# A framework for improving economic analysis of water reuse opportunities

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**Abstract:** The economic value of water is a critical part of economic growth, but often taken for granted. Decision-makers in both the private and the public sectors will need economic information that can help them maximise the benefits derived from sustainable water management. The framework must expand beyond the direct costs and benefits of the project, but include the indirect and induced effects such as job creation and expanded tax base for the region. Adapting the economic development evaluation framework from the transportation sector can help the water sector better quantify and enumerate the economic development impacts from water reuse projects and programs. Water sector investments were comparable to transportation investments on a job creation and return on investment scale.

**Keywords:** water reuse; economics; economic analysis; water; wastewater; agriculture; California; reclaimed water.

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## 1 Introduction

Since civilisation began on the banks of rivers, water has proven to be integral to economic development. To preserve this resource, communities have been reusing reclaimed water for decades to recharge groundwater aquifers, irrigate landscapes and agricultural fields, provide critical stream flows, and provide industries and facilities with an alternative to potable water for a range of uses (United States Environmental Protection Agency, 2012). With population exponentially increasing, continual land use changes, and unpredictable climate patterns, communities across the globe are facing water quality and quantity challenges.

To help mitigates these issues, a paradigm shift in the water sector is taking place where treated wastewater is being recognised as a high-quality resource that can be recovered. This shift has enhanced the status of water reuse as an alternative water source in integrated water supply planning. Economic evaluations of water reuse are often focused on the project itself and its direct benefits to the utility. As utilities expand the analysis beyond the project itself, sometimes the economic development indicators are seen in the social leg of the triple bottom line, such as the number of jobs created by the utility and water resources used for recreation (Liner et al., 2012). This paper seeks to provide a framework to help decision makers better quantify the indirect and induced economic development impacts of water investment, specifically for water reuse.

## 2 Water's impact on commercial and industrial business development

How water is used to support economic activity and how economic activity might be affected by changes in the water supply is largely influenced by the extent business development relies on its water supply. Prior to the 1970s, selecting a location to develop a business was based on the conventional view that access to markets, labor, transportation and raw materials, were the dominant factors (Blair and Premus, 1987).

However, the literature beginning in the 1970s illustrated a clear paradigm shift where economic impacts were heavily reliant on geographic factors such as an access to water which is seen as more influential than what was originally thought. The economic benefits of water infrastructure can be classified into direct, indirect and induced effects:

- *Direct effects* on workers and businesses engaged in the construction and operation of water distribution and treatment and wastewater collection and treatment.
- *Indirect effects* on supporting industries, i.e., those that supply goods and services to enable the direct spending – including workers in industries supplying the equipment parts, steel, concrete, etc. needed for building water infrastructure.
- *Induced effects* on the re-spending of worker income on consumer goods and services – including food, clothing, shelter, recreation and personal services (Weisbrod and Reno, 2009).

In 1975, the Council on Environmental Quality (CEQ), the United States Environmental Protection Agency (EPA) and United States Department of Housing and Urban Development (HUD) sponsored a study entitled, secondary impacts of transportation and wastewater investments: volume 2. The report discussed a 'ripple effect' that takes place when water investments in both industry and commerce improve the economics of a community. For example, an industry will find costs lowered over time if they choose to develop on land that already has adequate water infrastructure than to develop where land is cheap but no infrastructure is available. Although CEQ, EPA and HUD agreed that industrial location depends primarily on access to labor and external markets, the influence of public water investments is necessary for consideration because if no water infrastructure is available, an industry is forced to develop one on their own and no matter the industry this can prove both prohibitive and costly due to additional expenses (CEQ et al., 1975).

In fact, the CEQ, EPA, and HUD report concluded that commercial entities view the accessibility to water or water infrastructure as a direct and primary dependency for development. Primary factors are access to water, population distribution and access to households. Secondary (indirect) effects of water infrastructure development are the basis for economic growth. For example, new residential subdivisions of any size are followed by supermarkets, drugstores, and others while the reginal pattern of residential development – coupled with access to transportation – determines the optimum location of shopping centres and office buildings (CEQ et al., 1975).

When evaluating factors to consider when choosing a manufacturing facility location, Chen et al. (2014) identified water availability as critical to production factors, which drive economic growth. In addition, water was featured in the environmental health and ecosystem vitality categories of determinants of facility location.

