Biofilm remediation of Aluminum, Iron and Manganese using “microchip wetland” Metal Removal Units (MRU’s)

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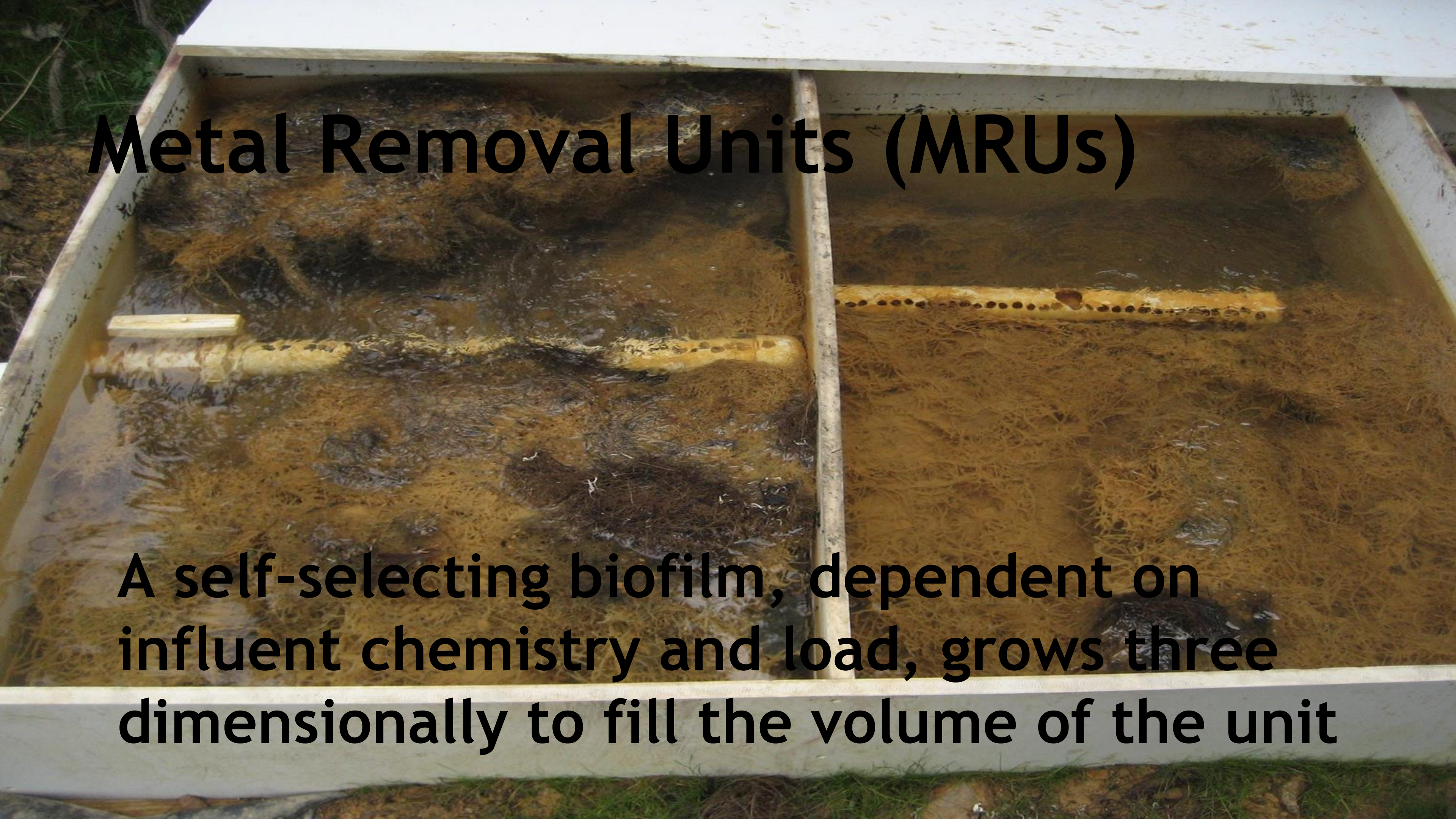
What is Biofilm?

“By the skin of your teeth”. A colloid, like mayo. Covers every square inch of surface area on the planet. Up to 50% of all biomass. Primary active/passive component of wetland conversion processes.

