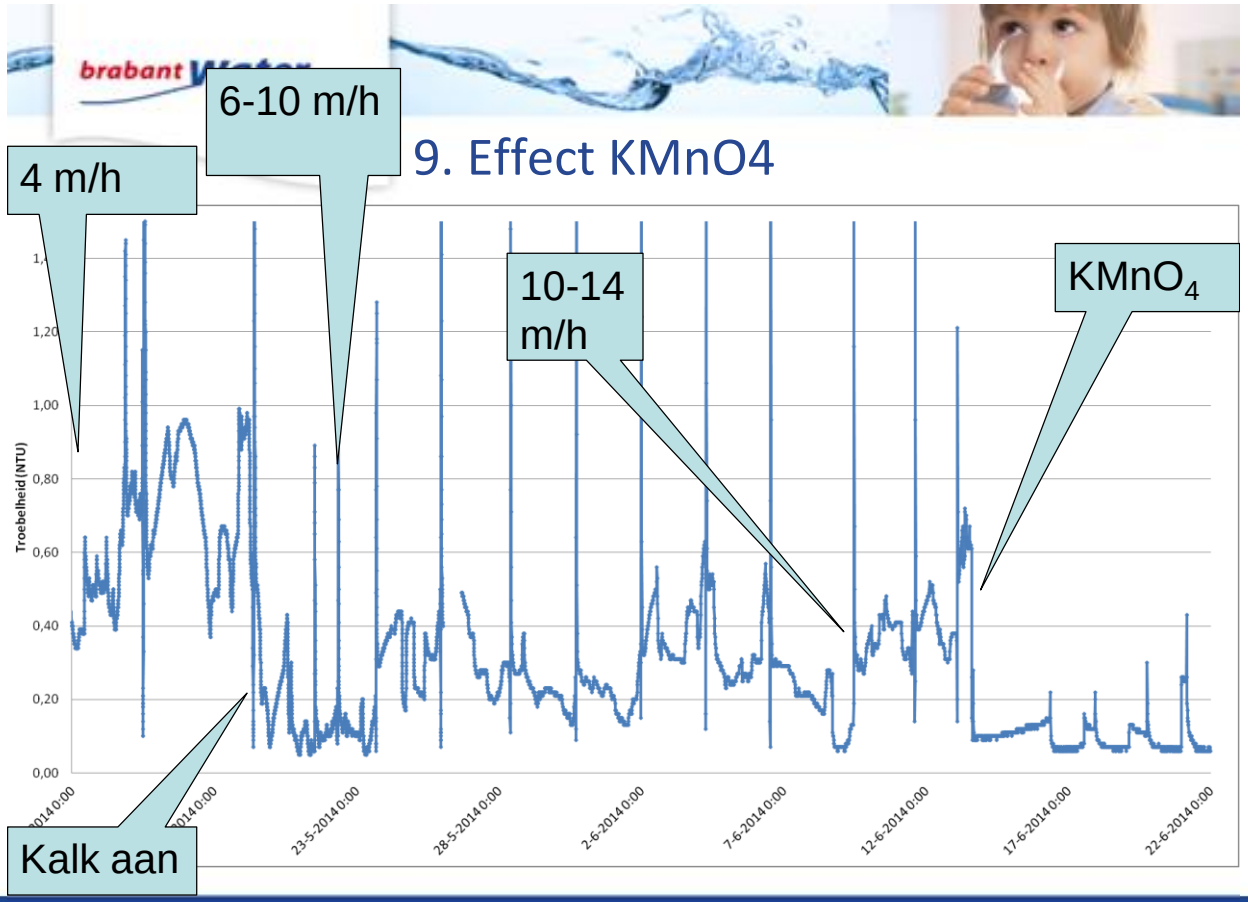
PP 159	13-12-2016	5080244	211	13,5	1,35	26,0	1,16	18,2	6172	30,9	149	6,8	17,9	124
PP 160	21-12-2016	5082050	200	11,4	14,51	24,2	1,07	18,1	7394	36	133	6,71	17,0	118
PP 162	14-12-2016	5080699	223	13,6	1,23	29,2	1,21	18,9	6916	32,1	152	6,8	18,2	129
PP 163	13-12-2016	5080245	334	14,9	2,61	39,6	0,79	29,0	3149	23,7	64	7,11	13,5	195
PP 165	13-12-2016	5080247	272	14,3	1,40	34,9	0,92	23,6	4352	28,1	82	6,94	14,3	156
PP 166	21-12-2016	5082048	308	13,2	1,35	34,8	0,75	26,8	3862	28,1	73	7	13,6	179
PP 402	16-12-2016	5081387	199	13,7	8,05	20,1	1,06	16,4	3156	15,7	78	7,05	14,2	112
PP 403	16-12-2016	5081385	230	13,4	11,55	23,4	0,87	19,0	3092	18,6	83	7,05	13,9	133
PP 404	16-12-2016	5081386	276	14,2	24,72	26,8	0,92	23,9	1720	10,2	38	7,42	13,2	172

