RENEWING THE WATER WORKFORCE

Improving water infrastructure and creating a pipeline to opportunity

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SUMMARY

As the U.S. economy continues to grow, many communities are struggling to translate this growth into more equitable and inclusive employment opportunities. Simultaneously, many of the nation's water infrastructure assets are in urgent need of repair, maintenance, and restoration. Yet the workers capable of carrying out these efforts are in short supply due to an aging workforce eligible for retirement and the lack of a pipeline for new talent.

However, addressing these two challenges together offers an enormous infrastructure and economic opportunity. Constructing, operating, designing, and governing water infrastructure systems demands a skilled workforce, and hiring a diverse workforce can support greater economic mobility. To unlock this opportunity, local, state, and national leaders must work together to better understand current workforce challenges and develop new techniques to hire, train, and retain water workers.

By analyzing occupational employment data, this report explores the water workforce in greater depth to uncover the accessible, well-paying opportunities in this sector. In particular, it finds:

A. In 2016, nearly 1.7 million workers were directly involved in designing, constructing, operating, and governing U.S. water infrastructure, spanning a variety of industries and regions. Water utilities employ many workers, but multiple other industries and establishments, including engineering firms and construction contractors, are essential to the water sector too. Collectively, the water workforce fills 212 different occupations—from positions in the skilled trades like electricians and technicians to financial, administrative, and management positions—that are found everywhere, from big metropolitan markets to smaller rural areas.

B. Water occupations not only tend to pay more on average compared to all occupations nationally, but also pay up to 50 percent more to workers at lower ends of the income scale. Water workers earn hourly wages of $14.01 and $17.67 at the 10th and 25th percentiles,

respectively, compared to the hourly wages of $9.27 and $11.60 earned by all workers at these percentiles across the country. Significantly, workers across 180 of the 212 water occupations—or more than 1.5 million workers—earn higher wages at both of these percentiles, including many in positions that tend to require lower levels of educational attainment.

C. Most water workers have less formal education, including 53 percent having a high school diploma or less. Instead, they require more extensive on-the-job training and familiarity with a variety of tools and technologies. While 32.5 percent of workers across all occupations nationally have a high school diploma or less, a majority of water workers fall into this category, speaking to the lower formal educational barriers to entry into these types of positions. However, 78.2 percent of water workers need at least one year of related work experience, and 16 percent need four years or more, highlighting the need for applied learning opportunities.

D. Water workers tend to be older and lack gender and racial diversity in certain occupations; in 2016, nearly 85 percent of them were male and two-thirds were white, pointing to a need for younger, more diverse talent. Some water occupations are significantly older than the national median (42.2 years old), including water treatment operators (46.4 years old). Meanwhile, women make up only a fraction of employment in some of the largest water occupations overall, including plumbers (1.4 percent). Finally, there is a particularly low share of black and Asian workers employed in the water sector; together, they only make up 11.5 percent of the water workforce, compared to 18 percent of those employed in all occupations nationally.

Based on these findings and dozens of conversations with utility leaders and other workforce groups, the report lays out a new water workforce playbook for public, private, and civic partners to use in future hiring, training, and retention efforts. Utilities and other employers need to adjust existing hiring procedures and pilot new training efforts in support of the water workforce; communities need to hold more consistent dialogues and develop more collaborative platforms; and national and state leaders need to provide clearer technical guidance and more robust programmatic support.

Ultimately, the report reveals the sizable economic opportunity offered by water jobs, including the variety of occupations found across the country, the equitable wages paid, the lower educational barriers to entry, and the need for more diverse, young talent.

INTRODUCTION

Nearly a decade since the end of the Great Recession, shared prosperity remains a challenge in many communities across the United States. High-income households are now earning up to 14 times as much as low-income households in some markets.[1] Racial disparities in employment are also widespread; from 2015 to 2016, employment rates for whites increased in 72 of the country's 100 largest metro areas, but they increased in only 41 of these metro areas for both whites and people of color.[2]

Individual neighborhoods are also experiencing deeply entrenched levels of poverty, as their residents remain disconnected from opportunity.[3] Meanwhile, smaller metro areas and rural localities account for a dwindling share of national output and a declining share of jobs.[4]

Nevertheless, many communities are also beginning to develop new strategies to promote more inclusive economic development and increase their economic competitiveness.[5] Despite continued uncertainty at the national level, local leaders are investing in technological innovation, affordable housing, and workforce development to help their residents overcome barriers to better pay and shared prosperity, particularly for women and people of color.[6] In support of an increasingly diverse population, these strategies are helping all types of individuals respond and adapt to the economic disruptions of today's digital age, where an ever-changing set of skills and training are needed to drive production.[7,8]

Investing in infrastructure represents one of the timeliest ways for the country to support long-lasting pathways to economic opportunity for all Americans. Infrastructure-related occupations tend to provide competitive wages, while not requiring as much formal education.[9] And the country's water infrastructure, in particular, is well positioned to offer more durable careers to a wide variety of workers across urban and rural areas alike.

The economic opportunity stems from the urgent investment needs around the country's water infrastructure assets. Municipalities, led by water utilities, are often at the front line of this challenge, responsible for more than 95 percent of public spending on operations and capital improvements annually.[10,11] With $655 billion in capital investments needed nationally over the next 20 years, utilities are working alongside a host of different partners to address physical infrastructure needs head-on.[12] Together, for instance, 30 of the country's largest water utilities are estimated to spend $23 billion annually on operations and capital projects, while contributing $524 billion to the economy over the next decade.[13]

Renewing America's water infrastructure will require a skilled workforce to construct, operate, and maintain facilities for decades to come. However, meeting these demands depends on more coordinated, purposeful actions by water utilities, other employers, workforce development partners, and state and national leaders. These actions also need to acknowledge how utilities are often positioned as anchor institutions in many regions, with nearly 52,000 water systems spread across the country.[14] There is a genuine opportunity to promote shared prosperity in the communities that utilities and other water sector actors serve, but seizing this opportunity requires a clearer recognition of the economic importance of the water workforce and a better articulation of future actions.

This report aims to identify the extent of the U.S workforce involved in overseeing water infrastructure. Through a combination of quantitative and qualitative information—including dozens of conversations with utility leaders and other workforce groups across the country—the report finds that the water workforce represents a crucial segment of the labor market.[15]

To start, the report first examines some of the major hurdles that face water workers and employers looking to fill positions. It then explores the economic opportunity offered by water jobs, including the variety of occupations found across the country, the equitable wages paid, the lower educational barriers to entry, and the need for more diverse, young talent. The report outlines some of the major implications emerging from this analysis, before finally laying out a set of actionable strategies—a new water workforce playbook—that local, state, and national leaders should use in future hiring, training, and retention efforts.

WHAT IS WATER INFRASTRUCTURE?

Water infrastructure spans several different man-made and natural systems that supply, treat, and conserve water.[16] These systems range from traditional gray infrastructure, such as pipes, pumps, and centralized treatment plants, to green infrastructure, such as rain gardens and other related natural assets that tend to be more decentralized.[17] They also include individual on-site treatment systems, such as septic systems, and other related physical assets specific to individual buildings, such as plumbing.[18] In addition, rivers, lakes, ponds, wetlands, and subsurface aquifers are critical components of water infrastructure, as well as large man-made structures, such as aqueducts and levees. When this report refers to "water infrastructure," it is referring to the entirety of the country's drinking water, wastewater, stormwater, and green infrastructure systems.

The water workforce carries out work activities that ultimately support this extensive network, which is vital to providing and protecting clean, safe, and reliable water each day. The report's methods section describes these definitions in greater depth.

The following sections describe the major employment opportunities—and challenges—found in the water sector. After first discussing the types of workers involved, the second section examines the primary groups focused on water workforce development. The final section introduces some of the prevailing difficulties that water utilities and other leaders face when trying to hire, train, and retain skilled water workers.

Who are water workers?

Traditionally, water utilities have taken a lead role defining and addressing the country's water workforce needs, particularly in terms of drinking water and wastewater operations and management.[19] For example, water operators carry out a range of duties to support utility activities, from ensuring compliance with federal, state, and local water quality standards, to testing water and sewage samples, to monitoring facility conditions.[20] Likewise, mechanics, machinists, electricians, and instrument technicians rank among the most important mission-critical occupations identified in previous utility surveys and studies; these workers are essential to installing, calibrating, and overseeing a variety of utility equipment.[21] Several administrative, financial, and management occupations help support utility operations as well, including customer service representatives and human resources specialists.

However, water utilities are just one of many employers looking for workers to construct, operate, design, and govern the country's water infrastructure assets.[22] The water sector captures a vast array of industries—from engineering and design firms to construction companies and contractors—and each rely on a different mix of occupations and workers.[23] Whether maintaining individual treatment plants or carrying out repairs in homes, there are

many different types of water workers in urban and rural areas nationally. They also do not exclusively focus on gray infrastructure facilities, such as pipes and pumps, but manage green infrastructure facilities too, such as rain gardens, which utilities and other local employers are increasingly using to better conserve environmental resources and more consistently handle stormwater runoff.[24]

The report's methods section describes the specific industries and occupations that employ water workers.

Who is responsible for hiring, training, and retaining water workers?

In short, water workers span multiple industries across the country, and utilities are not alone in hiring, training, and retaining these workers to oversee all the various infrastructure projects and facilities found across the sector. Although individual workers and employers may not always see themselves as part of a larger economic sector, their work activities hold a lot in common and demand coordinated action. Indeed, a wide assortment of employers, community partners, and national- and state-level actors each have roles to play in water workforce development.

To provide drinking water, treat wastewater, manage stormwater, and balance other programmatic responsibilities, **utilities** depend on a skilled workforce. Although utilities can vary markedly in the scale of their operations and workforce demands—depending on the facilities they oversee and customers they serve—they still assume a lead role onboarding and ultimately preparing workers to navigate long-term water careers. For instance, their human resources staff frequently manages recruitment and retention efforts, while their managers shape plans, budgets, and programs to emphasize particular training needs.[25] Indeed, utilities continue to rank workforce development as one of their top priorities, where they remain focused on identifying younger talent, onboarding workers more quickly, creating more flexible training platforms, and holding onto more skilled workers.[26]

Other water-related employers, including engineering firms, contractors, and related businesses, are also actively on the lookout for workers to carry out specific water projects and activities. As part of the procurement process, many of these employers respond to utility requests for project support, including design and construction, but they are also engaged in other miscellaneous services, ranging from vehicle maintenance to meter reading.[27] In addition, through project labor agreements with utilities and other public agencies, contracted firms may often be required to hire workers locally, amounting to 50 percent or more of the contracted workforce in some markets.[28] These employers, of course, can vary in their size and focus, providing services well beyond the purview of utilities; for example, local plumbing companies may cater more to individual households or install equipment in particular buildings.

Utilities and other water-related employers benefit from a wide range of **community partners** that educate, train, and assist workers interested in water careers. For instance, local community colleges, technical schools, and educational institutions provide courses and instruction in the skilled trades, offer certification and apprenticeship programs, and connect students with various training opportunities. Similarly, economic development organizations (EDOs) and workforce development boards (WDBs) are among the multiple regional partners that help oversee and collaborate on workforce development programs, by guiding financial resources, providing technical support, and forming strategic plans in support of training efforts.[29] Unions and labor groups not only provide worker protections—during the hiring process and wage

negotiations, for instance—but also offer training resources and assistance.[30] Finally, a number of community-based organizations and nonprofit groups offer job readiness programs, transition services, and other channels of support to workers.[31]

In addition to all the aforementioned groups, several **national- and state-level actors** are involved in water workforce development. Federally, the U.S. Environmental Protection Agency (EPA) is perhaps the most important agency when it comes to regulating utility activities and guiding workforce needs—via the Clean Water Act and Safe Drinking Water Act—while providing funding and technical assistance for training efforts, too.[32] Furthermore, the U.S. Departments of Labor (DOL), Education (ED), Veterans Affairs (VA), and Agriculture (USDA) monitor skill needs and employment trends, oversee labor standards, support apprenticeship programs, and provide targeted programmatic support for certain individuals and utilities.[33] Likewise, several industry associations are pioneering new research and collaborations to connect water workers with employment opportunities.[34] A host of other national- and state-level organizations—including workforce groups, environmental coalitions, and state boards of education—are also assessing existing training efforts and setting new strategic priorities.[35]

Recognizing barriers to hiring, training, and retaining water workers

Even with an extensive array of job types and supporting actors, there are distinct challenges facing the water sector. While the demand for water workers remains high among utilities and other employers, they struggle to attract and hold onto skilled talent; equipping workers with needed skills and credentials is not always easy; and even those workers who are eligible and interested in water work cannot always navigate an inflexible, time-consuming hiring process or progress their careers. Across the entire water sector, three categorical barriers face its workforce.

First and foremost, the water sector is aging, while employers are struggling to attract and hold onto skilled workers, particularly younger and more diverse workers. A "silver tide" of retirements is drastically cutting into the pool of skilled, qualified workers in many utilities and resulting in staffing vacancies of up to 50 percent in some cases.[36] Meanwhile, a lack of public visibility, combined with declines in career and technical education (CTE), has reduced interest and experience among prospective workers who could fill water-related positions.[37] Difficulties reaching out to different types of workers, inflexibilities in prevailing hiring procedures, and a lack of training programs for nontraditional workers make it hard to identify and support a broader pool of labor; these candidates may also fail to even launch their careers.[38] In turn, there is a lack of diversity in the water workforce, with industry surveys finding that women remain underrepresented in many positions and more than 72 percent of workers in water utilities are white.[39] Furthermore, retaining talent remains a challenge, as workers look to transition to other regions with a lower cost of living or to other industries that demand similar skillsets and offer better pay.[40]

In turn, identifying a new generation of workers will be key for the water sector in years to come. That task is challenging, though, given the wide range of curricula and ever-changing training requirements depending on the specific employer. Difficulties defining needed skills and creating portable, versatile credentials is an ongoing frustration across the sector, and the pathways to developing such knowledge and skills are unclear, especially from region to region. Similar to other skilled trades, many water workers start as apprentices, where a combination of on-the-job training and classroom instruction help equip them

with the practical and theoretical tenets of their occupation. After completing their apprenticeship, the worker becomes a journey level tradesman and then transitions into a role with more limited supervision.[41] However, the education and licensing requirements for these positions, including plumbers and water operators, can vary widely across different states, and not all utilities or regions have flexible training programs in place to equip workers with needed experience.[42,43] In addition, the changing nature of work in the sector, including new types of field work, new design guidelines, and increased automation, only add to the breadth of skills needed.[44] As a result, prospective job candidates may fail to pass certification exams or qualify for positions.

As more workers retire or leave the water workforce, it can be a struggle to find qualified replacements. Even when students and other prospective workers demonstrate an interest in water careers, pursue needed education, and gain relevant experience, there can still be challenges hiring them and providing long-term growth opportunities. Many prospective workers may lack job readiness, may remain out-of-work due to a criminal record, or may present a non-traditional background, which employers—and other community partners—may not have the time, resources, or programmatic flexibility to handle. Employers can also vary widely in their hiring practices, including how long it takes, how they rate individual candidates, and how much control they actually have over adjusting prevailing hiring standards. Some mission-critical positions in engineering and operations, moreover, remain especially hard to fill and retain talent. And while utilities and other water employers want to help prospective workers not simply find a "job" but secure a "career pathway," they face several programmatic constraints to fostering professional growth, including limited budgets.[45]

"The water sector captures a vast array of industries—from engineering and design firms to construction companies and contractors—and each rely on a different mix of occupations and workers"

Consequently, many of the problems the water sector is experiencing are emblematic of bigger economic trends and broader policy issues facing the country, including the continued need to support a new generation of workers amid mounting retirements, changing technologies, and other labor market shifts. The report's implications section describes these and other barriers in greater depth.

METHODOLOGY

Many previous reports covering the water workforce have only focused on those workers directly employed in the country's drinking water, wastewater, and stormwater utilities. However, as noted above, this approach can overlook the many additional workers employed across other establishments that provide goods and services essential to the country's water infrastructure, ranging from engineering firms to construction contractors.

To measure the full economic extent and impact of the U.S. water workforce—and the jobs they fill—this analysis relies on the following definition:

Water workers are directly involved in the construction, operation, design, and governance of water infrastructure systems nationally, including drinking water, wastewater, stormwater, and green infrastructure. These workers fill positions that span the public and private sector and involve oversight, maintenance, and financial and administrative support, including involvement in managing several closely-related physical assets, such as pipes and septic systems.

Based on a thorough review of academic literature, industry reports, government studies, utility surveys, and other workforce documents, the analysis builds off this definition to identify a consistent list of industries that carry out water-related activities nationally.[46] Spanning the public and private sector, a total of **eight different "water industries"** are included, which are involved in: (1) providing drinking water, treating wastewater; and managing stormwater; (2) overseeing water, sewer line, and related structures construction; (3) overseeing dredging and flood control project construction; (4) installing and servicing plumbing equipment; (5) trenching, excavating, and preparing sites for septic systems; (6) cleaning storm basins and sewers, in addition to remediating and

KEY TERMS[54]

Water jobs: Employment opportunities based on the total number of workers in occupations and industries involved in overseeing the country's water infrastructure, including drinking water, wastewater, stormwater facilities, and other related assets.

Occupations: The activities that employees regularly carry out for pay, which are grouped into distinct categories on the basis of similar job duties as outlined in the 2010 Standard Occupation Classification (SOC) system. In total, there are more than 800 detailed occupations found across all industries. "Water occupations," in particular, are often concentrated in activities and perform duties central to water infrastructure design, construction, operation, and governance.

Industries: Groups of establishments that provide similar goods or services, as determined by the 2012 North American Industry Classification System (NAICS). Private and government-owned establishments are included, while agricultural establishments and private households are excluded. "Water industries," in particular, provide services closely linked to water infrastructure.

Water utilities: Agencies or departments that provide drinking water, treat wastewater, manage stormwater, and carry out other essential water infrastructure activities.[55] Found across the public and private sector, they can vary widely in their physical scale and operations, but they employ many water workers across the country.

Employment: The total number of full-time and part-time workers paid a wage or salary, excluding household and self-employed workers, as defined in the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) survey.

Wages: Based on straight-time, gross pay over a standard work period, as defined in the OES survey. These include tips, production bonuses, cost-of-living allowances, and over-the-road pay based on mileage. However, overtime pay, back pay, and holiday bonuses are among the types of compensation excluded. Wages include mean hourly and annual pay, but also percentile wages (10th, 25th, 50th, 75th, and 90th). The latter are based on the percentage of workers who earn wages below a certain value. For instance, if $9.00 represents the 10th percentile wage for a given occupation, this means that 10 percent of workers employed in the occupation earn less than this amount.

revegetating contaminated sites to improve water quality; (7) providing environmental consulting services in support of regulatory compliance; and (8) performing other closely-related local government activities.[47]

The analysis then looks at the variety of positions—or occupations—that workers fill across these industries to get a more precise sense of the duties and tasks they carry out in support of the country's water infrastructure.[48] In total, **212 unique "water occupations"** are identified whose employment is often linked to specific water infrastructure assets and other relevant activities.[49] For example, water treatment operators, electricians, instrument technicians, meter readers, and septic tank servicers are among the vast number of occupations included in this analysis.

Similarly, a variety of engineering- and construction-related occupations, such as civil engineers, pile-drive operators, and pipelayers, use specialized knowledge and tools to draft plans, handle equipment, and install structures. In addition, several administrative, financial, and management positions, including secretaries, office clerks, and architectural managers, are found to provide essential support and oversight for these activities.