Glasgow, 2013, MRU prototype in operation

Metal Removal Units (MRUs)



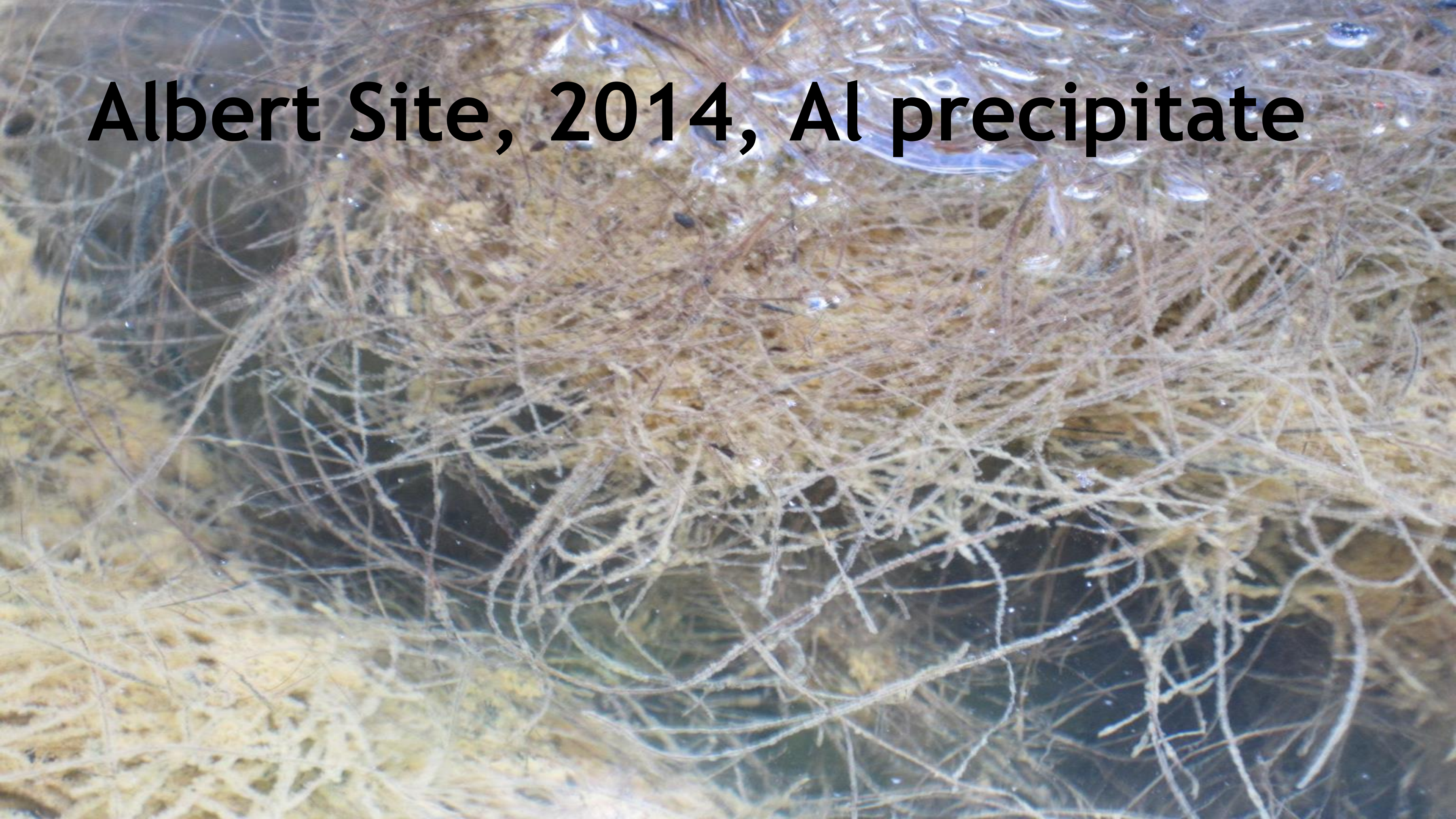
A self-selecting biofilm, dependent on influent chemistry and load, grows three dimensionally to fill the volume of the unit

Metal Removal Units (MRUs)

The biofilm expands from the loose fiber, neutrally buoyant, coconut coir endoskeleton which acts as the microbial growth matrix.

Waterfall steps provide periodic diffusion to saturation of dissolved O2 for BOD and COD satisfaction.

