

Fay Environmental



manganese removal

from ground water

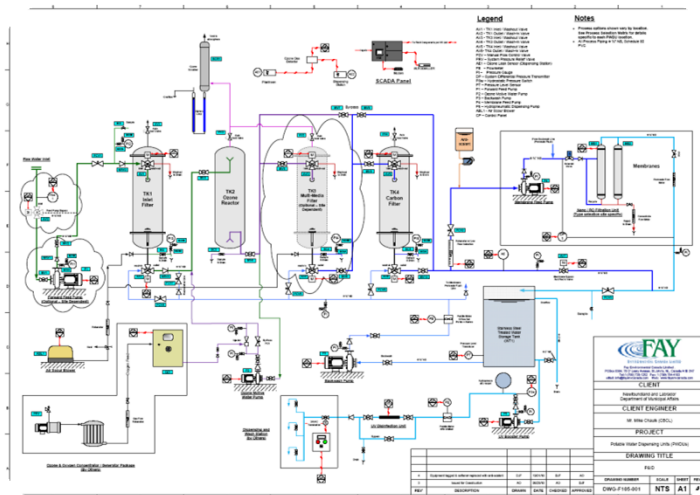


our company.



- Specialist process contractor
- Design / build water and sewage treatment plants

(...mostly water)



some projects.



- Small-scale Advanced Drinking Water Systems
- Holyrood (manganese removal)
- Burgeo
- Terra Nova Park
- Gander

The **CD400** – check out www.adws.ca



the CD400.



Several stages of filtration

There are several stages of filtration to get that pristine water.

First, the water passes through a sand filter. Then it undergoes ozonation, which bleaches and disinfects the water, and takes out different contaminants. The water then goes through a multimedia filter, with sand and anthracite, to help remove any organic material that the ozone had broken down or destroyed. Then there's an [activated carbon](#) stage, that further removes this organic material. And finally, the water passes through a very fine membrane filter.

"If THMs are present in the water coming into the system, it will destroy and remove them," Fay said.



David Fay says his company's system is designed specifically for smaller communities that can't afford a full water treatment plant. ([CBC](#))

"So you could have a heavily-coloured water that's been chlorinated, as is typically the case. It will take that water... and destroy and remove any THMs, or HAAs, or other nasties."

The CD400 system can serve a population of up to 1,000, and can dispense up to 4,000 litres of clean drinking water per day.

Fay said the system has simple instructions for residents to get their water.

"You can arrive with either a cooler-type bottle or a smaller container. You press a single button. It makes water available for five minutes. You rinse your container, and then fill it," he said.



what's manganese?



- Metal commonly found in ground water, eroded from rock
- Generally found in conjunction with iron in water and earth's crust
- Used extensively in production of steel
- Necessary in diet (small amounts) – required by enzymes
- Harmful in (very) high concentrations
- Confused with iron until 1700s

metallic Mn



Mn salt



Mn dioxide



a lot like iron.

Iron



- Radius: **140** pm
- Weight: **55.8** au
- Elec: 2, 8, 14, **2**

Manganese



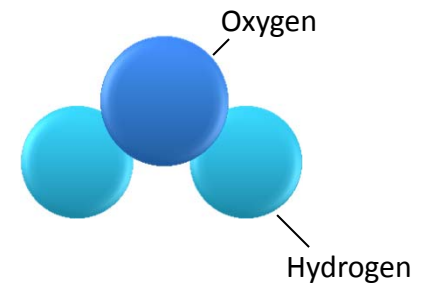
- Radius: **137** pm
- Weight: **54.9** au
- Elec: 2, 8, 13, **2**

Chlorine



- Radius: 100 pm
- Weight: 35.5 au
- Elec: 2, 8, 7

Water



Relative Size

why is Mn an issue?



It's normally not toxic:

- An aesthetic parameter according to CDWG
- Although toxic in high doses, exposure through diet normally ok
- Average manganese intakes range from 0.7 to 10.9 mg/day (IOM, 2002)
- Upper range of 11 mg/day from dietary studies considered a 'no observed-adverse effect level' (NOAEL) in a 60 kg adult (WHO, 2011)

(...that's the equivalent of 880 glasses at 0.05mg/l)



why is Mn an issue?



However in concentrations above 0.05 mg/L (CDWG MAC):

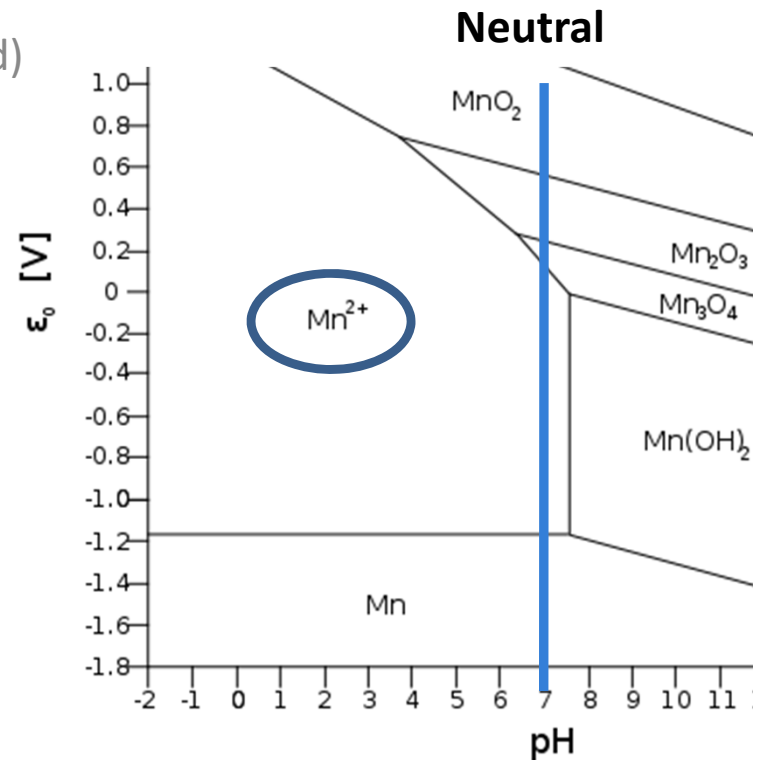
- Objectionable to consumers
- Undesirable taste
- Deposits in water mains as black, slimy material (mn(II) compounds)
- Causes water discoloration
- Stains plumbing fixtures and laundry (brown-black, iron more red)



how is it dealt with?



