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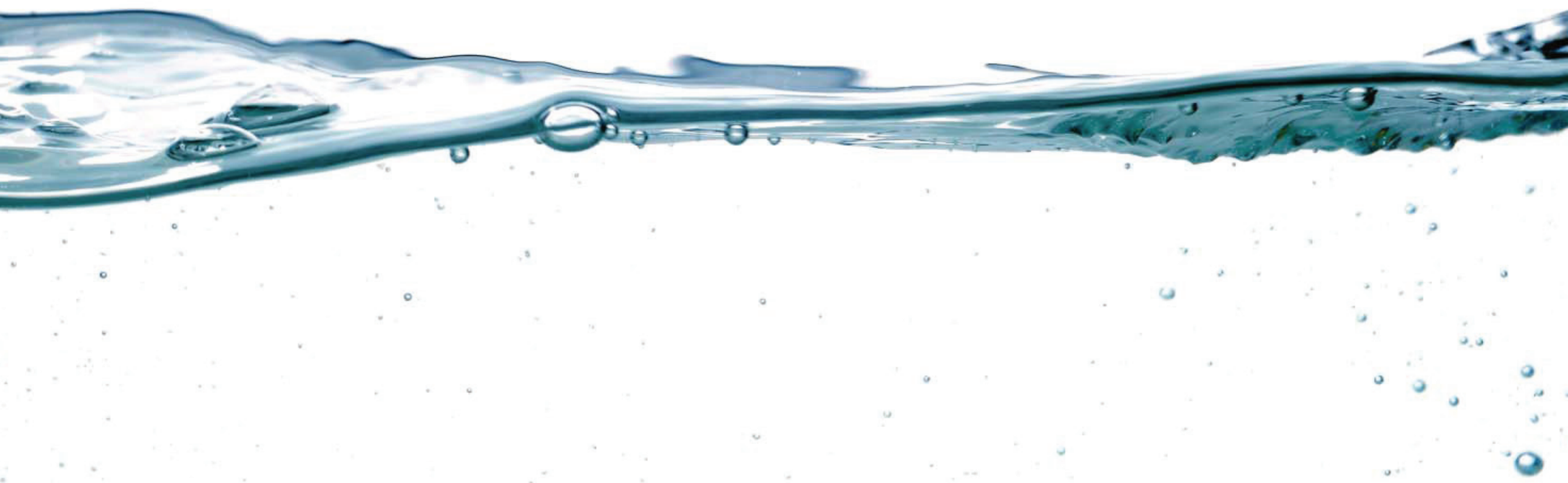
An Assessment of Southwestern Pennsylvania's Water Sector



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Acknowledgements

The United Nations Environment Programme appointed Pittsburgh to serve as North America's Host City for World Environment Day 2010.

In deploying its chosen theme and strategy, *Water Matters!*, the Pittsburgh World Environment Day Partnership commissioned Fourth Economy to develop this 2010 report.

Pittsburgh's H_2Opportunity: An Assessment of Southwestern Pennsylvania's Water Sector was made possible through the support of The Alcoa Foundation and generous funders of the Pittsburgh World Environment Day Partnership including: Bayer Corporation, Bayer USA Foundation, The Benter Foundation, Buhl Foundation, Claude Worthington Benedum Foundation, The Heinz Endowments, Hillman Foundation, LANXESS, and Richard King Mellon Foundation. The Pittsburgh World Environment Day Partnership was facilitated by Sustainable Pittsburgh.

Special thanks to the committee that provided direction for this report. They included:

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UNITED NATIONS WORLD ENVIRONMENT DAY 2010 PITTSBURGH

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Executive Summary

About

The Pittsburgh World Environment Day Partnership commissioned this report to take a snapshot of southwestern Pennsylvania's water-related industries and develop a basic understanding of the opportunities associated with a focus on this sector. This summary highlights our findings and recommendations. A PDF of *Pittsburgh's H_2Opportunity: An Assessment of Southwestern Pennsylvania's Water Sector* can be found at: www.pittsburghwed.com.

Regional Strengths and Challenges

Southwestern Pennsylvania is a water-rich region in a world of increasing water scarcity. A number of leading technology and solution providers are located here, serving traditional and emerging markets. The region has a unique opportunity to combine our traditional industrial strengths with innovations in the efficient use of water, new treatment technologies, devices and sensors for monitoring and protecting water quality with the services and know-how to develop a next generation of products and services that can be applied for the benefit of southwestern Pennsylvania residents and also exported to meet the demands of a thirsty world.

Defining the SWPA Water Cluster

The Sub-Sectors include:

- Supply and Treatment – treatment and remediation companies
- Components – companies making devices and instruments for measurement, control, security
- Services – technical, engineering, testing firms
- Transportation – water freight companies and administration

Our abundance of water provides the resource for many industries. There is a healthy mix of emerging entrepreneurial firms along with established firms with international reach. The region has more than 3,000 firms providing components, products and services that account for more than $5 billion in direct economic activity. In addition, our water supplies sustain more than $3 billion of output in agriculture and food processing. Water is also critical for the generation and cooling of more than $2.4 billion in electricity from the region's thermoelectric plants. Overall, water is used in a variety of ways for the extraction and production of energy as well as transporting materials and cleaning the emissions from this activity. **Without our abundant supply of water, we could not sustain the $13.7 billion energy sector.**

The water-related industry cluster in southwestern Pennsylvania has significant numbers of firms:

- Supply and treatment: 173 firms with nearly $3.5 billion in sales
- Components: 416 firms with more than $1 billion in sales
- Services: 2,456 firms with $509 million in sales
- Transportation: 20 firms with $32 million in sales

The presence of these firms demonstrates the potential for a regional industry cluster, but they do not currently identify or operate as a regional cluster. Work must be done to gauge the interest of these firms in exploring opportunities for collaboration and growth and securing economic benefits for the region from the growing markets related to water.

Growing Market

Based on our analysis the water cluster market is growing at a significant rate as high as 10 percent annually. The pressures of water security, purification and scarcity of water in many regions of the globe are creating new markets for the rapid adoption of new technologies.

Analysis for this report shows that the following market opportunities are available to regional firms over the next five years:

- $16.6 billion market for desalination
- $37 billion market for wastewater resource recovery
- $70.8 billion market for wastewater treatment
- Overall market for water-related products and services will reach $770 billion

Recommendations

The southwestern Pennsylvania region has the ability to develop a regional water cluster initiative designed to support a broad segment of the region's water related companies. This support can be provided in the following ways:

1. Develop a SWPA Water Cluster Consortium based on the Milwaukee Water Council approach
2. Support water innovation pilot projects as described in the following Table

3. Identify the occupational pipeline and workforce needs for the high priority sectors and develop training on more efficient uses of water for energy, industry and agriculture
4. Strategically identify and selectively recruit innovative firms and industries that can benefit from and be good stewards of the region's abundance of high quality water
5. Support innovation and commercialization in water technology
6. Promote green water management infrastructure
7. Initiate partnerships with other regions and identify national and international export opportunities for regional firms

The following Table describes water innovation pilot projects that can demonstrate how a water cluster consortium can work and build momentum for the region.

Sector	Regional Industry Opportunity
Supply and Treatment	The region has 173 firms providing treatment and remediation products and services with significant worldwide market growth (e.g., desalination to double by 2015). Sample firms: Calgon Carbon, Cardinal Resources, Epiphany Solar Water Systems, LANXESS, Siemens Water Technologies. Sample Pilot Project: Environmentally sound energy development initiative – Develop water monitoring and management strategies to permit the environmentally sound development of the Marcellus shale gas resources.
Components	The region has 416 firms that produce devices and instruments for measurement, control and security. Worldwide markets are growing six percent per year and could exceed $100B by 2015. Water security is a potential niche for the region. Sample firms: Curtiss Wright - Flow Control, Eaton, Emerson Process Management Power & Water Solutions, L.B. Foster. Sample Pilot Project: Water security initiative - Install water quality monitoring sensors in the Pittsburgh drinking water distribution system to ensure early detection of the deterioration of the water quality and the timely protection of the drinking water users.
Services	The region has more than 2,456 firms of all sizes in technical and engineering services, and testing services. There has been strong employment growth in water-related services in the region and the U.S. despite the current economic distress. Furthermore, the region has an opportunity in landscape services to provide green infrastructure solutions to some of our water management problems. Sample firms: Michael Baker Corporation, URS Corporation, Veolia/North American Water. Sample Pilot Project: Green infrastructure initiative - Integrate daylighting of subsurface urban streams with the application of green mitigation strategies such as green roofs, rain barrels, and water vaults as a means of managing stormwater.
Transportation	Inland water freight provides energy and carbon efficient transportation that supports regional industry, resulting in savings of more than $144 million per year over alternative transport modes. Sample firms: Ingram Barge, C & C Marine Maintenance, Centofanti Marine Systems, Inc. Sample Priority Project: Navigation infrastructure and monitoring initiative - Build on previous navigation initiatives such as SmartLock, River-Net and Wireless Waterway to improve the operations and safety of the current navigation system and to permit the collection of real-time water quality data from the three rivers of Pittsburgh.

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Introduction

The focus of this work was to assess the following premises:

- The business of water is rapidly becoming a critical issue, even for our region, and it may provide tremendous business and economic opportunity if we are able to properly align our assets.
- The region has sufficient assets to justify emphasis on the water quality/quantity sector as an economic development strategy.
- Innovations for protecting the region's water supply as energy demands and water use increases are essential components of realizing the region's great potential in the energy sector.
- Irrespective of the degree to which the region has sufficient assets to be a "player" in the business of water, ultimately our participation in the future of energy will require solutions to water issues and will not happen solely from the outside-in.

In order to address these premises the consulting team performed research and analysis including:

- Analyze the region's strengths, gaps and opportunities that would be associated with our growth as a leader in sustainable water development.
- Identify the water-related industry supply chain to assess the jobs and industries they support in the region.
- Provide analysis of how the water-related cluster in southwestern Pennsylvania compares to other regions.
- Identify important firms who provide water solutions: technologies, services, R&D, consulting, engineering, etc.
- Assess total employment and sales.
- Examine the ways in which water impacts energy and other economic interests in the region.

The ultimate goal however was to determine if the southwestern Pennsylvania region has the assets and resources of a water-related industry cluster and then to identify the opportunities for that cluster. Thinking of water as an industry cluster is a very new concept and therefore no ready-made way of digesting and reporting economic information exists. Unlike more familiar industry clusters, such as the automobile industry for example, the consulting team was required to consider the creation of a new cluster definition.

Water Markets

Worldwide the scarcity of stable supplies of potable water is a major driving force in the economics of water, energy and the overall economy. In southwestern Pennsylvania, our relative abundance of water is a blessing for our residents and industries but that abundance is also our burden when it causes floods or produces high volumes of polluted runoff. The region averages more than 37 inches of precipitation per year occurring on an average of 153 days.[1] Water is fundamental to our identity, especially the image of the Three Rivers. Rain and rivers are the water we see, but groundwater is estimated to be twice as abundant as the amount of water that flows annually in Pennsylvania's streams.[2]

The global market for water supply and treatment technology and services is projected to grow from $485 billion to $770 billion by 2016. The overall market will grow by more than 5 percent per year but it could be as high as 10 percent because some segments such as desalination will experience significant growth.[3] Markets for water technology and solutions compare favorably to other high profile markets. For example, the market for desalination is larger and will grow faster than the market for energy storage technology and the market for wastewater is larger than the market for transportation and smart grid technologies (see Figures 3 and 5).

Regional Opportunity

A number of leading technology and solution providers are located in southwestern Pennsylvania, serving traditional and emerging markets. The Table on page 3 identifies potential pilot projects in each sector, but alternative projects and priorities may emerge as Carnegie Mellon University is currently defining specific pilot projects to advance innovation in the region's water sectors.