Albert Site, 2014, Al precipitate



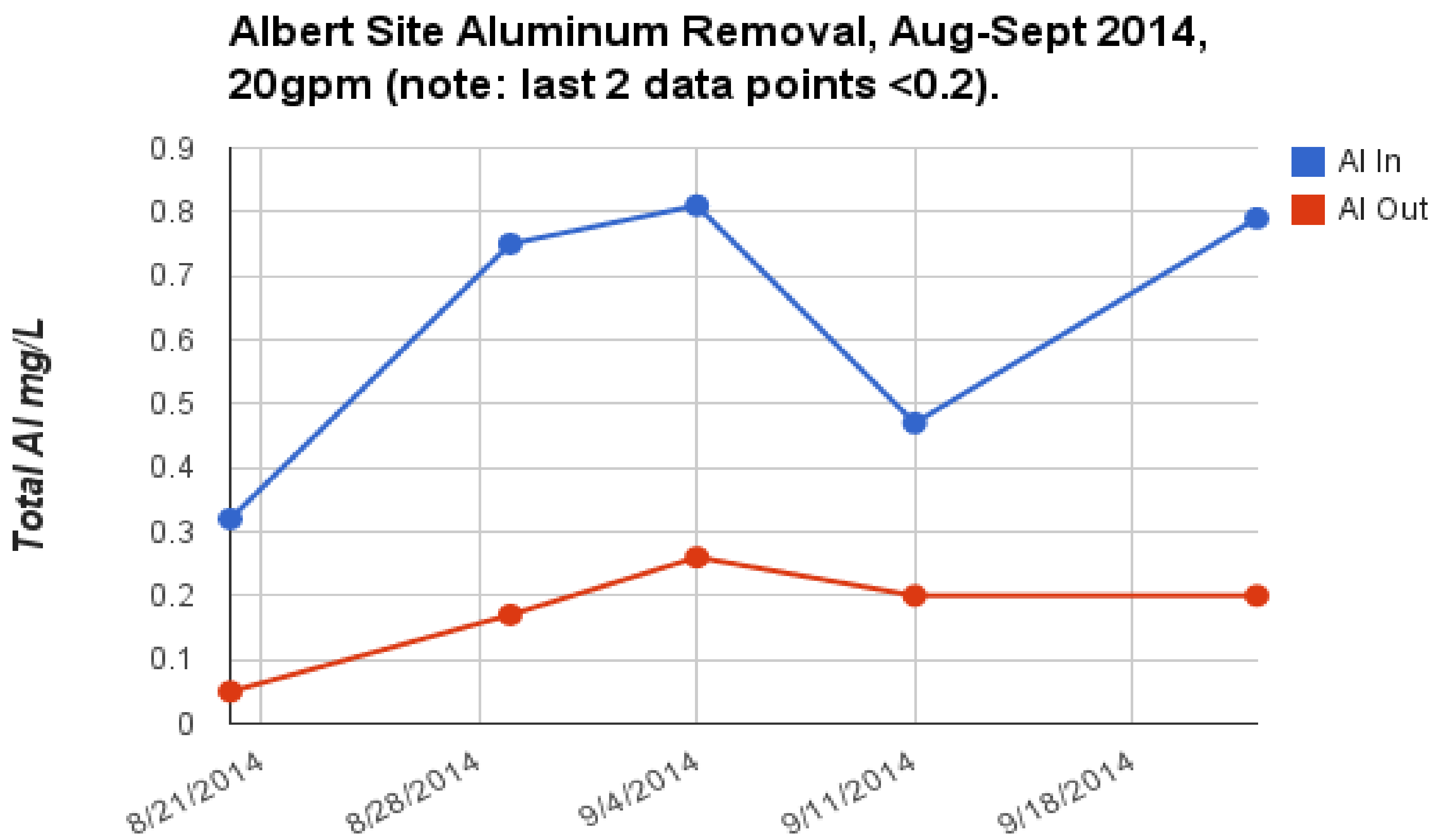
Aluminum

Ionic adhesion to biomass

Positive Charge of Al hydroxide and generally negative charge of the biomass.

No re-dissolution from high pH

Albert Site, 2014


Albert Site Aluminum Removal, Aug-Sept 2014, 20gpm (note: last 2 data points <0.2).
Total Al mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
8/21/2014
8/28/2014
9/4/2014
9/11/2014
9/18/2014
Al In
Al Out