- Manganese is *normally* removed by **oxidation and filtration**
- Ground water is generally close to neutral pH
- Manganese found in soluble form as Mn^{2+}
- Consider putting salt water through a sand filter...
(...it's still salt water after it's filtered)
- Other impurities in water can influence treatment

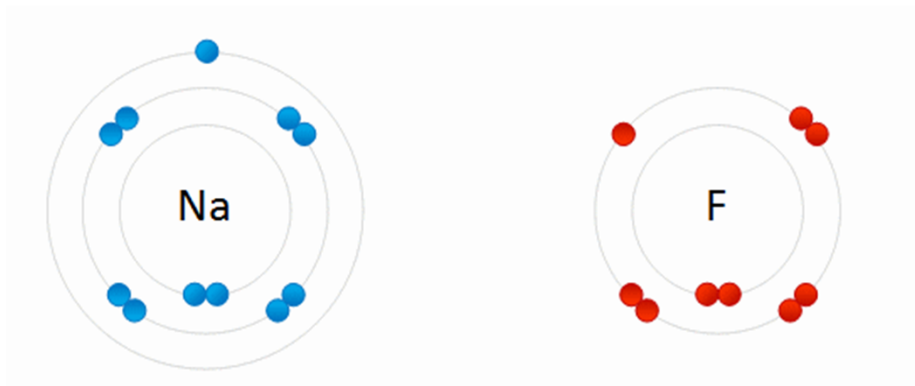


some (brief) chemistry.



- An oxidant gains electrons and is reduced
- A reducing agent gives electrons and is oxidized
- When dissolved manganese reacts, or 'comes together', with an oxidant, it drops out of solution and can be filtered

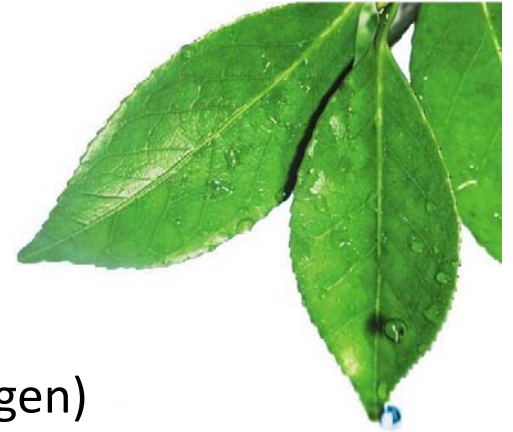
e.g.,



Reductant

Oxidant

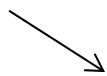
an analogy.



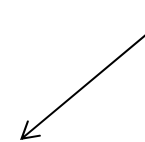
- Manganese latches on to an oxidant (ozone, chlorine, oxygen)
- The new compound is insoluble and 'falls out' of water

An Analogy:

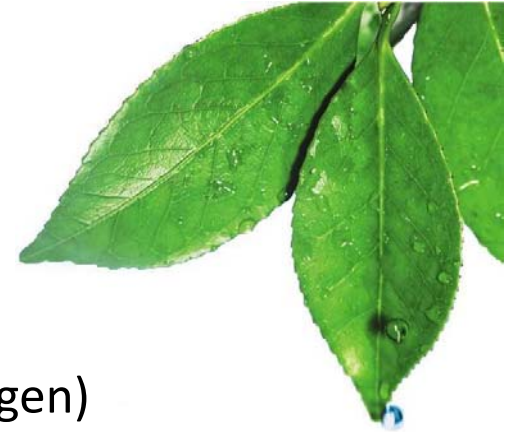
Dissolved Mn



Oxidant



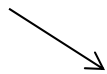
an analogy.



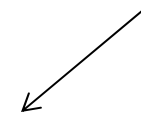
- Manganese latches on to an oxidant (ozone, chlorine, oxygen)
- The new compound is insoluble and 'falls out' of water

An Analogy:

Dissolved Mn



Now insoluble (drops out
and can be filtered)



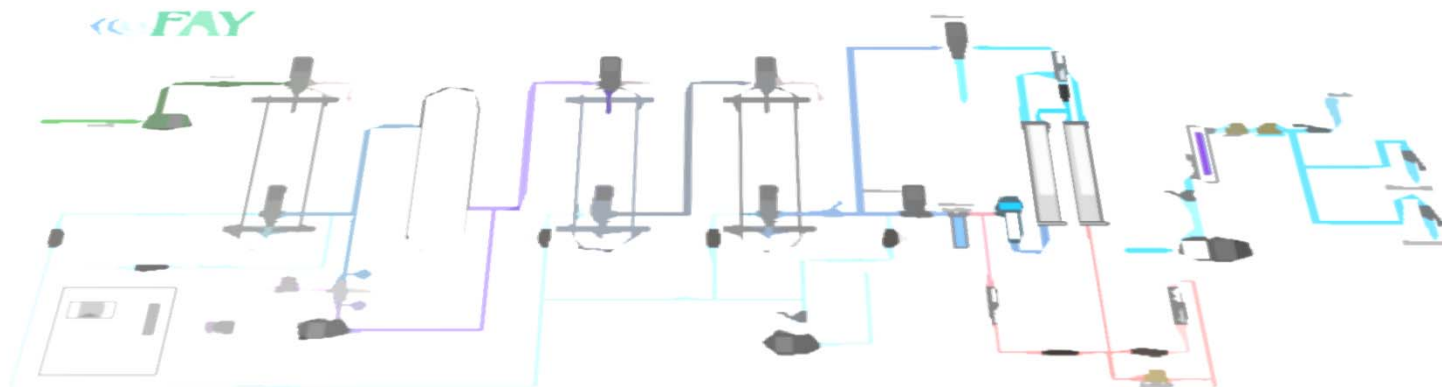
typical oxidative methods.



1. By adding air (oxygen)
2. By adding permanganate (MnO_4^-)
3. By injecting ozone (O_3)
4. By a biological process (Degremont's Mangazur reactor)
5. Filtering through MnO_2 (greensand)

Comprised of (at minimum) an oxidation step followed by filtration

Each method has practical advantages and disadvantages.



an ozone example.