By investigating these water occupations in greater depth, the analysis estimates employment totals for the water workforce as a whole. Specifically, employment totals are based on the concentration of the 212 water occupations in the eight water industries noted above.[50] For example, almost all water treatment operators nationally tend to concentrate in these eight industries—and thus account for high levels of employment in the water workforce overall. However, bill and account collectors work in an enormous range of national industries and represent a small share of total water employment. National levels of occupational employment serve as a foundation for other metrics, including estimated water employment in metro areas.[51] The analysis also creates separate estimates for water utility employment across the country.[52]

With specific levels of occupational employment determined, the analysis explores trends in wages, education, training, and skills for the water workforce. It additionally considers several demographic characteristics, such as age, gender, and race by occupation. Overall, this approach parallels many of the same methods used in previous Brookings Institution "infrastructure jobs" analyses, which focused on identifying and measuring the range of long-term positions that oversee the country's transportation, energy, water, telecommunications, logistics, and other related infrastructure facilities.[53]

For more information on the report's methodology, see Appendix A.

FINDINGS

A. In 2016, nearly 1.7 million workers were directly involved in designing, constructing, operating, and governing U.S. water infrastructure, spanning a variety of industries and regions.

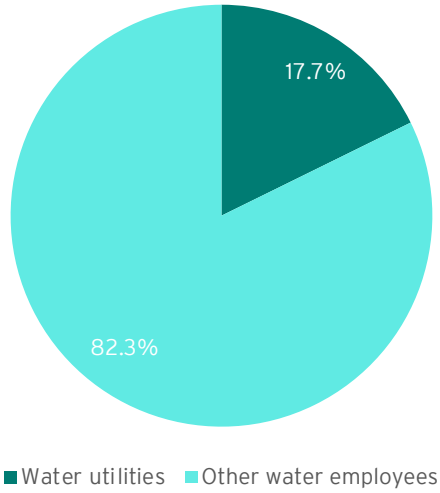
From water utilities, to specialty trade contractors, to heavy and civil engineering construction, there are hundreds of thousands of workers that carry out specialized activities crucial to the long-term operation and maintenance of the country's drinking water, wastewater, and stormwater facilities. Traditionally, water utilities are seen as the primary—or only—employer involved in overseeing the country's water infrastructure assets. However, a broader look at the water workforce nationally reveals that utilities employ 298,000 workers, or about 17.7 percent of the total water workforce. Other water-related employers, led by plumbing contractors and construction firms, employ nearly 1.4 million workers.

Water utilities represent one of the leading employers for water workers, but they are just one part of a complex economic sector filled by a variety of firms and establishments looking for skilled talent. However, since most utilities are publicly owned and operated and have formal responsibilities to serve the public, they are especially crucial to overseeing the country's essential water infrastructure facilities, such as water treatment plants, which can also provide clearer pathways to economic opportunity, as will be explored later in Box C.

Collectively, the water workforce fills 212 different occupations and carries out an enormous range of activities, whether installing and repairing equipment or analyzing and overseeing operations. For example, water treatment operators, electricians, and plumbers rank among the largest water occupations overall; just 15 water occupations employ 1.1 million workers, or almost two-thirds of all water workers nationally. Many of the same occupations are also common within water utilities, as Table 1 illustrates below.[56] In addition to positions in the skilled trades, there are tens of thousands of other workers involved in administration, finance, and management, including 116,000 office clerks, secretaries, and general and operations managers across the entire water workforce.

FIGURE 1

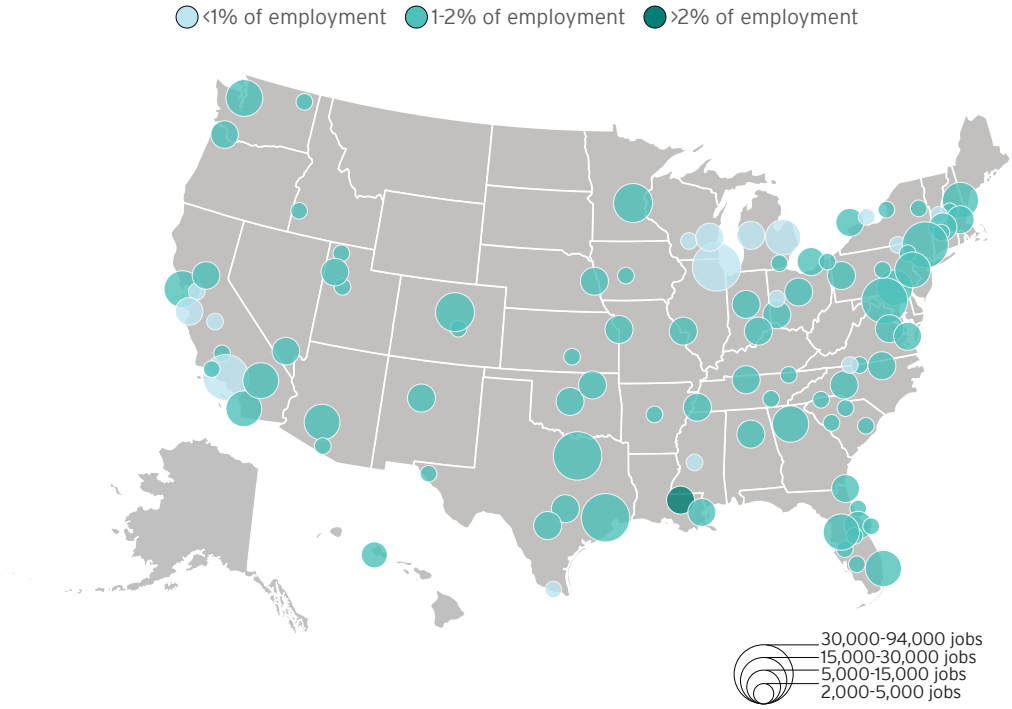
Utility share of total water workforce employment
2016



Source: Brookings analysis of BLS Occupational Employment Statistics
Note: While multiple industries employ water workers, this report only developed separate estimates for water utilities. For more information, see the report's methodological appendix.

FIGURE 2

Water workers in the 100 largest metro areas
By total employment and share of employment, 2016



Source: Brookings analysis of BLS Occupational Employment Statistics

TABLE 1

15 largest occupations, across the entire water workforce and across utilities
2016

Water occupations	Employment	Share of employment
Plumbers, Pipefitters, and Steamfitters	324,500	19.3%
Construction Laborers	149,513	8.9%
Water and Wastewater Treatment Plant and System Operators	115,840	6.9%
Operating Engineers and Other Construction Equipment Operators	79,900	4.8%
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	70,811	4.2%
First-Line Supervisors of Construction Trades and Extraction Workers	56,021	3.3%
Office Clerks, General	47,602	2.8%
Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	46,510	2.8%
Heavy and Tractor-Trailer Truck Drivers	38,548	2.3%
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	35,141	2.1%
Electricians	34,800	2.1%
Pipelayers	33,810	2.0%
General and Operations Managers	33,788	2.0%
Hazardous Materials Removal Workers	26,850	1.6%
Septic Tank Servicers and Sewer Pipe Cleaners	26,320	1.6%
Water Workforce Total	**1,679,971**	

Water utility occupations	Utility employment	Share of utility employment
Water and Wastewater Treatment Plant and System Operators	102,520	34.4%
Meter Readers, Utilities	17,500	5.9%
Electricians	14,900	5.0%
Plumbers, Pipefitters, and Steamfitters	12,850	4.3%
Pipelayers	9,880	3.3%
Industrial Machinery Mechanics	9,870	3.3%
Office Clerks, General	9,654	3.2%
Maintenance and Repair Workers, General	7,820	2.6%
Septic Tank Servicers and Sewer Pipe Cleaners	7,510	2.5%
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	7,080	2.4%
General and Operations Managers	4,441	1.5%
Bookkeeping, Accounting, and Auditing Clerks	4,124	1.4%
First-Line Supervisors of Office and Administrative Support Workers	3,570	1.2%
Landscaping and Groundskeeping Workers	3,537	1.2%
Customer Service Representatives	3,415	1.1%
Water Utility Total	**297,787**	

Source: Brookings analysis of BLS Occupational Employment Statistics
Note: Workers employed in water utility occupations represent a subset of all workers employed in the water sector. For example, 102,520 of the 115,840 water operators nationally are employed in water utilities.

Perhaps most importantly, water workers are not contained to only a few areas across the country but are employed everywhere. For instance, they consistently represent 1 to 2 percent of total employment in most of the country's metro areas. As Figure 2 shows, the country's 100 largest metro areas are job hubs for the water sector much like they are hubs for total U.S. employment. These 100 places are home to 1.1 million water workers, or 65 percent of the national total. Just 10 metro areas are responsible for 25 percent of the national total, led by New York, Los Angeles, and Houston. While not shown, smaller metro areas, non-metro areas, and rural localities also depend on many of these workers, boasting a total water employment of 584,000 workers.

The presence of water utilities in most places means their employment is also dispersed across all corners of the country. Similar to the water workforce as a whole, water utility workers are found in larger metro areas and smaller rural localities alike. The largest metro areas, however, tend to employ many of these workers overall; 109,000 workers, or almost 37 percent of their total national employment, are located in 25 metro areas alone, from Washington and Philadelphia to Seattle and San Francisco.

B. Water occupations not only tend to pay more on average compared to all occupations nationally, but also pay up to 50 percent more to workers at lower ends of the income scale.

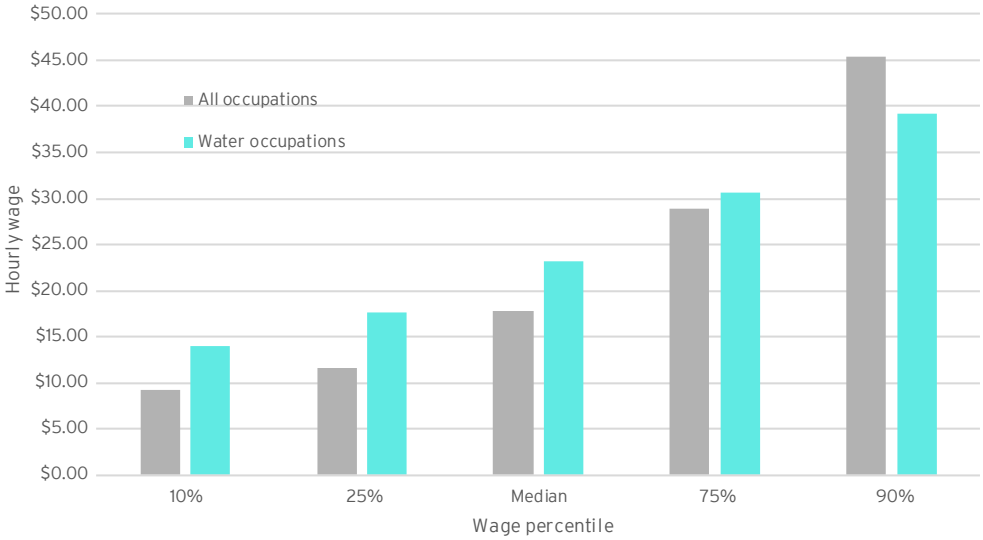
On average, water workers earn higher wages ($25.22 an hour) compared to all workers nationally ($23.86 an hour). These not only include higher-paying occupations overall, such as lawyers, hydrologists, and general and operations managers, but also span a variety of other technical and financial positions, such as civil engineers, environmental scientists, and budget analysts. Crucially, these wage premiums do not end there; water workers at lower ends of the income spectrum, especially at the 10th and 25th percentile, earn more competitive wages compared to all workers nationally. Specifically, water workers earn hourly wages of $14.01 and $17.67 at the 10th and 25th percentiles, respectively, compared to the hourly wages of $9.27 and $11.60 earned by all workers at these percentiles across the country.

In total, workers across 180 of the 212 water occupations—or more than 1.5 million workers—earn higher wages at both the 10th and 25th percentiles. Many of the biggest water occupations are represented here as well; workers employed in 23 of the 25 largest water occupations earn more at these percentiles. The only exceptions are: office clerks and laborers. As Table 2 shows, the fact that these equitable wages often appear in occupations where workers have lower levels of educational attainment further underscores the opportunity evident in the water workforce.

Furthermore, these equitable water wages reach all types of areas nationally. For example, Table 3 provides a snapshot of how water wages compare to the wages that all workers receive at the 10th and 25th percentile. From Minneapolis and Milwaukee to Kansas City and Phoenix, water workers can earn as much as $9 more per hour compared to all workers at these lower income levels. While several other factors, such as cost of living, need to be taken into account when comparing these differences across different regions, water workers are clearly gaining access to a variety of well-paying employment opportunities across the country.[57]

FIGURE 3

U.S. hourly wage comparison: water occupations vs. all occupations
2016



Source: Brookings analysis of BLS Occupational Employment Statistics

TABLE 2

Selected water occupations with higher wages at the 10th and 25th percentile
By educational attainment, 2016

Water occupation	Water employment	Percent with a high school diploma or less	10th percentile wage	25th percentile wage
Operating Engineers and Other Construction Equipment Operators	79,900	71.2%	$14.29	$17.19
Carpenters	19,449	68.5%	$13.02	$16.24
Pipelayers	33,810	63.0%	$12.66	$14.79
Sheet Metal Workers	22,084	62.8%	$12.81	$16.50
Septic Tank Servicers and Sewer Pipe Cleaners	26,320	61.4%	$11.13	$13.87
Industrial Machinery Mechanics	13,100	52.2%	$15.52	$19.10
Control and Valve Installers and Repairers, Except Mechanical Door	2,481	51.1%	$14.99	$19.01
Electricians	34,800	45.0%	$15.29	$19.02
Water and Wastewater Treatment Plant and System Operators	115,840	43.6%	$13.25	$16.96
Meter Readers, Utilities	17,780	42.9%	$11.03	$13.77
First-Line Supervisors of Mechanics, Installers, and Repairers	11,651	42.0%	$18.49	$23.74
All U.S. Occupations		**32.5%**	**$9.27**	**$11.60**

Source: Brookings analysis of BLS Occupational Employment Statistics and Employment Projections data

TABLE 3

Water wage differences in selected metro areas
2016

Metro area	Water workers		All workers		Difference in 10th percentile wages	Difference in 25th percentile wages
	10th percentile wage	25th percentile wage	10th percentile wage	25th percentile wage		
Minneapolis-St. Paul-Bloomington, MN-WI	$18.53	$23.87	$9.81	$13.33	$8.72	$10.54
Milwaukee-Waukesha-West Allis, WI	$17.70	$22.07	$9.05	$12.00	$8.65	$10.07
San Jose-Sunnyvale-Santa Clara, CA	$19.81	$25.81	$11.46	$16.08	$8.35	$9.73
New Haven, CT	$18.33	$22.31	$10.27	$13.52	$8.06	$8.79
Detroit-Warren-Dearborn, MI	$16.09	$20.73	$9.21	$11.71	$6.88	$9.02
Denver-Aurora-Lakewood, CO	$16.41	$20.11	$9.54	$12.79	$6.87	$7.32
Cleveland-Elyria, OH	$15.56	$19.48	$9.11	$11.57	$6.45	$7.91
Kansas City, MO-KS	$14.95	$19.03	$9.13	$12.02	$5.82	$7.01
Phoenix-Mesa-Scottsdale, AZ	$14.43	$17.87	$9.18	$11.64	$5.25	$6.23
Virginia Beach-Norfolk-Newport News, VA-NC	$13.97	$17.42	$8.74	$11.23	$5.23	$6.19

Source: Brookings analysis of BLS Occupational Employment Statistics

C. Most water workers have less formal education, including 53 percent having a high school diploma or less. Instead, they require more extensive on-the-job training and familiarity with a variety of tools and technologies.

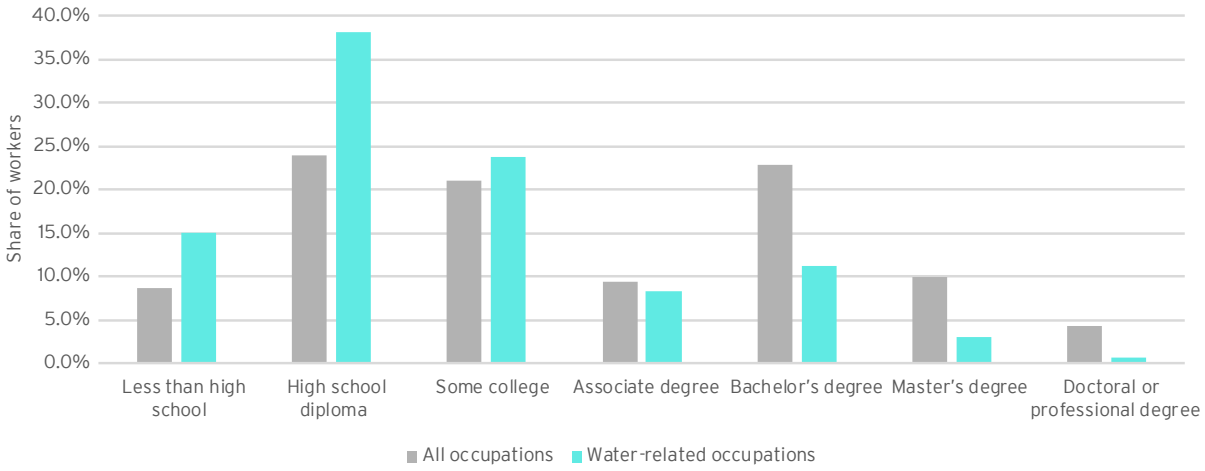
While 32.5 percent of workers across all occupations nationally have a high school diploma or less, a majority of water workers fall into this category, speaking to the lower levels of formal education found in many positions, as shown in Figure 4. In fact, workers across 111 different water occupations tended to only possess a high school diploma or less, including carpenters, welders, and septic tank servicers and sewer pipe cleaners.[58] Crucially, most of these workers still tended to earn competitive wages regardless of their levels of educational attainment, especially at the 10th and 25th percentile, as discussed in the previous finding.

However, as also illustrated in Figure 4, it is important to note that there are still many highly educated and specialized water workers as well. While only 14.9 percent of water workers hold a bachelor's degree or higher, landscape architects, environmental engineers, and computer systems managers often have higher educational credentials—and boast higher wages overall.

