Rapid Radicals

How One Milwaukee Woman & Her Team Innovated a Faster Way to Clean the World's Wastewater



ILLUSTRATION
SARAH GAIL LUTHER

STORY
MICHAEL ALAN TIMM

Rapid Radicals

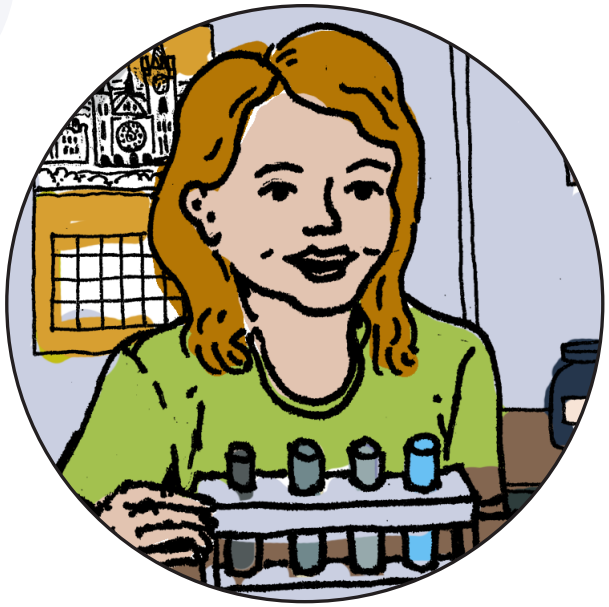
How One Milwaukee Woman &
her team innovated a faster way
to clean the world's wastewater

STORY BY MICHAEL ALAN TIMM

ILLUSTRATED BY SARAH GAIL LUTHER

MMXXIV

"What if we could intercept sewer overflow water and treat it with RAPID RADICALS before releasing it into rivers and lakes?"



Dr. Paige E. Peters

Rapid Radicals
Founder
Chief Technical Officer
&
Majority Owner

--Milwaukee, December 2024

Hi, I'm Paige!

I'm an engineer from Milwaukee, Wisconsin {and a real person, though, ahem, I do look pretty cool as a comic!}.

My goal is simple: clean water for the world.

When I was a kid, I never thought I'd form a company. But I've learned so much more than I ever expected.

I studied science and engineering in school. Science is pretty good at solving problems. Doing science together led my professor and me to develop a new technology that speeds up the way certain chemicals clean water.

We wanted a faster way to treat the sewer overflows that still pollute hundreds of the world's cities. Our innovation forms the core of a business I founded when I was still in school!

My team and I call our business Rapid Radicals. We made it to change the world. Our team is pretty dang awesome. You might even say, real-life heroes.

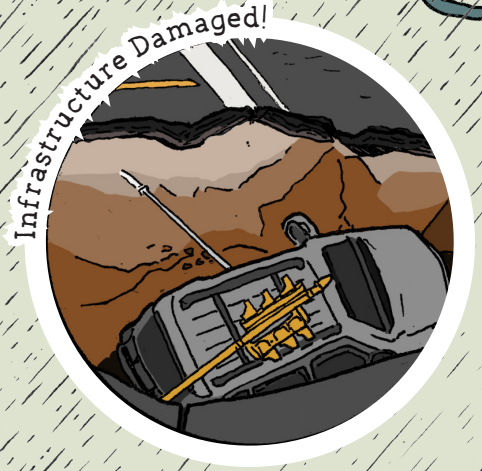
Our story is far from over and I don't know how it will end! But it starts with the bad guy: a dark and stormy SUPER STORM...

MILWAUKEE: JULY 2010

Storm Thrashes City!

On July 22, 2010 there was a HUGE storm after a really wet month. More than 6 INCHES of rain fell in ONE HOUR! There was more water than could seep into the ground, flow into sewers, or get treated at wastewater plants. Rivers swelled, sewers backed up into people's basements, and streets flooded. Stormwater caused millions of dollars of damage.









MILWAUKEE RIVER

LAKE MICHIGAN

MENOMONEE RIVER

KINNICKINNIC RIVER

HOLY CRAP!

What a mess!

Streets flooded like raging rivers!

Sewage backed up into my basement. Everything was ruined.

That rain was CRAZY.

There was so much rain we had to dump 2 billion gallons of untreated wastewater into the rivers. The system couldn't contain it all!





PAIGE PETERS, A MARQUETTE PHD STUDENT, MEETS WITH HER PROFESSOR DR. Z AFTER THE JULY 2010 STORM

MODERATE RAIN

HEAVY RAIN

Every time it rains in Milwaukee, water from any non-porous (impervious) surface drains into our sewer system.

In the core of our city, it gets combined with all the sewage from homes and businesses and flows together to wastewater treatment plants to be cleaned. The clean water then is discharged back into Lake Michigan.

Heavy rains can cause problems, though.

Inside Our Sewer System

COMBINED SEWER AREA

SEPARATED SEWER AREA

STORM SEWER PIPES

OVERFLOW PIPES

Sewer water flows by gravity to Jones Island.

RIVERS

With heavy rain or fast-melting snow, too much water enters the system too rapidly. To prevent water backing up into basements, overflow pipes release water into the rivers, which flow to Lake Michigan.

When there is more water than the system can carry, water can be diverted to the Deep Tunnel for temporary storage. When the treatment system has capacity, pumps bring that water up.

DEEP TUNNEL

Based on 1920s innovations, this system normally works well...

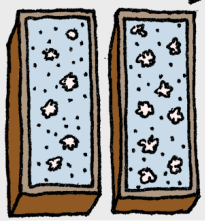
MILWAUKEE'S WASTEWATER TREATMENT PROCESS



