Manz Advances in Slow Sand Filtration

March 15, 2019

Manz Engineering Ltd.
Davnor Water Filters Ltd.

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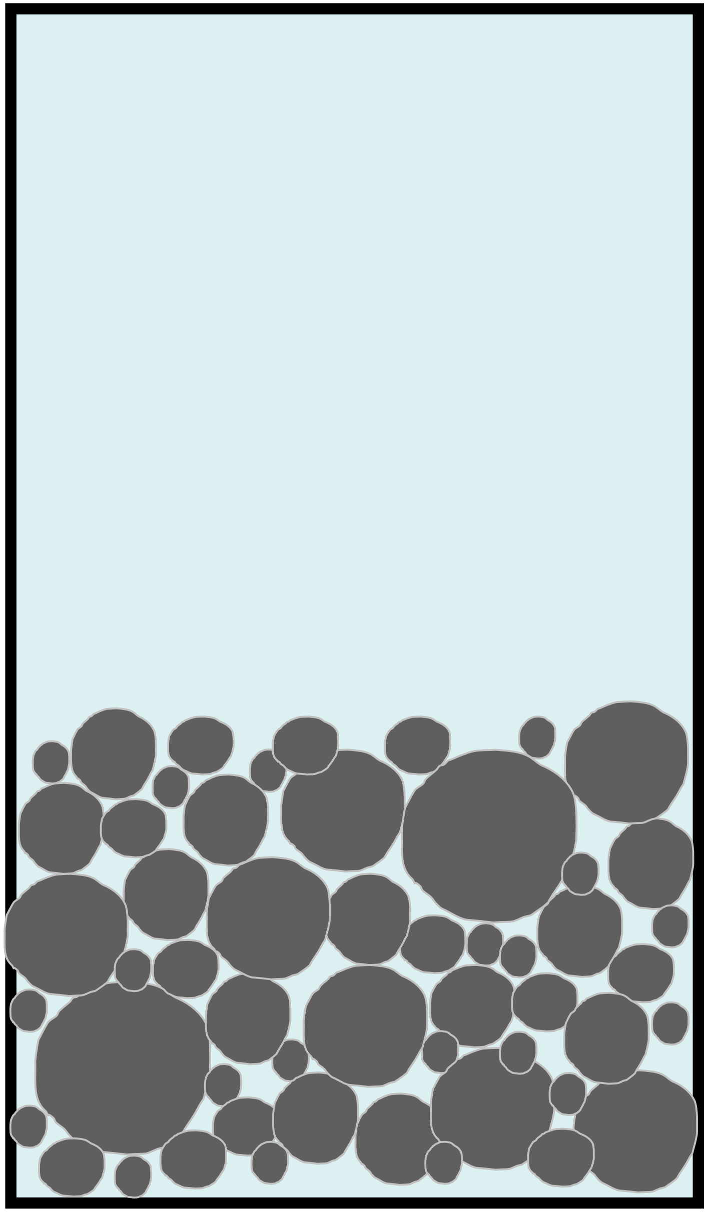
www.manzwaterinfo.ca
www.cabincleanwaterfilter.com

1. **It’s the BACKWASH!**

And

2. **Quality control as it relates to:**
   - **Construction materials (must meet NSF 61 certification).**
   - **Media (must meet AWWA standard B100-01 for filters and NSF 61).**
   - **Construction methodology.**

What is the backwash process?

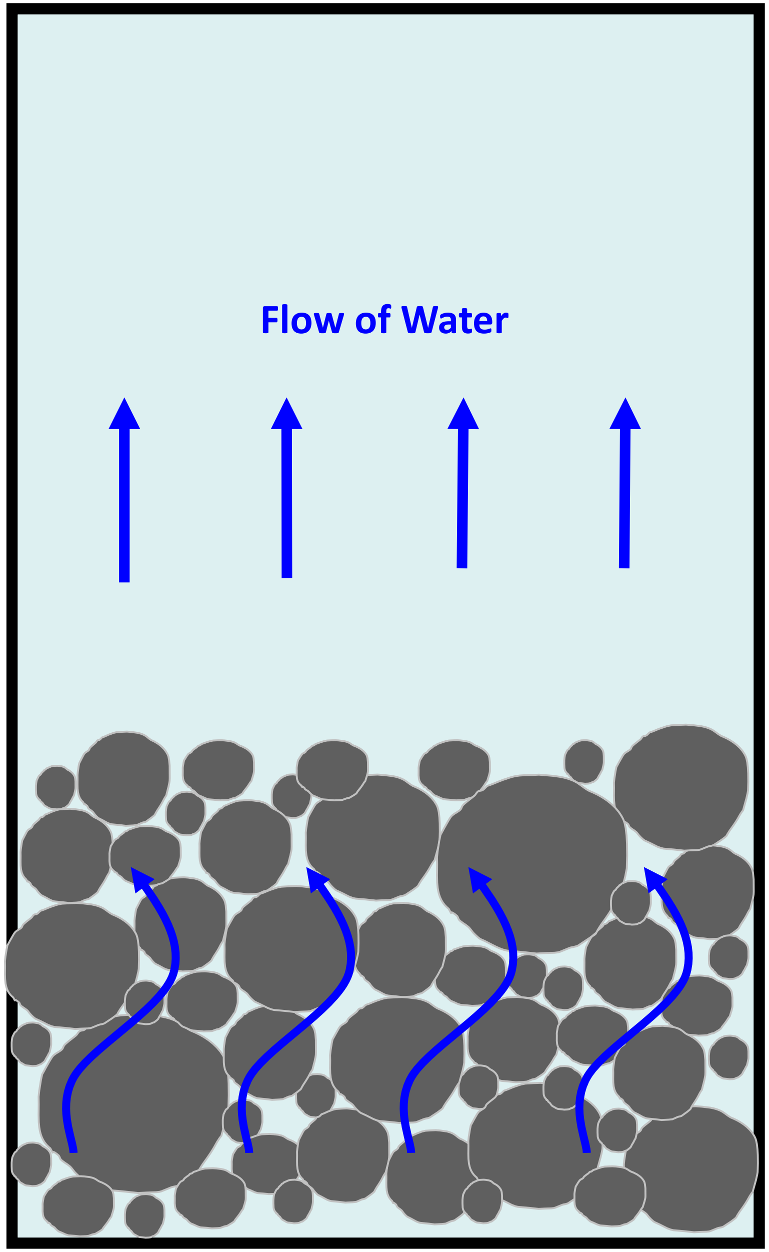


Review of Backwash Process (Commissioning a Filter

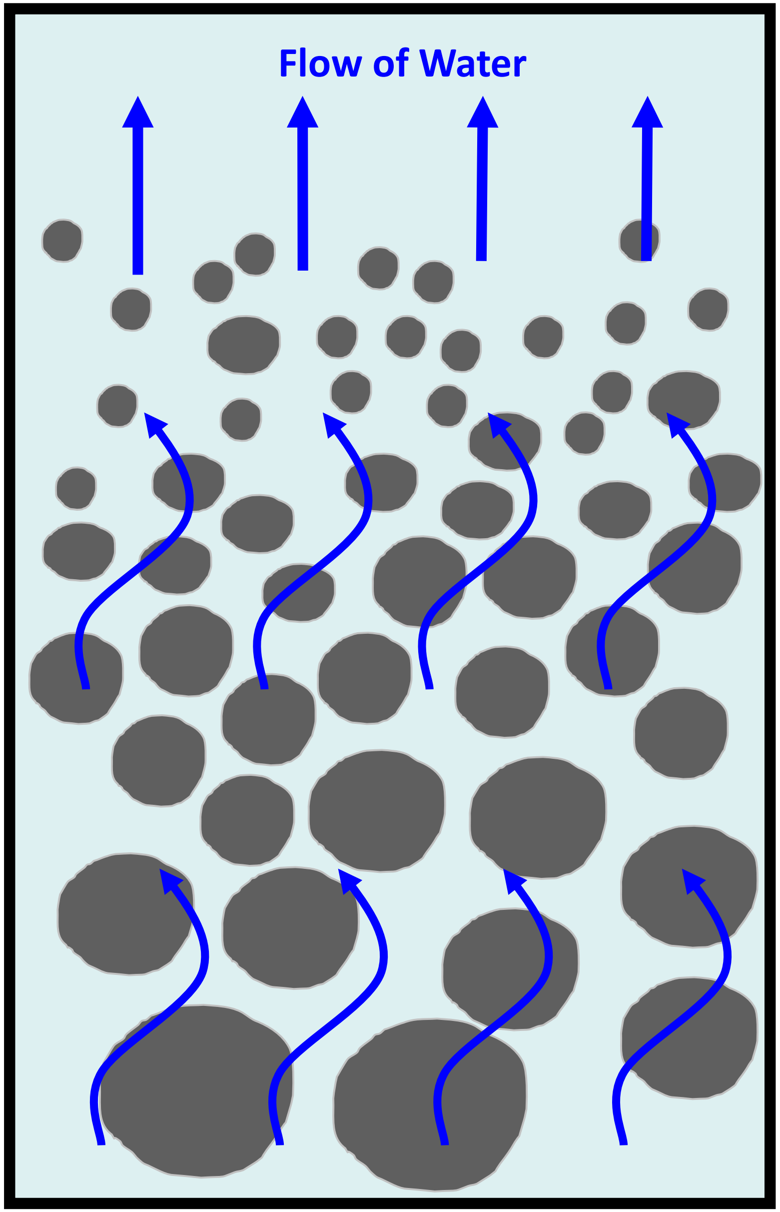
Consider a typical sand filter when media is first installed.

Initially particles having different diameters are mixed together.

Backwash starts.

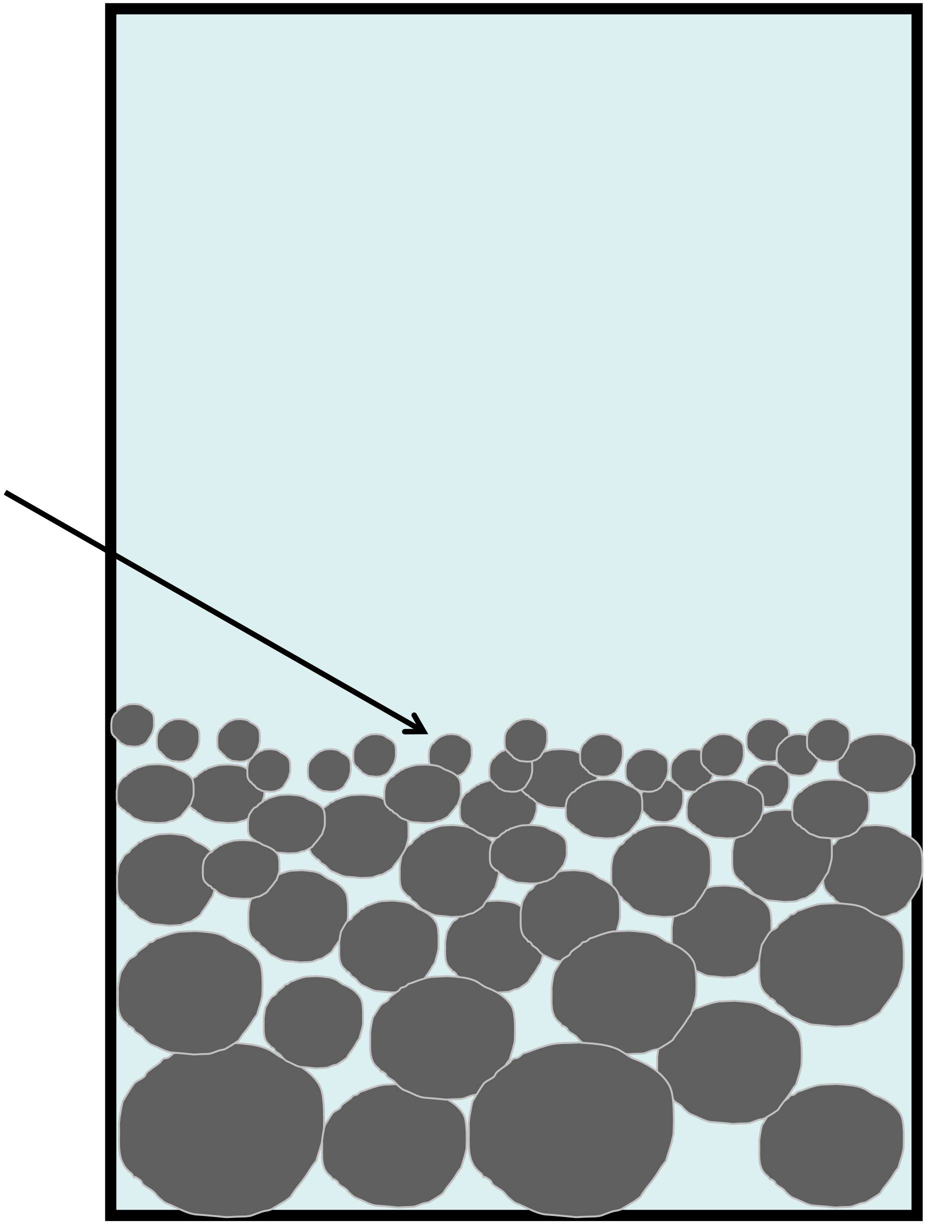


Bed fluidizes.