FIGURE 4

Educational attainment for workers in water occupations vs. all occupations

2016

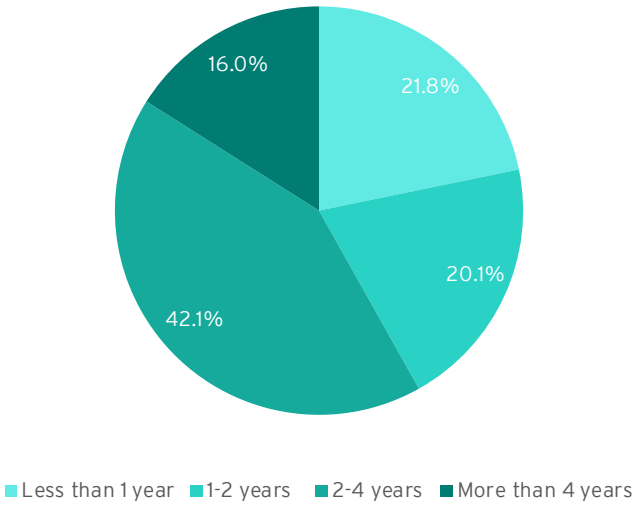


Source: Brookings analysis of BLS Occupational Employment Statistics and Employment Projections data

FIGURE 5

Related work experience often required in water occupations

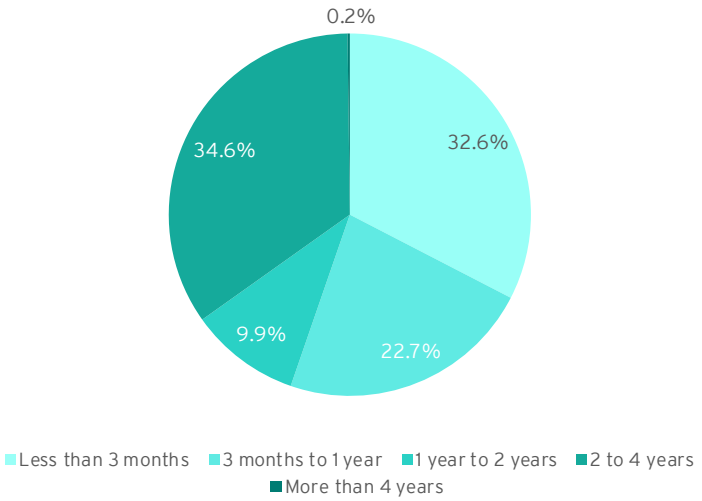
By share of employment, 2016



Source: Brookings analysis of BLS Occupational Employment Statistics and O*NET data

FIGURE 6

Levels of on-the-job training often required in water occupations
By share of employment, 2016



Source: Brookings analysis of BLS Occupational Employment Statistics and O*NET data

While levels of formal educational attainment are lower relative to many other occupational groups, nearly all water workers express a need to have some related work experience and on-the-job training, highlighting the importance of applied learning opportunities. For example, 78.2 percent of water workers need at least one year of related work experience, including 16 percent who need four years or more (Figure 5). Water treatment operators, plumbers, and HVAC technicians are among the many large occupations that require two to four years of related work experience.[59] In this way, water workers develop and depend on specialized skillsets over time.[60]

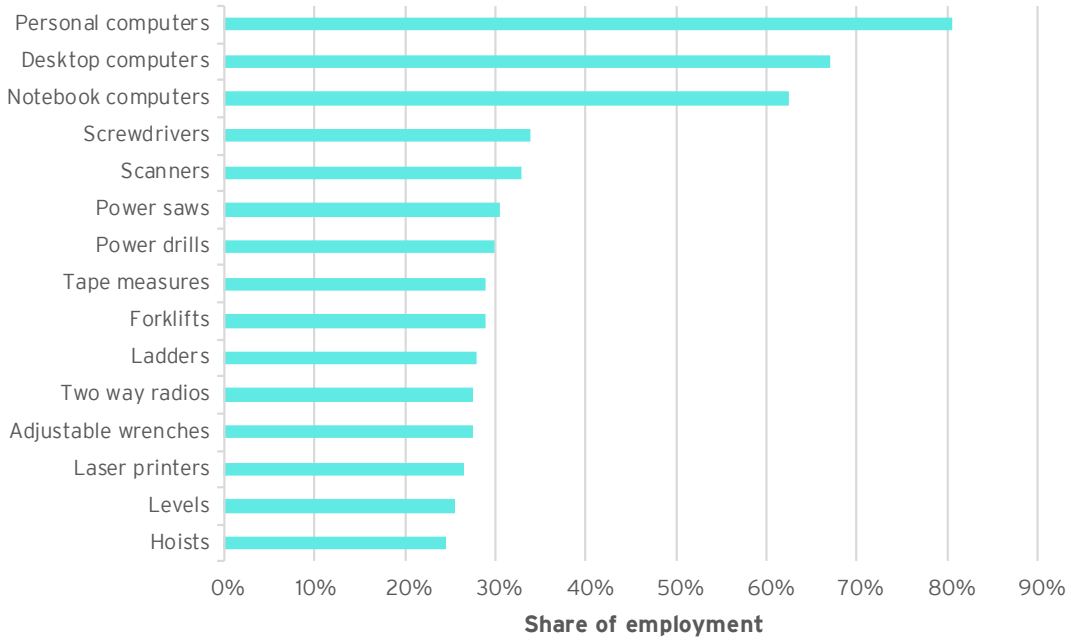
Not only do water workers require extensive experience, they usually need some level of on-the-job training, or hands-on knowledge, to qualify for their positions.[61] Although they tend to not require as much on-the-job training as they do related work experience—44.7percent of water workers need at least one year of on-the-job training—it is still a common requirement among the largest occupations overall. For instance, water treatment operators, electricians, and sheet metal workers need two to four years of on-the-job training. This is also significantly higher than what workers across all occupations nationally typically need; only 5.6 percent need more than one year of on-the-job training.[62]

Water workers embody the definition of skilled trades. On average, water workers use 63 different tools and technologies each, compared to the 6 tools and technologies typically used by workers in all occupations nationally.[63] While tools include specific physical commodities like screwdrivers, ladders, and claw hammers, technologies include specific software packages that deal with word processing, database management, and computer-aided design (CAD). Figures 7 and 8 below list the 15 most common tools and technologies used in water occupations, respectively. In many ways, the intense use of computers and software packages is indicative of their growing digitalization overall.[64]

FIGURE 7

15 most common tools used in water occupations

By share of employment, 2016

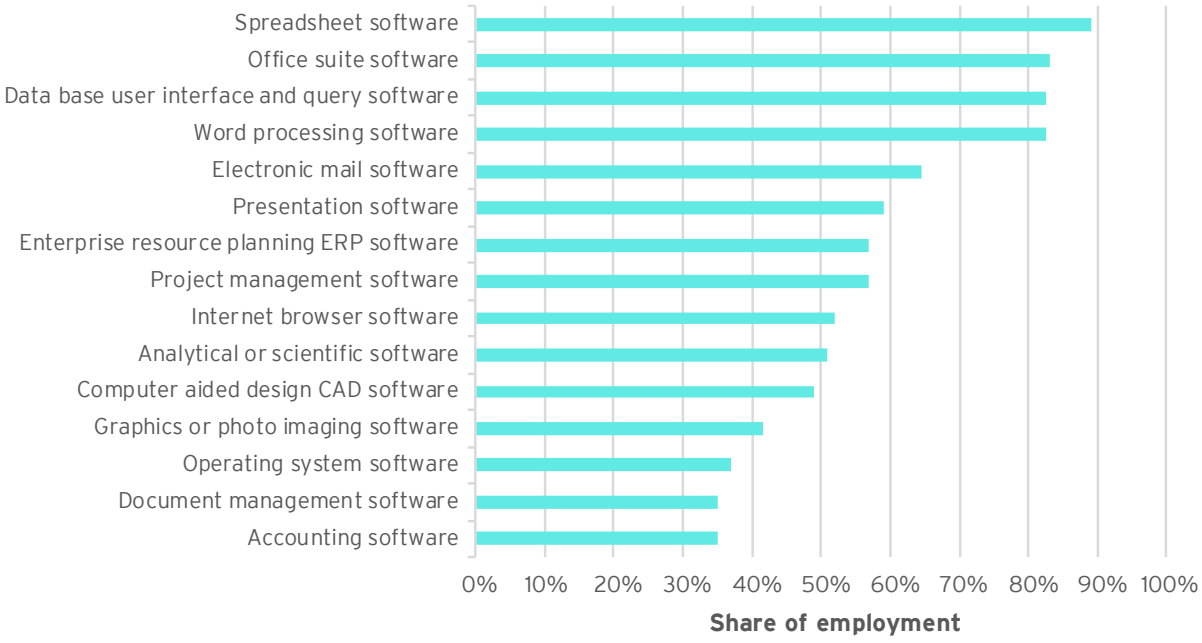


Source: Brookings analysis of BLS Occupational Employment Statistics and O*NET data

FIGURE 8

15 most common technologies used in water occupations

By share of employment, 2016



Source: Brookings analysis of BLS Occupational Employment Statistics and O*NET data

BOX A

WATER OCCUPATIONS SHARE SIMILAR EXPERTISE WITH OTHER INFRASTRUCTURE OCCUPATIONS

Work in the water industry requires a wide range of hard and soft skills; whether employed as carpenters and plumbers or as managers and budget analysts, water workers are often familiar with customer service, public safety, and administration, to name only a few content areas. Significantly, water workers possess higher levels of knowledge in many of the same content areas that other infrastructure workers do, who are employed in transportation, energy, and related industries.[65] By examining data in greater depth from O*NET—an information resource sponsored by the U.S. Department of Labor's Employment and Training Administration—it becomes easy to see how similar the water workforce and broader infrastructure workforce can be when it comes to their specific knowledge and skills development. And this similarity has significant and positive implications for shared workforce development ambitions.

Through a series of worker questionnaires, the O*NET database ranks the extent to which occupations require knowledge across 33 different categories on a scale from 0 (minimum) to 7 (maximum). Relative to all occupations nationally, infrastructure occupations score above average in 11 of these knowledge categories.[66] Previous Brookings analyses exploring infrastructure occupations have shown how many of these workers—from railroad conductors to ship captains to power line installers—are involved in the long-term operation and maintenance

TABLE 4. **Knowledge categories where infrastructure occupations score higher than the national average**

Knowledge category	Average knowledge score, all occupations (0-7)	Average knowledge score, infrastructure occupations (0-7)	Average knowledge score, water occupations (0-7)
Transportation	1.94	3.21	2.20
Mechanical	2.40	3.58	3.09
Public Safety and Security	2.60	3.48	2.75
Engineering and Technology	2.32	3.06	2.73
Building and Construction	1.64	2.36	2.81
Physics	1.87	2.49	2.00
Geography	1.77	2.37	1.71
Design	2.12	2.55	2.63
Chemistry	2.01	2.29	1.85
Law and Government	2.39	2.58	2.23
Telecommunications	1.78	1.92	1.42

Source: Brookings analysis of O*NET data

of the country's roads, waterways, and power plants. Not surprisingly, as illustrated in Table 4 below, they require especially high levels of transportation, mechanical, and public safety knowledge, among numerous other content areas.[67]

Critically, the water workforce tends to boast relatively high knowledge scores in the same categories as other infrastructure occupations. For instance, environmental engineers, civil engineering technicians, and electrical and electronics repairers tend to have extensive knowledge in many of these content areas, including mechanical, construction, and design knowledge.

Such *knowledge correlations* create a promising situation where water workers possess advanced skills that will often translate well across multiple infrastructure-related industries. Considering the 14.5 million jobs across the entire infrastructure supersector, this presents a national opportunity to create a shared workforce development platform covering common knowledge requirements, leaving only specialized trainings within specified occupations. The potential economies of scale—combined with the durable pathways to opportunity infrastructure jobs offer—make this a critical area for workforce development innovation.

D. Water workers tend to be older and lack gender and racial diversity in certain occupations; in 2016, nearly 85 percent of them were male and two-thirds were white, pointing to a need for younger, more diverse talent.

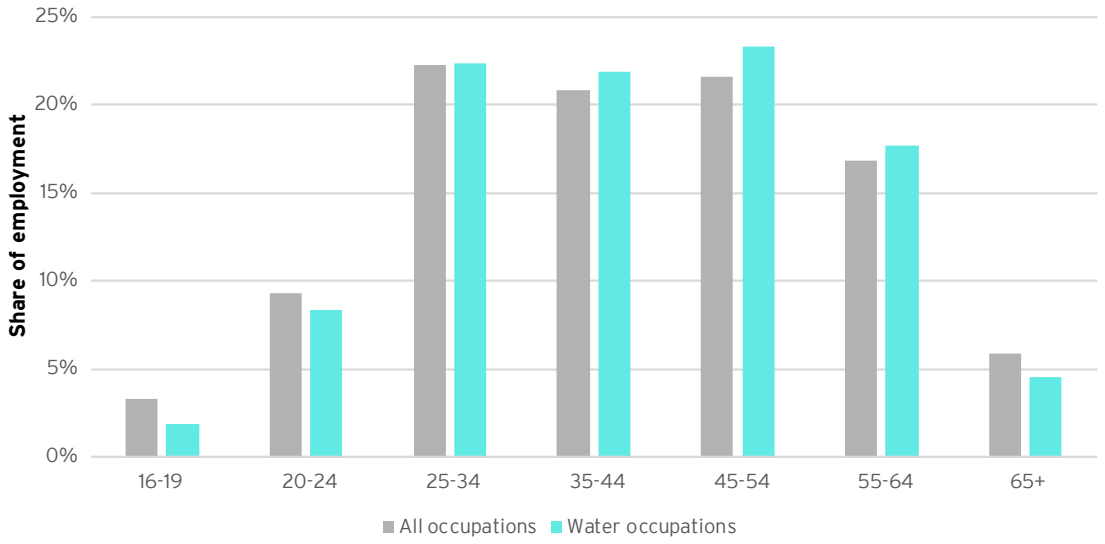
As many previous studies have shown, thousands of water workers are aging and expected to retire from their positions in years to come, creating a huge gap to fill for utilities and other water employers. With a median age of 42.8 years, water workers are slightly older than the national median (42.2) across all occupations. Yet some water occupations are significantly older, including architectural and engineering managers (48.9 years old), machinists (48.3), and water treatment operators (46.4). Depending on the specific utility, the age of individual employees must often be viewed in terms of their retirement eligibility as well, which may frequently be the case for these particular occupations.

However, the challenge is not simply limited to a workforce with a higher median age, which Figure 9 illustrates in greater detail. First, slightly more water workers (45.2 percent) are in the prime of their careers—considered 35 to 54 years old—when compared to all workers nationally (42.4 percent). Put another way, the water workforce has a relatively full pipeline of middle-aged workers. Second, and perhaps more importantly, there is a lack of younger talent in these jobs. Just 10.2 percent of water workers are under the age of 24, compared to 12.5 percent of all workers nationally, perhaps indicative of the more extensive work experience required in many water jobs.

Water workers are predominantly male as well, particularly among positions in the skilled trades. Although women make up 46.8 percent of workers across all occupations nationally, they only account for 14.9 percent of the water workforce. While women make up a majority of water workers in certain administrative positions—including 95 percent of secretaries—they only account for a fraction of employment in some of the largest water occupations overall, including plumbers (1.4 percent) and water treatment operators (5.2 percent).[73] Table 5 lists a few of the major water occupations that have relatively high and low shares of female workers.

FIGURE 9

Age range of workers in water occupations vs. all occupations
2016



Source: Brookings analysis of BLS Occupational Employment Statistics and CPS data

Finally, while the racial composition of the water workforce as a whole tends to generally parallel larger national trends, there is still a notable lack of diversity in certain occupations.

For example, nearly two-thirds of the water workforce is white, similar to the ratio found across all occupations nationally (65.3 percent). However, there is a particularly low share of black and Asian workers employed in the water sector relative to national averages across all occupations, which Figure 10 demonstrates. Together, they only make up 11.5 percent of the water workforce, compared to 18 percent of those employed in all occupations nationally. And while the Hispanic share of the water workforce (21.8 percent) actually exceeds the national average across all occupations (16.7 percent), this is primarily due to their concentration in construction jobs, as Table 6 illustrates. Along with black workers, in particular, they tend to be underrepresented in higher-level, higher-paying occupations involved in engineering or management.

In this way, while many water occupations pay more equitable wages and offer more accessible points of entry for all types of workers, especially in the skilled trades, there are still persistent gaps in black, Hispanic, and Asian workers filling some of these positions. This is especially true when looking at how many water jobs are found in the country's largest metro areas, where the working-population tends to be much more diverse but is often enduring high levels of poverty and unemployment.[74] From Detroit and St. Louis to Jacksonville and Orlando, for instance, thousands of water jobs are present, yet many residents, representing a variety of demographic and economic backgrounds, remain on the sidelines. While some individual water utilities and other water employers may have more diverse staff, the water workforce as a whole is still lacking in this regard nationally. However, viewing these trends more closely at a subregional scale offers additional insights into how the water workforce offers enormous economic potential in some of the country's most disadvantaged neighborhoods.

TABLE 5

Selected occupations with high and low shares of female workers, 2016

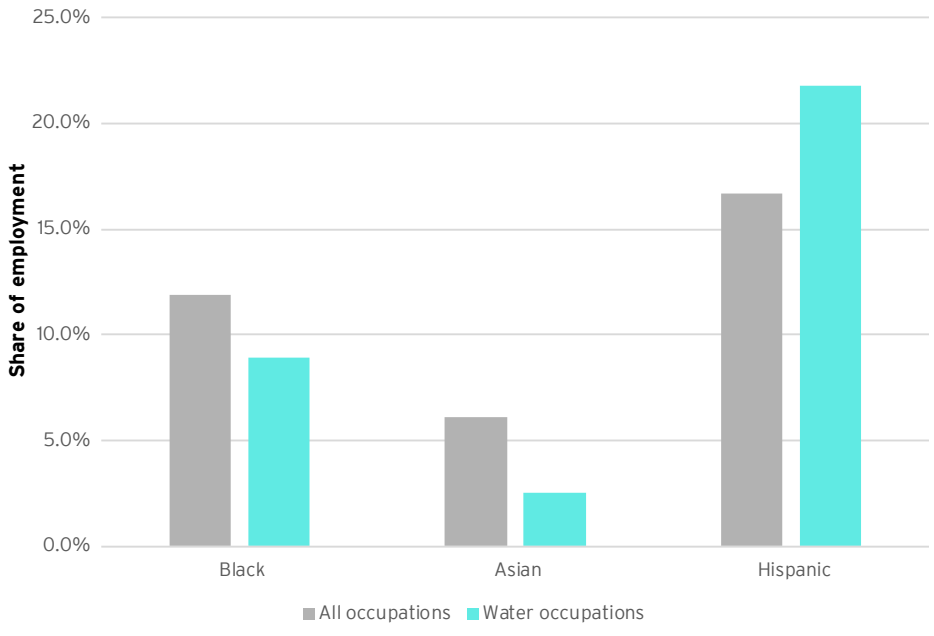
Water occupation	Water employment	Average hourly wage	Share of female workers
Secretaries and administrative assistants, except legal, medical, and executive	35,141	$17.38	94.6%
Receptionists and information clerks	4,150	$14.00	90.1%
Billing and posting clerks	2,973	$18.06	89.0%
Bookkeeping, accounting, and auditing clerks	22,308	$19.34	88.5%
Human resources specialists	3,385	$31.20	74.6%
Plumbers, pipefitters, and steamfitters	324,500	$26.94	1.4%
Heating, air conditioning, and refrigeration mechanics and installers	70,811	$23.23	1.4%
Pipelayers	33,810	$20.61	1.4%
Crane and tower pperators	6,189	$26.58	0.8%
Mobile heavy equipment mechanics, except engines	8,584	$24.43	0.5%
All water occupations	**1,679,971**	**$25.22**	**14.9%**

Source: Brookings analysis of BLS Occupational Employment Statistics and CPS data

FIGURE 10

Racial diversity in water occupations vs. all occupations

2016



Source: Brookings analysis of BLS Occupational Employment Statistics and CPS data

TABLE 6

Selected water occupations, by race, 2016

Water occupation	Water employment	Average hourly wage	Share of black/Asian/ Hispanic workers
Cement masons and concrete finishers	17,858	$21.02	60.9%
Painters, construction and maintenance	3,124	$19.96	60.0%
Industrial truck and tractor operators	2,938	$16.47	56.3%
Construction laborers	149,513	$18.22	55.8%
Landscaping and groundskeeping workers	7,766	$13.73	52.6%
Helpers--pipelayers, plumbers, pipefitters, and steamfitters	46,510	$14.73	52.6%
Helpers--electricians	2,930	$14.89	52.6%
Helpers, construction trades, all others	2,553	$15.12	52.6%
Civil engineers	6,188	$43.14	21.7%
Sales representatives, wholesale and manufacturing, except technical and scientific products	5,604	$32.89	19.8%
Hydrologists	6,300	$40.26	17.0%
Environmental scientists and specialists, including health	2,271	$36.23	17.0%
Construction managers	21,558	$47.84	16.8%
Chief executives	2,645	$93.44	15.0%
Lawyers	2,559	$67.25	14.7%
Cost estimators	15,609	$32.03	14.4%
All water occupations	**1,679,971**	**$25.22**	**33.3%**

Source: Brookings analysis of BLS Occupational Employment Statistics and CPS data

BOX B

MEASURING FUTURE EMPLOYMENT CHANGES IN THE WATER WORKFORCE

The infrastructure workforce is aging across the country, and almost 3 million workers will need to be replaced over the next decade due to retirements and other employment shifts.[68] In many ways, the water workforce reflects these broader trends, given its slightly older demographics. However, as estimated by the BLS Employment Projections program, there are several nuances to consider when looking at future employment changes in the water sector: (1) many water workers are not simply going to retire but are projected to transfer out of the sector; (2) the water workforce is projected to grow faster compared to national averages; and (3) these separations and levels of growth will lead to many openings in the water sector overall.