1 Big solids are screened out.



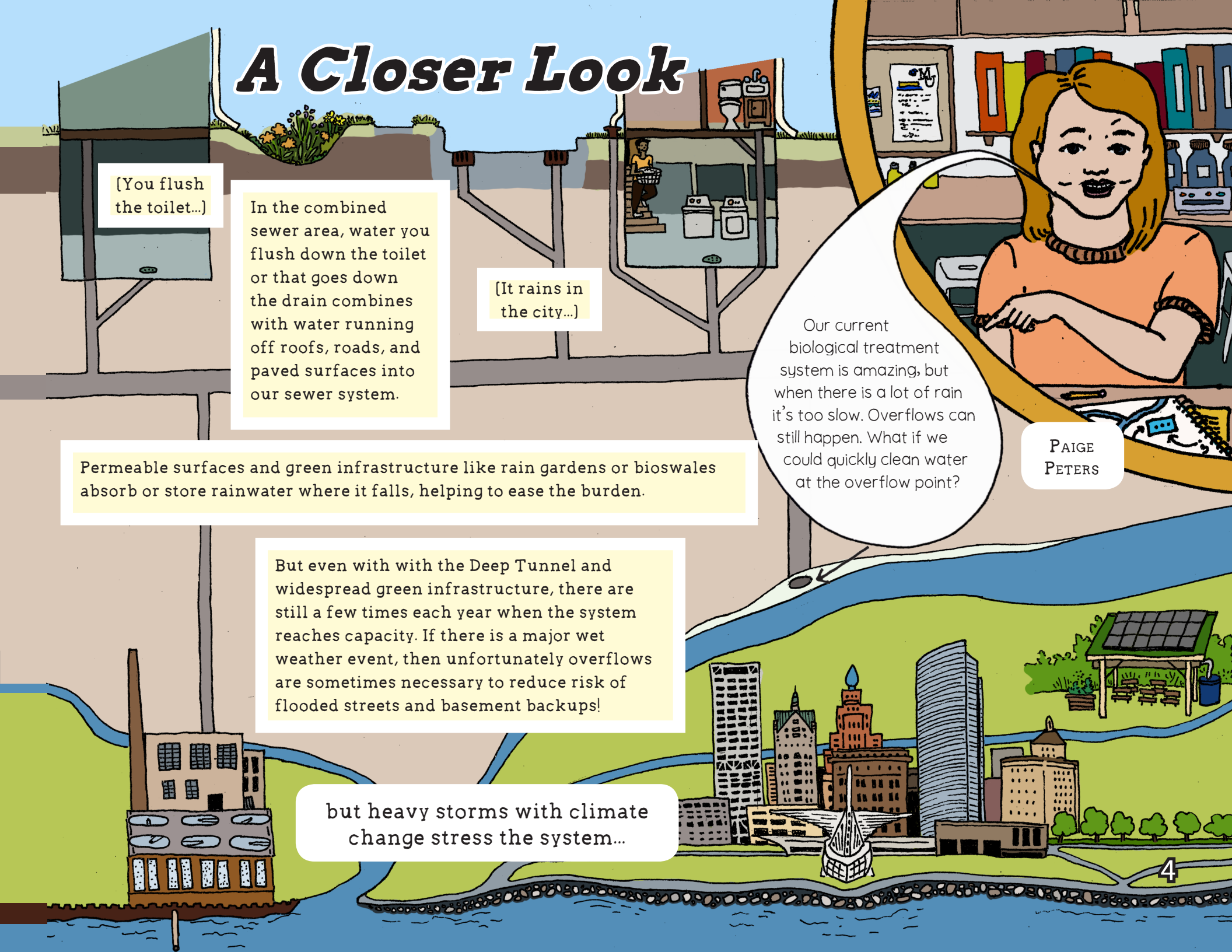
2 Smaller solids settle out.



3 Microbes digest biological waste.

4 Water is then disinfected and released to Lake Michigan.

A Closer Look



How did we get here?

Potawatomi, Ojibwe, Odawa (Ottawa), Fox, Ho-Chunk, Menominee, Sauk, and Oneida peoples call this area "Good Earth" or "The Gathering Place by the Waters" for generations.

Flashback Timeline

1833

Treaty of Chicago displaces Native peoples.



1846

City of Milwaukee incorporated from union of Juneautown, Kilbourntown, and Walker's Point.



1869 - 1893

Milwaukee builds sewers discharging wastewater into rivers and ultimately Lake Michigan.



1874

Milwaukee Water Works starts pumping water from Lake Michigan for public use in system designed by engineer E.S. Chesbrough.



1888

Milwaukee's E.P. Allis Co. builds world's largest pump to flush out putrid Milwaukee River with Lake Michigan water through a half-mile underground pipe.



Where are we going next?

We've come a long way! Milwaukee's "activated sludge" biological wastewater treatement system was innovative and world-leading in the 1920s. Milorganite® turned waste into a resource. The Deep Tunnel is an impressive feat of public engineering. But... What if there were a faster way...?

MKE Water Innovation

Paige Peters

1914

Under "Sewer Socialist" leadership, Milwaukee pilots "activated sludge" treatment on Jones Island based on European methods.



1925 - 1926

Wastewater treatment plant on Jones Island begins treating 85 million gallons of sewage daily. Nutrient-rich byproduct marketed as Milorganite®.



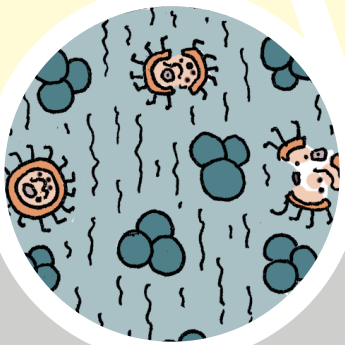
1939

Linnwood Treatment Plant opens, treating public drinking water drawn from Lake Michigan.



1994

After Cryptosporidium outbreak of 1993, Milwaukee Water Works installs ozone treatment in upgrades to make our drinking water supply among world's cleanest.