## 3 The cost of 'no water'

The economic impact of water can be most readily seen when society has insufficient water quantity or quality. The quantity issue is found in the overuse and extraction of both surface and ground waters, particularly in the western USA. The uneven precipitation levels recorded every year across the nation are noticeably different with the supply and demand of water in each state. The water quality issue is dominantly from surface pollution of non-point and point water sources such as nitrogen and phosphorus.

### *3.1 Economic impacts due to drought*

Droughts have a ripple effect across economies and exposes the vulnerability water quantity has to economic development and growth. For example, a shortage in agricultural outputs due to drought (direct impact) result in a shortage of inputs for a variety of industries, such as the food and beverage industry (indirect impact), which could be forced to curtail production, thus affecting the producers' purchasers who use less packaging from the paper and plastics industry (induced impact), which would force rail and truck transporters of food and beverage products to haul less freight, where wholesalers sell fewer food, etc. (US Environmental Protection Agency, 2013).

California is experiencing the water-energy-food nexus ripple to its economy as the state approaches its fourth year of severe drought. The University of California-Davis Center for Watershed Sciences et al. (2015) conducted a study that found economic losses to the state of California worse than projected.

The total economic impact of the California drought just in the year 2015 estimated total economic losses of $2.7 billion dollars to the state and a direct job loss total was estimated to be 21,000 and the numbers are set to increase. California agriculture alone accounts for about 400,000 full-time jobs, including 172,000 in crop production, 29,000 in livestock and dairies and 193,000 in agricultural support services (University of California Davis-Center for Watershed Sciences, 2015).

The effects of continued drought through 2017 based on 2015 water supplies is projected to be 6% worse with net water shortage increasing to nearly 3,600 million cubic metre per year (University of California-Davis Center for Watershed Sciences et al., 2015).

### *3.2 Economic impacts due to anthropogenic nutrient pollution*

Nutrient pollution defined by the United States Environmental Protection Agency as excess amounts of nitrogen and phosphorous in aquatic systems, is one of the leading causes of water quality impairment in the United States. Nutrients refer to the excess of nitrogen and phosphorous which can act as fertilizer to both land and aquatic flora. When there are too many nutrients, especially in aquatic environments an overstimulation to algae and plant growth leads to harmful algal blooms (HABS) that have severe economic losses to surrounding communities. Anthropogenic sources of nutrients are agriculture runoff, municipal and industrial wastewater discharge, storm water runoff and fossil fuel combustion (United States Environmental Protection Agency, 2015). Many state economies across the USA have been severely impaired by anthropogenic nutrient sources due to mitigation costs of reducing nutrient pollution and the direct, indirect and induced economic impacts nutrient pollution causes to water sources.

Tourism and recreation are the economic force behind certain states situated near waterbodies. HABs can lead to beach closures, health advisories, aesthetic degradation and other impacts that are damaging to tourism industries surrounding the affected waterbodies. Table 2 shows USA examples of estimated tourism and recreational economic losses due to HABs (United States Environmental Protection Agency, 2015).

Commercial fishing is extremely important for economies seasonal harvest especially along coastal areas. HABs can cause fish kills, shellfish poisoning and other major economic costs. In Galveston Bay Texas, a HABs event caused economic losses to the commercial oyster industry when shellfish beds were closed for 85 days with economic losses valued at $240,000 between September and December of 2000 (Evans and Jones, 2000).

Property values are proven to substantially decrease when nutrient levels are elevated on waterfront and nearby homes. A meta-analysis conducted by the United States Environmental Protection Agency (2015) of ten property value studies at waterfront and nearby homes showed that the impact on home price per 1 metre change in clarity (Secchi depth) generally had an impact of at least 1% on the low end, with the high estimates at nine, 30, and even 78%. Other indicators include a 9% decrease in property value per 1 mg/L increase in dissolved inorganic nitrogen in Maryland and a 0.6% increase in average property value per 1% increase in clarity in Florida.

Water reuse can itself can directly impact property values. For example, the water reuse program in Vancouver to provide additional flows at False Creek has helped raise property values for the waterfront property (Lucey, 2011).

## 4 Economic impact of water reuse

Demonstrating the value of water when facing a shortage is clear, enhanced focus on the economic benefits beyond the utility are beginning to be realised. Two examples are presented that demonstrate the economic impacts available from water reuse projects on the communities they serve, beyond the economic impact at the project level or due to common irrigation.