It is important to note that BLS no longer tracks "replacement needs"—the number of workers who will need to be replaced over the next decade—due to statistical limitations and other accuracy concerns.[69] Instead, BLS measures "occupational separations" to estimate an annual average of workers who are projected to permanently leave their jobs due to labor force exits (including retirements) and occupational transfers (including career changes).[70] In addition to projecting total employment growth, then, BLS looks at occupational separations as a way to measure employment shifts over time; and in many cases, even as new openings emerge as a result of future job growth, there will be far more openings as a result of workers leaving their current jobs.

From 2016 to 2026, BLS projects 10.6 percent of water workers each year on average to either permanently leave (i.e. retire) or transfer out of their current jobs.[71] This is slightly below the national average across all occupations (10.9 percent) over the same span, but there are many specialized water occupations facing above-average separations. In other words, while many water workers may be eligible for retirement and are simply going to exit the labor market, many others are searching for other jobs in the water sector or beyond it. Septic tank servicers and sewer pipe cleaners, for example, are projected to leave their current jobs more frequently (12.3 percent), signaling potential struggles within these occupations.

BLS also projects water occupations to see faster overall employment growth (9.9 percent) compared to all occupations nationally (7.4 percent) between 2016 and 2026. Figure 11 shows some of the water occupations with the best growth potential, including several technical positions like software developers and information security analysts. There is also expected growth in more traditional skilled trades like pipelayers and plumbers.

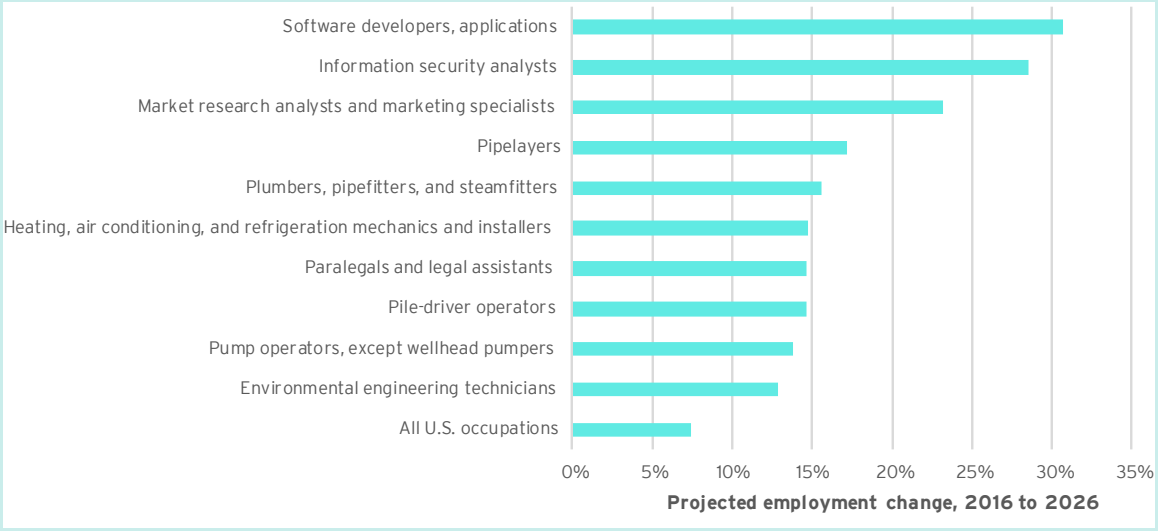
Together, the combination of separations and future growth in the water sector is projected to lead to about 220,000 occupational openings—on average each year—from 2016 to 2026. Almost 38 percent of these projected openings, 82,500, are concentrated in three occupations alone: plumbers, construction

laborers, and operating engineers. An additional 9,200 annual openings are projected for water treatment operators; many other occupations—such as electricians, carpenters, and general and operations managers—are also projected to see thousands of openings each year. In short, many of the biggest water occupations are projected to have thousands of open positions over the next decade in need of skilled talent.

While the accuracy of employment projections can be imperfect, this much is clear: the water workforce should continue to play a sizable role in the labor market for years to come.

And the sector's long-standing fixation on retirements does not fully capture the vast array of concerns likely to hit water workers and employers alike, including a continual ebb and flow of labor entering and leaving different positions. Similar to the entire U.S. economy, there are also likely to be uncertainties surrounding new technologies and automation—including the potential phasing out of some jobs and the potential creation of new jobs requiring new skills.[72] Continued monitoring of these trends is crucial to ensure the water workforce remains ready to take on new tasks and fill positions of greatest need.

FIGURE 11. **Selected water occupations projected to see faster employment growth**
2016 to 2026



Source: Brookings analysis of BLS Employment Projections data

IMPLICATIONS

At a time when many workers remain disconnected from economic opportunity and lack the skills, training, or awareness of where to turn, the water sector offers a variety of pathways to more inclusive employment outcomes; in other words, it is supporting economic opportunities that are more shared and enduring for all types of workers.[81] Water jobs tend to pay more than the average American job, especially at lower ends of the income scale. They also require significantly less formal education and help workers develop a wide range of technical skills. And with 1.7 million total jobs and geographic diffusion, water jobs exist in every corner of the country.

However, while the water sector offers clear opportunity for so many prospective workers, there are still several gaps to address in order to hire, train, and retain a skilled and diverse water workforce in years to come. Expanding recruitment, improving training efforts, and responding to other workforce needs cannot simply fall on the shoulders of utilities—and other employers—who are often balancing multiple operational responsibilities. The limited financial and programmatic capacity of these actors calls for a clearer recognition of the most pressing workforce priorities, a more targeted approach to investments, and a more coordinated response by all types of local, state, and national leaders.

Understanding some of the fundamental barriers facing the water sector is essential in this respect, as outlined below. Not all regions, of course, have the same ability to respond to these challenges, but they offer a starting point to drive further conversations, collaborations, and actions.

MAJOR NEEDS IN WATER WORKFORCE DEVELOPMENT

- Acknowledge the varying scale and capacity of different communities—and utilities across urban and rural areas in particular—to expand the water workforce opportunity
- Emphasize that the water workforce needs greater public visibility, especially when trying to reach younger workers and other prospective job candidates
- Consider barriers to support a more diverse water workforce, including the importance of looking for talent in places that may not traditionally have attracted as much attention
- Investigate why identifying and hiring skilled workers remains a struggle for many utilities and other water employers, including the lack of proactive recruitment strategies
- Note the need for more extensive work experience and on-the-job training in the water sector, including the frequent difficulty to equip workers with hard and soft skills
- Examine the ongoing need to retain and grow talent within the water sector, including the development of new competencies and adapting skills to new demands and technologies

First, **there must be an acknowledgement of the varying scale and capacity of different communities—and utilities across urban and rural areas in particular—to tackle these challenges and ultimately expand the water workforce opportunity**. For instance, personnel costs comprise more than 47 percent of total operations and maintenance expenses each year for utilities, and growing pension obligations are increasing the burden.[82] Additional capital expenditures to repair pipes and other facilities can also create a difficult balancing act for utilities, who may feel the need to prioritize physical infrastructure upgrades over looming workforce demands.[83] Financial and programmatic capacity issues can be a particular concern among smaller utilities; after all, more than half of all water and wastewater utilities nationally have only one or two employees, and about 85 percent have three or fewer.[84] Some smaller systems even share operators or depend on volunteers to reduce costs.[85] As a result, there are only so many supervisor-level positions in some utilities, and career advancement for individual workers often means finding another agency or organization that is looking to hire. Training and salaries are necessary for utilities to meet their obligation to the public to provide safe, reliable, and affordable service, but they are often limited in their financial means to do so.[86]

Second, as the background section briefly described, **the water workforce needs greater public visibility**, especially when it comes to its ability to support more inclusive economic opportunities. The water workforce captures a broad range of accessible employment opportunities, from those involved in the skilled trades to a variety of technical, financial, and administrative positions. But despite the higher pay and lower formal educational barriers to entry, students and other prospective workers are still not gaining the needed skillsets, not looking to pursue careers in the water space, or may simply fail to get into entry-level positions due to a lack of experience and other factors.[87]

Indeed, several studies point to a general shift away from the skilled trades and

vocational education among students, which is compounded by the many existing water workers nearing or eligible for retirement.[88] The physically demanding nature of work in some water jobs can also be a turnoff for prospective workers and existing staff.[89] And it's not just entry-level job candidates either—there is a shortage of mid-career professionals to take on supervisory roles as well.[90] The timing could not be worse for water utilities, in particular. Many utility employees first started working for utilities during a "hiring boom" in the 1970s when the federal government launched new water investments and implemented new regulations across the country.[91] For instance, in an independent survey of water and wastewater professionals, respondents were on average 56 years old, and 38 percent were 60 years or older; meanwhile, just 3 percent of respondents were 30 years old or younger.[92] These responses point to an even more dire employment challenge than this report has shown.

Third, **the water sector continues to struggle with a lack of diversity**. The water workforce is aging and faces a growing employment gap. Although the water sector provides durable employment opportunities for many male workers concentrated in construction and other related activities—who were hit particularly hard during the recession—there are clear areas where more women could be exploring water careers.[93] Women are consistently under-represented across many water utilities, particularly in the skilled trades and in management positions, where they make up just 6 percent of water utility CEOs.[94] The underrepresentation among black and Asian workers overall—and Hispanic workers in certain occupations—spells a particular need to connect with a wider pool of prospective workers, particularly those living in areas with higher levels of unemployment and poverty. Even though utilities are often located in disadvantaged communities where a diverse range of residents and workers live, they do not always reflect the demographics of the population they serve.[95] And while some utilities boast higher shares of black, Asian, and Hispanic workers, there can still be notable gaps in particular occupations.[96]

Yet, the report has pointed to the importance of looking for talent in places that may not traditionally have attracted as much attention. For instance, since water workers rely on broad-based infrastructure knowledge, including familiarity with construction, engineering, and design principles, there are likely many workers with complementary and transferable skills employed in transportation, energy, and other related industries. Community colleges and technical schools are already providing coursework and instruction in these fields, and they should continue to advise students and partner with employers in support of cross-cutting learning opportunities. In addition, the fact that the physical operations of many water utilities are located in areas with lower levels of educational attainment, higher unemployment rates, and higher levels of poverty illustrates the vast economic opportunity facing communities nationwide; while utilities may not have hiring needs in all these areas, they stand as important anchor institutions that could serve as outlets for additional training and collaboration.

Fourth, **identifying and hiring skilled workers remains a struggle for many utilities and other water employers**. The creation of new internship programs, directed toward high school students and other young workers, is helping to address these gaps, but many job candidates still lack the minimum experience needed to fill certain positions. There is also often a lack of predictable long-term funding and staffing for these efforts.[97] Furthermore, the creation of more proactive, visible recruitment strategies helps, drawing from efforts across multiple employers, training providers, and other local leaders. However, collaboration among these different groups can be notoriously difficult; for instance, competition and hoarding of information among different employers looking for workers with similar skillsets can stop collaboration before it starts.[98] Instead,

recruitment efforts often occur in isolation and some workers may have limited awareness about what specific water positions are available.

Given the highly localized nature of water operations, capital planning needs, and labor demands, there are no one-size-fits-all strategies to address these recruitment challenges, which often spill over into the hiring process. For example, when looking to contract out certain projects, utilities can rely on local hiring preferences to support minority and women business enterprises (M/WBEs), but this requires creative thinking, diligent monitoring, and continued experimentation.[99] In addition, job classifications developed by human resources decades ago—and created to support merit-based hiring and more equitable, fair employment—may make adjusting new job specifications and requirements a long and political process.[100] Likewise, some utilities may need to partner with broader city departments to receive necessary approvals for new job classifications or training programs. Finally, existing human resources staff may not always have the capacity, flexibility, or experience themselves to relate to (or address) the concerns of more diverse, nontraditional job candidates.

Fifth, **the need for more extensive work experience and on-the-job training in the water sector highlights the skilled tasks that the water workforce carries out every day, but equipping workers with these skills is not always easy**. As water workers embark on long-term careers that depend on lifelong learning, the importance of supporting applied learning opportunities is crucial, and that support—financially, programmatically, or otherwise—may not always be in place. In addition to emphasizing technical and vocational education, for instance, support for internships, apprenticeships, and other training programs is also required. And while equipping younger students with needed skills and experience matters, so does training (and retraining) workers further along in their careers. Prospective job candidates often need to acquire knowledge quickly, but gaining experience is not always easy; training programs are often geared toward younger workers, licensing requirements can vary widely across states, and workers with nontraditional backgrounds may not even know where to start.

Although levels of formal education required can be low for many positions in the water sector, workers still require an extensive range of knowledge: chemistry theory, hydraulics principles, water and ventilation systems, basic plumbing, math, and statistics, among other disciplines. Many water workers must understand operating manuals and plumbing specifications, operate precision instruments, and communicate technical and non-technical information.[101] The sector is becoming increasingly dependent on supervisory control and data acquisition (SCADA) systems and other related computer systems, which may decrease the number of operators needed to run water plants and require an evolving set of qualifications for future job candidates.[102] However, not all workers gain the needed education or experience to develop competency in the mix of hard and soft skills essential to their occupation, and basic math, science, and English skills that high schools are supposed to teach do not consistently get taught.[103] These varying skill requirements may also fall outside the typical job readiness training efforts and assistance programs offered by a range of community partners, including WDBs, which help connect prospective workers with potential employment opportunities.[104]

Finally, **workers already employed throughout the water sector must continue to strengthen their competencies and adapt their skills to a rapidly evolving workplace, increasingly filled with new demands and technologies**. The need to retain and grow talent within the water sector remains a pressing concern for utilities and other employers who depend on a steady

stream of operators, engineers, analysts, and managers, among numerous other workers. Projected replacement needs, moreover, are expected to grow in coming years, including high levels of turnover among some of the most specialized water occupations. Whether investing in continued training, defining new competency models, or empowering workers in other ways, many employers are striving to develop and hold onto skilled water workers. Doing so, though, often hinges on progressive leadership in these organizations, an ability to balance long-term budgets with staffing needs, and an appetite for experimentation—which can be rare in a sector known more for its cautious, conservative approach to managing change.[105] Moreover, many utilities face pressure to keep rates down, fail to make adequate investments in their workforce, and do not develop proficiencies in competency analysis, which result in poor training for their current staff and inefficient knowledge management.[106]

Without actively investing in the current workforce or qualified candidates, the water sector will likely continue to struggle retaining and upskilling workers. For example, while water utilities offer numerous employee benefits and tend to pay attractive wages, salaries can be modest compared to competitor industries, including private sector peers in energy or construction.[107] In regions with a high cost of living and productive economies, the lure of relocating to a lower-cost region or another employer can be a frequent consideration for workers with in-demand skills.[108] Meanwhile, smaller, more rural utilities frequently lose workers looking to transition to bigger utilities that may offer more growth opportunities and higher pay.[109] Across the entire economy, many younger workers are also showing an interest in jumping from one employer to another on a more frequent basis than in the past; this new normal is a reality that utilities and other water employers are likely to face in future retention efforts.[110]

BOX C

WATER UTILITIES AS ECONOMIC ANCHORS

Water utilities represent significant employers for water workers at both a national and metro level. In particular, they control some of the most critical public infrastructure assets in need of long-term operation and maintenance and in many ways are anchor institutions for their communities. The subregional analysis here aims to delve deeper into that role by exploring where utilities are located and how their establishments relate—geographically and otherwise—to the communities they serve.[75]

Using a spatial dataset based on EPA's Facility Registry Service (FRS), this analysis looks at more than 12,847 publicly-owned water treatment plants nationally, with a particular focus on their location and the characteristics of the neighboring population served.[76] The water treatment plants are organized by ZIP code which are then linked to census tracts to investigate several relevant variables, including demographics, educational attainment, unemployment, and poverty rates.[77,78]

These data are based on five-year estimates from the American Community Survey (ACS).

In total, the plants analyzed are found across 32,659 unique census tracts, serving a total population of nearly 146 million people. Given the enormous geographic extent and reach of these plants, the demographic characteristics of the population they serve often closely mirror those of the United States as a whole. However, there are three distinguishing characteristics worth noting: water treatment plants tend to be located in neighborhoods with (1) lower levels of educational attainment, (2) higher unemployment rates, and (3) higher levels of poverty, speaking to their importance as economic anchors to many disadvantaged workers and residents.

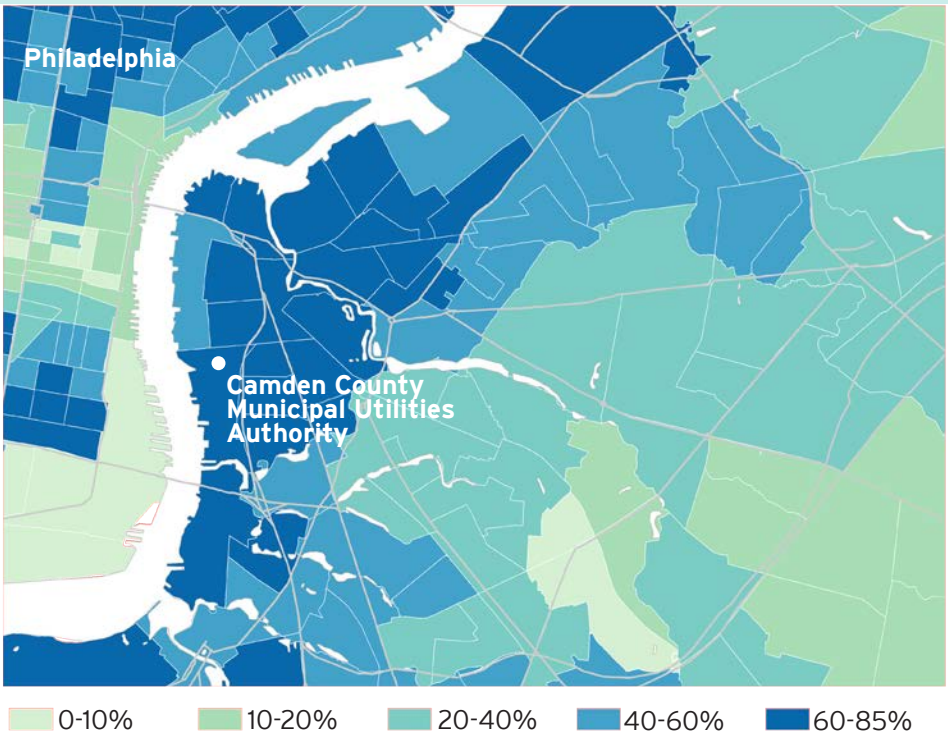
For example, in tracts with water treatment plants, 43.6 percent of workers have a high school diploma or less, compared to 32.5 percent of all workers nationally.[79] In addition, unemployment rates typically exceed 5 percent, compared to the 4.5 percent unemployment rates seen nationally in 2016. Finally, 15 percent of residents in these same tracts live below poverty, slightly more than the 14 percent poverty rate seen nationally in the same year. Collectively, water treatment plants are located in tracts where: 42.5 million workers have a high school diploma or less, 5.6 million workers are unemployed, and 21.2 million residents live below the poverty line.

Of course, there is wide variation in these demographic and economic characteristics depending on the particular region—and tract—observed.

As just one example, consider the case of Camden, New Jersey. Among those living near one of the biggest water treatment plants in Camden, 69.3 percent of workers have a high school diploma or less and unemployment stands at almost 10 percent. The poverty rate stands at 57.5 percent. Furthermore, nearly half of all residents—47.4 percent—are black, which the previous finding has shown are a group of workers underrepresented in the water sector compared to national averages. Camden continues to face a long list of economic and environmental struggles, but leaders are pioneering collaborative solutions focused on infrastructure investment and workforce development. Led by the Camden County Municipal Utilities Authority (CCMUA), the region's primary wastewater utility, a variety of groups have partnered together to improve existing water services, promote green infrastructure development, and help local residents fill positions connected to all these activities.[80] One such effort, PowerCorps Camden, has helped promote environmental stewardship and applied learning in the community by recruiting young people to maintain green spaces and improve formerly polluted sites as part of a six-month AmeriCorps program. Several additional regional efforts are highlighted in the recommendations section below.

