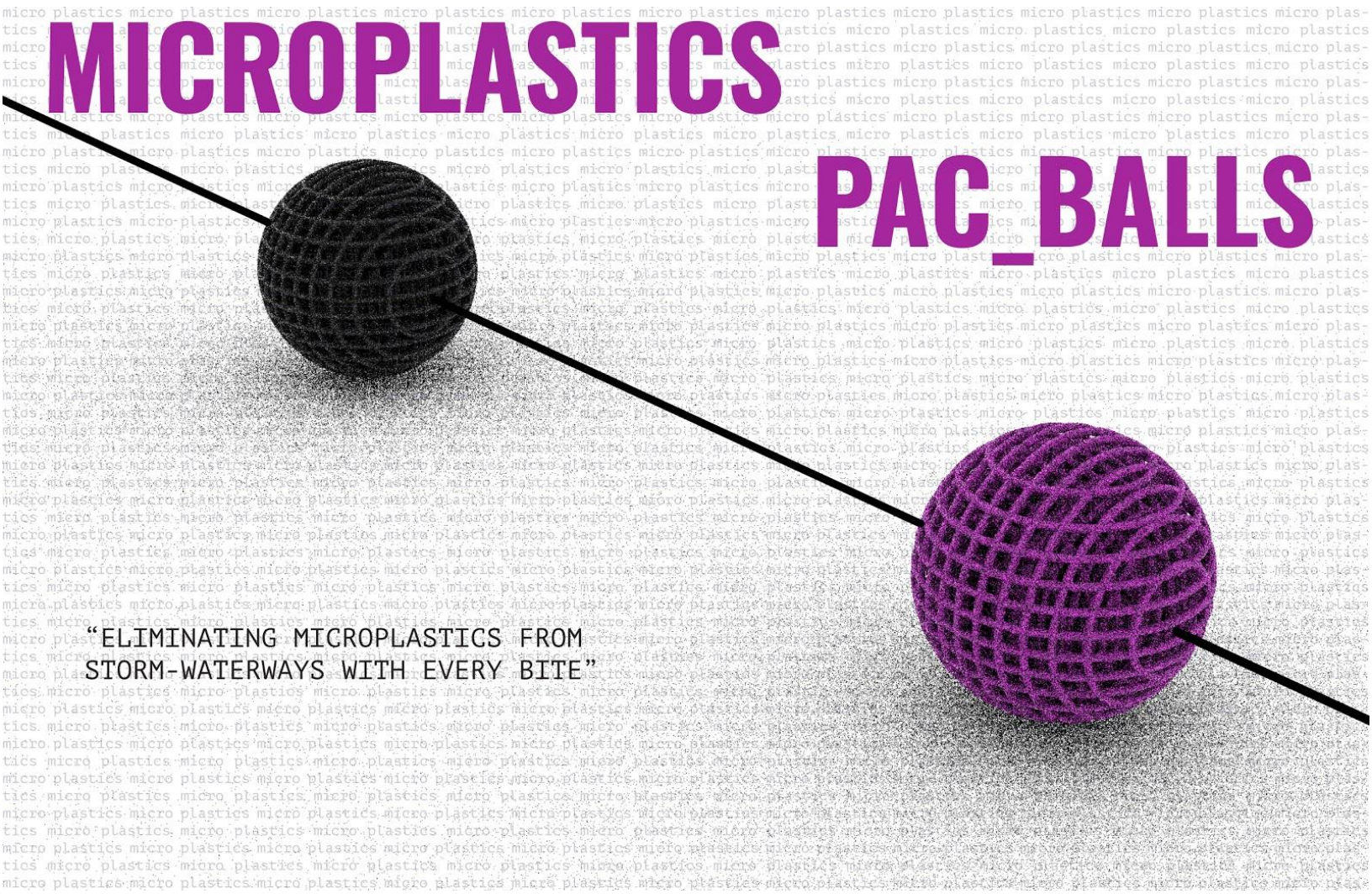
MICROPLASTICS PAC_BALLS



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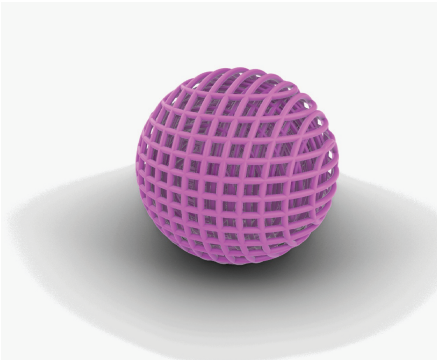
MICROPLASTICS PAC_BALLS



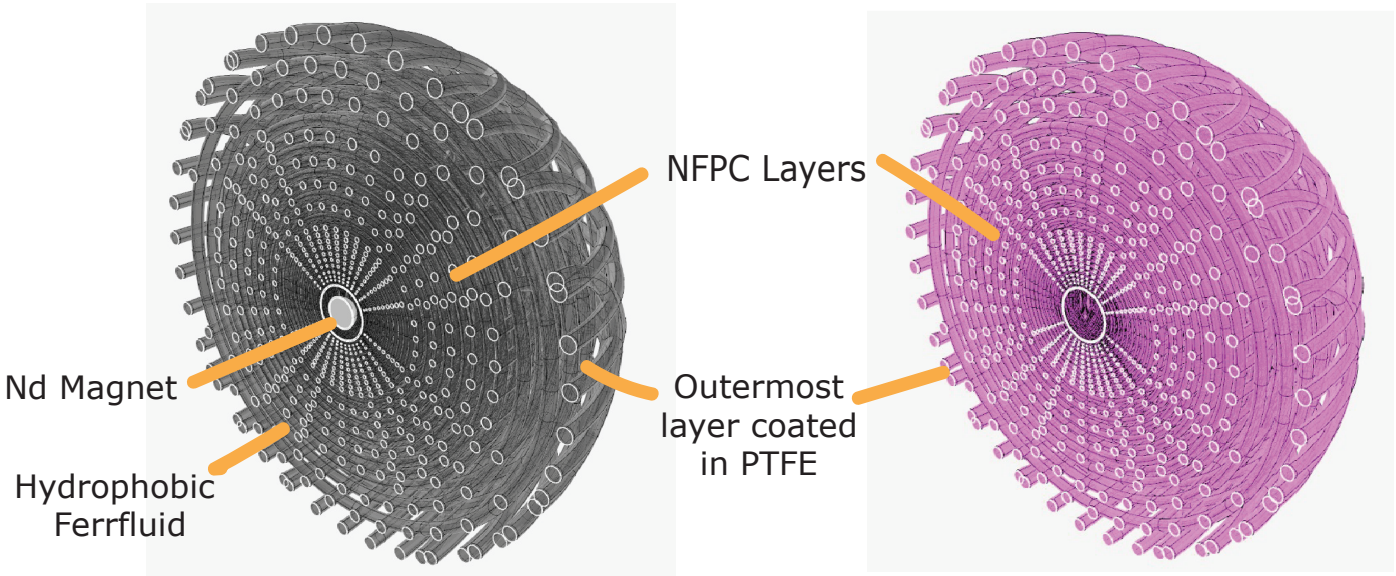
In New York City, about 60& of sewers consist of a Combined Sewer Overflow (CSO) structure. Heavy rain can overwhelm the system, and excess untreated water overflows directly into NYC waterways exiting through sewer outfalls.

This overflow is a mixture of raw untreated sewage and stormwater, and is a major source of pollution. Currently, there is no existing protocols in municipal water treatment system to remove microplastics (MPs).

We designed TWO types of MICROPLASTICS PAC_BALLS to trap and remove MPs from sewer outfalls:

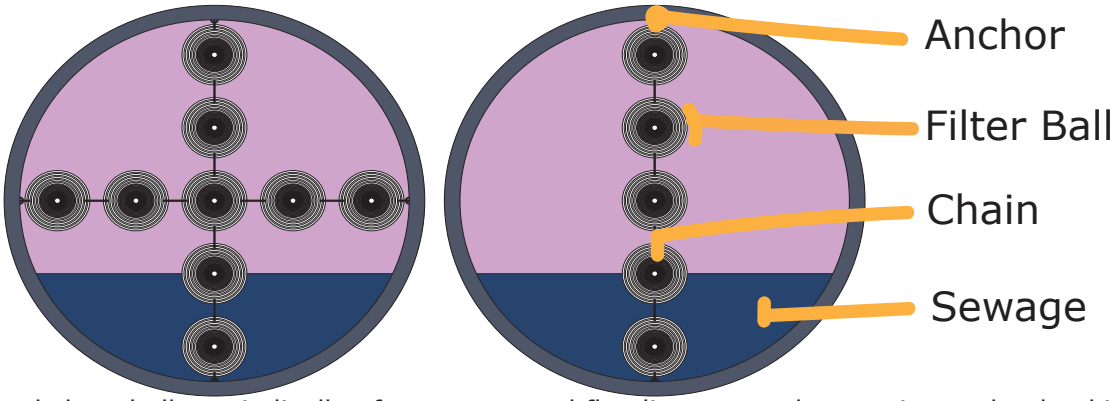
MR. PAC_BALL (HYDROPHOBIC)

MS. PAC_BALL (HYDROPHILIC)

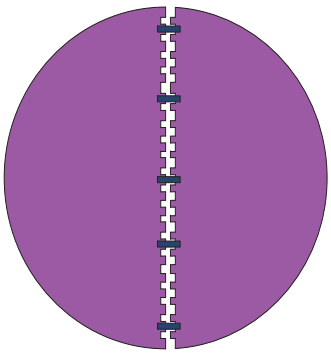


PAC_BALLS are highly adaptable and modular to work in any size CSO outfall.