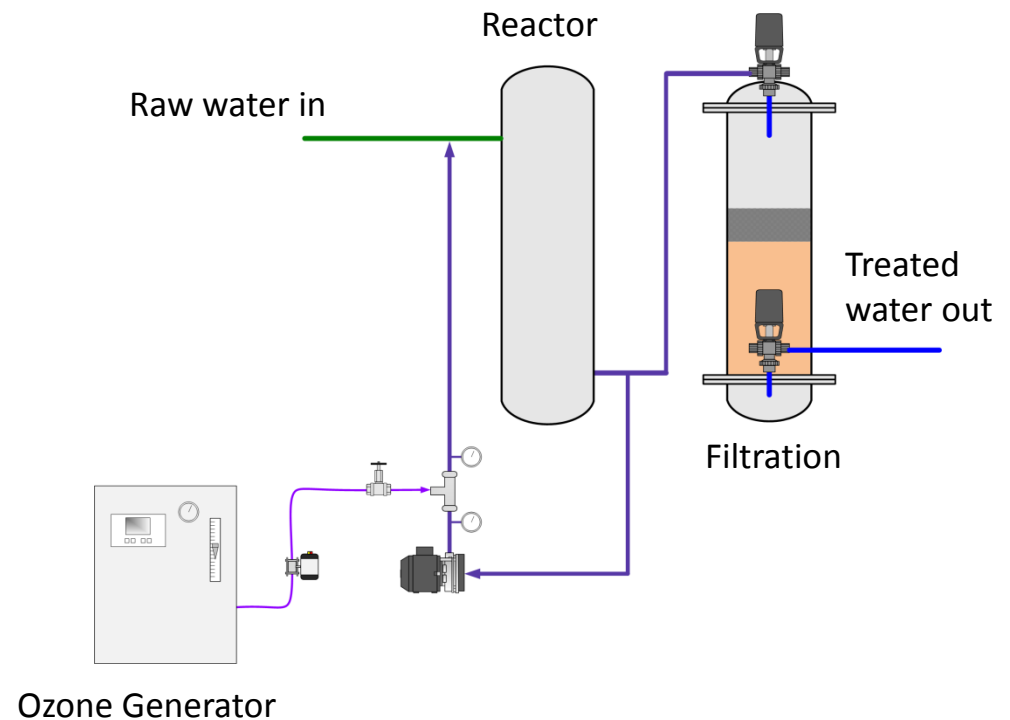
Ozone used for oxidation followed by filtration (multimedia)

PROS

1. Fast, effective oxidation
2. Oxidant generated on site
3. No costly chemical consumption
4. Assisted by 'seeding' of sand

CONS

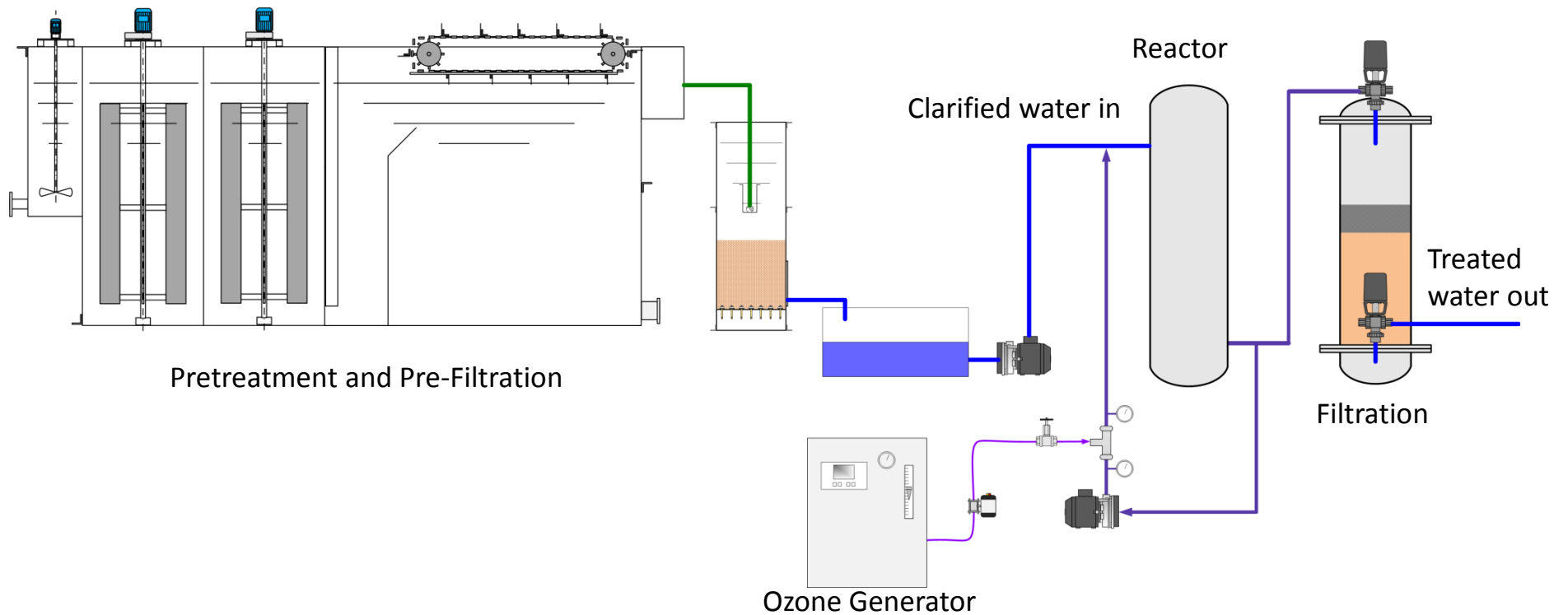
1. Formation of byproducts (bromate)
2. Ozone system capital cost high
3. Careful dosing to prevent pink water (MnO_4^- ... Mn^{2+} oxidized further)
4. pH Sensitive



an ozone example.



If other impurities are present (e.g., organics in surface water), treatment becomes more complicated.



a greensand example.