Total Iron

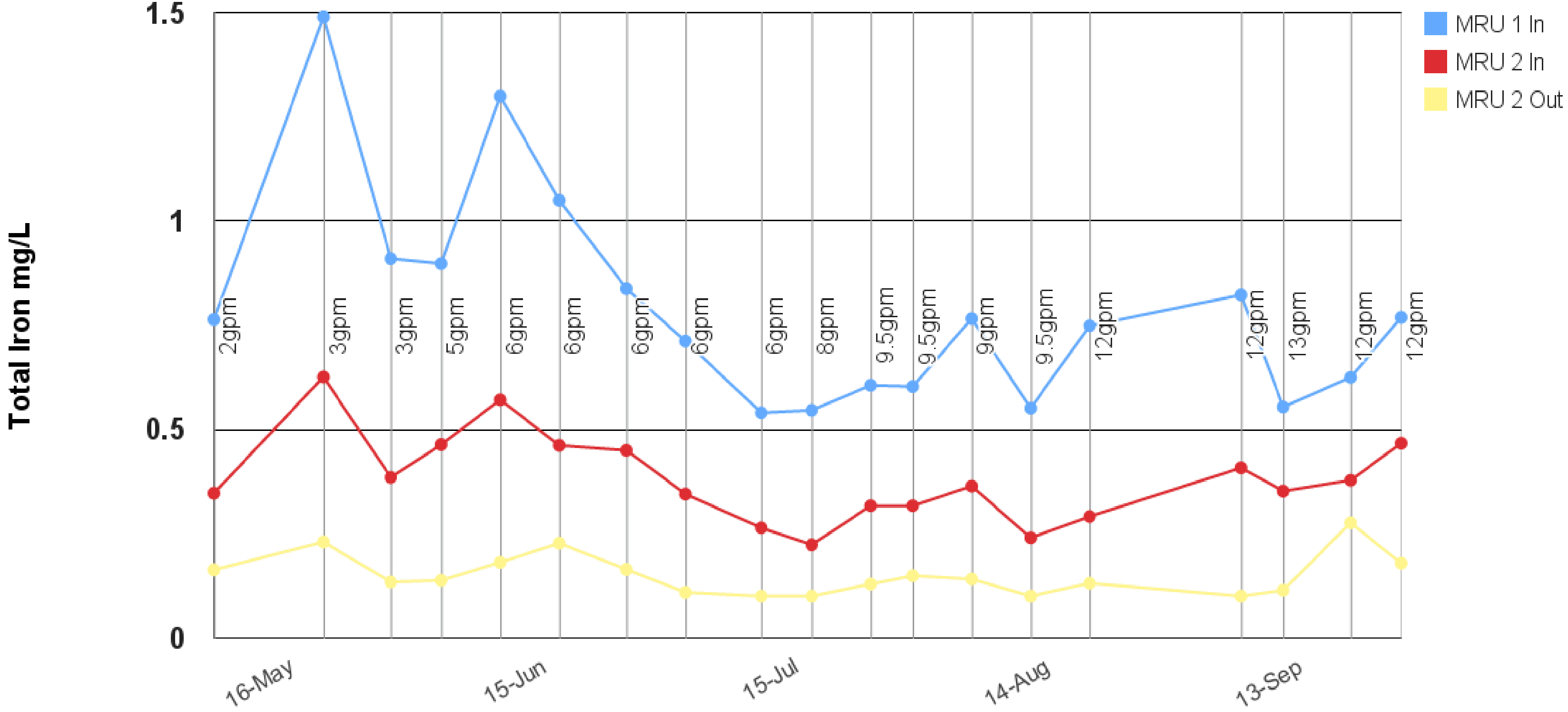
Dissolved and Precipitating Iron are both removed using Metal Removal Units.

Ferrous finishes it's oxidation to ferric, and is then removed, like aluminum, through adhesion to biofilm.