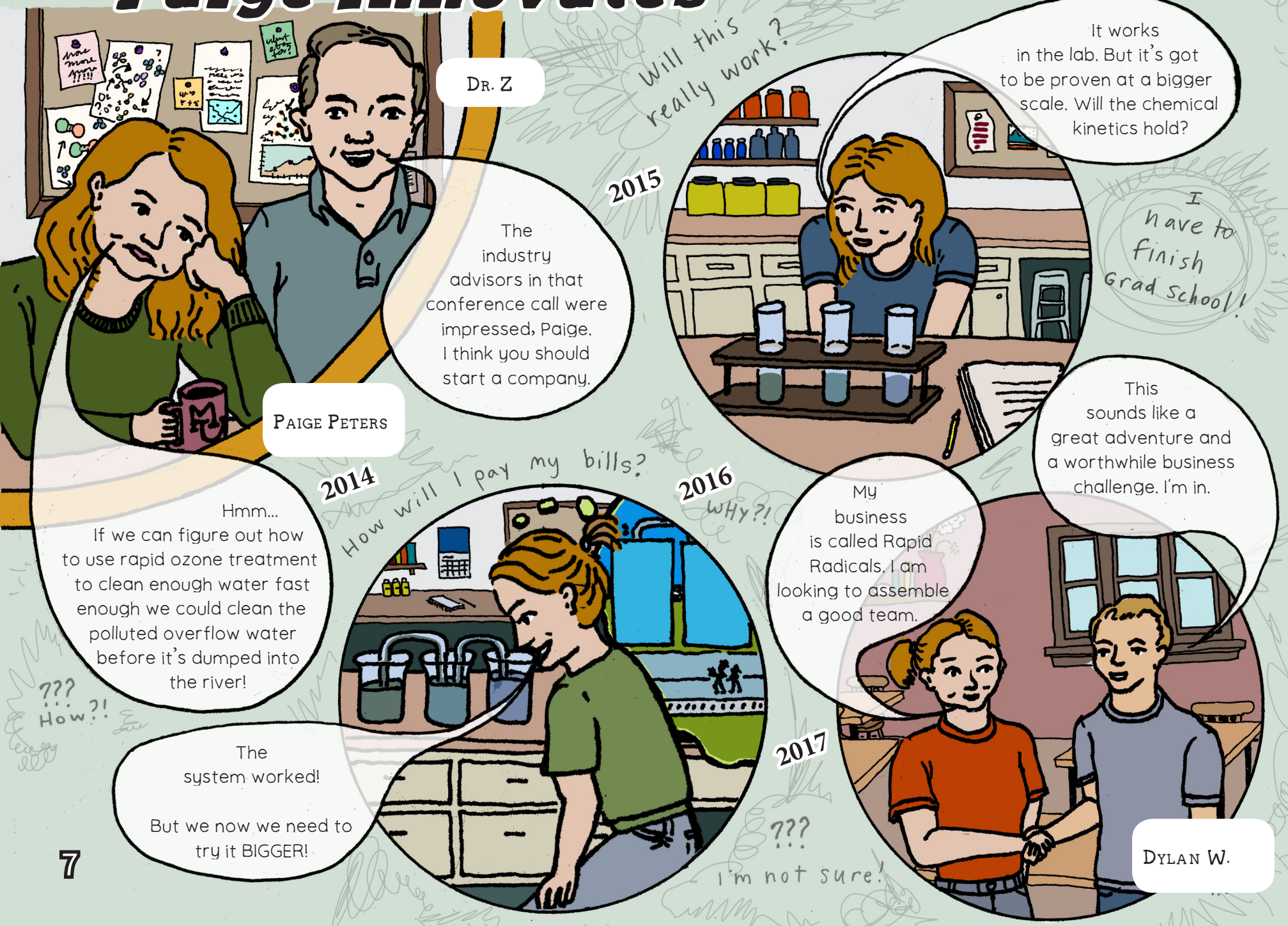


1993-2010

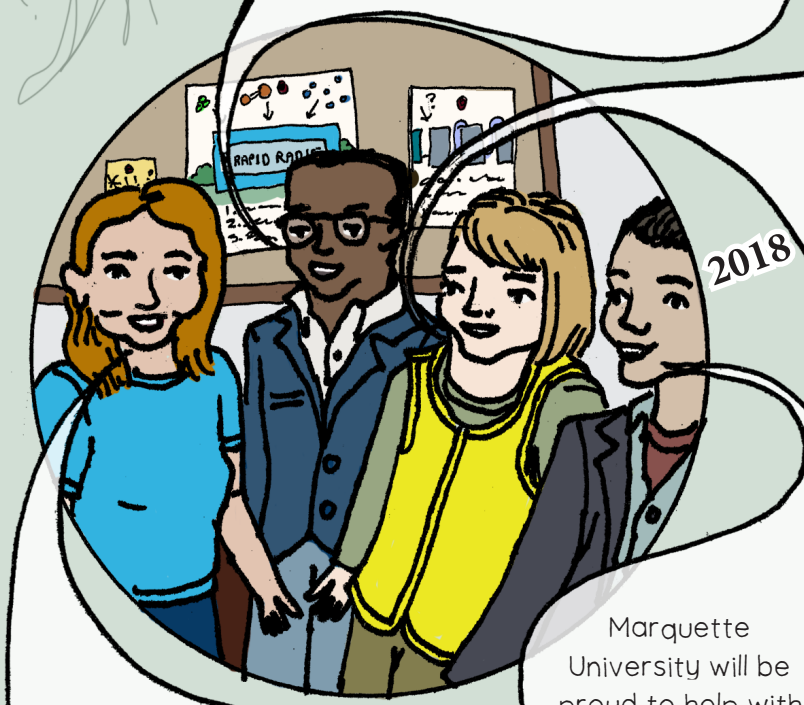
MMSD completes Deep Tunnel, reducing sewer overflows. It is expanded through 2010 with total capacity for 521 million gallons.



Paige Innovates



Her Team Assembles



2018

Let's talk. At MMSD we want to help find a solution to overflows too.

The Water Council's BREW accelerator could help you learn about launching a business.

Marquette University will be proud to help with your patent.

We have a BIG idea but we need your expert advice!

Industry advisors are telling me to ask: Who are our customers and what do they need?

Can you help?

2019

Wow, there is so much to learn about how to make an idea into a functional business that serves real customers.



What "gain" can you provide customers or what "pain" can you remove?

How will we get funding?

A PANDEMIC?!?!

2020

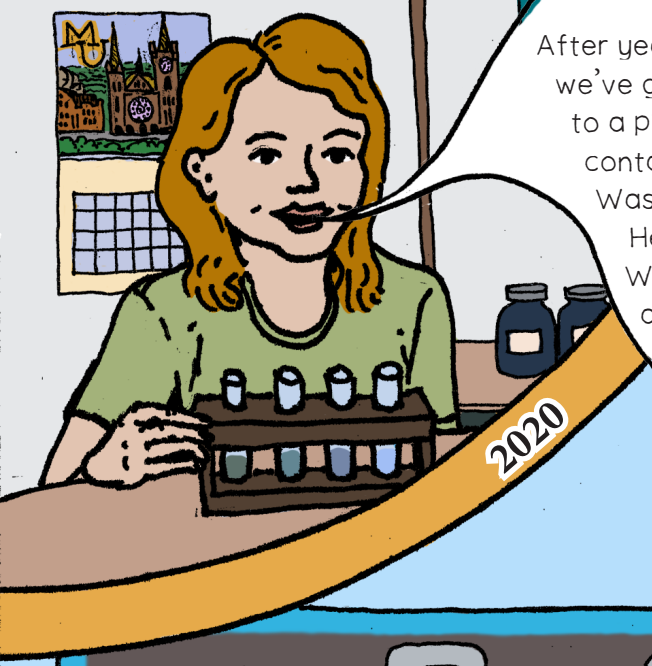


Will it be too expensive?!

Wow. It's **2020.** We are ready to test out Rapid Radicals inside a shipping container at Milwaukee Metropolitan Sewerage District's South Shore Wastewater Treatment Plant!