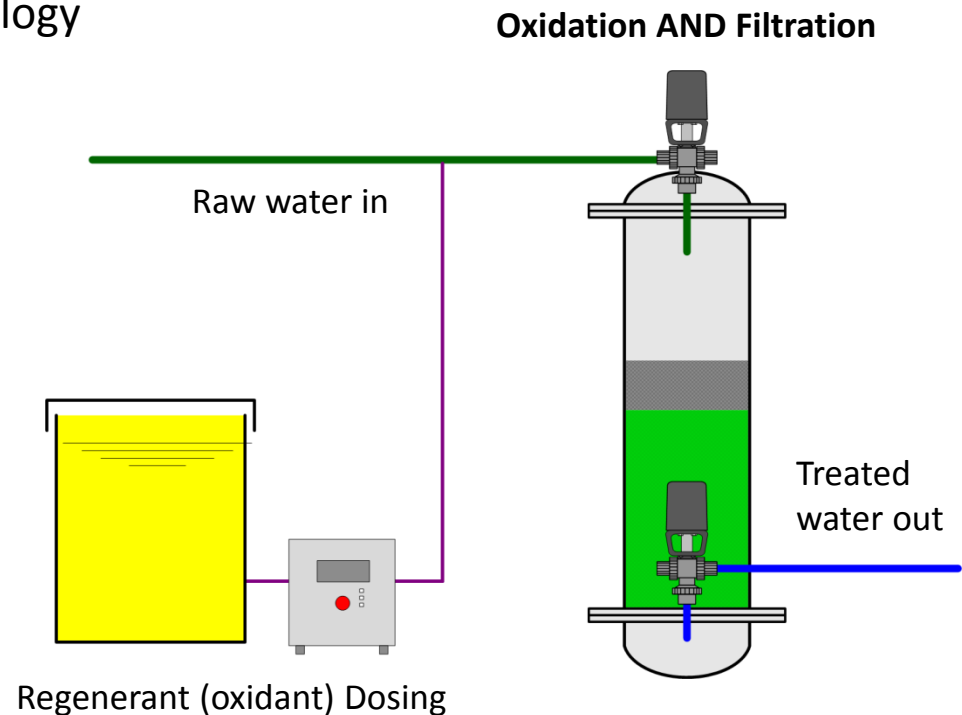


PROS

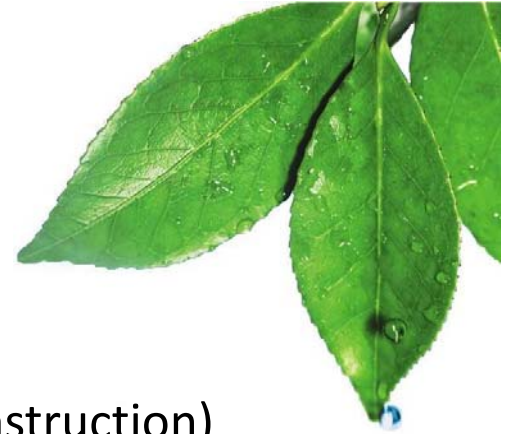
1. One filtration step required for most clear waters
2. Effective, proven, easy-to-use technology for removing manganese

CONS

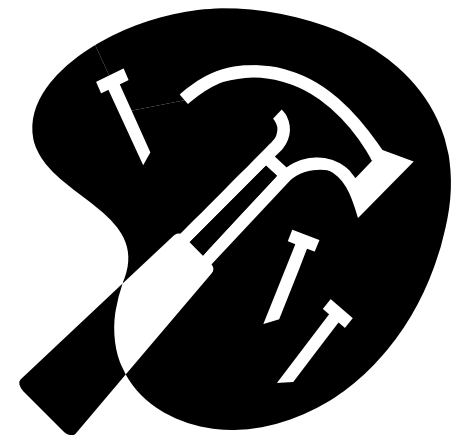
1. Possible formation of byproducts
2. pH sensitive
3. Requires rigorous washing
4. Can be fouled by iron



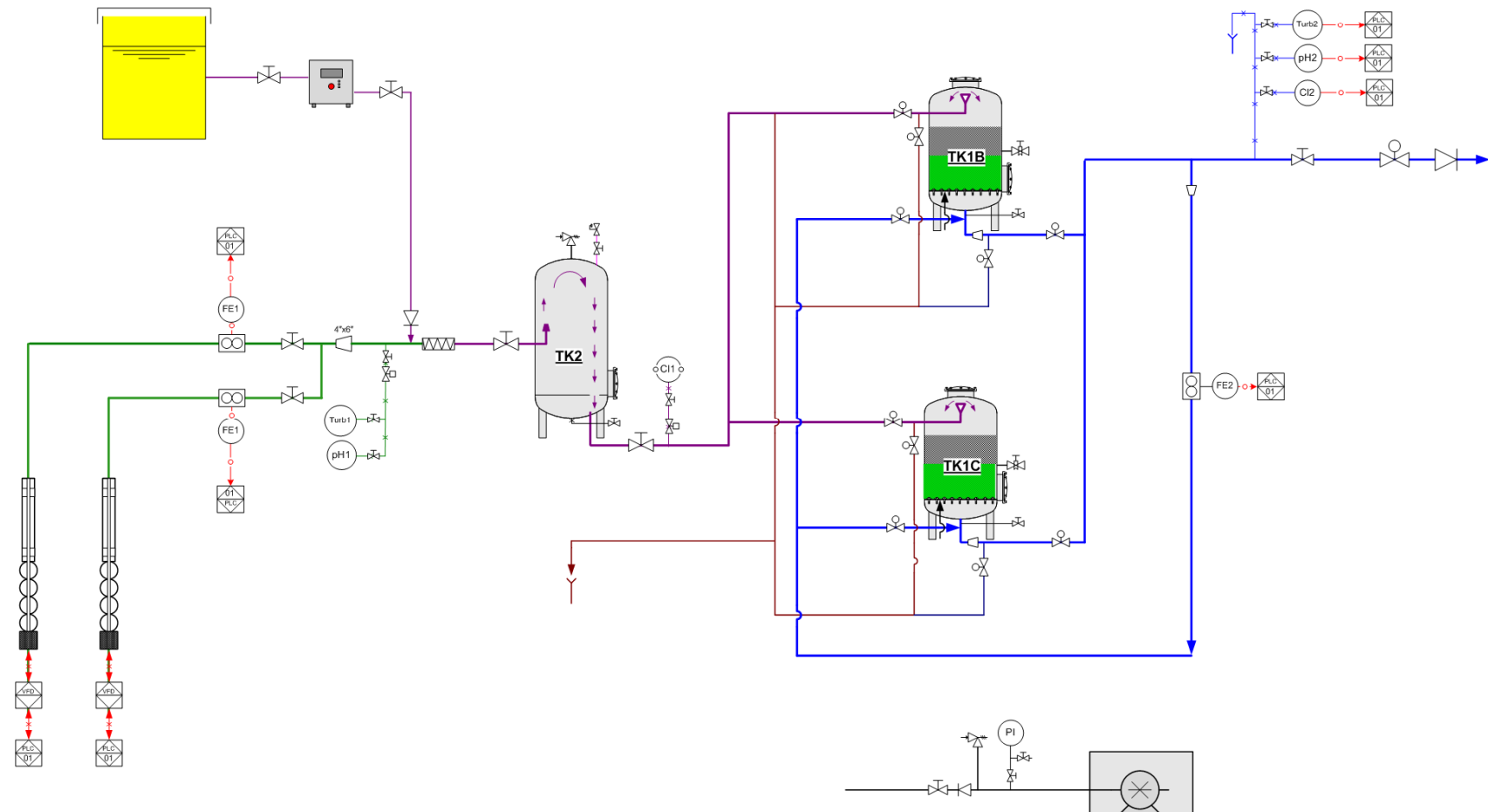
greensand locally.