### *4.1 Industrial partnership at west basin (Los Angeles, CA)*

In the early 1990s, the West Basin Municipal Water District in Los Angeles, California West Basin added recycled water to its portfolio to serve a population of a million people. To meet the unique needs of their commercial and industrial customers, the utility produces ‘designer water’, or amended tertiary water for industrial and irrigation use. The types of designer water the district produces include the following:

- irrigation water: filtered and disinfected for industrial and irrigation use
- cooling tower water: tertiary treated water with ammonia removal
- seawater barrier and groundwater replenishment water: secondary water, with either lime clarification or microfiltration and reverse osmosis
- low-pressure boiler feed water: microfiltration and reverse osmosis membranes for pure RO water
- high-pressure boiler feed water: ultra-pure RO water treated by microfiltration membranes and passed through reverse osmosis membranes twice.

The designer water strategy enables the use of recycled water far beyond the potential of common irrigation applications for street medians, parks, and golf courses. West Basin also helps ensure the economic production in the area by supplying a critical resource to several local refineries and a power generation company. While this strategy aids the economic impact of the local region, it also helps the utility diversify its revenue streams (ASME and WEF, 2012).

### *4.2 Habitat restoration and public recreation at Tres Rios Wetlands (Phoenix, AZ)*

In 1990, the Arizona Department of Environmental Quality (DEQ) released new water quality standards for wastewater discharges into Arizona waterways. To meet these standards, the City of Phoenix estimated a $600 million investment to upgrade the 153 million gallon per day water utility, the 91st Avenue Wastewater Treatment Plant. The upgrades however would not give the plant any additional capacity for treatment and the city decided to seek an alternative solution.

The solution that was selected was the construction of the Tres Rios wetland project near the WWTP which was located near the convergence of three local tributaries. The wastewater would be discharged into the wetland which would reduce the effluent toxicity of the water providing a natural ‘polish’ to meet the new standards.

The economic impacts proved beneficial for the City of Arizona who were able to not only meet new standards but were able to treat 100% of its wastewater providing an estimated savings of about $500 million per year to the community. Additional recreational benefits of $480,000 to $660,000, aesthetic improvements, and habitat creation for threatened and endangered species (WateReuse Foundation, 2006). The direct impacts of the project such as habitat creation, recreation, capital costs, operation and maintenance costs were just as beneficial to the economy as the induced and indirect economic impacts such as water quality (regulatory compliance) and aesthetic improvements.

## 5 Economic and labor impacts of water utilities

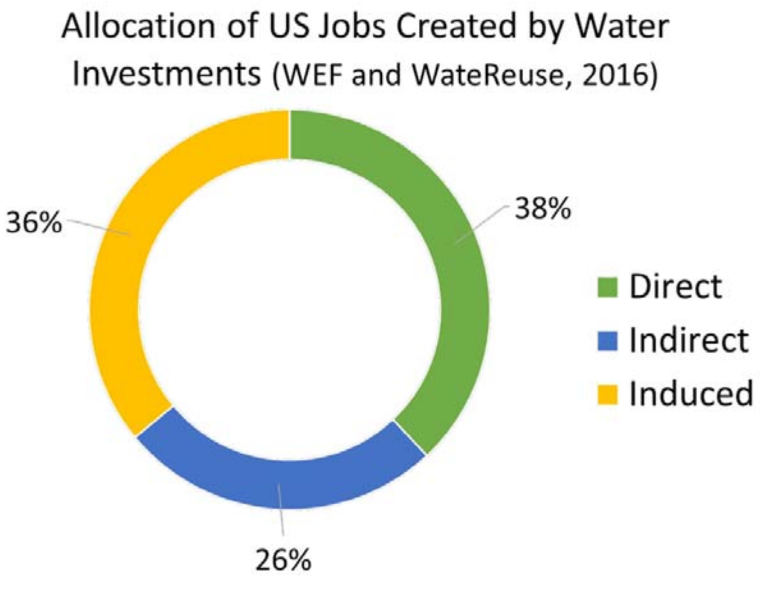
The economic value of water is a critical part of economic growth, but often taken for granted. Decision-makers in both the private and the public sectors will need economic information that can help them sustainably maximise the benefits derived from this resource’s use (United States Environmental Protection Agency, 2013). United States wastewater and stormwater infrastructure investments are at an estimated need of $271 billion over the next 20 years while drinking water is estimated at $384 billion over the next 20 years (Water Environment Federation and WateReuse, 2016).

