INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN

The Economic and Fiscal Costs of Water Supply Disruption to the National Capital Region

Prepared for:

Interstate Commission on the Potomac River Basin

Prepared by:

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Executive Summary

The issue of resiliency in municipal water supplies is receiving increasing attention from regional economic researchers. This is not surprising given the public attention given to notable disruption events in the U.S. and elsewhere. In this analysis, we assess the potential economic consequences of losing water supply services in key areas of the National Capital Region due to disruptions in the availability of raw water from the Potomac River. Our methods and key findings include:

- Using research published in peer-reviewed academic journals, we examine business operational resilience to a disruption in the availability of treated water by industry sector measured as the proportion of gross regional product that a given industry can continue to deliver without treated water.
- The impacts of water loss are different across industry sectors and will worsen as the duration of service disruption lengthens. Moreover, as the duration of service disruption extends, it will take longer to return to "normal" levels of business activity.
- The analysis presented here examines the potential economic losses of treated waters services supplied by the Potomac River for the District of Columbia (DC) and other areas in the National Capital Region supplied by Washington Aqueduct, WSSC Water, and Fairfax Water.
- Even a short-term loss of water services will spark a devastating reduction in economic activity and severely disrupt federal, state, and local government revenues in the National Capital Region with notable losses beginning in as little as two-hours from the initiation of service disruption. These losses will be endured in spite of government interventions to maintain essential services and the ability of some jobs to shift to remote work.
- Within the first month the region could see a loss of almost $15 billion in gross regional product (GRP) and hundreds of millions in tax losses. By the end of four months, the cumulative losses would rise to more than $65 billion (see Table ES1).
- Because of capital and resource availability, these business losses will be borne disproportionately by small businesses and women-owned and minority-owned businesses.
- The analysis focuses on business impacts; however, it is important to recognize that, on average, the most vulnerable industries employ a disproportionate share of lower wage earners, and the specific occupations that will be hardest hit will be lower paid positions. These households do not have the financial resources to temporarily relocate if they lose water services at their homes and will therefore bear a disproportionate share of the impacts associated with water supply disruptions.

1. Delta Point Solutions, LLC and Clower & Associates, LLC.

Table ES1: Cumulative Losses from Extended Water Supply Service Disruptions, Selected Water Supply Service Providers in the National Capital Region

	GRP	Total Taxes	Federal Taxes	State Taxes	Local Taxes
District of Columbia					
Month 1	$(6,050,316,781)	$(227,866,826)	$(161,513,774)		$(66,353,053)
Month 2	$(12,864,894,466)	$(484,517,221)	$(343,429,564)		$(141,087,657)
Month 3	$(19,679,472,151)	$(741,167,616)	$(525,345,355)		$(215,822,261)
Month 4	$(26,494,049,836)	$(997,818,011)	$(707,261,145)		$(290,556,866)
Arlington					
Month 1	$(1,068,585,202)	$(61,920,566)	$(48,351,528)	$(5,733,772)	$(7,835,266)
Month 2	$(2,280,908,941)	$(132,170,250)	$(103,206,963)	$(12,238,811)	$(16,724,477)
Month 3	$(3,493,232,679)	$(202,419,934)	$(158,062,397)	$(18,743,849)	$(25,613,688)
Month 4	$(4,705,556,418)	$(272,669,618)	$(212,917,832)	$(25,248,888)	$(34,502,898)
Fairfax Water					
Month 1	$(3,595,417,298)	$(162,100,591)	$(113,802,764)	$(23,418,850)	$(24,878,977)
Month 2	$(7,667,984,949)	$(345,713,666)	$(242,708,373)	$(49,945,631)	$(53,059,662)
Month 3	$(11,740,552,601)	$(529,326,740)	$(371,613,981)	$(76,472,413)	$(81,240,346)
Month 4	$(15,813,120,252)	$(712,939,814)	$(500,519,590)	$(102,999,194)	$(109,421,030)
WSSC Water					
Month 1	$(4,161,250,389)	$(200,397,676)	$(150,486,664)	$(28,392,900)	$(21,518,113)
Month 2	$(8,843,257,345)	$(425,873,970)	$(319,805,868)	$(60,339,008)	$(45,729,094)
Month 3	$(13,525,264,300)	$(651,350,263)	$(489,125,073)	$(92,285,115)	$(69,940,074)
Month 4	$(18,207,271,255)	$(876,826,556)	$(658,444,278)	$(124,231,223)	$(94,151,055)
Total Regional Losses					
Month 1	$(14,875,569,670)	$(652,285,660)	$(474,154,730)	$(123,898,574)	$(54,232,356)
Month 2	$(31,657,045,701)	$(1,388,275,107)	$(1,009,150,768)	$(263,611,106)	$(115,513,232)
Month 3	$(48,438,521,731)	$(2,124,264,553)	$(1,544,146,807)	$(403,323,639)	$(176,794,108)
Month 4	$(65,219,997,762)	$(2,860,254,000)	$(2,079,142,845)	$(543,036,171)	$(238,074,983)