Albert Site Total Fe and Al Removal, Sept 2014

Flight 93, 2014, operational in 2013

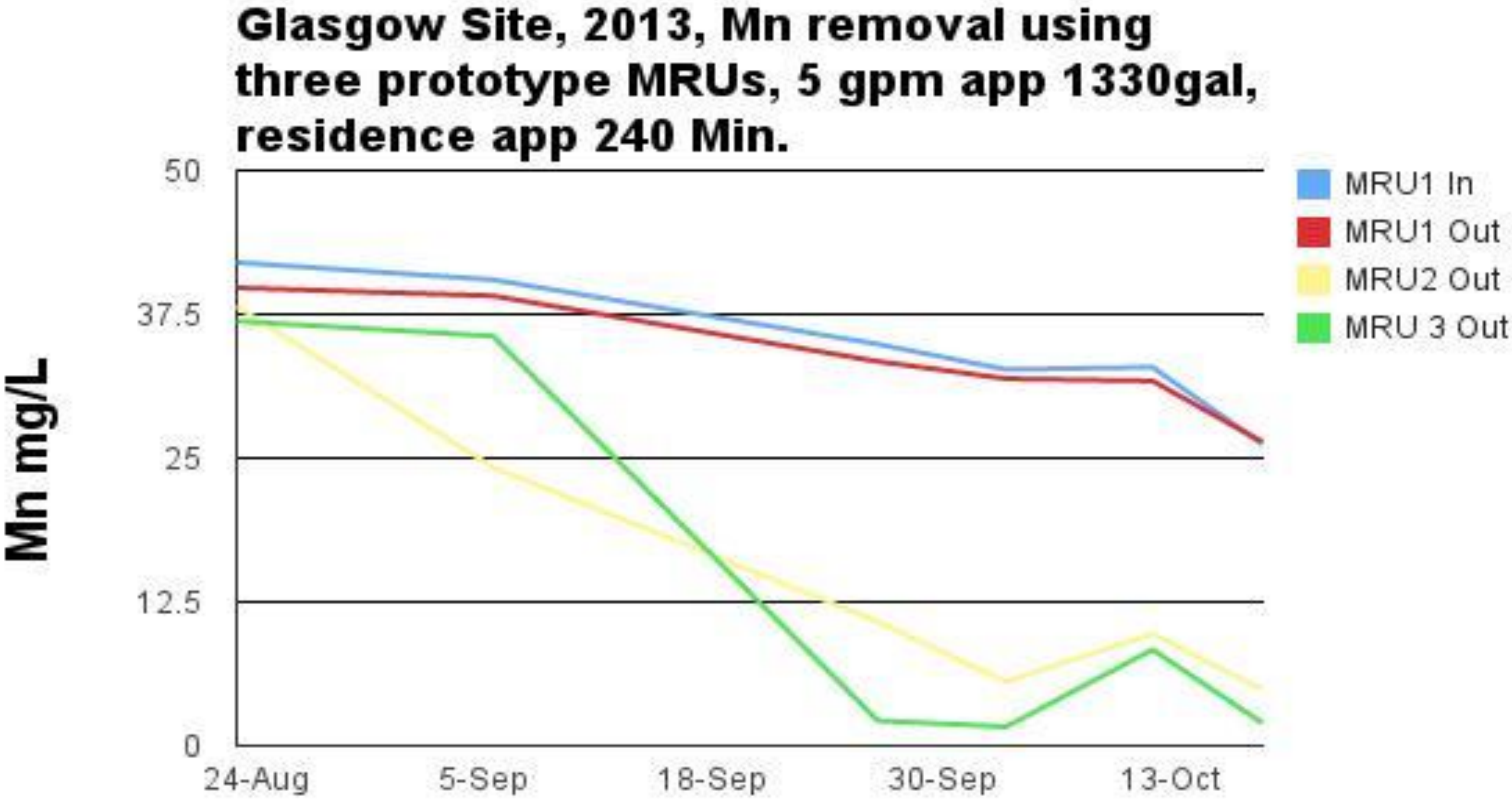
Figure E, Flight 93 Memorial, 2013 Total Iron Removal Comparisons, app 530 Gallon Total Volume, Residence Time of 176 minutes (3gpm) to 44 Minutes (12gpm).



Key discovery: manganese will not bio-oxidize at pH 7 until ferrous iron (dissolved), and even ferric iron (precipitate), are roughly below 0.42 to 3.0mg/l. Between cell 1 and cell 2, redocline was surpassed and MnO_2 precipitated.