Treatment schematic Eindhoven



Existing treatment

Water quality without chemicals



Water quality Eindhoven 2015

Random raw water quality treatment

Parameter	Eenheid	Aantal metingen	Bedrijfsnorm	Gemiddeld	Min	Max
Troebelheid	NTU	44	<0.5	< 0.10	<0.10	0.37
IJzer	µg/l	44	<50	<10	<10	10
Mangaan	µg/l	44	<20	<10	<10	<10
Arseen	µg/l	16	<1	0.84	0.70	0.99
Ammonium	mg/l	44	<0.05	<0.03	<0.03	0.03
Nitriet	mg/l	44	<0.05	<0.01	<0.01	<0.01
Totale hardheid	mmol/l	4	< 2.0	1.16	1.10	1.23
Kol 22	kve/100 ml	44	<100	2	0	42
Aeromonas	kve/100 ml	44	<20	0	0	0
Zuurgraad	pH-eenheden	44	7,3 > pH < 9	8.03	7.92	8.15

Pilot research

- The renovation of the treatment in Eindhoven is planned for 2020
- Understanding role of chemicals existing treatment
- Looking for an alternative treatment
  - Reducing use of chemicals
  - Reducing maintenance treatment

Iron removal in general

aeration – filtration treatment

- Design and operating mostly based on experience and rules of thumb
- pH is widely regarded as a major parameter that determines the iron removal efficiency
- The ionic composition of water may also strongly affect iron removal, especially during the flocculation phase

Research goal

Understanding the important role of calcium (Ca) and bicarbonate (HCO_3) in iron removal during aeration—rapid sand filtration

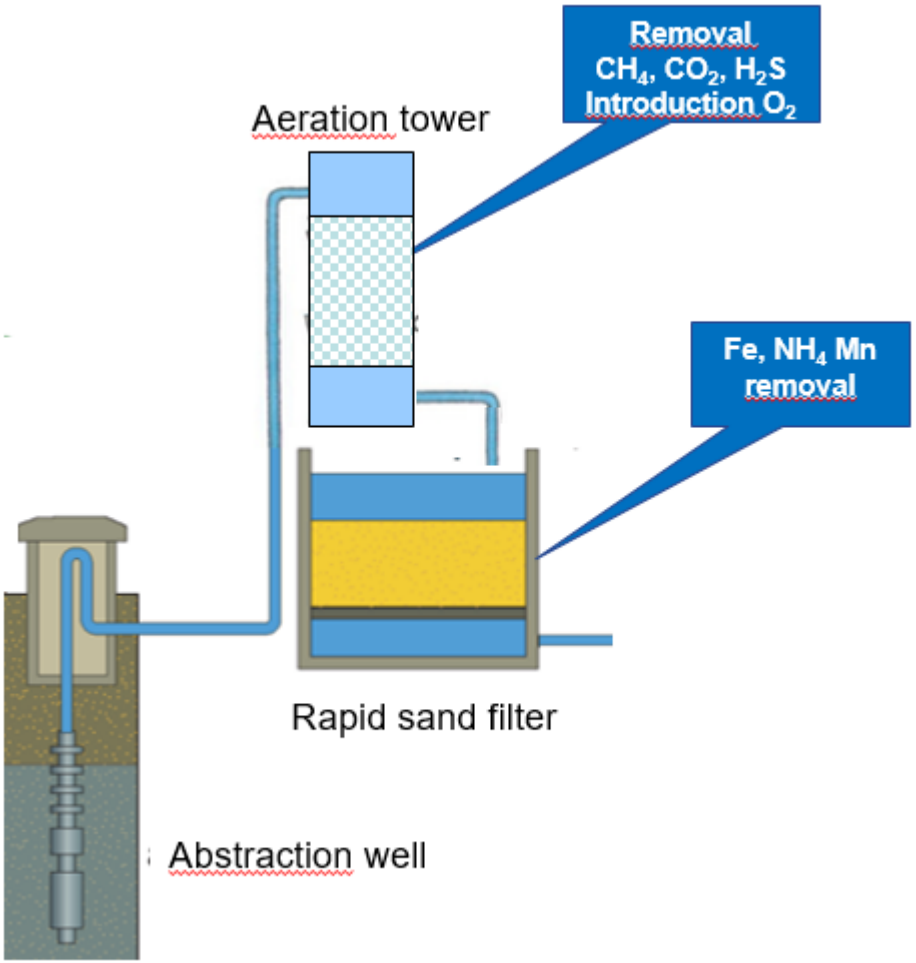
Pilot set up

Aeration tower

- Filtration rate 60 – 120 m/h
- Filling material 25 mm plastic Pall ringen
- Bed height 2.0 m
- Surface area 0.27 m^2
- Air / water ratio 3

