PREMIER TECH

Comparing treatments for high-strength wastewater

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Introduction

Most states do not consider high-strength wastewater characteristics when defining guidelines for designing on-site sewage disposal systems.

High-strength wastewater can be caused by:

- high inputs of BOD, TSS, FOG, nitrogen
- lack of dilution from low-strength inputs – use of low-flow water fixtures
- chemical upset of the septic tank
- operation and maintenance issues

Introduction

A brief overview:

- Wastewater is usually defined as high-strength when concentrations of BOD, TSS, FOG, or nitrogen are higher than typical domestic wastewater.
- The focus is commercial and non-residential water usages that lead to unusual or high wastewater strengths. These include restaurants, truck stops, breweries, etc.
- Many states now recognize that the treatment of high BOD_5, TSS, or FOG concentrations requires different strategies than those used for typical domestic applications.
- Several pre-treatment possibilities exist, but the extent to which they reduce high-strength wastewater is not fully understood.

High-strength wastewater

Main contributors

On-site wastewater treatment system design and sizing is typically based on wastewater design flows, with the assumption that wastewater strength is within standard ranges for domestic (residential) wastewater.

Domestic wastewater

Raw sewage

Parameter	Concentration Range	Typical Concentration
TSS (mg/L)	155 – 330	250
BOD_5 (mg/L)	155 – 286	250
pH (s.u.)	6 - 9	6.5
Total coliform (CFU/100 mL)	10^8 – 10^{10}	10^9
Fecal coliform (CFU/100 mL)	10^6 – 10^8	10^7
NH_4-N (mg/L)	4 - 13	10
NO_3-N (mg/L)	< 1	< 1
N total (mg/L)	26 - 75	60
P total (mg/L)	6 - 12	10

Ref: U.S. EPA Onsite Wastewater Treatment Design Manual

Domestic wastewater

Septic tank effluent

Parameter	Concentration Range	Typical Concentration
TSS (mg/L)	36 - 85	60
BOD_5 (mg/L)	118 - 189	120
pH (s.u.)	6.4 - 7.8	6.5
Fecal coliform (CFU/100 mL)	$10^6 – 10^7$	10^6
NH_4-N (mg/L)	30 - 50	40
NO_3-N (mg/L)	0 - 10	0
N total (mg/L)	29.5 - 63.4	60
P total (mg/L)	8.1 - 8.2	8.1

Ref: U.S. EPA Onsite Wastewater Treatment Design Manual, 2002, EPA/625/R-00/08 and Crites and Tchobanoglous, Small and Decentralized Wastewater Management Systems, McGraw-Hill, 1998

High-strength wastewater

Main contributors

While many applications are within the low- or moderate-strength ranges, many non-residential or commercial establishments produce higher wastewater strengths or include chemicals that harm or reduce treatment performance.

What is high-strength wastewater?

Parameter	Raw Wastewater		
	Domestic/ Low Strength	Moderate Strength	High Strength
BOD_5	100 – 300 mg/L	300 – 1,000 mg/L	> 1,000 mg/L
TSS	100 – 350 mg/L	> 350 mg/L	> 350 mg/L
TKN	40 – 60 mg/L	60 – 100 mg/L	> 100 mg/L
FOG	50 – 150 mg/L	> 150 mg/L	> 150 mg/L

High-strength wastewater

Main contributors

Designers and owners of non-residential or commercial enterprises should be aware of some unique and potentially damaging wastewater characteristics that may be encountered in the waste stream.

These establishments may produce wastewater with high strengths:

- characterized by high BOD, TSS, and FOG influent numbers
- containing harsh chemicals used in processing or cleaning activities

BOD, COD, FOG, and TSS can indicate wastewater strength and its biodegradability.

High-strength wastewater

Main contributors

The types of establishments that may produce non-domestic or high-strength wastewater include:

- food establishments, such as restaurants, fast food restaurants, coffee shops, delis, convenience stores, cheese makers, breweries, wineries, bakeries, and food courts
- hotels, motels, campgrounds, and churches
- hospitals, nursing homes, dental offices, and schools
- laundromats, funeral homes, taxidermy operations, slaughterhouses, pet kennels, and beauty salons

Factors that influence design

Considerations include:

- organic matter
- FOG
- emerging contaminants
- temperature
- pH
- flow
- others

Organic matter

BOD is directly related to the amount of food products in wastewater:

- unused coffee
- dairy products
- soda
- juices or other beverages with high sugar content

High BOD concentrations can adversely affect a treatment/disposal system if they are not taken into account when the system is designed.

BOD loading example

High strength

Food type	BOD_5 (mg/L)	pH
Soda	Up to 79,500	2.4
Beer	Up to 80,000	
Whole milk	104,600	
Skim milk	67,000	
Orange juice	7.85 lb/100 lb	
Potatoes	4.20 lb/ 100 lb	
Potato chips	1.25 lb/ 100 lb	

Ref: Carawan, R.E., NC State University, Water and Wastewater Management in Food Processing (1979)

Restaurant type*	n	Average BOD (mg/L)	Average TSS (mg/L)	Average FOG (mg/L)
Fast food	6	2,137	233	102
Pizza	1	1,856	321	183
Chinese	4	1,364	448	241
Mexican	9	1,254	668	190
American	1	1,063	297	147
American buffet	1	792	195	63
Steakhouse	2	601	160	77
Seafood	3	555	229	47
Typical residential range		**100 - 400**	**100 - 350**	**10 - 65**

* Not all restaurants are created equal.
Ref: Harris county Public Infrastructure Department - 2013

Organic matter

If mixed with domestic wastewater, unusual waste streams should be carefully evaluated to understand their characteristics. This includes waste streams from:

- breweries
- wineries
- cheese makers
- slaughterhouses

Organic matter

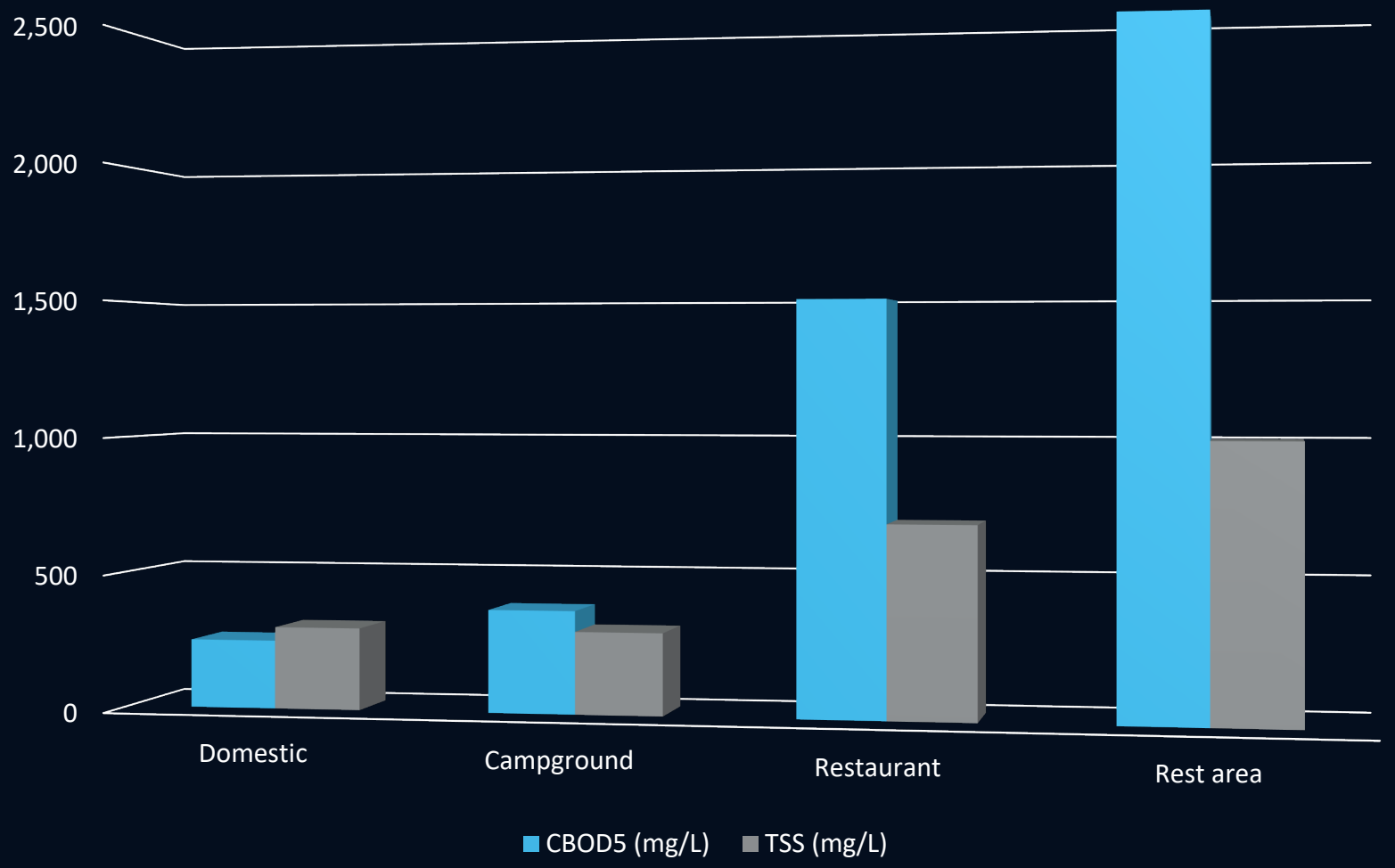
Sometimes these wastewaters are deficient in:

- nitrogen
- phosphorus
- bacteria

All are needed to begin to treat the wastewater.

Consideration should be given to collecting and disposing of these wastewaters separately from domestic wastewater sources.

Types of organic loads



FOG

With grease traps, be careful with:

- high grease loads
- emulsified grease
- undersized grease traps
- poor maintenance
- surges in wastewater flow

All may cause grease and oils to escape the grease trap.

Differences between fats, oils, and greases

Fats:

- animal fats from cooking, clean-up, or dishwashing
- relatively easy to hold in septic tank grease trap
- quite sensitive to temperature
- solid at 25 °C
- break down through biological process, but about four times more demanding

Differences between fats, oils, and greases

Oils:

- often vegetable-based
- less sensitive to temperature
- break down through biological process, but about 12 times more demanding
- liquid form more difficult to hold in tank
- ability to separate influenced by temperature and how oil was generated and used

Differences between fats, oils, and greases

Greases:

- petroleum-based (lotions, hair products, soaps)
- can be toxic
- difficult to break down, but can be separated
- can build up over time, coating components and inhibiting treatment of other contaminants

Emerging contaminants

Little is known about these contaminants.

Harsh cleaning chemicals can harm septic tanks and treatment performance:

- quaternary ammonia (QUATs) and other harsh chemicals
- QUATS = formaldehyde-releasing toxic chemicals associated with multiple health risks

Pharmaceuticals:

- majority of compounds are excreted by patients

Temperature

Typically, it must be warm enough to encourage biological activity.

Commercial dishwashers can be set to very high temperatures, which may impact treatment and/or the ability of fats, oils, and greases to solidify in grease traps and septic tanks

pH and alkalinity

These can be affected by chemicals in cleaning products and certain food wastes.