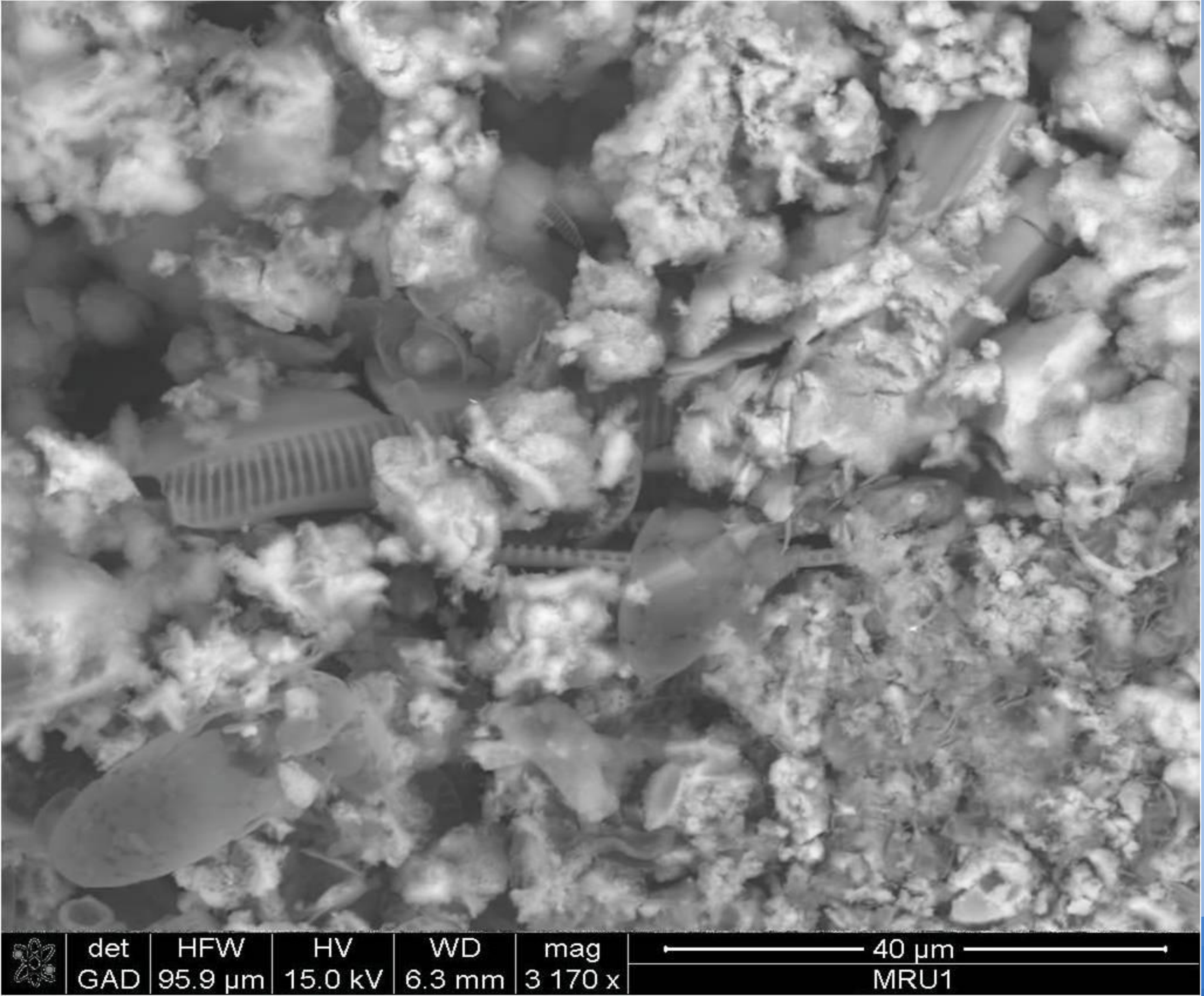
Glasgow, 2013, MRU prototype in operation


Glasgow Prototype MRUs
2012-13


Glasgow Site, 2013, Mn removal using three prototype MRUs, 5 gpm app 1330gal, residence app 240 Min.
Mn mg/L
50
37.5
25
12.5
0
24-Aug
5-Sep
18-Sep
30-Sep
13-Oct
MRU1 In
MRU1 Out
MRU2 Out
MRU 3 Out

“{(5 gal/min) * (23 mg Mn/L)]/24 ft^2) * (1/1000) (g/mg) * 3.78 (L/gal) * 1440 (min/day) * 10.76 (ft^2/m^2) = **281 (g Mn/d*m^2).**