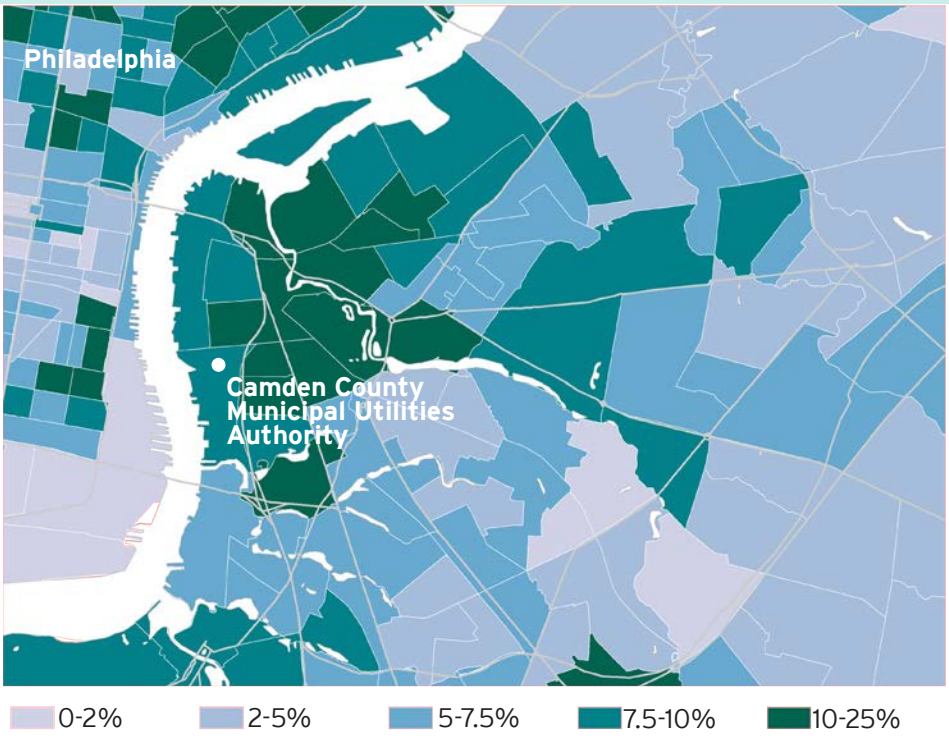
While Camden only provides a snapshot of this issue, it demonstrates how water utilities—and the public assets they oversee—can potentially play a key economic role in the communities they serve. Obviously, the hiring needs and capacities of each utility vary from region to region—and from facility to facility—but many utilities are already pioneering new workforce strategies across the country. While doing so, they are forging new collaborations and training efforts to not only improve their operations, but also to connect more workers with economic opportunity. This analysis shows that utilities are strategically located in many places where the benefits could spell economic gains in their backyard.

FIGURE 12. **Share of Camden workers with a high school diploma or less, 2016**



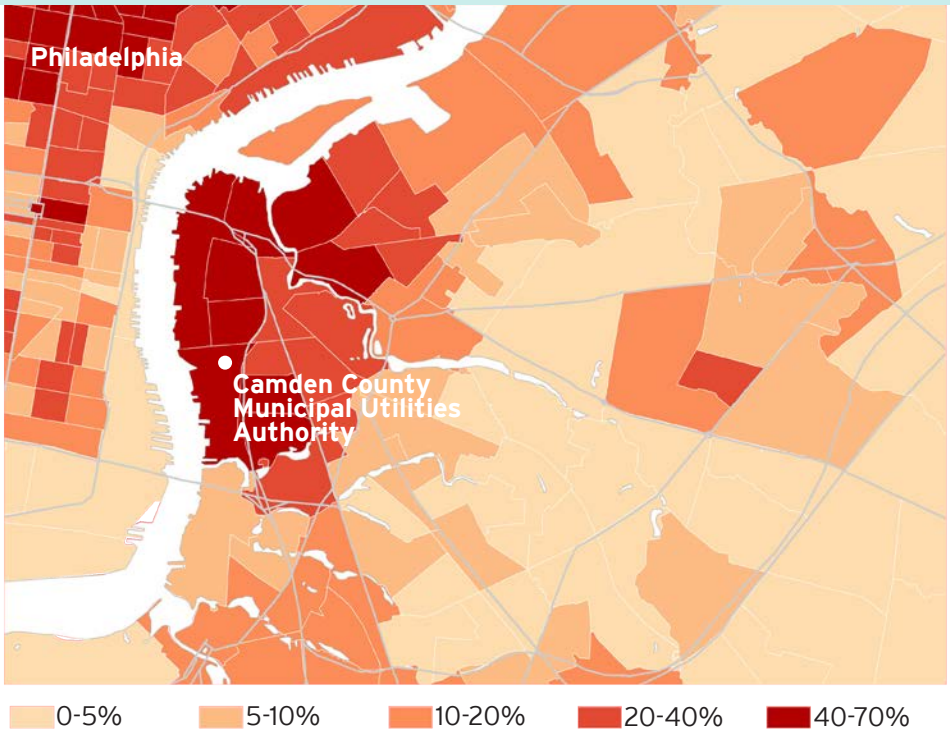
Source: Brookings analysis of EPA, FRS, and Census ACS data

FIGURE 13. **Unemployment rates in Camden, 2016**



Source: Brookings analysis of EPA, FRS, and Census ACS data

FIGURE 14. **Poverty rates in Camden, 2016**



Source: Brookings analysis of EPA, FRS, and Census ACS data

RECOMMENDATIONS

Together, water utilities, other water employers, community partners, and federal and state leaders have a long task list to further elevate and expand the country's water workforce opportunity. Ultimately, given the nuances in many of the barriers to hire, train, and retain skilled water workers, locally driven actions are crucial to develop new strategies and target new investments.

But the scale of the issue demands broader regional collaborations and national support to build additional financial, technical, and programmatic capacity. Not all places, or utilities, are equally equipped to accelerate their workforce development efforts, even if they have an appetite to test out new ideas.

To revamp the nation's water workforce there needs to be a **new water workforce playbook** to accelerate thinking, action, and investment. No single strategy—or individual actor—is going to lead these efforts, and some issues will be costlier and take longer to address. In many ways, utilities and other water employers need to be supported and encouraged to take action. Rather than continually reflecting on what needs to be done, having a consistent and discrete list of action items can help utilities, other water employers, community partners, and national and state leaders begin to prioritize and launch solutions.

It is key that these actions do not start or end in utilities and employers that already have resources at their disposal. Rather, these actions should be broadly applicable across all types of municipalities, where all types of organizations and policymakers can help create an environment that supports additional innovation in water workforce development.

With that context in mind, the following three sections discuss specific steps that three

different groups can take in the years to come. The first section covers utility- and employer-driven actions, developed and executed internally. The second section considers several regional actions, driven in concert between employers and other community partners. Finally, several national and state-level actions are proposed, designed to build additional local financial and technical capacity. As a starting point, these strategies can serve as a guide for communities and leaders depending on their specific needs and priorities.

Many of these recommendations emerged during site visits and interviews carried out in advance of this report's release. Over the course of several months, Brookings researchers traveled to three different regions—California's Bay Area; Louisville, Kentucky; and Camden, New Jersey—to better highlight best practices and other on-the-ground experiences in water infrastructure. Brookings researchers also held an expert roundtable in Washington, D.C., to investigate cross-cutting national issues focused on water workforce development. In addition to exploring the role of water utilities to support greater economic opportunity, these events aimed to bring several different voices to the table—including educational institutions, workforce development groups, and researchers, among other stakeholders—to reflect on a broad scope of issues related to the recruitment, training, and retention of water workers.

1. Utilities and other water employers need to empower staff, adjust existing procedures, and pilot new efforts in support of the water workforce

EMPLOYER-DRIVEN ACTIONS
✓ Hire and train dedicated staff to meet with younger students, connect with more diverse prospective workers, and explore alternative recruitment strategies
✓ Create a new branding strategy to more effectively market the utility or organization to younger students and a broader pool of prospective workers
✓ Account for workforce needs as part of the budget and capital planning process, while creating more detailed and consistent labor metrics
✓ Update or create new job categories to provide greater flexibility for potential applicants
✓ Develop competency models—or customize existing models—to promote continued learning and skills development among staff
✓ Design and launch new bridge programs, including "water boot camps," to provide ways for younger workers and other nontraditional workers to explore water careers and gain needed experience
✓ Implement a formalized mentorship program to provide interns and younger workers a clear point of contact and better monitor their career progression

Locally driven actions are crucial to help workers achieve the needed skills and identify the available pathways to securing greater economic opportunity through the water sector. And these actions naturally start at the source: utilities and other water employers looking to hire, train, and retain a skilled, diverse workforce. Investing in a more skilled workforce, after all, can help them improve their operations and realize other efficiencies over time.[111] Water utilities, in particular, not only need to focus on recruiting and retaining workers for themselves, but they should be a standard bearer for the entire water sector. Through a variety of internal programmatic changes, they can heighten awareness of the water workforce opportunity and further prioritize action around faster hiring, more flexible training, and more predictable retention.

To do so, utilities and other water employers need leadership willing to explore and test out new ideas. Ideally, other public agency departments, including those involved in IT management, parks maintenance, and general facilities oversight, need to be involved in these efforts as well, given the wide reach of many water infrastructure activities.[112] Engaging in continuous knowledge sharing and experimentation, and piloting new efforts, depends on active leaders coordinating across different programs. And it's not just about leadership at the top, but individual staff stepping up and taking action—and giving these staff the flexibility and time to pioneer new ways of thinking and administer change.

For instance, expanding public outreach and awareness, particularly among a more diverse set of prospective workers, depends on having skilled staff in place to pioneer new strategies. Utilities and other water employers should **hire and train dedicated staff to meet with younger students, connect with more diverse prospective workers, and explore alternative recruitment strategies**. Relying on word-of-mouth and hiring "friends and family" have often defined past entry points for workers into the water field, which does not come close to addressing the more pressing needs of the water sector today.[113] There is a need to more directly market and reach out to the community and having a liaison in place to coordinate with other community partners. For instance, several utilities are already doing this, including the East Bay Municipal Utility District, which has an equal employment opportunity coordinator seeking to further diversify the agency's workforce.[114] Having skilled human resources, communications, and operations staff in place—who understand the work and can communicate it clearly to prospective candidates—is essential to future outreach. And making sure these outreach efforts are grounded in hiring workers for the most pressing, mission-critical jobs is key.[115]

Expanding recruitment efforts also hinges on the development of a more proactive and intuitive message on water careers. To help connect with younger students and a broader range of prospective workers, utilities and other water employers should **create a new branding strategy** to more effectively market their organization—and the variety of work opportunities in the water space. Developing clearer metrics on the age and diversity of new workers can help further contextualize the goals of such a strategy. For example, the Baltimore Public Works Department recently rebranded some of their training efforts under a new title and logo, "Y-H2O," to appeal more directly and intuitively with students and other prospective workers.[116] In particular, connecting earlier and often with students can help create a stronger pipeline for years to come, especially in elementary and middle school. Demonstration projects in the community, including new rain gardens and other visible green infrastructure upgrades, can also create opportunities for the water sector to highlight their leadership in the community and introduce their work, not just as service providers but as environmental stewards.

Programmatically, conducting more extensive public outreach and hiring more workers, though, require a long-term commitment to balancing infrastructure and facility budgets (typically the biggest priority for utilities) with workforce demands. Succession planning is crucial in this respect, but so is a more detailed accounting and measurement of labor demands, including where hiring needs in the organization are most pressing and what skills are most needed. In turn, utilities and other water employers should **account for workforce needs as part of the budget and capital planning process, while creating more detailed and consistent labor metrics.** This is not only true when projecting labor needs at individual facilities as part of the capital planning process, but it is also needed when looking at the demographic profile of existing workers and planning for the rise of digital skills and other emerging technologies in the workplace. The San Francisco Public Utilities Commission (SFPUC) is one of many utilities, for instance, that has aimed to customize their budget planning process not simply in light of the physical infrastructure demands, but in terms of the pressing staffing needs as well.[117]

At the same time, getting more skilled workers on board quickly depends on adjusting internal human resource processes and other prevailing administrative procedures, which may be holding back the creation of newer hiring and training platforms. Many human resource departments may instead by focusing on operational needs rather than defining new strategic priorities.[118] Utilities and other water employers should **update or create new job categories to provide greater flexibility for potential applicants**. Among public sector employers, in particular, strict civil service hiring requirements—often developed decades ago—make it hard to create "exceptions" to hire candidates who may lack a very narrowly-defined set of credentials and experience. Adjusting these anachronistic practices is easier said than done but should be addressed with a greater sense of urgency, as some public agencies continue to consider on an ongoing basis.[119]

Once workers are actually in the system, employers must continue investing in their skills development and valuing their role in the organization. One way to do so is for utilities and other water employers to **develop competency models—or customize existing models—to promote continued learning and skills development among staff**. Specifically defining and measuring the types of knowledge, skills, and abilities needed among water workers can better target future training efforts; competency models help organizations do so in light of individual worker needs and career trajectories, in addition to the actual positions of greatest need. Some utilities are beginning to test out new models in this way, although the time commitment to do so must remain a consideration.[120] Likewise, utilities like Atlanta's Department of Watershed Management are continuing to focus on new technologies in the workplace and the need to consider "smart utility" actions in the future.[121]

Of course, training workers, especially those just starting out their water careers, depends on having well-defined, accessible opportunities to develop skills and gain needed experience. And while existing internship and apprenticeship programs help in this respect, the demand to fill these programs often outstrips the number of openings—and not all candidates may qualify. For that reason, utilities and other water employers should **design and launch new bridge programs, including "water boot camps," to provide ways for younger workers and other nontraditional workers to explore water careers and gain needed experience.** It is critical that prospective workers, including students and other nontraditional candidates like veterans, have flexible opportunities to become familiar with the work and the types of opportunities available in the water sector. On-the-job training and other work-based learning can ensure all types of workers gain timely experience and skills.[122] Furthermore, connecting with high schools can ensure students at the beginning of the water career pipeline are gaining the basic skills needed for successful vocational training.

From California to Kentucky to New Jersey, a variety of innovative training programs are emerging to equip workers with needed skills and experience. In the Bay Area, for instance, utilities have worked closely with local schools and neighborhoods to provide engaged learning opportunities, including green infrastructure demonstration projects.[123] Likewise, in Louisville, some employers, including those in the energy sector, have already organized or are looking to hold weekly boot camps to quickly introduce prospective workers to careers in the trades.[124] Through its Green Jobs Summer Ambassadors Program, Camden has sought to create a quick immersive experience for high school students aimed at introducing them to green and water-related careers, which has already helped support 50 different green spaces across the city.[125]

The creation of these programs, though, should only represent a start to expanding needed skillsets and exposing workers to water careers. Some of the most innovative training programs (including those listed above) are still nascent, and continued monitoring of program performance is essential to gauge the outcomes of past interns and better meet the needs of new interns. Utilities and other water employers should **implement a formalized mentorship program to provide interns and younger workers a clear point of contact and better monitor their career progression.** The Louisville Metropolitan Sewer District (MSD), for instance, is currently testing out this approach in its internship programs.[126] Supporting mentorships would also help empower existing workers in their current roles, who often represent the best teachers and models to demonstrate the skilled nature of their everyday work.

2. A broad range of employers and community partners need to hold consistent dialogues, pool resources, and develop platforms focused on water workers

REGIONAL ACTIONS
✓ Identify a common regional point person—or organization—to schedule and steward consistent meetings among a broad range of community partners
✓ Hold an annual water summit/meet-and-greet where prospective workers, employers, and community partners can connect with one another regionally
✓ Out of these dialogues, develop a comprehensive water workforce plan, highlighting regional training needs and avenues for additional collaboration
✓ Develop a more predictable, durable channel of funding to support these efforts, driven by public fees and private sector support
✓ Strengthen local hiring preferences in support of more minority and women business enterprises
✓ Create a new web platform to connect water workers and employers, serving as a simple, consolidated site for regional job postings
✓ Launch a new regional academy—designed and run by employers and community partners—in support of more portable infrastructure education, training, and credentials

Many localities and utilities are already driving new workforce solutions, but there needs to be continued dialogue and shared learning via stronger community partnerships. In other words, to reach more prospective workers, all types of community partners and employers—not just utilities—need to sit at the same table. Educational institutions, WDBs, unions, and a range of other organizations all have a role to play, and it is critical for communities to keep stretching the tent to capture more partners and act more collaboratively. Without coordinated leadership and action, it will be difficult to achieve scale across a sector that can be highly fragmented and localized in its operations; moreover, the value of sector-wide collaborations and partnerships is gaining greater momentum among many workforce development leaders nationally.[127]

Of course, it is also crucial to emphasize that different regions have different needs and capacities. While larger metropolitan areas may have dozens of groups with the interest and ability to coordinate on new workforce development activities, smaller or more rural communities may only have a couple organizations engaged in these efforts. Smaller, rural localities may also not offer as much pay or upward career growth to workers, resulting in numerous retention issues. No two places are the same—even those located in the same region or state—and ultimately the roles and responsibilities must be tailored to the unique concerns of a given community. However, there are some common practices that could translate well across different places, which serve as the basis for this section.

Indeed, just as utilities and other water employers need to have specific staff members driving change internally, **there needs to be a common regional point person—or organization—to schedule and steward consistent meetings among a broad range of community partners**. Obviously, the individual players and needs identified will vary from region to region, but having a consistent person or group to mobilize action is essential, even if it means picking a specific date and location to meet. Whether formal or informal, arranging time for new dialogues and planning should be a first step to unite different community partners around a common set of priorities. And that is much easier to do when there is a common point of contact. For example, the Camden Collaborative Initiative (CCI) has served as a regional body and platform to define priorities, encourage discussion, and test out new ideas, with a focus on improving environmental and economic outcomes; and CCI's success has depended on specific nonprofit partners to schedule and plan meetings.[128]

Collaborating on a daily, weekly, or even a monthly basis can be challenging, and not all community partners may have the time, resources, or willingness to engage that frequently. Sometimes, even having just one opportunity to meet can lead to new connections, jumpstart thinking, and drive action throughout the community. For instance, **holding an annual water summit, or meet-and-greet, where prospective workers, employers, and community partners can connect with one another regionally** would mark a step in the right direction. To build community connections, for instance, the Louisville MSD holds an annual outreach session designed to inform and educate the community on upcoming wastewater and water projects and employment opportunities, called "Can You Dig It?"[129] In some cases, utilities might be the natural leader of such a convening, but the key is to involve all types of employers and community groups to consider specific plans, projects, and positions of need—centered on identifying and connecting with prospective workers across the region.

Ideally, through more consistent dialogues and other community-wide events, certain issues or concerns would begin to emerge. And depending on the capacity and level of engagement among different partners, these conversations may be the start to a more strategic approach to a region's water workforce needs. Alongside

utilities and other major water employers in the region, community partners should **develop a comprehensive water workforce plan, highlighting regional training needs and avenues for additional collaboration**. For example, BAYWORK, a consortium of Bay Area water and wastewater utilities focused on workforce development, has developed new research and other training resources to help clarify strategic priorities across the region.[130] To be sure, not all regions have the same technical or programmatic ability to design such plans or conduct studies to monitor specific employment needs, but even developing basic guiding principles can establish clearer objectives for future conversations and efforts.