On the business side, the region has more than 3,000 firms providing components, products and services that account for more than $5 billion in direct economic activity. In addition, our water supplies sustain more than $3 billion of output in agriculture and food processing. Water is also critical for the generation and cooling of more than $2.4 billion in electricity from the region's thermoelectric plants. Overall, water is used in a variety of ways for the extraction and production of energy as well as transporting materials and cleaning the emissions from this activity. **Without our abundant supply of water and supporting businesses, we could not sustain the $13.7 billion energy sector.[4]**

A number of cities are marketing to "wet" industries, which are industries that use large amounts of water. Pittsburgh has had and will continue to have success in attracting these "wet" industries, but this approach does not develop the regional economy any more than a traditional industry recruitment approach. Other regions, especially in the southwest, are pursuing water efficiency and reduction strategies

to optimize their limited water supplies, but they are not leveraging the technology and economic development opportunities from their efficiency programs. Only one other region, Milwaukee, has attempted to build a competitive advantage around a comprehensive approach to water.

Many industries within the water cluster are growing even during our current recession and the global demand for water management solutions provides growth opportunities for the foreseeable future. The market for desalination is larger and growing more rapidly than other high profile growth markets, such as energy storage.

Southwestern Pennsylvania has a unique opportunity to combine our traditional industrial strengths with innovations in the efficient use of water, new treatment technologies, devices and sensors for monitoring and protecting water quality with the services and know-how to develop a next generation of products and services that can be applied for the benefit of southwestern Pennsylvania residents and also exported to meet the demands of a thirsty world. The region has a healthy mix of emerging entrepreneurial firms along with established firms with international reach. The jobs that these firms create are mostly considered green jobs although specific reference to water-related industries in the green jobs discussion is only recently emerging. One of the critical elements will be finding partners with the potential and the interest to partner as a cluster. This cannot be determined by a report, but through the networking and organizing activities of a regional cluster effort.

Recommendations

Based on the research and analysis conducted through this project there is an opportunity to develop a water-related industry cluster in the southwestern Pennsylvania region. The following recommendations provide an initial action plan for leveraging our regional assets to develop the opportunity represented by the water cluster. The region has the elements for successful clusters within any of the following four segments: 1) Supply and Treatment, 2) Components, 3) Services and 4) Transportation. An organizing effort is needed in order to realize this opportunity and develop the potential for these clusters. The situation is similar to many other clusters before the formation of the Digital Greenhouse, Life Sciences Greenhouse or Pennsylvania Nanomaterials Commercialization Center. Each of these efforts began with the elements of a cluster and then developed into functioning clusters.

- The region's water-related industrial assets and supply chain are substantial but the **level of interest in collaboration must be verified.** Regional assets and market growth have to be assessed against the potential for collaboration in developing priorities for investment and action.
  - The region does not need a new organization focused on water opportunities. The preferred structure would be a task force, working group or consortium that will assess, organize and advance the regional opportunities related to water and coordinate existing resources aligned with those opportunities.
    - The Milwaukee Water Council, which convenes regional business leaders and public officials in addition to academic researchers, provides a model for how southwestern Pennsylvania should structure our response to these water opportunities.
    - Convene a fact-finding trip to Milwaukee to learn about their integrated, multi-sector approach to water innovation that goes beyond attracting wet industries.
  - Carnegie Mellon University is managing development of the regional Water Innovation Consortium that is identifying collaboration and demonstration projects that represent sustainable innovation opportunities for the region. Through this effort, Carnegie Mellon University researchers are conducting focus groups with researchers, industry and municipal water authorities. The results of their analysis are expected to be available in the summer of 2011. If the region waits until this study is released, and then begins to organize industry groups around these opportunities, valuable time may be lost. Therefore, we recommend an effort to organize the representatives from the business community as well as representatives from the water-related authorities and academia while the study process is completed.
    - Recruit participants of the focus groups to participate in a research, industry or municipal water authority/water utility leadership group to increase outreach to these organizations.
    - Sponsor a series of industry networking events to promote collaboration opportunities.
    - Create enthusiasm and opportunities for regional demonstration projects that apply regional expertise for the benefit of the region, as well as developing exportable products and services. The Table on page 3 identifies potential pilot projects, but alternative projects and priorities may emerge from the workshops conducted by Carnegie Mellon University.
- Identify the occupational pipeline and workforce needs for the high priority sectors and develop training on more efficient uses of water for energy, industry and agriculture.
- Identify industries that require significant amounts of water and that are located in areas where water availability is at risk due to climate and cost factors. Southwestern Pennsylvania's regional economic development organizations

could then strategically identify and selectively recruit innovative firms and industries that require high quality water but which will also serve as good stewards of the region's abundance of high quality water, promoting sustainable development of this precious resource.

- Create a Water Innovation Fund that could be based on one or more of the region's successful models for innovation commercialization that can encourage the development of regional businesses while also providing benefits to residents.
    - Direct funding towards the portfolio of products, services and technologies where the region can establish the niches where it can be most competitive in developing products and services for the market or providing benefit to regional residents.
- Create a task force to promote incentives and policies to encourage green water management infrastructure for both stormwater management and drinking water supply to reduce combined sewer overflows (CSOs) and other negative impacts on our water supply. These incentives can support the growth of local industry while providing benefits to regional residents.
- Initiate a dialogue with the Philadelphia Water Department and its regional partners, like the Sustainable Business Network of Greater Philadelphia, to provide a mechanism for statewide collaboration. There are models of statewide collaboration on common economic development priorities. The Life Science Greenhouse model created a common framework that facilitated regional advancements. In addition, the region should explore partnerships with neighboring regions such as Cleveland. One goal is to identify opportunities for national and international exporting for regional firms.

What is an Industry Cluster

According to the Economic Development Administration, "Industry clusters are geographic concentrations of competing, complementary, or interdependent firms and industries that do business with each other and/or have common needs for talent, technology, and infrastructure. The firms included in the cluster may be both competitive and cooperative. They may compete directly with some members of the cluster, purchase inputs from other cluster members, and rely on the services of other cluster firms in the operation of their business."[5] There are many businesses that work in water-related industries from filter manufacturers to engineering firms and from wastewater treatment facilities to chemical manufacturers. These businesses are the foundation of a potential water cluster in the region. It is not enough for these businesses to be present; they must be willing to work together. One of the goals of regional cluster development is to foster the mechanisms for collaboration, so that related but disconnected organizations become partners in the growth of the cluster and to fill the gaps that may exist within a regional cluster.

Water is unique in that it is both a product in itself but it is also a critical component to the ability to produce other products. Energy is the best example. Water is one of the most critical components to the production of energy and without water a region would have limited alternatives. As we go through this report we have considered water-related industries that are both a product related and supported by water. We have identified the following high level categories of industry in an attempt to begin to frame a definition:

- Health & Living: how water supports the quality of life in the region.
- Production and Consumption: how water is directly used and changed in support of economic activity.
- Transportation: how water supports economic activity by moving materials.

Before discussing the region's opportunities and weaknesses within each category we must first understand the economic and environmental drivers of the water industry. A number of internal and external factors propel the significance of water as an economic opportunity.

- Water is relatively plentiful in the southwestern Pennsylvania region but it can be spoiled.
- The region is focused on eliminating a health risk by better managing stormwater runoff. Estimates of the investment required to resolve the Combined Sewer Overflow (CSO) problem range from $5 billion to $15 billion over the next twenty years, although the figure may be even higher.[6]
- Water scarcity is rapidly becoming a global issue that attracts investment in innovations for purification, recovery and other techniques that will mitigate water scarcity impacts. In twenty years, the current shortage of clean, accessible fresh water will grow from 300 million cubic meters to 2.8 billion cubic meters.[7]
- Many parts of the world are experiencing steep increases in the price of drinking water, where they have enough safe drinking water at all. People are dying due to lack of sufficient supplies of clean drinking water.[8]

International Reach - Regional Strengths

With the facts mentioned above under consideration, the consulting team began to analyze the region's water strengths. We began by first breaking down the categories mentioned previously into some additional subcategories. The table below summarizes our high level findings.

Table 1: Water Cluster Matrix

	Subcategory	Assets and Natural Resources	Supply Chain	Innovation
Health and Living	Drinking Water	Groundwater is estimated to be twice as abundant as the amount of water that flows annually in PA's streams	Global market for water supply, treatment technology and services growing by 5-10% annually	Reverse osmosis, membrane systems, solar systems, monitoring
	Stormwater Management	The region averages more than 37 inches of precipitation each year.	Infrastructure is aging and requires investment	Green mitigation strategies (roofs, rain barrels, water vaults, swales)
	Recreation	Rivers and lakes are regional assets for residents and attract tourists	Improved water quality has generated additional recreational use – Bass Masters Fishing tournament	All innovations that address water quality and quantity
Production and Consumption	Industrial Use	Abundance of fresh water; withdrawals of more than 500 million gallons per day	Expected growth in industrial wastewater treatment from $25B to $45B in 2020	Wastewater can be turned into energy, phosphorous and other products
	Energy Production	All forms of energy production are water dependent	1.6 billion gallons of water is withdrawn for thermoelectric cooling per day	High-efficiency drift elimination technologies for cooling towers, advanced hydroelectrics
	Farming	Water availability (490 billion gallons annually) supports farming and food manufacturing	Agriculture and food processing accounts for nearly $3B in annual output	Overhead and drip irrigation systems, organic methods
Transportation	Regional	The Port of Pittsburgh Commission maintains 200 miles of commercially navigable waterways in southwestern Pennsylvania	Water transportation requires less fuel ($144M annual savings) Waterway infrastructure supports 45,000 jobs	Smart, sensor based systems to improve freight management
	National/ International	The region's rivers link to domestic and international transport routes	Region is home to 500 shippers and receivers	Reducing emissions from watercraft

Note: Citations would reduce the clarity of the matrix, but they are provided in the text where appropriate.

The industries in the water-related cluster do not perfectly align with the various segments of the water cluster matrix. Industries may serve several aspects of the cluster. For this report, the firms and industries are grouped in four subcategories including:

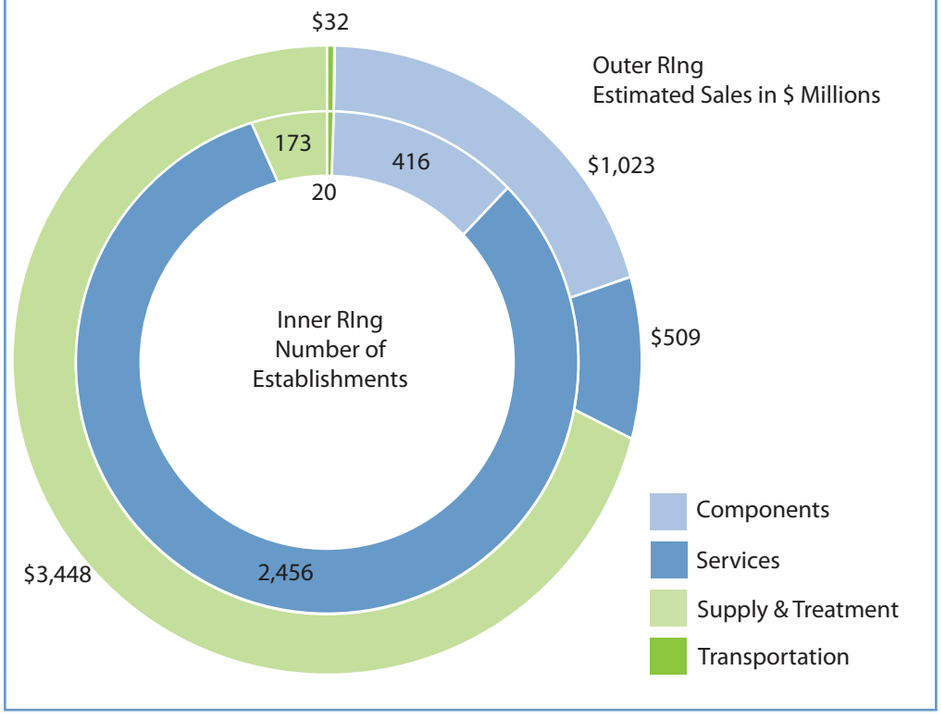
- Components
- Services
- Supply and Treatment
- Transportation

Table 2: Aligning Industries and the Water Cluster Matrix

		Components	Services	Supply & Treatment	Transportation
Health and Living	Drinking Water	x	x	x	
	Stormwater Management	x	x	x	
	Recreation			x	x
Production and Consumption	Industrial Use	x	x	x	x
	Energy Production	x	x	x	x
	Farming	x	x	x	x
Transportation	Regional		x		x
	National/ International		x		x

The following diagram illustrates how these 3,065 firms are divided and estimates their 2009 sales, estimated at more than $5 billion (Figure 1). The supply and treatment sector is the largest in terms of current revenue at nearly $3.5 billion, but growth in this sector will be driven by the growth of population and industry demand in the region. The majority of firms are service providers with $509 million in 2009 sales. This sector supports local residents and businesses, but also serves other national and international markets. We also have a strong base of more than 400 firms that make various components that are critical to water supply and treatment that accounts for more than $1 billion. This sector serves our local market, but also presents significant opportunities for exportable innovation.