- The water treatment plant at Holyrood is a local (under construction) facility using greensand filtration
- Scheduled for commissioning in the coming weeks
- Three greensand filters in parallel
- Continuous regenerant (oxidant) dosing



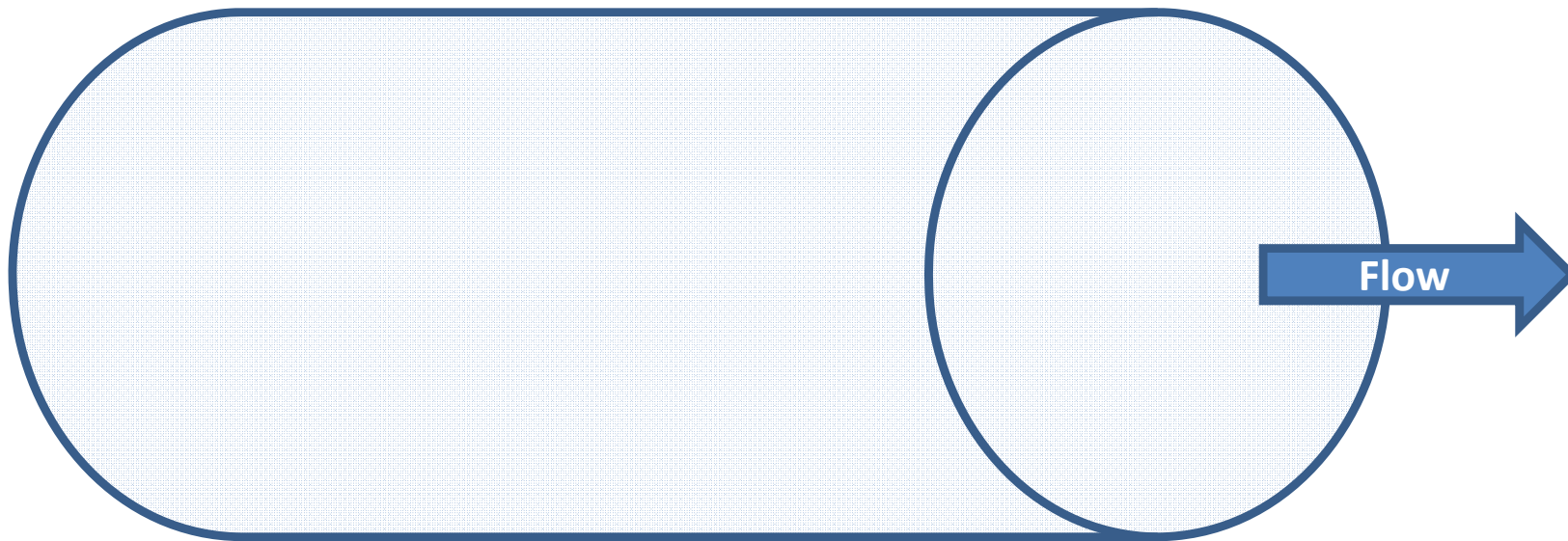
Holyrood flow diagram.



how it works.



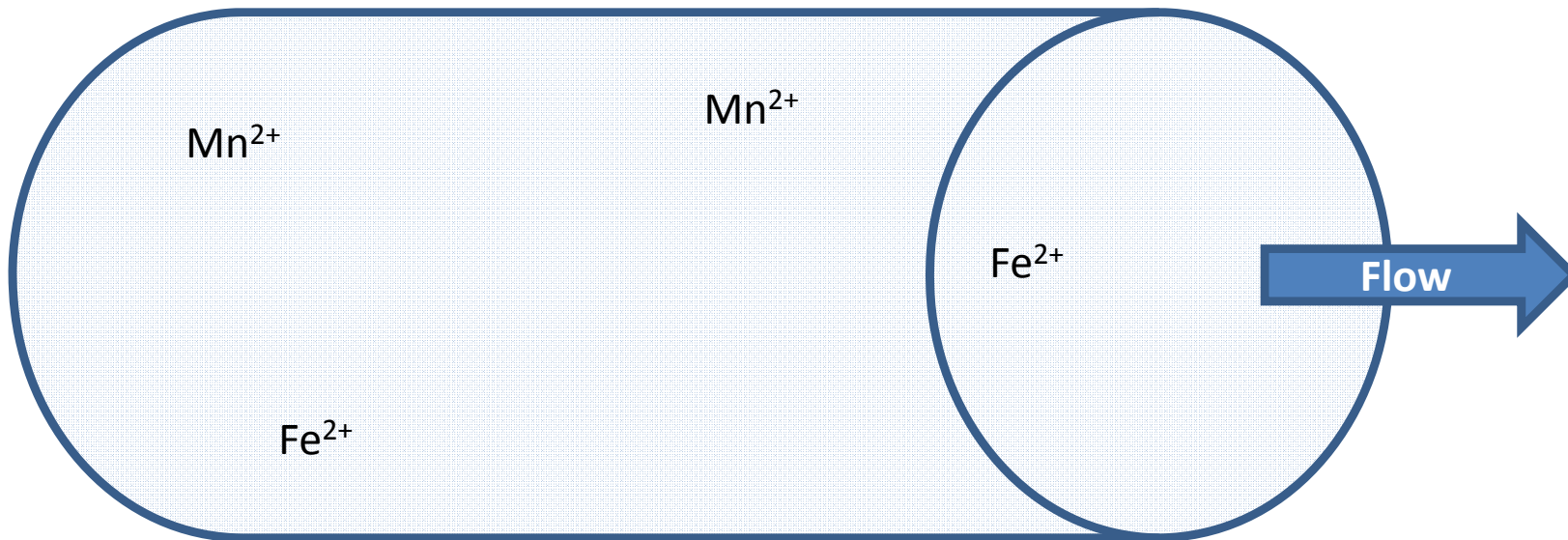
In the piping system...



how it works.



