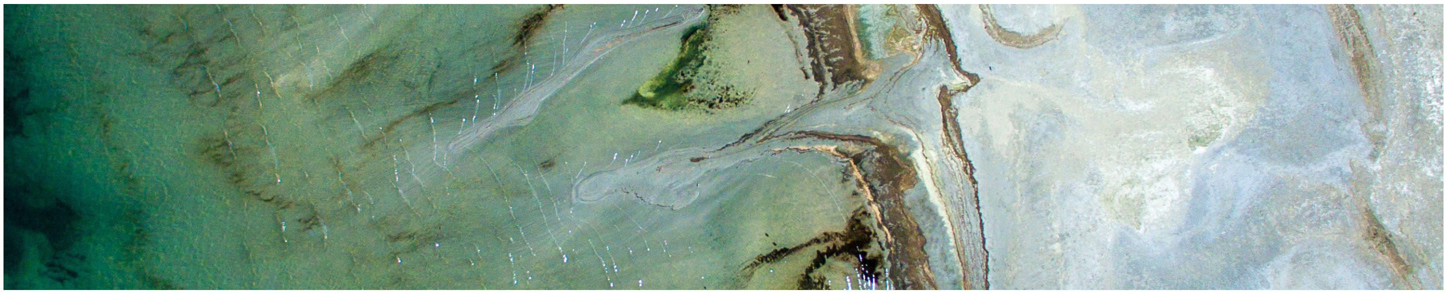
CREO

IMPACT INVESTMENT STRATEGIES IN WATER:

Distributed Wastewater Treatment and Water Reuse



About CREO

The CREO Syndicate ("CREO") is a 501c3 public charity founded by wealth owners and family offices with a mission to address some of the most pressing environmental challenges of our time affecting communities across the globe—climate change and resource scarcity—by catalyzing private capital into innovative solutions to protect and preserve the environment and accelerate the transition to a more sustainable economy for the benefit of the public.

CREO works closely with a broad set of global stakeholders, including Members (wealth owners and family offices), Friends (aligned investors such as pension funds and university endowments), and Partners (government, not-for-profit organizations and academia) who collaboratively develop and invest in solutions across sectors, asset classes and geographies.

CREO primary activities include 1) capacity building by providing an expert and peer-to-peer educational platform where Members and other stakeholders can share applied knowledge and expertise, resources, and investment opportunities; 2) relationship building; and 3) conducting select research to support the advancement of its mission.

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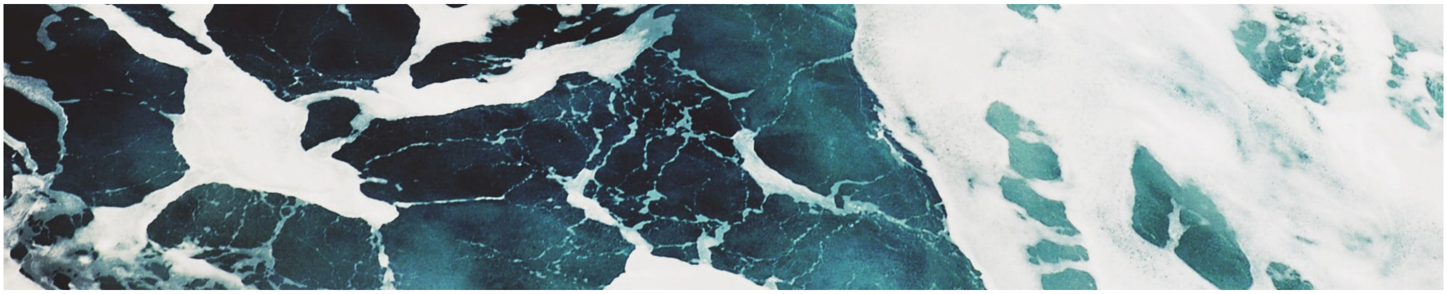


Executive Summary

This investment thesis by CREO is the first of two reports designed to serve as primers for those considering investing in water to achieve both financial results and positive sustainability impacts. This investment thesis is focused on opportunities to capitalize on the emerging shift from centralized to distributed wastewater systems, as well as related water reuse technologies. The second, which is to be published by the end of 2019, is focused on the water and agriculture nexus.

Experienced investors are suggesting distributed water and wastewater are coming to life as an investment opportunity and will drive future growth of the industry. At the same time, CREO members are increasingly expressing interest towards investing in maturing water and wastewater opportunities with clear environmental and social benefits.

Opportunities for positive impact are wide because water and wastewater are interconnected with energy, climate, human health, food production, climate resiliency and ecosystem services. Further, investments in water and wastewater align with Sustainable Development Goal 6: Clean Water and Sanitation (SDG 6), which underscores global recognition of the potential positive impact. This covers opportunities in both advanced as well as emerging markets.

From our research and interviews, we present three core investment theses along with a technology solutions landscape (Appendix B). From lower risk and lower expected return to higher risk and higher expected return, the opportunities are:

1. Project financing industrial wastewater treatment projects in advanced markets, emphasizing the food and beverage industry;
2. Investing in corporate equity of best-in-class growth-stage wastewater treatment and water reuse companies with a market focus on leapfrogging wastewater technology in emerging markets; and
3. Investing in early stage water technology companies.

This thesis will review current market dynamics, why now may be a good time to invest, and considerations for measuring net positive impact of investment. Whether investors are seeking direct equity investments, project financing, funds, or acquisition, investments in wastewater and water reuse can be a good fit for families and family offices with an interest in making a difference in human health, environmental outcomes, and climate resilience.

Introduction

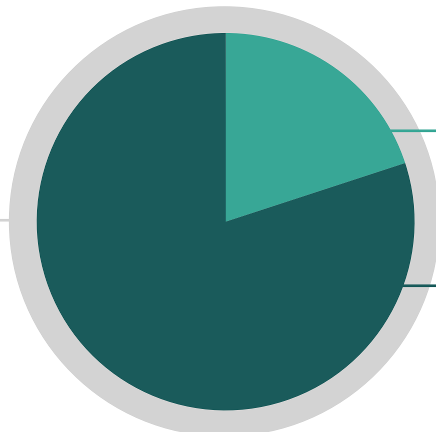
This thesis delves into water and wastewater sector investing, building on the prior 2017 report by CREO and The ImPact entitled "Water: An Impact Primer for Family Offices and Foundations." The earlier report introduced the topic focusing primarily on why water investing fits well for this class of investors. Opportunities that were previously detailed by CREO and The ImPact include:

- Optimization of water systems, including but not limited to pressure management, smart distribution or smart pumping
- Conservation and efficiency technologies
- Quality enhancement
- Non-revenue water technology, including advanced metering and leak detection
- Smart digital water technology including sensors, drones, satellites, and artificial intelligence tools such as machine learning
- Resource recovery for water reuse, nutrients, fertilizer, metals and energy
- Filtration
- Sludge management
- UV disinfection including LEDs to reduce energy consumption

Since the previous report, several indicators show a market around distributed wastewater treatment that is maturing and is a sector in need of new technologies.

THE MARKET

Global Water and Wastewater Market, 2018



The global water and wastewater market in 2018 hit $695 billion. Municipal markets were growing at a 6.4 percent compound annual growth rate (CAGR) compared to the industrial segment, which was growing slightly faster at a 7.5 percent CAGR. Some wastewater technology segments are growing even faster, driven by increasing demand for membrane-based solutions and smart, internet-enabled and digital solutions. Advancements in chemistry, membranes, sensors and industrial internet of things (IIoT) are spurring the adoption of higher-performance water and wastewater solutions and are enabling new business models.

Much of this growth is due to necessary system upgrades for deteriorating systems (capital costs) and increasing operating costs. From 1996 to 2016, the annual average increase in water and wastewater rates were 4.71 percent, more than double the U.S. economy wide inflation rate of 2.15 percent. Globally, water rates are rising two to three times inflation, as well. While the water and wastewater industry is quite conservative, it is also stable year after year. People continue to need water and wastewater services, and the industry doesn't suffer from global economic crises.

Currently, wastewater treatment is based on large centralized facilities with piping infrastructure designed to capture economies of scale. Given the challenges of centralized systems, large cities are moving towards decentralizing distributed solutions because incremental system improvements can be more economical and yield greater compliance and resilience.[1] The continued rise in wastewater spending highlights an industry on the verge of transforming towards distributed solutions that are cheaper and more technologically advanced.

THE IMPACT

Unprecedented climate-related events and human crises have elevated the importance in water and wastewater management since the 2017 Primer. More extreme fire events occurred across the world, cyclones and hurricanes caused widespread flooding, and prolonged droughts undermined agricultural production and human needs. The 2019 WHO/UNICEF Joint Monitoring Programme Report reminds us that even well into the 21st century "more than 2.1 billion people lack access to safe, readily available water at home, and 4.4 billion lack safely managed sanitation."[2]

Cities, factories and farms are within reach of the next wave of technology that will enable sources of "new" water that were seen as waste before by reusing wastewater and stormwater, and desalinating brackish water and seawater.[3] Wastewater and reuse solutions are also becoming accepted in ways that would not have been accepted in the past, such as direct potable reuse.[4]

Developing and implementing new water technologies will require a shift in public acceptance in the U.S. and, in emerging economies, to completely skip a generation of aging wastewater treatment systems. Much as the developing world has skipped the introduction of wired telephone networks in favor of cellular mobile phones, the wastewater industry is on the verge of bypassing the aging, concrete, expensive and smelly wastewater collection and treatment systems (WWTPs) of yesterday.

THREE OPPORTUNITIES FOR INVESTMENT

Early evidence of a shift to displace systems comes from small to medium size firms signing contracts worth from $40 to $50 million to install municipal and industrial wastewater systems at multiple sites.[5] Municipal systems often are supportive, though they are careful to make sure that distributed solutions are aligned with their longer-term economic interest and avoid undermining their financial fundamentals of revenue collections from fixed and variable rates.

Investors can take advantage of the steepening demand curve for distributed infrastructure across various geographies and customer profiles. The benefits of distributed infrastructure for wastewater are significant. Distributed infrastructure is more controllable, the scale capital needed is smaller, and even operating expenses are smaller. In many contexts, distributed infrastructure makes financial and operational sense.[6]

First, a prevalent new business model is project financing of distributed, onsite wastewater treatment and water reuse plants with proven technology in advanced markets. These facilities can now be profitably deployed at smaller sites with high loads, like microbreweries. They can also be deployed with lower volume, high concentration industrial facilities, like pharmaceutical and microelectronics plants. Containerized, packaged plants with sensors that transmit data via internet, cloud-based communications enable remote monitoring and reduce operating costs.

These projects are most easily financed through fund managers who aggregate these opportunities across industries, geographies and facility types. Family offices can be a critical source of risk capital to finance the growth in these distributed facilities that will lead the way in ushering in the next generation of wastewater treatment.

Second are opportunities in emerging markets that address SDG 6 through for-profit projects to retrofit wastewater treatment in urban areas in Southeast Asia, China, India and some African nations. This also includes distributed infrastructure in planned, greenfield cities in China. While these opportunities include more investor risk, they also have greater potential for impact and returns.

Investors can opt to invest directly and acquire mature, growth-stage technology solution providers with traction in these markets. Alternatively, investors can choose to invest indirectly through funds that supply geographically focused growth or venture capital, or in pools of projects. While cultural and political risks are considerable, demand for superior technologies and trusted, reliable brands is strong. Third, thousands of entrepreneurs globally are vying to bring hardware and software solutions to market. Just in the last few years, accelerators and competitions across the U.S.and globally have embraced water. They have been and continue to act as effective frontline diligence filters for investors, backed up by research aggregators and evaluators in specialized water-tech.

Inherent risks of investing globally in early stage water companies remain, such as slower market adoption and highly variable needs, or variable priorities and budgets across target customers. Investing in early stage water technology solutions exposes investors to technology risk, team risk, and idiosyncratic risk, all of which must be compensated with higher returns. As such, patience and expectations tuned to longer time horizons are necessary for investors.

The Problems of Centralized Wastewater

Centralized wastewater systems are beset with major engineering, financial and technological challenges.

The engineering challenges are considerable as utilities continue operating assets, like pipes and pumps, beyond the 50 to 100 year expected life they were designed for. The results are evident every day in the U.S., where there are over 250,000 water main breaks each year.

Yesterday's centralized wastewater treatment plants cannot completely address tomorrow's growing demands. Centralized wastewater treatment plants (WWTPs) and their associated collection systems are expensive and inefficient. They require oversized capacity today to meet long-term demand.[7] Pipes are expensive to install, repair and replace. Costs can range from $1 to $10 million per kilometer, meaning that 90 percent of the capital costs for centralized wastewater is in the collection system, plus operating costs, electricity for pumping and storage.