Figure 1: Water Cluster Firms and Sales



Source: U.S. Bureau of Labor Statistics, QCEW (establishments); Dunn & Bradstreet (Sales); Industry estimates extrapolated by Fourth Economy. Data for 2009.

The water-related industry cluster is comprised of small and large firms with several recognizable names. The chart below highlights some of these market participants to illustrate the kinds of businesses we have in the region but it is not intended to be a comprehensive directory.

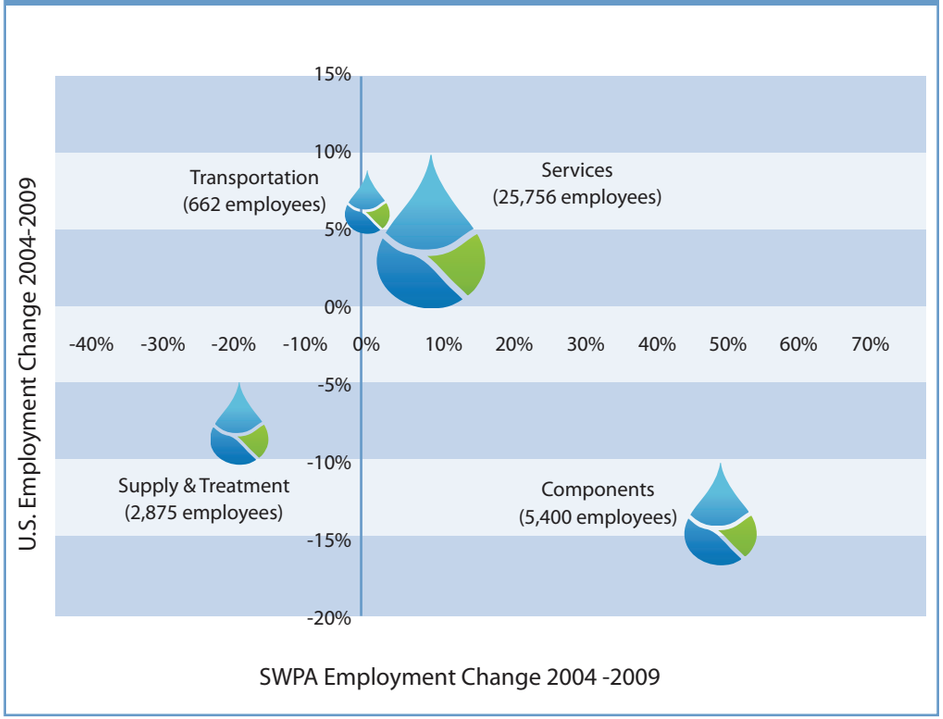
Table 3: Example Firms by Water Sector

Subcategory	Regional Company Name	Location
Components	ChemImage	Pittsburgh, PA
	Curtiss Wright - Flow Control *	Glenshaw, PA
	Eaton *	Pittsburgh, PA
	Emerson Process Management Power & Water Solutions	Pittsburgh, PA
	Penn Separator Corp.	Brookville, PA
	L.B. Foster *	Pittsburgh, PA
	Red Valve	Carnegie, PA
Drinking Water Supply & Treatment	AllProbe Environmental Inc.	Pittsburgh, PA
	Aquatech	Canonsburg, PA
	Calgon Carbon *	Pittsburgh, PA
	Cardinal Resources	Pittsburgh, PA
	Epiphany Solar Water Systems	New Castle, PA
	LANXESS *	Pittsburgh, PA
	Siemens Water Technologies (FKA U.S. Filter) *	Warrendale, PA
Water Management Services	Bradburne, Briller, and Johnson	Pittsburgh, PA
	Chapman & Lewis Environmental Service Inc	Slippery Rock, PA
	URS Corporation *	Pittsburgh, PA
	Veolia / North American Water *	Pittsburgh, PA
Transportation	**Ingram Barge ***	Pittsburgh, PA
	Port of Pittsburgh	Pittsburgh, PA

*Note: * Indicates larger domestic or foreign firms in the Pittsburgh area. Source: Pittsburgh Business Times 2010 Book of Lists and Pittsburgh Regional Alliance. This is not a complete inventory.*

The following diagram illustrates the region's performance as compared to similar sectors in the overall U.S. economy (Figure 2). The graph shows the employment change in southwestern Pennsylvania on the horizontal axis and the change in national employment on the vertical axis. The size of the droplet indicates the number of employees in the region in 2009. The water-related services sector, which contains the greatest number of regional jobs, demonstrates growth in both the southwestern Pennsylvania region as well as the overall U.S. This suggests that current conditions in this sector are favorable for growth in the region and the United States, and we need only look at how we can sustain that growth.

Figure 2: Employment Change in Water Sectors



Note: Droplet size = number of employees in 2009. Source: U.S. Bureau of Labor Statistics, QCEW.

The water-related components sector demonstrates strong regional growth (over 45 percent) while the sector has declined nationally. This is the second largest sector of the water cluster in the region. The loss of jobs in the U.S. may reflect the recessionary conditions, but it may also be related to component markets that are not related to water because most indications are that the water markets will be growing for at least the next five to ten years. The growth in southwestern Pennsylvania suggests that we are in a relatively healthy position to capture that future growth.

The water-related supply and treatment category has declined at both the regional and national level. It is unclear what is causing this retraction but it should be noted and discussed in future sector analysis. In this region, the decline might be attributed to the lack of population growth, as well as slowing industrial production. The decline in industrial production may also explain the national drop as well.

In order to better understand the opportunity for the region, we explore each sector in depth in the following sections.

Health and Living

Water is critical for health and living. The average person needs to drink two to three liters of water every day. In the United States, we use 100 gallons of water per day per person for household use alone. Treating and managing water to promote healthy living represents one dimension of the economic opportunity from water.

Table 4: Health and Living Matrix

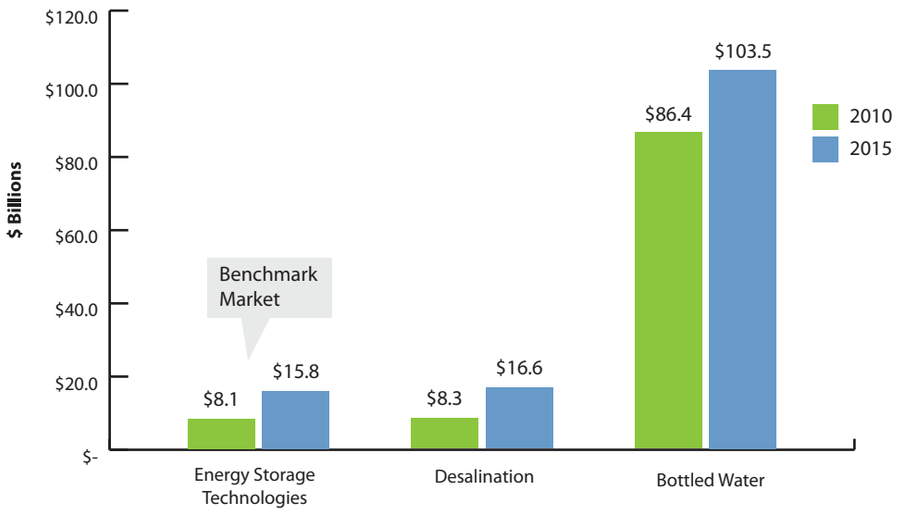
	Subcategory	Assets and Natural Resources	Supply Chain	Innovation
Health and Living	Drinking Water	Groundwater is estimated to be twice as abundant as the amount of water that flows annually in PA's streams	Global market for water supply, treatment technology and services growing by 5-10% annually	Reverse osmosis, membrane systems, solar systems, monitoring
	Stormwater Management	The region averages more than 37 inches of precipitation each year	Infrastructure is aging and requires investment	Green mitigation strategies (roofs, rain barrels, water vaults, swales)
	Recreation	Rivers and lakes are regional asset for residents and attract tourists	Improved water quality has generated additional recreational use – Bass Masters Fishing tournament	All innovations that address water quality and quantity

The Market

We need water to live and currently the world is living beyond its means. Globally, our supply of accessible and reliable fresh water falls short of what we need for people, agriculture and industry by 300 billion cubic meters. The shortage is projected to grow to 2,800 billion cubic meters by 2030 unless we figure out better ways to manage this finite resource.[9]

We don't typically think of water as an industry, in part because it is so fundamental to our lives and it impacts people and businesses in so many ways that it is difficult to grasp. It helps to break it down, so we begin with some different perspectives on the market for water and how that compares to some other high profile sectors. Reports on market sectors can cost anywhere from $500 to $5,000 per report so we cannot provide comprehensive data on every sector. Therefore, we provide only a sampling of available market data for comparison purposes. The current and projected market for water desalination is comparable to the market for energy storage technologies.

Figure 3: Benchmarking International Water Supply Markets



Sources: Lux Research (Energy Storage, Transportation and Smart Grid); King and Ling (Bottled Water); Pike Research (Desalination). Estimates were adjusted to comparable 2015 values by Fourth Economy.

The market for bottled water beats them all. We need to begin to appreciate that water is a critical growth market for the world and potentially for southwestern Pennsylvania. The global market for bottled water was $61 billion in 2006 and it is projected to exceed $86 billion in 2011.[10] This demand is driven by different consumer needs. In places like the United States, it is a combination of convenience and a preference for a healthier alternative to sodas and other convenience beverages. In other parts of the world, however, bottled water is the only safe alternative for drinking. The region has only seven establishments producing beverages and bottled water.[11] Despite the growing market demand, we have not developed a bottled water sector in the region. Consolidation in beverages and food manufacturing demonstrate that global conglomerates with established marketing and distribution channels are dominating these markets, not the presence of local resources.

Citizens of southwestern Pennsylvania spend about $1.3 billion each year to treat their drinking water. The American Society of Civil Engineers (ASCE) rated Pennsylvania's drinking water infrastructure with a D+ for 2010. ASCE estimates that the state will have to spend $39 billion over the next 20 years to improve drinking water infrastructure alone. The region's municipal drinking water system is complex because it is includes a number of small systems. The Pittsburgh Water and Sewer Authority alone maintains more than 930 miles of water lines, more than 1,200 miles of sewer lines, and more than 25,000 valves.