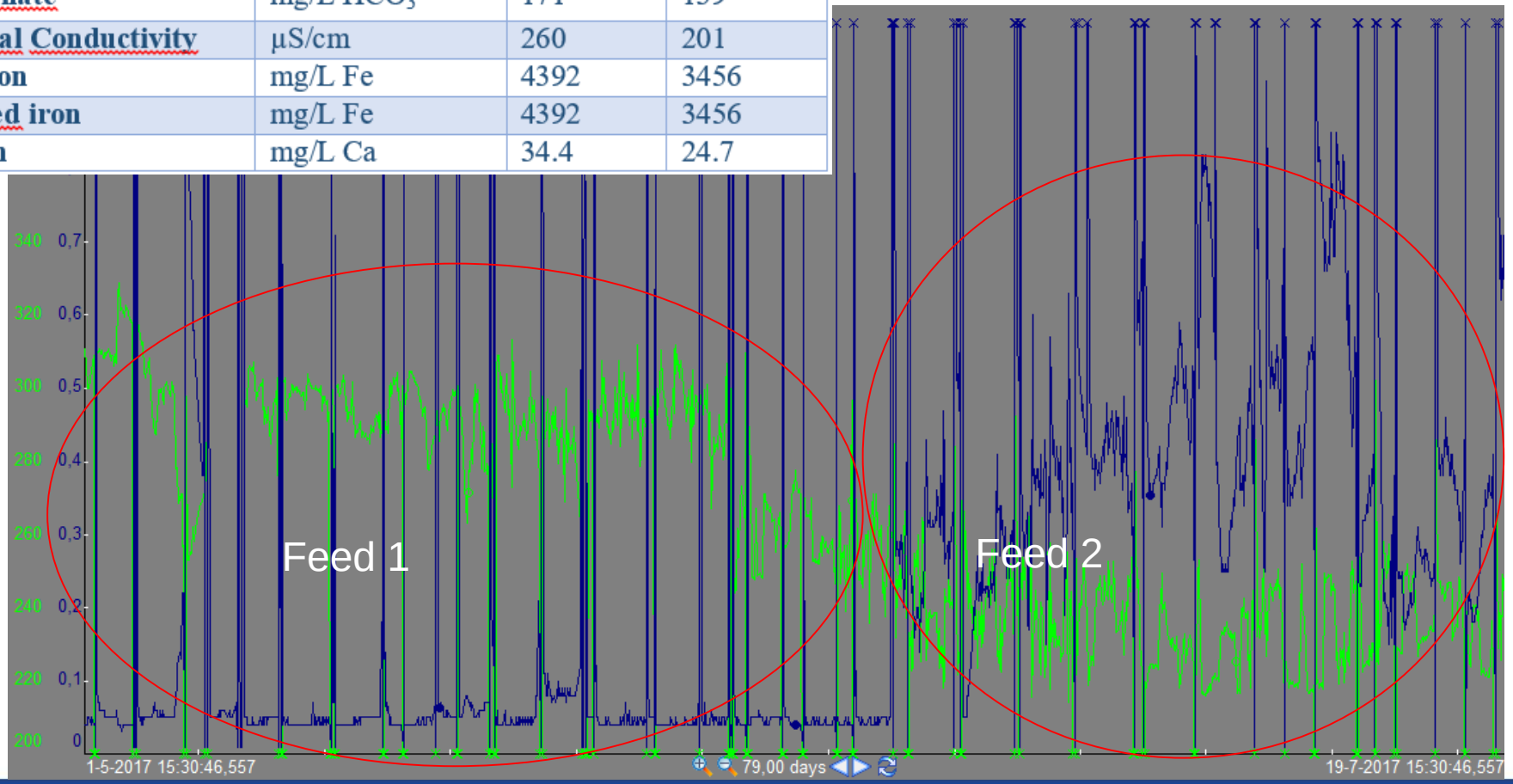
Rapid sand filter

- Filtration rate 3 – 7.5 m/h
- Filter media 0.71 – 1.25 mm
- Surface area 0.8 m^2
- Bed height 2.0 m
- Running times 35 – 120 hours
- Backwash speed 35 m/h
- Water loss 1,6%