Financially, operating costs are increasingly putting a strain on capital budgets. Although municipal utilities have access to low-cost and tax-exempt debt, they are not able to raise enough funds to cover growing costs. Their billing and rate setting models do not generate enough revenue to stay on top of the costs of maintaining deteriorating systems. Water continues to be the lowest cost utility in real dollars for most residential customers compared to electricity, gas and telecommunication.

Another cost is around land values, as land is a key consideration for centralized municipal wastewater treatment. Many of these treatment centers face high costs as land values in urban areas, where they are most needed, continue to rise. This limits the ability to expand in the future when growth is needed, or add equipment to address community concerns related to impacts on air quality from these facilities.

Technological and innovation changes are introducing challenges for centralized systems that were not originally designed. For example, sewer blockage challenges are increasing because of the combination of low-flow plumbing, flushable wet wipes and personal care fabrics, and fats, oil and grease (FOG) that get poured down drains of these systems.

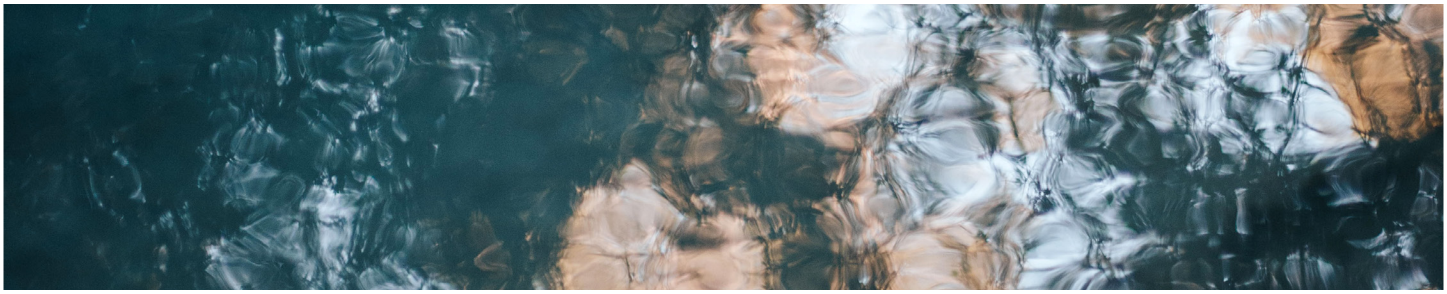
The Solution of Decentralizing Wastewater Treatment

“Distributed systems, whether modular or containerized, treating at point of use in a more distributed fashion, will drive growth in the industry broadly” notes one longtime investor and operator.

Distributed wastewater infrastructure can address the major problems from centralized systems by preventing the introduction of contaminants at their source and before they enter the wastewater stream. Smart, internet-connected systems can be remotely operated, odorless, energy efficient, and recover biosolids for another use, and reuse water for irrigation (non-potable) or drinking (potable). These systems can be placed onsite at industrial facilities and built as needed for new residential and commercial construction.

Some countries like Israel are leading the way by recycling and reusing over 90 percent of its municipal wastewater, mostly for irrigation via centralized municipal treatment systems. By comparison, California leads the U.S. by recycling just 5 percent of its municipal wastewater, usually with centralized treatment plants, indicating considerable room for expansion into a large market opportunity. Data indicates that the distributed wastewater market is growing quickly into a significant opportunity with a market size forecast to grow from $13.3 billion in 2016 to $21.8 billion in 2021.

A key economic driver for investing in onsite distributed treatment is regulatory surcharges that centralized municipal wastewater utilities may apply to high load contributors. This also includes unfunded mandatory requirements for installation and operation of screens or traps of fats, oil and grease. For these reasons, governments globally are moving to design, mandate or incentivize distributed solutions that are more economical and yield greater compliance and resilience. Or in some instances, municipalities are selling their wastewater assets or subcontracting facility management to private operators.



Opportunity 1: Project Financing Industrial Wastewater Treatment

The global growth of modular, distributed wastewater plants is expected to rise 64% from $13.3 billion in 2016 to $21.8 billion in 2021. Of the $21.8 billion, $9.1 billion is forecast to be purchased by municipal wastewater, $8.4 billion by industrial wastewater and $4.4 billion for municipal drinking water.

There is tremendous growth in the modular, distributed wastewater plant industry. This opportunity targets U.S. and European industrial customers because they tend to adopt new technologies first, have clear economic pain points with shorter sales cycles, and are not driven by political decision-making the way municipal utilities are. Moreover, as noted by one expert investor, industrial needs are growing in the U.S. as operations and factories are expanding. This provides a timely opportunity to invest in this geography.[8] Both the U.S. and Europe have favorable regulatory environments, driven by specific rates, surcharges and fines in some areas.

There are many industrial segments that have needs for distributed wastewater infrastructure. This includes food and beverage, oil and gas, refining and petrochemicals, pulp & paper, mining, chemicals, pharmaceuticals, microelectronics, remote camps, and power generation. Treating the wastewater streams of these facilities can have measurable environmental benefits. These include reducing oxygen depletion in rivers and lakes, reducing nutrient pollution from nitrogen and phosphorus that can lead to algae blooms, preventing toxic pollution from industrial effluents including ammonia, acids and caustics, and reduction of unpleasant odors. Energy efficient plants can also reduce greenhouse gas emissions.

Since the food and beverage industry (F&B) attracts the largest share of capital expenditures for wastewater treatment of any industry, according to Global Water Intelligence (Figure 1), this thesis will delve more deeply into the Food and Beverage market. The thesis will guide the reader toward further exploration of this and other segments by highlighting companies on the accompanying Opportunity Map serving these and other industrial segments.[9]

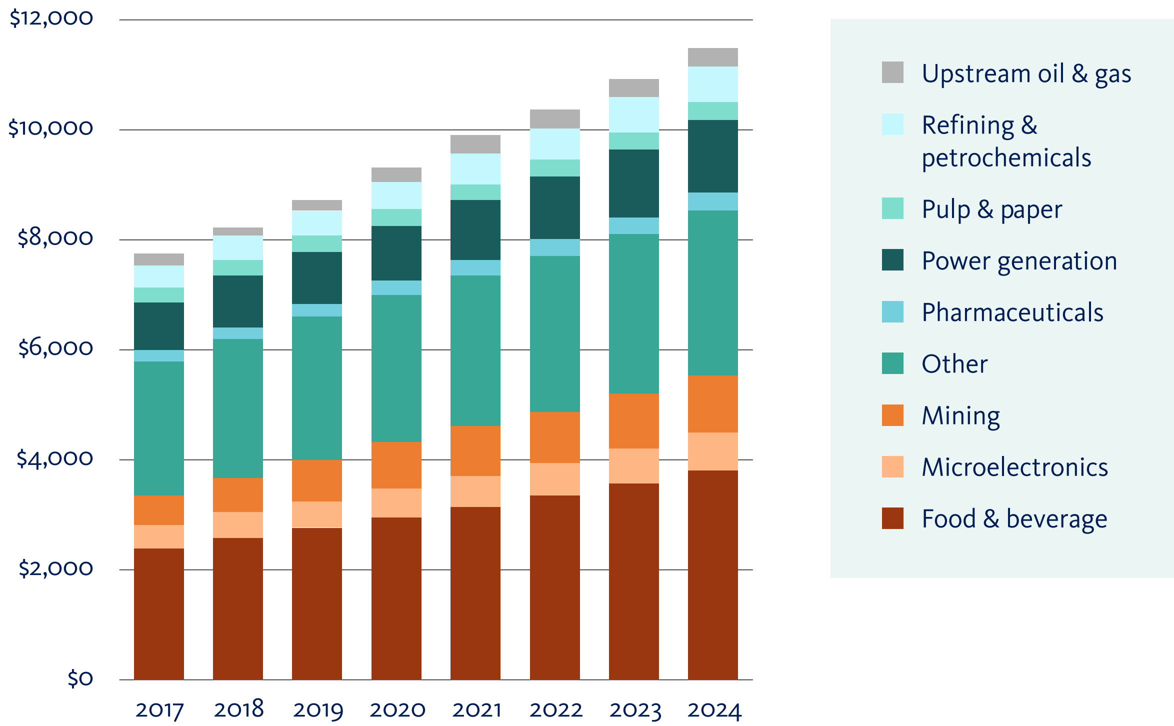


Figure 1: Capital Expenditure on Suspended Solids Removal by Industry, 2013-2020[10]

FOOD AND BEVERAGE

F&B provides opportunity for project financing of distributed wastewater treatment and reuse plants in the U.S and Europe. F&B businesses generate high volumes and loads of biochemical oxygen demand (BOD) and are seeing significant numbers of new facilities come online. Onsite water treatment provides significant economic advantages because of the growth of new F&B facilities, the increase in surcharges and fines per pound of BOD placed on these facilities.

Among industrial sectors buying smart, packaged wastewater systems, F&B is expected to see the fastest growth (Figure 2). Additionally, F&B spent $26 billion on structures and equipment in 2017, second only to Chemicals, and added 7,000 new facilities between 2014 and 2018 when compared to Chemicals, which added 1,879 facilities (Figure 3).[12]

It should be noted that though the capital expenditures of the F&B leads investment in the industrial segment, as illustrated in Figure 1, some wastewater treatment suppliers have looked beyond F&B and intentionally moved into more specialized industries like microelectronics, chemicals and pharmaceuticals. Partly, this may be explained by the application fit of that technology, or it may indicate that other industries are less competitive or provide more attractive economics.

Axine Water, for example, specializes in harder to treat organics and ammonia by oxidizing and destroying pollutants with double and triple bonds. The pollutants get converted into by-product gases with no liquid or solid waste generated. Similar to other containerized systems, Axine systems are fully automated and remotely monitored.[11] Axine is indicative of the specialization and fragmentation that one would expect in a move towards decentralization. But it requires multiple types of expertise to spot the profitable niches in advance, whereas F&B is larger, more consolidated, and could be easier for investors to approach.

Change in Number of Establishments by Sector
2014–2018

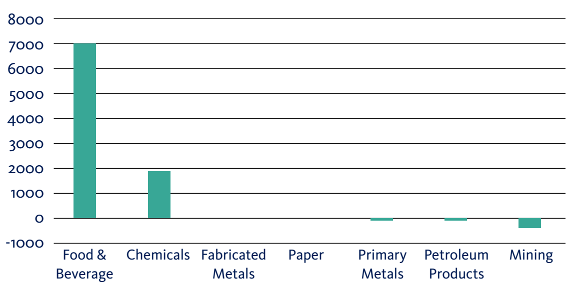


Figure 2: Change in Number of Establishments by Sector 2014-2018[13]

Size of industrial segments by annual revenue
2017 ($ Billions)

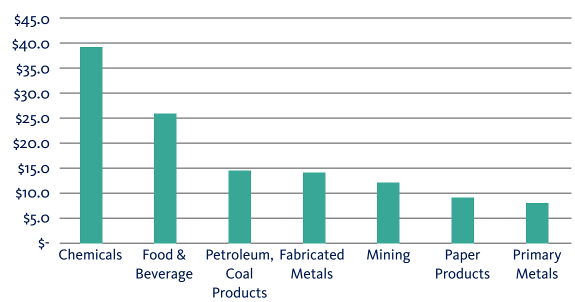


Figure 3: Size of Industrial Segments by Annual Revenue for 2017 ($ Billions)[14]

F&B companies are sensitive to three types of drivers in wastewater treatment:

1. Legislative or regulatory drivers when companies are forced to treat wastewater because of surcharges or indicators that local wastewater treatment plants do not have capacity to receive more flows.
2. Business case on cost as water becomes more expensive due to municipal wastewater charges increasing or when wastewater must be trucked away at high expense.
3. When corporate reputations and brands are at stake, and companies must operate sustainably in water stressed regions.

Surcharges

F&B segments with high BOD and COD streams that are adding distributed systems include wineries, maple syrup producers, soda and juice bottlers, poultry processors, and breweries to deal with surcharge issues. While the wastewater rates vary widely, the potential incremental surcharges can rapidly increase costs of food and beverage. Since F&B typically serves price-sensitive customers and competition can be fierce, the higher costs of incremental surcharges can significantly deteriorate profit margins.