Installation requires attaching hooks to the ceiling and floor of the outfall pipe, and the balls are linked by a chain suspended between these two points. Number and size of filters and chain length are adjustable.



Maintenance: Remove and clean balls periodically after storms and flooding events by rotating and unhooking the two halfs apart. The ferrofluid can be removed from the magnet with strong suction and centrifuge to separate the MPs. and then recycled into new fluid.



The MPs can be recycled and donated to research institutions, or sold to industries with environmental reprocessing for their products such as Adidas, Patagonia, and West Paw. Or even to waste-to-energy facilities.

Detailed Narrative of Microplastics Pac_Balls

Background:

New York City: A booming metropolis with numerous waterways that decorate the borders and snake through the districts. Daily, sewage and street runoff are treated by municipal wastewater treatment plants.

However, during the wet season, these waters are overrun with 27 billion gallons of polluted stormwater flooding out from our outdated CSO (or combined sewer overflow) structure. Samples taken from Columbia University's Earth Institute have shown that an overwhelming "19 tons of microplastics a year flood into NYC waterways alone" (Krajick, 2017).

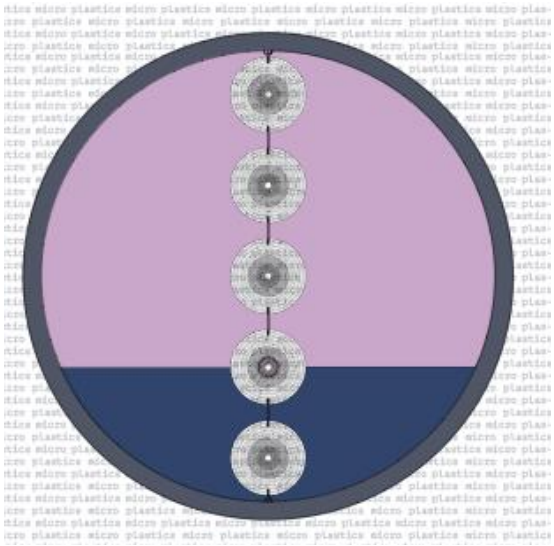


Figure 1: Showcasing Microplastic Pac_Balls suspended across an outfall pipe filtering and removing microplastics from flowing water.

In New York City, about 60% of the sewers consist of a Combined Sewer Overflow (CSO) structure. Under typical conditions, both sewage and street runoff flow into the same sewage pipes and are treated by municipal wastewater treatment plants. However, heavy rainfall can overwhelm the system, and excess untreated water overflows directly into NYC waterways through sewer outfalls.

The overflow is a mixture of raw untreated sewage and storm water, and it is also a major source of water pollution. In addition, no protocols exist in any municipal water treatment system to remove microplastics (MPs). Our project aims to implement a mechanism to filter microplastics out of this overflow.

Design Solution & Technical Aspects:

We created two types of filtering pac_balls (inspired by the arcade game 'Pac Man') designed to trap and remove MPs from sewer outfalls-- one with a magnetic core and one without. Each ball is made of layers of natural fiber polymer composite (NFPC) filters of progressively smaller size.

These layers filter litter of varying sizes, with the smallest of approximately 5mm. The outermost two layers are also coated in a PTFE (Teflon®) lubricant coating to prevent scum buildup. MPs in pure water are hydrophobic, and

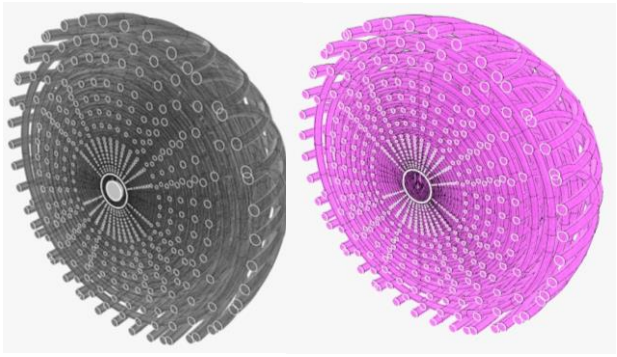


Figure 2: Mr. Pac_Ball (left) with magnetic core and ferrofluid and Ms. Pac_Ball (right) filtered layers. Both Pac_Balls are coated in PTFE Teflon lubricant to prevent scum buildup.

research has shown that both magnetic nanoparticles and oil are effective ways to attract and sequester them.

One of our filter designs, Mr. Pac_Ball, implements both mechanisms, using a magnet in the center surrounded by a hydrophobic suspension of magnetic nanoparticles-- a ferrofluid. However, due to the presence of detergents and other contaminants in sewage, MP fragments may also become hydrophilic. To address this property of MP pollution, we have also designed a filter ball, Ms. Pac_Ball, that lacks this hydrophobic magnetic center and just filters the litter in sewage by size.

Maintenance:

Our filters are highly adaptable and modular to work in any CSO outfall. Installation requires attaching hooks to the ceiling and floor of the outfall pipe, and the balls are linked by a chain suspended between these two points. The number and size of the filter layers can be adjusted as needed, as well as the lengths of the chains.

Maintenance involves removing and cleaning these balls after floods and rainstorms. Each ball can open to facilitate this process. The ferrofluid can be removed from the magnet with strong suction and centrifuge to separate the MPs, then recycled into new fluid. The MPs can be recycled or donated to research causes and companies utilizing microplastics for their products such as Adidas, Patagonia, West Paw, etc. The NFPC material is also biodegradable, should it become too damaged to reuse (except for the PTFE-treated layers).

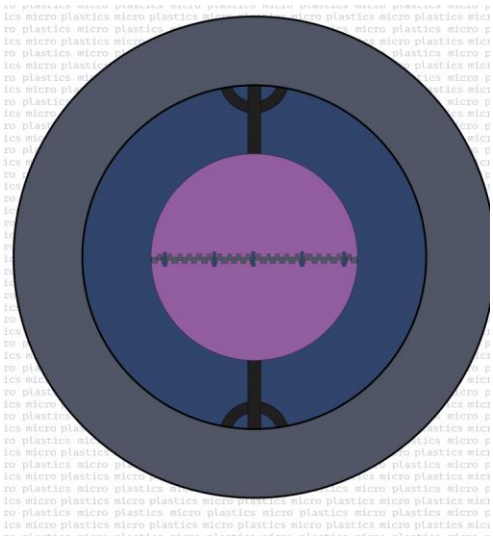


Figure 3: Middle area is where one twists apart Microplastic Pac_Balls to remove filtered microplastics during maintenance.

Scalability & Conclusionary Remarks:

The construction of the filters themselves can also be adjusted as needed to cover a wide variety of applications. For instance, in a rural setting where the facilities needed to handle the ferrofluid may not be available or generating more waste is of concern, the filters could be adapted to just consist of the biodegradable NFPC layers. The magnetic filtering mechanism could also work in standing water, and by attaching filter balls to buoys they could even be adapted for larger waterways.

Though we were inspired by the pollution issues caused by NYC's CSOs, our design's functionality is not limited to this system. Our design and our filtering mechanisms could be implemented anywhere where the presence of MPs in wastewater is of concern and the water can flow through the filters. Installation is quite simple and adjustable-- all it requires is a place to anchor the chain of filters. This opens a great number of possible implementations beyond just urban stormwater management systems.

MICROPLASTICS PAC_BALLS

"ELIMINATING MICROPLASTICS FROM STORM-WATERWAYS WITH EVERY BITE"