If pH is out of the normal range (typically 6.4 to 8):

- negative impact on biological activity
- if too acidic, phosphorus precipitate becomes soluble, increasing effluent concentrations of P total

pH and alkalinity

Alkalinity is important, particularly in the nitrification/denitrification process:

- 7 alkalinity to 1 N ratio
- depending on soil, can vary greatly between regions
- maintain minimum alkalinity of 50 mg/L to prevent acidification

Flow

Average daily flow rate

- average volume of wastewater in a 24-hour period
- calculated from values measured over a period of time

Daily flow rate

- measured volume of wastewater generated from a facility in a 24-hour period
- expressed as a volume per day

Flow

Daily design flow rate

- estimated peak volume of wastewater for any 24-hour period
- parameter used to size non-residential systems

Design flow rate

- estimated volume of wastewater per unit of time for which a component or system is designed
- commonly called ‘design flow’
- usually based on theoretical values taken from local regulations

Flow

Hourly peak flow rate

- highest flows measured for a one-hour period

Instantaneous peak flow rate

- highest recorded flow rate within a given period of time

Surge flow

- flow of effluent greater than average and occurring for short periods of time

Flow

Daily fluctuation vs. longer period of time

Flow equalization:

- damping peak; or
- regulating flow

Other considerations

Operation and maintenance:

- limited operator knowledge in decentralized applications

Less conservative designs or higher-than-anticipated waste strengths or flows may require more frequent:

- tank pumping intervals
- system maintenance

Treatment of commercial waste containing FOG

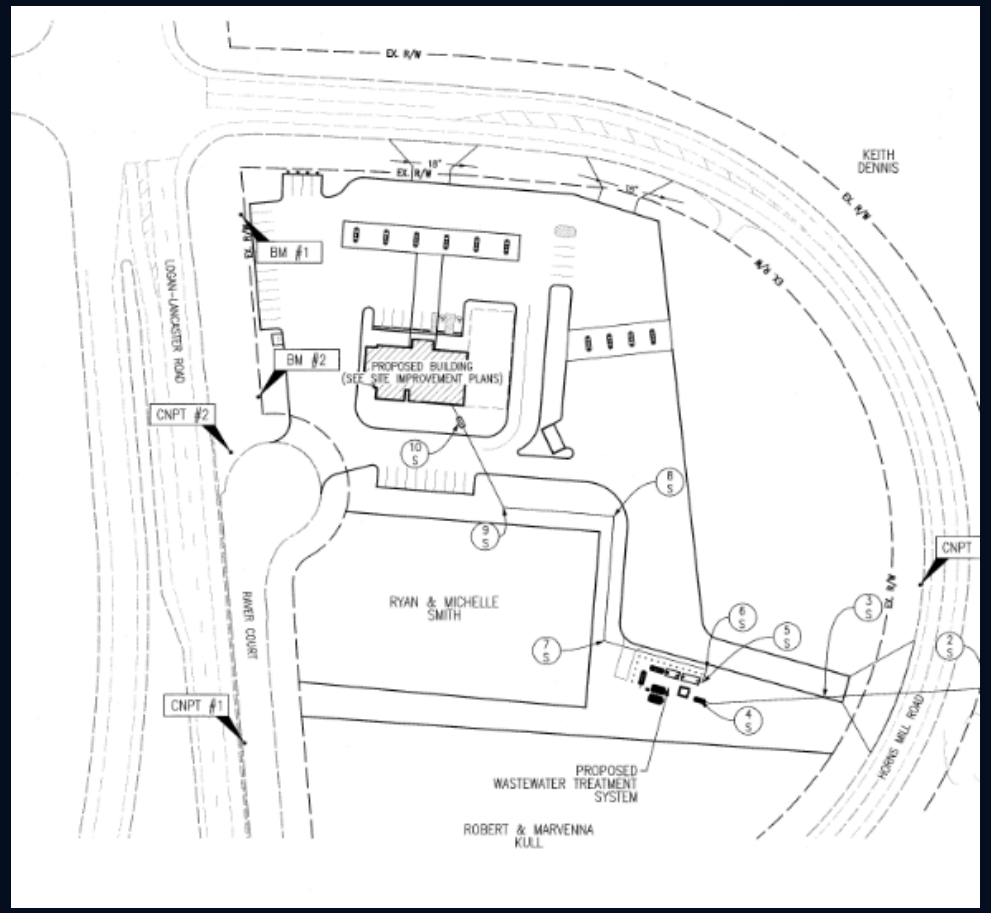
Three main challenges:

1. Have enough oxygen to treat or break down FOG.
2. Keep the pH in a neutral range to ensure that most microorganisms survive.
3. Guarantee that an ongoing monitoring program is in place.