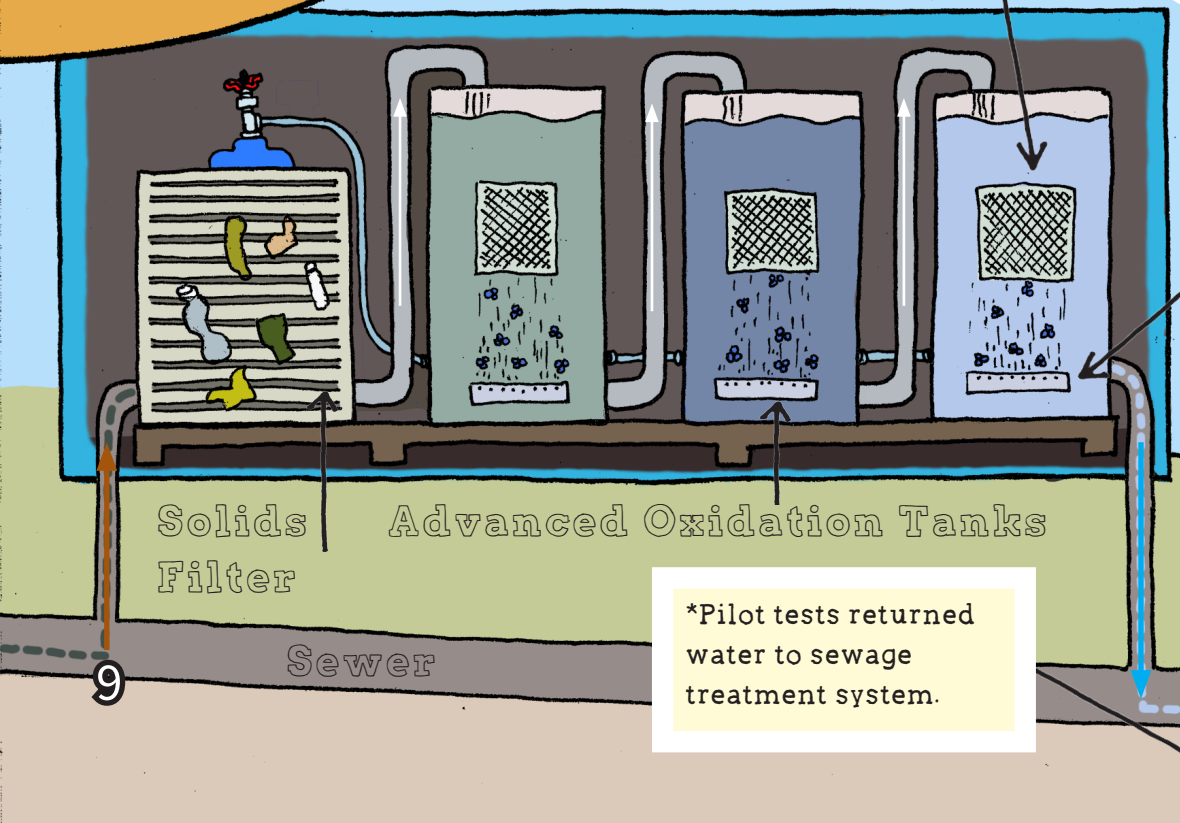
What's that smell?

Pilot Project



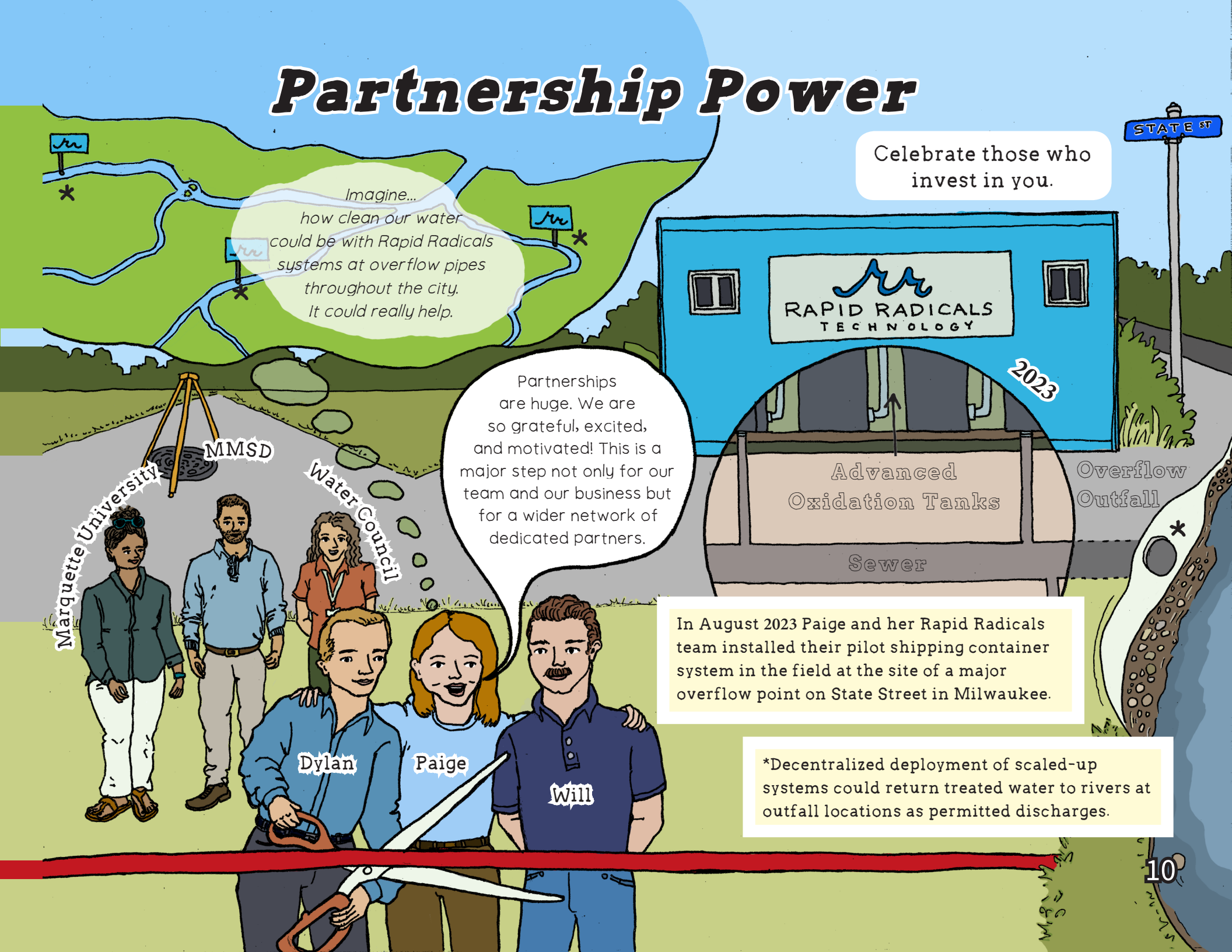
After years of testing, I think we've got it! We're ready to scale up to a pilot system inside a shipping container at MMSD's South Shore Wastewater Treatment Plant! Here's how it works: We inject ozone into tanks and our catalyst speeds up radical formation.