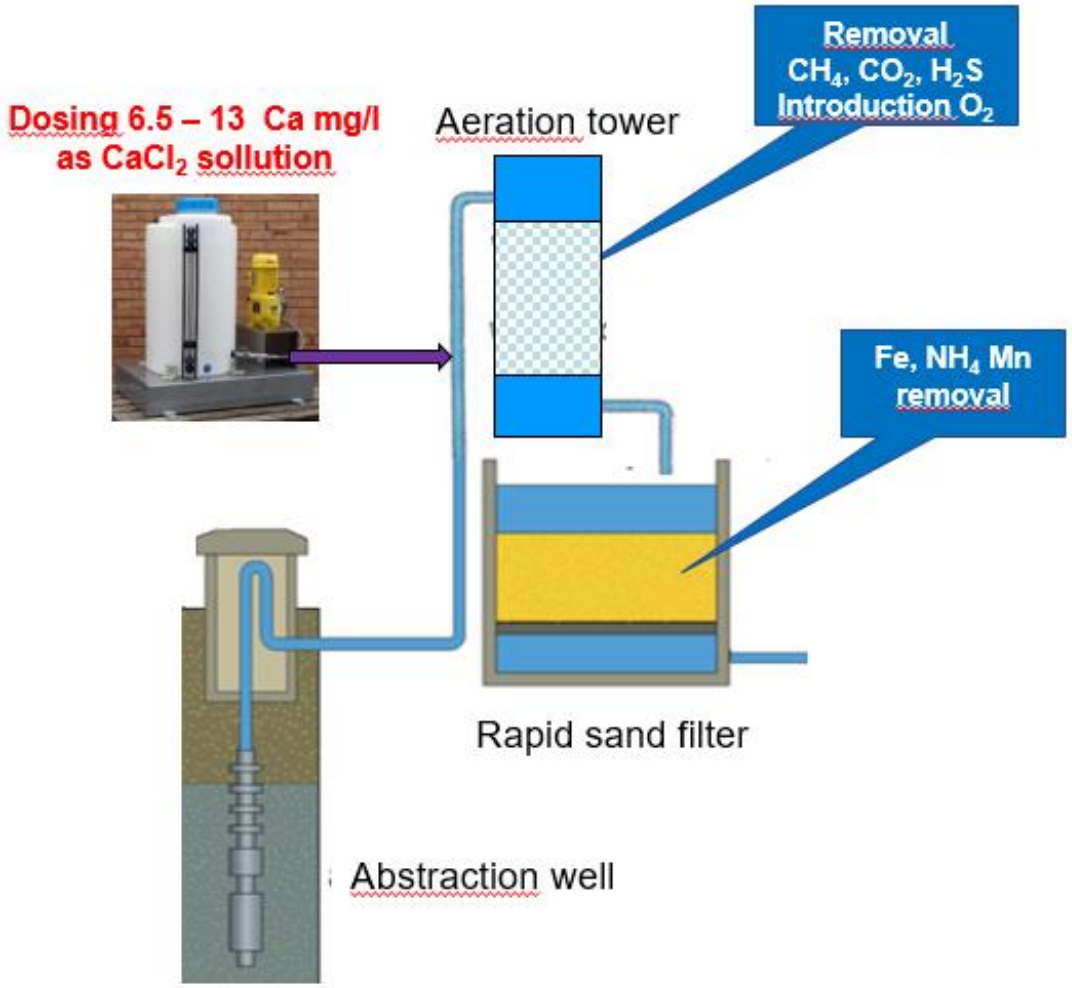


Iron removal as function of water quality

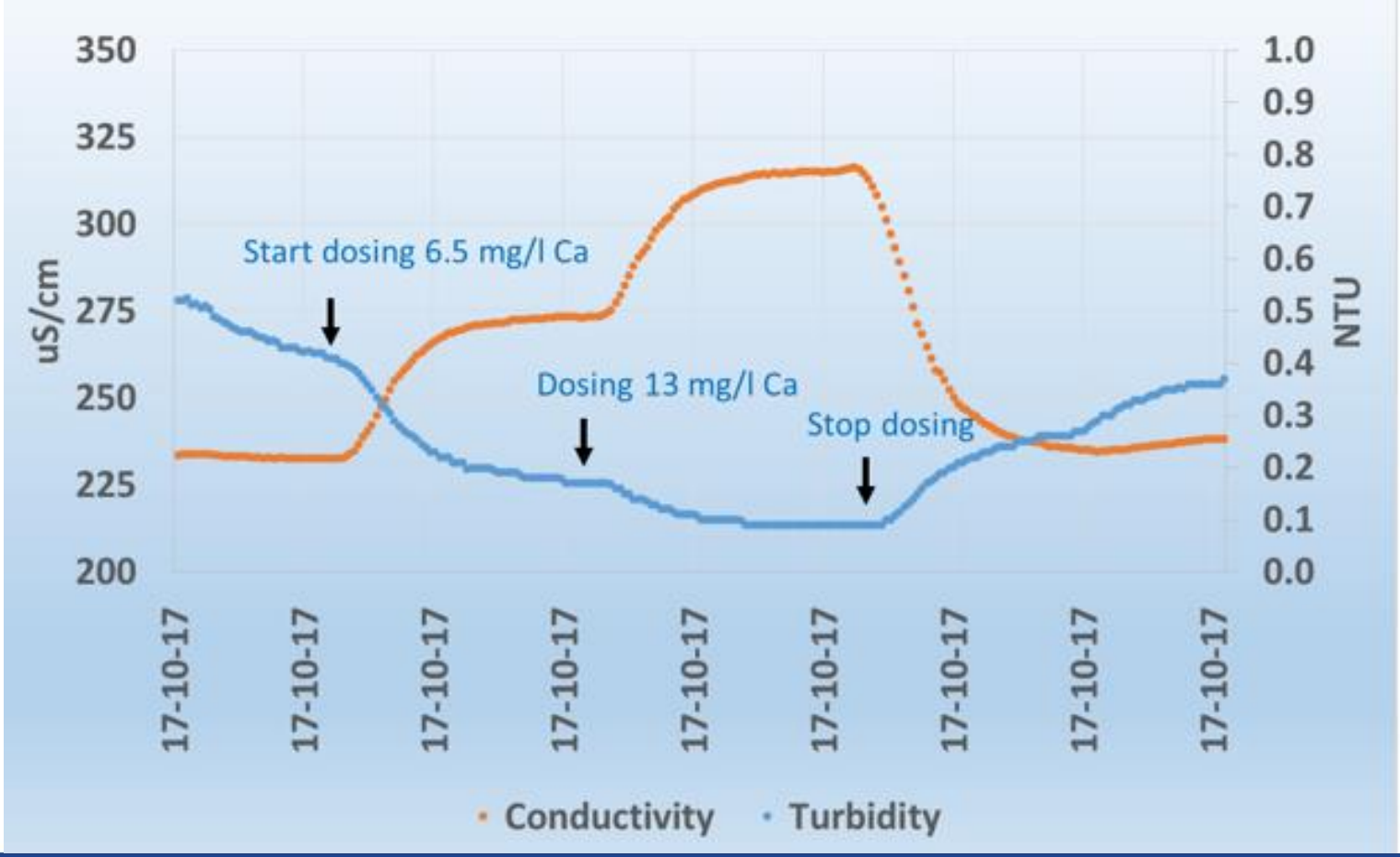
Parameter	Unit	Feed 1	Feed 2
pH		6.96	7.18
Bicarbonate	mg/L HCO_3	171	139
Electrical Conductivity	µS/cm	260	201
Total iron	mg/L Fe	4392	3456
Dissolved iron	mg/L Fe	4392	3456
Calcium	mg/L Ca	34.4	24.7