Ref: Stuth, 1989

Case study

Convenience store and gas station



Case study

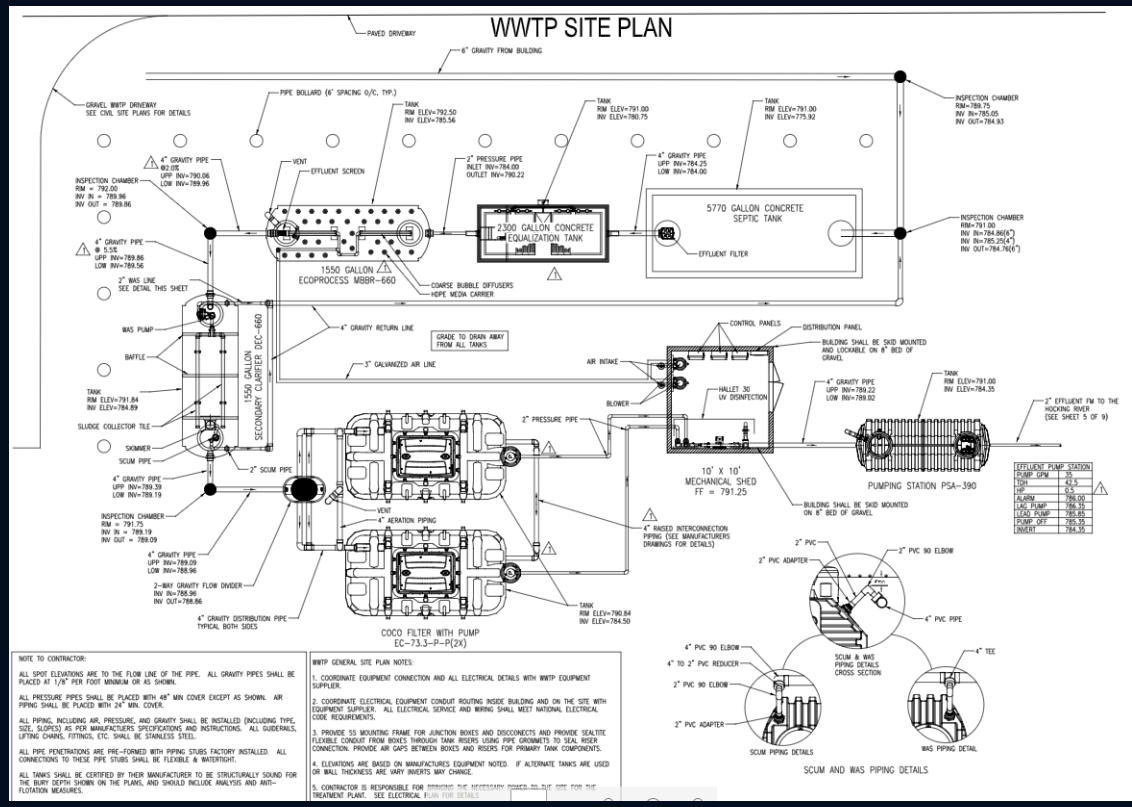
Convenience store and gas station

Design criteria:

- Q 2,500 gpd
- $CBOD_5$ 350 mg/L
- TSS 225 mg/L
- TKN 50 mg/L

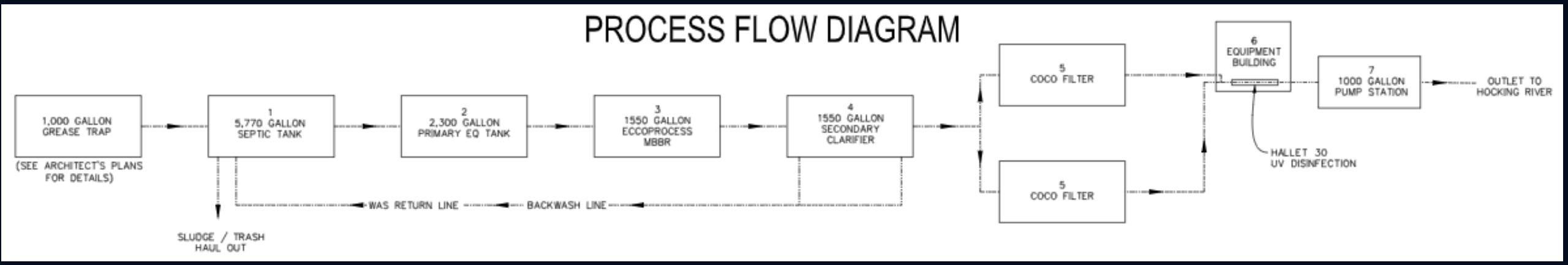
Treatment objectives:

	Monthly	Weekly
BOD_5 (mg/L)	< 10	< 15
TSS (mg/L)	< 12	< 18
NH_4 (mg/L)	< 1	< 1.5
Fecal (CFU/100mL)	< 126	< 284