In 2022 Rapid Radicals tested their shipping container system at MMSD's South Shore Wastewater Treatment Plant.



*Pilot tests returned water to sewage treatment system.

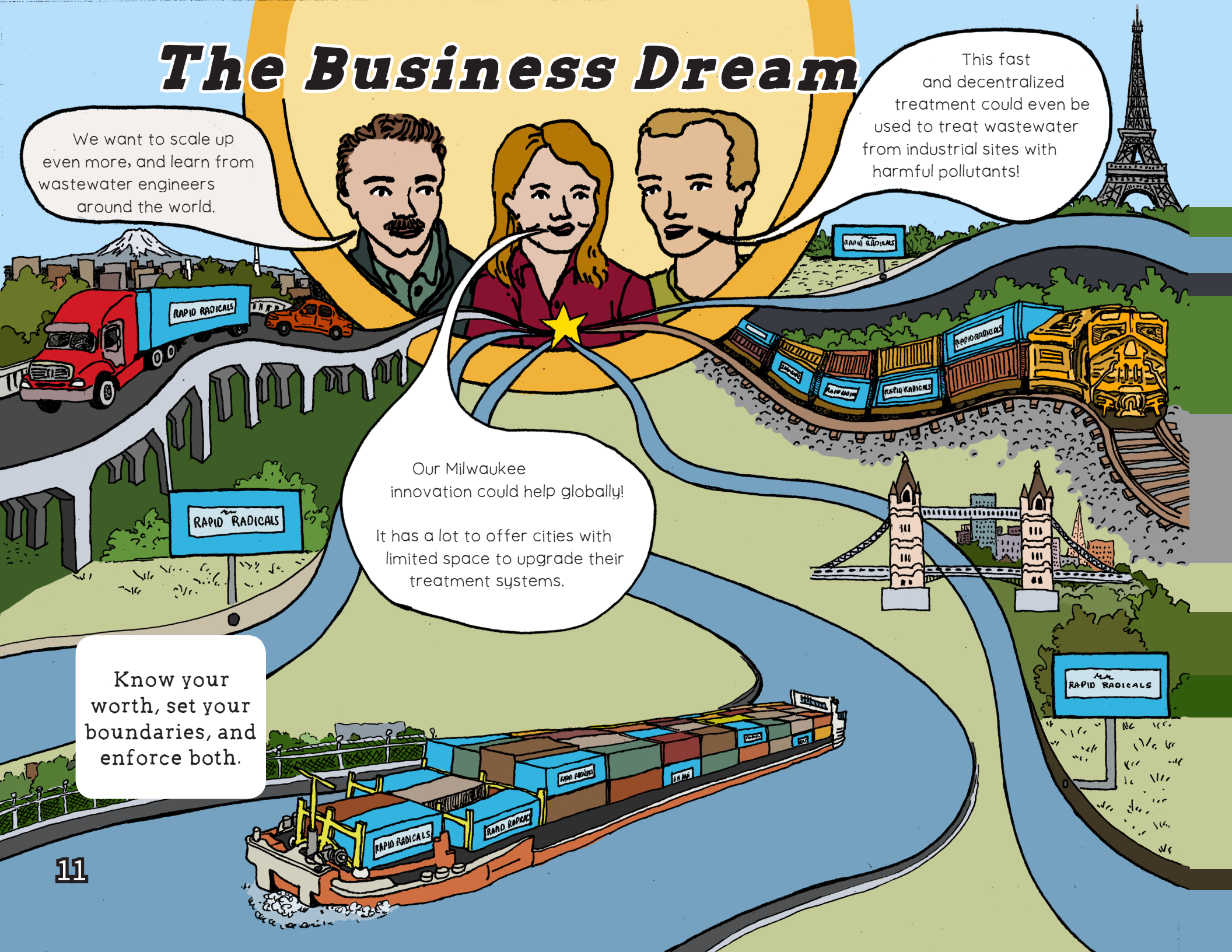
Partnership Power



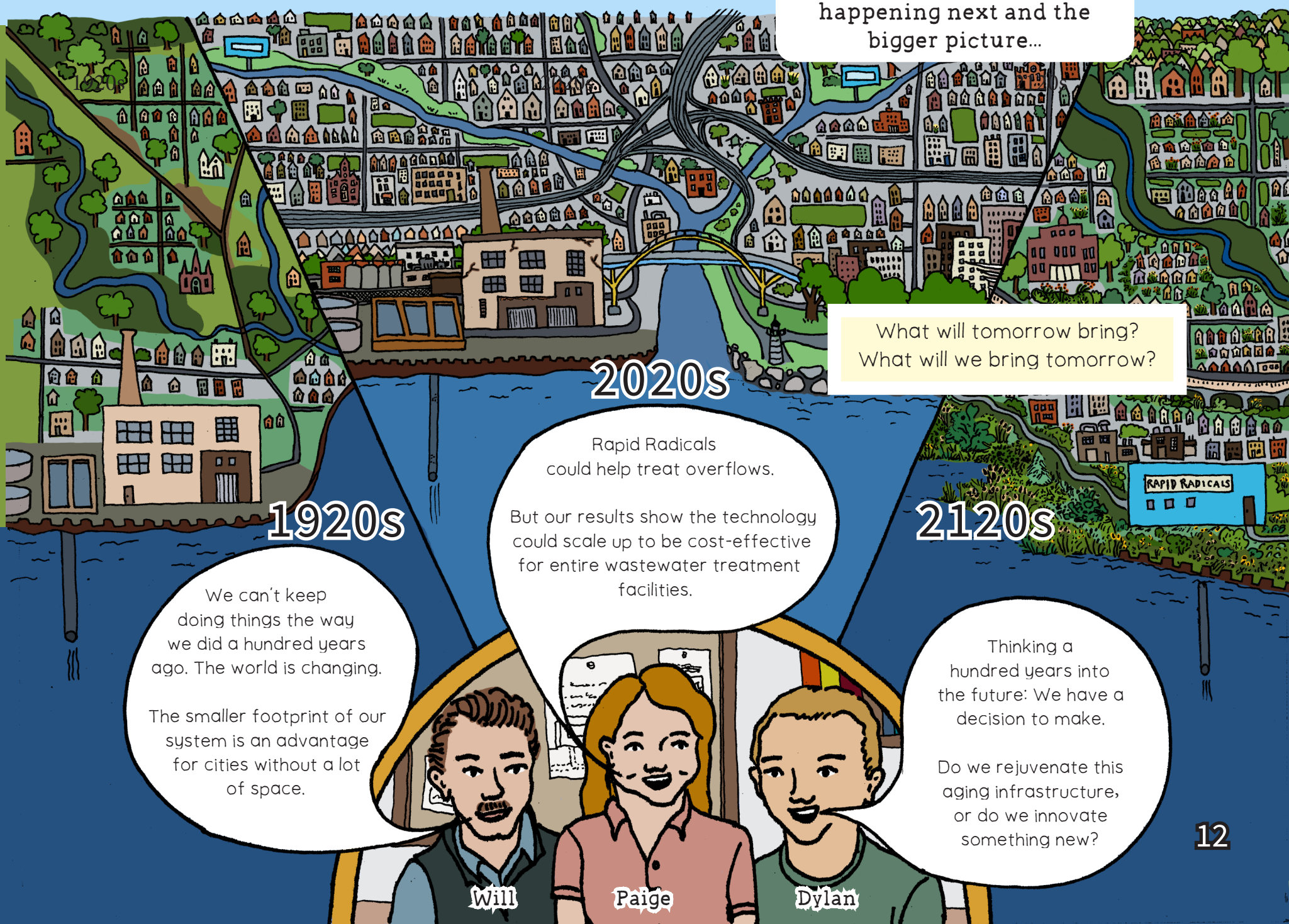
In August 2023 Paige and her Rapid Radicals team installed their pilot shipping container system in the field at the site of a major overflow point on State Street in Milwaukee.