In some examples, the addition of a surcharge may double a company's overall wastewater costs, from about 1 percent to 2 percent of costs, adding an average cost of more than $4 per barrel of beer with some reaching $12 per barrel.[15] In one example, a Coca-Cola facility was paying $1.8 million per year in wastewater surcharges. By installing an onsite wastewater treatment facility, Coke reduced and levelized their payments to $200,000 per year over a 10-year period.[16]

US Average Wastewater Surcharge Rates:[17]

Industry Rates	Min	Average	Max
Flow ($/1000 gal)	$0.25	$0.25	$13.27
BOD Surcharge ($/lb)	$0.11	$0.11	$0.69
TSS Surcharge ($/lb)	$0.11	$0.11	$0.77

In Europe, surcharges are also prevalent. There are uniform surcharge structures in the Netherlands, Ireland and the UK. In Germany and Scandinavia, companies have been able to negotiate surcharges with local authorities, using the potential to locate a plant to a site where charges will be lower as leverage. Elsewhere, surcharge rates can vary widely.[18]

In an example of responding to wastewater charges by applying technology, Grundfos partnered with dairy producer Arla Foods in Denmark to install their BioBooster distributed wastewater treatment solution. It treats 750 cubic meters of wastewater per day in a biological process and then uses ultrafiltration to remove bacteria, complying with discharge limits and water reuse quality. Arla reuses 300 cubic meters of water daily and avoids sending 450 cubic meters to the expensive wastewater treatment plant by discharging directly to a local river.[19]

MEMBRANE BIOREACTORS

Membrane bioreactors (MBRs) are the current standard for wastewater treatment with F&B. They are being applied at an ever-increasing number of locations. Figure 4 illustrates the treatment process for a biologically based MBR that uses agitation, aeration and membrane filtration to create a clarified and disinfected product effluent.

The major drawback for MBR is membrane fouling, which reduces performance and lifespan, while increasing operating and maintenance costs. There are other biological systems that do not use membranes, such as hydroponic systems, food chain reactors and wetlands, as well as non-biological systems, such as polymeric membranes and ceramic filters. When used in municipal in-situ wastewater processing, they are replacing the secondary clarifier (sedimentation tank) and tertiary filtration processes, which typically are used in conventional activated sludge (CAS) systems.

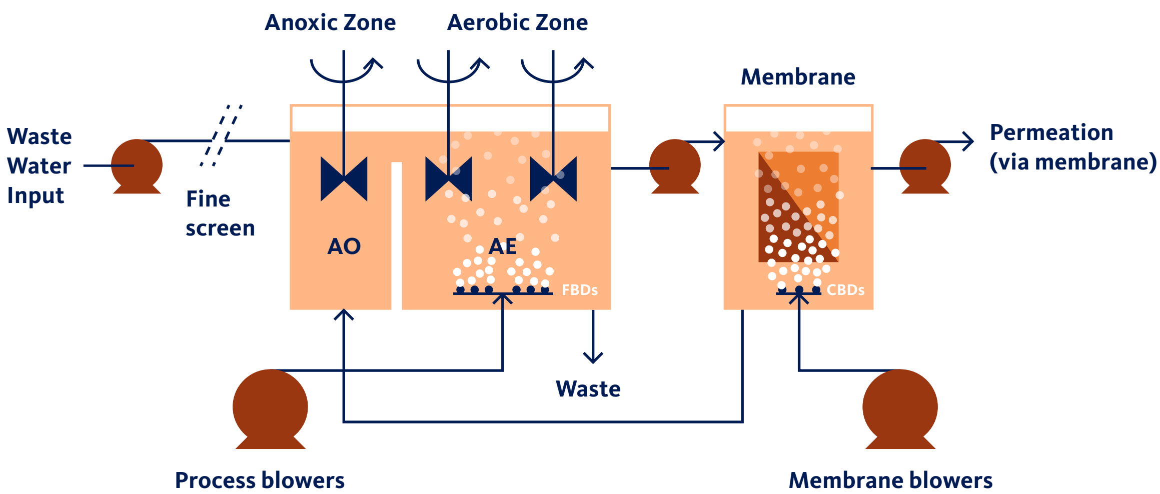


Figure 4: Schematic of Membrane-Based Biological Wastewater Treatment Process[20]

Case Study: The Water Treatment Demands of the Growing Craft Brewery Business

Within F&B, demand by breweries is the big driver. Craft breweries are carving out 12.6 percent of the total annual production volume of 25 million barrels and capturing $26 billion in sales. There was an 8 percent sales growth in 2017.[21]

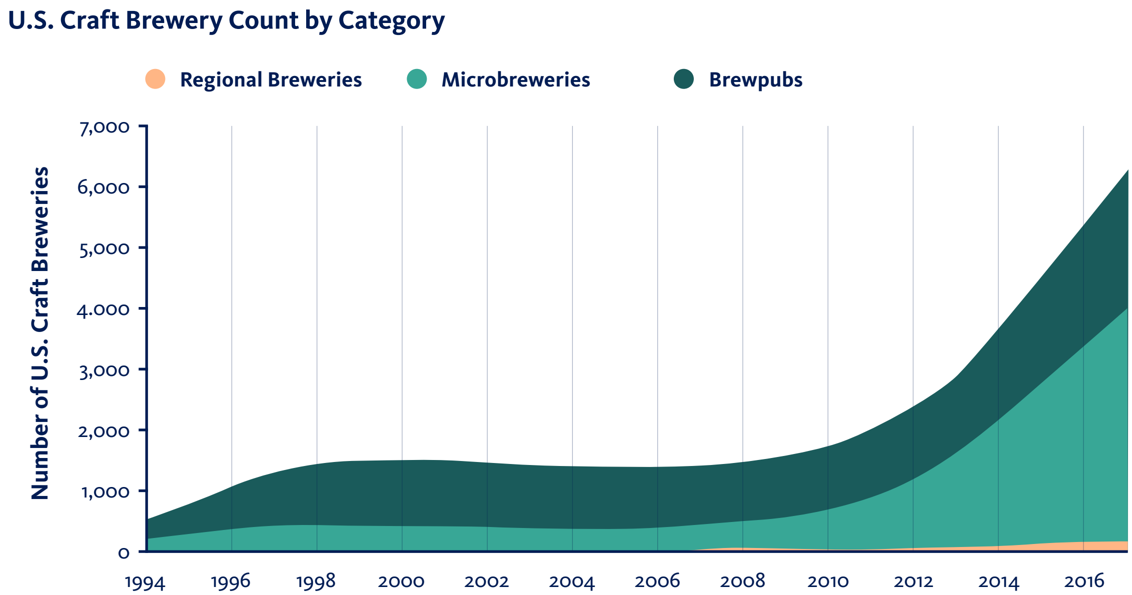


Figure 5: Growth in US Craft Breweries by Category[22]

It takes about five liters of fresh water to make a single liter of beer, on average, meaning a water use ratio of 5:1. Larger brewers and those with more ambitious sustainability targets have an ideal water use ratio of about three to one. That still means discharging water three times the beer production volume.[23 24] Those at the cutting edge have a goal for zero liquid discharge, which includes the reuse of all wastewater onsite for other uses.

The pain point for craft brewers and wineries is that the wastewater they are sending to a centralized municipal treatment plant can exceed load limits, which trigger expensive surcharges, or even steeper fines.[25] Brewery wastewater has four problematic characteristics: Biochemical Oxygen Demand (BOD), pH, Chemical Oxygen Demand (COD) and total suspended solids (TSS). Each of these vary widely across time during the brewing process when high volume discharges can send load spikes downstream to a municipal plant.[26]

The Brewery Process

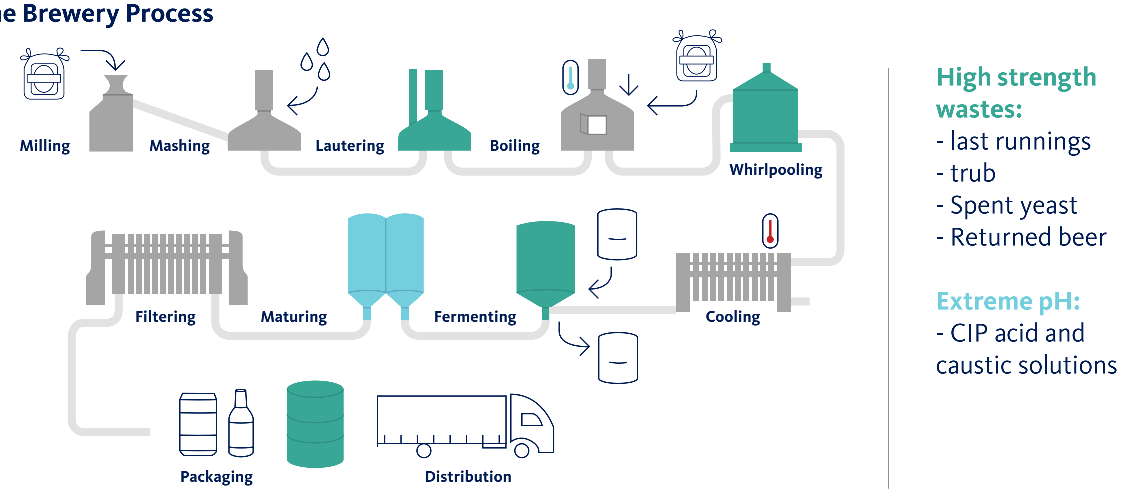


Figure 6: Schematic of the Brewery Process and Sources of Load[27]

Municipal sewer districts place restrictions and surcharges on contributions from these facilities. These swings may violate the plant's environmental permits, adversely affect employee health and safety, or damage the environment.[28] Wastewater "load" is a combination of concentration and volume, so a larger brewery will create higher loads and greater potential problems. The higher the load, the more energy a wastewater plant will need to digest the high BOD and TSS through aeration, a highly energy intensive phase of treatment.

In the traditional centralized business model, surcharges to industrial facilities like breweries fund the incremental costs of treating loads at centralized WWTPs. Then, if discharge falls outside those limits, a plant may incur fines by their state regulatory agency. As such, the pain points for breweries can be both economic and regulatory.

Brewers large and small, especially in California and Texas, are committing to add onsite wastewater treatment for cost reductions, for a reliable clean water supply, and for energy generation and heat recovery, closing the circle a bit tighter.[29] One operator reports that industrial customers make their economic buying decisions on either total cost of ownership, where payback periods are two to three years, or by capital expenditure decisions for where to invest their next incremental spend.

The increasing number of breweries in Europe is likely to contribute to demand for onsite treatment there, as well.

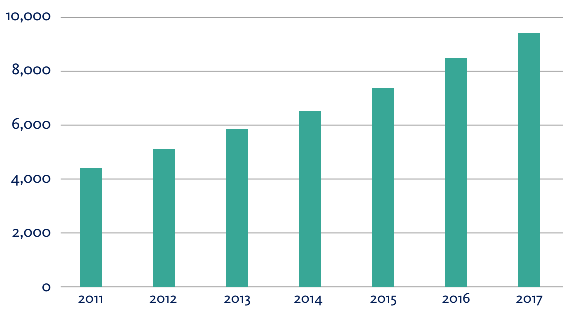


Figure 7: Recent Growth in Active Breweries in Europe, 2011-2017[30]

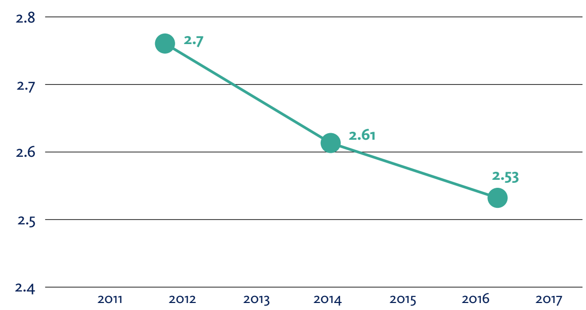


Figure 8: Beverage Industry Water Efficiency (liters water/liters beverage), 2013-2017[31]

Hood River Example

Hood River Brewing in Oregon, U.S., is connected to their municipal sewer system and has previously installed settling tanks to reduce its contributions of TSS to under 500 and BOD under 1000. The brewery produces 500 barrels per day. Without these tanks, the daily fine would amount to $10,000, or over $200 per barrel of beer. Next year, the local sewer utility will be tightening the loading limits even further, which will require the purchase and installation of a membrane bioreactor system.[32]

Baswood Example

Baswood is one technology provider targeting the food and beverage industry, which has provided data and case studies. Using its biological control system, Baswood contends that breweries can reduce BOD by more than 90 percent, use 60 percent less energy compared to alternative wastewater systems, at 50 percent lower operating costs, and have a 30 to 40 percent reduction in sludge.

Brewery BOD load compared to municipal wastewater[33]

Municipal Wastewater	Brewery Wastewater (high-strength waste)
BOD: 250-450 mg/L	BOD: 600-5000 mg/L
TSS: 200-400 mg/L	TSS: 200-1500 mg/L
pH: Neutral	pH: Lower than neutral (typically)

Baswood provided the following chart for a brewery installation presenting reduction in COD over three months of operation in 2019. The chart shows that the influent COD level averaging about 7,058 mg/L that is reduced by treatment to an average of 410 mg/L, or a 94 percent reduction.