On that same note, perhaps one of the one most important issues that utilities, employers, and community partners must address is how they are going to pay for (or staff) any regional workforce efforts. While some efforts may only involve simple conversations, adjustments to existing programs, or other ad hoc considerations—limited perhaps to a specific utility—other efforts may require additional staff support to develop and manage. Launching a new technical study or training program, for instance, does not always come easily or cheaply. **Developing a more predictable, durable channel of funding to support these efforts, driven by public fees and private-sector support**, will be key moving forward. Rate adjustments and other fees are two areas of obvious action for water utilities, who are not only providing a public service, but are active community partners too. Supporting the local workforce demonstrates a clear value to the local community, and ratepayers need to see these efforts in action to justify potential rate adjustments.

Of course, that does not mean utilities should singlehandedly be responsible for any funding needs, particularly given ongoing water affordability concerns nationally.[131] The need for nimble ways to generate additional and alternative support is crucial too, especially from private sector firms who stand to benefit from a more skilled pool of workers locally. From Sturgis, South Dakota, to Lonoke County, Arkansas, regions across the country are devising new ways to fund and finance water infrastructure projects with greater community buy-in.[132] Whether engaging in broader system partnerships, contributing to community economic development, or simply demonstrating the value of water to the community, utilities are working closely with other groups locally to drive needed infrastructure improvements and oversee other programmatic advances.

Given the range of water workers—and employers—across regions, any collaborative efforts must aim to connect with diverse local talent. One way that utilities, in particular, can do this is to **strengthen local hiring preferences in support of more minority and women business enterprises** (M/WBEs). By reaching out to a greater variety of local firms during the procurement process, including M/WBEs, utilities can forge stronger community connections as they pursue infrastructure upgrades. The city of Chicago, for instance, is among many areas nationally looking to expand hiring efforts for more diverse local workers by requiring a higher percentage of these workers in construction projects—up to 50 percent depending on the project cost.[133] Individual private sector companies—including contractors involved in engineering, design, and construction—should also recruit more local workers; for instance, utilities should work closely with firms to help place former interns from their training programs into entry-level private-sector positions where talent and needs align.[134]

However, simply raising the bar to hire more local workers does not solve another pressing issue facing many communities: connecting prospective workers with specific employment opportunities. For example, WDBs may not always have the most relevant water employment information, including the types of projects and exact facilities where future workers may be needed. Likewise, groups

representing non traditional candidates, including veterans and women, should be meeting with water employers to realize opportunities in the water sector. To do so, utilities, employers, and community partners should **create a new web platform to connect water workers and employers, serving as a simple, consolidated site for regional job postings**. For instance, the Louisville MSD just launched a free online tool designed to better connect local workers and employers, called JobLink, which provides a consolidated, easy-to-access platform where new jobs are posted by contractors and resumes are uploaded by individual applicants.[135]

The creation of new community platforms to encourage additional regional collaboration, planning, and action needs to be the norm, not the exception. Similar to regional efforts already underway for manufacturing and health care led by WDBs, there should be an effort focused on infrastructure and the skilled trades. Ultimately, elevating the water workforce as a regional economic priority should feed into a broader infrastructure workforce effort, focused on training and job placement for all types of workers with transferable skills. DC Water, for instance, is working with several other employers regionally as part of a newly launched "DC Infrastructure Academy," a new platform that "coordinates, trains, screens, and recruits residents to fulfill the needs of the infrastructure industry."[136] In this way, a logical step would be to **launch a new regional academy—designed and run by employers and community partners—in support of more portable infrastructure education, training, and credentials**. Water workforce development should be a formative part of these broader efforts, with the aim to support a skilled labor pool that benefits all employers.

3. National and state leaders need to provide clearer technical guidance, more robust programmatic support, and targeted investments in water workforce development

NATIONAL AND STATE ACTIONS
Hire or assign specific program staff to serve as common points of contact across relevant federal agencies, with a focus on water workforce development
Supported by federal agencies or other national organizations, conduct a series of dialogues and learning sessions in a broad range of markets to assess water workforce needs and priorities
Develop a common landing page, or repository, that highlights regional best practices and other innovative water workforce development strategies
At a national level, form a "water workforce council" among leading groups to serve as an advisory body, with an eye toward future priorities
With guidance from employers, industry associations, and other stakeholders, establish more versatile and streamlined water certifications nationally
Expand federal and state funding via existing workforce development programs and educational initiatives, including apprenticeships
Expand federal and state funding via newly targeted and competitive grant programs, in support of alternative bridge programs and other innovative training programs

Utilities and employers cannot act alone when addressing their water workforce demands, and broader regional collaborations are not going to solve all these issues either. National and state leaders need to provide greater capacity and support for these locally driven efforts. Federal agencies, including EPA, DOL, ED, USDA, and the VA, are already playing a part in related workforce development programs, and several national groups, including an assortment of water industry associations and workforce groups, remain active.[137] State-level groups, including labor and education departments, must also remain closely-attuned to water workforce needs.[138] However, many of these actors need to provide improved technical and programmatic assistance, while targeting additional investments in training and skills development.

Currently, one challenge on the federal front is the lack of consistent contacts, or liaisons, across different agencies focusing on water workforce development. This is not only true when it comes to communicating with regions, but also when it comes to collaborating across the federal bureaucracy. Within EPA, the key federal agency for water infrastructure oversight, coordination remains a work in progress between offices that deal with wastewater and those that deal with drinking water. However, workforce issues represent a common priority across these offices—and other organizations they work with—and have led to the assignment of staff covering these topics. To continue building off the momentum of such efforts, **federal agencies should hire or assign specific program staff who focus exclusively on water workforce development and serve as common points of contact for local partners**. That would help provide greater transparency and make it easier to direct any ongoing engagements, externally or internally. Even hosting informational webinars, co-sponsored by different federal agencies like EPA and DOL, would increase greater awareness and knowledge on the water workforce.

Beyond staffing needs, **federal agencies or other national organizations should conduct regular dialogues and learning sessions in a broad range of markets to assess water workforce needs and priorities across the country.** To do so, federal agencies, water associations, researchers, and broader workforce development groups should gather together in a series of markets—which offer geographic, economic, and infrastructure diversity—to investigate the common ingredients that all types of regions should seek in their future water workforce development efforts. While having a menu of regional best practices would help (as discussed below), having a sense of the individual ingredients would help jumpstart workforce development efforts in many regions.[139] Initially, these ingredients could take the form of a basic guide, or national template, applicable to a wide range of utilities and other water employers, including suggested steps they could take to develop an effective workforce plan and drive more collaboration.

In addition, exploring specific labor metrics, financing tools, and programmatic options across different markets would shed more light on how specific strategies and innovations are actually taking hold. These same dialogues would also provide collaboration opportunities for utilities, researchers, and a range of other community partners to gather and support national planning efforts. The timing of these meetings would ideally take place every couple of years to provide a consistent benchmark for guiding future conversations.

When developing these ingredients as part of a larger menu, federal agencies or other national organizations should **develop a common landing page—or repository—that highlights regional best practices and other innovative water workforce development strategies**. Many utilities and workforce development groups have expressed frustration at the lack of consistent or comprehensive information concerning best practices in water workforce development.[140]

While a number of industry reports and utility surveys discuss the shared workforce challenges across the water sector, there are few centralized resources that list and examine region-by-region innovations. Having a common landing page—supported by EPA in concert with water associations, for instance—would help provide a "menu" of cases for all types of utilities and regions to consider, and ideally promote greater shared learning and replication across the country. Some regions, including the Bay Area, have already created websites with common materials and resources for utilities, educators, and prospective workers to consider, which could offer a useful model to consider nationally.

Through continued dialogues and the development of new shared learning resources, ideally a number of different employers and organizations will connect around the water workforce opportunity. Ideally, many of these employers and organizations will not just be focused on water infrastructure either; in other words, the aim should not be simply having utilities talking to other utilities, but having a variety of government agencies, workforce groups, and industries at the table discussing inclusive pathways to economic opportunity. In light of these ongoing efforts, EPA and DOL should **form a water workforce council among leading groups to serve as an advisory body, with an eye toward future priorities**. Without having highly visible and imaginative leadership on the water workforce at a national level—supported by a broad coalition of groups—it is hard to imagine these conversations or planning efforts going anywhere in coming years. As a first step, this council should prioritize the completion of the national template noted above, providing a guide that all utilities and municipalities could follow.

In terms of future training efforts, national leaders are also strategically positioned to bring greater consistency and direction to the water workforce, including greater portability of credentials. **With guidance from employers, industry associations, and other stakeholders, federal agencies and state leaders should establish more versatile and streamlined water certifications nationally.** The Department of Labor, for instance, has considered reforms to occupational licensing requirements, which represent a barrier to many workers in the water sector and beyond it to qualify for positions across different states.[141] State-level educational bodies and other certifying organizations should aim to create more harmonized requirements, which will make it easier for workers to navigate the water jobs landscape. The creation of new certificates, including green infrastructure certifications, are helping in this respect, as are more detailed competency models that help workers consistently gain needed skills and knowledge.[142]

The financial barriers many regions face to create new training programs also stand as another clear area of priority nationally. First, **federal and state leaders should expand funding via existing workforce development programs and educational initiatives, including apprenticeships.** For instance, national apprenticeship programs geared toward smaller utilities and regions, developed in concert with states, are accelerating efforts to train water treatment operators and fill other mission-critical occupations, which could benefit from additional capacity. Doing so would acknowledge the varying scale of the water workforce challenge, opportunity, and response. The WaterPro Apprenticeship program represents one such effort, with the aim to connect to water professionals across all states.[143] Likewise, the recent Omnibus Appropriations Act of 2018 has increased federal funding for apprenticeship programs centered on construction, transportation, and other related activities.[144] Moreover, some utilities are taking advantage of State Revolving Funds (SRFs) and other federal programs to support the completion of needed water infrastructure projects while expanding community benefits

and workforce training.[145] Moving forward, federal leaders should make it easier for utilities and other eligible entities to use SRF funding in more nimble, flexible ways to support workforce development.[146]

In addition to supporting existing programs, **federal and state leaders should also expand funding via newly targeted and competitive grant programs, in support of alternative bridge programs and other innovative training programs**. Several pieces of legislation have been proposed in Congress, but little traction has existed amidst other budget priorities.[147] Meanwhile, federal education grant programs, including those for STEM fields, remain highly fragmented and inefficient.[148] Traditional educational and training programs need more targeted federal and state financial support, to be sure, but utilities, employers, and other community partners are launching several new innovative training programs that receive little to no financial support. Aimed at exposing younger workers to water careers, retraining older workers, and helping non traditional job candidates get a foothold into the sector, these alternative internship programs represent crucial avenues for future action, where agencies like EPA, DOL, and the VA should all administer through clearer channels of funding and programmatic support.

CONCLUSION

At a time when many Americans are struggling to access economic opportunity and many of the country's water infrastructure assets are at the end of their useful life, there is a need for a new generation of water workers. As this report has shown, the water workforce does not simply begin or end within a single utility or single facility, but the jobs they fill provide a bridge to greater economic opportunity for all workers across all skill levels across all regions. The water sector as a whole—and water utilities in particular—need to serve as a standard bearer for the vast array of infrastructure-related employment opportunities facing the country.

Indeed, filling almost 1.7 million jobs across the country, water workers are engaged in a variety of activities, crucial to the construction, operation, design, and governance of U.S. water infrastructure. And crucially, the jobs they fill pay competitive, equitable wages, while posing lower educational barriers to entry. Moreover, there is a need for younger, diverse talent to fill these positions.

However, that does not mean workers and employers are always finding it easy to fill water jobs. The need for on-the-job training and related work experience demands vigilant planning and action on the part of utilities—and multiple other employers, community partners, and national and state leaders. Though the water workforce is focused on meeting the water infrastructure needs of many different communities across the country—and has the potential to pull from an increasingly diverse working-age population—the worker demographics do not always reflect this diversity. Existing recruitment strategies, hiring processes, and training pathways may fail to connect workers with opportunities in the water

sector—and even when workers are employed, they may opt for positions in other industries or struggle to strengthen their skills. Moreover, the varying financial and programmatic capacity of different utilities, and regions, can make it difficult to drive new solutions.

Ultimately, to reach more prospective workers and prepare them for accessible, well-paying water careers, communities have a shared responsibility in these efforts and should spearhead more collective action. While many regions across the country are already deploying more collaborative, forward-looking approaches to take advantage of the water workforce opportunity, many others are struggling to address what they see as an intractable challenge. The country's water infrastructure is strategically positioned to support more inclusive economic development, especially given the role of water utilities as anchor institutions in some disadvantaged communities nationally. It is time to build off this unique position—and the innovative efforts already underway—to help improve infrastructure and promote greater economic opportunity.

ENDNOTES

1 Alan Berube, "City and Metropolitan Income Inequality Data Reveal Ups and Downs through 2016" (The Brookings Institution, February 5, 2018). Note that high-income households refer to those in the top 5 percent of all households by income, while low-income households refer to those in bottom 20 percent of all households by income.

2 Chad Shearer, Isha Shah, Alec Friedhoff, and Alan Berube, "Metro Monitor 2018" (Brookings, February 20, 2018).

3 Raj Chetty and Nathaniel Hendren, "The Impacts of Neighborhoods on Intergenerational Mobility: Childhood Exposure Effects and County-Level Estimates" (Harvard University and National Bureau of Economic Research, May 2015).

4 Mark Muro and Jacob Whiton, "Geographic Gaps Are Widening While U.S. Economic Growth Increases (Brookings, January 23, 2018).

5 Joseph Parilla, Brad McDearman, Ryan Donahue, and Rachel Barker, "Building Inclusive Cities: A Framework and Lessons for Local Leaders" (Brookings, September 27, 2017).

6 Joseph Parilla, "Opportunity for Growth: How reducing barriers to economic inclusion can benefit workers, firms, and local economies" (Brookings, September 28, 2017).

7 William H. Frey, Diversity Explosion: How New Racial Demographics are Remaking America (Brookings Institution Press, 2014).

8 Mark Muro, Sifan Liu, Jacob Whiton, and Siddharth Kulkarni, "Digitalization and the American Workforce." (Brookings, November 15, 2017).

9 Joseph Kane and Robert Puentes, "Expanding Opportunity through Infrastructure Jobs" (Brookings, May 7, 2015).

10 For simplicity and consistency, "water utilities" referred to in this report include those public and private utilities focused on drinking water, wastewater, and stormwater needs.

11 Joseph Kane, "Investing in Water: Comparing Utility Finances and Economic Concerns Across U.S. Cities" (Brookings, December 14, 2016).

12 Joseph Kane, "Less Water, More Risk: Exploring National and Local Water Use Patterns in the U.S." (Brookings, October 2017).

13 Alexander Quinn et al., "National Economic and Labor Impacts of the Water Utility Sector." (Water Research Foundation, 2014), http://www.waterrf.org.

14 Andrea Kopaskie, "Public vs Private: A National Overview of Water Systems." (Environmental Finance Blog, October 19, 2016), http://efc.web.unc.edu/2016/10/19/public-vs-private-a-national-overview-of-water-systems/. [Accessed April 2018].

15 Over the course of the project, Brookings researchers traveled to three regions and held a roundtable in Washington, DC, to examine water workforce development. These will be described in more depth in the recommendations section.

16 David Monsma, Regan Nelson, and Ray Bolger, "Sustainable Water Systems: Step One - Redefining the Nation's Infrastructure Challenge" (The Aspen Institute, June 30, 2009).

17 For more information on defining green infrastructure, see: U.S. Environmental Protection Agency, Office of Water, "What Is Green Infrastructure? Overviews and Factsheets" (U.S. EPA, September 30, 2015).

18 For example, see: U.S. Environmental Protection Agency Office of Water, "Septic Systems Overview" (U.S. EPA, June 9, 2015).

19 U. S. Government Accountability Office, "Drinking Water and Wastewater Infrastructure: Information on Identified Needs, Planning for Future Conditions, and Coordination of Project Funding" (GAO, October 23, 2017).

20 Alan Manning, Terry Brueck, Marcia Isbell, and Penny Brink, "Workforce Planning for Water Utilities - Successful Recruiting, Training, and

Retaining of Operators and Engineers" (AWWA Research Foundation, 2008).

21 BAYWORK, Jewish Vocational Service, and The Centers of Excellence, "Water and Wastewater Career Pathways: Connecting People to Water Industry Jobs in the Bay Area" (October 2017).

22 Beyond examining workforce development activities specific to individual utilities, considering industry-wide trends can help highlight broader workforce needs and encourage greater collaboration. For instance, see: Brueck et al., "Water Sector Workforce Sustainability Initiative" (Water Research Foundation, 2010).

23 As such, there can often be tremendous overlap with other industries, including energy production and distribution, which demand workers with similar skillsets to oversee similar types of gray infrastructure assets. For example, see: , Nihal Shrinath and Allison Plyer, "The Water Workers: Workforce Opportunities in Water Management in Southeast Louisiana" (The Data Center, December 23, 2014), https://www.datacenterresearch.org/reports_analysis/the-water-workers/. [Accessed April 2018].

24 As a result, a widening set of careers related to green infrastructure design, installation, and maintenance are emerging in many regions. For more background, see: Jobs for the Future, "Exploring the Green Infrastructure Workforce" (2017).

25 Water Research Foundation, "Utility Management: Employee and Leadership Development" (July 2016).

26 American Water Works Association, "2017 State of the Water Industry" (2017).

27 National Research Council, Privatization of Water Services in the United States: An Assessment of Issues and Experience (National Academy Press, 2002), https://doi.org/10.17226/10135. [Accessed April 2018].

28 For example, see: DC Water, "DC WaterWorks Program Plan" (October 1, 2016).

29 David H. Bradley, "The Workforce Innovation and Opportunity Act and the One-Stop Delivery System" (Congressional Research Service, October 27, 2015).

30 There are multiple examples of how unions are helping train workers and partner with other regional stakeholders. As just one example, see: Ellen Avis and Carol Zabin, "Training for the Future: Workforce Development for a 21st Century Utility, Los Angeles's Utility Pre-Craft Trainee Program" (U.C. Berkeley Labor Center, 2013).

31 Again, many efforts are taking place across the country by a variety of organizations. One relevant example from the Bay Area site visit for this project was Young Community Developers (YCD), a non-profit group with activities concentrated in San Francisco's Bayview Hunters Point neighborhood. For more information, see: https://0391029.netsolhost.com/WordPress/who-we-are-2/ [Accessed April 2018].

32 U.S. Environmental Protection Agency Office of Water, "Water Sector Workforce" (U.S. EPA, January 26, 2016).

33 For example, see: "Water and Wastewater Industry Competency Model" (Competency Model Clearinghouse, 2017) https://www.careeronestop.org/competencymodel/competency-models/water-sector.aspx [Accessed April 2018].

34 For instance, see: Water Environment Foundation, "Task Force on Workforce Sustainability Final Report" (Oct. 15, 2008)

35 Terry Brueck, Marcia Isbell, Denise O'Berry, and Penny Brink, "Water Sector Workforce Sustainability Initiative" (Water Research Foundation, 2010).

36 The National Rural Water Association, "NRWA to Announce Creation of Workforce Advancement Center" (November 10, 2016).

37 Brian A. Jacob, "What We Know about Career and Technical Education in High School" (Brookings (blog), October 5, 2017).

38 Based on Brookings site visits and interviews. In some cases, younger workers

from disadvantaged communities may lack job readiness and other hard and soft skills needed to qualify for entry-level jobs, let alone grow their careers and gain additional experience over time. Meanwhile, the lack of visible outreach strategies, flexible training programs, and hiring standards to help onboard these workers easily reinforces barriers in many regions.

39 U.S. Bureau of Labor Statistics, "Employed Persons by Detailed Industry, Sex, Race, and Hispanic or Latino Ethnicity" (January 19, 2018).

40 This is a particular challenge for smaller and rural water utilities which often train operators and managers that ultimately move on to larger utilities in search of better pay.

41 BAYWORK, Jewish Vocational Service, and The Centers of Excellence, "Water and Wastewater Career Pathways: Connecting People to Water Industry Jobs in the Bay Area." (2017).

42 American Water Works Association, "Operator Certification Requirements Catalogued for All 50 States" (AWWA Connections (blog), March 1, 2018).