*Decentralized deployment of scaled-up systems could return treated water to rivers at outfall locations as permitted discharges.

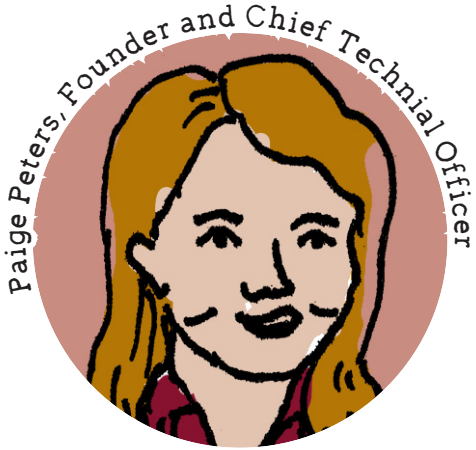
The Business Dream



The Future Vision



Real-Life Heroes



Favorite Book:
The Ghost Map by Steven Johnson

Favorite Song:
Light On by Maggie Rogers

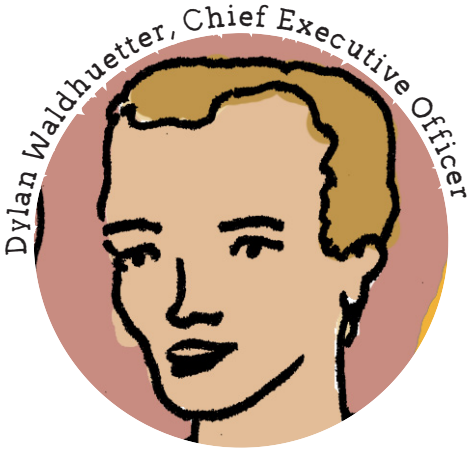
Favorite Food:
campfire nachos

Hero Growing Up:
My parents, Toby & Patti

Born: Cancer, 1988

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

- Margaret Mead



Favorite Book:
Harry Potter and the Half-Blood Prince

Favorite Song:
That's the Way That the World Goes 'Round by John Prine

Favorite Food:
My friend Sam's smash burger

Hero Growing Up:
My parents

Born: Libra, 1990

"Just that you do the right thing. The rest doesn't matter"

- Marcus Aurelius, Meditations



Favorite Book:
The Old Man And The Sea
by Ernest Hemmingway

Favorite Song:
Good Riddance by Green Day

Favorite Food:
My mother's beef stroganoff

Hero Growing Up:
Great-grandpa William Frank Schanen Jr.

Born: Sagittarius, 1997

"Live in the sunshine, swim the sea, drink the wild air's salubrity."

- Ralph Waldo Emerson, Merlin's Song

Real-Life Mentors



Dr. Dan Zitomer has over 25 years of experience in the environmental engineering industry. Dr. Zitomer joined Marquette University in 1995 where he is currently a civil and environmental engineering professor. He serves as the Director of the Water Quality Center and is the Marquette Site Director for the NSF WEP IUCRC.

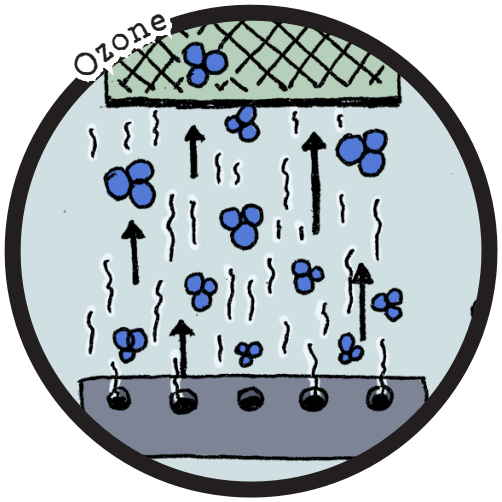


Matt Magruder at MMSD (the Milwaukee Metropolitan Sewerage District) has been a partner and advocate whose curiosity doesn't quit. Matt helpd Rapid Radicals test its pilot system at South Shore Wastewater Treatment Plant in 2020 and also in the field at State Street in 2023.



Dr. Kalpa Vithalani is executive director of Tech Transfer at Marquette University. She believes in the importance of collaborative applied research, "We can't keep our incredible academic discoveries within academic walls... How do we turn them into products and services that really help the public and benefit society and save our world?"