Note: These losses begin on the first full day of water supply outage within each service area. The day the water service is disrupted may not be the same across all service areas.

Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

The cost of doing nothing to address water supply vulnerabilities in the District of Columbia and the larger National Capital Region is too high. Even allowing for risk-adjustments to these costs, investing in resiliency enhancements is an imperative from both human safety and economic perspectives.

Introduction

The issue of resiliency in municipal water supplies is receiving increasing attention from regional economic researchers. This is not surprising given the public attention given to notable disruption events in the U.S. and elsewhere. In this analysis, we assess the potential economic consequences of losing water supply services in key areas of the National Capital Region due to disruptions in the availability of raw water from the Potomac River. A research article published in the journal Water in 2021 offers a detailed assessment of business operational resilience to a disruption in the availability of water (treated). The results of this research were then mapped to the industry structure of the subject areas to obtain an estimate of economic losses associated with losing access to water. Importantly, the research used for this analysis considers that the impacts are different across industry sectors and will change based on the duration of the disruption. In addition, as the duration of service disruption lengthens, it will take longer to return to "normal" levels of business activity. We analyze impacts on the District of Columbia (DC) and other areas in the National Capital Region supplied by Washington Aqueduct, WSSC Water, and Fairfax Water.

In Table 1 below, the average water supply resiliency indices by industry sector for the District of Columbia are shown. The resiliency index, which is derived from the work of Sjostrand, et al (2021), represents the proportion of economic activity as measured by gross regional product (GRP) that an industry can continue to deliver during a water supply disruption. The columns show the duration of the disruption at 2-Hours, 4-Hours, 12-Hours, 24-Hours, 1-Week, and 1-Month. The final column is a time-to-recovery factor at the 1-month time disruption where 1.0 equals one month of time for recovery to normal operations.

Examining industries at a slightly more detailed level shows the sectors that are more resilient and less resilient, which includes accounting for loss of building services such as sanitation plumbing and consideration of safety issues such as the loss of fire protection. However, these losses do not explicitly account for an escalation of impacts associated in simultaneous multiple hazards, such as a fire event when firefighting systems are impaired.

Industries which show the largest drop in resilience over the duration of the event were also shown (see Table 2). For example, food production activities and the combined sector of lodging and restaurants are among the least resilient. Whereas information services and financial activities are more resilient. Some of these industries are not very large in the National Capital Region, such as chemical manufacturing. Note that Real Estate industry activities show the largest drop in resilience between the initial 2-hours of service disruption versus a 1-month disruption. This makes sense given that the real estate sector would see increasing losses as residential and commercial buildings become uninhabitable with the loss of water services for an extended time. Importantly, the estimated resilience ratios show that industries can adapt by altering processes and/or using alternative sources of water. Any rationing of alternative water resources would lower resilience.