43 While plumbers, pipefitters, and other technicians follow the apprenticeship path, not all water workers follow this track. As one example, those interested in becoming water operators must hold at least a high school diploma, obtain a combination of training and experience at a utility, and pass an operator exam in order to become licensed or certified. For more background, see: "Occupational Outlook Handbook: Water and Wastewater Treatment Plant and System Operators." (Bureau of Labor Statistics. October 24, 2017).

44 Brad Williams, "Automation: Redefining the Modern Water Utility" (WaterWorld, April 1, 2016).

45 Based on Brookings site visits and interviews.

46 Additional information on these studies is provided in the methodological appendix, including links to the AWWA Career Clusters study, the WRF Workforce Sustainability Initiative, and other BLS utility analyses.

47 The eight NAICS industries are listed in full detail in the methodological appendix.

48 By doing so, the analysis also aims to overcome statistical limitations in many existing data sources, which tend to group together utility-specific activities under several broad industries, including local government. This has been a constraint for many previous analyses looking at the water workforce.

49 As described more extensively in the methodological appendix, individual water occupations are analyzed in terms of their specific tasks and other responsibilities according to O*NET definitions.

50 To calculate national shares of occupational employment, the analysis goes through a multi-step estimation process explored more fully in the report's methodological appendix.

51 As defined by the U.S. Office of Management and Budget, Metropolitan Statistical Areas (or MSAs) are standardized regional geographies used in many public and private datasets. There are a total of 382 MSAs nationally, which serve as the basis for the metropolitan totals analyzed in this report.

52 Water utility employment is based on looking at two industries in greater depth: Water, Sewage, and Other Systems (NAICS 2213) and Local Government, excluding schools and hospitals (OES designation) (NAICS 9993). Additional background on these industries is provided in the methodological appendix.

53 Joseph Kane and Robert Puentes, "Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs." Brookings, 2014).

54 The following terms are drawn from: Kane, and Puentes, "Beyond Shovel-Ready." In addition, see the main OES website for more specific details at: https://www.bls.gov/oes/. [Accessed April 2018].

55 For more background on the data used to delineate water utilities in this report, see the methodological appendix.

56 Beyond utilities, many other public agencies and departments rely on workers employed in these same occupations. For instance, mechanics and landscaping workers may be

employed in other departments, which are not separately measured in this report.

57 Standards of living can vary widely from region to region, and any wage differences should be viewed in this context. For example, see: James Lin and Jared Bernstein, "What we need to get by: A basic standard of living costs $48,778, and nearly a third of families fall short" (Economic Policy Institute, 2008).

58 In other words, more than 32.5 percent of workers in these water occupations held a high school diploma or less.

59 Note that related work experience for water occupations is drawn from O*NET, where the mode (or most common) levels of experience were analyzed based on worker responses.

60 Approximately 86.5 percent of workers across all occupations typically need little to no related work experience according to BLS Occupational Employment Statistics and Employment Projections data. Note that work experience totals for all occupations are based on three categories: 5 years or more, under 5 years, or none. "Little to no related" experience equates to those workers with under 5 years of experience or none. As such, these figures represent more aggregated totals compared to the detailed responses in O*NET.

61 For more information on what on-the-job training specifically entails, see the report's methodological appendix.

62 Based on Brookings analysis of BLS Occupational Employment Statistics and Employment Projections data. Note that on-the-job training totals for all occupations here are based on the following categories: internship/residency; apprenticeship; long-term on-the-job training (more than 12 months); moderate-term on-the-job training (more than 1 month and up to 12 months); short-term on-the-job training (1 month or less); and no training. The 5.6 percent figure cited includes long-term on-the-job training, internships, and apprenticeships.

63 For more background on infrastructure-related tools and technologies, see: Joseph Kane and Adie Tomer, "Infrastructure Skills: Knowledge, Tools, and Training to Increase Opportunity" (Brookings, 2016).

64 For example, several recent labor market trends point to growing technology use among many workers across the country. See: Mark Muro and Sifan Liu, "Five Takeaways on How Technology Has Changed the American Workforce" (Brookings. November 17, 2017).

65 Kane and Tomer, "Infrastructure Skills."

66 Note that average knowledge differences shown in this table may vary from those shown in previous infrastructure jobs analyses due to updated O*NET data.

67 Furthermore, by calculating a cumulative "Infrastructure Knowledge Score" across all 11 categories, it is possible to better quantify the extent of total infrastructure knowledge required for individual occupations. As previous Brookings analyses have shown, this cumulative score is based on summing the differences between an infrastructure occupation's actual knowledge score in each of the 11 categories and the average knowledge score across all occupations. For instance, since nuclear engineers tend to require higher levels of knowledge across all of these 11 content areas, they have a higher cumulative infrastructure knowledge score. In contrast, less specialized occupations like cashiers, janitors, and food preparation workers do not.

68 Joseph Kane and Robert Puentes, "America's Infrastructure Needs the Next Generation of Workers" (Brookings, July 2, 2014).

69 For more background, see: U.S. Bureau of Labor Statistics, "Estimating Occupational Replacement Needs." Available at: https://www.bls.gov/emp/ep_replacements.htm. [Accessed April 2018].

70 Joseph Kane, "The future American workforce will have a lot of jobs to fill, particularly in infrastructure" (Brookings, December 7, 2017).

71 Note that projections for the water workforce as a whole are based on a weighted average of employment associated with individual occupations.

72 For example, the potential for automation is likely to lead to new types of jobs and skills, as is currently happening in the transportation

sector. For more background, see: Joseph Kane and Adie Tomer, "Automated trucking's rapid rise overlooks the need for skilled labor" (Brookings, March 21, 2017).

73 Many of these occupations also have higher physical demands and present other hazards that might make them less appealing to prospective female candidates.

74 Many metro areas contain thousands of water jobs, but experience persistently high levels of unemployment and poverty, particularly among less educated workers. In Riverside, for instance, more than 16,900 water jobs are present, yet the unemployment rate reaches up to 10.5 percent among workers without a high school diploma. Moreover, the black unemployment rate stands at 15.8 percent. These and other trends deserve closer analysis, but it's clear that there remains a clear divide in the water workforce opportunity in many markets.

75 It is important to note that many wastewater treatment plants are located near low-lying water bodies for the discharge of treated effluent. Residential neighborhoods were frequently built afterward, which could have an effect on the types of development analyzed here.

76 These include publicly owned treatment works (POTW) only, as classified by EPA.

77 Of course, some ZIP codes can have multiple water treatment plants. While the analysis looks into ZIP codes (and tracts) served by multiple plants, this distinction is less useful for analyzing the characteristics of the neighboring population. The more salient point is whether at least one water treatment plant is located nearby.

78 Note: since (1) ZIP codes can stretch across multiple tracts and (2) this analysis is primarily concerned whether a water treatment plant is in close geographic proximity (rather than determining a specific allocation of water treatment plants), all tracts are counted that are likely to be served by a particular plant. For instance, the Springfield Water Treatment Plant, under the ZIP code 01001, is linked to five total census tracts. Thus, these five census tracts are included in the analysis.

79 Again, 5-year ACS estimates (2012-2016) were used to measure tract-level demographics.

80 For more background on Camden's efforts, see: Joseph Kane, "The water workforce opportunity: How Camden is driving collaborative solutions around its infrastructure and economy" (Brookings (blog). May 14, 2018).

81 For a more complete description of inclusive economic development, see: Amy Liu, "Remaking economic development: The markets and civics of continuous growth and prosperity" (Brookings, February 29, 2016).

82 Jeff Hughes et al., "Defining a Resilient Business Model for Water Utilities" (Water Research Foundation, 2014).

83 This is particularly true for upgrades needed to comply with federal and state regulatory mandates.

84 Neil S. Grigg, "The Water Workforce: Strategies for Recruiting and Retaining High-Performance Employees" (American Water Works Association, 2011). https://books.google.com/books?id=LBIt2BU2tvoC&source=gbs_navlinks_s. [Accessed April 2018].

85 Ann Espinola, "How Much Do Water Professionals Make?" (American Water Works Association, February 4, 2016).

86 Devla Singh and Marzia Zafar, "Utility Workforce Development: Should the CPUC Play a Role in This Issue?" (California Public Utilities Commission Policy and Planning Division, 2012).

87 As noted previously, certain human resources processes and other administrative procedures may make it difficult for workers with non-traditional backgrounds or criminal records to fill water jobs.

88 Mark P. Mills, "Issues 2016: Are Skilled Trades Doomed to Decline?" (Manhattan Institute, October 20, 2016).

89 For example, see: "National Census of Fatal Occupational Injuries in 2016" Bureau of Labor Statistics, News Release USDL-17-1667, 2017).

90 U.S. Department of Energy, "Chapter V: Electricity Workforce of the 21st-Century: Changing Needs and New Opportunities" in

Transforming the Nation's Electricity System: The Second Installment of the Quadrennial Energy Review (January 2017).

91 Carol Milano, "Go with the Flow: A Wave of Water-Related Opportunities" (Science, May 14, 2010).

92 "2016 State of the Industry" (Water & Wastes Digest, December 2016).

93 Derek Thompson, "It's Not Just a Recession. It's a Mancession!" (The Atlantic, July 9, 2009).

94 Manuel P. Teodoro and Travis E. Whisenant, "Water Utility Executive Leadership, Part 1: Who Our CEOs Are." (Journal American Water Works Association, 105 (12): 22–30, 2013).

95 Chris Schildt, "Key Strategies to Advance Equitable Growth in Regions" (PolicyLink, Sustainable Communities Series, 2015).

96 "2017 Philadelphia Workforce Diversity Profile Report." (The Mayor's Office of Diversity & Inclusion, 2017).

97 Ibid.

98 Ibid.

99 For example, Prince George's County has launched an ambitious effort in this respect: "Prince George's County Leads Way with Clean Water Partnership." (Prince George's County Department of the Environment, press release, 2014) https://www.princegeorgescountymd.gov/ArchiveCenter/ViewFile/Item/785. [Accessed April 2018].

100 Based on Brookings site visits and interviews. Indeed, this process, despite its initial aims to promote greater equity, may now have unintended consequences of creating lengthy timelines to adjust job descriptions and hiring processes to respond to modern HR issues.

101 Felicia Bechtoldt, "Drinking Water and Wastewater Operators, the Work Behind Our Water" (State of Oregon Employment Department, October 12, 2017).

102 Ibid.

103 As a result, many of the community colleges who want to provide vocational training must begin with remedial work in these areas. However, some regions are trying to address this issue. For example, BAYWORK, in collaboration with the Jewish Vocational Service (JVS), has tried to support the work of high school teachers, including the creation of contextualized learning materials.

104 Based on Brookings site visits and interviews.

105 Ibid.

106 For example, see: Cheryl Davis, "Staff Preparedness: Lessons Learned from Star Utilities" BAYWORK, 2013).

107 Madeline Snow and Deborah Mutschler, "Promoting Entry to Career Pathways in the Drinking Water and Wastewater Sector" (Lowell Center for Sustainable Production, 2012).

108 Based on Brookings site visits and interviews.

109 For instance, retention issues can be a challenge for many smaller utilities, which need to provide continued pathways for learning and skills development. For more context, see: U.S. Department of Agriculture and U.S. Environmental Protection Agency, "Rural and Small Systems Guidebook to Sustainable Utility Management" (2016).

110 Not all young adults are switching jobs as quickly as prior generations, but less-educated workers appear to be switching more frequently. For more context, see: Richard Fry, "Millennials aren't job-hopping any faster than Generation X did" (Pew Research Center, April 19, 2017).

111 For example, see: U.S. Department of Labor Employment and Training Administration, "Employer's Playbook for Building an Apprenticeship Program." Available at: https://www.doleta.gov/oa/employers/playbook.pdf. [Accessed May 2018].

112 Indeed, as local leaders look to address their infrastructure needs more comprehensively, particularly when it comes to the integration of new technologies, other departments should be part of these workforce discussions.

113 Based on Brookings site visits and interviews.

114 Ibid.

115 Utilities and other water employers need to define workforce goals based on an assessment of those job categories with the greatest weaknesses, risks, and needs. For example, see: Water Services Association of Australia and Water Environment & Reuse Foundation, "Workforce Skills of the Future" (2017).

116 Baltimore City Department of Public Works, "City Leaders Celebrate Latest Class of Y-H20 Water Mentoring Program Graduates" (November 30, 2017). Available at: https://publicworks.baltimorecity.gov/news/press-releases/2017-11-30-city-leaders-celebrate-latest-class-y-h20-water-mentoring-program. [Accessed April 2018].

117 Based on Brookings site visits and interviews.

118 For instance, many companies, even beyond the water sector, rely on human resources departments that do not always focus on new strategic needs for their organizations. For more background, see: Martha Ross and Marek Gootman, "Help Wanted: How Middle Market Companies Can Address Workforce Challenges to Find and Develop the Talent They Need to Grow" (Brookings, August 29, 2017).

119 Minneapolis, for instance, has a set process in place to consider job classification changes over time, available at: http://www.minneapolismn.gov/hr/civilservice/rule4. [Accessed April 2018]

120 Nancy McTigue and Richard Mansfield, "Competency Modeling and the Water Industry: A Good Fit" (Journal American Water Works Association 103 (8): 40-43, 2011).

121 Based on Brookings site visits and interviews.

122 For additional resources on work-based learning and apprenticeships, see: National Governors Association, "Work-Based Learning & Apprenticeship." Available at: https://www.nga.org/cms/center/issues/eo/work-based-learning-apprenticeship [Accessed May 2018].

123 For instance, see: San Francisco Public Utilities Commission, "Demonstration Gardens." Available at: https://sfwater.org/index.aspx?page=503 [Accessed April 2018].

124 Based on Brookings site visits and interviews.

125 "Camden's sustainability efforts highlighted at summit," June 21, 2017. Available at: http://www.nj.com/south-jersey-towns/index.ssf/2017/06/camdens_sustainability_efforts.html. [Accessed April 2018].

126 Based on Brookings site visits and interviews.

127 Sector-wide collaborations have been cited in youth workforce development efforts and other industry partnership activities. For example, see: Martha Ross et al., "Unemployment Among Young Adults: Exploring Employer-Led Solutions" (Brookings, July 21, 2015). Also see: The National Fund for Workforce Solutions, "Characteristics of a High-Performing Industry Partnership" (2014).

128 For more background on the Camden Collaborative Initiative, see: http://www.camdencollaborative.com/. [Accessed April 2018].

129 "MSD hopes to connect local workers with $80 million in projects." January 23, 2018. Available at: https://insiderlouisville.com/business/msd-hopes-to-connect-local-workers-with-80-million-in-projects/. [Accessed April 2018].

130 For more background on BAYWORK's activities and other technical resources, see: http://baywork.org/about-us/background/. [Accessed April 2018].

131 Joseph Kane and Lynn E. Broaddus, "Striking a Better Balance between Water Investment and Affordability" (Brookings (blog). September 12, 2016).

132 U.S. Environmental Protection Agency, "Water Infrastructure Financial Leadership: Successful Financial Tools for Local Decision Makers" (2017).

133 "Mayor Emanuel Issues Executive Order to Require City's Largest Construction Projects Commit to Hiring Diverse Workforce" (August 16, 2017). Available at: https://www.cityofchicago.org/city/en/depts/mayor/press_room/press_releases/2017/august/EOConstruction.html [Accessed April 2018].

134 Based on Brookings site visits and interviews.

135 For more background on JobLink, see: https://msdjoblink.org/faqs.html. [Accessed April 2018].

136 Additional information on the DC Infrastructure Academy, including its scope and partners, is available at: https://does.dc.gov/service/dc-infrastructure-academy. [Accessed April 2018].

137 For more context, see: "Water and Wastewater Workforce: Recruiting Approaches Helped Industry Hire Operators, but Additional EPA Guidance Could Help Identify Future Needs." (U.S. Government Accountability Office, GAO-18-102, 2018).

138 For instance, see: Singh and Zafar, "Utility Workforce Development" (2012).

139 Several water industry associations have been actively engaged in compiling best practices for workforce development in utilities and regions across the country.

140 Based on Brookings site visits and interviews.

141 "U.S. Secretary of Labor Acosta Addresses Occupational Licensing Reform." (United States Department of Labor, July 21, 2017).

142 "About NGICP." n.d. National Green Infrastructure Certification Program. Accessed April 23, 2018.

143 The National Rural Water Association (NRWA) has partnered with states to develop a new apprenticeship program in this respect, as outlined at: https://nrwa.org/initiatives/apprenticeship-program/. [Accessed April 2018].

144 U.S. Department of Labor "Omnibus Appropriations Bill Supports Important Priorities for the American Workforce" (2018).

145 Based on Brookings site visits and interviews.

146 EPA's Brownfields Grant Program is another lever by which communities are looking to train water workers. For more background, see: https://www.epa.gov/brownfields/types-brownfields-grant-funding [Accessed May 2018].

147 For example, legislation has been proposed in the Senate on the water utility workforce training efforts. See: Ariel Wittenberg, "Booker, Capito seek to replace aging utility workforce" (E&E News, January 30, 2018).

148 U. S. Government Accountability Office, "2018 Annual Report: Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits" (GAO, April 26, 2018).

Note: To classify water jobs, this report relies on many of the same methods used in previous Brookings research to identify infrastructure jobs. For more information on these methods, see "Beyond Shovel-Ready: The Extent and Impact of U.S. Infrastructure Jobs" available at:

https://www.brookings.edu/wp-content/uploads/2014/05/Beyond-Shovel-Ready.pdf

1. Employment data

This report primarily uses 2016 employment data publicly available from the U.S. Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES) program, which releases estimates annually. The OES program bases these estimates on a semi-annual mail survey in May and November in partnership with state workforce agencies. The survey measures employment for workers in non-farm establishments. Estimates for 2016 were drawn from 1.2 million establishments across six panels of data collected over three years (May 2016, November 2015, May 2015, November 2014, May 2014, and November 2013). The sample is developed from state unemployment insurance files.[1]

OES employment and wage data are defined in terms of specific occupations and industries, as established under the 2010 Standard Occupational Classification (SOC) system and 2012 North American Industry Classification System (NAICS). This report focuses on detailed SOC occupations and 4-digit NAICS industries. OES cross-industry occupational employment and wage estimates are available across national, state, metropolitan statistical area, metropolitan division, and nonmetropolitan geographies, while industry-specific estimates are available for the nation only.

Supplemental information has also been gathered from the BLS Employment Projections (EP) program, Quarterly Census of Employment and Wages (QCEW) program, Current Employment Statistics (CES) program, and the Occupational Information Network (O*NET), an online resource center and database sponsored by the Department of Labor's Employment and Training Administration. Additional demographic and economic data come from the U.S. Census Bureau's American Community Survey (ACS) and the Current Population Survey (CPS), a joint effort between BLS and the U.S. Census Bureau. Finally, to analyze the location of specific water utilities, we use information compiled by the U.S. Environmental Protection Agency (EPA) in its Facility Registry Service (FRS), an online database that tracks environmental compliance in individual facilities across the country.

2. Defining water jobs

This analysis aims to classify the most relevant jobs linked to water infrastructure construction, operation, design, and governance nationally. While many previous studies have conducted surveys of individual water utilities—to focus on utility-specific operations in a given region—this analysis aims to build off this work and define a broader suite of water jobs across the country.

Developing a clear and concise definition of the types of activities involved in water jobs is key when investigating specific industries and occupations. In particular, we define water jobs as:

"Jobs directly involved in the construction, operation, design, and governance of water infrastructure systems nationally, including drinking water, wastewater, stormwater, and green infrastructure. These positions span the public and private sector and involve oversight,

maintenance, and financial and administrative support, including involvement in managing several closely-related physical assets, such as pipes and septic systems."

In turn, water jobs are not simply limited to the internal operations of utilities, but also cover a wide assortment of industries and establishments across the country.