Table 5: Water-Related Investment Drivers

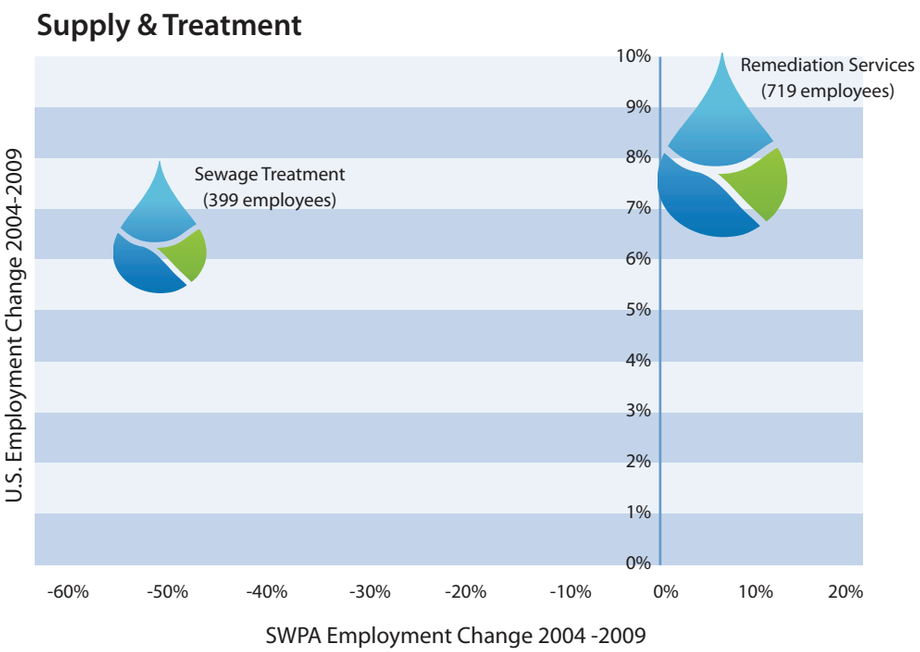
Investment Need	Amount	Timeframe	Source
Pennsylvania Drinking Water Infrastructure	$39B	20 years	ASCE
Regional Stormwater Infrastructure	$5-$15B	10 to 20 years	ASCE; PWSA; 3RWW; IOP
Philadelphia Stormwater Management	$1.6B	20 years	Philadelphia Water Department

The region maintains an estimated 4,000 miles of sewer lines. The ASCE rated the state's stormwater infrastructure as a D-. In southwestern Pennsylvania the estimates range from $5 billion to $15 billion to improve our stormwater and Combined Sewer Overflow (CSO) infrastructure. The cost may be even higher because it is not clear that these estimates include the dollars needed for the people who have no treatment, failing on lot systems or small package systems. Using the most conservative estimate, if the region invests $5 billion to upgrade its water and sewer infrastructure, this spending will impact more than 60 percent of the 500+ industries in southwestern Pennsylvania. An estimated 5,300 construction jobs (or 500 jobs per year for 10 years) will be sustained by this investment with an additional 9,400 jobs in other industries.[12]

Regional SWOT

There are 173 firms in the water supply and treatment cluster that represent nearly $3.5 billion in sales (Figure 1). As a cluster, the water supply and treatment sector has experienced declining employment in the region and the nation from 2004 to 2009 (Figure 2). In the current economic climate, some of this decline may simply be due to the overall contraction in the economy and the lack of public funding, which is the primary revenue for these systems. In any case, it indicates that these industries may be cautious about their plans for future expansion given their recent history. If southwestern Pennsylvania were to match the expected employment levels in the nation, we would need an additional 175 jobs in water supply and treatment. This does not predict that this sector will grow, but it suggests that the region should not experience additional job losses in this sector.

Figure 4: Select Industries in the Water Supply and Treatment Sector



Note: Droplet size = number of employees in 2009. Source: U.S. Bureau of Labor Statistics, QCEW.

Within the cluster, two industries show some positive signs for growth. Sewage treatment has declined in the region, but growth in the U.S. could help to reverse that trend. The decline may be the result of decreased industrial activity in the recession, as well as the lack of population growth in our region. Remediation services on the other hand, grew by 4 percent in the region and 8 percent in the U.S. This market is driven by a combination of public funding, industrial activity and the need to manage various wastewater streams for the protection of public health. We have not had adequate public funding for treatment and remediation, but if the region is to continue to grow in a sustainable manner, we will need to figure out a combination of prevention and treatment and how to pay for it.

The region has an abundance of water. We withdraw nearly 2.6 billion gallons per day of surface water for use by the public and by industry. Compared to many other places in the country and the world, we have an abundance of high quality, fresh water. The primary threat to that water supply, however, is that demands are constantly rising and we are putting more and more stress on our aging water treatment infrastructure.

> *…trend analyses of nitrate; sodium, chloride, and total hardness suggest that ground water quality in Pennsylvania is undergoing some change. Increases in TDS, chloride, calcium, potassium, total hardness and sodium at many monitoring points may be the result of increased nonpoint source pollution such as road salting and sprawling paved developments and suburbs. It is most likely that human activities are affecting the ground water quality on a regional scale.*[13]

At the present time, we are still using less water than our current treatment capacity, but it is not clear how long we can maintain that capacity as our infrastructure deteriorates. Across the region we have been repairing hundreds, if not thousands of water and sewer leaks each year.

Annual precipitation in the region has ranged from as little as 27 inches to more than 49 inches over the past thirty years. Pittsburgh is wetter than Seattle, but we rank 101st out of 195 cities for annual precipitation.[14] This precipitation is enough when combined with our natural topography and the built environment to cause an average of 16 billion gallons of combined sewer overflows (CSO) annually in the system served by Alcosan alone, which limit recreational use of the rivers. River advisories have affected a significant portion of the season from May 15 to September 15:

> *Eleven alerts lasting an average of five days each were issued last summer, which had a moderate amount of rainfall. By contrast, six alerts lasting an average of 21 days each occurred during the very wet summer of 2004 and 11 alerts lasting an average of three days each occurred during the dry summer of 1999.*[15]

This means that people could have been exposed to health risks resulting from contact with river water on more than 4 out of every 10 summer days in 2009 and every day in the 2004 season. In the future, our aging infrastructure may be overwhelmed by the challenges posed by CSOs, industrial discharges and nonpoint pollution from land runoff, precipitation, atmospheric deposition, drainage or seepage.

However, there are more immediate economic threats related to the quality of water in the region. The region has invested $4 billion to revitalize the riverfronts. The clean up and investment along the rivers has helped to bring in events like the Bassmaster Classic which had an estimated economic impact of $45 million. Kayak rentals are now serving more than 15,000 people each year. Our rivers help to sustain tourism in the region which attracts more than 10 million people each year that provide a $3 billion boost to the economy.[16] Any reversal of our water restoration efforts can significantly impact these opportunities.

Innovation

Southwestern Pennsylvania has been and continues to be a leader in water treatment. The region has three of the 33 firms with EPA Drinking Water Verified Technologies that represent two of the seven verified technologies (Table 6).[17] These represent some established technologies for use in drinking water systems. We found no other region that could claim to have as many firms on the EPA's list. Each of these firms represents an established market presence that can be helpful in building a cluster. Both the firms themselves and the professionals working within them can provide critical market expertise for guiding new innovations to market and providing the mentoring to help startup firms reach maturity. A successful cluster has a mix of market leaders and market innovators.

In addition to firms that have EPA Drinking Water Verified Technologies (Table 6), the region hosts several other firms that are developing and introducing water-related innovations. Membrane filtration systems and UV treatments represent two critical areas of innovation and the region is a leader in both areas. Calgon Carbon has developed products and services using activated carbon, ultraviolet light disinfection and oxidation representing alternative technology solutions and market applications. Carbon nanotubes are also being explored in desalination and other applications where the region can bring to bear considerable resources in the form of Bayer Material Science and a number of other firms partnered with the Pennsylvania Nanomaterials Commercialization Center. Table 7 illustrates a few examples of the treatment innovations in regional firms, but it is by no means a complete inventory. Carnegie Mellon University is currently conducting an analysis of water-related innovation in the region that should produce a more comprehensive listing.

Table 6: EPA Verified Drinking Water Technologies

Verified Technology	Pittsburgh Company & Technology
Alternative filtration and media	None
Membrane filtration systems	The F.B. Leopold Co. Inc. • Ultrabar Ultrafiltration System Siemens Corporation • Memcor® L10V, L20V and S10V Ultrafiltration Modules US Filter (acquired by Siemens) • 3M10C Microfiltration Membrane System
Point-of-use devices	None
Technologies for reduction of arsenic and inorganic chemicals	None
Technologies for reduction of disinfection by-products	None
Ultraviolet (UV), ozone, and alternative technologies	Calgon Carbon Corp. • Sentinel Ultraviolet Reactor
Whole building and mobile treatment systems	None

Source: Environmental Protection Agency. Drinking Water Verified Technologies.

Table 7: Examples of Water Treatment Innovation in Southwestern Pennsylvania Firms

Company	Innovation
Cardinal Resources	A self-contained, solar-powered water purification system that is a high-tech solution designed to function in any environment and without any existing infrastructure.
Aquatech	A global leader in water purification technology for industrial and infrastructure markets with a focus on desalination, water reuse, and zero liquid discharge.
Calgon Carbon	Manufactures activated carbon and innovative treatment systems (ultraviolet light disinfection and oxidation). Calgon Carbon has pioneered cutting-edge purification systems for drinking water, wastewater, and other industrial applications.
Epiphany Solar Water Systems	Epiphany Solar Water system purifies both fresh and salt water, which has tremendous implications in a world where the scarcity of water affects one out of three people in the world, according to the World Health Organization.
LANXESS	LANXESS water treatment solutions include ion exchange and special absorber resins. LANXESS is also entering the field of membrane technology.
Siemens Water Technologies (FKA U.S. Filter)	Offers everything from emergency water supply and conventional water treatment processes to wastewater reuse systems, membrane bioreactors, UV disinfection systems and reverse osmosis (RO) cleaning contracts.

Source: Fourth Economy. This is for illustration only; it is not a complete list.

Production and Consumption

Water is a key support for several of the region's economic sectors. Without easy and affordable access to water these industries would not be able to maintain their locations and employment in the region. The table below illustrates some of the ways that water supports these regional industries.

Table 8: Economic Drivers Matrix

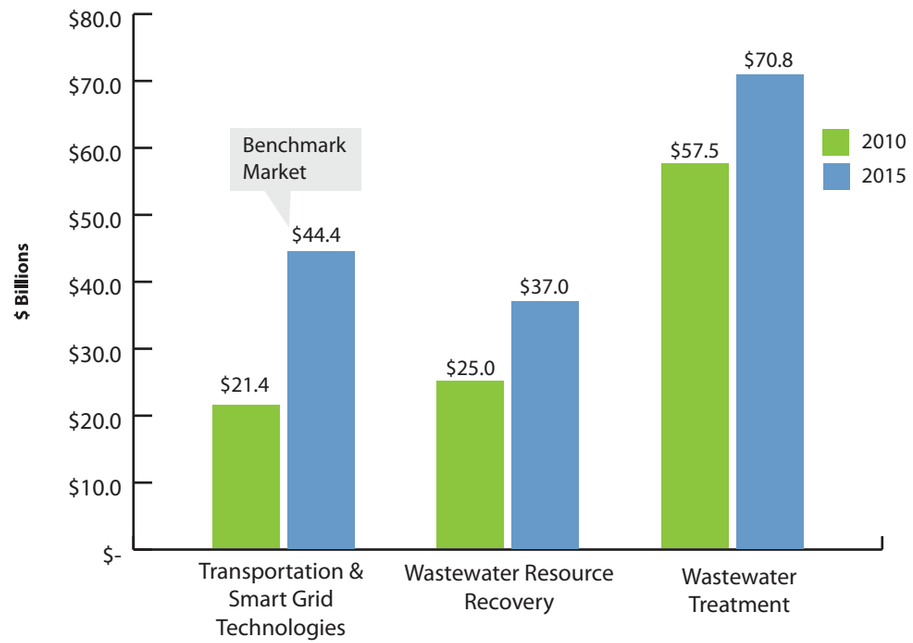
	Subcategory	Assets and Natural Resources	Supply Chain	Innovation
Production and Consumption	Industrial Use	Abundance of fresh water; withdrawals of more than 500 million gallons per day	Expected growth in industrial wastewater treatment from $25B to $45B in 2020	Wastewater can be turned into energy, phosphorous and other products
	Energy Production	All forms of energy production are water dependent	1.6 billion gallons of water is withdrawn for thermoelectric cooling per day	High-efficiency drift elimination technologies for cooling towers, advanced hydroelectrics
	Farming	Water availability (490 billion gallons annually) supports farming and food manufacturing	Agriculture and food processing accounts for nearly $3B in annual output	Overhead and drip irrigation systems, organic methods

Many users are looking at ways to use less water, rather than relying on treating large quantities of wastewater. Increasing water efficiency requires a combination of behavioral changes and new technologies. In many cases the new technologies reduce the need for those behavior changes, such as sensor-automated faucets while in other cases the new technologies require a change in people's behavior. Very little data exists on the emerging market opportunities in all of the applications of water efficiency (Table 9), and the region does not have a strong competitive position in many of them. For these reasons, the next section profiles the emerging opportunities from recovery and re-use of industrial wastewater.