Brewery Baswood Pilot –
BioViper Soluable COD Destruction – 1/29/19–3/10/19

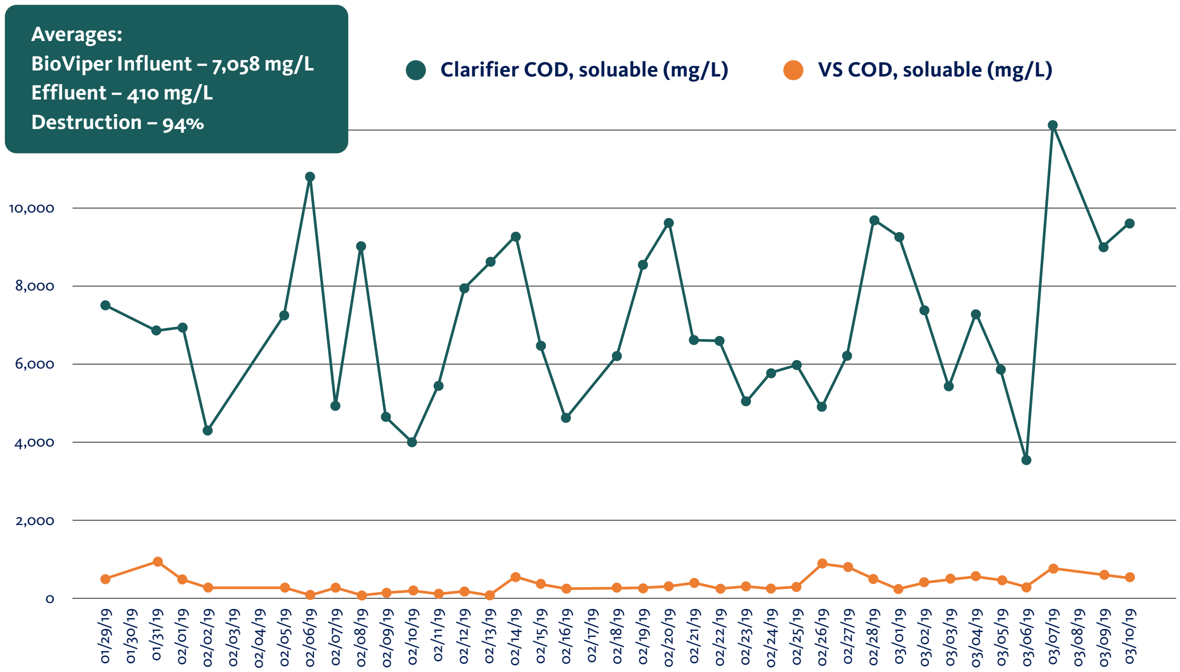


Figure 9: Reduction in COD Levels at a Brewery Pilot Project[34]

Reducing costs and managing brand reputations

Reducing water waste and reusing water are major ways that companies in F&B are lowering their costs, as well as managing their brand reputations. In 2015, Coca-Cola had a water-to-product ratio of 2.2 liters per liter while setting a longer-term goal of 1.2 liters per liter.[35] Some brands, including Carlsberg in Denmark, aim for zero waste processes and 100 percent water recycling (a ratio of zero), also known as a closed loop.[36] Alternatively, Dow supports a standard called Minimal Liquid Discharge, with a water recovery rate of 95 percent that can be achieved at a fraction of the cost of zero liquid discharge.[37]

UK beverage company Diageo plc reduced the volume of its water withdrawals by nearly one million cubic meters in 2014 and estimates the associated cost savings at $3.2 million total, according to a CEO Water Mandate report.[38]

According to Søren Bak, expertise director for water in Food and Beverage for NIRAS Consulting, the only way to achieve these lower water use ratios is to treat process water to drinking water quality for use of technical purposes such as cleaning the plant. Water reuse plants used to be designed to "fit for use" where they would match water quality with intended use type. In that model, if you wanted to distribute a certain water quality, you needed more pipes, which costs €150-300 per running (linear) meter.

Therefore, to save these costs, plants today will look to treat wastewater to drinking water quality. Then they can insert the treated water into existing water lines. Drinking water quality in water reuse from combined wastewater and water treatment can be achieved with biological treatment with membrane bioreactors plus reverse osmosis. In Europe, economic feasibility of treated wastewater is achievable in a range of €2 to €3 per cubic meter.

Labor savings are another source of cost efficiency for distributed industrial wastewater treatment because qualified treatment plant operators can manage multiple plants remotely. Most plants have sensors and are cloud-connected. This enables operators to monitor, manage and troubleshoot these plants from afar via digital devices. It makes operational, economic and regulatory sense to concentrate expertise in the hands of the few qualified operators available today. Software, sensors, and industrial internet of things are enabling technologies that are accelerating the adoption of smart, packaged and distributed treatment plants.

INVESTING IN OPPORTUNITY 1

How are family offices investing in industrial distributed wastewater in advanced markets? Off-balance sheet financing for project developers appears to be the preferred vehicle so far.[39] This allows investors like family offices to avoid technology risk. Since many of the large individual deals of $10 million to $100 million have been done, the smaller end of the market is becoming more active in the $2 million to $10 million per project range. Project financiers are searching out technologies to solve identified problems as tighter regulations come into play.[40] The smaller projects are unable to carry the financial burden of several hundred thousand dollars of capital and transaction costs.[41]

One strategy is to invest in a portfolio of smaller projects with a standardized, streamlined diligence and documentation process of at least $50 million in assets.[42] Some investors assembling a portfolio through varying strategies include Generate Capital, Spring Lane Capital, Vision Ridge Partners, Ultra Capital and Upwell.

To remain competitive, project developers and technology providers are forming their own financing facilities from $20 to $50 million. The underlying project internal rates of return can vary. Equity pools managed by already established developers with a track record of using capital well can provide internal rates of returns of 12 to 14 percent. A first-time project equity pool may require a significantly higher target return of mid- to-high teens with shared upside between the developer and financier. So overall equity returns to the financier could exceed 20 percent.

For C&I projects, debt financing is generally much harder to come by. To the extent it is available, it is still seen as “equipment financing” rather than “water as a service.” In these cases, the cost of capital is tied back to the end customer’s credit quality more than anything else (e.g. technology performance). It is a different risk profile that the financier is bearing. Where available, debt return rates range from high single digits to low double digits. Often debt simply is not available for a first project pool.

Some firms also invest in distributed wastewater as a project developer and financier and comingle a variety of sustainable infrastructure investments that may include energy, food, and materials in addition to water. While these vehicles provide exposure to water, there are not many pure products that direct investment vehicles towards water only.

Some financiers have established partnerships with developers and technology providers. There are hundreds of project developers. Well-known names in this category include Fluence, H2O Innovation, Sustainable Water, Evoqua, Natural Systems Utilities and Organica Water.

Though the current demand is largest in Food and Beverage, other sectors continue to contract for plants at various facilities serving the produced water of oil and gas extraction, petroleum refining, mining, chemicals, remote camps, and power generation. These are important industrial segments as well, though perhaps not growing as quickly as the food and beverage segment.

Despite a strong investment case, experienced operators expressed caution about focusing too intensely on food and beverage for four major reasons. First, there is remaining conservatism in the industry. Second, there is risk in public perception of reusing treated water in food and beverage processes. Third, regulators and authorities that oversee food safety risk need to get on board. Fourth, various projects inside companies will be competing for internal investment. Changing wastewater treatment is likely to affect the processes of the plant, which requires investment and may complicate technology adoption. Staff in a facility that manages wastewater are highly technical and progressive, and are driven by economic returns, which means they may not be an easy target. For these reasons F&B segment, they caution, may not always be the lowest hanging fruit.

SUMMARY FOR OPPORTUNITY 1

Avenues for Investing: Project financing in this sector is suitable for direct equity or debt in large individual projects over $10 million level; corporate equity in project developers; and limited partnership in funds or financing facilities of at least $20 million with multiple projects and streamlined processes.

What needs to be true for a project addressing the pain points to be successful?

- The project will reduce high total costs from wastewater surcharges, trucking costs and/or tipping/offloading fees by the receiving treatment center.
- The project enables compliance with load capacity constraints by the local centralized wastewater treatment facility for BOD, COD, TSS or pH.
- The customer’s payback period is ideally less than 2 years.

Investors can consider the following questions in due diligence

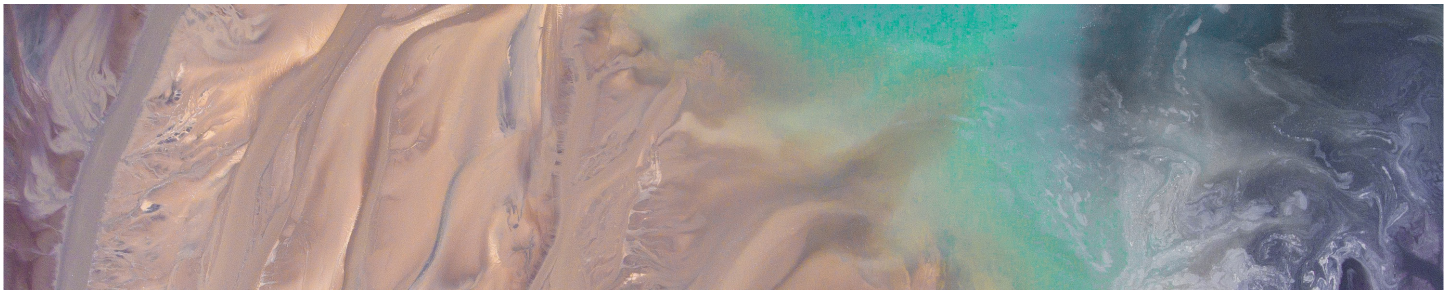
» What are the pain points that the industrial customer is trying to solve?
» Will the industrial customer be connected to the local centralized wastewater utility? If so, are there utility surcharges or fines for exceeding certain contaminant levels? Does the utility require primary or secondary treatment onsite? If not, there may not be compelling pain points for the customer.
» What are the state onsite wastewater and distributed reuse regulations? Are they clearly stated?
» Are there wastewater surcharges or exceedance levels by the wastewater utility or regulator?
» Is the proposed system aligned with the local utility's interests? If it's not, then the project might not be used that much and could become a stranded asset.
What will be the utilization risk of the system not running at full capacity?
Are the selected technologies proven and reliable for the intended purpose?
Are there onsite uses for treated wastewater? If so, what is cost parity with the local municipal water source?
» Are there other revenue streams from resource recovery including energy (electricity, biogas or heat), nutrients, irrigation or groundwater recharge?
» Are there opportunities to enhance local ecological or natural sites? Will the wastewater stream be treated appropriately for that use?
» Do the project developer and technology providers have good track records?
» What is the credit risk of the industrial customers?
» What is the maturity of discussions with the industrial host(s)? Final approval and contract negotiations with larger institutions can be a lengthy and time-consuming process.
» What is the potential for changes to the municipality's existing rate structure in order to recapture lost revenues? This is unlikely unless the industrial customer was a major rate payer.
» Will new regulations of small distributed facilities greatly increase monitoring and reporting costs?

Investors in project development funds can consider all the above plus

» Does the GP have the right network to identify and bundle projects and the right experience to assess the financeability of the projects?
» Do the developer teams have a good track record for the type of projects they plan on doing? Are they capable?
» •Does the math on the project economics pencil out? What is the return of each project? What are the sources and costs of capital? What are the project economics vs. cost of capital, where the difference indicates the project return to the developer?
» Does the firm have strategic partners in the industry?

Investors seeking net positive impact can consider the following questions during due diligence

- Will the project yield reduced carbon emissions, groundwater recharge, or reduced water extraction from ecosystems?
- Will the project enable sustainable, low- or zero-impact economic growth?
- Will the project make a centralized WWTP more sustainable for the region by reducing future capital costs?
- Will the project yield public benefits and therefore stakeholder alignment by offloading public risk, maintenance and financial responsibility to private, onsite partners?
- Is the project facility located in a Water Stressed region, as determined by the World Resources Institute Aqueduct Water Risk Atlas tool?[43] If so, there is likely to be stakeholder support among the NGO and advocacy community.
- Potential negative consequences to consider include the possibility of destabilizing a volumetric revenue base of centralized wastewater utilities if unprepared or misaligned with distributed, onsite systems.



Opportunity 2: Growth Stage Wastewater Treatment and Water Reuse Companies

According to Kala Vairavamoorthy, Executive Director of the International Water Association, the next 20 years will be the Golden Age of wastewater provision – wastewater treatment in emerging economies has been a testbed for the future.[44] Emerging economies will look at the mistakes already made in other areas. They will deploy efficient, smaller, more effective wastewater technologies.