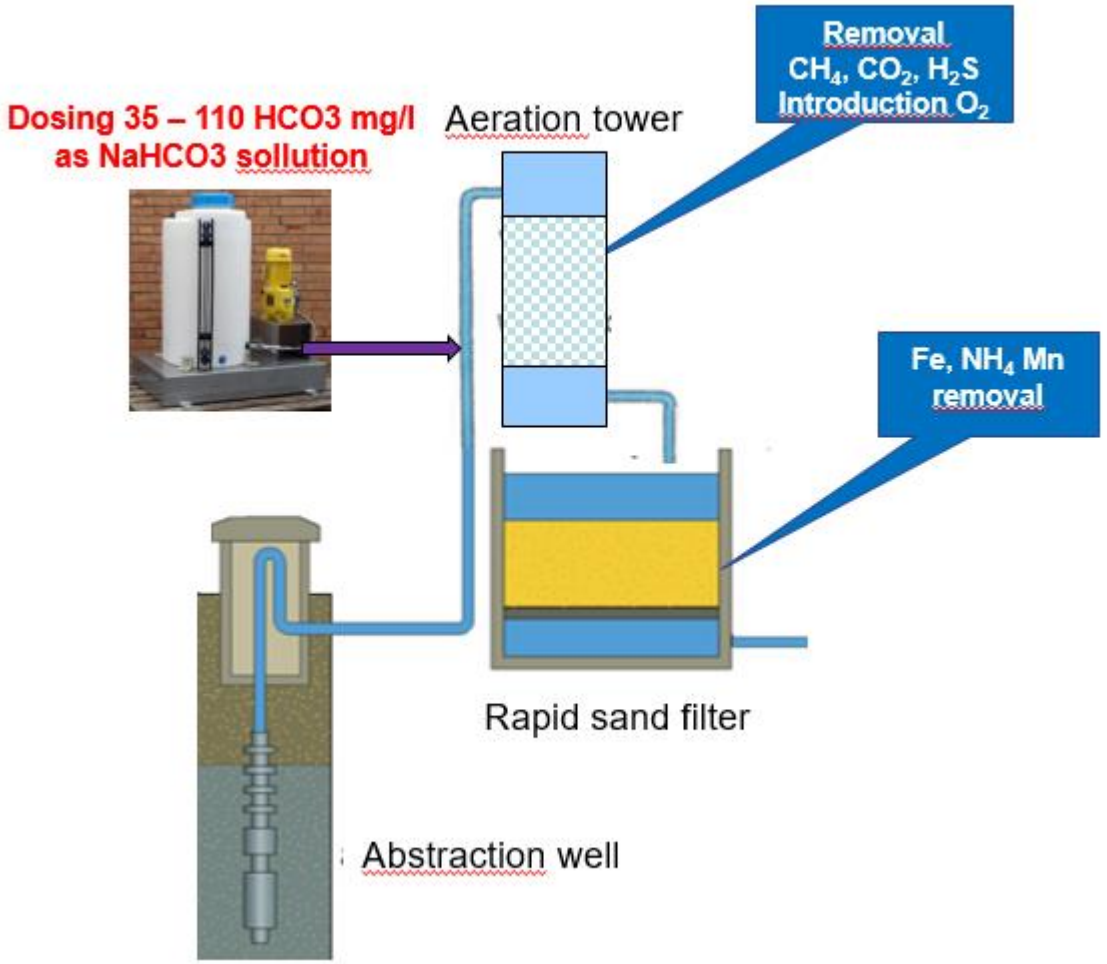
Effect of Calcium dosing



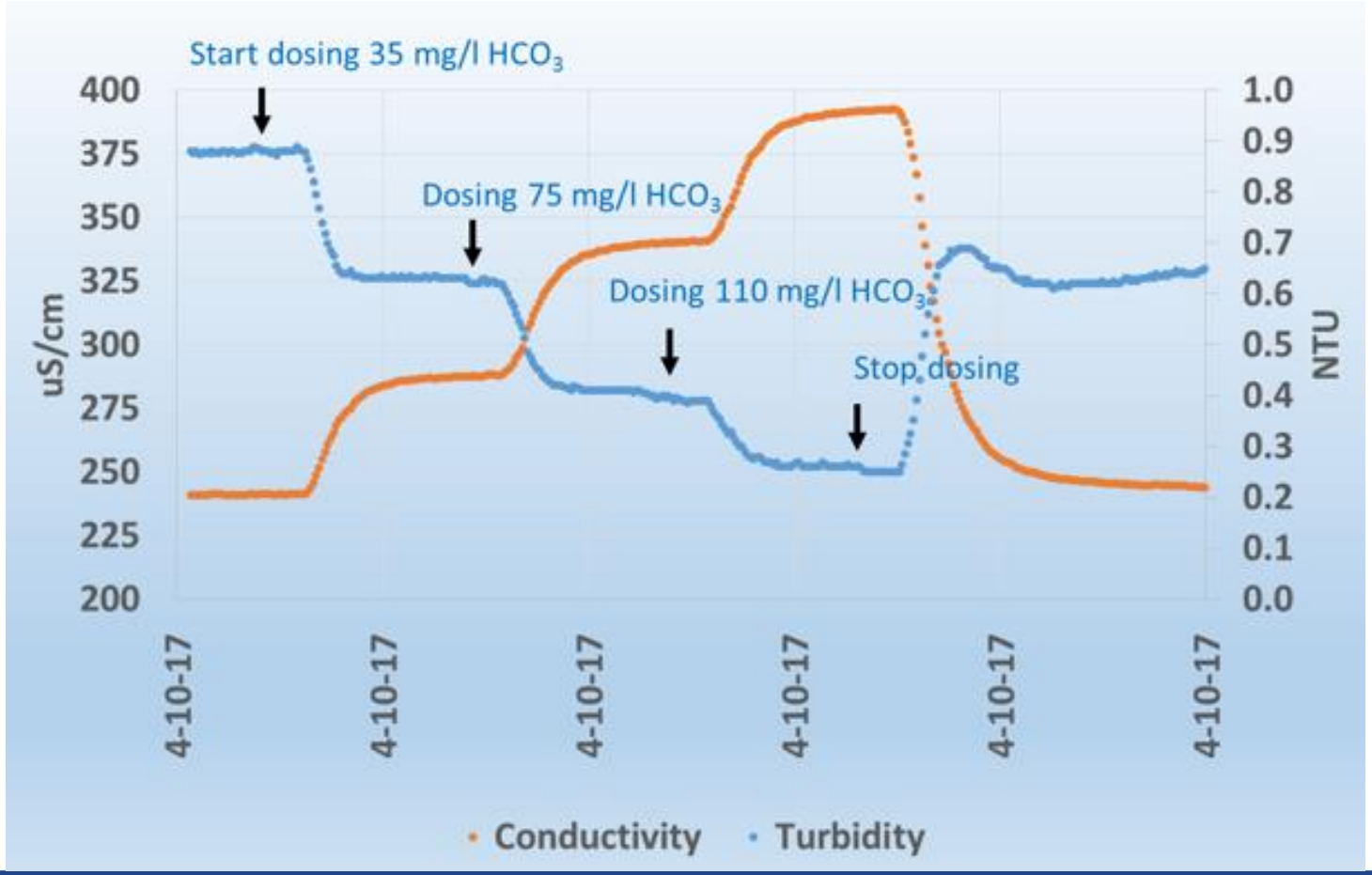
Effect of Calcium dosing



Effect of bicarbonate dosing