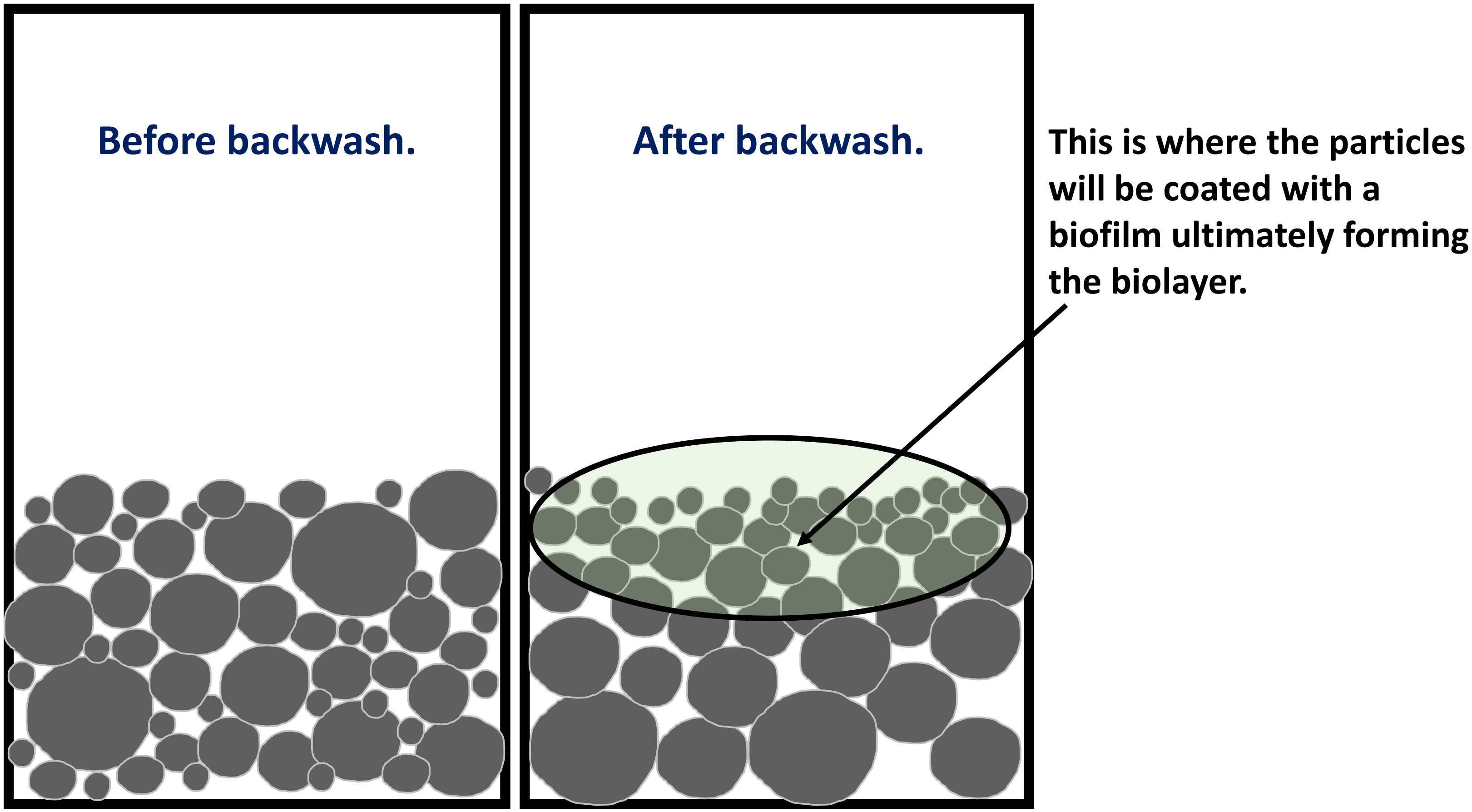
Backwash stops.

The <u>same</u> ‘smallest diameter particles’ will be at the media surface after every backwash.

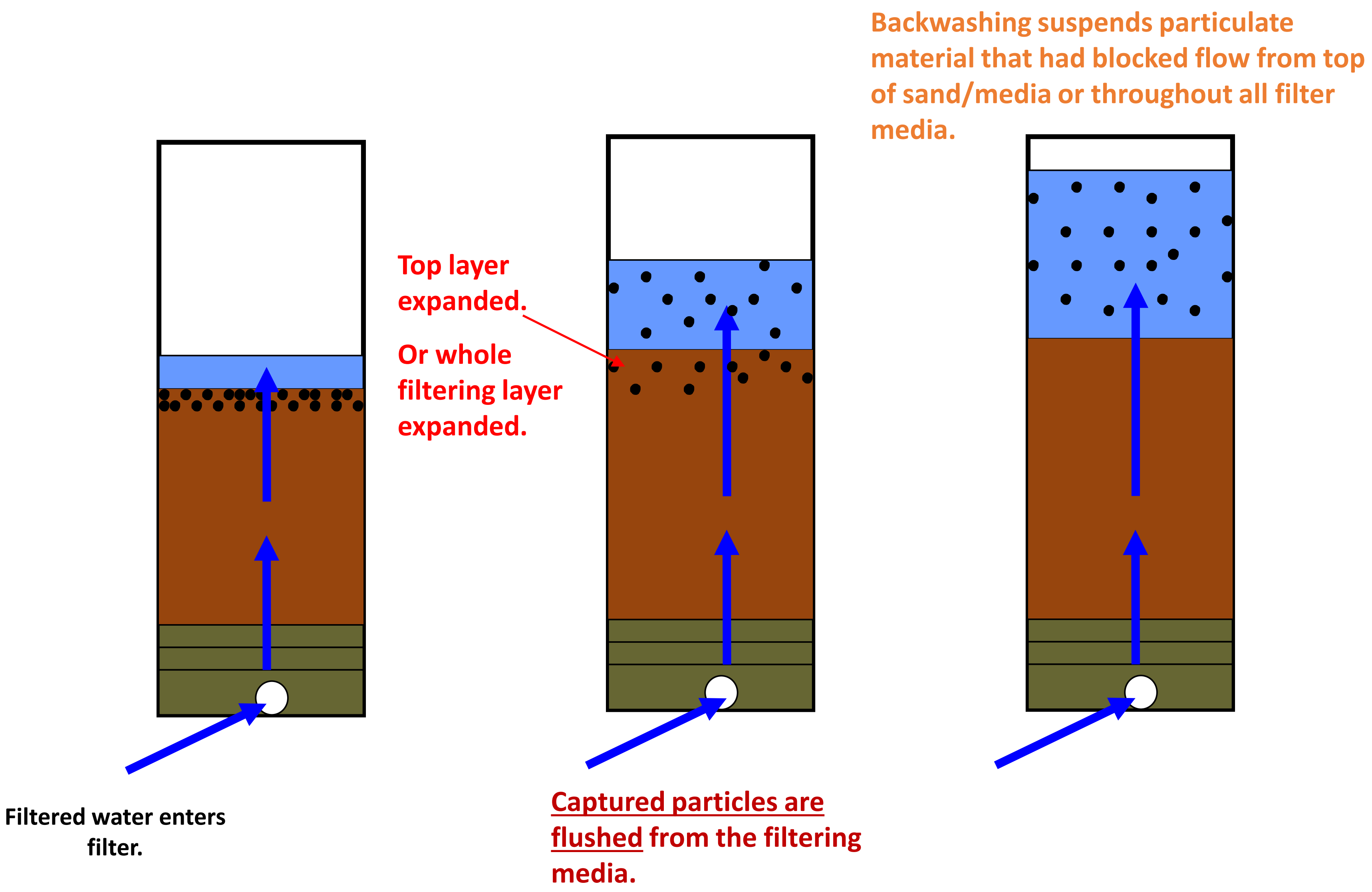


The backwash is unique in that filter media can never be lost.

Filter is commissioned.

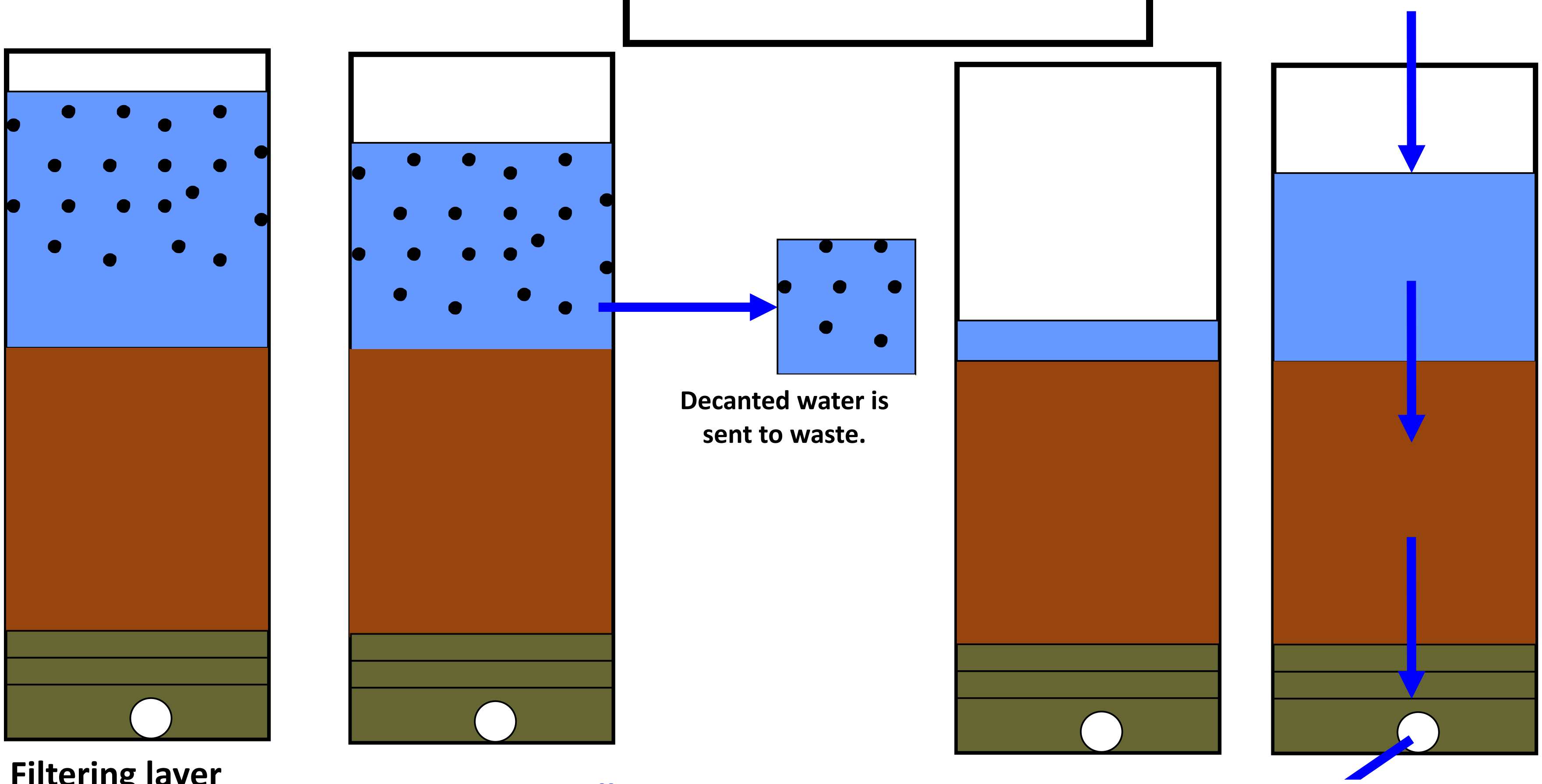


Cleaning a filter using backwash.