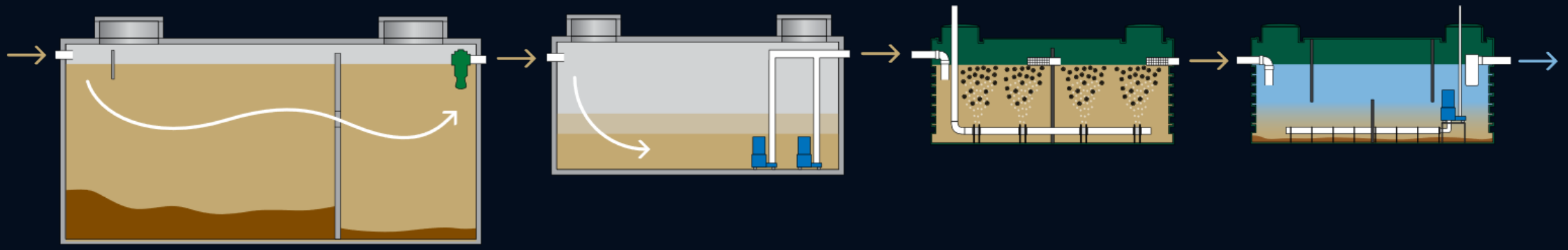


Case study

Convenience store and gas station



MBBR • Operation



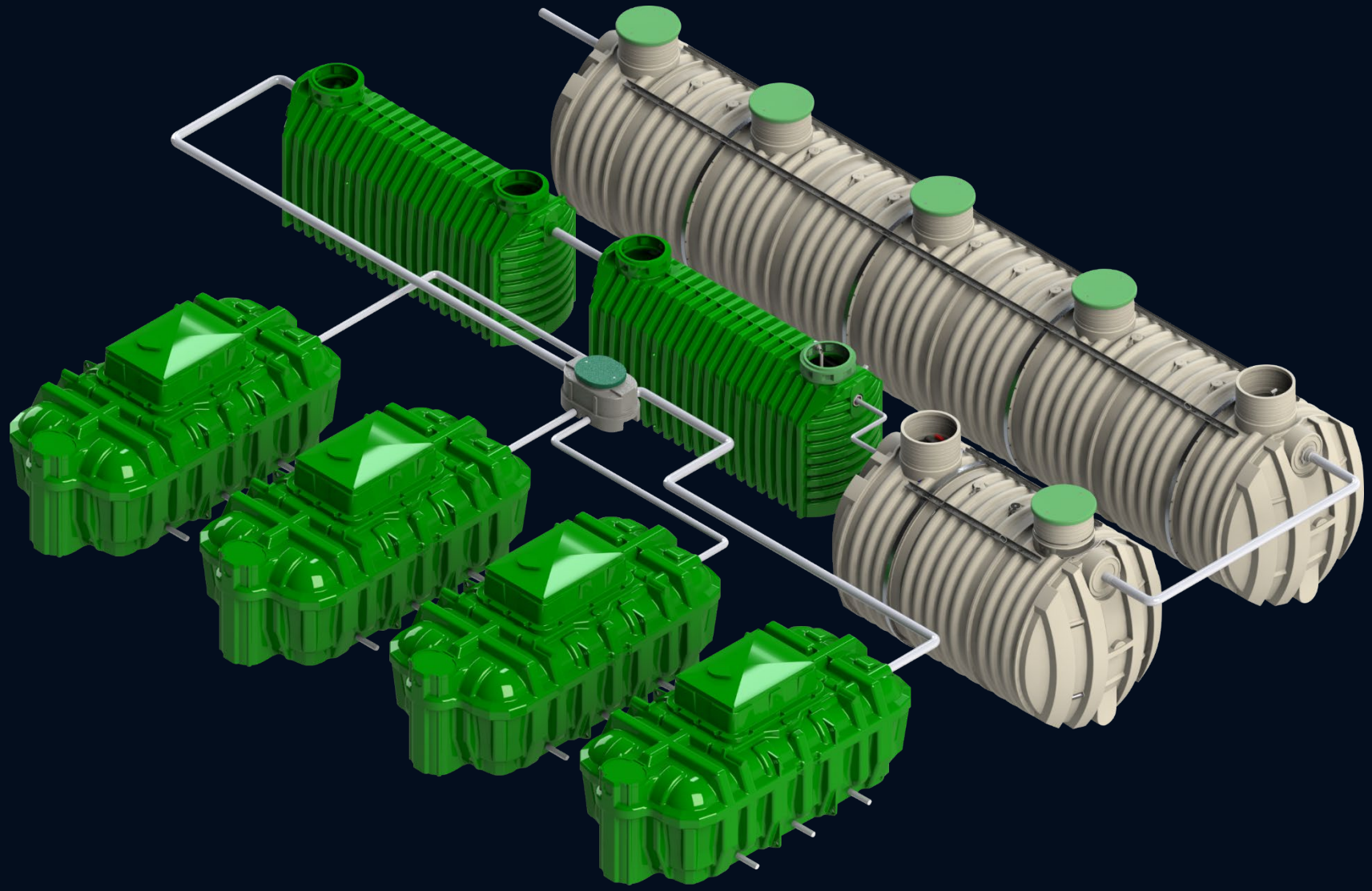
Primary tank

Equalization tank

MBBR

Clarification tank

MBBR • Typical Layout with Ecoflo



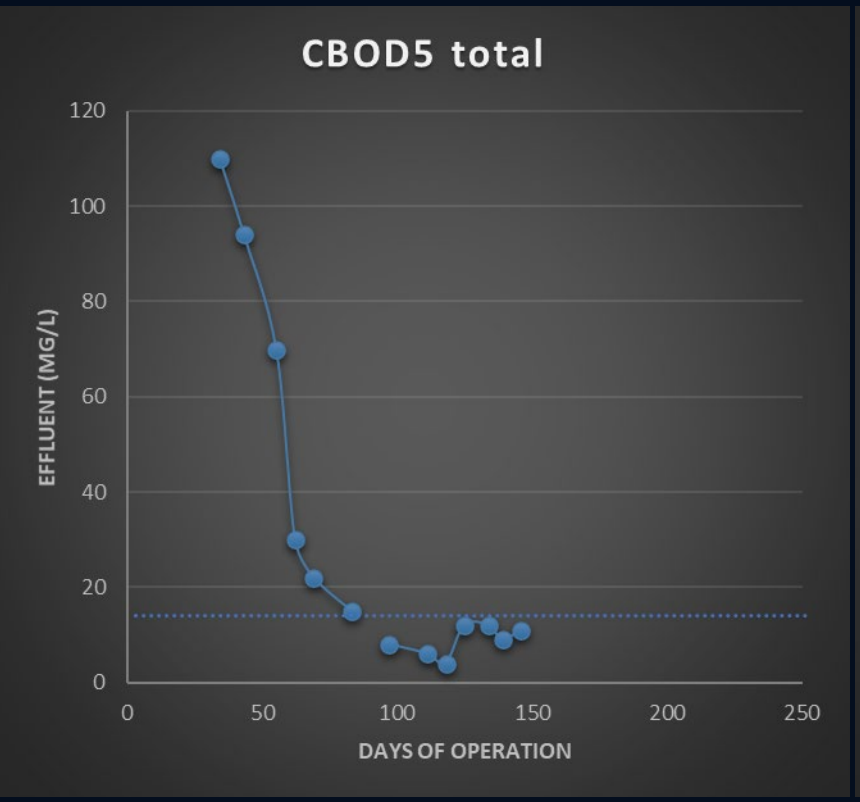
Case study

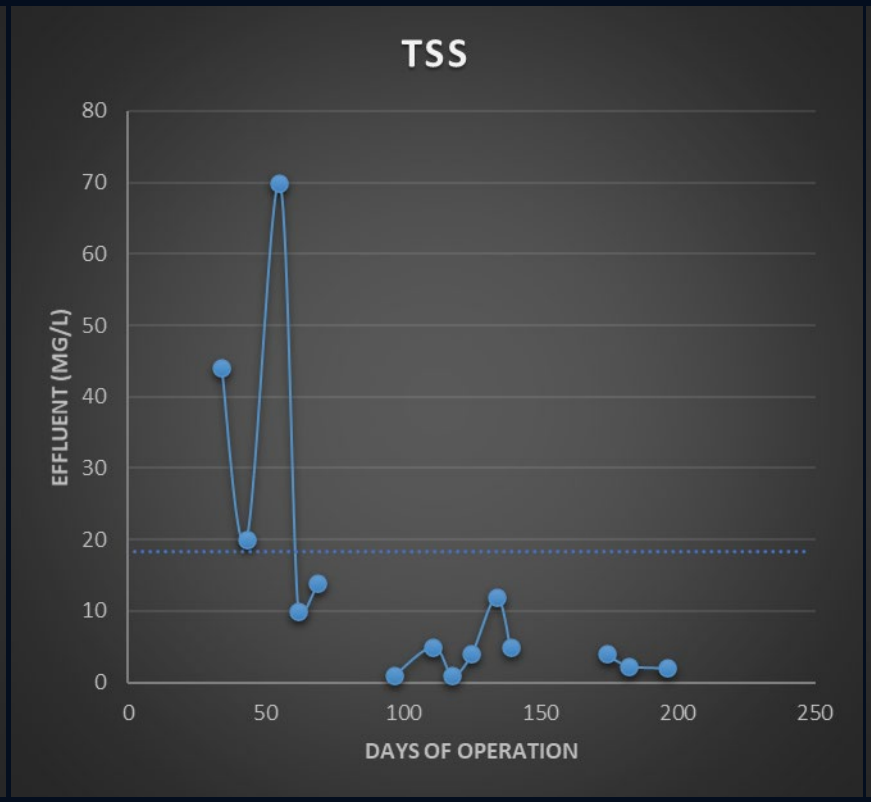
Convenience store and gas station

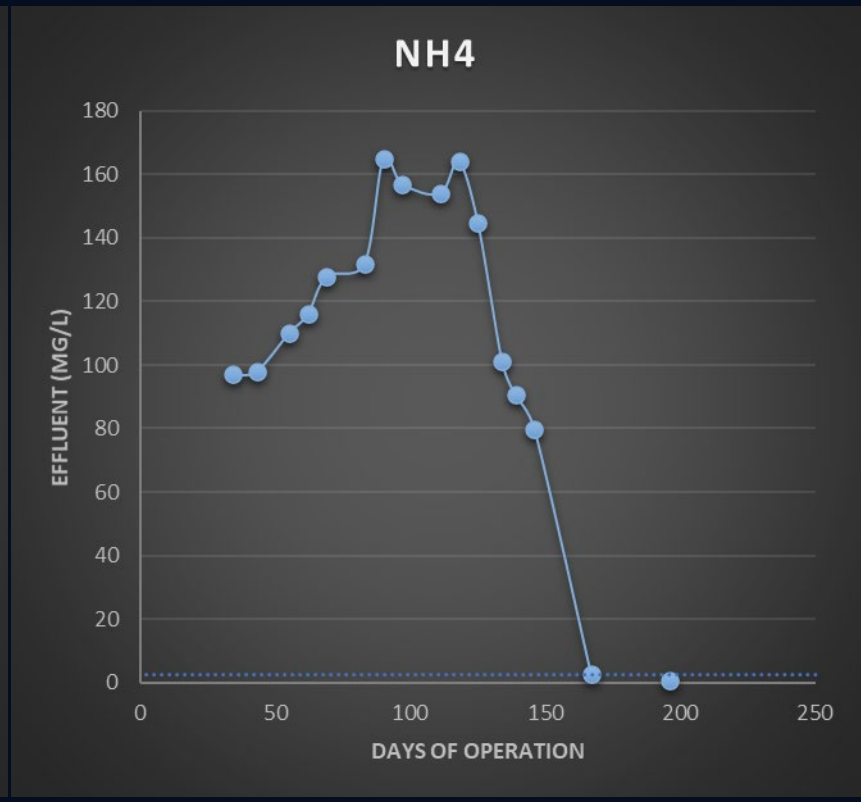
Design		Actual
Q:	2,500 gpd	Q: **300** gpd
$CBOD_5$:	350 mg/L	$CBOD_5$: **585** mg/L
TSS:	225 mg/L	TSS: 300 mg/L
TKN:	50 mg/L	TKN: **181** mg/L
		NH_4: 148 mg/L

Case study

Convenience store and gas station







Case study

Convenience store and gas station

Start-up time and adjustments required:

- cold climate
- low flow, leading to lack of aeration (logic control)
- higher concentrations
- NH_4 level