Table 9: Applications of Water Efficiency Technologies

	Residential	Commercial	Industrial	Agricultural
High efficiency toilets, urinals, and washing machines	Yes	Yes		
Efficient showerhead retrofits	Yes	Yes		
Rinse water reuse systems	Limited	Yes	Yes	
Solar hot water	Yes	Yes	Yes	
Waterless, air cooled chillers		Yes	Yes	
Closed-loop cooling systems		Limited	Yes	
High-efficiency drift elimination technologies for cooling towers			Yes	
Overhead irrigation with center-pivot or lateral sprinklers				Yes
Drip irrigation				Yes

Figure 5: Benchmarking International Wastewater Markets



Sources: Lux Research (Transportation and Smart Grid, Wastewater Resource Recovery); OECD Environmental Compendium 2003 (Wastewater Treatment). Estimates were adjusted to comparable 2015 values by Fourth Economy.

The Market

Transportation and smart grid technologies have attracted significant attention for their growth potential. Comparable to that market is the emerging market for resource recovery from wastewater and the residual solids known as sludge, which Lux Research has estimated at $25 billion in 2010, growing to $37 billion in 2015 and $45 billion by 2020 (growth of 8-10 percent per year). A major focus of the technology is for the production of biogas and alternative fuels from sludge. This market is separate from wastewater treatment. In the fifteen largest markets, the treatment of wastewater amounts to $57.5 billion. With moderate growth in expenditures in the rest of the world, this market could approach $71 billion by 2015 (growth of 5 percent per year).

Regional SWOT

Water is used in extracting energy from fossil sources such as coal, oil and gas, as well as producing energy from renewable sources such biofuels and solar. In southwestern Pennsylvania most of the water use is for energy generation, not extraction. We use 1.6 billion gallons of water per day for thermoelectric cooling and less than 7 million gallons for extraction of fossil fuels, although this estimate pre-dates the development of the Marcellus shale reserves.

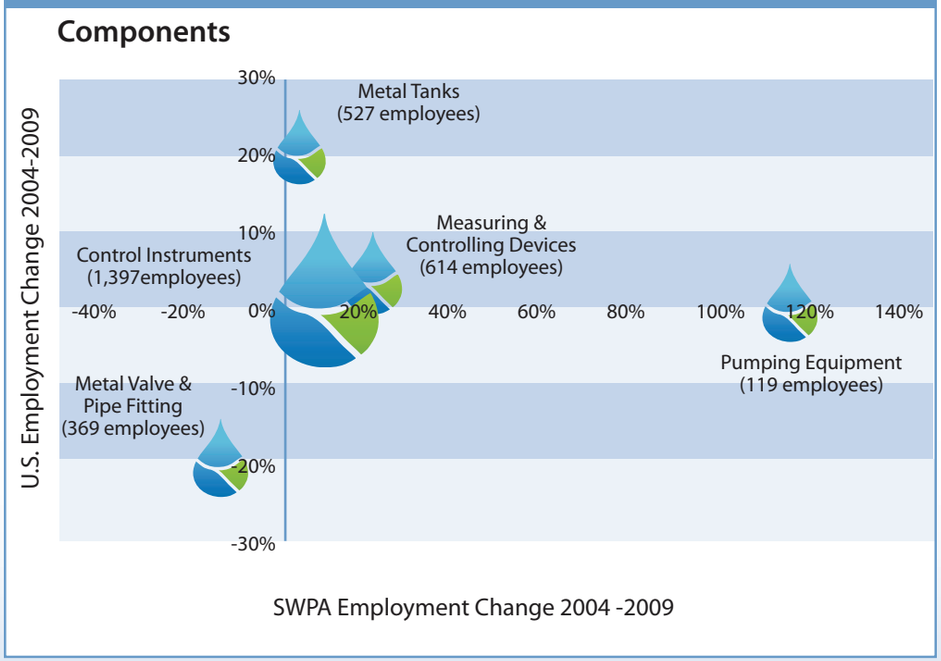
Water is a key element in the generation of power from the region's coal-fired thermoelectric plants and nuclear plants. The thermoelectric power plant burns coal that converts the heat to mechanical energy with steam turbines that operate electricity generators. Water is also used to cool and condense the exhaust to scrub

emissions. Nuclear plants are similar to coal thermoelectric plants in how they use water. Nuclear plants use the energy from the atomic fission process to power steam turbines that generate electricity. Nuclear plants also use water for cooling.

The region's availability of water is also crucial for supporting agriculture and food processing, which accounts for nearly $3 billion in economic output. An estimated 490 billion gallons of water each year or 1.3 billion gallons per day is withdrawn for agricultural use. This is nearly as much as we use for thermoelectric cooling, although the water supplies for agriculture are not withdrawn from and returned to public water supplies in the same way as other industries.[18]

The region has 416 firms that manufacture more than $1 billion of components for increasing the efficiency and effectiveness of the treatment, supply and distribution of water (Figure 1). This segment of the cluster includes firms that make valves, pipes and pumps as well as firms that make control and testing devices and instruments. The overall components sector has enjoyed strong job growth in the region even while it has declined in the U.S. (Figure 2). Given the global need for water treatment and rehabilitation technologies, this sector should be positioned for strong growth when the national and international economies revive. Within the cluster, instruments and devices represent the industries with expanding employment in both the region and the nation (Figure 6).

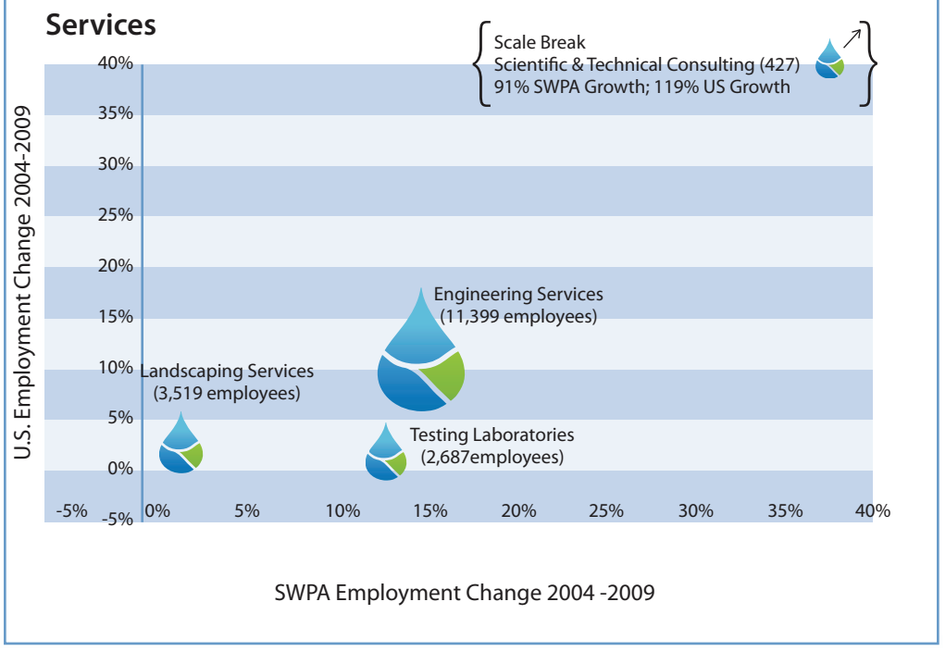
Figure 6: Select Industries in the Components Sector



Note: Droplet size = number of employees in 2009. Source: U.S. Bureau of Labor Statistics, QCEW.

Several industries in the Water Services sector show strong growth in southwestern Pennsylvania and the U.S. Scientific and technical consulting services, while relatively small in the region have experienced tremendous rates of growth, which could not be represented on the same graph as the other industries without distorting the scale (Figure 7). Engineering services and testing laboratories are larger industries that have also been growing. Landscaping Services is also included because landscape design and maintenance is a critical component of green stormwater management where greenscaping strategies such as rain gardens and bio-swales can greatly reduce the cost of managing water.

Figure 7: Select Industries in the Water Services Sector



Note: Droplet size = number of employees in 2009. Source: U.S. Bureau of Labor Statistics, QCEW.

Innovation

Pittsburgh has a large base of firms that design and build a variety of devices for filtering, pumping, cleaning and generally managing water. The region also has an established base of engineering consulting services that initially served local industries but which are now exporting their services around the world. Carnegie Mellon University, the University of Pittsburgh and a number of companies in the region are also leaders in environmental sensors, imaging and nanomaterials technologies which are all have emerging applications in water purification, desalination and the emerging area of water security.

Table 10: Examples of Regional Component and Service Firms

Company	Water-Related Products & Services	Location
Components		
Curtiss Wright - Flow Control	Specializes in flow control equipment for military, commercial nuclear power generation, and oil and gas processing. Provides highly engineered valves, pumps, motors, generators, instrumentation and control electronics and related products that manage the flow of liquids, vapor and pressurization in critical applications.	Glenshaw, PA
Eaton	Provides pumps, motors, transmissions, valves, cylinders, controls, hose and fittings for wastewater treatment.	Pittsburgh, PA
Emerson Process Management Power & Water Solutions	Delivers superior control and operational solutions with a broad range of instrumentation, valves, and actuators.	Pittsburgh, PA
Penn Separator Corp.	A certified ASME Code Sec. VIII Div. 1 welding shop manufacturing boiler auxiliaries and pressure vessels since 1956. Penn is a leading supplier of Boiler Blowdown Separators and Flash Separators.	Brookville, PA
Red Valve	Provides control valve products and engineering services for wastewater treatment plants: sludge handling, grit removal, raw sewage, lime, carbon slurry.	Carnegie, PA
ChemImage	Advanced chemical imaging technology for air and water testing and security.	Pittsburgh, PA
Services		
Bradburne, Briller, and Johnson	A national environmental consulting firm committed to helping clients create value and avoid loss in their management of environmental obligations and opportunities.	Pittsburgh, PA
Chapman & Lewis Environmental Service Inc	A geological and environmental consulting firm specializing in hydrology and ground and surface water.	Slippery Rock, PA
URS Corporation	A fully integrated engineering, construction and technical services organization with the capabilities to support every stage of the project life cycle—from inception through start-up and operation to decommissioning and closure.	Pittsburgh, PA
Veolia / North American Water	Provider of comprehensive water and wastewater partnership services to municipal entities, businesses and manufacturers.	Pittsburgh, PA

Note: This is not a complete inventory.

Water security presents a unique opportunity for the region to leverage its strengths to provide solutions for the water management needs of the next century. Water security is driven by the need to protect our water supply from terrorist attack, but it also reflects the need to maintain a safe drinking water supply in the face of more

mundane threats from leaky water pipes that might allow normal toxins to leach into the water supply after it has been treated at the water plant. Recent estimates are that even with all of our precautions, waterborne diseases cost more than $500 million annually in the U.S., none of which is due to terrorism.[19] All of the testing and purification is done at the treatment plant but much can happen when the water travels through a thousand miles of pipe to the household.

Much of the focus in water security is on centralized protection and monitoring of the water supply. The EPA has organized protocols and products into three categories for this centralized protection:

- Physical security that includes walls, gates, and manhole locks,
- Electronic or cyber security that includes computer firewalls and remote monitoring systems, and
- Monitoring tools that identify potential threats in process streams or finished water.