by Las Bangles

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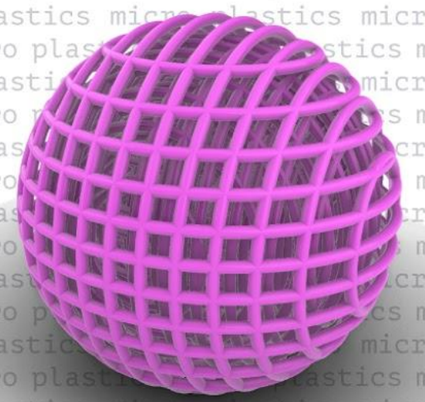
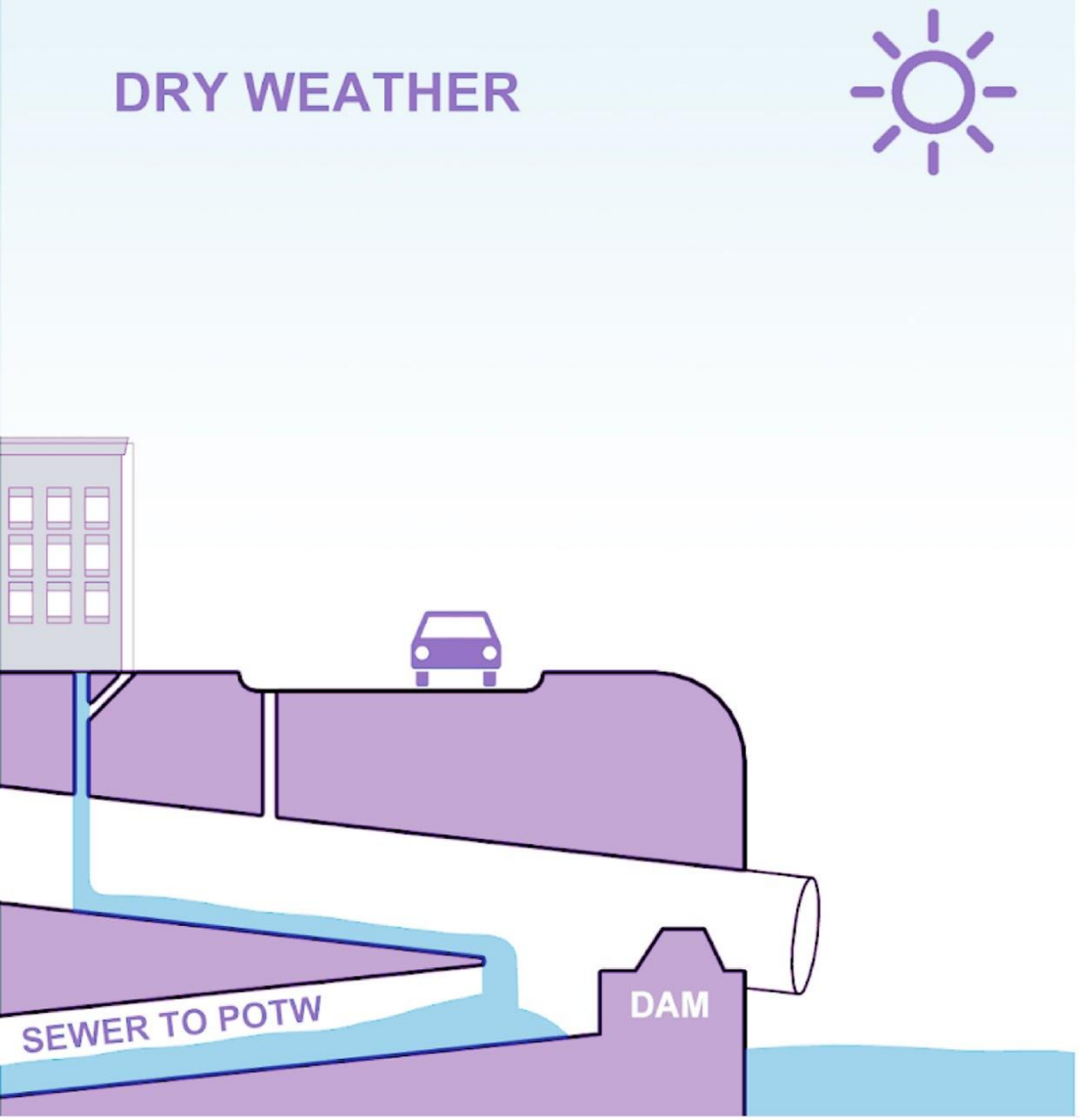
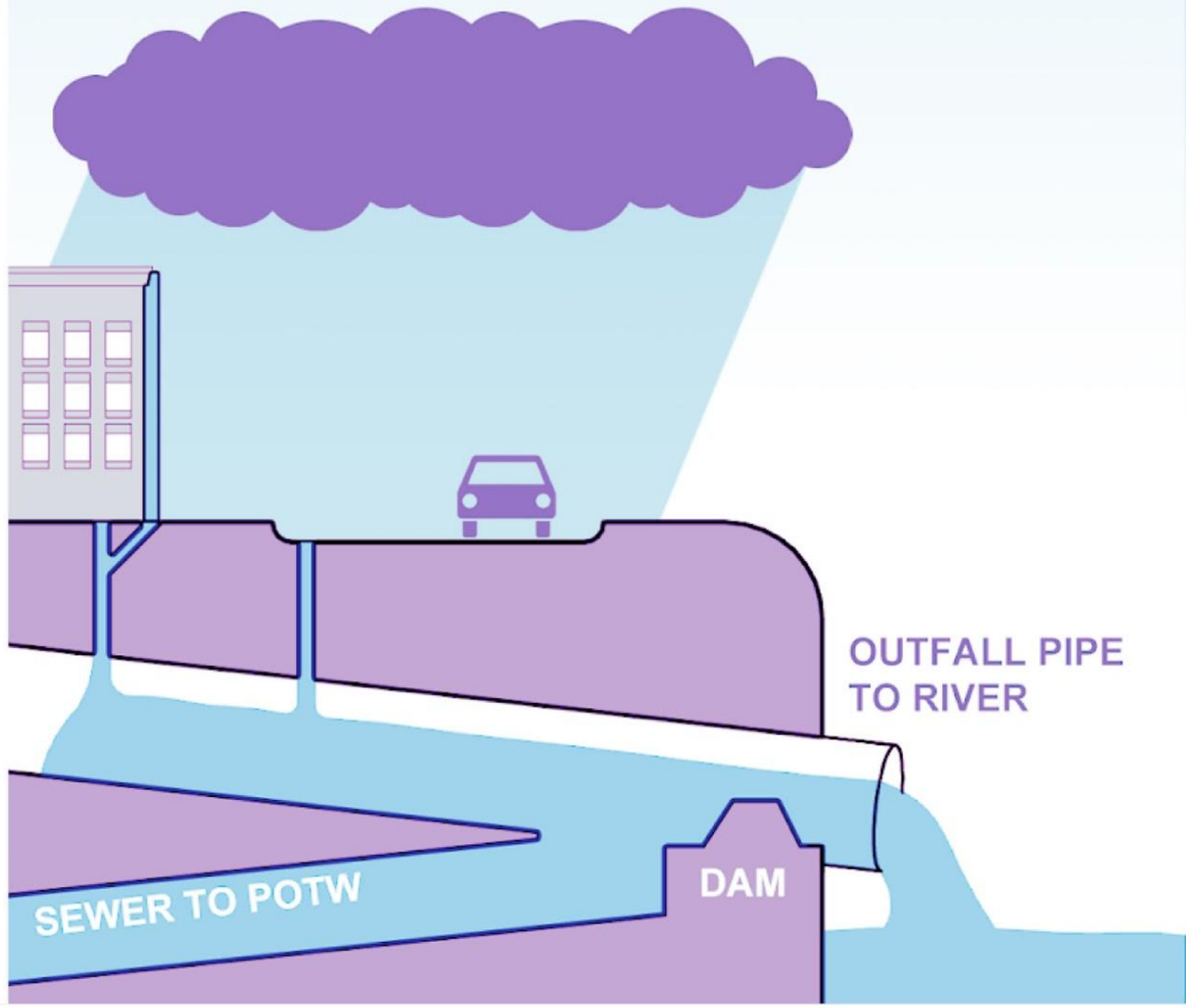


CONTEXT

DRY WEATHER

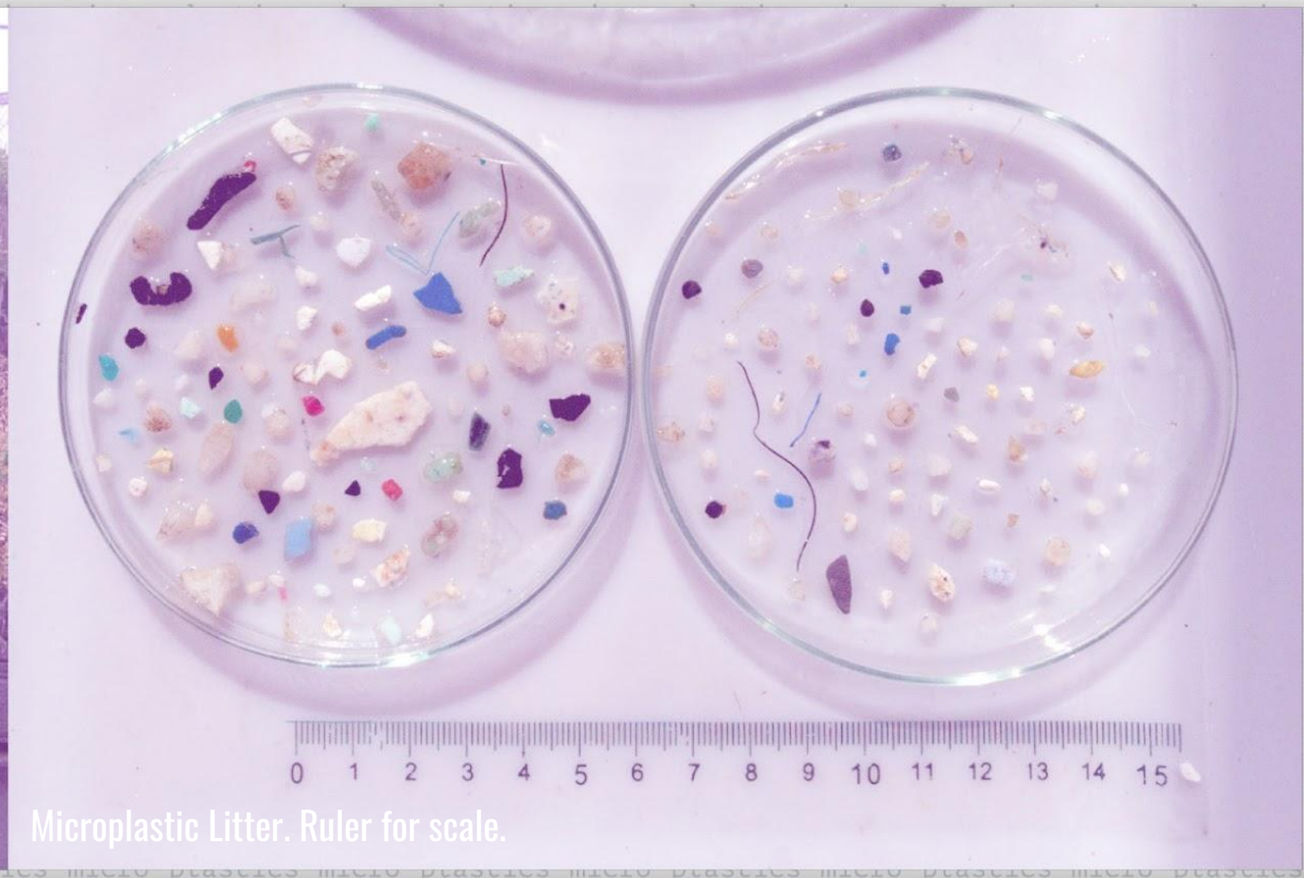


WET WEATHER



CONTEXT

A CSO outfall in NYC.