Table 1. Resiliency Index by Major Industry by Duration of Disruption

Industry	2021 DC GRP (000s)	2 hrs	4 hrs	12 hrs	24 hrs	1 wk	1 mo	Time Factor
Crop Production	$2,106	0.92	0.90	0.73	0.65	0.44	0.32	1.09
Construction	$1,886,049	0.91	0.86	0.77	0.72	0.54	0.57	1.07
Manufacturing	$423,314	0.77	0.82	0.61	0.53	0.40	0.33	1.09
Utility & Transportation	$1,519,355	0.92	0.90	0.74	0.69	0.55	0.47	1.07
Wholesale and retail	$3,186,405	0.89	0.83	0.71	0.63	0.48	0.38	1.06
Finance, Insurance & Real Estate	$10,033,045	0.93	0.88	0.71	0.61	0.46	0.37	1.06
Information & Communication	$9,518,953	0.97	0.94	0.86	0.80	0.71	0.66	1.00
Professional & Business Services	$35,836,318	0.91	0.86	0.74	0.67	0.56	0.48	1.03
Leisure & Hospitality	$4,392,459	0.73	0.66	0.42	0.35	0.23	0.16	1.19
Health & Human Services	$11,299,421	0.83	0.76	0.58	0.49	0.37	0.31	1.08
Other Services	$9,227,112	0.84	0.78	0.62	0.54	0.40	0.33	1.04
Public Administration & Defense	$57,524,341	0.91	0.86	0.71	0.64	0.51	0.44	1.02

Sources: Sjostrand, et al (2021); Lightcast; author's estimates.

Table 2. Most and Least Resilient Industries

Least Resilient		Most Resilient		Largest Drop in Resilience 2hr to 1 mo	
Industry	**2hr r**	**Industry**	**2hr r**	**Industry**	**r-drop**
Chemical Manufacturing	0.61	Information	0.97	Real Estate	0.61
Food &Beverage Mfg	0.69	Metal Products Mfg	0.96	Crop Production	0.60
Lodging & Food Services	0.70	Computer/Electronics Mfg	0.96	Lodging & Food Services	0.60
Human Health Services	0.79	Finance & Insurance	0.96	Transport Equipment Mfg	0.59
Arts & Entertainment	0.82	Transportation & Storage	0.95	Food and Beverage Mfg	0.58

Sources: Sjostrand, et al (2021), author's estimates.

Estimating Business Losses

Using the data shown in Table 2, we estimate the loss in economic activity within the District of Columbia related to a water supply disruption. Given that this analysis does not consider the short-term impacts of minor system disruptions, we only estimate losses that would occur if water services became unavailable for at least one full day after the depletion of water reserves. At the upper end, we also only consider losses over a few months. The resiliency measures estimated by Sjostrand, et al (2021) only consider disruptions lasting one month. We can expect that the decline in resilience shown in the first month of service disruption would continue to worsen if the event duration lasts for a longer period of time. However, it is also likely that over time alternative resources would come online and soften the impacts of the service disruption. For illustrative purposes, our estimates of losses after one month of service disruption assume that these contrasting influences balance out – a notable assumption but reasonable for this initial assessment of potential losses.

The analysis presented here uses Gross Regional Product (GRP) as the key economic measure. This metric, which is equivalent to Gross Domestic Product (GDP), is a measure of the value added by an industry's activities. It includes net earnings plus taxes on production and imports. Net earnings include revenues less salaries and benefits paid to employees, rents and rent equivalents, and other costs of doing business. Using this measure, instead of industry output, avoids the potential for double counting economic activity, such as when an employee contributes to the production of a good or service and is also a consumer of that service or product. Gross Regional Product is a more accurate way of describing regional impacts of business activity gains, or losses.

For purposes of this analysis, we use estimates of GRP by industry for 2021. Given that some sectors of the regional economy were still being negatively impacted by the pandemic in 2021, our estimates will likely understate total potential losses if the water service disruption occurs after the economy has recovered to pre-pandemic activity levels.