Southwestern Pennsylvania can certainly be a leader in these centralized systems, but can also take the lead in distributed systems that provide point of use security. Much like distributed generation is changing the way we produce and consume energy, distributed water systems can manage water purification and security at the point of use. A simple model of these distributed systems is already in place as people use Brita™ filters for their home drinking water, rain gardens and bioswales to filter and manage on-site stormwater, and other systems that divert gray water from storm gutters, bathing, clothes washing and bathroom sinks to be used to water plants or flush toilets. A next generation of these systems will clean water at the appropriate level for the appropriate use and have sensors that can alert the user when drinking water is not up to standard.

Transportation

In addition to the water we drink, the water we use to produce energy and the water that sustains agricultural and industrial production, we rely on our natural supply of water for transportation. Water transportation is critical to the coal mining and thermoelectric plants as well as many of the region's manufacturing industries.

	Subcategory	Assets and Natural Resources	Supply Chain	Innovation
Transportation	Regional	The Port of Pittsburgh Commission maintains 200 miles of commercially navigable waterways in southwestern Pennsylvania	Water transportation requires less fuel ($144 M annual savings) Waterway infrastructure supports 45,000 jobs	Smart, sensor based systems to improve freight management
	National/ International	The region's rivers link to domestic and international transport routes	Region is home to 500 shippers and receivers	Reducing emissions from watercraft

The Market

The U.S. market for freight transportation has suffered in response to decreased consumer demand and production in the U.S. and worldwide. However revenues in water transportation in the U.S. fell by only 8.4 percent in 2009 compared to 25.2 percent for rail freight in the U.S.[20]

Regional SWOT

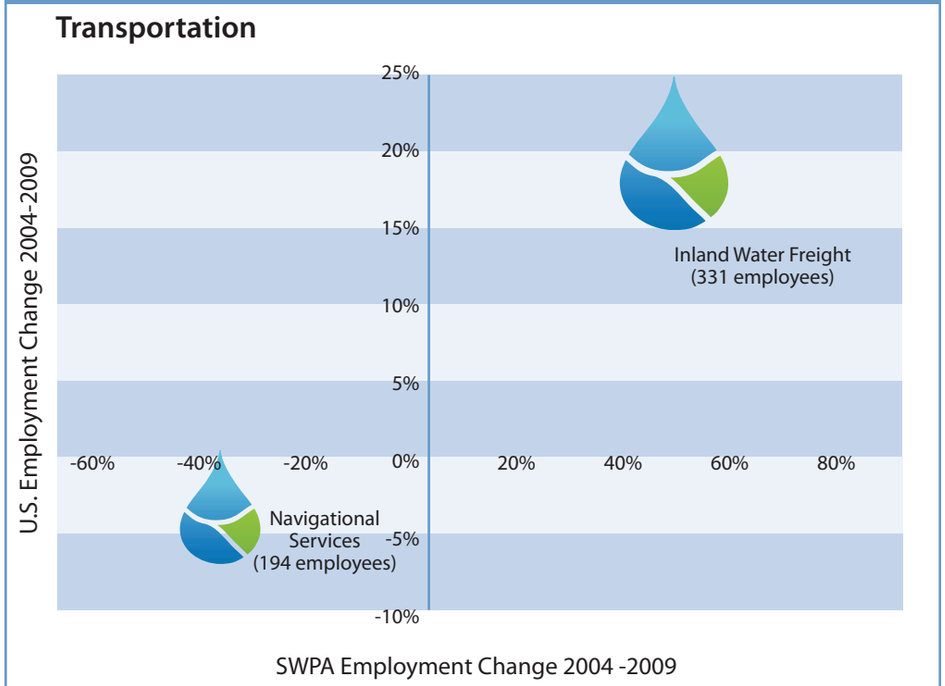
The water transportation industry in southwestern Pennsylvania has a greater impact than numbers would suggest. According to the Bureau of Labor Statistics, there are 20 establishments in the water transportation sector while the Port of Pittsburgh Commission cites 500 shippers active in the port system.[21] This discrepancy may be due to a large number of self-employed shipping proprietors, or that shipping firms are using the Port of Pittsburgh but are not based in Pittsburgh.

The Port of Pittsburgh is the third busiest inland port and the 19th busiest port in the U.S. The Port of Pittsburgh handled in excess of 41 million tons of freight in 2008, nearly 10 percent higher than in 2007[22]. The majority of the product shipped through the port is coal but other materials including sand and gravel, iron and steel, petroleum products and other components are shipped through the region. The Port of Pittsburgh supports the region's energy and steel industry by providing affordable transportation access for their raw materials. According to the Port's Executive Director, Jim McCarville, river transportation provides annual savings of $144 million versus alternative modes of transportation.[23]

Table 11: The U.S. Army Corps of Engineers Port Rankings (top 25) for 2007		
RANK	**PORT**	**TOTAL TONS (millions)**
1	South Louisiana, LA, port of	229.0
2	Houston, TX	216.1
3	New York, NY and NJ	157.2
4	Long Beach, CA	85.9
5	Beaumont, TX	81.4
6	Corpus Christi, TX	81.1
7	Huntington - Tristate, WV, OH, and KY	76.5
8	New Orleans, LA	76.0
9	Los Angeles, CA	65.5
10	Mobile, AL	64.5
11	Lake Charles, LA	64.2
12	Plaquemines, LA, port of	58.8
13	Texas City, TX	56.8
14	Baton Rouge, LA	54.6
15	Tampa, FL	46.9
16	Duluth-Superior, MN and WI	46.5
17	Baltimore, MD	41.3
18	Norfolk Harbor, VA	39.7
19	***Pittsburgh, PA***	***38.1***
20	Paulsboro, NJ	38.0
21	Valdez, AK	37.8
22	Savannah, GA	36.5
23	Pascagoula, MS	35.2
24	Philadelphia, PA	35.1
25	St. Louis, MO and IL	32.1

The primary weakness for the region is that we are land-locked, so our Port is limited in its market reach. Another critical weakness, but one which can be solved, is that our navigation infrastructure is crumbling. The U.S. Army Corps of Engineers has determined that all 17 locks in western Pennsylvania do not meet acceptable standards.

Figure 8: Select Industries in the Water Transportation Sector

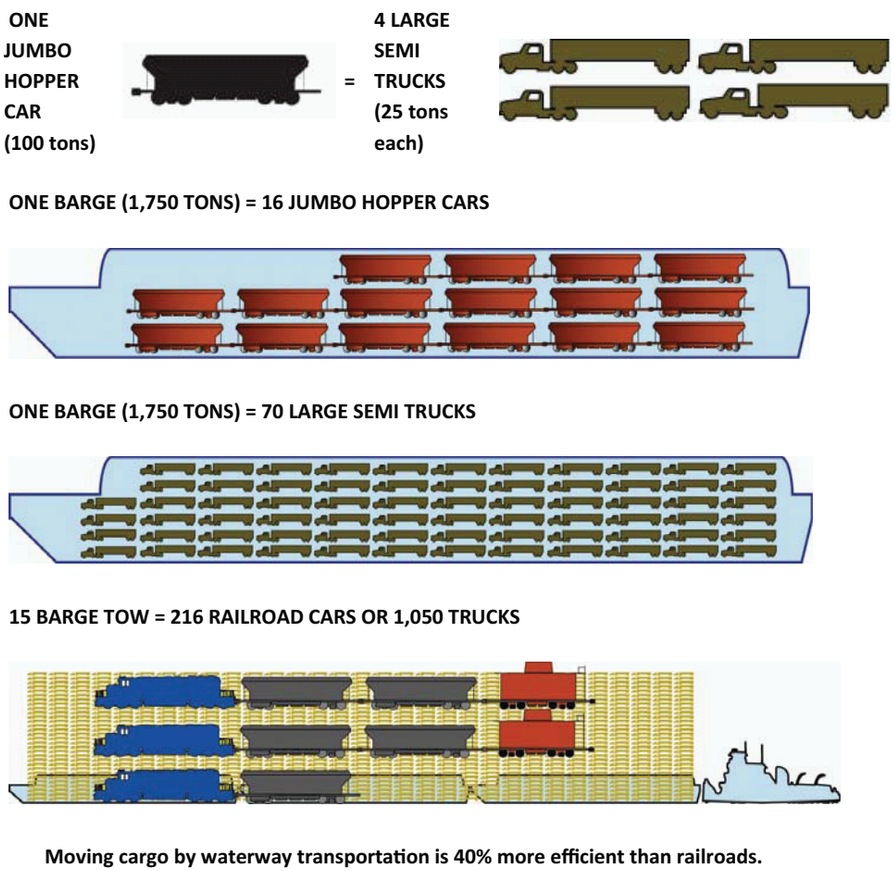


Note: Droplet size = number of employees in 2009. Source: U.S. Bureau of Labor Statistics, QCEW.

Innovation

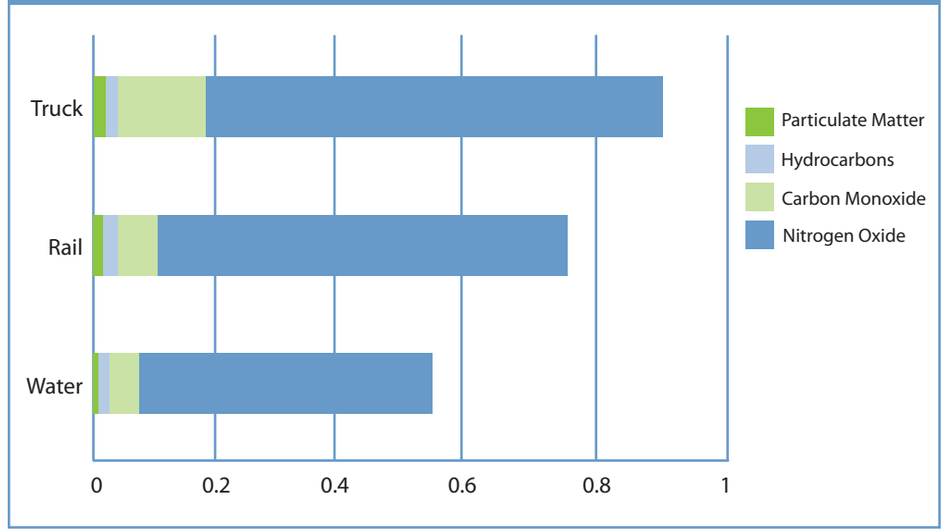
Moving cargo by water is a more efficient and environmentally friendly mode of transportation. One barge carries the equivalent of 16 large rail cars or 70 large tractor-trailers (Figure 9). The emissions from water transportation are 60 percent of the emissions from truck and 70 percent of the emissions from rail (Figure 10).

Figure 9: Cargo Capacity Comparison



Source: Port of Pittsburgh Commission.

Figure 10: Emissions by Mode of Transportation



Source: National Waterways Foundation.

In 2003, the Port of Pittsburgh Commission partnered with Carnegie Mellon University, Campbell Transportation and the Army Corps of Engineers to develop a communication-based innovative technology. The goal of the joint-venture was to better assist ships and barges in navigating the locks of southwestern Pennsylvania's waterways. The SmartLock System improves inland waterway transportation by reducing accidents and improving efficiency at locks. Along with SmartLock, the Port of Pittsburgh has also teamed up with Carnegie Mellon University on River-Net (an information distribution system for the Port of Pittsburgh waterways) and Wireless Waterway (wireless internet service and communication network along the entire Inland Waterway transportation system).

Regional Water Strategies

Two regions have launched efforts to capitalize on the growth of water – Erie, PA and Milwaukee, WI.

Erie

Erie's effort, Tap into Erie, is focused on industry attraction – attracting "wet" industries with cheap, plentiful water. Erie is offering a five year 40 percent discount on water for new investment in the region. Erie is seeking to capitalize on 36 million gallons of daily excess water capacity and its proximity to the abundant waters of Lake Erie.

The Erie Regional Chamber and Growth Partnership is promoting the cost and availability of water available in Erie versus other regions. With the 40 percent discount, water in Erie ranges anywhere from $0.15 to $1.70 less for every 100 cubic feet of water (CCF). Erie also highlights the stability of its water supply as represented by excess capacity.