3. Defining water industries

Next, we identified a list of industries closely linked to this definition. Relevant information from the U.S. Census Bureau Industry Statistics Portal has aided in the identification of these industries. In addition, we considered relevant industry clusters identified in previous research, including the AWWA Career Clusters study, the WRF Workforce Sustainability Initiative, and BLS utility analyses.[2] It is important to note that there can be difficulties defining a precise range of water-related industries due to aggregations in existing public data sources.[3]

A list of eight water industries have been identified[4], with relevant sub-industries highlighted below:

- **Water, Sewage and Other Systems (NAICS 2213)**
  - Includes water supply and irrigation systems, sewage treatment facilities, and steam/AC supply

- **Utility System Construction (NAICS 2371)**
  - Includes water, sewer line, and related structures construction
  - Most relevant sub-industry: Water and sewer system construction (NAICS 23711)

- **Other Heavy and Civil Engineering Construction (NAICS 2379)**
  - Includes channel, land drainage, dredging, pipeline, and flood control project construction

- **Plumbing, Heating, and Air-Conditioning Contractors (NAICS 23822)**
  - Includes contractors primarily engaged in installing and servicing plumbing equipment, who may provide both parts and labor when performing work.

- **Other Specialty Trade Contractors (NAICS 2389)**
  - Includes site preparation contractors involved in trenching, excavating, and draining, including weeping tile and septic tank installation
  - Most relevant sub-industry: Site preparation contractors (NAICS 23891)

- **Management, Scientific, and Technical Consulting Services (NAICS 5416)**
  - Includes environmental consulting services, such as water quality inspection
  - Most relevant sub-industry: Environmental consulting services (NAICS 54162)

- **Remediation and Other Waste Management Services (NAICS 5629)**
  - Includes septic tank cleaning and servicing, sewer and storm basin maintenance, and the remediation of contaminated sites, including soil remediation and revegetation
  - Most relevant sub-industries: Remediation services (NAICS 56291) and All other waste management services (NAICS 56299)

- **Local Government, excluding schools and hospitals (OES designation) (NAICS 9993)**
  - Includes many local publicly owned water utilities; note that federal and state government employment is excluded here, which in general covers a broader range of unrelated workers and activities

Other miscellaneous industries, such as Architectural, Engineering, and Related Services (NAICS 5413), are excluded due to the lack of reliable information to pinpoint water-specific activities or employment.

Note that BLS QCEW and CES data provide additional clarity for 5- and 6-digit NAICS industries missing from the OES estimates. By calculating a relevant share of employment found in these industries, it is easier to see how much employment is directly related to water infrastructure operation, maintenance, and so on. This will be explored in more detail below.

4. Defining water occupations

Based on the water jobs definition and list of industries described above, the analysis next attempts to determine the most relevant occupations.

TABLE A1

25 Largest occupations in water, sewage and other systems (NAICS 2213)
2016

SOC code	Occupation	Employment
51-8031	Water and Wastewater Treatment Plant and System Operators	13,500
49-9071	Maintenance and Repair Workers, General	2,630
43-9061	Office Clerks, General	2,400
43-5041	Meter Readers, Utilities	2,310
11-1021	General and Operations Managers	2,010
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	2,000
51-1011	First-Line Supervisors of Production and Operating Workers	1,910
43-4051	Customer Service Representatives	1,620
47-2152	Plumbers, Pipefitters, and Steamfitters	1,500
43-3031	Bookkeeping, Accounting, and Auditing Clerks	1,370
47-2061	Construction Laborers	1,320
43-1011	First-Line Supervisors of Office and Administrative Support Workers	1,080
49-9012	Control and Valve Installers and Repairers, Except Mechanical Door	910
49-9041	Industrial Machinery Mechanics	790
47-2151	Pipelayers	660
53-3032	Heavy and Tractor-Trailer Truck Drivers	640
45-2099	Agricultural Workers, All Other	580
51-8021	Stationary Engineers and Boiler Operators	550
47-2073	Operating Engineers and Other Construction Equipment Operators	540
43-3021	Billing and Posting Clerks	530
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	530
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	470
13-2011	Accountants and Auditors	360
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	320
17-2051	Civil Engineers	280

Source: BLS Occupational Employment Statistics

It does so by following three steps: (a) considering the largest occupations in NAICS 2213 (water, sewage, and other systems), the cleanest industrial categorization related to water utility activities; (b) considering occupational definitions and activities, as defined by BLS, alongside other crucial occupations identified in previous studies[5]; and (c) considering employment concentrations of these occupations across the core set of eight industries identified above.

For step (a), 95 different occupations were found in NACIS 2213 with employment totaling 47,500 workers; however, only 84 had data available (i.e. non-suppressed). The top 25 occupations accounted for 86 percent of all employment in this industry, as highlighted below.

For step (b), 35 occupations were identified, based on BLS definitions and other studies as being essential to water utility operations.[6] Many of these occupations paralleled those identified in NAICS 2213 (water, sewage, and other systems).[7] However, some went beyond this industry, including many engineering and administrative positions found in other closely related establishments across the country; for instance, engineering technicians, architectural and civil drafters, and bill and account collectors were among the occupations identified.

For step (c), we identified a total of 212 occupations as being particularly essential and concentrated across the eight water industries.[8] Many of the biggest occupations, such as plumbers, water treatment operators, and pipelayers, had more than 50 percent of their national employment concentrated in these eight industries, as shown in Table A2. While no statistical benchmark was established to include or exclude certain occupations, most

TABLE A2

Selected occupations with high shares of employment in the eight water Industries

2016

SOC Code	Occupation	Employment across the eight water industries	Total U.S. employment	Water share
47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	24,510	26,320	93.1%
51-8031	Water and Wastewater Treatment Plant and System Operators	103,750	115,840	89.6%
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	46,510	54,080	86.0%
47-2151	Pipelayers	33,810	39,620	85.3%
47-2152	Plumbers, Pipefitters, and Steamfitters	324,500	411,870	78.8%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	212,620	294,730	72.1%
47-2072	Pile-Driver Operators	2,440	3,570	68.3%
47-2073	Operating Engineers and Other Construction Equipment Operators	204,050	356,750	57.2%
43-5041	Meter Readers, Utilities	17,780	34,070	52.2%
19-4091	Environmental Science and Protection Technicians, Including Health	16,020	32,950	48.6%

Source: Brookings analysis of BLS Occupational Employment Statistics

occupations had 2 percent or more of their national employment concentrated in the eight water industries.[9] All of the largest occupations in NAICS 2213 identified in step (a) were found here, and the 35 occupations identified in step (b) were also found.[10]

5. Calculating water employment

Finally, based on these water industries and occupations, we aimed to identify the total number of workers employed in water jobs nationally and across different regions. Imprecise data classifications make it challenging to count the number of workers employed in water jobs – and to group together a definite list of occupations. For instance, by their occupational definitions alone, workers in only 3 occupations are exclusively (and explicitly) employed in water jobs. They total nearly 150,000 workers nationally.

To calculate the number of workers employed in water jobs, this report uses a two-step process: (a) first, it includes all workers employed in the 3 occupations above nationally (regardless of industry), before (b) adding this total to a share of workers employed in the remaining 209 water occupations identified in the previous section (section 4). By doing so, we developed employment estimates for the 212 water occupations.

Unfortunately, carrying out step (b) is easier said than done since OES data tend to only be available for a broader group of NAICS industries (at the 2-, 3-, or 4-digit level). To determine the most relevant occupational employment totals, the analysis uses QCEW and CES data when possible to create a finer cut of employment, based on the most relevant 5- and 6-digit NAICS industries. Table A3 shows the relevant employment "weights" used for each of the eight water industries.

For example, since NAICS 2213 (Water, sewage, and other systems) is entirely related to the water definition spelled out in the first section, 100 percent of its occupational employment is included. However, NAICS 2371 (Utility system construction) includes a broad swath of unrelated energy construction, so only a portion of its employment is counted; in particular, NAICS 23711 (Water and sewer line construction) is the most relevant sub-sector in this industry and is responsible for employing 177,390 workers nationally (or 36.8 percent of all workers in NAICS 2371). Likewise, according to CES data, local government utilities account for 4.3 percent of local government employment, excluding schools and hospitals; in turn, 4.3 percent of local government employment associated with the 212 occupations is included.

A similar process is followed for NAICS 2389, NAICS 5416, and NAICS 5629. For NAICS 23822 (plumbing and HVAC contractors), additional

TABLE A3

Relevant water occupations, regardless of industry

SOC code	OCC title	Total U.S. employment
51-8031	Water and Wastewater Treatment Plant and System Operators	115,840
47-4071	Septic Tank Servicers and Sewer Pipe Cleaners	26,320
19-2043	Hydrologists	6,300

Source: BLS Occupational Employment Statistics

TABLE A4

Employment weights for the eight water industries

2016

NAICS code	Water industry	Weight	Total U.S. employment	Adjusted employment
2213	Water, sewage and other systems	100.0%	48,848	48,848
2371	Utility system construction	36.8%	481,639	177,390
2379	Other heavy construction	100.0%	107,810	107,810
23822	Plumbing and hvac contractors	34.0%	1,014,061	344,333
2389	Other specialty trade contractors	49.7%	627,964	312,198
5416	Management and technical consulting services	6.2%	1,356,433	83,487
5629	Remediation and other waste services	87.9%	138,280	121,567
****	Local government, excuding ed and hospitals	4.2%	5,757,600	244,500

Source: Brookings analysis of BLS QCEW and CES data

****Note: Employment totals shown for local government shown here do not equate directly to NAICS 9993 (OES designation) due to CES definitions

weights were applied to control for unrelated employment associated with heating and air conditioning repair.[11]

At the same time, we adjusted employment totals for specific occupations found to be mission-critical in previous utility studies. In particular, rather than weighting these occupations like all other occupations, 100 percent of their employment is counted across the eight water industries instead. For instance, industrial machinery mechanics are often found to be mission-critical, and there are 13,100 of them employed across the eight water industries. In turn, all 13,100 of these workers are included. A total of 10 occupations are treated this way: electricians, meter readers, industrial machinery mechanics, helpers—electricians, architects, machinists, landscape architects, plumbers, helpers--plumbers, and pipelayers.[12]

Beyond looking at the water sector as a whole, we also calculated utility-specific employment totals. In particular, by looking at NAICS 2213 and NAICS 9993 together, it becomes easier to see how many workers may be employed in water utilities nationally. In total, nearly 298,000 workers are estimated to be employed in water utilities using this method. Not surprisingly, the largest occupation are water treatment plant operators (102,500 workers), which account for about 34 percent of this total.

Since occupational data by industry are not available at a sub-national level, we used national occupational shares to determine regional water employment totals.

For example, when calculating the water employment for each metropolitan area, cross-industry occupation totals are weighed by national water shares. These "water weights" are based on the share of employment for a given occupation in the eight water industries. For example, as shown earlier in Table A2, 52.2 percent of all meter readers are employed across the eight water industries, so this share (.522) is used to weigh their cross-industry employment at the metropolitan scale. Similarly, because water treatment operators are identified as always being water-related, their share (1.00) is used to include all of their employment in every metropolitan area. The same process is repeated to calculate

utility-specific employment totals at a metropolitan level.

Notably, cross-industry occupational employment for individual metropolitan areas in this report is based on detailed occupation totals. In short, this means only employment in occupations that were not suppressed at the detailed level is included. Likewise, wages are only counted for those occupations without suppressions. Typically, OES cross-industry totals for metropolitan areas, in particular, are higher than totals seen here because OES totals include suppressed and non-suppressed data.

6. Comparing wages at the national and metropolitan levels

Throughout the report, OES wages are based on straight-time, gross pay, which includes forms of compensation such as cost-of-living allowances and over-the-road pay, but excludes overtime pay and holiday bonuses. Mean hourly and annual wages are highlighted in this report, in addition to percentile wages (10th, 25th, 50th, 75th, and 90th). By definition, workers at the 10th and 25th percentiles earn wages at the lower end of each occupation and industry, while workers at the 75th and 90th percentiles earn wages at the higher end.

Nationally, we look exclusively at cross-industry wages for the 212 water occupations. Although wages for individual occupations can vary by industry, this cross-industry perspective follows the same approach used to count national water employment, consistently viewing these occupations in a larger national context.

As such, mean and percentile wages for individual occupations like water treatment operators and pipelayers are a main focus of this report. When viewed together, though, we average wages for all 212 water occupations based on employment. Without the full OES survey sample, this approach is intended to approximate a distribution of earnings across all water occupations, reflecting the large number of workers earning competitive wages at lower percentiles compared to the small number of workers earning competitive wages at higher percentiles.

At the metropolitan level, we also consider cross-industry wages for these 212 water occupations. Because most areas do not employ workers across all of these occupations—and some records may be suppressed—we examine wages only for occupations with reported employment. We calculate overall water wages for each metropolitan area on the basis of the relative weight for each water occupation. All hourly and annual wages—mean and percentile—are averaged for each area using levels of occupational employment.

7. Measuring skills in terms of education and training

This report examines skills in terms of education and training typically needed for the 212 water occupations.

BLS tracks levels of education required for different occupations. Typical levels of education attained—and needed for entry—are based on the following education levels for workers ages 25 years and older: doctoral or professional degree; master's degree; bachelor's degree; associate degree; postsecondary non-degree award; some college, no degree; high school diploma or equivalent; and less than high school.

To get a more precise sense of the knowledge, tools/technologies, and levels of training needed to fill water occupations, we also looked more deeply into the 22.2 version of the O*NET database, updated in February 2018.[13] Since O*NET uses a slightly different occupational classification system compared to the 2010 SOC system, we used a crosswalk to consistently relate the two systems. In total, O*NET codes more than 900 occupations, which have been

related to 772 detailed SOC occupations. 200 of the 212 water occupations had complete information in O*NET.[14]

Through a series of worker questionnaires, O*NET ranks the extent to which occupations require certain types of knowledge, tools/technologies, and levels of training. In these surveys, incumbent workers select one of several possible categories to describe the training and experience typically needed for their occupation. In turn, each category reveals a specific share of these responses; for example, 34.6 percent of water treatment operators indicated that they needed 2 to 4 years of on-the-job training. To determine the most relevant categories of training and experience frequently required for water occupations, we have focused our attention on those categories that received the greatest share of responses from incumbent workers (the mode).

For on-the-job training, O*NET includes 9 different categories based on duration: none or short demonstration; up to 1 month; 1 to 3 months; 3 to 6 months; 6 months to 1 year; 1 to 2 years; 2 to 4 years; 4 to 10 years; and over 10 years.

For related work experience, O*NET includes 11 different categories, also based on duration: none; up to 1 month; 1 to 3 months; 3 to 6 months; 6 months to 1 year; 1 to 2 years; 2 to 4 years; 4 to 6 years; 6 to 8 years; 8 to 10 years; and over 10 years.

O*NET also compiles extensive information on the tools and software technologies used in individual occupations. While O*NET provides specific examples – such as Adobe Systems software or Microsoft Word—used by each occupation, the focus of this analysis is on more generalized commodities – like personal computers, forklifts, and two-way radios—as defined in 6 the United Nations Standard Products and Services Code (UNSPSC). In total, 4,300 individual commodities are classified, including 4,174 tools and 126 software technologies.

In this report, we analyzed the number and type of commodities associated with each detailed SOC occupation nationally. An aggregation of these commodities revealed distinct concentrations of tools and technologies in water occupations. Plumbers and electricians, for instance, use more than 100 different tools and technologies to perform their jobs. Associated levels of employment were also compared alongside these commodity totals.

8. Investigating demographic characteristics

Finally, we explored certain demographic characteristics for the 212 water occupations, primarily at a national level. Through a combination of data provided by the BLS Employment Projections (EP) program, the Current Population Survey (CPS), and the American Community Survey (ACS), we looked at age, gender, and race by detailed occupation. It is important to note that data quality issues exist for many smaller occupations, in particular; where gaps existed, we looked at broad occupational totals instead.[15]

In addition to examining the median age of detailed occupations, we also examined relevant age ranges, which include: 16 to 19, 20 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 64, and 65 and over. To calculate age ranges for the water workforce as a whole, we used a weighted average based on employment levels across the 212 water occupations.

Similar methods were used to calculate gender ratios (male vs. female) and racial information (white, black, Asian, and Hispanic). While weighted totals are reported for the water workforce as a whole, looking at individual occupations tends to offer the greatest clarity for analyzing gender and racial breakdowns within the water sector.

Appendix endnotes

1 For more information on the OES survey's methods, see: https://www.bls.gov/oes/2016/may/oes_tec.htm [Accessed April 2018].

2 For more information, see: https://www.careeronestop.org/competencymodel/competency-models/water-sector.aspx, http://www.waterrf.org/publicreportlibrary/4206.pdf, https://www.bls.gov/careeroutlook/2017/article/pdf/water-utility-jobs.pdf [Accessed April 2018].

3 For instance, many utility-specific activities are bundled under local government, which also includes several unrelated activities, including healthcare and education. Additional background on this issue is described in BAYWORK, 2017.

4 Note that six of these eight industries – NAICS 2213, NAICS 2371, NAICS 2379, NAICS 23822, NAICS 2389, and NAICS 5629 – were found to be particularly important in designating related water occupations. A more detailed approach was needed to weight employment in NAICS 9993 (local government), in particular.

5 For instance, see: Quinn, 2014.

6 Previous Brookings research on infrastructure jobs was especially helpful in designating other related occupations in this respect. In other words, since water industries tend to share many similarities with the infrastructure sector as a whole, we would expect some of the same types of occupations to be engaged in water construction, operation, design, and governance.

7 Note that some of the previous water occupations identified in NAICS 2213 are also included on this list of 35 occupations.

8 Note that an additional 67 occupations were removed, due to being (1) suppressed or (2) out-of-scope per BLS and Census definitions. Some examples of these include: firefighters (SOC 33-2011), roustabouts, oil and gas (47-5071), and rail-track laying and maintenance equipment operators (SOC 47-4061).

9 It is important to note that many water occupations – 199 of the 212 – were found in local government, including maintenance and repair workers, civil engineers, and meter readers for utilities. However, calculating a precise number of workers to include for each of these occupations in local government required a more nuanced approach, as explored below.

10 The only occupation not previously identified – or found among the eight water industries – were hydrologists (SOC 19-2043), which by definition, are water-related.

11 In particular, employment totals for four water-related occupations – plumbers (SOC 47-2152), helpers—plumbers (SOC 47-3015), septic tank servicers (SOC 47-4071), and pipelayers (SOC 47-2151) – were used to calculate the relevant share of water employment in NAICS 23822. Since QCEW and CES do not offer a finer look into plumbing-specific contractors, the employment totals for these four occupations were divided over the industry total, leading to a share of 34 percent.

12 While small, employment was also reduced for two additional occupations primarily concentrated in local government activities – bus and truck mechanics (SOC 49-3031) and automotive service technicians (SOC 49-3023) – given their out-of-scope activities.

13 Additional information on the O*NET 22.2 database is available at: https://www.onetcenter.org/db_releases.html [Accessed April 2018].

14 Due to a lack of O*NET data, the following 12 water occupations are excluded in the skills and training analysis: Drafters, All Other (SOC 17-3019), Designers, All Other (SOC 27-1029),

First-Line Supervisors of Protective Service Workers, All Other (SOC 33-1099), Building Cleaning Workers, All Other (SOC 37-2019), Sales and Related Workers, All Other (SOC 41-9099), Information and Record Clerks, All Other (SOC 43-4199), Office and Administrative Support Workers, All Other (SOC 43-9199), Agricultural Workers, All Other (SOC 45-2099), Helpers, Construction Trades, All Other (SOC 47-3019), Motor Vehicle Operators, All Other (SOC 53-3099), Transportation Workers, All Other (SOC 53-6099), and Material Moving Workers, All Other (SOC 53-7199).

15 For instance, occupations like dredge operators (SOC 53-7031) only amount to about 1,760 workers across the country and may have data quality issues. Thus, demographic information for Transportation and Material Moving Occupations (SOC 53-0000) as a whole are imputed for suppressed data at a detailed level.

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