Since the resilience measure is calculated as a proportion of contributions to gross regional product by industry, we can use a simple inverse function to estimate lost regional product using the following formula:

$$\text{GRP impact} = \sum_i GRPd * (1\text{-}r_t) * T$$

where: GRPd is the average gross regional product for industry i per day,

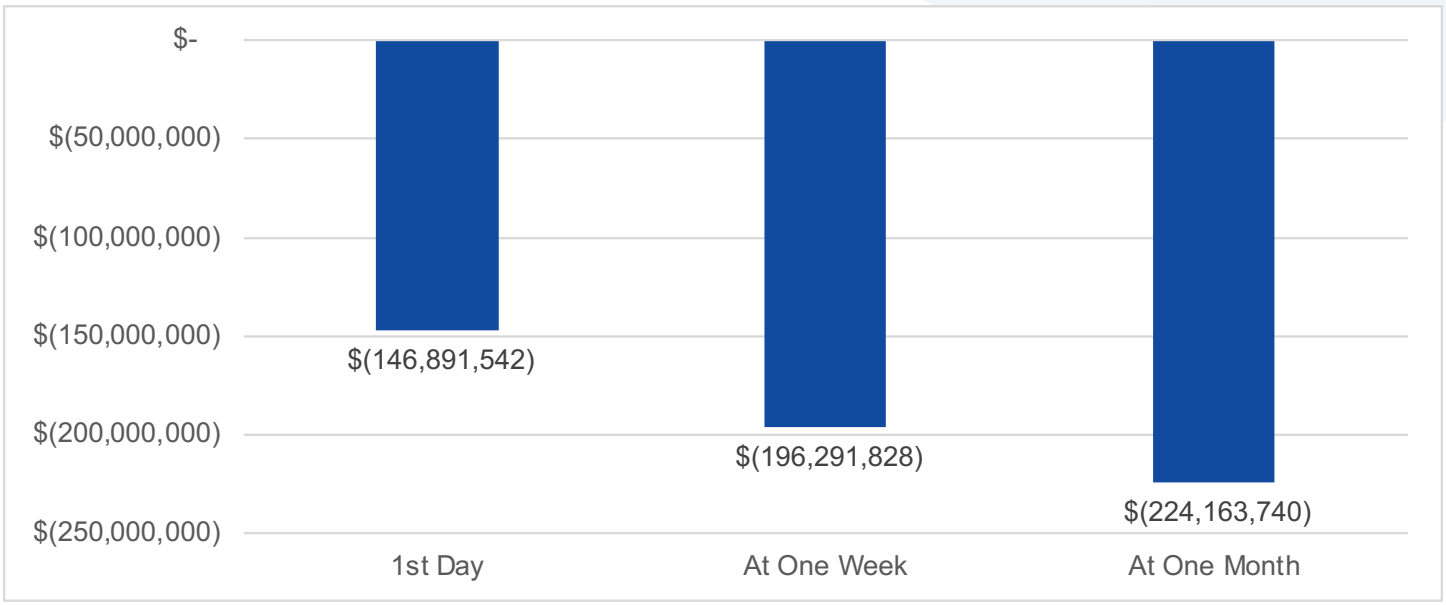
r_t is the resilience factor for industry i for the relevant event duration (1 day, 1 week, 1 month),

T is the number of days.

Figure 1 shows that as the water disruption event duration lengthens, the average daily losses increase. By the end of the first day of service disruption, losses across all measured industry sectors in the District of Columbia will reach about $146.9 million per day. After one week of disruptions, the losses will increase to $196 million per day. By the one-month mark, losses to GRP will be more than $224 million per day. For illustrative purposes, Figure 2 shows that the rate of increases in daily losses moderates somewhat, but the magnitude of total daily losses continues to rise. The cumulative daily total of lost economic activity quickly becomes staggering. By the end of the first month of water supply service disruption, total cumulative economic losses will increase to more than $6 billion (see Figure 3). If the water service disruptions last for an extended time, the loss of economic activity mounts. As shown in Table 3 below, total cumulative losses in GRP would reach about $12.9 billion at the end of 60 days, $19.7 billion at 90 days, and $26.5 billion by 120 days, or more than 10% of total annual GRP.