Table 12: Tap into Erie Water Comparison

	Wastewater Issues	Water Cost per CCF (+20,000 CCF)
Erie, PA	68 MGD capacity recently updated 30-40 MGD excess capacity EPA approval $65 million 10-year improvement plan to be complete by 2020	$0.97 w/ 40% Discount Base $1.62
Cleveland, OH	Treatment update in progress	$2.27
Detroit, MI	Massive updates are in progress after the managing authority devised the "Decades Plans" - costing $8.9 billion	$1.24
Pittsburgh, PA	Multiple EPA violations ranging from errors in reporting to high levels of contaminants. In 2005, the city borrowed $50 million to repair the system	$1.49
Portland, OR	Treatment update in progress	$1.86
Fairfax, VA	Numerous projects in progress to expand and update infrastructure	$1.27- $1.38

Table 12 Continued

	Wastewater Issues	Water Cost per CCF (+20,000 CCF)
Green Bay, WI	25 MGD excess treatment capacity	$1.67
Minneapolis, MN	Constantly maintained and updated to meet and exceed needs	$2.67
Eugene, OR	Treatment update in progress. No EPA violations. Rated #1 in the country by Organic Style Magazine	$1.12

Source: Tap into Erie, Erie Regional Chamber and Growth Partnership.

Even though the Tap into Erie brochure claims multiple violations for Pittsburgh's water system, neither Pittsburgh nor Erie had any violations in 2009 according to the EPA Water Quality Reports. Using data on water quality monitoring from the EPA, it appears that while Pittsburgh has a significant issue with metals in the water, Erie has a greater problem with microbiologicals, PCBs and pesticides (Table 13). As Erie begins to attract more "wet" industries that use and discharge more industrial water, they may well see an increase in problems with contamination from metals. Mitigating future impacts on Erie's water quality from an aggressive industrial recruiting strategy is not part of the Tap into Erie strategy.

Table 13: Comparison of Water Quality

	Erie Results Found in		*Pittsburgh Results Found in*	
	(# of stations)	(% of stations)	(# of stations)	(% of stations)
Metal	1	5.3	2	40
Microbiological	15	78.9	3	60
PCB	1	5.3	0	0
Pesticide	1	5.3	0	0
Radiation	1	5.3	0	0

Water is and will continue to be important to Pittsburgh's industries. The Tap into Erie recruiting campaign is a well-organized and executed, but still one-dimensional economic development strategy. It does not provide a desirable model for the Pittsburgh region.

Milwaukee

Milwaukee has developed a cluster of 120 companies in the water industry that includes filtration, testing, desalination, pumps, valves and controls. The water industry in Milwaukee traces its origins to three sources:

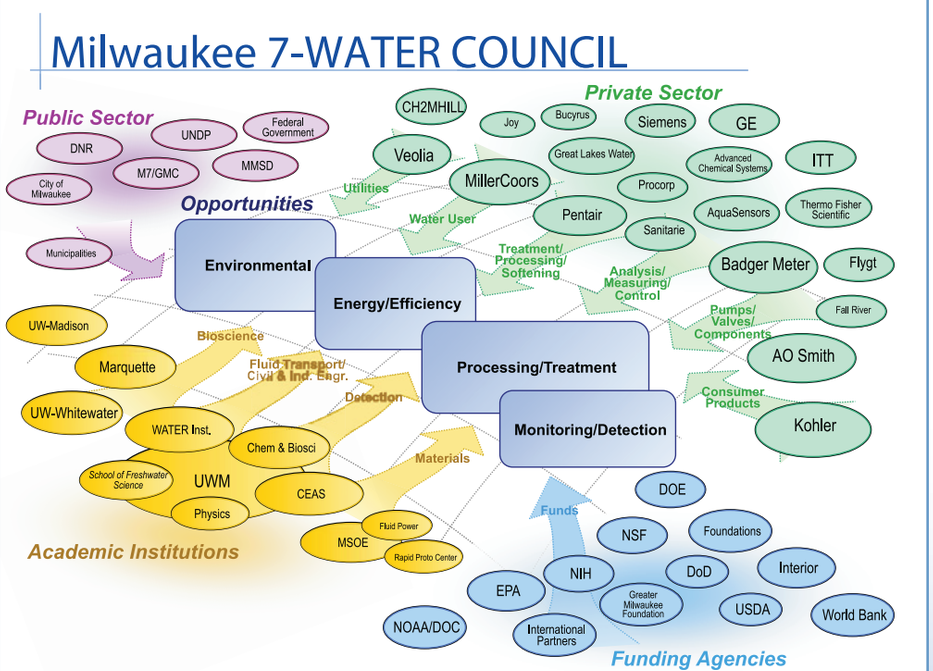
Johnson Controls – creator of the electric thermostat and the building control industry.

A.O. Smith Corporation – creator of the glass lined water heater which has become one of the leaders in residential and commercial water heating.

Demand from wet industries, such as beer and other beverages in Milwaukee.

Innovation in the form of R&D activity and patents has been lacking in the Milwaukee area. The Great Lakes WATER Institute at the University of Wisconsin-Milwaukee provides a foundation for increasing freshwater research and represents a regional focal point for innovation.

Figure 11



The Milwaukee Water Council is a broad-based collaboration that brings together industry, researchers, the public sector and funders (Figure 11). The Council is transitioning from a mostly volunteer organization with a budget of $50,000 to an operating economic development entity. The Water Council received more than $200,000 from several foundations in early 2010. In September of 2009, the U.S. Department of Commerce provided $172,000 to explore methods to enhance Milwaukee's capabilities for freshwater processing and treatment.[24]

The Milwaukee Water Council pursues its mission to make the Milwaukee Region the world water hub for freshwater research, economic development and education.

Milwaukee does not necessarily have an edge in terms of its industry or research assets, but it is more organized and has a higher level of interest and collaboration among key stakeholders in the water cluster due to its early organizing efforts. It is difficult to gauge the scope of research activity in a region but as noted previously, Carnegie Mellon University is working on a soon to be published report that will profile research and innovation in the Pittsburgh region. Those results should be integrated with the examination of industry sectors in this report. Just the same, we benchmark here active federally-funded R&D projects in Milwaukee and Pittsburgh. Milwaukee has less than $7 million in active federal R&D projects related to water while the Pittsburgh region has $19 million from the National Science Foundation, Department of Energy, Environmental Protection Agency and other federal entities.[25] This comparison does not include corporate R&D activity but it does demonstrate that Pittsburgh has an edge in pre-commercial research.

Milwaukee presents a better model for Pittsburgh to follow in order to tap the water related opportunities because it is more comprehensive. Erie focuses on water-using industries with the promise of cheap water. The Milwaukee model unites a wide array of stakeholders around a broad array of economic opportunities and public benefits.

Special Section: Marcellus Shale and Water Issues

There are a number of ways in which water impacts energy and where improvements are needed. These include but are not limited to acid mine drainage management, power plant cooling, and Marcellus shale. This section explores the innovation opportunities related to Marcellus shale and not other aspects of the water-energy nexus because this is an emerging area where there are few if any established solutions. Developing innovative solutions for extracting gas from the Marcellus shale while protecting and preserving water could enable the region to capture a significant early lead in this industry because there are few if any established competitors. Our region cannot afford to be on the wrong side of history again in the way we address our precious water resource. We can ill-afford to trade water for natural gas or other non-renewable resources.

The economic opportunity for water-based businesses related to Marcellus shale exploration is not in the direct employment from oil and gas drilling. According to the Bureau of Labor Statistics oil and gas drilling and support operations employed an estimated 835 workers in the Pittsburgh metropolitan area in 2009. The larger opportunity is related to the need for water as an input to the drilling and hydro-fracturing process, as well as managing and treating the output of water from the well.

How much risk should we take with contamination?

We don't fully understand how much risk exists from the fracturing process, but the risk is great enough for caution. Testing of domestic wells in the Fruitland Formation in New Mexico and Colorado found that gas in a domestic well had the same gas composition and carbon-13 isotope ratio as gas from a nearby gas well also in the Fruitland Formation. The Bureau of Land Management found that C13 isotopic signatures of individual near-surface gas samples correlated with production gas from discrete formations beneath the study area. One well contained 680 ppm TDS, primarily sodium bicarbonate, the same as produced water from the Fruitland well. Both the gas and the water analyses indicate that the shallow aquifer in the area (from which the methane-contaminated domestic wells draw drinking water) is in hydraulic communication with the deeper Fruitland Formation coalbeds. *Source: EPA 2004*

Drilling companies are always looking for more efficient ways to use water as well as store, treat or dispose of the wastewater. Advances that reduce the water used in the hydro-fracturing process or which increase the productivity of the water used are highly desired and critical to our region's sustainable development. These innovations can also provide some savings on treating wastewater, although it should be noted that in some cases, using less water produces more concentrated contamination that can be more difficult and more expensive to treat, such as with high salinity produced water.

The Marcellus industry also needs effective wastewater treatment because accidents, spills and contamination are a threat to public health and ecology and can require long-term treatment and remediation that can be very expensive, or even cause the suspension of permits. The Department of Environmental Protection has fined Talisman Energy USA Inc. for a spill of hydraulic fracturing flowback fluid. This is the substance that returns to the surface after pressurized fluid is injected underground to fracture, or "frack," a geologic formation and extract natural gas. The spill occurred at the Klein gas well pad in Armenia Township, Bradford County. An estimated 4,200 to 6,300 gallons of fracking flowback fluids were discharged into an unnamed tributary to Webier Creek (part of the Tioga River basin) when a pump failed and sand collected in a valve. In another recent incident, Cabot Oil and Gas is providing temporary water services to local residents until a permanent solution for whole-house water treatment systems can be installed in the 14 affected homes in Dimock Township.[26] These expenses and negative impacts can be avoided with improved technology.

According to the University of Pittsburgh Center for Healthy Environments and Communities, there have been 675 Marcellus wells drilled from 2007 to August 2010.[27] Two to five million gallons of water are required to fracture one horizontal Marcellus shale well, so the total water to fracture these 675 wells ranges from 1.4 to 3.4 billion gallons. Water used for fracturing fluids is acquired from surface water or groundwater in the local area. [28] Fracturing fluids can be up to 99 percent water, which means that each well produces 20,000 to 50,000 gallons of contaminants.

Through the fracturing and recovery processes some of the fluids remain trapped underground, with an estimated 15-80 percent of the injected volume being recovered. Wastewaters from the hydraulic fracturing process may be re-injected into the ground, discharged to surface waters after decontamination or dispersed onto land to evaporate or filter into the ground (Figure 12).[29] There is an opportunity for more sophisticated and effective management of this wastewater that can provide environmental and economic benefits.

Figure 12: On-Site Storage of Fracturing Fluid Prior to Disposal

Source: EPA 816-R-04-003. Figure 4-10.