Quantifying the economic benefits is very difficult not only from an investment standpoint but also from cross sector indirect impacts. Energy production, water supply and food production together accounts for over 94% of water withdrawals from groundwater, streams, rivers, and lakes in the USA (United States Environmental Protection Agency, 2013). Interactions among these sectors have given rise to a recognised paradigm called the energy-water-food nexus, in which demands for water, energy resources, and agricultural products are interrelated. As a result, the use of water in these sectors cannot be viewed in isolation; changes in one sector can have a direct and significant impact on the demand for, and availability of water to the others connecting nearly all economic activity to the nation's water supplies.

Perhaps the complexity and ubiquity of water in the economy is the reason why the economic growth benefits of water reuse investments are often overlooked. In 2014, the Water Research Foundation (WRF) and the Water Environment Research Foundation (WERF) released a report called the "National Economic and Labor Impacts of the Water Utility Sector." This study examined the actual or planned expenditures of 30 water utilities across the United States and quantified direct, indirect, and induced economic benefits. This report was the first to aggregate the national economic impact of water utilities' planned and capital budgets using an economic input-output analysis. The study used the tool IMPLAN which models the way a dollar injected into one sector is spent and re-spent in other sectors of the economy, generating waves of economic activity. The findings were a combined total of 289,000 jobs and $52 billion per year generated in economic activity (direct, indirect and induced combined). The utilities directly employ 36,500 workers.

In 2016, the Water Environment Federation and the Water Reuse Association conducted an analysis to estimate the economic impact of the Clean Water and Drinking Water State Revolving Fund (SRF) programs. These SRF programs are considered to be among the most successful infrastructure funding programs administered by the United States federal government and implemented by individual states, having provided billions of dollars in low-interest loans for thousands of United States projects.

**Figure 1** Allocation of USA jobs created by water investment (16.5 jobs created per million dollars invested) (see online version for colours)




As the USA Government investigates the potential for increased SRF appropriation levels, the benefits identified include taxes that return to the federal government, employment and economic output that the spending generates. The study showed that every federal dollar of SRF spent, 21.4% is returned to the federal government in the form of taxes. An advantage of the SRF program is the leveraging of state program funds to enhance the federal investment. Thus, the proposed $34.7 billion in federal allocation will leverage an additional $116.2 billion in state spending. Together, the proposed federal allocations and state SRF program funds will result in $32.3 billion in federal tax revenue. When these leveraged state funds are taken into account, $0.93 of federal tax revenue is generated for every $1.00 of federal investment. The study also documented increased employment and labor income as well as increases in total economic output.

Water Environment Federation and WateReuse (2016) evaluated the economic impacts of proposed federal SRF allocation used through an IMPLAN model results per 1 billion of State revolving fund (SRF) summary. The SRF spending generates high paying jobs – each job estimated to bring about $60,000 in labor income. On average, 16.5 jobs are generated for every million dollars in water and wastewater capital investments. Figure 1 shows the distribution of employment impacts between the direct, indirect, and induced effects.

The employment impacts of the water sector range between ten and 25 jobs created per million dollars of capital expenditures. Comparatively, studies in the transportation sector show equivalent impacts, with job creation estimates ranging between 13 and 20 jobs per million dollars invested. Table 1 shows the comparison between the sectors.

**Table 1** Job creation per million dollars capital invested

| *Sector* | *Study* | *Year* | *Jobs created/$million* |
|---|---|---|---|
| Transportation | APTA | 2014 | 15.9 |
| Transportation | Heintz et al. | 2009 | 13–20 |
| Water | Gordon et al. | 2011 | 10 |
| Water | Heintz et al. | 2009 | 15 |
| Water | WEF and WateReuse | 2016 | 16 |
| Water | PA Consulting Group | 2009 | 19–25 |

## 6 Learning from transportation sector

The 2014 Water RF/WERF study helps the water sector begin to understand the benefit of quantifying and communicating its full impact on the general economy. Other infrastructure sectors are more developed than the water sector when it comes to the identification of economic impacts for project investments, especially with respect to quantifying the indirect and induced effects. For example, full economic frameworks and tools already exist in the transportation sector and have been successfully implemented in communities throughout the country and the world.