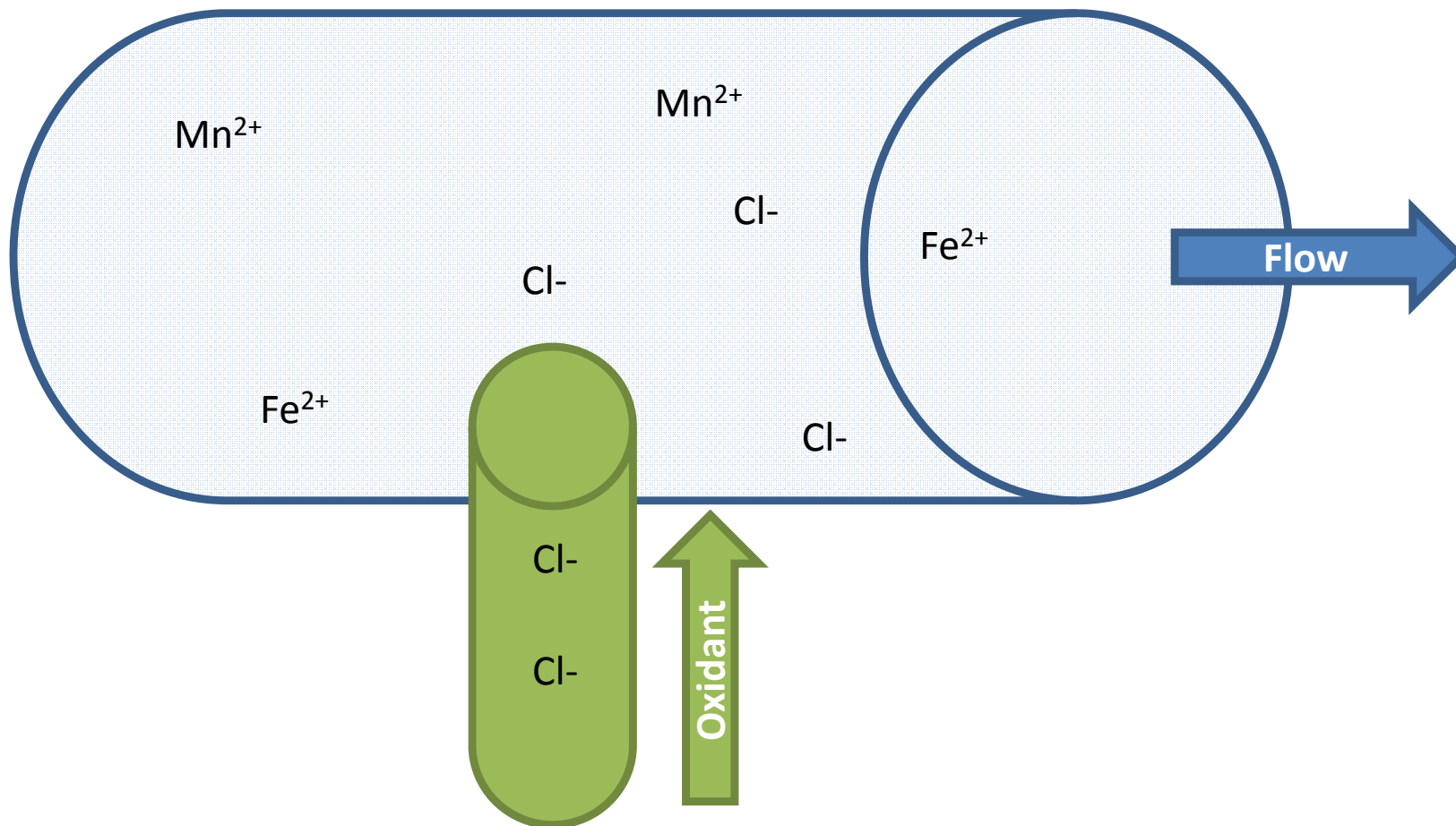
Iron and Manganese are dissolved in the water



how it works.