Backwash is stopped – smallest sand particles remain at surface. NO LAYERS.

Not possible to lose media during backwash process!



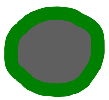
Filtering layer collapses to original depth.

Water containing all of the captured material is decanted from filter.

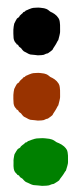
Decant is complete.

Filter is put into production without filter-to-waste cycle.

Looking at backwash another way.

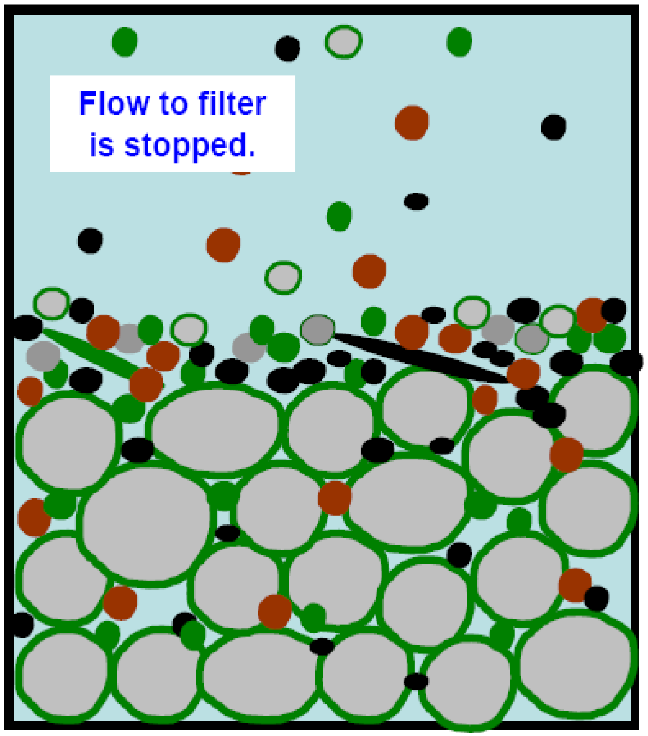


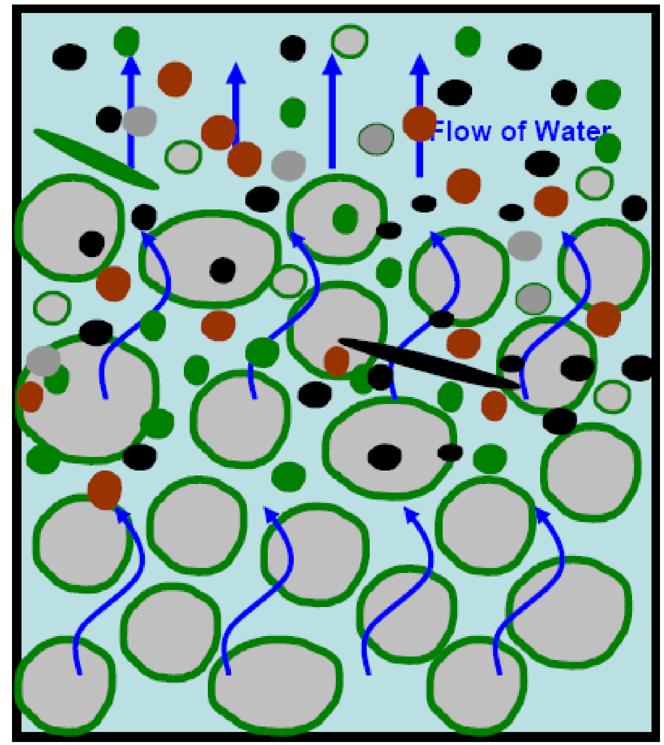
Media particle covered with a surface biofilm including bacteria and organic matter.



Other mineral and organic particles or <u>flocs</u> of particles.

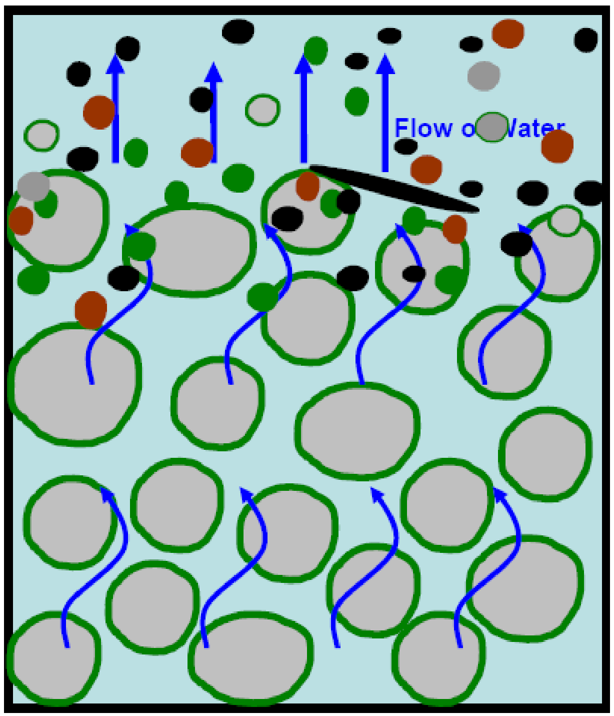
Also includes large living organisms such as parasites, algae, helminths and the cysts of parasites.



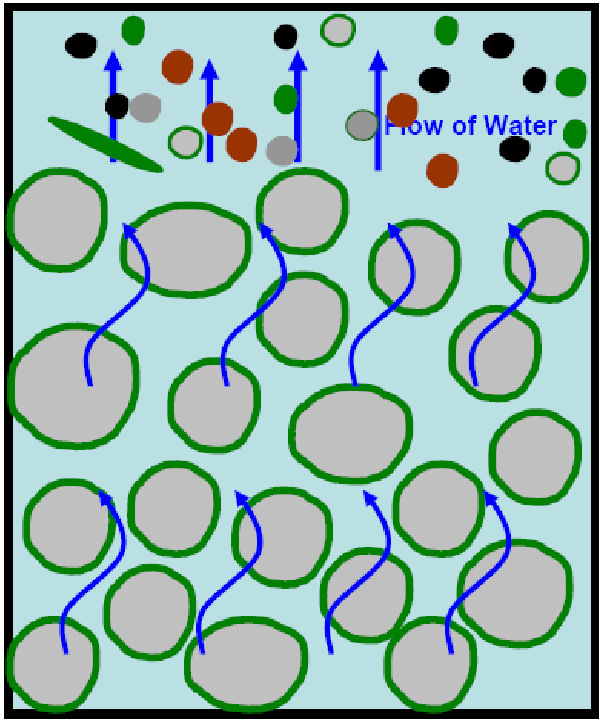


Backwash is started and bed fluidizes.

Backwash Process.

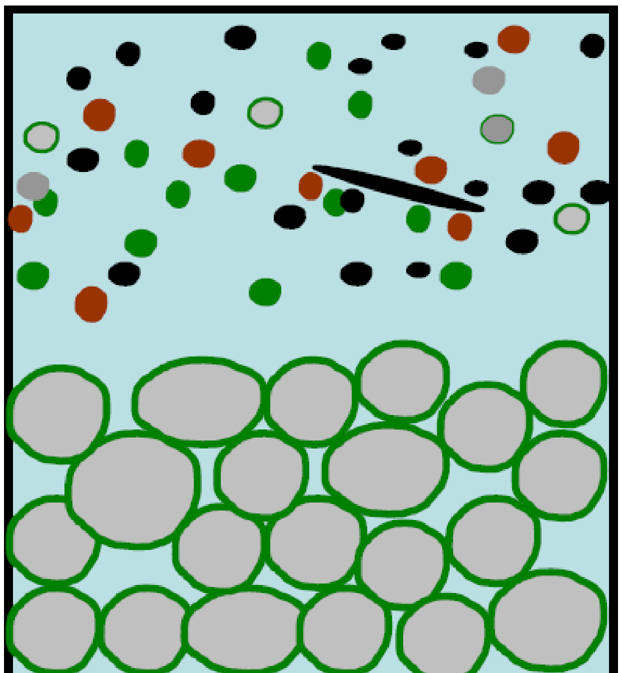


Backwash continues as long as required to flush particles blocking flow from filter.



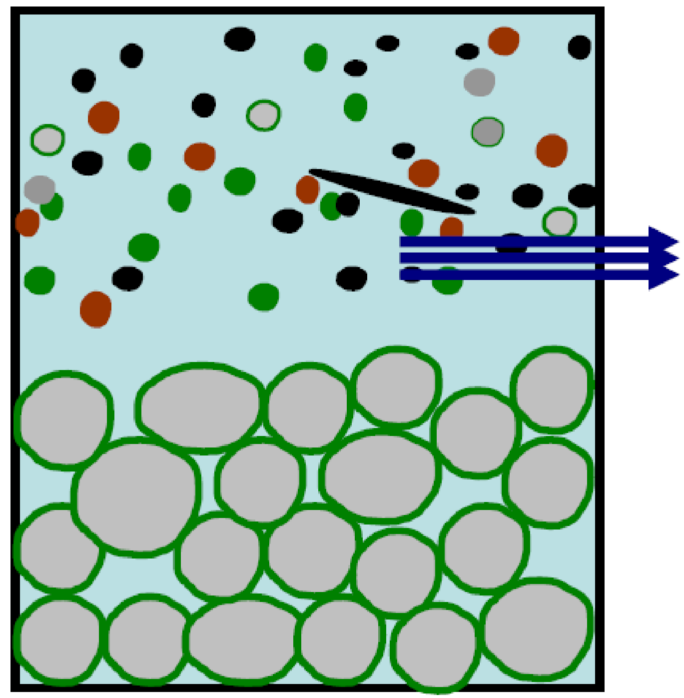
Particles blocking flow from filter are now in water above media.

Backwash Process.



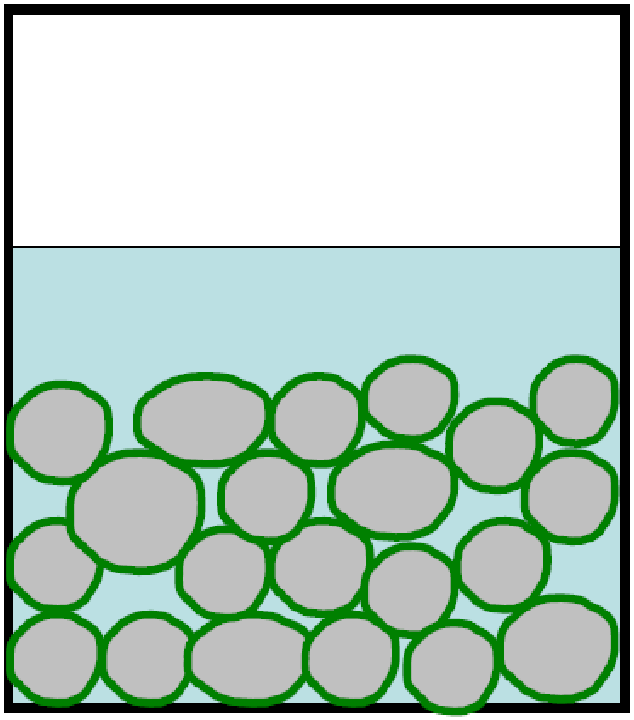
Backwash stops.