In 2009, the American Public Transportation Association (APTA) conducted an economic impact analysis that identified the direct, indirect and induced effects of transportation investments. The direct effects were defined as job creation, capital investment, and income by supporting manufacturing, construction and public transportation operation activities. The study found that nearly 65,000 jobs are supported per year, per billion dollars of spending on public transportation capital and operations.

The transportation sector is aided by the availability of tools such as the transportation economic development impact system (TREDIS), a transportation system model used to provide economic development impact evaluation and benefit-cost analysis for transportation investments and policies. This tool frames the decision making into six categories and uses data from the Bureau of Economic Analysis, the Bureau of Labor Statistics, the Bureau of the Census, and Department of Commerce agencies. A 2012 independent evaluation by the State Smart Transportation Initiative sponsored by the Wisconsin Department of Transportation and the Federal Highway Administration scored TREDIS as a top tool for measuring economic impacts on transportation projects (North Carolina Department of Transportation, 2014). Currently, 45 United States governmental agencies utilise this tool and it has been used in 35 states across the country.

Having a tool like TREDIS leads to the development of favorable estimates of economic development, such as those shown in the Utah Mobility Coalition's 2014 study. Analysing the economic impacts of Utah's Unified Transportation Plan of 2013–2014 led to the conclusion that by investing another $11.3 billion dollars on top of their allotted $54.7 billion in new transportation funding, 182,618 jobs would be created by 2040, $130.5 billion in additional household income, $183.6 billion in additional GDP, and $22.2 billion in tax revenues from economic growth (Utah Transportation Coalition, 2014).

The Virginia Department of Transportation (VDoT, 2010) successfully utilised the TREDIS model to implement their economic impacts and benefits. With 246,000 direct transportation related jobs (not including induced and indirect projected jobs) across the state, the importance of investing in transportation was a priority for the state.

## 7 Enhancing existing water reuse economic analysis framework

In 2006, the Water Reuse Association released a report called, "An economic framework for evaluating the benefits and costs of water reuse." This report identified the need to further evaluate the direct, indirect and induced economic development and economic growth impacts that water utilities should examine prior to conducting water reuse projects. The report attempted to address the question that came from a workshop of water sector leaders in 2004: "What are the essential components of an economic framework that would promote broad recognition of the full range of services and benefits that water reuse provides?" (WateReuse Foundation, 2006).

Five of the six groups in the resulting framework (financial costs, avoided costs, reliability and quality, public health and safety, and environmental and recreation) capture the direct economic impacts and begin to address indirect impacts. The majority of the indirect and induced economic impacts are mostly combined into the 'economic development/growth' subcategory of the sixth group (economic, social and equity impacts), something the authors of the report identified as opportunity for future research.

The existing WateReuse Foundation (2006) economic framework clearly contains the key elements to quantify direct impacts.

- *costs to water agency* – capital, water, land, treatment, distribution, administrative fees, administrative costs
- *avoided water supply and wastewater costs* – supply costs, treatment capacity, wastewater capacity, treatment variable costs

- *water reliability and quality* – water quality (aesthetics), water quality (regulatory compliance), quality reliability, supply reliability
- *public health and safety* – change in risk of illness (morbidity), change in risk of premature fatality (mortality)
- *environmental and recreational impacts* – sourcewater protection, downstream habitats, environmental restoration, groundwater, coastal ecosystems, threatened and endangered species, terrestrial ecosystems, recreation.

While the existing water reuse framework addresses direct economic effects, the ability to quantify the indirect and induced effects can be enhanced by learning from the transportation sector by adapting the six categories from TREDIS to flesh out the economic, social, and equity impacts group of the water reuse framework. Adapting the TREDIS framework to water enables decision makers to evaluate economic impact of a water reuse project or program by asking the following six sets of questions.

### *7.1 Category 1: the economic role of water reuse*

- What is the role of current water supply facilities and services in supporting the local economy?
- What are the stakes associated with failure to continue to support them?

The impact measure involves tracking the number of jobs in the region, as well as the level of regional products and services that are supported by the provision of water.