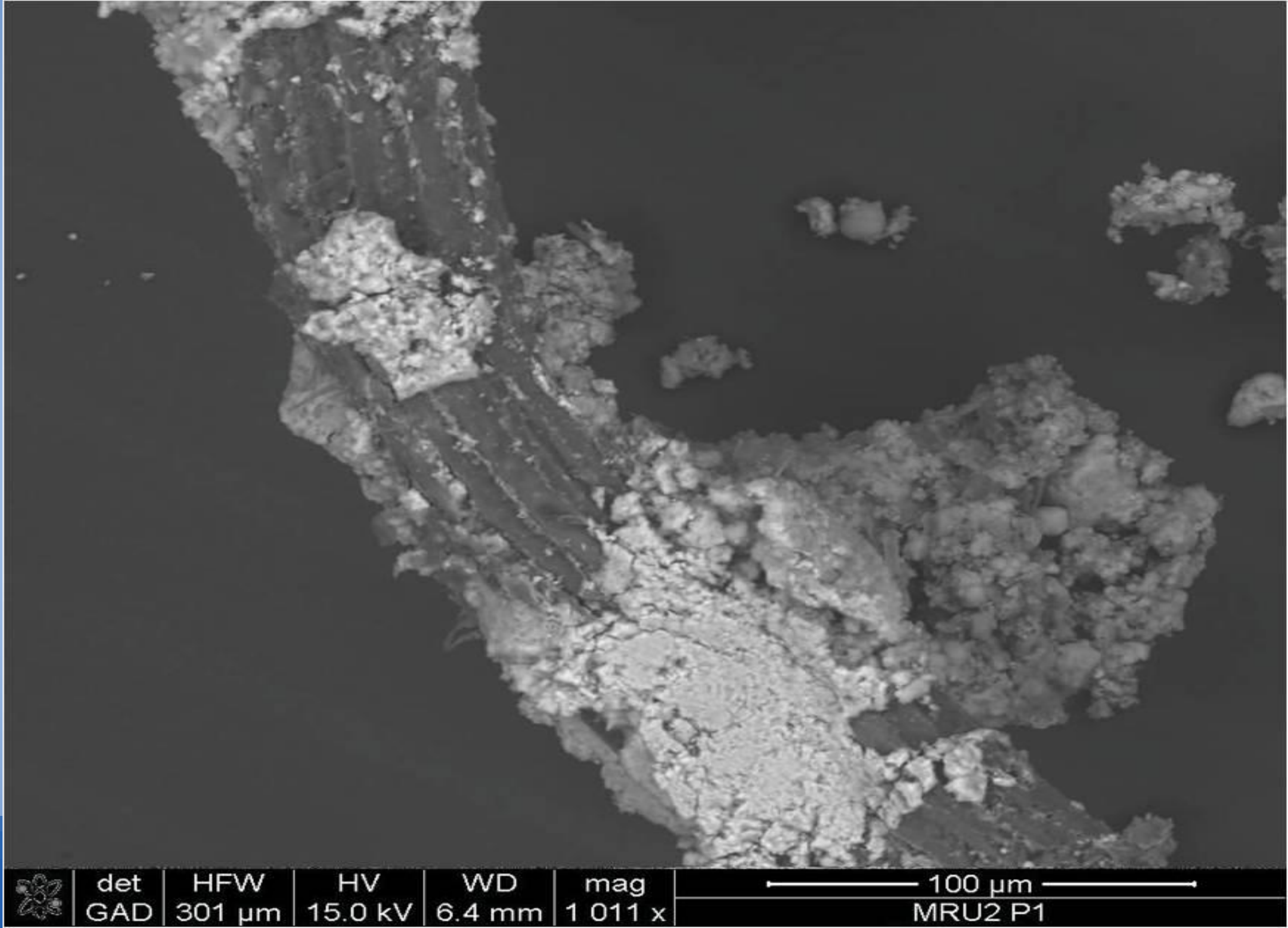
We examined 8 conventional limestone-based Mn removal beds and calculated GDM values of ~2 – 10 (g Mn/d*m^2) (see Santelli et al. 2010). Your unit is 28 – 140 times better than any of those!” (W. Burgos, 2014, personal correspondence concerning Glasgow calculations.)