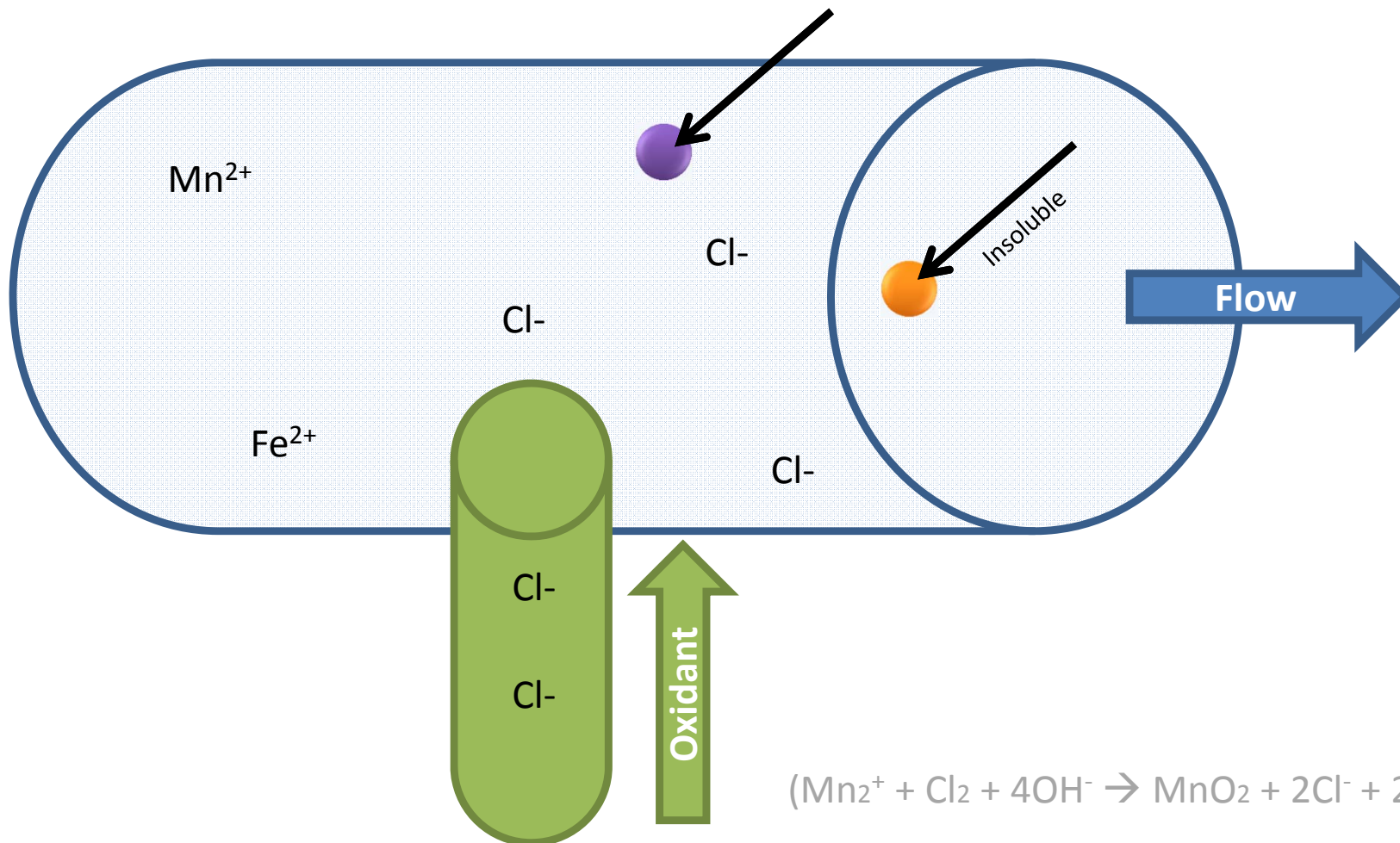
An oxidant is added to the main system flow



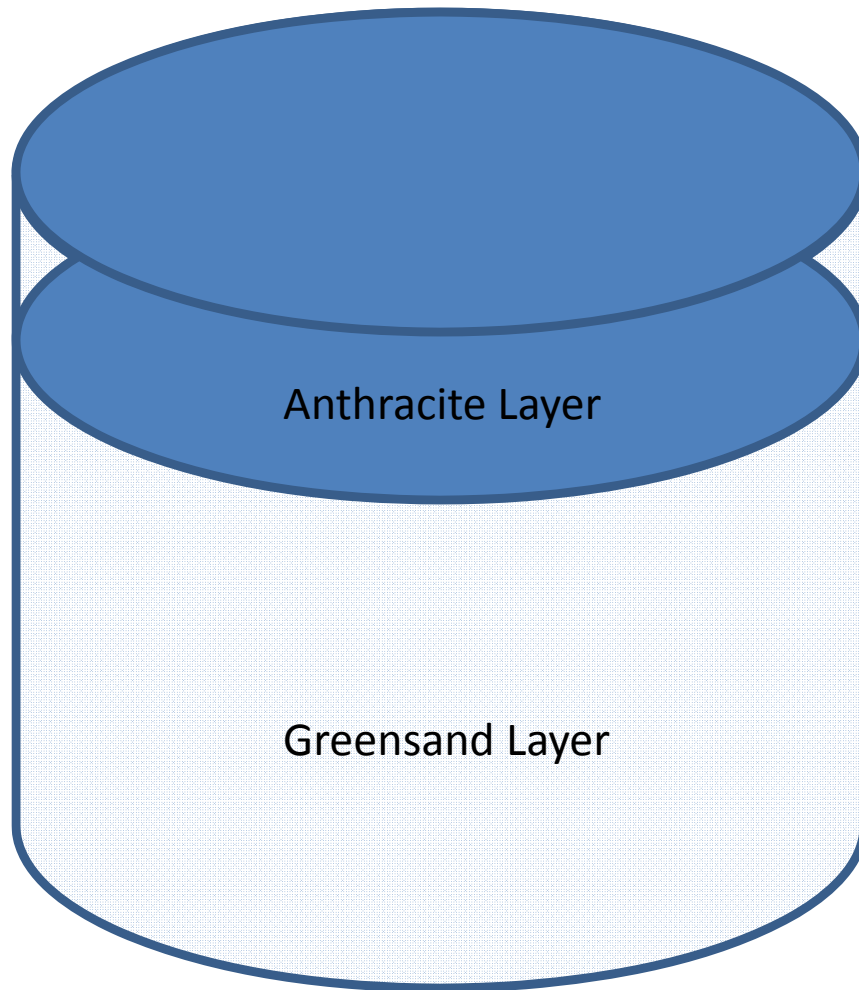
how it works.