Particles, with biofilm settle into original pre-backwash position – on the surface of the media.



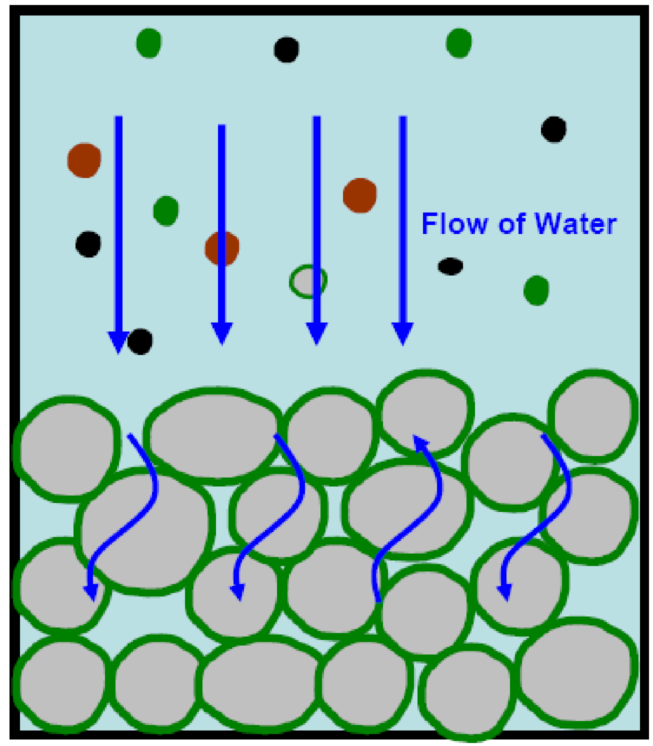
Water containing suspended particles is decanted.

Backwash Process.



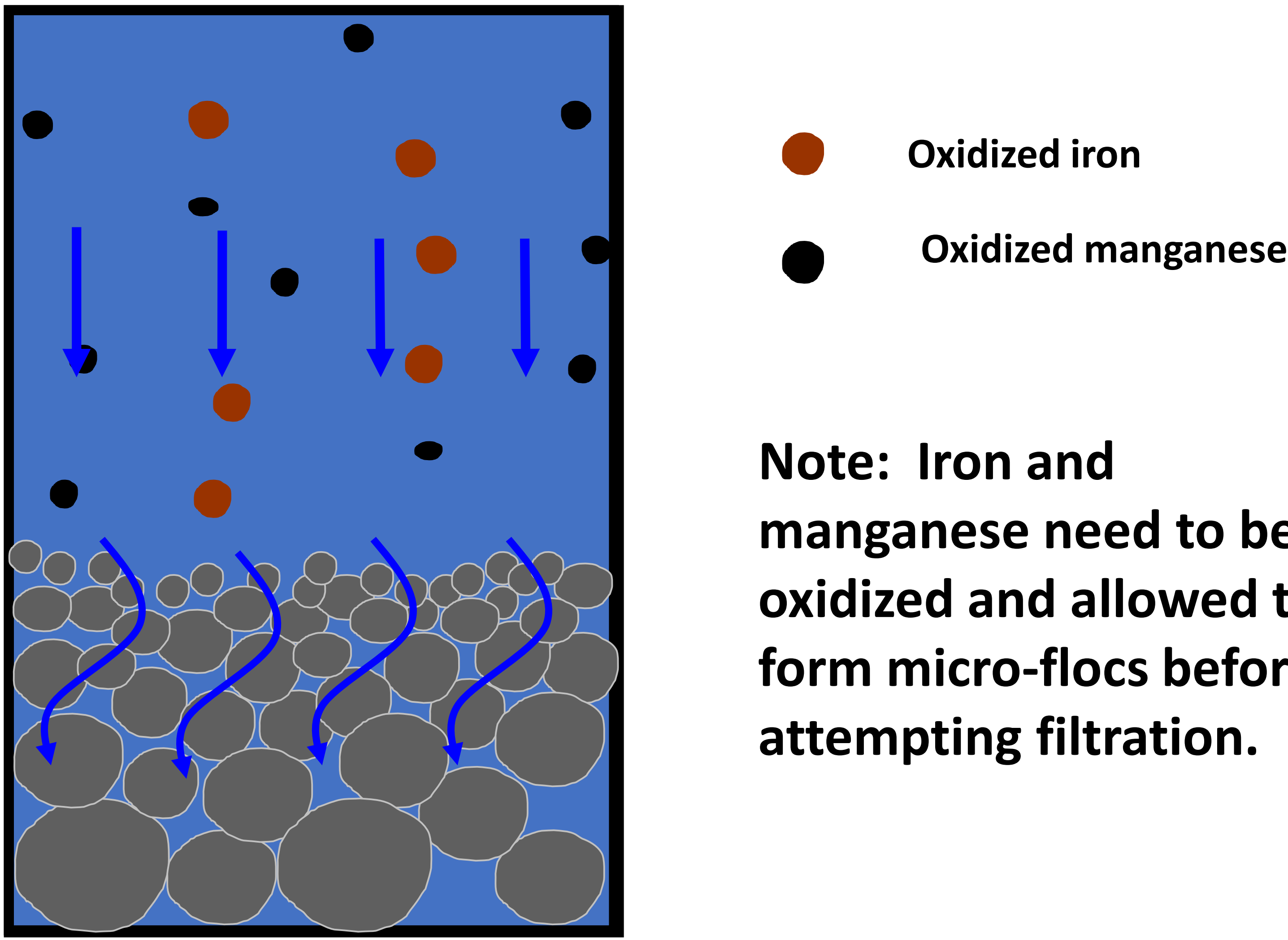
State of filter after backwash and decant complete.

Note that the particles with biofilm are at the surface.



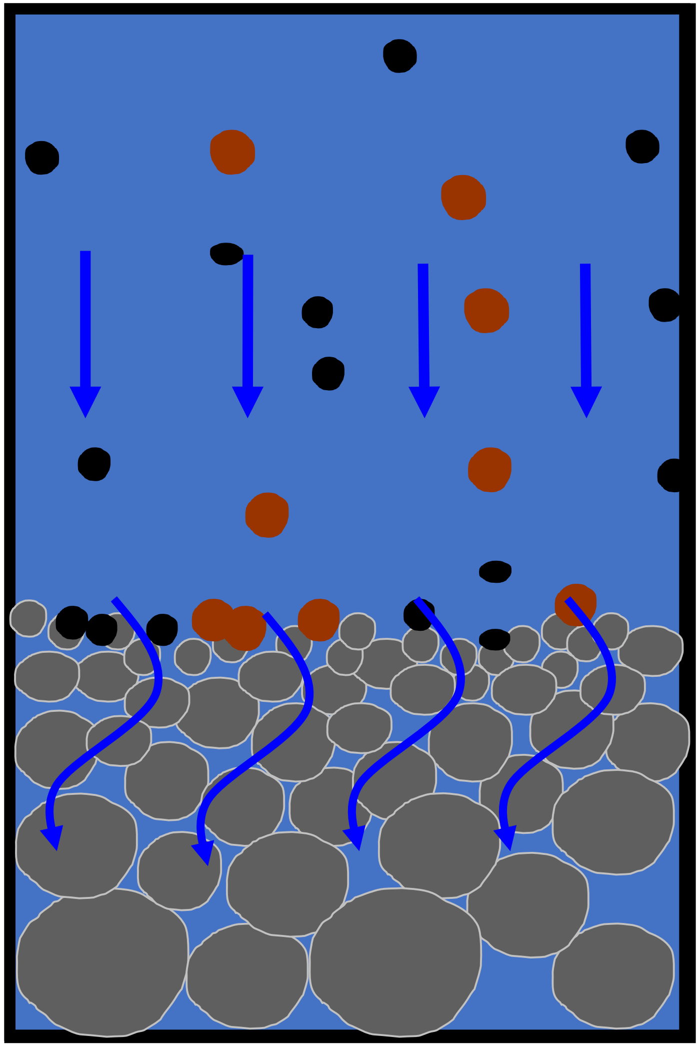
Filtration resumes.

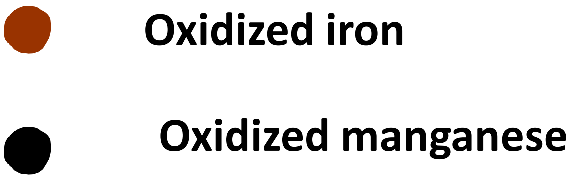
Operation of commissioned filter when used to remove iron and manganese (and arsenic adsorbed by oxidized iron.)



Note: Iron and manganese need to be oxidized and allowed to form micro-flocs before attempting filtration.

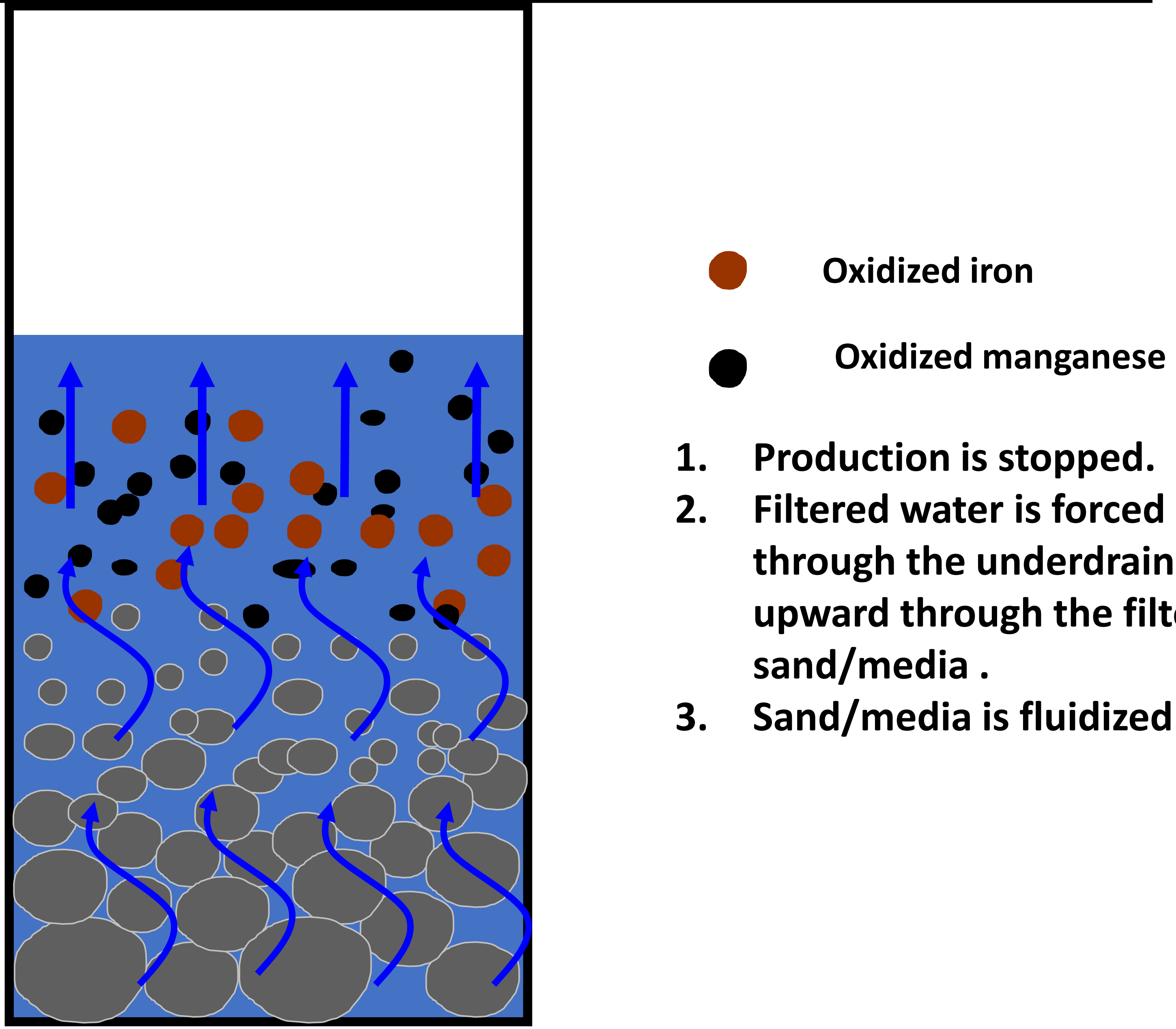
Operation of commissioned filter when used to remove iron and manganese.