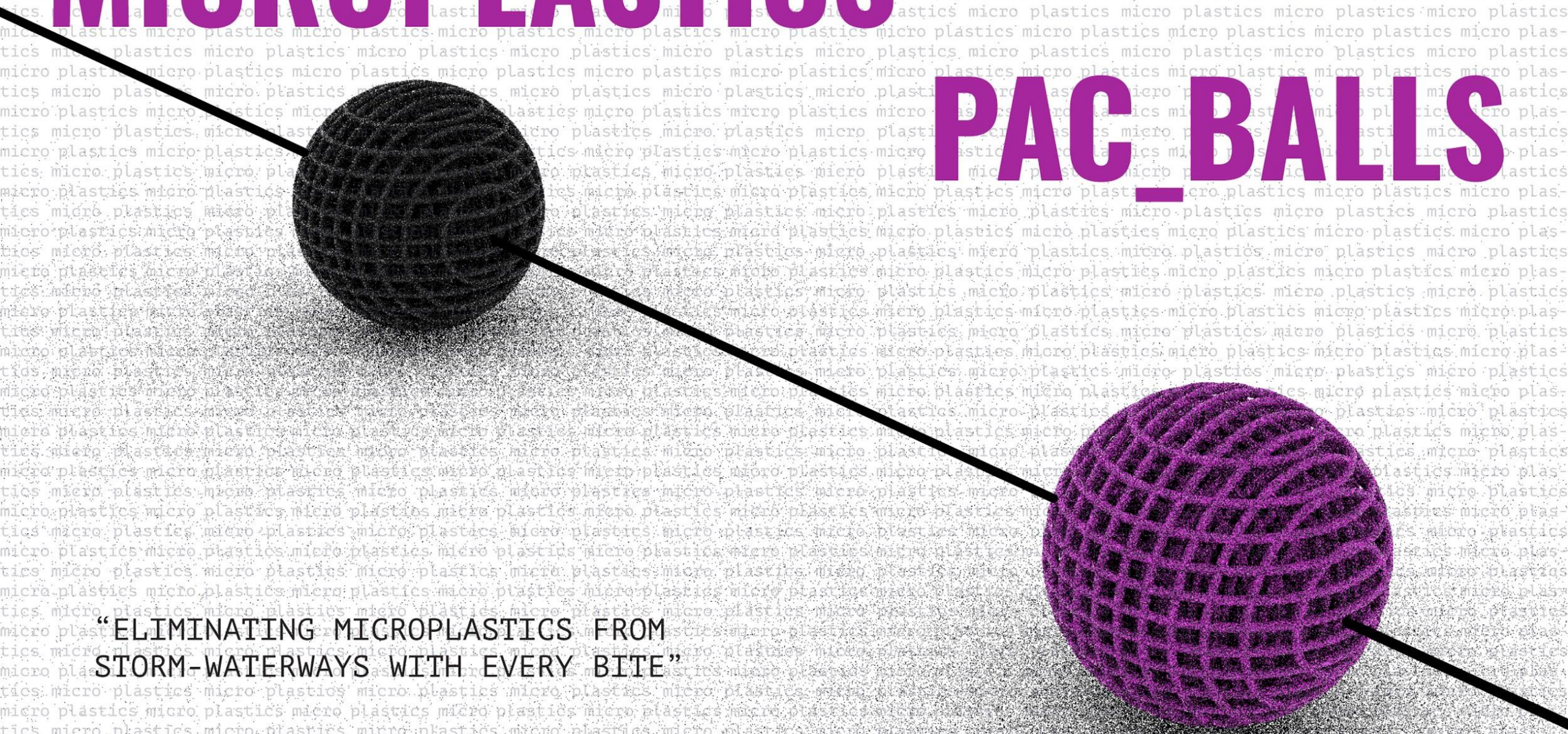


Microplastic Litter. Ruler for scale.

CONTEXT

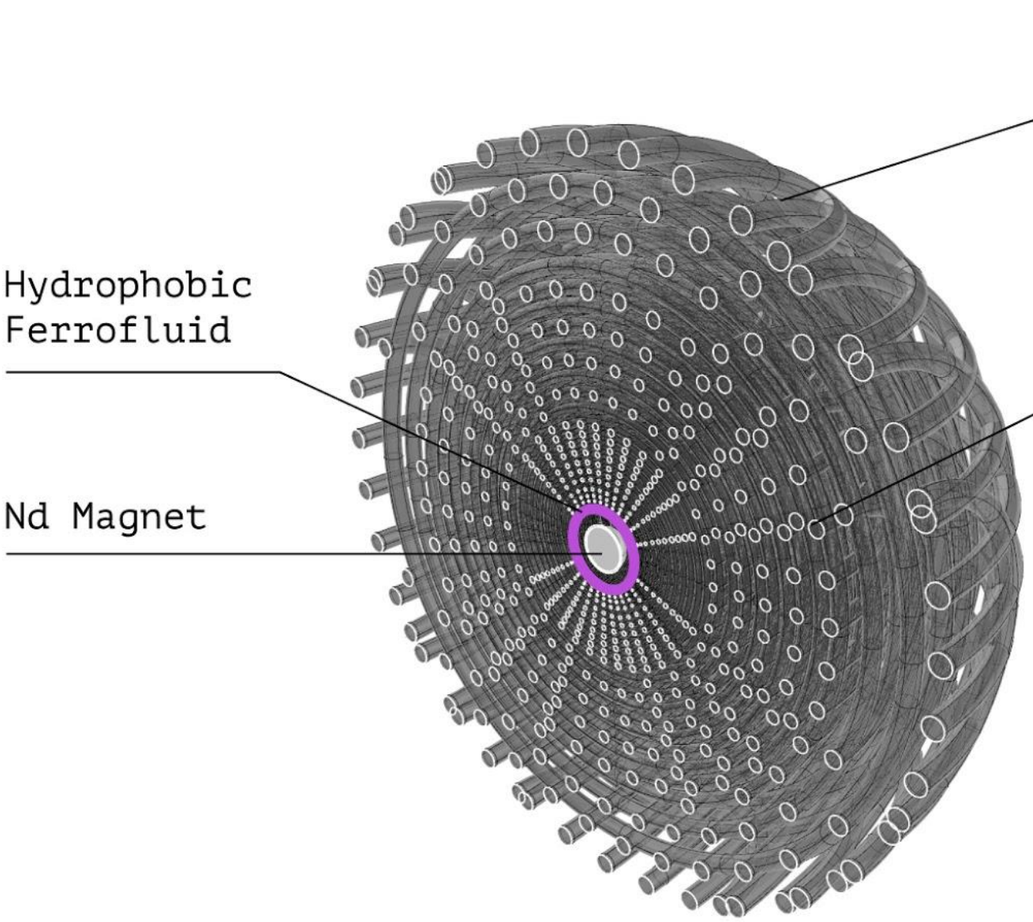
MICROPLASTICS

PAC_BALLS

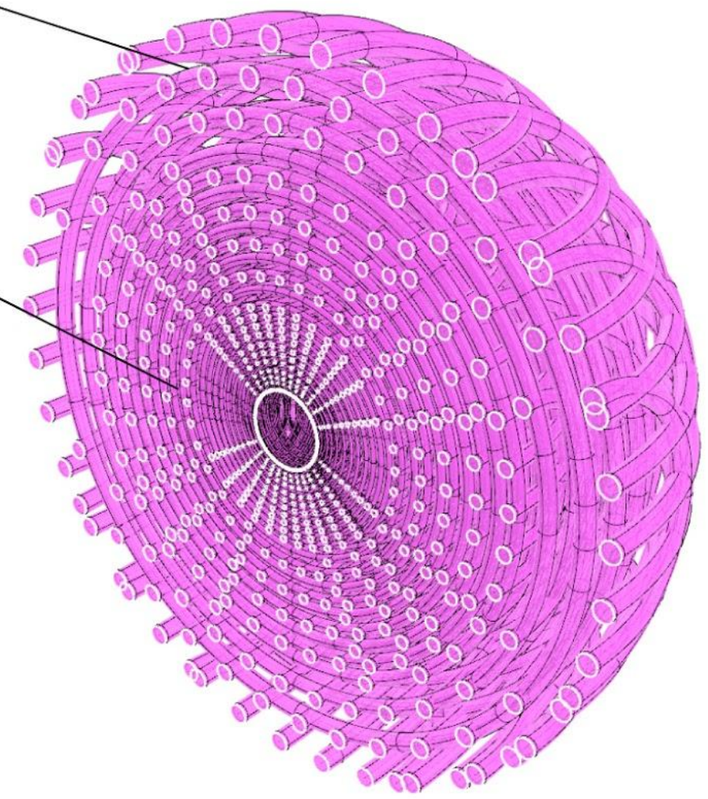


“ELIMINATING MICROPLASTICS FROM
STORM-WATERWAYS WITH EVERY BITE”