While the political, currency, and execution risks in emerging markets are more substantial than the advanced markets, so too are the potential rewards. China and India continue to invest massive sums to limit the alarming increase in wastewater flows due to rising industrialization. They have gone so far as to compel or require zero liquid discharge for high waste industrial plants. The zero liquid discharge market segment alone is forecast to reach $9 billion by 2025 with a 5.5 percent CAGR.[45]

Forecasted Total Municipal Expediture on Wastewater Treatment Plants (Billions of USD)

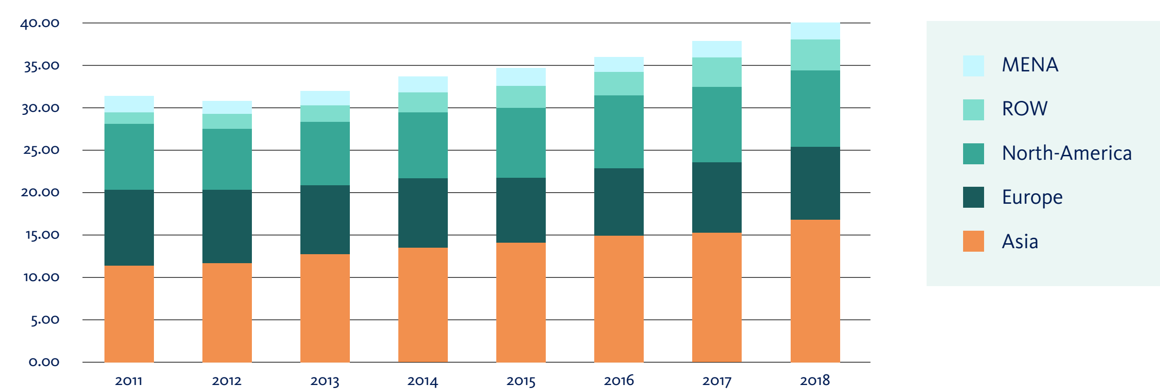


Figure 10: Global Forecasted Spend on Wastewater Treatment Plants[46]

CHINA

According to Udi Tirosh and Ronen Schechter, senior executives at Fluence, the market in China is "blasting open" and "infrastructure is miles behind the growth."[47] They believe China has the potential of adding tens of thousands of small wastewater treatment plants, a full order of magnitude greater than the total market in the U.S.

China is poised to do so with a compelling business model for foreign technology providers by leapfrogging over the obsolete centralized wastewater treatment systems at new greenfield urban developments. Directed and funded through its Horizon 2020 program, China is awarding developers contracts to build multiple cities at once. Distributed wastewater is the choice for these green field projects not because it is the safe, proven path, but because of the capital and operating efficiencies of these newer technologies. The business model for wastewater companies is compelling: large quantities of small plants contracted in a single deal. One technology provider was awarded one deal for 200 new plants worth a total of $45 million. Investors have the opportunity to fund companies with the core elements of an innovative solution, which are likely to be adopted in China at scale.

Mixed economic signals could however portend an infrastructure funding slowdown. One company reports that new project awards already have slowed, while another investor says it is not the case. Also, only large deals with dozens of installations would typically have a strong investment case. For many reasons, foreign companies with strong global brands usually operate through a strong local partner.

China ranks 87 out of 180 on the Transparency.org list that measures and ranks relative positions of corruption in countries. Chinese buyers are moving away from good enough toward buying from strong global brands, according to Alex Crowell, a global water investor at PureTerra.[48] Hence, global brands like Veolia, Suez and Pentair spend large sums to have on-the-ground operations and joint ventures.[49] There is plenty of competition and pricing pressure, though foreign companies remain in higher demand.

China also has championed the Build-Own-Transfer (BOT) model in wastewater with contract awards based on a price per treated cubic meter (metric ton) of 1 RMB. In China, 20 companies won projects on this model.[50]

INDIA

Another emerging market that is ripe for solutions is India, according to some investors and company executives.[51] The primary challenge in India is preventing raw sewage from entering surface and groundwater. India arguably represents the largest opportunity for positive environmental, health and social impacts considered in this analysis.

Seventy percent of the centralized wastewater treatment plants do not operate as envisioned, and many towns and cities in India do not have sewage treatment facilities or have inadequate facilities.[52] Today, India is in an upgrade cycle and there is plenty of funding for infrastructure development. The industry in the country is facing stricter regulations on wastewater discharge, along with requirements for high-polluting industries to shift towards zero liquid discharge.[53]

Beginning in 2017, India shifted to a BOT model where developers get paid a fee. This is the same model that China used 20 years ago; it was the first country to award projects on a price per cubic meter of treated wastewater. India recently implemented the BOT model, and the market remains early.

An attractive business model in India, says one tech company executive, is Wastewater-as-a-Service. It works by installing new distributed plants that produce drinking water at a cost below a benchmark of $3 per cubic meter, then generating revenue through the sale of drinking water in an offtake contract back to industrial customers. The treatment of sewage water for industrial purposes can be done at a cost of about INR 30 to 35 per cubic meter assuming a 10-year guaranteed offtake contract with a creditworthy industrial partner. Their offering would be about half of the price typically charged by drinking water companies in large cities in India. One example is Qstone, which is offering these prices by building equipment in India according to Dutch design. Qstone projects would be financed by offering investors 10-year annuities with a fixed yield of between 16 percent to 18 percent in Indian Rupees.[54] These projects also could be equity financed through special purpose vehicles.[55]

These projects could provide potable drinking water if a reverse osmosis plant was added on the back. Reverse osmosis is so energy intensive, however, that non-potable reuse is more efficient, especially in an urban area, where non-potable water could be redirected toward cooling towers for air conditioning.[56] Wastewater in India is considered a resource. Recovery of energy and nutrients could be enough to fund the operations. One company estimates the annual capital needs for the Indian market, once it takes off, at $100 million per year.[57]

It is helpful for investors considering India to know that this country does not present an actual "leapfrog" strategy. Rather, the Indian market is about retrofitting buildings, villages and whole existing cities. Experienced investors expressed that while the needs are massive in India, there are cultural challenges, including castes and a history of graft, that can present challenges for investors.

India ranks 78 out of 180 countries on the Transparency.org list that measures and ranks relative positions of corruption in countries. According to U.S. Commerce, customs duties or tariffs rates can run from 7 to 48 percent, depending on the type of good, the country of origin and existence of trade agreements that may confer lower tariffs under Most Favored Nation status.[58] Manufacturing technology and hiring staff locally can mitigate some of the cultural challenges and confer businesses an advantage in sales, marketing, and government relations.[59]

Tech company executives are aware that India is trying to attract and build new distributed infrastructure, but most are watching from the sidelines for now.

OTHER GEOGRAPHIES

Additional opportunities exist in Latin America, Asia, and Africa. These market opportunities currently see investment from diversified investors with international water and wastewater funds such as Blackstone Global Water Development Partners, Macquarie Infrastructure Funds and Resonance Industrial Water Infrastructure Fund. EBG Investment Solution AG is one example of a targeted investment vehicle, mostly around project investments. In some regions financing mechanisms around Public-Private-Partnerships or Build-Own-Transfer models are also attractive for investors.

The potential for positive impact in supplying new distributed wastewater technology in developing countries is large enough to be a fit for the appropriate longer-term investor who has the stomach for local market and culture risks. Two examples illustrate the types of recent deals available in developing markets outside China and India.

First, Fluence, a technology provider, has arranged a $50 million credit facility to finance a set of decentralized projects for industrial development in Peru, for serval hotels and resorts in the Caribbean, and a BOT project in Mexico that expects to provide investors with 14 to 16 percent return. Perhaps a similar arrangement is possible for other providers (e.g. hotel/resort development on islands).[60] Second, Water.org also has a new $50 million microfinance fund, which is targeting developing countries and recently closed in March 2019.[61] The fund is targeting a 3.5 percent return while providing clean water and sanitation to over four million people during its 7-year term.

Case Study: Addis Ababa

Addis Ababa is an example of an African megacity with the right mix of development, demographics, and economics to attract the interest of water tech companies. It has a population of about three million people that has no centralized sewage for 97 percent of residents.[62] Instead the city relies on pit latrines, open sewers, and septic systems in each house that all eventually overflow into surface water and infiltrate into groundwater, which is the source of their drinking water. 60 percent of the food that is consumed in the capital is irrigated with untreated wastewater leading to food poisoning and other health issues.[63]

Under Sustainable Development Goal 6, Target 6.2 calls for ending open defecation, recognizing that 4.5 billion people worldwide still lacked a safely managed sanitation service in 2015 where excreta were safely disposed of in situ or treated off site. A surprising 892 million people still practice open defecation.[64] Installing modern centralized wastewater treatment for a city of one million people would cost billions of dollars and likely would take well over 20 years of complete specification, design, funding, budgeting, fundraising, tendering, and eventually installing these systems.

With the right mix of capital and on-the-ground execution, Addis Ababa could start treating immediately with hundreds of small plants all over the city with multiple suppliers.[65] Multiple utilities might operate in the city, working in coordination with city government, to reuse or to replenish their rivers or their groundwater basins. Distributed wastewater would provide additional economic benefit by delaying the need to pre-treat drinking water. Just as some cities have by-passed landlines in favor of cell phones, and other cities have installed solar powered street lights without running electricity cables, there is room to leapfrog centralized sewers to distributed wastewater treatment and water reuse. Dozens of cities in Africa share the same infrastructure challenges and investing opportunities of Addis Ababa.[66]

INVESTING IN OPPORTUNITY 2

To deploy capital towards technology that will leapfrog to distributed wastewater infrastructure in the emerging economies, the best course is investing equity in technology solution providers. In order to mitigate technology risk and business risk, many investors target companies with annual revenue (turnover) of at least $10 million, in line with private equity and growth stage firms. The Opportunity Map in Appendix B lists companies including those in the growth stage. This list samples several active companies, illustrating variations in traction and market share, as well as in-country manufacturing and distribution partnerships.

Beyond residential markets, investors may also consider companies that serve the Food and Beverage market in developing countries. F&B companies are looking at India, Southeast Asia and Africa, since that is where F&B companies are seeing growth and putting in new plants. In one Indian state, new F&B plants will be required to have Zero Liquid Discharge.[67] Investors thus can gain exposure to the positive environmental impacts within the risk profile of a developed market equity investment.

STATE OF THE MERGERS AND ACQUISITIONS (M&A) MARKET

During the 2000s, M&A from multinationals was more active. In the 2010s, multinationals have sold or spun off their water assets including ITT spinning off Xylem in 2011, Siemens doing the same in 2013, and then GE selling its Water Process and Technology unit to Suez in 2018. Today financial investors such as private equity firms are more active in acquiring midsize companies.

Pension funds are also supplying new capital into water and wastewater because they see a premium over a long-term holding period. Pension funds are limited because the size of the investments to date remains relatively small. They also still need vehicles to invest at scale. The Dutch pension fund PGGM announced a €20M fund, Swedish national pension fund AP1 and BAE created a €300M clean water fund in 2016 focused on industrial water projects in Europe and Asia, and Resonance Asset Management of London launched a $300 million industrial water infrastructure fund from six limited partners in U.S., UK and Nordic regions.

SUMMARY FOR OPPORTUNITY 2

Avenues for Investing: Growth stage wastewater investing in developing countries is well suited for corporate equity investment or acquisition of companies with advanced technologies and/or business models with localized markets. Typical criteria that experienced investors consider could include, but are not limited to, traction and market share, extent of manufacturing, and distribution partnerships in-country.

What needs to be true for a project addressing the pain points to be successful?

- Local project developers have interest in selected technology companies.
- Local governments or industrial customers can pay for water or wastewater offtakes for the life of the project.
- Local partners are manufacturing products in-country.

Investors can consider the following questions in due diligence

- » What is the right innovative solution for that local market?
- » Does the company have the potential to scale globally, beyond the local market?
- » What would be the payback period and project economics?

Investors seeking net positive impact can consider the following questions during due diligence

- » Are the projects likely to reduce raw sewage inputs to rivers, thereby improving public health outcomes from direct contact with receiving water bodies?
- » Is there potential to increase drinking water supply through direct potable reuse, or indirect potable reuse with aquifer recharge?
- » Negative impacts or unintended consequences, if any: potential negative health outcomes if reuse is not operated and maintained appropriately, undue burden on low income communities if pricing strategies are not well suited.

Opportunity 3: Early Stage Water Technology Companies

Water treatment technology development is under-financed and in need of incremental capital. The gap in early stage investments in water has widened due to investor perceptions. Observers commonly state challenges include the mispricing of water, few exits (especially above $20 million valuation), perceived risks of selling to municipal utilities with long sales cycles, and challenges scaling many utility customers. The water industry is slow to buy and adopt new technologies and services. Revenue models often rely on regulated utilities as customers, many of which are under municipal control, and venture capitalists will often discount the viability of sales models to utilities.