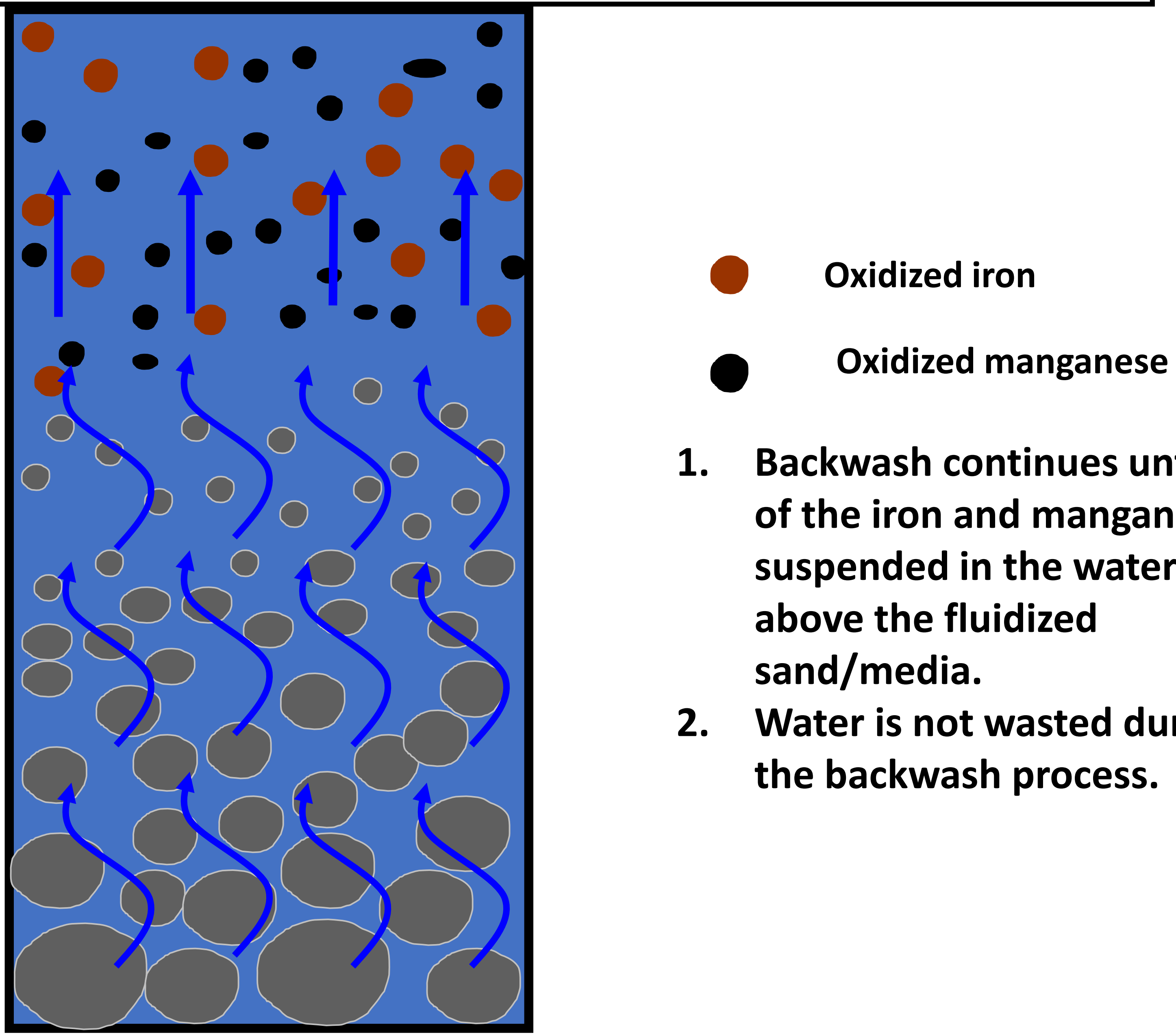
Iron and manganese are captured at the surface of the media – a mechanical filtration process that does not require formation of the 'schmutzdeke' that is developed by a traditional slow sand filter when removing micro-organisms.

Backwash to remove captured iron and manganese.



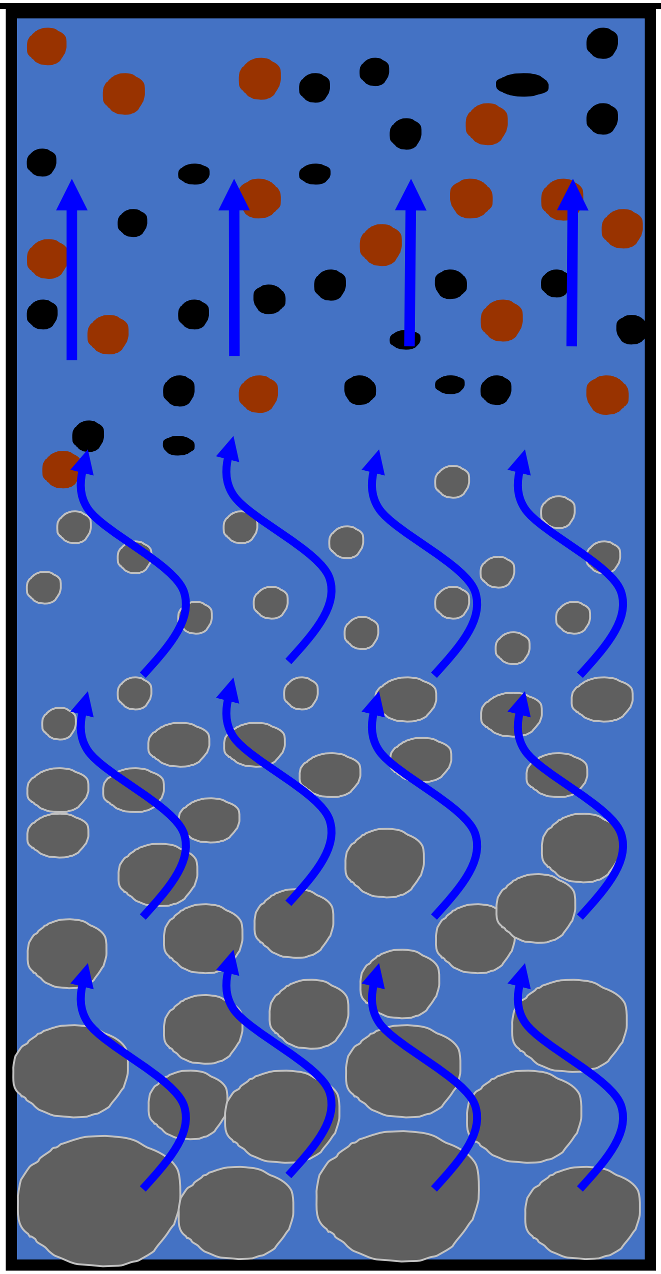
1. **Production is stopped.**
2. **Filtered water is forced through the underdrain and upward through the filter sand/media .**
3. **Sand/media is fluidized.**

Backwash to remove captured iron and manganese.



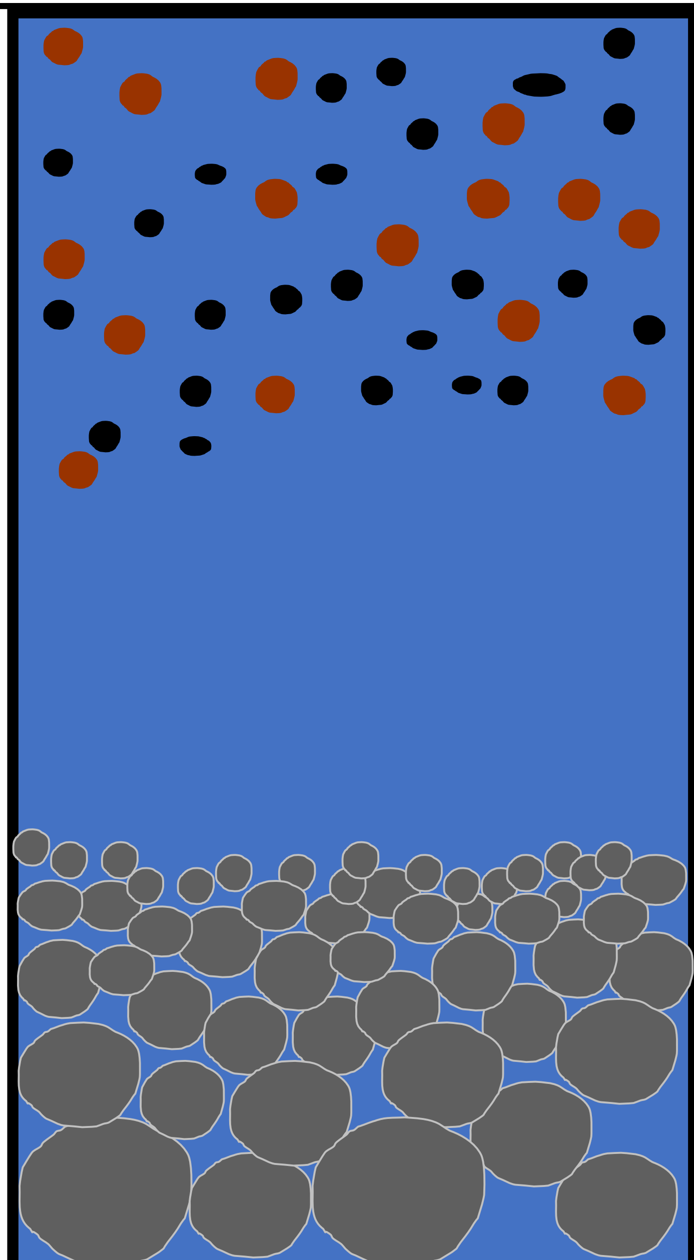
1. Backwash continues until all of the iron and manganese is suspended in the water above the fluidized sand/media.
2. Water is not wasted during the backwash process.

Backwash to remove captured iron and manganese.



1. All of the iron and manganese that was captured on the sand/media surface is suspended in the water above the filter sand/media (less than 1 metre depth).

Backwash to remove captured iron and manganese.