PRODUCT DESIGN & SPECIFICATIONS



MODEL 1 Mr. PAC_BALL



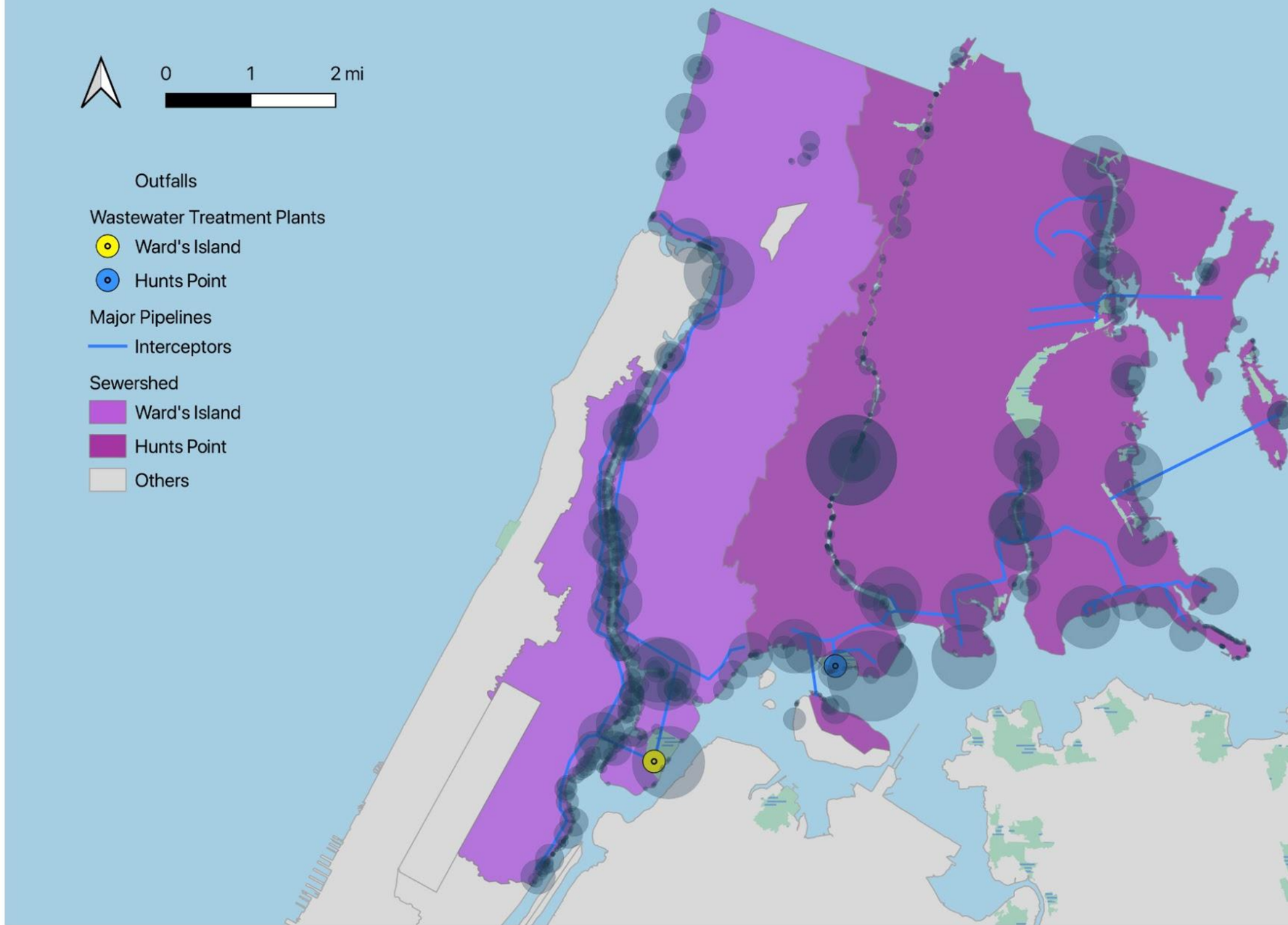
MODEL 2 Ms. PAC_BALL

OUTFALL SIZING

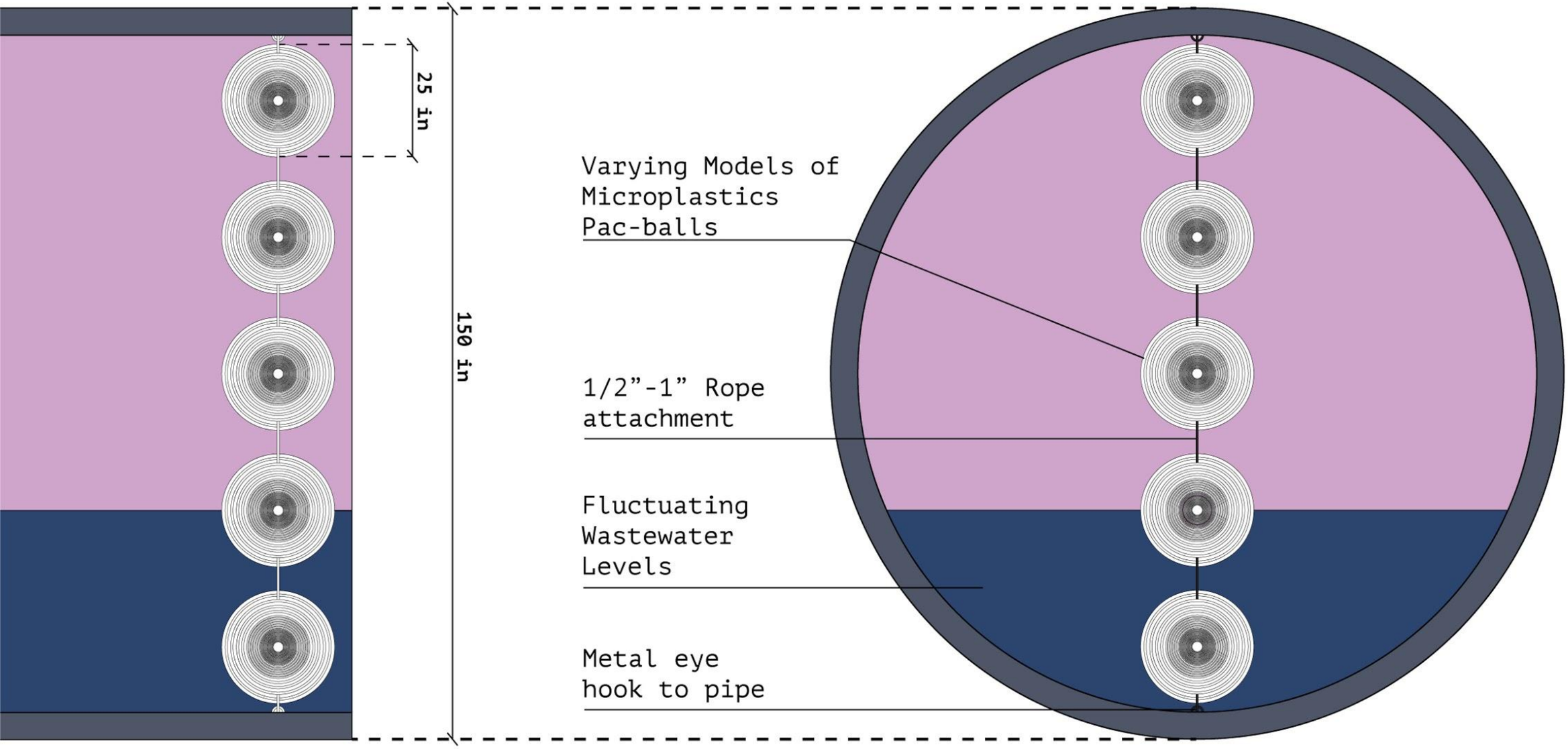
Mapped locations of outfalls to place microplastic pac_balls.

Understand the various outfall sizes throughout the Bronx.

What areas in the Bronx would benefit most from filtering out microplastics pollution.