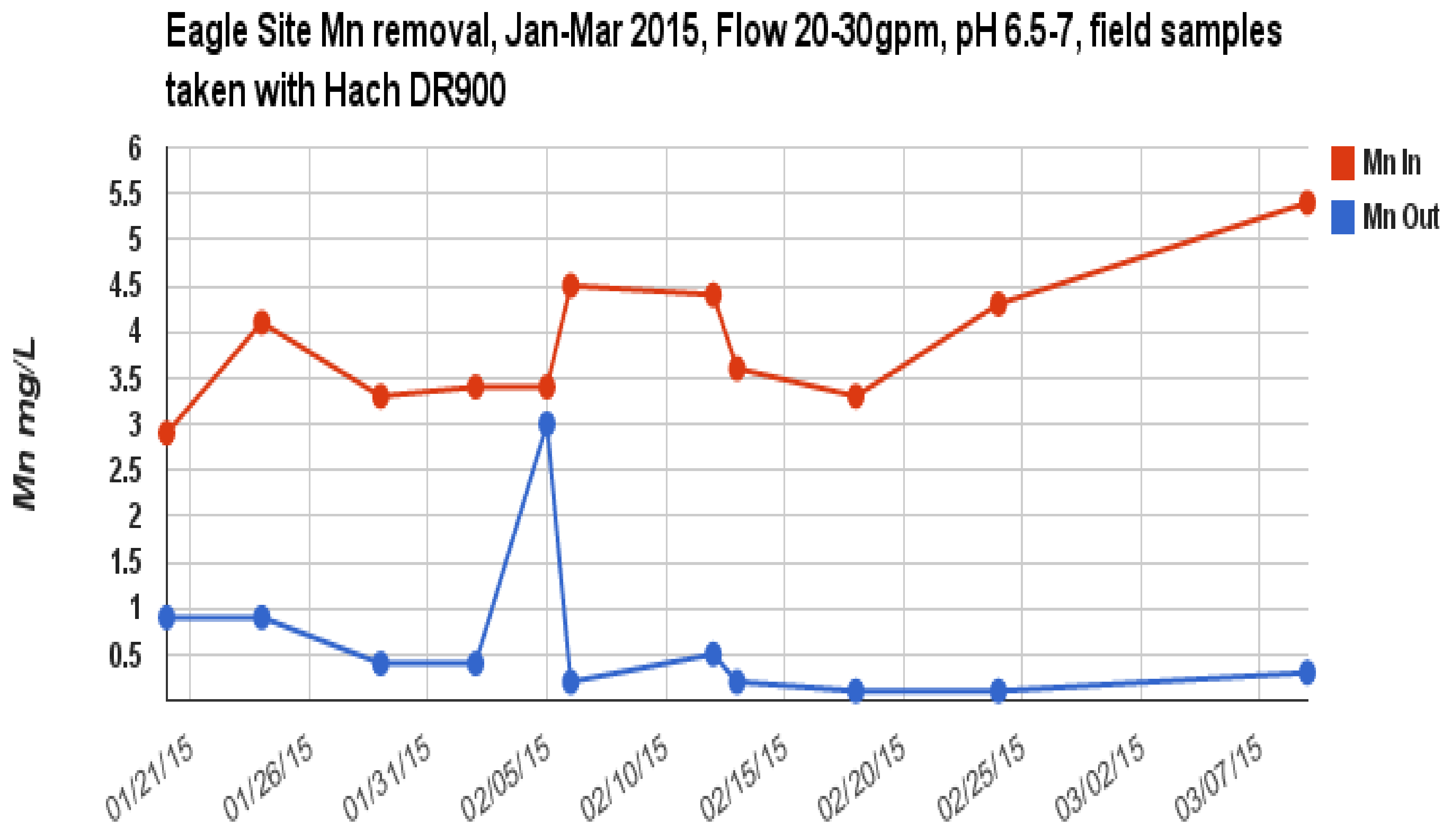


Manganese Dioxide, identified as rancieite mixed with diatoms, SEM. (Ling. F. 2014. Glasgow Site.)

Coir and MnO2 particles

(Ling, F. 2014.Glasgow Site.)




Eagle Site Mn removal, Jan-Mar 2015, Flow 20-30gpm, pH 6.5-7, field samples taken with Hach DR900
Mn mg/L
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
01/21/15
01/26/15
01/31/15
02/05/15
02/10/15
02/15/15
02/20/15
02/25/15
03/02/15
03/07/15
Mn In
Mn Out

Eagle Site, Dec 2014, special thanks to Bentley Development Co. Inc.

Eagle Daily Removal @ pH 6.5-7

Average In = 3.7mg/L Mn. Out = 0.39 mg/L Mn (when the 3.0mg/L outlier is removed).

(25gpm x 3.78L/gal x 3.3mg/l Mn x 1440min x 1/1000) / 3 meters square = 149.68 grams/day/m2 or, 158.67g/d/m3
449 grams/day/3m2 for both MRUs

Coconut Coir: Lignin

“the 3rd most common plant polymer”, “Lignin degrades slowly (bc) it is constructed as a highly heterogeneous polymer (which) precludes the evolution of specific degradative enzymes.”

“The peroxidase enzyme and H2O2 system generate oxygen-based free radicals that react with the lignin, (Morgan et. al 1993. from Environmental Microbiology. 2000. pg 325,).

So what?

In theory, the dissolved metal ions are scavenging the Oxygen-based free radicals. This could prolong the life of the coir while gaining additional dissolved ion oxidation.

For consultations, site visits, or professional or educational presentations please contact:
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Bibliography

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