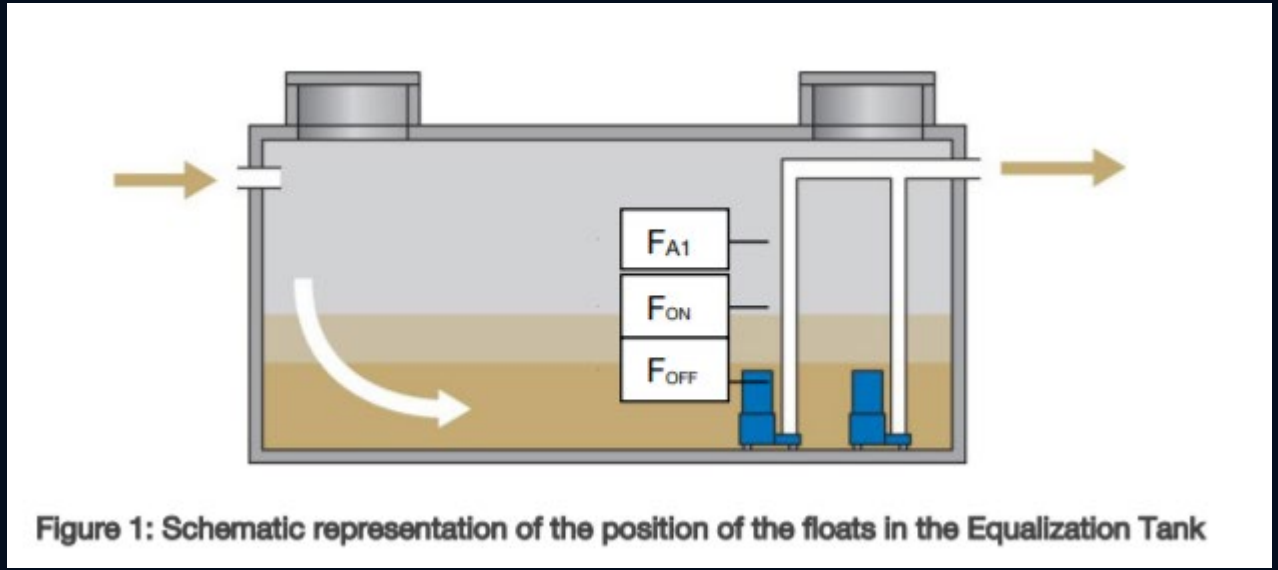


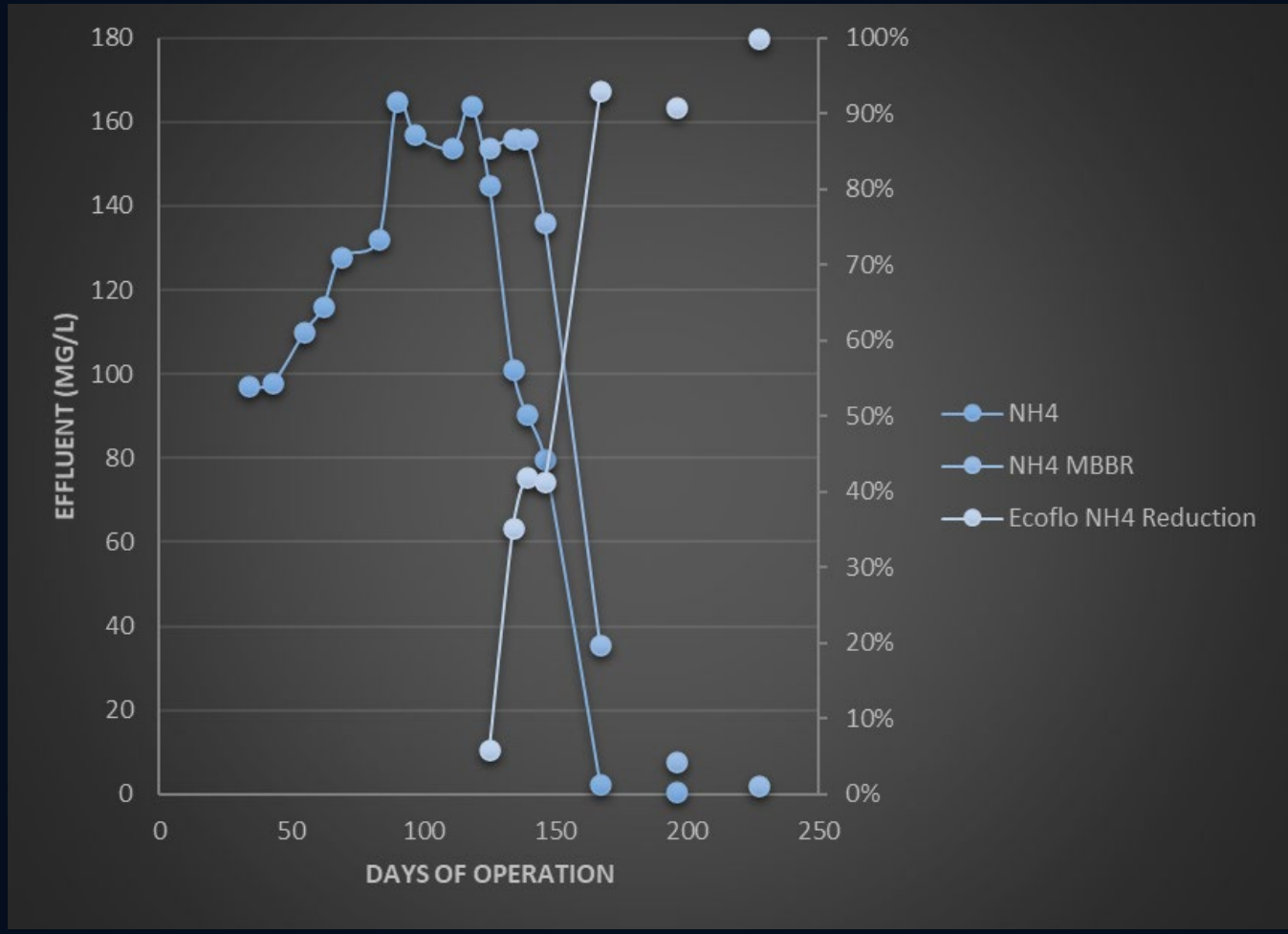
Figure 1: Schematic representation of the position of the floats in the Equalization Tank

Case study

Convenience store and gas station

NH_4 reduction:

- MBBR aeration
- Ecoflo biofilter with
  100% coco filtering medium



Case study

Convenience store and gas station

Ecoflo biofilter contribution to NH_4 reduction

$CBOD_5$ Concentration biofilter effluent	25.00	mg/L		Oxygen available / surface of biofilter	134.00	gO_2/m^2 day
$CBOD_5$ Concentration biofilter influent	10.00	mg/L		Surface available / biofilter	79	ft^2
Oxygen available per day with biofilters	1.96	kgO_2/day		# biofilters on site	2	
$CBOD_5$ Oxygen consumption	0.21	kgO_2/day		Oxygen demand rate for $CBOD_5$	1.50	$kgO_2/kgCBOD_5$
Oxygen available for nitrification	1.74	kgO_2/day		Oxygen demand rate for TKN	4.57	kgO_2/kgTKN
				TKN consumption by Ecoflo	**0.38**	**kg/day**
				Concentration TKN consumption by biofilters	**40**	**mg/L**

Case study

Convenience store and gas station

Simple, flexible, reliable, and robust.