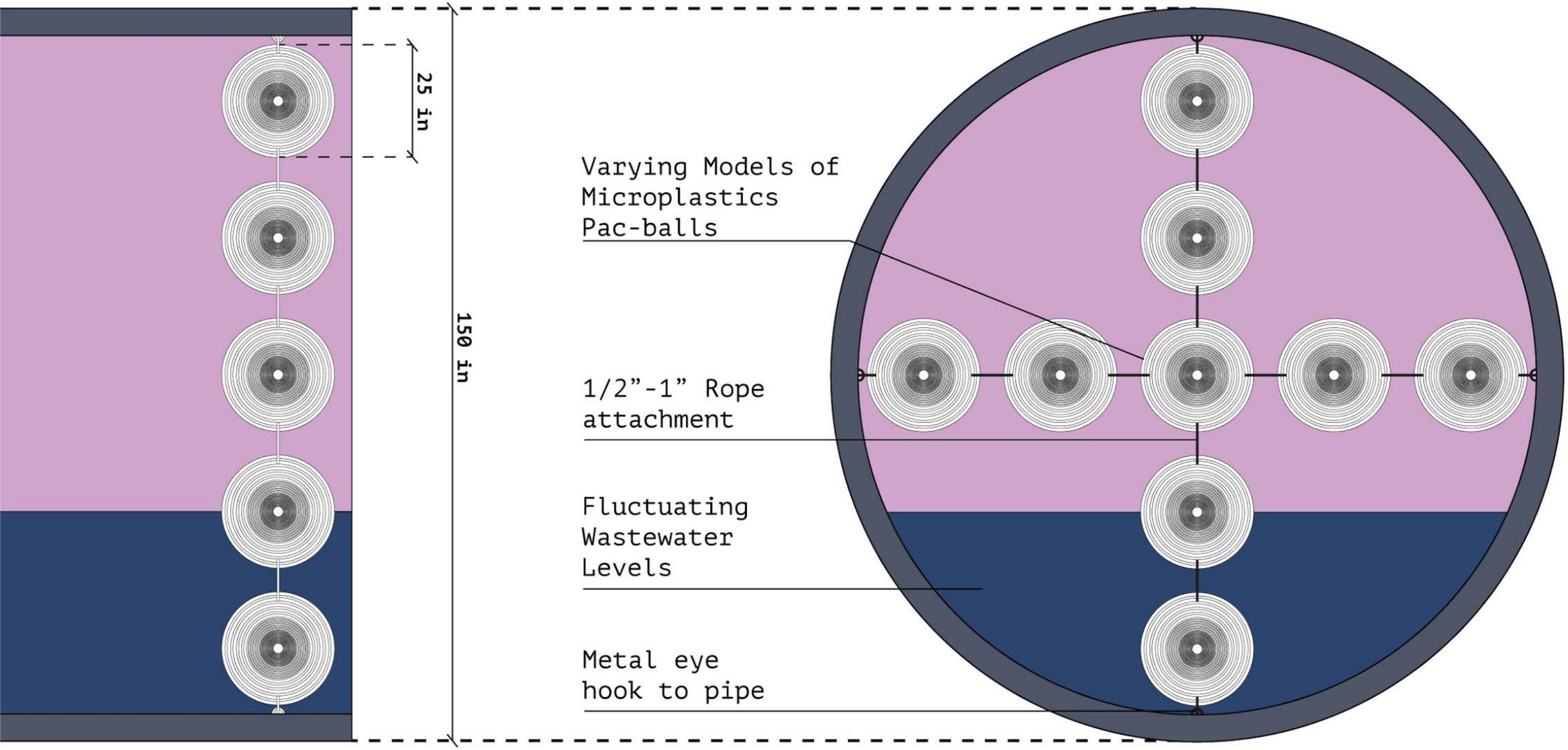


INSTALLATION



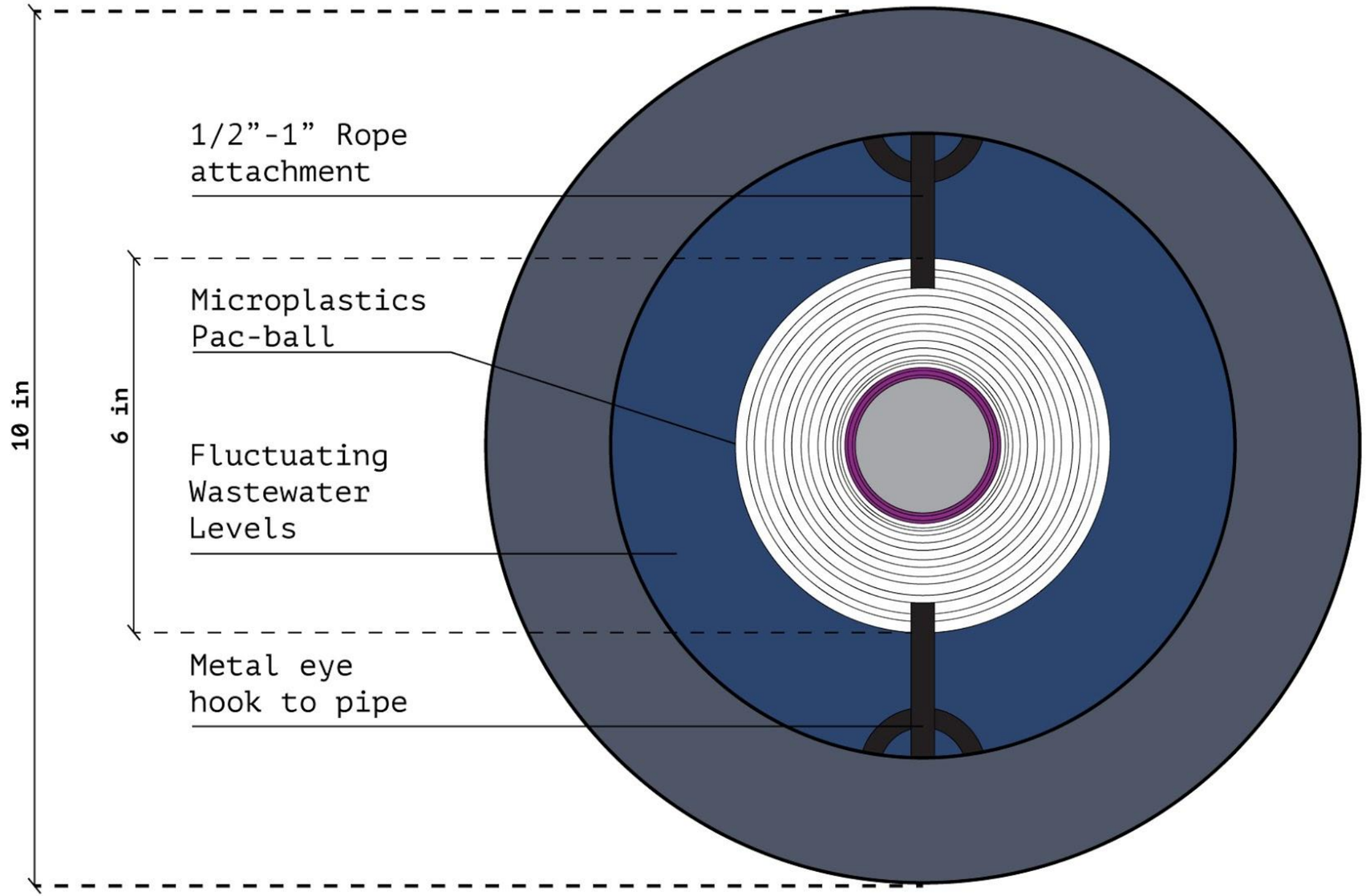
EXAMPLE Cross-section of sewer outfalls

INSTALLATION



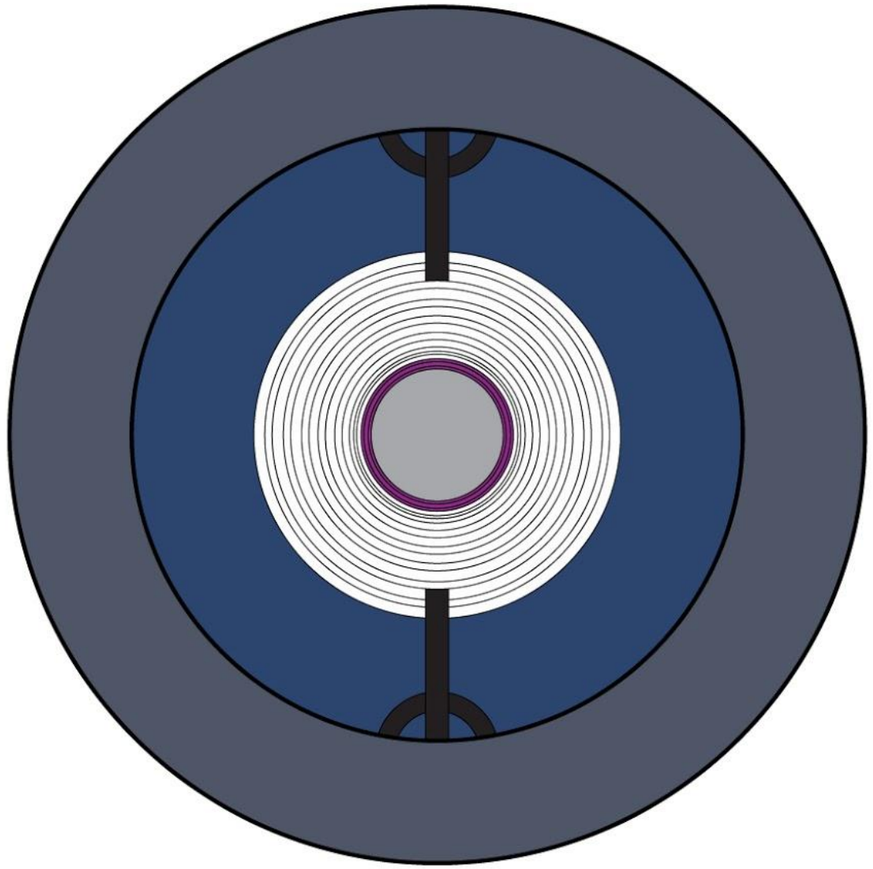
EXAMPLE Cross-section of sewer outfalls

INSTALLATION

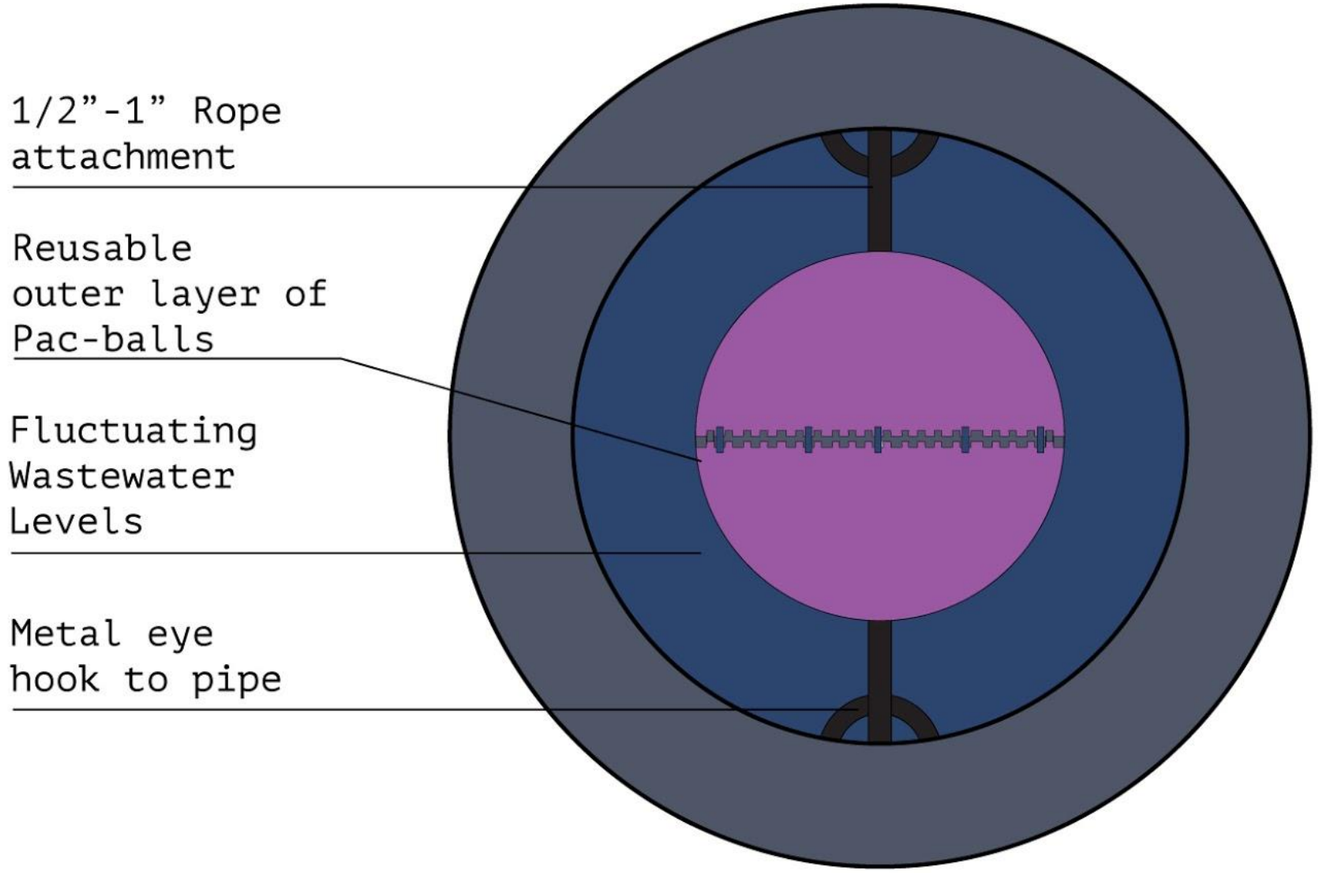


EXAMPLE Cross-section of small sewer outfalls

MAINTENANCE



INTERIOR 6 in Microplastics Pac-Ball



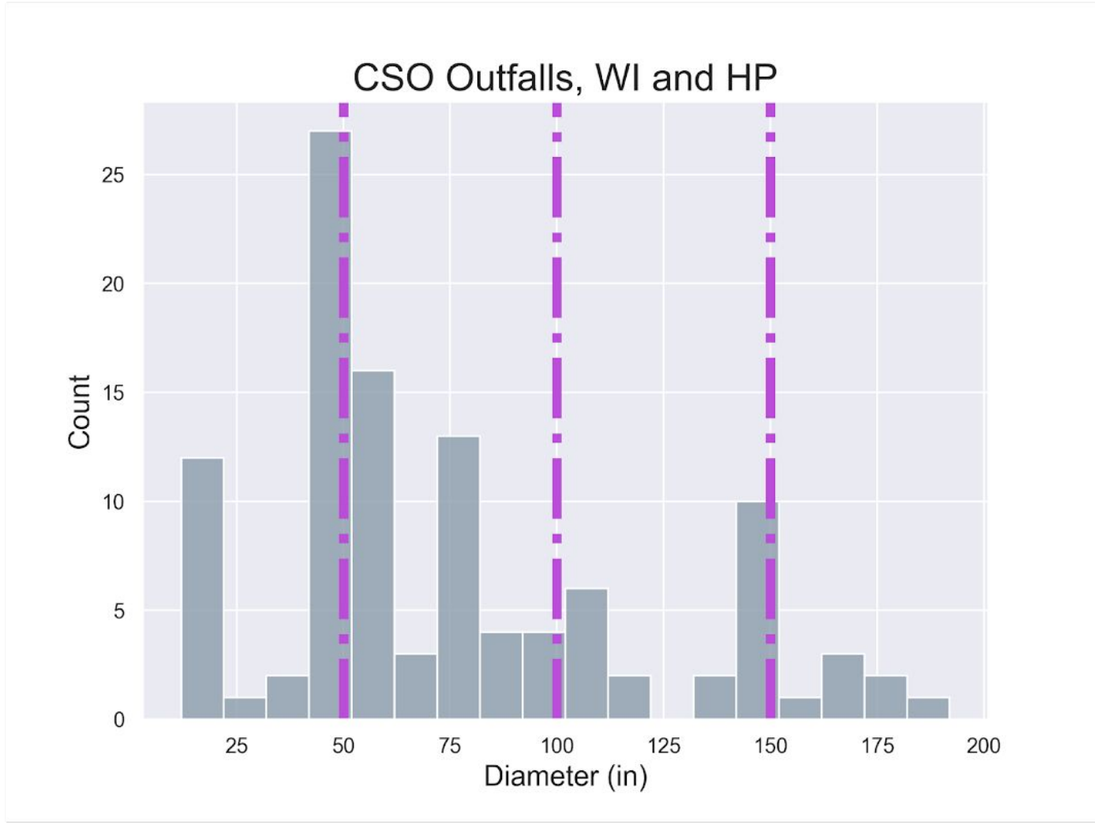
EXTERIOR 6 in Microplastics Pac-Ball