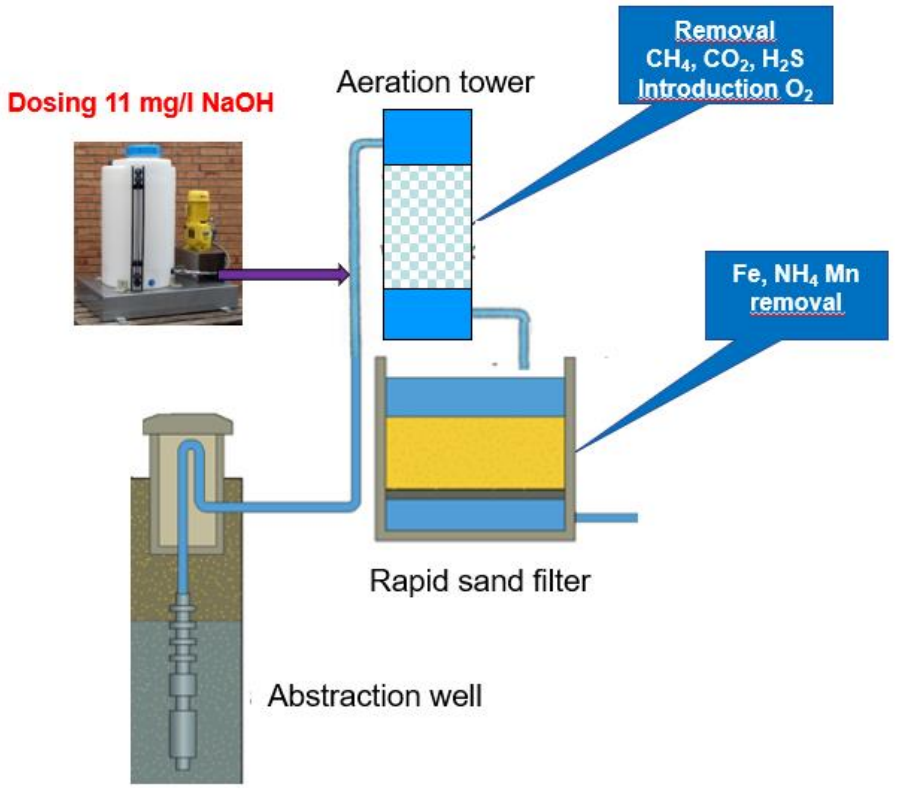


Effect of bicarbonate dosing



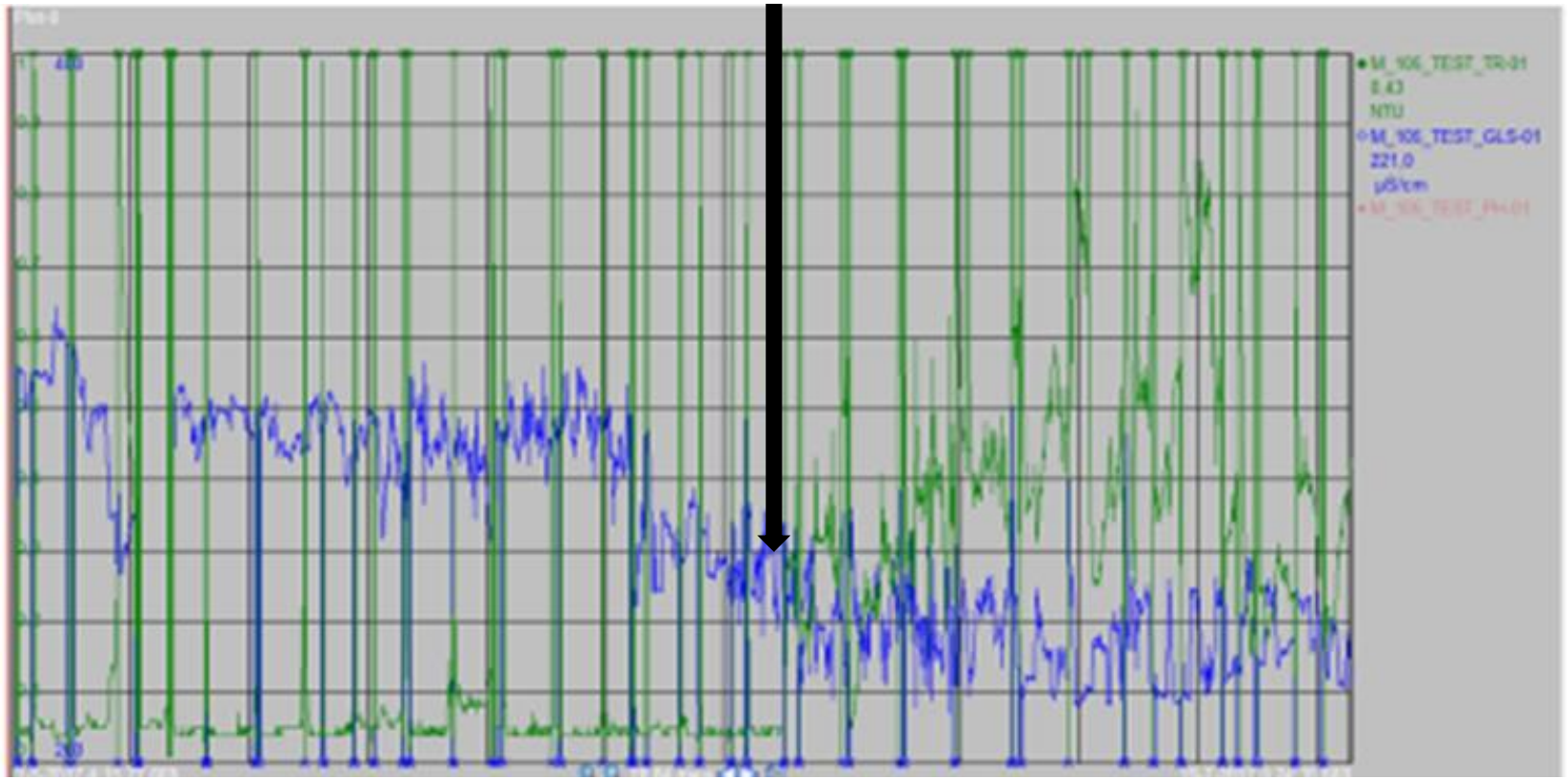
Final treatment schematic for Eindhoven

To support iron removal we dosed NaOH instead of $CaCl_2$ or $NaHCO_3$.
A small increase in HCO_3 was enough for excellent and robust iron removal