Over the last 10 years, changes have occurred that mitigate these risks. There are more economic price signals today, as providers implement tiered volumetric pricing, volumetric and BOD/COD loading surcharges, and as rates rise at twice the pace of inflation. Utilities are deploying modern technologies including cloud computing, internet of things, and decentralized solutions to lower operating costs and increase capital efficiency.

CREO's research and interviews with investors indicate there are over 5,000 emerging distributed water and wastewater technology companies globally. Decisions by sophisticated evaluators and judges indicate that there remains latent demand for technology solutions for the distributed wastewater market in both developed and developing countries.

The following snapshot from Cleantech Group during 2000 to 2013 is the comparison of water investments by investor type in the U.S., showing a majority of innovation investment coming from venture capital. Comparable figures for Europe indicate stronger contributions from the public sector.

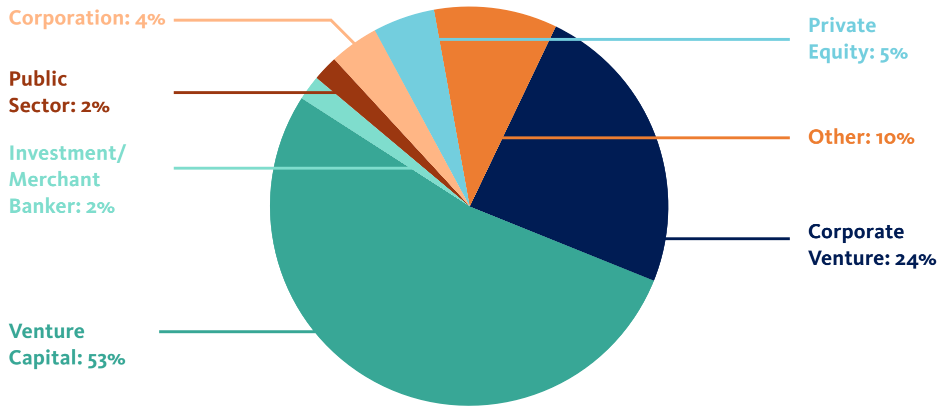


Figure 11: Sources and Level of Investment Dollars for US Innovation in Waste and Wastewater Sectors, 2000-2013[68]

Since 2013, two important trends have emerged to de-risk investing in water technologies.

First, the emergence of water accelerators and incubators in various geographies including North America, Europe and Singapore. Imagine H2O, a globally operating non-profit accelerator focused exclusively on water, received over 260 applications for its 2019 competition alone. Reviewing the 13 companies accepted into the accelerator, many had over $1 million in revenue before entering the competition. The quality of companies emerging from this and other accelerators is maturing rapidly. Four were deemed immediately investible by an experienced investor.

These accelerators are consolidating the work of attracting entrepreneurs, vetting their business models, and supporting their growth with a support system. Beyond the accelerators, there remains a persistent funding gap from Seed to Series B/C. Yet the deals getting done indicate room for additional risk capital, as data from Imagine H2O demonstrates below.

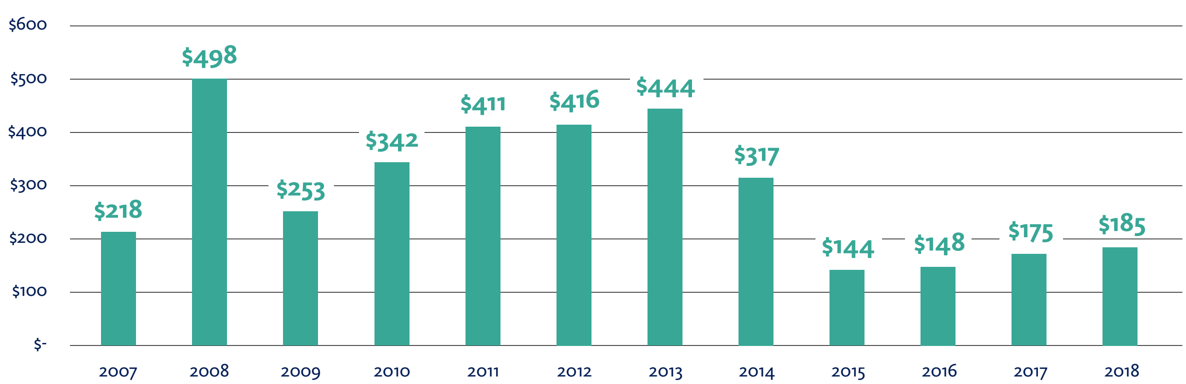


Figure 12: Dollars Investing in Early Stage Water Companies (US$ millions, 2007-2018)[69]

Second, specialized research shops now cover the water sector exclusively including Bluetech Research, Bluefield Research, Global Water Intelligence, Current, Isle, and Lux Research. These water industry experts are a resource to investors seeking to assess and highlight technologies, including those on offer from the accelerators. Specialized accelerators and mature research operations greatly reduce the labor needed to source deals and allow venture investment professionals to focus on targeting and differentiating their pipelines.

Accelerators, incubators and competitions are enabling a higher volume of entrepreneurs to enter the water space, increasing the demand for venture capital.[70] Unfortunately, traditional venture capital is often not the right fit for water. The traditional VC model relies on spreading bets across a portfolio in hopes of seeing a few big winners in fewer than ten years, with the explicit understanding that seven out of 10 won't make it. However, revenue projections for early stage water companies are less likely to resemble the fabled hockey stick of Silicon Valley tech investors and more likely to follow a slow and steady upward trajectory over 10 to 30 years. This means that alignment of timing expectations between companies and long-term investors is more important than in other sectors. It also translates into a wide Valley of Death, as companies need years to pilot their technologies, build evidence of success, earn a credible reputation, and build partnerships with larger firms who have customer trust, reliable sales channels and a strong balance sheet.[71]

INVESTING IN OPPORTUNITY 3

Mission-driven family offices active in venture equity and debt financing are a good fit for emerging water technology companies. Many family offices have opportunities to invest in corporate equity from Seed to Series B/C and venture capital or project debt as early as post-Series A. Several experienced institutional investors have identified early stage water technology as a gap that should and will be filled by investors with an appetite for technology risk and an appropriate time horizon.[72] The success stories so far have come from software companies, such as AquaCue, Emagin, Fracta, Valor, and Visenti. However, there are still too few exits in the industry and acquirers are sparse. Those looking include Xylem, Suez and Danaher, but few deals have closed in recent years. "The market will come back," predicts Eytan Levy, the long-time entrepreneur and investor, "and the good times are ahead of us."

There have been some notable exits already, including Aquabio by Freudenberg in 2013 in the distributed wastewater treatment space. The following lists show recent transactions in 2017 and 2018 according to Bluefield Research.

RECENT SELECT M&A WATER TRANSACTIONS

Date Announced	Acquiror/Investor	Target	Transaction Value (US$M)
10/1/18	Blue Orange SAS	Optimatics Pty, Ltd.	
9/20/18	Ovivo Inc.	Filterboxx	
9/3/18	DuBois Chemicals, Inc.	Triwater Holdings - Treatment	$148.00
8/30/18	XPV Water Partners	Metasphere Ltd	
8/28/18	WCS Group	Suez UK Water Conditioning Service Unit	
8/7/18	Culligan International Company	Water Co. Holding LLC	£4.5
8/6/18	Kai USA, Inc.	Washing Systems, LLC	
7/30/18	Northwest Pipe Company	Ameron Water Transmission Group, LLC	$38.30
7/26/18	PGGM Infrastructure Fund	SUEZ Water Resources Inc.	$3,005.00
7/23/18	Culligan International Company	Aqua Vital	
7/18/18	Custom Molded Products	Aqua Sun Ozone International	
6/28/18	Bain Capital Private Equity, LP	Italmatch Chemicals S.p.A	€700.00
6/20/18	Evoqua Water Technologies LLC	ProAct Services Corporation	$132.00
6/7/18	Milestone Partners	RedZone Robotics, Inc.	
5/30/18	Kurita Water Industries	51% of Fracta, Inc	$37.00
5/3/18	Solenis International	BASF	
4/23/18	SPX Corporation	ELXI Corporation (d/b/a Cues)	$189.00
3/14/18	Culligan International Company	Paragon Water Systems	
2/20/18	Ancala Partners LLP	South Downs Capital Limited	
2/20/18	IFM	49% of FCC Aquaalia	€1,024.00
2/15/18	AquaVenture Holdings Limited	Abengoa Water Investments Ghana B.V.	
2/15/18	Quench USA	Clarus Services & Watermark USA	$1.60
2/14/18	Granite Construction Incorporated	Layne Christenson Company	$495.80
2/12/18	Cott Corporation	Crystal Rock Holdings, Inc.	$34.80
2/1/18	Xylem Inc.	EmNet, LLC	
2/1/18	Evoqua Water Technologies LLC	Pure Water Solutions	
1/11/18	Sulzer Pumps Equipment	JWC	$215.00
1/2/18	Ecolab Inc.	Cascade Water Servies	$40.00
12/26/17	Hubbell Incorporated	Aclara Technologies LLC (affiliate of Sun Capital)	$1,100.00
12/20/17	Levine Investments LP	Global Water Resources	$288.80
12/11/17	Xylem Inc.	Pure Technologies	$395.20
9/18/17	Itron	Silver Spring Networks	$838.80
9/12/17	Enable Midstream Partners	Align Midstream Partners	$300.00
8/29/17	May River Capital	BJM Pumps	
7/18/17	Select Energy Services	Rockwater Energy Solutions	$515.80
7/11/17	XPV Water Partners	Aquatic Informatics	
7/3/17	Alston Capital & PPC Enterprises	Severn Trent Business	$62.00
6/26/17	Thompson Pipe	Assets of Forterra	$23.20
6/6/17	Clayton, Dubilier & Rice	HD Supply Waterworks	$2,400
6/2/17	Eversource Energy	Aquarion Holdings	$1,675.00
6/2/17	Worthington Steel of Michigan	AMTROL	$283.00
5/12/17	City of Misoula	Mountain Water Company	$103.00
5/8/17	Itron	Comverge	$100.00
3/22/17	Golden Gate Capital	Cole-Parmer Instrument	
3/21/17	EQT Partners	Innovyze	$270.00
3/9/17	XPV Water Partners	Environmental Operating	
3/8/17	CDPQ & SUEZ	GE Water	$3,374.80

FUNDING SECURED BY SELECT EARLY STAGE WATER TECH COMPANIES 2018-19[73]

(Includes all market segments including Wastewater Treatment and Water Reuse)

Year	$ Million
Funding 2019	
Bevi	$35.0
Flo Technologies	$28.0
Infinite Cooling	$4.0
Zilper	$0.4
Apana	$11.0
Mitte	$11.0
Ketos	$9.0
2019 Total YTD	$98.4
Funding 2018	
Aquacycl	$2.0
Fracta	$36.0
Precision Hawk	$75.0
Ceres Imaging	$25.0
Atlantis Technologies	$1.0
WellIntel	$0.2
California Safe Soil	$1.4
WatrHub	$1.0
PaverGuide	$0.3
Drinkwell	$0.3
Microlyze	$1.5
Ignitia	$1.1
Intelliflux Controls	$2.8
Mapistry	$2.5
Lotic Labs	$0.2
CustoMem	$2.0
Cloud to Street	$0.4
Water Pigeon	$0.8
2018 Total	$153.30

Experienced investors remark on the difficulty of investing equity successfully into individual water companies – the financial needs of single companies are relatively small, they take time to manage and serve on the board, and they require a sophisticated background to assess the risks. Product demand is driven more by regulation than by technological innovation. Most investors are extremely selective. Investors who do not want the technology nor market risk have focused on companies that have already surpassed $10 million of revenue.[74]

For those considering technology manufacturers, there are significant market risks to analyze. Scaling and exiting early stage water companies is complicated, and leading-edge technology does not guarantee success.[75] Venture capital in pre-revenue companies is tough, as are minority investments. The biggest challenge to seed-stage companies is the adoption cycle, which even major multinational brands have chosen to forgo; GE and Siemens divested their water technology companies into Suez and Xylem, respectively. Yet strategies bring validation, piloting and real capital, making them attractive investing partners.

The analogous opportunity is family-owned businesses, which may be able to leverage family office capital and operating expertise to create new technical knowledge and pilots. Few examples exist to date, so there is room for novel approaches and input.[76] Rather than investing directly or through a fund, family offices may acquire majority positions or whole companies and manage them under a holding company, as is done by SKion. Some investors see an opportunity to run these companies as a horizontal or vertically integrated business. Other experienced investors have suggested keeping these companies decentralized and separate. A target company's unique or different approach usually serves very well, so there is usually little reason to build another Veolia or Xylem conglomerate.