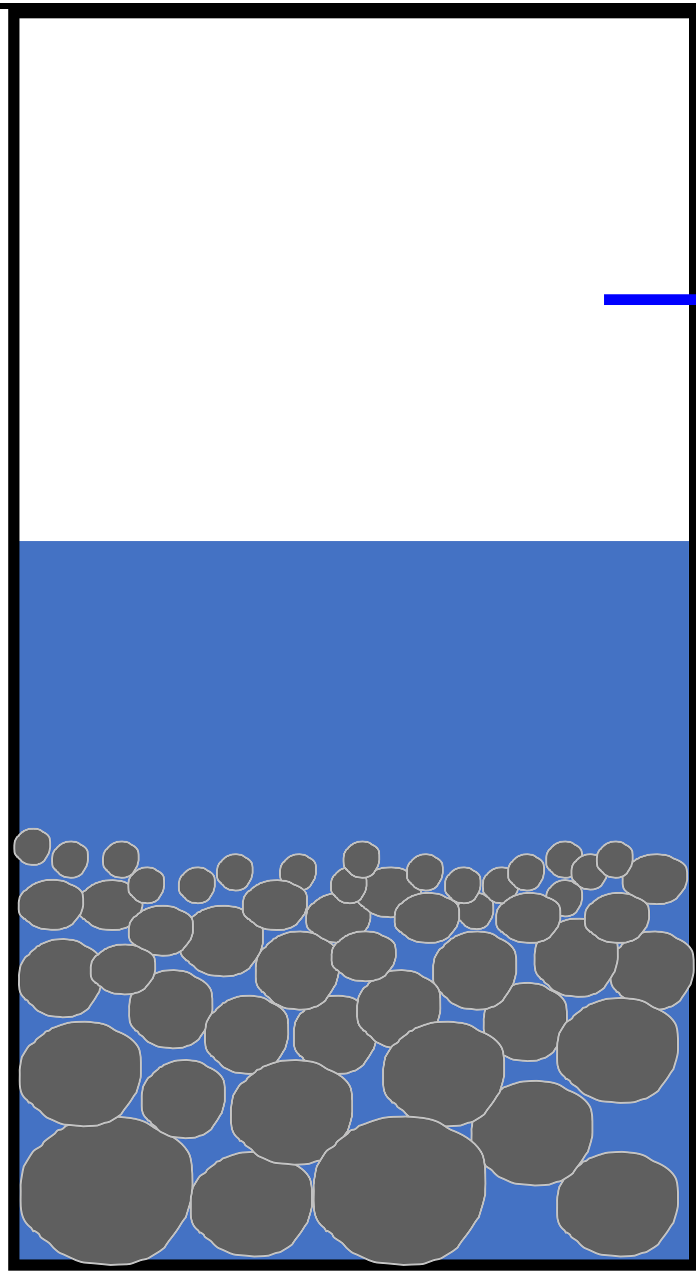
Oxidized iron

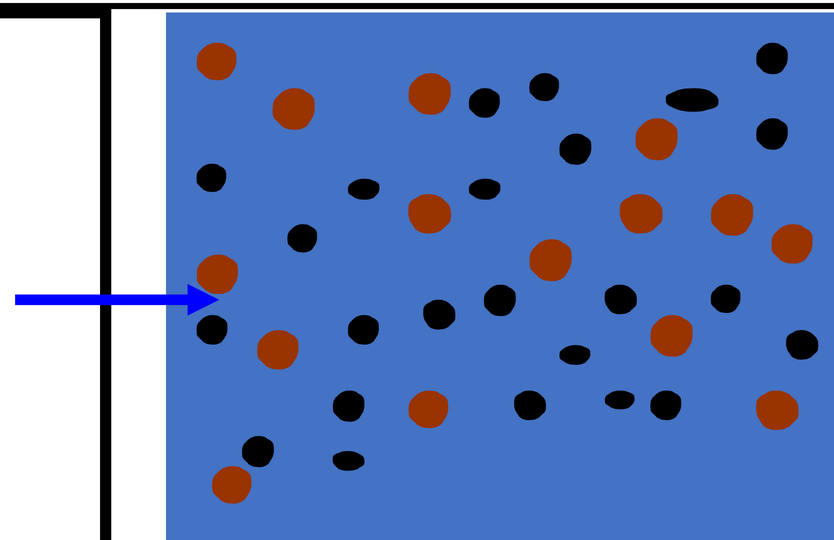
Oxidized manganese

Note:

1. Backwash is stopped.
2. Sand/media settles back to original position with finest particles at the top.

Backwash to remove captured iron and manganese.





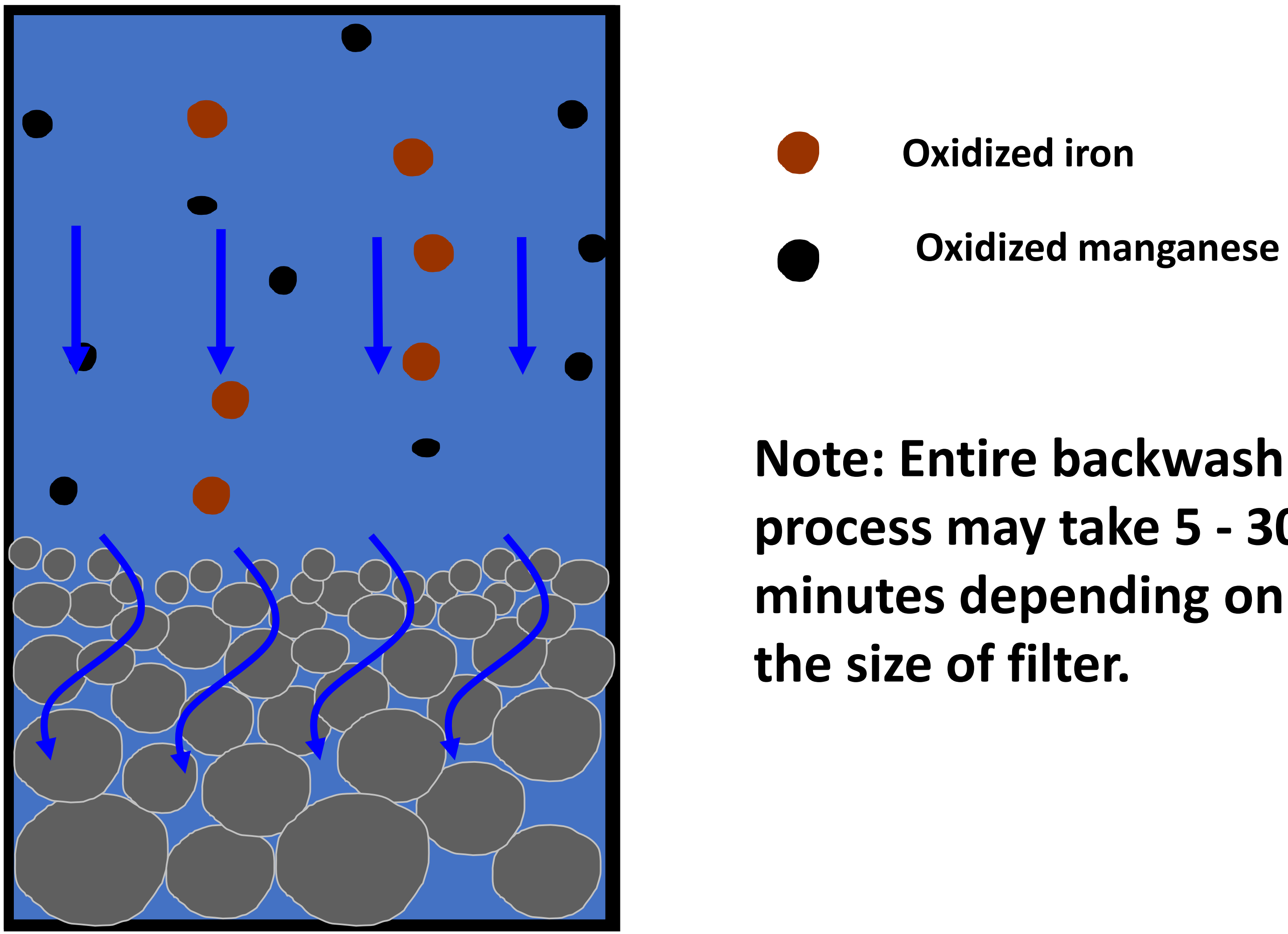
Oxidized iron

Oxidized manganese

Note:

1. Water with the suspension of iron and manganese is drained from the filter (to waste) at desired rate without use of pumps.

Filter is put back into production.



Note: Entire backwash process may take 5 - 30 minutes depending on the size of filter.

Conclusion:

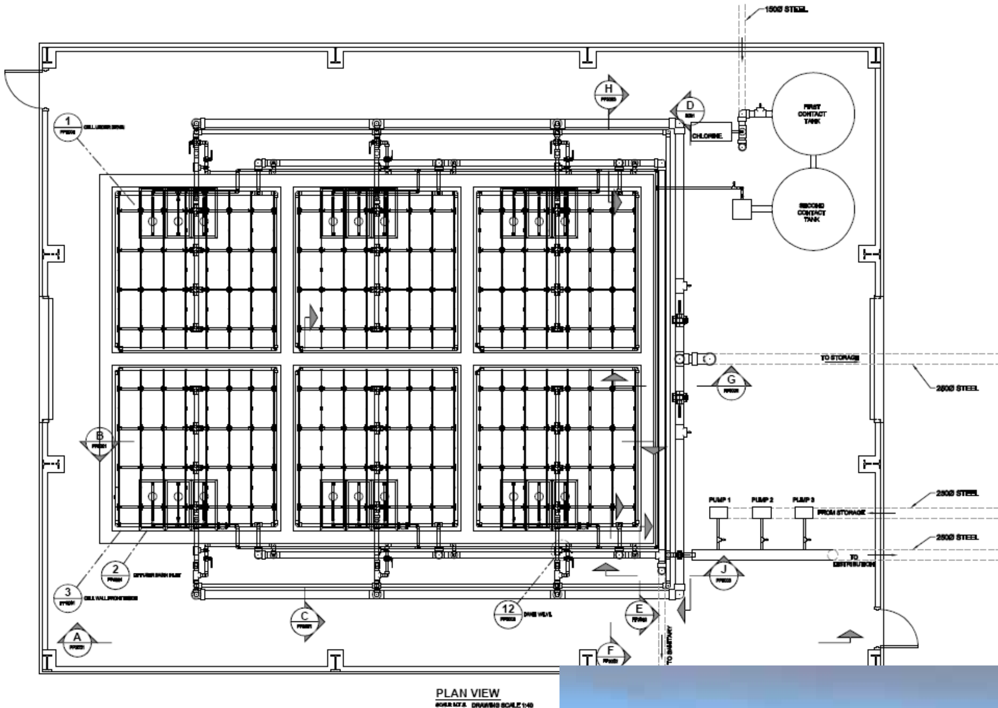
Cleaning using backwash can eliminate or compliment cleaning using surface agitation.

This is a really big deal when it comes to the larger filters.

What do the filters look like?

- Using diffuser basin and diffuser tubes.
- Cleaned using backwash.
- Wastewater removed using siphon.

Stavely, Alberta: Manganese removal. Commissioned 2007.



- 6 cells (4m x 4m x 1.8m)
- Each cell can treat a maximum of 16,000 L/h. (Loading of 1 $m^3/m^2/h$)

- Building approximately 20 m by 16 m.

Interior of Stavely water treatment plant.

Has worked very well for 12 years.

Inside of a filter cell.

Testing the underdrain.

Installing the media.