- Maximum allowable flow/ [$CBOD_5$] – expansion:
  - With design [$CBOD_5$] concentrations - maximum flow of 2,750 GPD
  - With design flow of 2,500 GPD - maximum [$CBOD_5$] of 400 mg/L
- Concern if combined to increase in load
  - With present [$CBOD_5$] - maximum flow of 1,650 GPD
  - With present [TKN] entering system with higher flows, must add second MBBR
- Ecoflo Coco = goaler

Case study

Convenience store and gas station

Different possibilities to show system flexibility if flow increases:

- increase media to treat greater loads of $CBOD_5$
- increase amount of oxygen
- possible addition of MBBR unit to further nitrify if TKN concentrations remain high after flow increases

MBBR + Ecoflo biofilter • Advantages

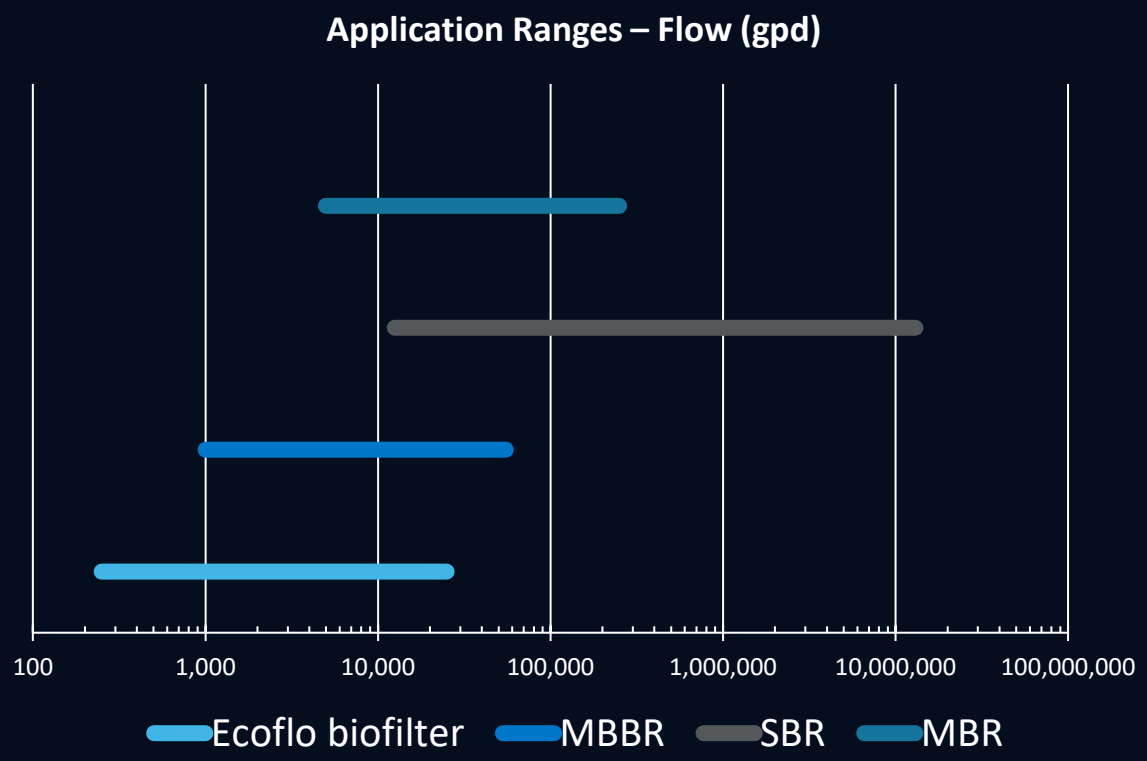
MODULAR AND READY TO USE

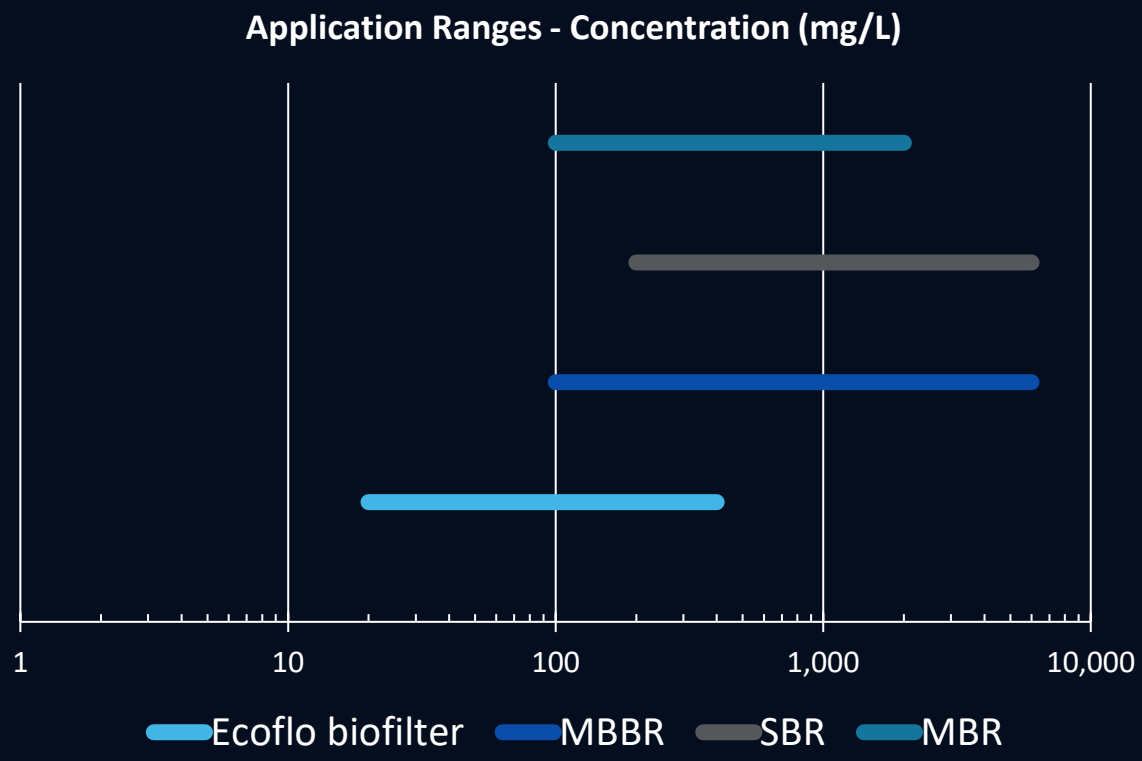
COMPACT AND ROBUST

FLEXIBLE OPERATIONS

TREATS HIGH-STRENGTH WASTWATER

Comparing technologies





QUESTIONS?

THANK YOU!