Experienced investors have also mentioned being aware of personal expertise, both technical and financial. Steve Kloos of True North and Current remark that anything with a high degree of technical risk is difficult and should only be adopted by more technical and operationally sophisticated investors. "Many technical entrepreneurs want to form a company so badly, and competitions and accelerators are egging them on, but they fail to understand the realities of past failed attempts, of techno-economics, development risks, and market pragmatism," he says. For example, companies are still being formed around the idea of super low energy seawater desalination, assume getting free waste heat – but that heat is still energy, and when included in the calculations the technology turns out to be an energy hog. Free waste heat is hard to come by, so after years of development and millions spent, they find out that their once high-flying great idea does not make sense beyond small niches. Investing in new hard tech companies requires the ability to see forward at the beginning.

INVESTING IN VENTURE, PRIVATE EQUITY AND GROWTH CAPITAL FUNDS

Direct investments in private equity are a preferred mechanism for many family offices. Nonetheless, venture capital, private equity, and growth capital funds can present investment options. For family offices that prefer not to invest directly into early stage companies, an opportunity exists for a portfolio approach.

Arguments to turn to funds include risk management, global economic outlook, operational capacities, shorter investment paybacks, limited bandwidth to take board positions or available subject matter expertise. Investing through a fund would enable access to techno-economic expertise and existing relationships with strategic partners, accelerators, and research hubs. There are only a few fund managers who hold the required subject matter expertise in the water technology niche.

There are at least two early stage institutional investors raising funds now: Emerald Technology Ventures and PureTerra. Both are raising new funds from $50 to $100 million targeting early stage water tech, including distributed infrastructure. Beyond those currently raising, Montcalm Capital has established a water sector track for early to mid-stage companies focusing on debt-oriented securities including revenue-based investments. XPV Water Partners is the only private equity firm specializing in water that invests in majority stakes at later stages in proven companies. Another PE manager, Halder Beteiligungsberatung GmbH, holds a fund that previously had water distribution technology companies embedded. Worth mentioning is Ambienta Sgr S.p.A. whose funds invest in businesses that foster resource efficiency or pollution control across a broad range of industries. There are also multi-sector, diversified funds that offer exposure to distributed wastewater treatment and reuse technology. These fund strategies may include clean tech, environmental infrastructure and Sustainable Development Goal funds.

There are some reasons to be cautious investing in funds. Since selectivity is the most desirable criteria in early stage water investing, a fund may be under pressure to deploy capital. Talent is essential, the funds mentioned are indicative of highly technical managers who have the skills to actively manage strategy and R&D process. There should be an appropriate alignment of timing and valuations for an exit with a 10 to 15 year time horizon. Diligence on the general partners on returns and sustainability metrics, among others, is necessary. With these caveats, Eytan Levy notes that "investing in early stage water technology (not seed) is a good investment with a risk/reward profile that is better than high tech."[77]

SUMMARY FOR OPPORTUNITY 3

Avenues for Investing: Well suited areas are around direct corporate equity investment in early stage seed companies through Series B/C; indirect investment as limited partners in early stage fund; and acquisition and long-term management.

In addition to early stage funds, there may be room for a non-profit platform, similar to the PRIME Coalition, whose role would be to vet water companies, invest in those that have high return and impact potential but are not yet ready for commercial investment, and de-risk their technologies with approved companies teed up for family office investments.

What needs to be true for early-to-mid stage venture investments to be successful?

- The Valley of Death is vast in the water space. To address this, look for mid-sized companies that are cash-flow and EBITDA positive, and have a reasonable time horizon.
- Invest into teams and not efforts. Is there a management team fit between the company and the leadership culture? Is management decentralized and trust-based?
- Look for real entrepreneurs and team players because there is a great deal of collaboration between companies. This requires openness, and a culture without politics.
- Find people who are intrinsically driven and want to be part of the journey. They should have good technical skills, with solid sales, marketing and real project management.
- Assess whether the cap table is simple and clean in order to invest in a company's potential growth, instead of paying off multiple shareholders

Considerations for due diligence in

- Direct early stage corporate equity investments
  - Does the innovative technology have a significant advantage in technological or economic metrics compared to incumbent or legacy technology (e.g. 30 percent more energy efficient)?
  - What are the pain points the industrial customer trying to solve?
  - Has the company differentiated their offering on product and performance, rather than on marketing?
  - Is intellectual property protection available and strong? This is more relevant for hardware companies and less relevant for software.
  - Does the technology have a positive GHG impact?
  -
- Early stage water impact funds
  - Do managers have abilities to determine techno-economic benefits of specific technologies?
  - Will investments be purely in water companies? Some investment firms are integrated across multiple sectors.
  - Does the fund or the manager have a successful track record of exits in the water industry?
  - Does the fund have relationships with strategics or utilities that can assist portfolio companies in piloting and testing their technology, and may also be investors or acquirers themselves?

Impact considerations for early stage water technology

- Companies
    - Does the company have innovative technologies that improve water, wastewater or energy performance by 30 percent or more?
    - Have the results been independently tested and validated by a neutral third party?
- Funds
    - Does the firm have impact-first criteria? Will the company only invest in companies that can demonstrate improved environmental performance versus incumbents or legacy technologies?
    - Does the firm have criteria to measure environmental performance of its projects, and procedures to report on that performance?
    - Will the fund's financial and environmental performance be reviewed by a third party?
    - Will the firm develop or invest in sectors that are not aligned with your values? For example, will the fund invest in technologies that target extractive industries like oil, gas and mining?

Criteria for Determining a Project's Environmental Impacts

Below are a set of criteria to consider when evaluating whether an investment provide integrated positive environmental impacts. Most of the solutions discussed here generate positive impacts in the direction of reduced water use and improved water quality.

More challenging secondary impacts include those connecting water use or treatment to energy use and greenhouse gas emissions. These are more difficult to measure and to assign relative values. A rule of thumb is to remember that while climate emissions are global, water impacts are local. So the scale and extent of these potential impacts should be considered in the context of local conditions such as whether a population is water stressed, a river is drinkable or fishable, and groundwater basins are sustainable.

» Preventing the discharge of untreated industrial and commercial waste improves environmental and human health. Industrial and commercial wastewaters are rich in organic nutrients (measured as BOD & COD) and reduce health of lakes, rivers and oceans. These nutrients deprive water of available oxygen for animals and lead to eutrophication and algae blooms. Algae blooms can produce toxins with harmful effects on people, fish, shellfish, marine mammals, and birds. Organic and inorganic wastes in coastal ecosystems lead to coral reef die-offs.

» Reduction in energy consumption and greenhouse gas emissions compared to a centralized wastewater treatment system. Onsite reuse is more sustainable for buildings that are far from centralized facilities, as less pumping and energy are required. (CUWA) In emerging economies, building a new centralized system will require many kilometers of underground piping for sewage collection, then running into pumping stations to pump out to a centralized treatment plant outside the city. In the end, there could be treated wastewater that could be reused, but then it is far away from where it is needed. Energy demand is doubled by delivering treated wastewater back to the urban population center, and more investment is needed in infrastructure than in the treatment itself.

» Increasing the drought-resiliency of a water supply portfolio. Areas like Los Angeles are reducing reliance on imported water by investing in water reuse in centralized and decentralized forms.[78] Treating wastewater for urban reuse creates local supplies that also are not subject to disasters like earthquakes, flooding and subsidence that may cut off the distant supply for extended periods. Recycled water, while more expensive than imported water, is likely to reach cost parity by 2035.[79] Distributed solutions may play an important role as a supplement to centralized wastewater treatment plants.

- Offsetting potable water demand through water reuse can reduce a city's total water demand, relieving pressure on existing supply portfolio including reservoirs that may be needed for multi-year supply during extended drought periods, especially in semi-arid / Mediterranean climates (e.g. Western Australia, Southern California, South Africa, Southern Europe, western South America).
- Avoiding sewer overflows by relieving volumetric loads on a centralized system that reaches capacity. This often occurs in the Eastern US cities with combines sewer overflows, or in developing areas of the US or developing countries that are reliant on septic systems.
- Replenishing degraded or polluted aquifers and to defer or delay human consumption of bacterially polluted waters, and the expense needed to build and operate pre-treatment drinking water plants.
- Supporting environmental stewardship since addressing one environmental issue can have ripple effects on other environmental or social issues.
- Reducing extraction from ecosystems by reusing wastewater for potable and non-potable applications including fire flow, irrigation, groundwater recharge, evaporative cooling and others.
- Strengthening social justice by creating integrity of water services. While distributed systems do not equal social justice, providing water and wastewater service can be an environmental justice issue, as is complying with the UN mandate for the human right to water. There remain places in the US that truly have no access to wastewater or drinking water service. No one is pursuing that business because of a lack of ability to pay. In California's Central Valley, Governor Newsom has proposed a water fee that would extend services to the underserved. Advocates trying to make the case for taxation need to better understand how decentralized services are provided.

Potential negative or unintended consequences of distributed wastewater projects

- Operational safety. Even if feasible economically and from an engineering perspective, with cloud-based remote SCADA, can these systems be operated safely, remotely, without endangering human health and the environment?
- Regulatory compliance. Are onsite, non-potable systems designed and regulated to a quality that is protective of public health?
- Secondary effects. Can impact investors accelerate technologies that may enable or extend the capabilities of harmful effects, such as improved economic performance for fracking in the Permian Basin?

Moving Forward

Distributed wastewater infrastructure delivers technical, economic and environmental benefits. The industry is still in the early stages and just beginning to blossom. In addition to the strategies outlined here for consideration, more opportunities are likely to emerge as new industries recognize the benefits of new technology, and as more developing economies leapfrog legacy centralized wastewater systems. Distributed, onsite wastewater treatment and water reuse is poised to lead the way toward more resilient, just and ecological communities of the future.

UN's Report describing SDG Target 6.3 states: "Wastewater is an undervalued source of water, energy, nutrients and other recoverable by-products. Recycling, reusing and recovery of what is normally seen as waste can alleviate water stress and provide many social, economic and environmental benefits."[80]

Case Study: Is the US Municipal Residential Market Ready for Distributed Infrastructure?

Some analysts argue that there is tremendous interest in how to build wastewater for subdivisions differently.[81] Municipal utilities that continue to build out their centralized systems are using technology that is 15 years old or more. They are missing a technological advancement that can cut costs and improve environmental performance. Moreover, many utilities are not able to expand their systems due to land constraints and have instituted regulations and surcharges that require new residential developments to build their own systems, create their own municipal utility districts, or put in pre-treatment systems.

In places with growing populations, like Texas, or with regular drought cycles, like California, distributed systems can make economic sense if cost parity exists with new connections to existing centralized systems. One operator marks cost parity for combined water and wastewater service at about $12 per thousand gallons.

In other cases, policy interventions are needed. One option is regulatory requirements for new developments to conduct primary and secondary treatment onsite in order to then connect with the municipal centralized system.[82] Another option is Tax-Increment Financing (TIF) or Community Facilities District (CFDF) financing, which are used to build-out new subdivisions, public improvements and basic infrastructure. TIF and CFD allow local governments to invest in infrastructure and other improvements and pay for them by capturing the increase in property taxes (and in some states, other types of incremental taxes) generated by the development. TIF could be assigned to accredited investors for specific improvements like wastewater treatment and reuse. One investor says local improvement districts and TIF usually require robust tax base or public backstop (e.g. double-barreled revenue pledge) to receive market acceptance. These debt instruments are generally issued through the municipal marketplace, so it is not clear that there is a fit here for family offices.[83]

The need for residential wastewater infrastructure is growing across a range of user types. Most appealing for investors is to partner with growing residential greenfield developments. Texas is the logical location in the U.S. as the nation's fastest growing state. New satellite developments not connected to a centralized system often create their own municipal utility district (MUD) to provide new drinking water supply and wastewater treatment because of the massive cost of extending pipelines of existing centralized systems, which might cost $20 million for a 10-mile pipeline.[84]

Private financing can help communities avoid costly engineering and unnecessarily expensive systems. Even though a private home or project developer might lead new residential construction, the customer in this case is still considered "municipal" with all the inherent risks of selling to this customer type. Sales cycles can be long; wins may go to legacy technologies seen as safer or more familiar; and decision-making processes are prone to political influence.