### *7.2 Category 2: impact of water spending*

- How does ongoing and planned water spending affect the regional economy, and what is the income benefit from it?

This impact measure reflects the effect of ongoing spending to operate and maintain water supply. It encompasses both water utility (direct effects) and non-water businesses supported because of them (indirect and induced effects).

### *7.3 Category 3: benefit of water reuse investment*

- How does ongoing and planned spending on water reuse in provide benefits for users of those facilities?

When evaluating the indirect and induced impact of a water reuse project, the potential users must be identified. While the reuse project is generally evaluated on the direct impacts, decision makers should consider the jobs and tax base created or maintained by enticing a business to relocate to the area, to stay in the area, or to expand operations due to the availability of a reliable water source. Water is directly used in major sectors of the economy including agriculture, forestry, mining, energy resource extraction, manufacturing, and electric power production (Water Research Foundation and Water Environment Research Foundation, 2014).

Many of these industries have direct withdrawals from ground our surface supplies that may not be provided by a water utility. Looking at the opportunities for water reuse to contribute to the economy as an alternative source can focus on those sectors, except that many of these large water users are not in an urban environment where water reuse opportunities exist.

In the North Pinellas project referenced, the reuse project benefitted the following sectors: real estate and easing, professional tech, forestry and fishing, utilities, construction, educational, and arts and entertainment. Gleick et al. (2003) identified the sectors of largest water use (excluding residential and agriculture) in urban environments in California, as shown in Table 2. Many of these business sectors are opportunities for reuse, providing opportunities for associated regional economic development, as well.

**Table 2** Sectors with potential for economic development benefits due to water use (in million cubic metres)

| *Commercial sector* | *Annual water use* | *Industrial sector* | *Annual water use* |
|---|---|---|---|
| Offices | 418 | Refining | 104 |
| Schools | 310 | High tech | 93 |
| | | Fruit and vegetable | |
| Golf courses | 282 | Processing | 86 |
| Restaurants | 201 | Beverage processing | 70 |
| Retail | 189 | Textiles | 36 |
| Hospitals | 46 | Paper | 27 |
| Hotels | 37 | Fabricated metals | 25 |
| Laundries | 37 | Dairy processing | 21 |
| Other | 766 | Meat processing | 19 |
| | | Other industrial | 340 |
| Total | 2,286 | Total | 820 |

## *7.4 Category 4: economic return on investment*

- How will planned future capital investments affect the future competitiveness, productivity, and growth of the region’s economy?
- What is the payback from it?

Economic impact measurement is accomplished by calculating the ways in which current and planned water spending leads to impacts on income received, expenses incurred, and productivity of operations by businesses and households. Much of this will also be due to the ability to keep, attract, or expand businesses due to having a high-quality, reliable supply of water.

## *7.5 Category 5: impact of future scenarios for strategic planning*

- How will alternative scenarios for future water supply capital investments affect the future competitiveness and growth of the region’s economy?
- How can that information help identify investment gaps that need to be funded to allow economic growth opportunities to occur?

This economic impact measurement is accomplished by identifying the need for future water supply investments in the region to keep up with an ever changing economy. It is also accomplished to help define new initiatives in water policy, funding and finance that may be needed to bolster regional economic development. It can also show the cost of underfunding water investment, and the investment gaps that need to be filled to meet other strategic planning objectives.

### *7.6 Category 6: ongoing performance tracking*

- How can evaluation and selection of future projects incorporate economic impacts and benefit/cost relationships?
- How can that approach apply to integrated water resources planning?

Measuring success can provide a means of placing individual projects in the context of an overall strategy and plan. In transportation, the focus is on multimodal planning (roads, transit, air, etc.), which is analogous to the issues faced by the water sector in integrated water resources management.

## 8 Conclusions

Water reuse is, by its nature as both water and wastewater, a critical aspect in total water management. The ability to provide a high-quality, alternative water source makes a utility that practices water reuse even more valuable to the local economy. While many water reuse projects are evaluated on the direct impacts of the project, utilities are beginning to highlight the overall impact of water supply operations on the region's economy. The water sector can learn from the transportation sector and better identify the indirect and induced impacts of a water project. By highlighting these impacts which help drive economic growth, water reuse projects may have opportunities for additional allies in a region's economic development initiatives, especially since water sector investments are comparable to transportation investments on a job creation and return on investment basis.

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