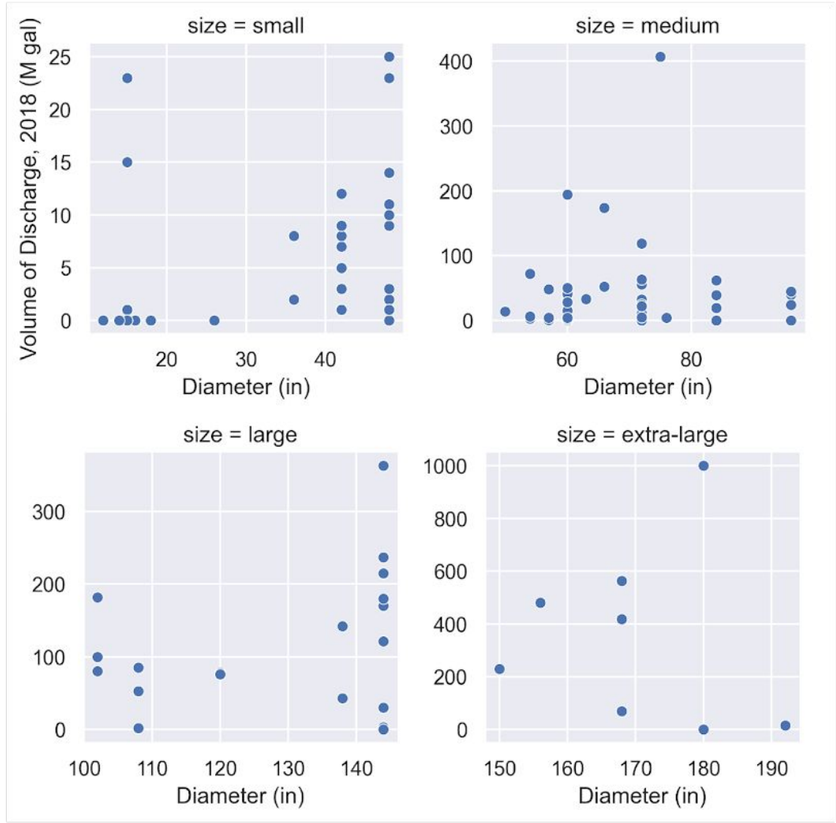
BUSINESS MODEL & COSTS

MODEL 1 Mr. PAC_BALL

Diameter of Outfall (in)	Diameter of pac ball (in)	Number of balls	Efficacy	Number of fiber layers	Cost of mesh fiber / ball	Cost of magnet/ ball	Cost/ ferrofluid	Cost / ball	Total Cost per Outfall / Installation
150	25	5	13.89%	20	$41.20	$25	$8	$74.20	$375.00
100	20	4	16.00%	15	$30.17	$25	$8	$63.17	$260.00
50	10	4	16.00%	10	$7.58	$25	$8	$40.58	$165.00
10	6	1	36.00%	6	$1.96	$25	$8	$34.96	$40.00