Distributed treatment plants for residential sewage are susceptible to national pollutant discharge elimination system (NPDES) permit requirements and pre-treatment permit costs.[85] In Arizona, for example, if a facility is classified as publicly owned treatment plants (POTW), it could be charged up to a maximum fee $50,000 per year for a NPDES permit to operate as a WWTP.[86] In one reported case, an operator decided to send sewage to a centralized treatment facility instead of building its own onsite plant to avoid this fee.[87]

Some experts believe that distributed wastewater for municipal use is not ready to take off because, if it becomes widespread, it could leave incumbents (legacy centralized wastewater systems) with stranded assets, similar to electric utilities under solar PV adoption growth.[88] Others remark that municipal adoption may be limited in certain states by water right restrictions that could prevent onsite treatment and water reuse. Good technology and solid business models do not mean that incumbent players are going to allow or invite new technologies to disrupt their traditional business model.

To the extent possible and allowed by the law, some suggest that there is an opportunity for family offices to make investments with commitments of side-car grants to advocates working with state agencies, regulatory authorities, utilities, elected officials, to enable and facilitate onsite systems. "I don't see the residential opportunity growing unless stakeholders are supportive. There is too much inertia, and we are not there yet," says Sharlene Leurig, task force chair of Austin Forward, an innovative 100-year plan for municipal water sustainability.[89 90] What will it take for municipal wastewater systems to embrace distributed systems? Three to five more years, observable demand exceeding supply, and success stories at new construction resorts and residential communities.[91]

SEPTIC REPLACEMENT: A NEED WITHOUT AN INVESTMENT SOLUTION.

Many small residential communities in suburban and rural areas are experiencing failing septic systems. This is most applicable to small communities, which are often populated with people of low to modest incomes. Informal and low income housing areas in Travis County, Texas and central Alabama are often mentioned as needing financial support and investment for the environmental, health and social benefits that distributed wastewater system upgrades would provide. However, the investment opportunity is not yet clear for this septic replacement strategy.[92]

An Invitation

This publication was informed by the work of several family offices and other investors as they have built experience in the space of wastewater treatment and water reuse investment. CREO invites family offices and wealth owners to tell us and others in the community about the work they are doing so that we can all continue to help and grow the capital going toward sustainable investments in this space.

Appendix A: Annualized Performance of Mutual Funds and ETFs[93]

	Returns (%)		
	1 Y	3 Yr	5 Y
Amundi Funds Aqua Global	20.0		57.1
BNP Paribas Equity World Aqua	8.1	39.0	
DWS Water Sustainability Fund	0.5	23.4	61.9
iShares S&P Global Water *	14.3		77.4
JSS Sustainable Equity	3.0	23.1	67.6
KBC Eco Fund Water	5.6	24.3	79.9
KBI Water EUR A	9.6	23	81.4
Lyxor ETF World Water *	18		87.1
Ökoworld Water for Life	5.6	10.3	42.9
Parvest Aqua	8.2		
Pictet - Water P EUR	5.6	30.3	66.8
Powershares NASDAQ OMX Global Water Fund *	19.7		78.5
RobecoSAM Sustainable Water Fund	7.2	35.2	90.5
Sarasin Sustainable Water Fund	20		101
Swisscanto Equity Fund Global Water	5.5	21.2	65.8
Tareno Waterfund R1 EUR	1.0	18.8	65.7
Vontobel Fund II - Sustainable Water	4.6	28.3	

* Indicates ETF

Note: Diligence on returns and sustainability metrics is necessary

Appendix B: Technology Solutions Landscape

Through the work of Current Innovation, NFP and Isle Consulting a set of companies have been assessed based on technical viability and pain points solved, potential for scaling up, and potential for business viability. In no particular order, the below lists are companies that stood out from that assessment. They are separated in five major categories that fall within this report. While they are to provide a helpful start in reviewing companies in the space, the assessment was not exhaustive for all companies.

	COMPANY NAME	DESCRIPTION	HEADQUARTERS
Decentralized Wastewater Treatment	Baswood Solutions	Advanced biological wastewater treatment and biosolids management in a small footprint	Allen, TX, USA
	BioFiltro	Aerobic biological wastewater treatment	Davis, CA, USA
	BioGill	Nano-particulate MBR	Taren Point, NSW, AUS
	Cambrian Innovation	Ecovolt Reactor and MBR biologically enhanced wastewater treatment	Watertown, MA, USA
	Clearas	Advanced bioengineered system with algae-based biologic remediation	Missoula, MT, USA
	Cloacina	MEMPAC™-I MBR designed to treat highstrength process waste	Arroyo Grande, CA, USA
	Fluence	Containerized membrane aerated biofilm reactor for wastewater treatment	White Plains, NY, USA
	Orenco	Compact and efficient recirculating packed-bed filter using alternative media	Sutherlin, OR, USA
	Organica Water	Biological wastewater treatment using natural elements in a greenhouse setting	Budapest, HUN
Industrial Internet of Things, Remote Management, and Analytics	Ayekka	End-to-end remote data acquisition and visualization	Newark, NJ, USA
	Emagin	Artificial intelligence platform with hybrid adaptive real-time virtual intelligence for process optimization	Kitchener, Ontario, CAN
	Intelliflux	Autopilot optimization software for filtration systems	Irvine, CA, USA
	IOSight	Infrastructure facility management platform for management and optimization	Benei Brak, ISR
	OptiRTC	Predictive control for maximized stormwater reuse	Boston, MA, USA
	XiO Systems	Cloud-based SCADA for all types of distributed infrastructure	San Rafael, CA, USA

	COMPANY NAME	DESCRIPTION	HEADQUARTERS
Physical or Chemical Wastewater Treatment	Aquafortus	Non-thermal crystallizer using patented absorbent and regenerant	Auckland, NZL
	Cerahelix	Ceramic Pico filtration technology for high-recovery wastewater treatment and reuse systems	Orono, ME, USA
	ClearCove	Settling and screening with a 50 micrometer screen	Victory, NY, USA
	Desalitech	Highly efficient reverse osmosis system	Newton, MA, USA
	Nanostone	Ceramic ultrafiltration membranes that are cost comparable to polymerics	Waltham, MA, USA
	Pharem	Enzymatic filtration for wastewater treatment	Södertälje, SWE
	Powertech	Inverted Capacitive Deionization for multi-contaminant removal without chemicals or membranes	Lexington, KY, USA
Resource Recovery or Biosolids Removal	Cambi	Thermal hydrolysis and energy recover	Asker, Akershus, NOR
	Genifuel	Hydrothermal processing for resource recovery and elimination of biosolids	Salt Lake City, UT, USA
	KORE Infrastructure	Modular, closed-loop integrated thermal system	El Segundo, CA, USA
	Lystek	Hydrolysis for biofertilizer production	Cambridge, ON, CAN
	Ostara	Phosphorus recovery in the form of high value fertilizer	Vancouver, BC, CAN
	SuperCritical Fluids International (SCFI Group)	AquaCritox	Newark, DE, USA
	Susteen Technologies	Thermo-catalytic conversion of biomass into high quality biofuels and resources	Den Haag, NLD
	Vironment	Vacuum solids separation	
Full Service Integration, Technology Agnostic, and/or Multiple Solutions	Evoqua	Diversified	Sevenoaks, GBR
	Fluence	Containerized membrane aerated biofilm reactor for wastewater treatment	White Plains, NY, USA
	Natural Systems Utilities	Technology agnostic water resource management company	Hillsborough, NJ, USA
	NewTerra	Technology agnostic with some niche markets and scale operations	Brockville, Ontario, CAN
	Sustainable Water	Novel technology/solutions provider	Glen Allen, Virginia, USA

Appendix C: Definitions and Acronyms

Aerobic Digestion: A biological treatment process using aeration and oxygenation usually applied through bubblers to reduce total organic wastes in a sewage process. This step is particularly effective to reduce sludge, odors, and bacteriological hazards.[94]

Anaerobic Digestion: Anaerobic digestion is the natural process in which microorganisms break down organic materials made of plants or animals. Anaerobic digestion happens in closed spaces where there is no air (or oxygen). These materials can be processed in a digester: Animal manures; food scraps; fats, oils, and greases; industrial organic residuals; and sewage sludge (biosolids). (US EPA)

Biochemical Oxygen Demand (BOD): BOD measures the amount of dissolved oxygen (DO) required by aerobic organisms to break down organic material present in a given water sample at a given temperature and specified time. BOD is a widely used test method, indicating the organic quality of water. BOD is expressed in milligrams of oxygen consumed per liter of the sample for five days (BOD5) of incubation at 20 °C. Sources of BOD are leaves, woody debris, topsoil, animal manure, food-processing plants, wastewater treatment plants, feedlots, failing septic systems, urban stormwater runoff, and effluents from pulp and paper mills. BOD is typically measured in milligrams per liter. (PEDIAA.com)

Chemical Oxygen Demand (COD): COD measures the amount of dissolved oxygen (DO) required by the decomposition of organic matter and the oxidation of inorganic chemicals like ammonia and nitrite. COD measurements are commonly made with the samples of wastewater or natural water, which are contaminated by domestic and industrial wastes. COD is typically measured in milligrams per liter. (PEDIAA.com)

Food Chain Reactor (FCR): A biological process takes place in a series of cascade reactors, with standard pretreatment at the beginning, and phase separation (via disk filters or secondary clarifiers) and final polishing at the end. As water flows through from one reactor zone to the next, different ecologies will grow and adapt to the conditions in each stage. This configuration allows the “food chain effect” to develop, as higher level organisms become predators for the simpler organisms. The result is enhanced removal efficiency and resiliency, while utilizing less energy and producing less sludge.[95]

Membrane Biological Reactor (MBR): A combination of a suspended growth biological treatment method, usually activated sludge, with membrane filtration equipment, typically low-pressure microfiltration (MF) or ultrafiltration (UF) membranes. An MBR system is often comprised of ten or eleven sub-systems and includes fine screening (headworks), the Membrane Zone and, in most cases, some type of post-disinfection process. (AMTA)

Membrane-Aerated Biofilm Reactor (MABR): A new hybrid Membrane-Aerated Biofilm Reactor (MABR) can be a critical component of an energy-neutral wastewater treatment flowsheet. The MABR process offers the benefits of biofilm reactors while efficiently transferring oxygen with low energy input. (AMTA)

Total Suspended Solids (TSS): The weight of solids remaining after a well-mixed sample is filtered through a standard glass filter and the suspended portion is dried to a constant weight at 103-105 degrees C, typically measured in milligrams per liter. (PEDIAA.com)

Wastewater Treatment Plant (WWTP): A municipally owned and managed centralized treatment facility. These plants are permanently installed in the ground (in-situ) and follow the traditional, conventional three-stage disinfection process of (1) primary settling pond for removal of solids; (2) secondary dissolution and digestion of biosolids, organic materials, and nutrients via various methods; and (3) tertiary treatment, or polishing, of effluent, before disposal using microfiltration, synthetic membranes or ozonation.

Water Resource Recovery Facility: Wastewater is packed full of resources — nutrients, micronutrients, metals, grit, biopolymers, biosolids, and more — and much of that can be recovered and sold, offering additional income for WWTPs.

Appendix D: Segments Excluded and Reasoning

Produced water from oil and gas sector. CREO members desire a positive environmental impact and enabling the extraction of ever-more hydrocarbons is not always aligned with desired environmental outcomes. If technologies emerge that allow the reuse of produced water for other, safe uses such as discharge into surface waters or surface applications in agriculture, then this industrial sector should be considered for a new positive impact.[96]

Municipal tax-exempt debt. The combined U.S. municipal water and wastewater industry issues upwards of $50 billion in tax-exempt debt every year. These bonds are issued into a deep and liquid market. Investments in municipal bonds from CREO members do not add value or fill a financing gap.

"Ag-Tech" – Agricultural Irrigation Water Technologies. Ag-tech will be considered under a separate investment thesis.

Municipal Drinking Water Treatment Technology. Wastewater treatment was determined to be a higher growth, higher margin business with more opportunities as compared to drinking water treatment.

Pumping, pipes, chemicals and movement of substances within distributed wastewater. Traditional "pumps and pipes" technologies, while large in annual investment, were deemed insufficiently innovative to warrant the need for risk capital as compared to the rapidly advancing areas of treatment, reuse and control technologies, otherwise known as IIOT. Likewise, chemicals are a large segment of the traditional water industry and did not emerge as an innovative area; rather technologies that replace chemical additions such as membranes comprise more current innovation.

Storm water / drainage water / green infrastructure: Storm water was not considered as a separate distinct technology need for this paper. It is acknowledged that in many cities, particularly in the Eastern United States, that wastewater and stormwater are often treated together by combined municipal wastewater treatment plants. These systems are described as "combined sewer overflows" and are heavily regulated by the U.S. EPA. Solutions to these problems often lie in the area of distributed "green infrastructure" assets that act to limit, reduce, retain or infiltrate pulses of stormwater. Green infrastructure was included in early expert interviews and failed to yield significant investment opportunities.

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