Pennsylvania requires that Marcellus shale effluent be processed through wastewater treatment plants, even though the effectiveness of the treatments has not been established. Reserve Environmental Services received a permit for a new facility located in New Stanton that is planned as a zero-discharge wastewater recycling facility. With an expected capacity of one million gallons per day, the facility can to treat the wastewater from 350 Marcellus wells, about half of the number of wells in the region now. The facility will meet DEP's new regulations, where "[wastewater discharges from] new and expanded facilities must meet a concentration threshold of 2,000 milligrams per liter and wastewater discharges from drilling operations cannot exceed 500 mg/l."[30]

Wastewater treatment primarily dilutes but does not remove most salts or other dissolved solids in brines.[31] Furthermore, desalination is expensive and briny wastewater with high total dissolved solids (TDS) can react with the chlorine treatments typical in wastewater treatment. Re-injecting the fluids back into the ground is common in Texas and parts of West Virginia, but fears of contaminating underground sources of drinking water (USDWs) has limited its application in the Appalachian States.[32] The other disposal practice is to evaporate the fluids in an open tank and then dispose of the remaining dry solids. This method, which works in dry southwest climates, may not be effective in Pennsylvania where rain and flooding can create a problem with open trenches and pools.[33]

Another opportunity for innovation is in the recovery of fluids from the fracking process. According to Palmer et al. (1991) fluids can be trapped as a result of a collapsed or narrowed fracture that prevents recovery of the fluid through the production well. Fluid can also be trapped because the injection pressure is greater than the recovery pressure so some of the fluid will be forced beyond the capture zone of the production well.[34] "The capture zone of a production well is the portion of the aquifer that contributes water to the well. The size of this zone will be affected by regional groundwater gradients, and by the drawdown caused by the well.[35] Fluids that flow beyond the capture zone of the production well generally are not recovered during the flowback process."[36] Gels contained in fracturing fluids are also often unrecovered because it can clump and stick to subsurface formations. One mined-through study reviewed by EPA described evidence of gel clumps within many fractures. "One observed concentration of gel in a fracture was 15 times the injected concentration."[37] Technologies that can increase the capture zone or increase the recovery of fracturing fluids would have tremendous economic and environmental benefits.

Water with a high salinity is harmful to living things and corrosive to metal. The salinity of sea water averages between 10,000 and 35,000 PPM. The flow-back water has a salinity that ranges from 2,000 PPM to 45,000 PPM the longer it remains in the shale.[38] Flowback water is estimated at an average of 1.26 million gallons per well. Treating the water off-site requires hundreds of truck trips or a pipeline system. Off-site treatment is estimated to cost anywhere from $1.25 per barrel to $12 per barrel.[39] Innovations in on-site treatment and reuse solutions can cut treatment costs by half or more. Southwestern Pennsylvania has a number of companies that can help in the development of improved treatment and disposal processes including Cardinal Resources, Aquatech, Calgon Carbon, LANXESS and Siemens Water Technologies (FKA U.S. Filter). The most promising on-site options are evaporation, advanced oxidation and membrane filtration (Table 14).

Table 14: On-Site Treatment Options

Treatment	Advantages	Disadvantages
Advanced oxidation • Peroxide/ultraviolet light (H_2O_2/UV), • Ozone/ultraviolet light (O_3/UV), • Hydrogen peroxide/ozone (H_2O_2/O_3) • Hydrogen peroxide/ozone/ultraviolet (H_2O_2/O_3/UV) processes. • Ozone/Ultrasonic cavitation	• Rapid reaction rates • Small footprint • Can reduce toxicity and complete mineralization of organics treated • Does not concentrate waste for further treatment unlike membranes • Does not produce materials that require further treatment such as "spent carbon" • Non selective pathway allows for the treatment of multiple organics at once	• Capital Intensive • Complex chemistry must be tailored to specific application • For some applications quenching of excess peroxide is required
Evaporation • Mechanical Vapor Recompressor • Evaporation • Crystallization	• Can create drinkable water from briny water if other requirements are met • Newer mobile systems do not require permits	• Not cost effective for low TDS water sources • Stationary systems are capital intensive and require permits
Reverse Osmosis	• More cost effective at lower TDS	• Potable water only from sources with TDS less than 35,000 mg/L
Membranes	• More cost effective at lower TDS	• Potable water only from sources with TDS less than 35,000 mg/L

Source: Venture Engineer.[40]

Many of the compounds used in fracturing fluids are in common use, but there could be a significant opportunity for the development of more environmentally safe fracking fluids. According to the National Energy Technology Laboratory's primer on shale gas development, these compounds are safe when handled properly and are commonly used in a variety of daily applications (Table 15). The compound that is referenced the most often to demonstrate the safety of these chemicals is guar gum, which is used in ice cream.

Table 15: Fracturing Compounds and Common Uses

Compound	Common Use
Hydrochloric acid	Swimming pool chemical and cleaner
Glutaraldehyde	Disinfectant; sterilize medical and dental equipment
Ammonium persulfate	Bleaching agent in detergent and hair cosmetics, manufacture of household plastics
N,n-dimethyl formamide	Used in pharmaceuticals, acrylic fibers, plastics
Gel Guar gum (hydroxyethyl cellulose)	Cosmetics, toothpaste, sauces, baked goods, ice cream
Ethylene glycol	Automotive antifreeze, household cleansers, and deicing

Source: National Energy Technology Laboratory, U.S. Department of Energy. Modern Shale Gas Development in the United States: A Primer. April 2009. Sample compounds from Exhibit 36: Fracturing Fluid Additives, Main Compounds, and Common Uses.

Despite their common use, these chemicals must be handled safely, because accidental discharge can be very harmful. According to the Pennsylvania Land Trust, Marcellus drilling has resulted in 952 potentially serious environmental violations in 2.5 years.[41] Any of these violations could lead to contamination of streams and aquifers. Furthermore, while compounds like guar gum that is used in ice cream are often highlighted to demonstrate the benign nature of fracturing fluids, there are more dangerous compounds that are used, such as Benzene and Naphthalene that can be lethal at 0.1 PPM and the actual concentrations at the point of injection can far exceed safety standards (Table 16).

Table 16: HF Fluid Concentration and Water Quality Standards

Chemical Compound	EPA's estimated point of injections concentration (µg/l)	Acceptable concentration in drinking water (mg/l)	How many times more than the acceptable concentration	Water quality standard used
Benzene	313	5	63	MCL
Naphthalene	14,094	20	705	RBC
1-methylnaphthalene	71,340	20	3,567	MCP
2-methylnaphthalene	34,974	121	289	RBC
Fluorenes	31,320	2,190	14	RBC
Phenanthrenes	7,830	300	26	MCP
Aromatics	574,200	200	2,871	MCP
Ethylene glycol	285,788	73,000	4	RBC
Methanol	236,070,000	18,250	12,935	RBC

Source: Sumi, Lisa. 2005. Our Drinking Water at Risk. Table 4: Hydraulic fracturing chemicals exceeding a water quality standard. Oil and Gas Accountability Project. Durango, CO. p. 8.

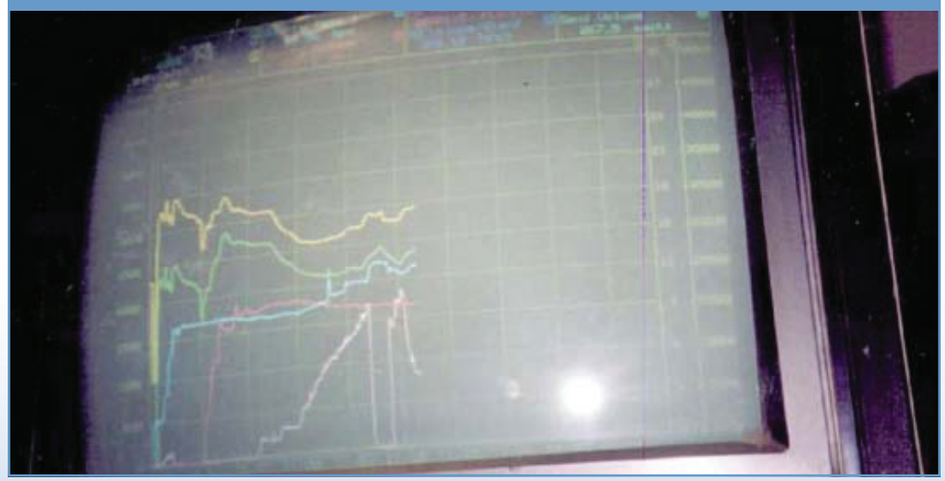
One of the biggest opportunities related to water in the development of Marcellus shale gas would be the development of environmentally safe chemicals – a "green" fracturing fluid. As early as 2007, Schlumberger formulated its GreenSlurry system for use in the North Sea and Gulf of Mexico. Approximately half a dozen companies have "green" or non-toxic fluids that are in development, but may not have been verified for their environmental impacts. The lack of development in this area is a tremendous research and commercialization opportunity for the region. However, we must keep in mind that however clean or green the fracturing fluid is when it is injected into the well, the flowback and produced water that comes back out can carry with it a host of contaminants. The primary contaminant, as mentioned earlier is salt, which in low concentrations is harmless and used every day but which makes the water unusable for drinking, irrigation and most household and industrial uses.

Figure 13: Gas Well Control Room

Source: EPA 816-R-04-003. Figure 4-8.

Another area of opportunity for southwestern Pennsylvania is to apply our expertise in instrument and sensors to improve the monitoring and control technologies used in the industry (Figure 13, Figure 14). The massive discharge of oil in the Gulf of Mexico from BP's Deepwater Horizon well, in addition to recent oil spills in Kalamazoo, Michigan and the EOG Resources gas well blowout demonstrate that improvements in the safe development of our oil and gas resources are worthy investments.

Figure 14: Monitoring Injection Fluids



Source: EPA 816-R-04-003. Figure 4-9.

Appendix - Water Related Industries

Table 17: Supply and Treatment

2007 NAICS Code	2007 NAICS Title
221310	Sewage Treatment Facilities
237110	Water and Sewer Line and Related Structures Construction
221320	Sewage Treatment Facilities
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing
562910	Remediation Services

Table 18: Components

2007 NAICS Code	2007 NAICS Title
326122	Plastics Pipe and Pipe Fitting Manufacturing
326191	Plastics Plumbing Fixture Manufacturing
326199	All Other Plastics Product Manufacturing
326220	Rubber and Plastics Hoses and Belting Manufacturing
326299	All Other Rubber Product Manufacturing
327111	Vitreous China Plumbing Fixture and China and Earthenware Bathroom Accessories Manufacturing
332420	Metal Tank (Heavy Gauge) Manufacturing
332911	Industrial Valve Manufacturing
332919	Other Metal Valve and Pipe Fitting Manufacturing
332996	Fabricated Pipe and Pipe Fitting Manufacturing
333911	Pump and Pumping Equipment Manufacturing
333996	Fluid Power Pump and Motor Manufacturing
333999	All Other Miscellaneous General Purpose Machinery Manufacturing
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing
334512	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use
334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables
334514	Totalizing Fluid Meter and Counting Device Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
334519	Other Measuring and Controlling Device Manufacturing

Table 19: Services

2007 NAICS Code	2007 NAICS Title
23822	Plumbing, Heating, and Air-Conditioning Contractors
541320	Landscape Architectural Services
541330	Engineering Services
541370	Surveying and Mapping (except Geophysical) Services
541380	Testing Laboratories
541620	Environmental Consulting Services
541690	Other Scientific and Technical Consulting Services
561730	Landscaping Services

Table 20: Transportation

2007 NAICS Code	2007 NAICS Title
336611	Ship Building and Repairing
483211	Inland Water Freight Transportation
488310	Port and Harbor Operations
488330	Navigational Services to Shipping

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Notes

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[2] Pennsylvania State University, College of Agricultural Sciences. 2007. A quick guide to groundwater in Pennsylvania. Page 7.

[3] 2030 Water Resources Group. 2009. *Charting our Water Future: Economic Frameworks to Inform Decision-making*. Prepared by McKinsey Consulting. According to McKinsey, the total water market estimated to grow approximately 5% annually. Other reports from Lux Research, Venture Engineering, BlueTech and others that cover various water market segments have estimated growth rates higher than 100%. Fourth Economy's weighted index of these estimates suggests a growth range between 5% to 10%.

[4] Estimates developed by Fourth Economy with data from U.S. Bureau of Labor Statistics, Dun and Bradstreet and IMPLAN.

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[6] Combined Sewer Overflows results from stormwater feeding into the same pipes as the sanitary sewers.

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[8] 1.1 billion people do not get enough safe drinking water and 2.6 billion are without adequate sanitation. 3,900 children die from water born diseases every day. World Health Organization, UNICEF, JMP, 2004.

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[18] Water use based on Blackhurst et al. Direct and Indirect Water Withdrawals for U.S. Industrial Sectors, Environmental Science and Technology. 2010, 44, 2126-2130 and output for agriculture and food processing derived from Fourth Economy's IMPLAN models for the Pittsburgh MSA.

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