OUTCOME STUDY

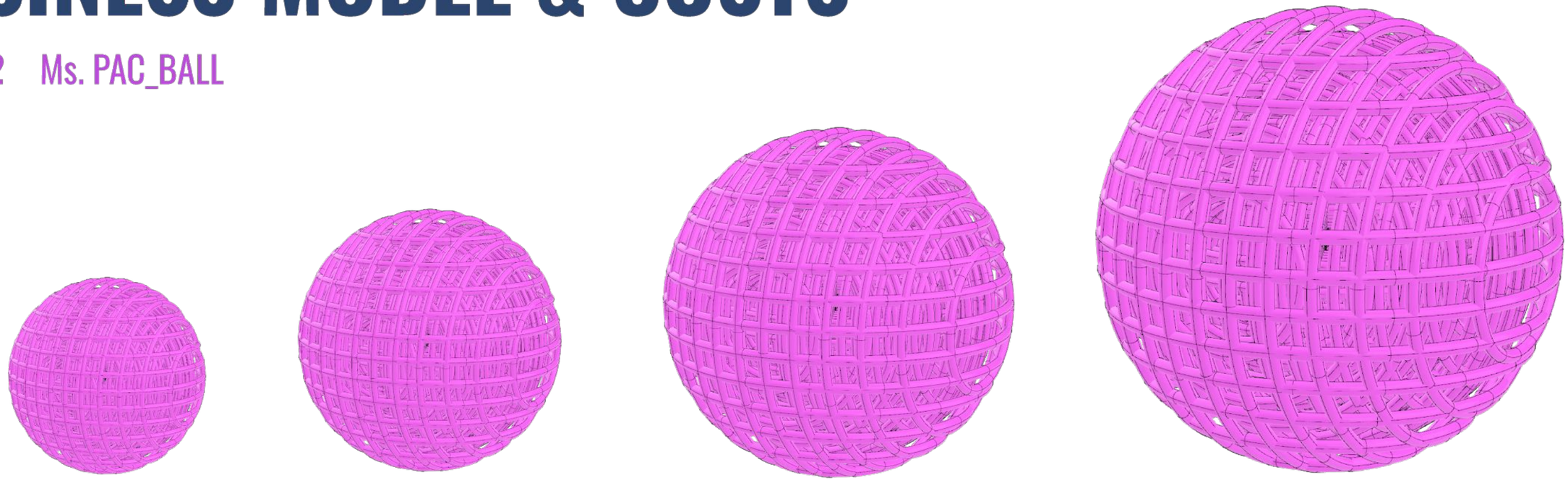




Pac-Ball Capacity	MP Capacity (kg)	Number of balls implemented	Total Capacity per Use (kg)	Application	Max Removal Efficiency	Max Percentage of Removal
25''	119.99	5	599.9	extra-large	13.9%	13.9%
20''	123.46	4	493.9	large	16.0%	16.0%
10''	8.18	4	32.7	medium	16.0%	16.0%
6''	1.33	1	1.3	small or medium	36.0%	7.6%

BUSINESS MODEL & COSTS

MODEL 2 Ms. PAC_BALL



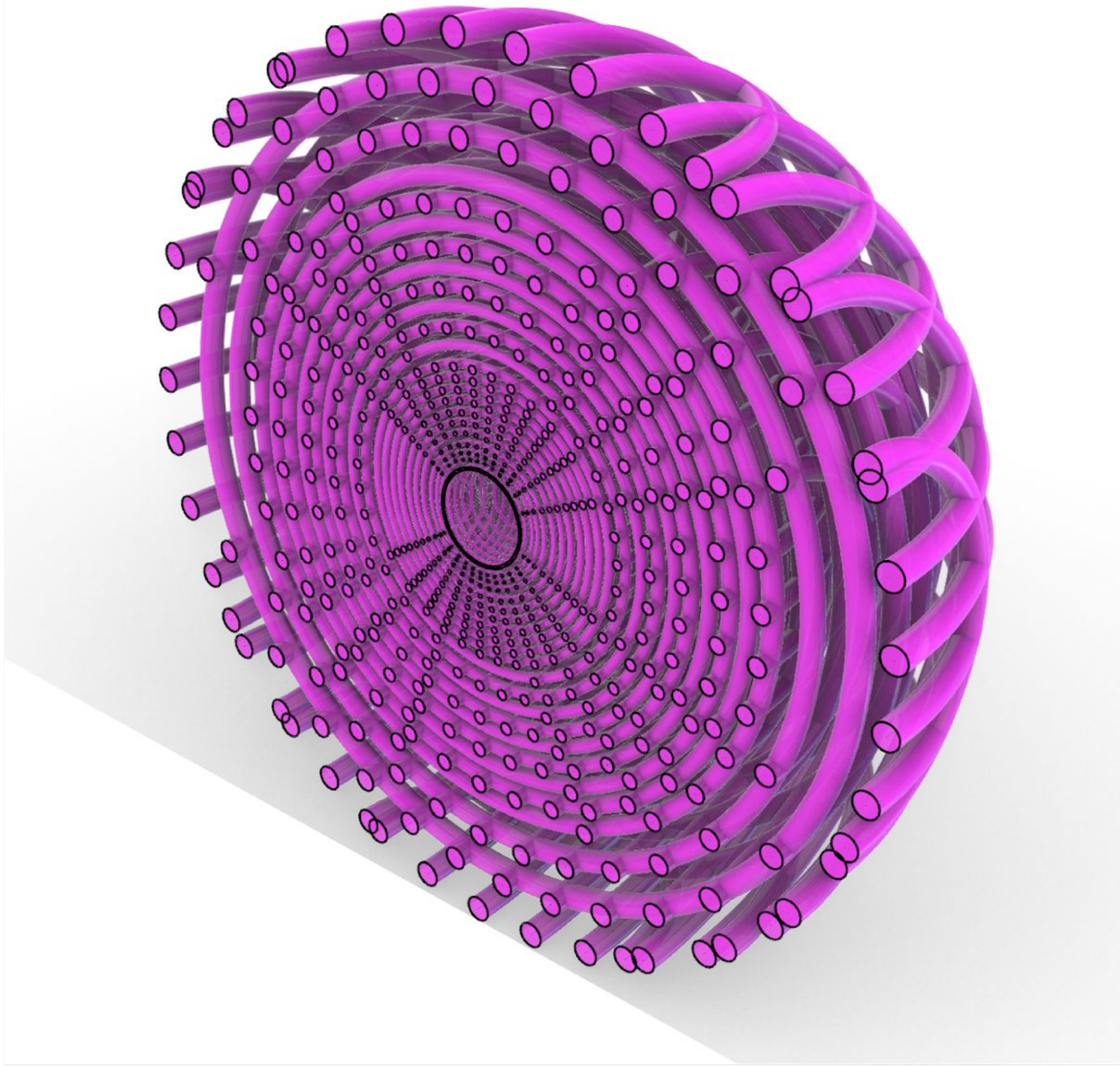
Diameter of Outfall (in)	Diameter of pac ball (in)	Number of balls	Efficacy	Number of fiber layers	Cost of mesh fiber / ball	Cost / ball	Total Cost per Outfall / Installation
150	25	5	13.89%	25	$44.61	$44.61	$230.00
100	20	4	16.00%	25	$37.60	$37.60	$160.00
50	10	4	16.00%	15	$19.94	$19.94	$85.00
10	6	1	36.00%	12	$3.55	$3.55	$10.00

> First of its kind!

> Straightforward installation process

> Can be implemented anywhere where there is microplastics in stormwater

> Highly adaptable and modular beyond urban stormwater management systems



VALUE PROPOSITION

Thank you_

microplastics_pac_balls

REFERENCES

Academic Research:

Estimation of the mass of microplastics ingested-a pivotal first step towards human health risk assessment

Wastewater treatment plants as a source of microplastics to an urban estuary: Removal efficiencies and loading per capita over one year

NYC Stormwater Management Plan

How microplastics quantities increase with flood events?

Microplastic Contamination in NYC Waterways: New Detection Methods

Microplastic contamination of river beds significantly reduced by catchment-wide flooding

NYC waterways teeming with microplastics

Interactions of microplastic debris throughout the marine ecosystem

Fate and effects of microplastics in wastewater treatment processes

Magnetic extraction of microplastics from environmental samples

Datasets:

https://openseweratlas.tumblr.com/data

News:

Flash floods found to send massive amounts of microplastics from rivers to the sea

Zooming in on the Five Types of Microplastics

Images & Videos:

Stormwater Catch Basin Inlet Filters

Stop Pollutants from Going Down the Drain-Ultra Drain Guard

Up-Flo Filter Stormwater Treatment System