Most iron and some manganese drop out and can be filtered

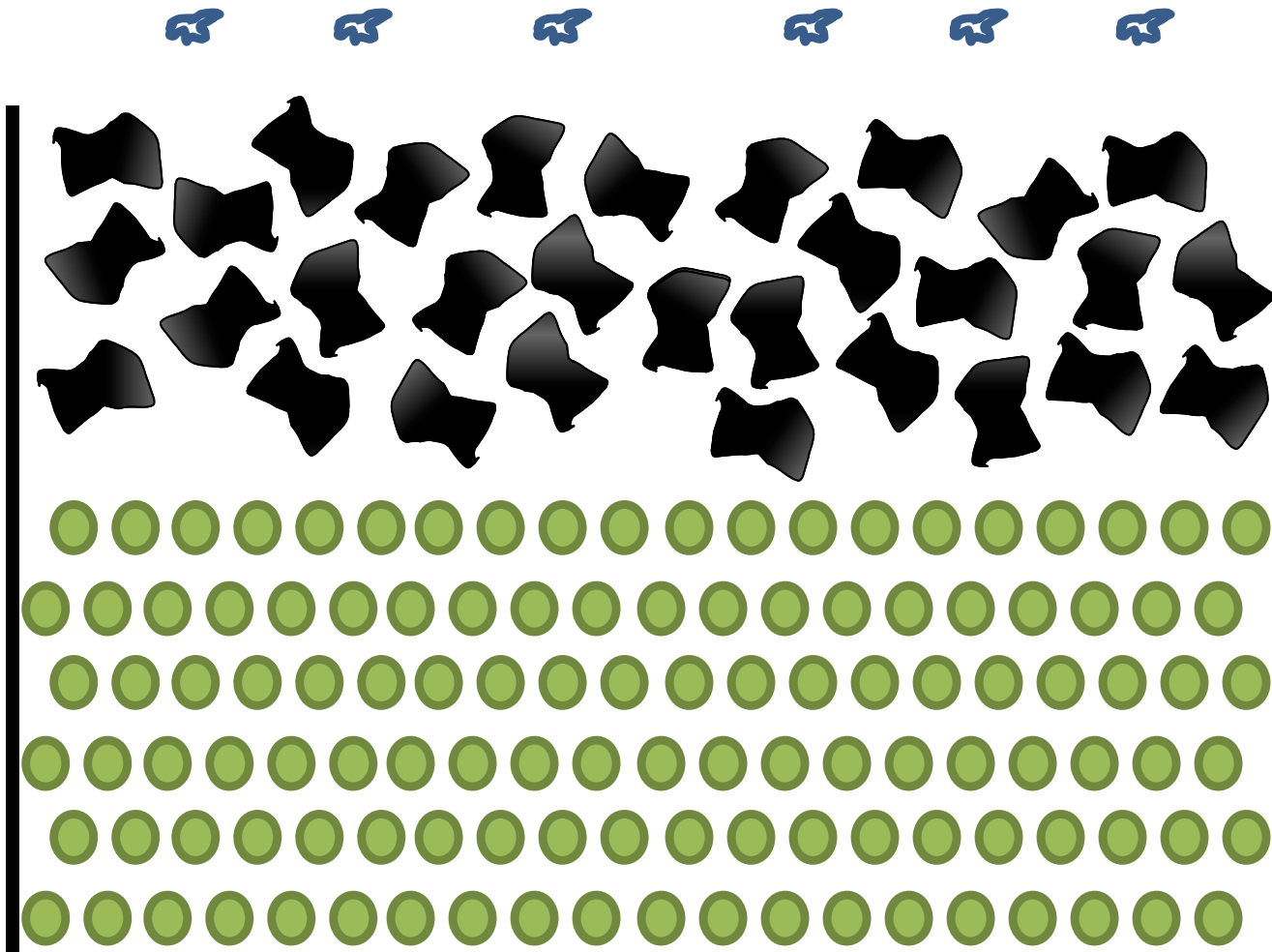


in a greensand filter.



- Most insoluble iron is filtered by anthracite cap
- Insoluble manganese is also filtered
- Manganese in solution deposits on greensand

in a greensand filter.

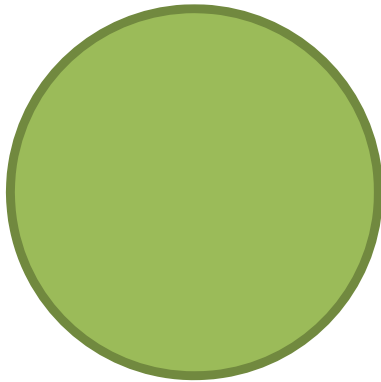


Iron is generally filtered by anthracite. Some insoluble manganese / iron carries through and is filtered by greensand.

in a greensand filter.



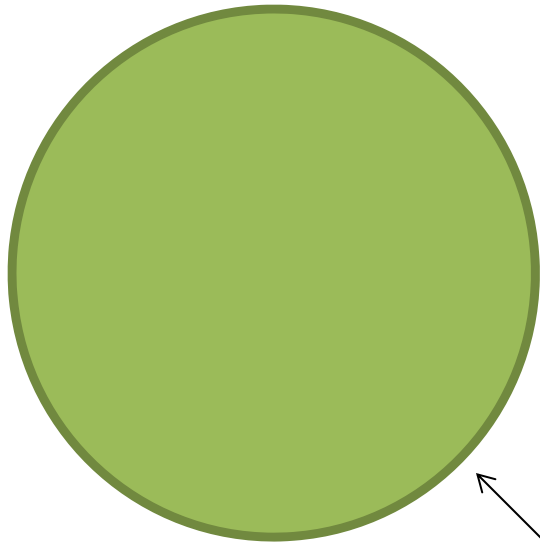
Mn^{2+}



Mn^{2+}

Dissolved manganese around
a greensand particle attach
causing it to grow

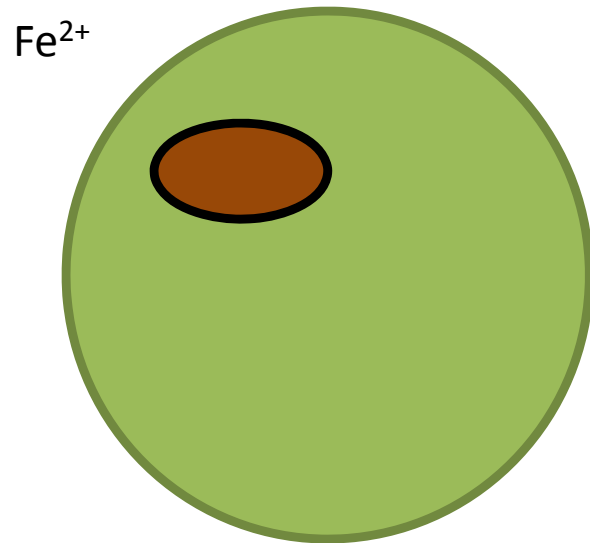
in a greensand filter.



Grain of greensand

Mn^{2+} becomes MnO_2
pH a major consideration

in a greensand filter.



- Greensand must remain activated with chlorine or dissolved manganese will not adhere
- Dissolved iron can also adhere, fouling greensand
- Greensand covered with iron oxides will not operate properly
- Rigorous backwashing required to remove iron deposits

to summarize.



- 1) Manganese can stain laundry and precipitate in networks
- 2) Manganese is normally found as Mn^{2+} in ground water at neutral pH
- 3) Manganese is removed by oxidation and filtration
- 4) Treating water with manganese depends on water chemistry
(Affects process, amount of oxidant used, etc.)
- 5) One method to remove manganese is by filtering through greensand
- 6) Holyrood is a local example of a facility using greensand filtration



thank you for your attention.





contact us.

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