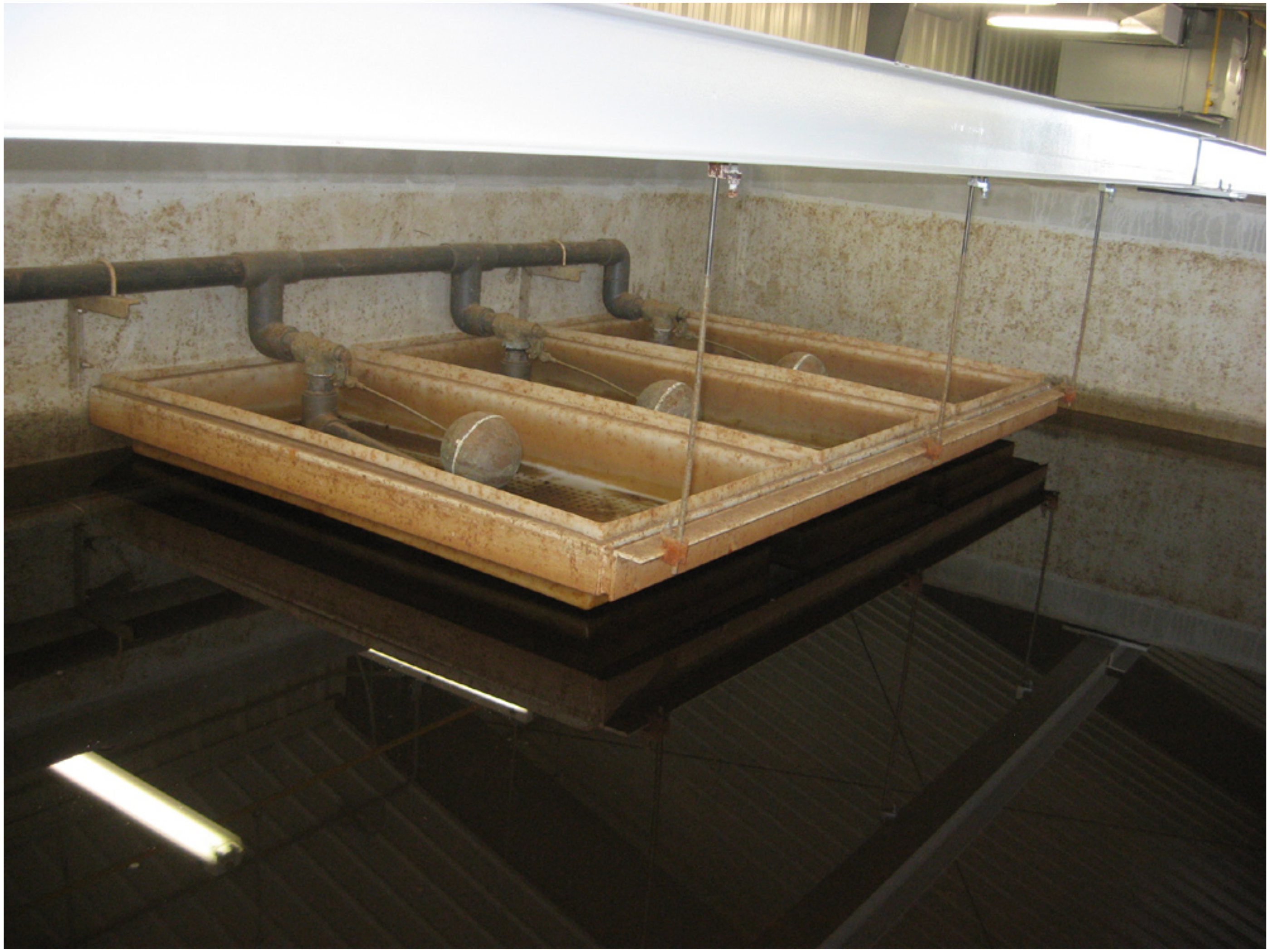
Adding media using 'Stone Slinger'.

Underdrain (bottom layer)

Underdrain (second layer)

Installing the media.

Operating Filter



Backwash in Progress

Backwash once every six weeks – one cell per week (30 min.).

Produce 6 m^3 wastewater per backwash per cell.

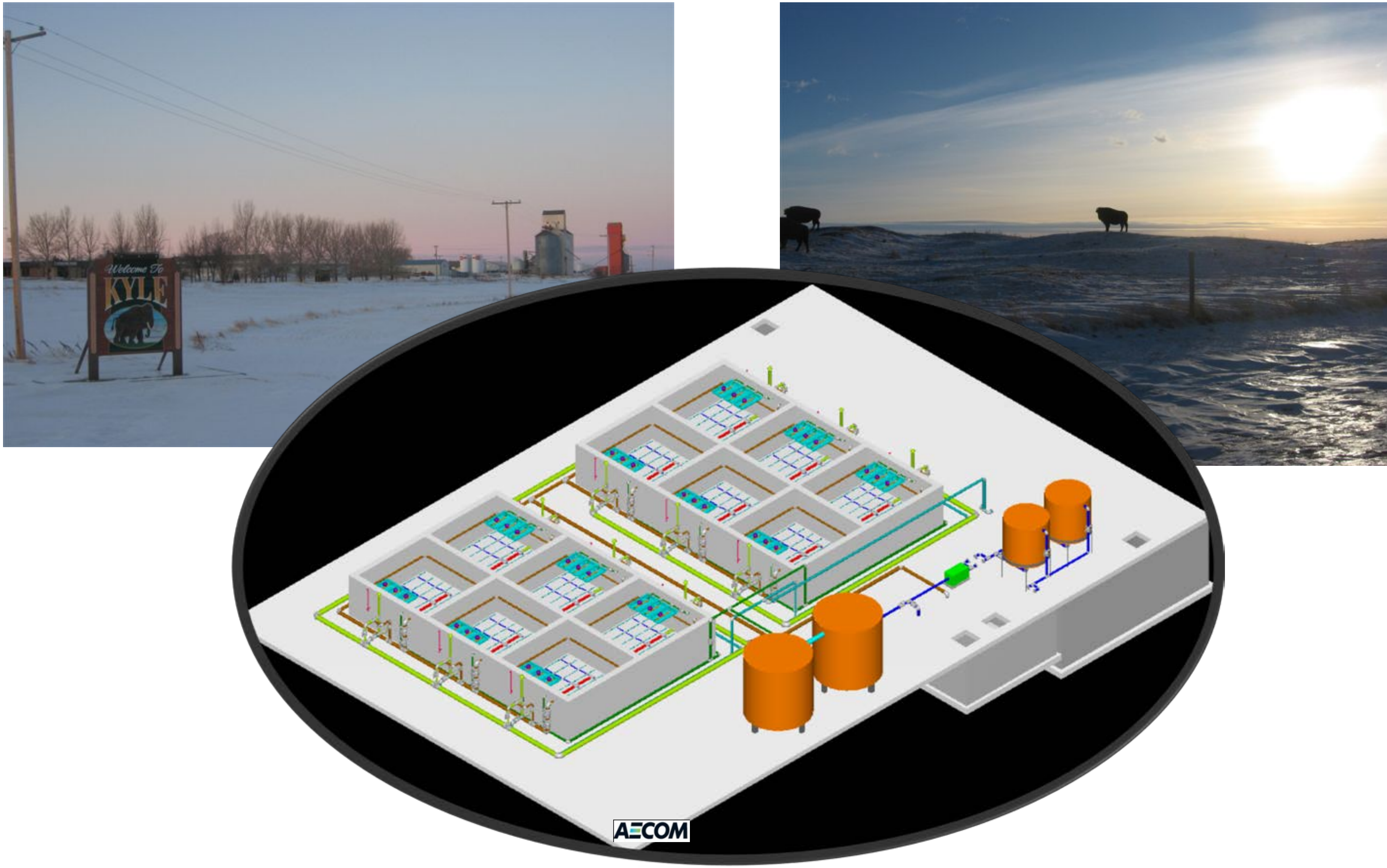
Wastewater is less than 1 % <u>of production</u>.

(36 m^3 of wastewater with 42,000 m^3 of production.)

Has worked very well – no media replacement or repairs for 12 years.

Inside Exshaw water treatment plant showing four filters (4m x 6m x 1.8m) and three contact tanks. Removal of iron, manganese and hydrogen sulfide.

Commissioned in 2011 and going strong.



Water treatment plant using MEL-PF technology to remove complexed iron and manganese from groundwater - Saskatchewan, Canada construction completed 2014- 100,000 LPH with 100% recycle of wastewater.

Commissioned in 2014 and working well.

Learning from experience: Complete review and redesign of previous filters. Stainless steel filters. 1m x 1m, 1m x 2m, 2m x 2m, 2m x 4m and 4m x 4m.

Prefabricated MEL filters
Stainless steel construction

- 4m x 4m x 2m
- 2m x 4m x 2m

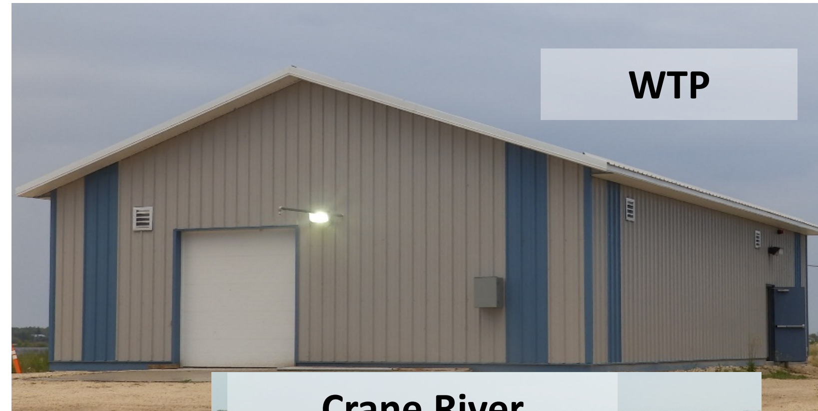
4m x 4m x 2m filters ready for transport to plant.

Array of four 4m x 4m x 2m filters installed and operating.

Array of two 2m x 4m x 2m filters installed and operating.

Manitoba – Indigenous Community. Treat lake water.

Manitoba indigenous community. Treat river water.

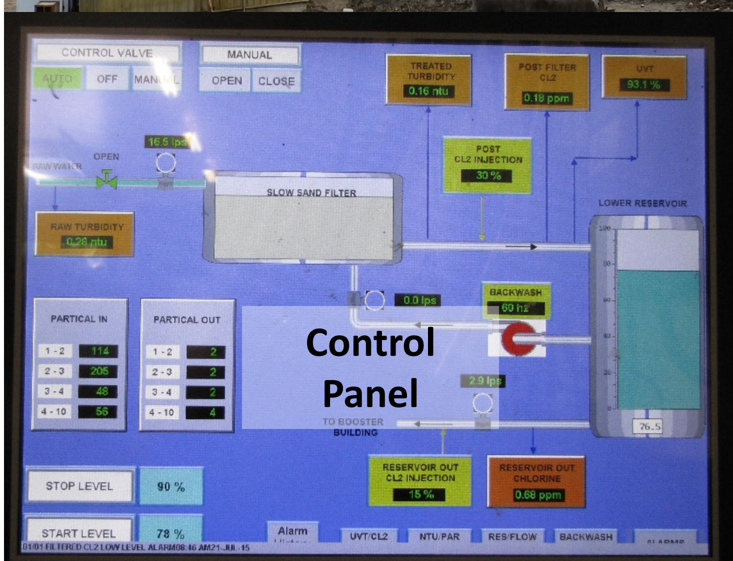


UV Disinfection following nanofiltration

Water is chlorinated using sodium hypochlorite prior to storage and distribution

British Columbia. River water.

Transport to site.



UV disinfection is being added.

Pilot Filter

ALL applications are pilot tested BEFORE recommending technology and producing designs.

Prefabricated filters
Polyethylene construction

Filtration capacity depends on surface loading rate; that is, whether filter is a BF or PF. BF's range in capacity from 12 Lph to 1350 Lph.

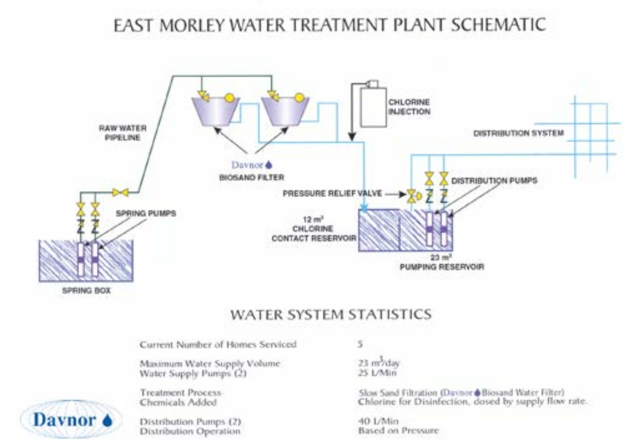
2 x 180 Lph BF polyethylene filters followed by UV disinfection.

8 x 1000 Lph polyethylene PF filters followed by GAC and chlorine disinfection.

8 x 3500 Lph PF polyethylene filters ready for shipping.

East Morley (1st Nations Community), Alberta, Canada

- Water supply is a shallow spring.
- 2 x 600 Lph BioSand filters (Variation of MEL-BF previously manufactured by Davnor) used in parallel followed by chlorine disinfection.
- In operation for more than 15 years.



New Davnor 60 LPH (when treating surface water)

No diffuser basin!
Cleaned using backwash.
Wastewater removal using siphon.

The introduction of backwash process has eliminated almost all of the limitations of the 'old' commercial versions of the large scale BioSand water filter technology.

Independent performance evaluations were performed pertaining to the removal of bacteria (e-coli) by the Microbial Research Group at Lethbridge College, Lethbridge and removal of parasites (giardia and cryptosporidium cysts and oocysts) by Hyperion Lab in Medicine Hat.