Real-Life Science

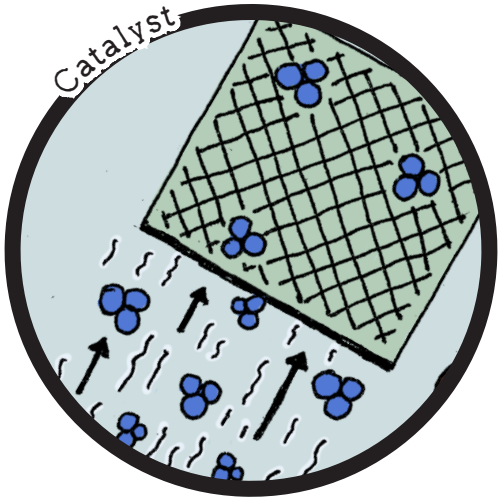


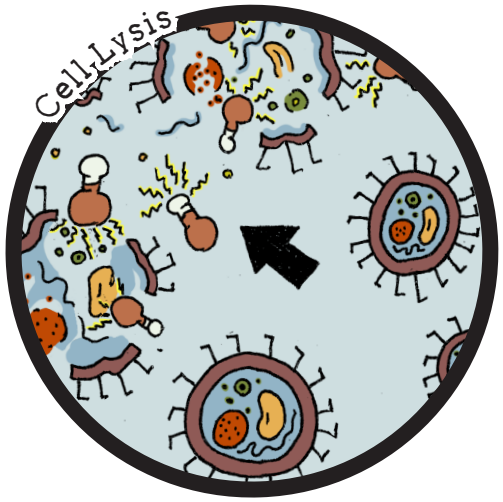
Ozone is three oxygen atoms fused together when diatomic oxygen (the kind we breathe in the air) is energized by ultraviolet radiation.

When ozone is injected into water, it breaks down into hydroxyl radicals. These are very reactive molecules that pull and rip at electrons, destroying cellular membranes and rupturing cell "machinery."

Paige Peters and her Marquette University advisor Dr. Dan Zitomer knew that ozone has been used for water treatment to kill pathogens (germs that make us sick).

In fact, the City of Milwaukee implemented ozonation of drinking water after the 1993 Cryptosporidium outbreak sickened over 400,000 people in the worst waterborne disease outbreak in U.S. history.





But in the early 21st century, ozonation is not typically used for wastewater treatment due to two factors: speed and cost.

Paige and Dr. Z studied water chemistry -- how catalysts can speed up chemical reactions like those that change ozone into hydroxyl radicals.

Real-Life Business

Regulations do not typically require treated wastewater to be as clean as treated drinking water, so under normal conditions there is little incentive (special reason) to innovate (imagine or invent new ways) for trusted systems that cities depend on to treat our wastewater.

But heavy storms like those in 2010 that flooded Dr. Z's basement also triggered sewer overflows. Neither basement backups nor sewer overflows are healthy. Even with a regional focus on managing water where it falls with green infrastructure like rain gardens and bioswales, intense storms remain a threat to water quality and public health and safety. Climate change is increasing their frequency.

During intense storms, there is an incentive for speedier treatment innovation because wastewater treatment plants relying on biological treatment can only process water as fast as their microbes can digest material. These systems are often injected with oxygen to speed up microbial respiration (like breathing hard during exercise), but even that has limits. (Imagine being forced to do a hot-dog-eating contest over and over and over -- even if they paid you a million dollars you could only eat so many hot dogs!)

That's why Paige's "Rapid Radicals" catalyst and treatment process could offer an advantage to wastewater utilities or industrial operators that need to clean water to regulatory standards quickly. Their business model is based on adapting to customer needs.

Many partners (below) have believed in them.

Will they succeed?

HE WATER COUNCIL NSF MARQUETTE UNIVERSITY wep Water Equipment & Policy I/UCRC Research Center IMAGINE H2O MMSD PARTNERS FOR A CLEANER ENVIRONMENT

Real Numbers

Rapid Radicals chemical treatment
$0.10/m³
ozone generation energy cost for COD removal to regulatory standard

Conventional activated sludge biological treatment
$0.20/m³
conventional activated sludge and ***$0.03/m³*** *for chlorination and dechlorination*

> ***$9,900***
> *nominal chemical cost for Rapid Radicals treatment for 12-hr, 36 MGD storm*

Quotations & figures sourced from Paige Peters' PhD dissertation, Feasibility of Sewer Overflow Treatment Using Chemical Oxidation After Rapid Solids Removal, published in May 2023, Marquette University



August 2023 ribbon cutting at State Street

The pilot study conducted at MMSD South Shore from 2020 to 2022 demonstrated that advanced, decentralized, end-of-pipe, high-rate sewer overflow water treatment is feasible and can be cost-effective. The larger pilot system operated at MMSD State Street generated a lot of important information about the challenges with remote treatment (i.e., automation and solids handling) and treating real sewer overflow water (i.e., more variable influent conditions).

Business Timeline

2010	Storms flood Milwaukee and Dan Zitomer's basement
2014	Marquette University research supported by NSF Water & Equipment Policy IUCRC
2016	Paige Peters founds Rapid Radicals Technology LLC
2017	Paige hires Dylan Waldhuetter as an independent contractor
2018	Customer discovery and Lean launch processes through NSF Innovation Corps
2019	Technology Transfer | The Water Council's BREW Accelerator | gBeta gener8tor | Imagine H2O
2020	Global novel coronavirus pandemic | Will Schanen hired as first full-time employee | Containerized pilot system tested at MMSD South Shore (2020-2022)
2022	Dylan becomes full-time CEO | Governor's Business Plan Contest won
2023	Paige Peters earns her PhD | Containerized pilot system installed on MMSD State Street | Rapid Radicals converted to Delaware C Corp
2024	Rapid Radicals secures four grants to further commercialization efforts.
2025	What's next?

Rapid Radicals has been successful in applying for non-dilutive (meaning no company equity was taken) grant awards and we will continue along this path until we need to accelerate our growth to meet growing customer demands.

Learn More

ABOUT OUR SEWER SYSTEM

History of Milwaukee Metropolitan Sewerage District (MMSD)
https://www.mmsd.com/about-us/history

About MMSD's Deep Tunnel
https://www.mmsd.com/what-we-do/wastewater-treatment/deep-tunnel

ABOUT OUR WATER SYSTEM

How Milwaukee Water Works Treats Drinking Water
https://city.milwaukee.gov/water/customer/FAQs/qualityandhealth/Water-treatment-process.htm

History of Milwaukee Water Works
https://city.milwaukee.gov/water/customer/FAQs/additionalinfo/History-of-the-Milwaukee-Water-Works.htm

OTHER RESOURCES

A look inside Milwaukee Water Works
https://onmilwaukee.com/articles/linnwood-water-treatment-facility

Timeline video of 30 years of key water story headlines, 1993-2019
https://vimeo.com/382211134

It was not easy, and the knowledge and insight I gathered along the way has made me a better and more curious leader, researcher, and engineer, and a stronger version of myself.

It is my hope that other budding, go-getter, entrepreneurial-minded graduate students may see this and know they can make their own dream a reality, too.