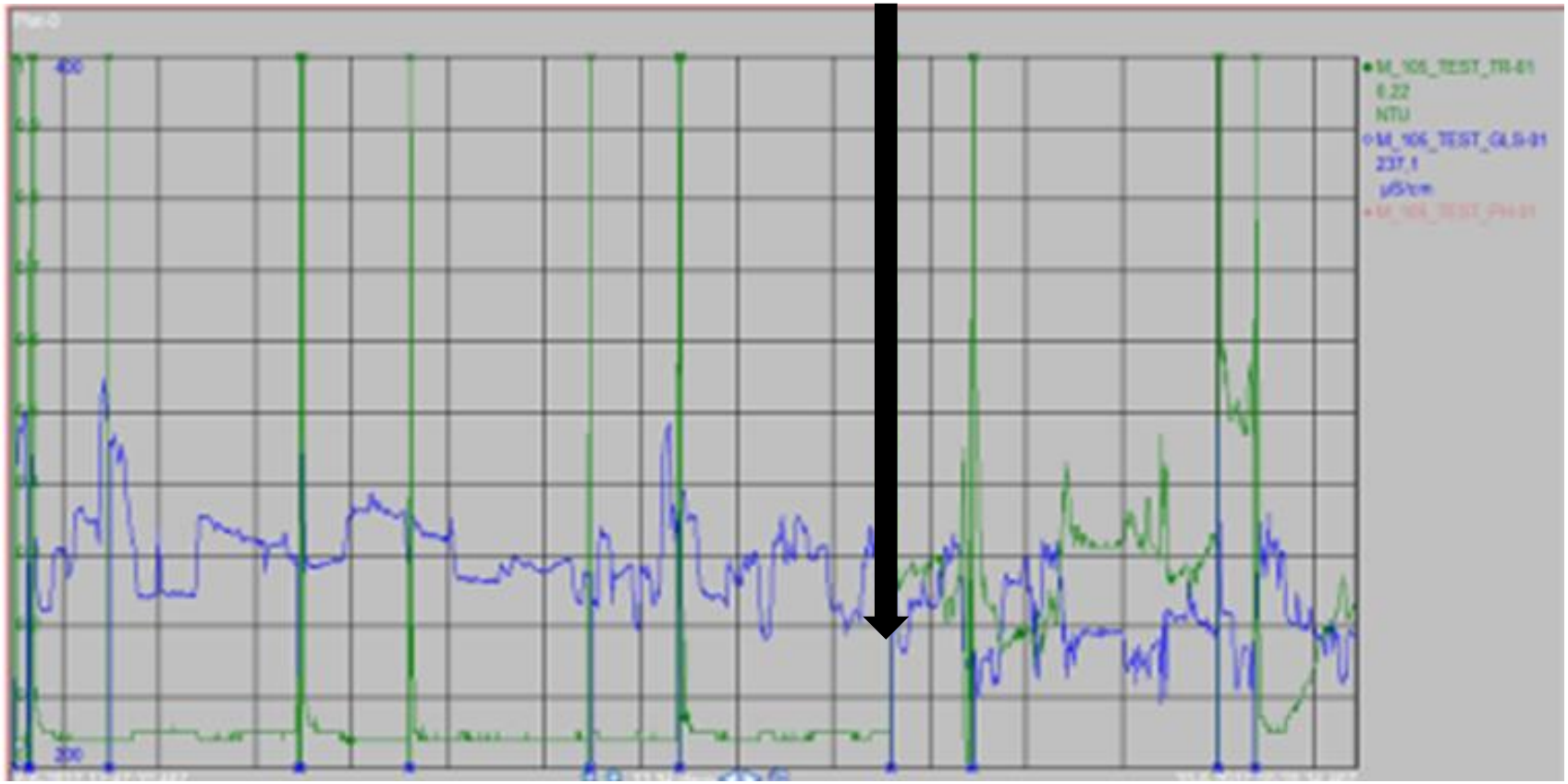
Without dosing NaOH

Lower conductivity, higher turbidity



With dosing NaOH

Effect switching of NaOH dosing



Conclusions and outlook

- Major groundwater ions HCO_3 and Ca have a profound impact on the filterability of iron in rapid sand filters. Higher concentrations of these ions in raw water may lead to better removal of iron in rapid sand filters
- These new insights have been already helpful in optimizing iron removal at several other treatment plants of Brabant Water
- The specific role of Ca and HCO_3 during Fe removal in classic rapid sand filtration should be studied further to gain mechanistic insights
- Fundamental research on this topic is started at WETSUS institute
- HCO_3 an Ca as ions are added to the KWR modeling research on iron removal with rapid sand filtration

Thank you for your attention

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http://www.h2o-watermatters.com/

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