Efficiency Study Of Manz Engineering LTD. Pilot Filter At Removing Bacterial Coliforms From Water

Karli Tremel[1], Thomas Graham[1], David Manz[2], Leanne DuMontier[1], and Sophie Kernéis[1],
1-Microbial Research Group, Lethbridge College, Lethbridge Alberta; 2- Manz Eng. Ltd. Calgary, Alberta.

SITUATION

According to the World Health Organization, 2.1 billion people worldwide do not have access to safe water for drinking, food preparation, hygiene and sanitation. This mostly effects places of poverty and people in extremely rural areas where the water is contaminated by animal waste or sewage. These contaminants can contain harmful coliforms such as *E. coli* O157:H7.

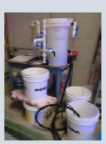
COMPANY

Manz Engineering Ltd is a Calgary, Alberta based BioSand filter company, founded by Dr. David Manz. He was a professor of environmental engineering at the University of Calgary when he began working on the BioSand filter. His goal is to improve the quality of accessible water around the world.

http://www.manzwaterinfo.ca

REQUEST

The request was to test different parameters (time, Flow rates, biofilm formation, bacterial inoculum...) to optimize the efficiency of the BioSand filter at eliminating bacteria from water.
This project was brought to Lethbridge college in 2015.
Below: Karli Tremel (left), David Manz (right)

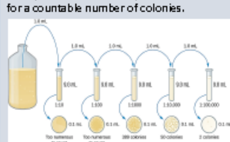


THE PROJECT

Procedure

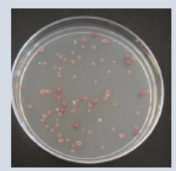
- We used fish water from our aquaponics center to mimic river water.
- Fish water (18 liters) were collected daily and passed through the Slow Sand filter.
- Different flow rates are considered to test their impact on BioSand Filter efficiency.
- Bacterial analysis are performed on Filtered and Fish waters (Serial dilutions were performed, analysis were done in triplicate).
- Chromogenic media is used to select coliforms bacteria.
- Colony forming units (CFU) are counted to calculate the Percentage of coliforms removed by the BioSand filter.

Example of serial Dilution, this allows for a countable number of colonies.

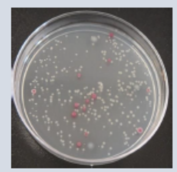


After dilution, the spread plate technique is used to incubate and grow colonies.

Filter water bacterial analysis Chromogenic medium

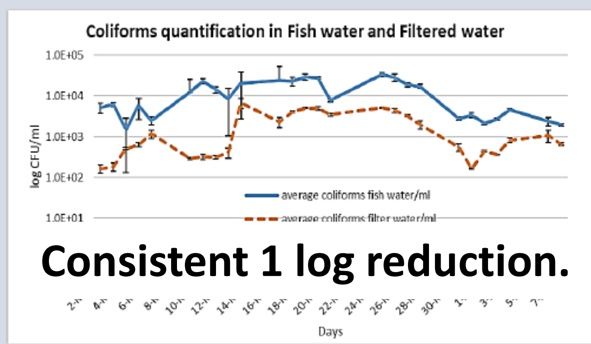


Fish water bacterial analysis Chromogenic medium



RESULTS

We can see a clear efficiency of the Sand Filter at removing the coliforms bacteria, the maximum log reduction being 1.9.



THE EXPERIENCE

I was trained and guided by the Microbiology Research group to:

- Conduct the research using the Scientific method
- Utilize the microbiology laboratory
- Access fish water that would mimic a natural water source at The Aquaponic Centre of Excellence
- Analyzing my results using Excel and Word.

THE GAIN

Dr. Manz was provided with monthly reports and a final report that described the effect of the flow rates and biofilm formation on the efficiency of his system. This information was used to teach people how to utilize effectively the Manz Engineering Ltd. Pilot Filter to have safe drinking water in places that do not have the access of having clean water.

As a student focused on healthcare, this opened doors to a network of resources that I would not have otherwise. Being involved in this research and innovation, I have a passion for an area of study and career opportunities that I did not know previously. My goal is to enhance our Canadian healthcare and the healthcare professionals' ability to care for people both in urban centers and remotely through research and innovation.

APPLIED REASERCH AT LETHBRIDGE COLLEGE

Applied research offers an opportunity for students to become involved in areas of study that interests them while gain practical experience and new resources for the future.
Lethbridge college has been and is currently involved in several different applied research projects including but not limited to:

- A prairie plant project, this is working on identifying antibiotic properties in plants native to Alberta
- A method of eliminating *E. coli* using dissolved ozone in water to treat cattle trucks(see Ashtin Halmrast)
- Also different projects involving agriculture and irrigation

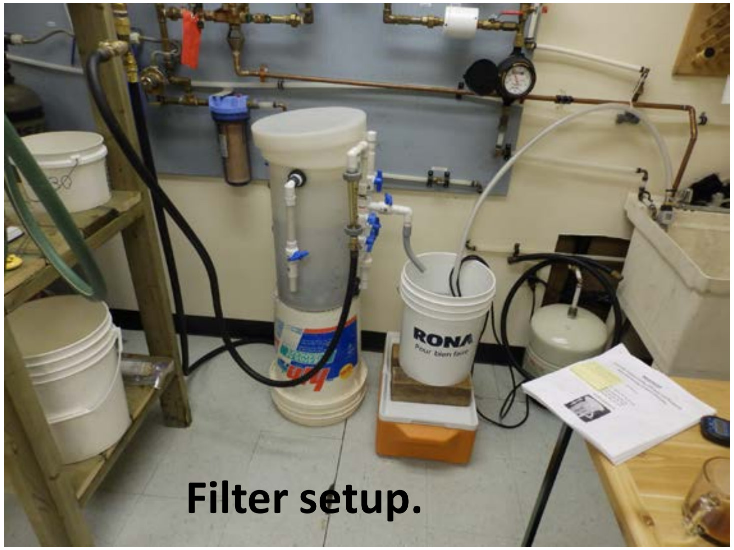
ACKNOWLEDGMENTS

We would like to thank Dr. Jagvir Singh, Applied Research, Lethbridge College.
This work was funded by Lethbridge College and Manz Engineering Ltd.

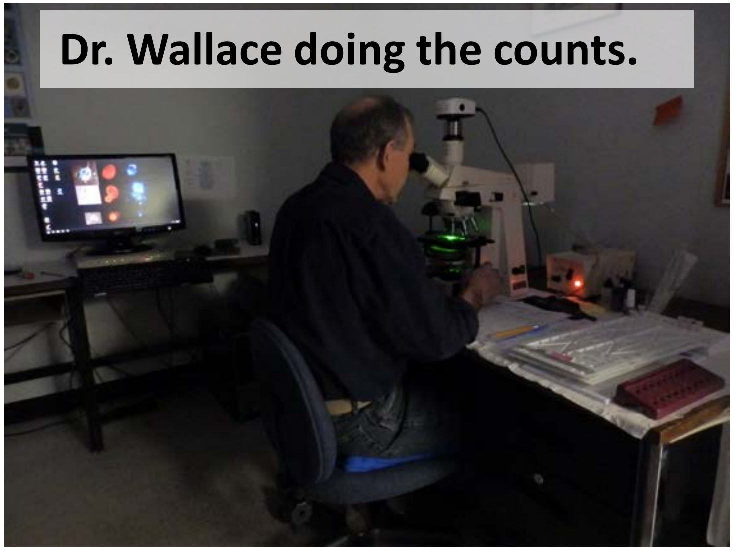
Parasite removal evaluation in Hyperion Laboratory.

Both unchlorinated and chlorinated water were used (typical of most urban communities in developing countries).

4 log removal of both live giardia cysts and cryptosporidium oocysts were achieved using both water types.


Filter setup.


Parasite 'Ranch' in Hyperion Lab


Dr. Wallace doing the counts.

So what about a household filter?

I wanted to develop a filter that would appeal to the widest market possible – while still basically being a 'BioSand Water Filter' – not necessarily the poorest but anyone who would benefit from production of their own safe drinking water (instead of bottled water).

The filter had to overcome most of the objections to the household concrete BSF and currently produced plastic versions of the BSF. Also, it had to be inexpensive and capable of being reliably manufactured, marketed and technically supported throughout the world in the simplest of circumstances. i.e. multi-level marketing. Had to appeal to 'big business' and the intended consumer.

My solution is what I named the 'Cabin Clean Water Filter'

With media kit and commissioning kit.

Filter is 50 cm tall and 30 cm wide and weighs 15 kg complete with commissioning kit. Can be shipped anywhere.

Filter is designed to produce 12 Lph when newly commissioned or cleaned.

Filter has same performance characteristics as all other MEL or Davnor backwashed filters.

Commissioned using a backwash process; but, cleaned using 'swirl and dump'.

Filtered water is intended to be disinfected and stored in a container allowing for sanitary dispensing.

This is consistent with recommendations dating back to 1993 when filters were first introduced into Nicaragua.

This also appears consistent with CAWST's recommended multi-barrier approach.

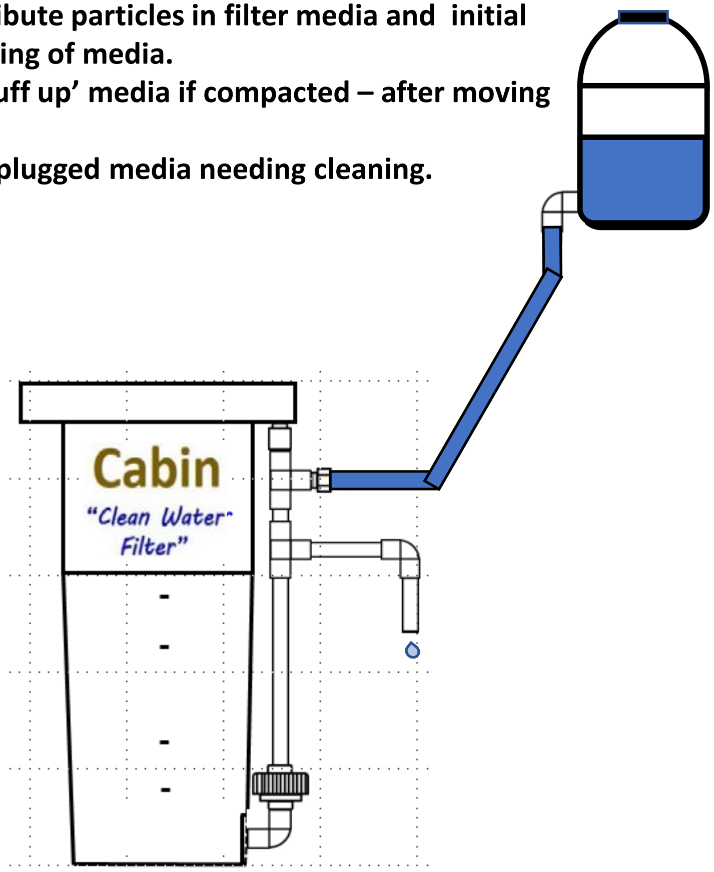
It should be obvious that the MEL and Davnor filter technologies are complementary to the concrete household BSF.

Commissioning, re-commissioning or emergency cleaning

Commissioning: distribute particles in filter media and initial cleaning of media.

Re-commissioning: 'fluff up' media if compacted – after moving filter.

Emergency cleaning: plugged media needing cleaning.



Raise bucket approximately 1.5 to 2 m above top of filter.

Water will flow through standpipe, into the underdrain and upward through the media. The media should behave like 'quick sand'. It should be possible to push your fist through filtering media down to separating media. (Do not disturb separating media.)

There will be some leakage from filter outlet.

Today the emphasis is getting the technology more widely available to people who need it too – like the large and small urban and peri-urban (slum) communities as well as the rural poor.

Hard to believe that these two filters use identical design criteria.

Actively marketing in Canada, Africa, Cambodia, India and China – soon the whole world!
E –commerce rules! Still empowering! Billions of filters! Safe water for the world!

Lots more to tell.

Thankyou.

www.cabincleanwaterfilter.com

www.manzwaterinfo.ca