Key Terms

Basement Backup
During heavy storms or melting snow, so much water enters the sewer system so rapidly that it can be overwhelming. When the system cannot hold or treat the water it must go somewhere. That water can "back up" from the sewer system into people's basements.

Biological Water Treatment
Using microbes to digest wastewater is known as biological treatment because microbes are alive. Sometimes they are given extra oxygen to speed up their digestion.

Catalyst
A substance that speeds up a chemical reaction but does not itself get used up. Enzymes are examples in the human body. Reactions in the presence of a catalyst happen faster.

Chemical Water Treatment
Using materials like chlorine, ozone, or sodium hypochlorite to kill organisms in water, sometimes forming byproducts. Ozone is useful in that it does not create harmful byproducts.

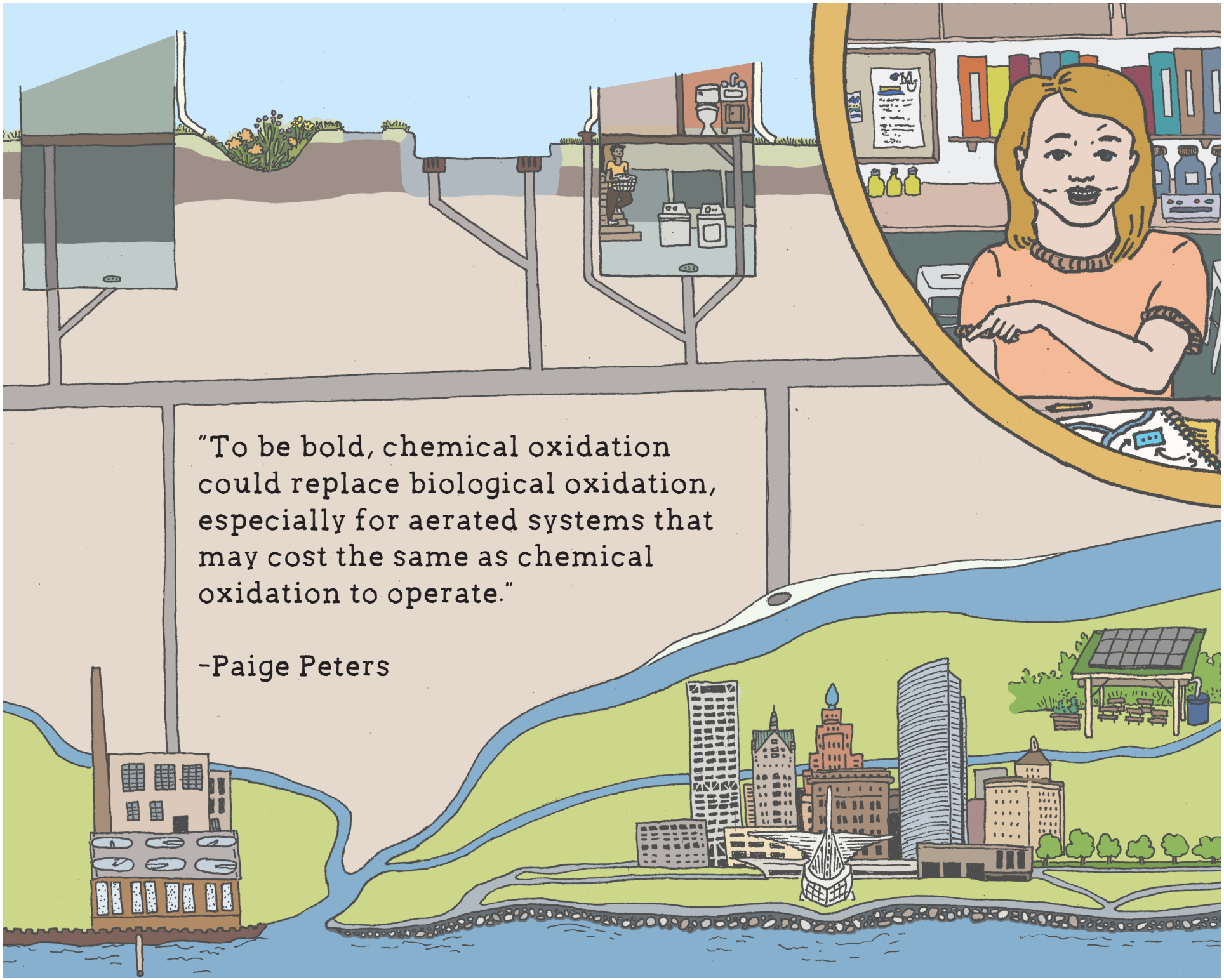
Combined Sewer
The area of cities where what you flush down the toilet goes into the same pipes as what washes off the street. Outside that area, the separated sewer area contributes wastewater to the same system, but stormwater flows directly into rivers.

Deep Tunnel
In Milwaukee, a massive engineering project that burrowed a giant tunnel network beneath the city able to hold 521 million gallons of water during heavy storms so it can be pumped up later for treatment. Did you know the rock from excavating the Deep Tunnel was used to form Lakeshore State Park?

Green Infrastructure
Nature-inspired practices like rain gardens, bioswales, rain barrels, cisterns, native plantings, or porous pavers that store water or help it soak into the ground rather than going right into "gray infrastructure" pipes.

Overflow
Initiated to prevent basement backups when the sewer system gets overwhelmed with too much water too fast, overflows occur at outfall pipes discharging into Milwaukee's three rivers.

Ozone
Three oxygen atoms fused together, which can be harmful to life. When injected into water as a bubbling gas, ozone forms hydroxyl radicals, which are used to kill pathogens to clean the water.


"To be bold, chemical oxidation could replace biological oxidation, especially for aerated systems that may cost the same as chemical oxidation to operate."
-Paige Peters



Favorite Book
Any Golden Press field guide!

Favorite Food
Thai Curries

Zodiac Sign
Aries

I love playing music! I have a flute, guitar, ukulele, cello, harp, trombone, accordion, concertina, kalimba, and a keyboard! I can't play all of them well, but I like practicing and experimenting.



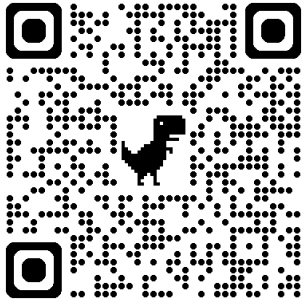
Favorite Book
The Hitchhiker's Guide to the Galaxy
by Douglas Adams

Hero Growing Up
Captain Kirk

Zodiac Sign / Year of Birth
Pisces / 1982

"Nature is a living whole."
--Alexander von Humboldt













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