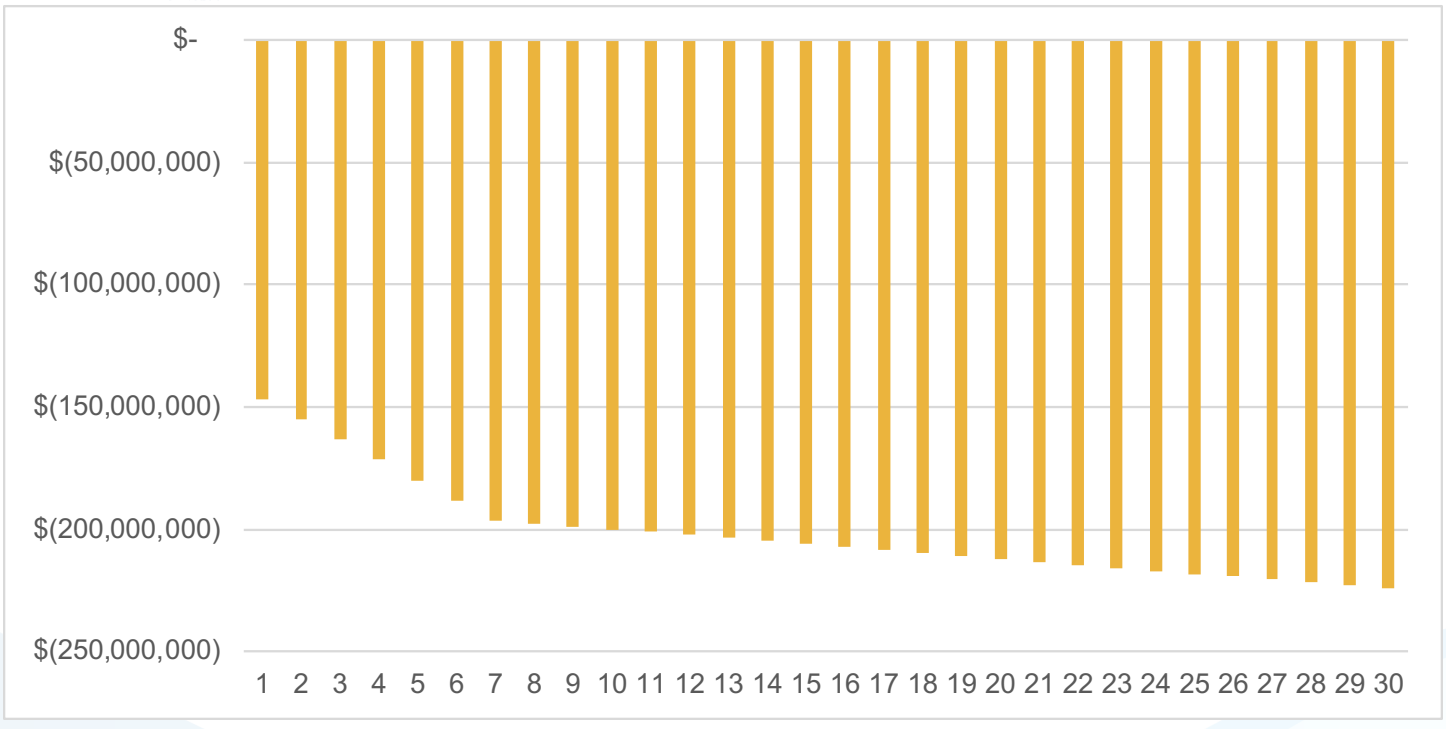
The analysis shows that much economic activity will continue due to two likely influences. First, essential functions of the federal government will continue as resources are mobilized to provide subsistence levels of water in fixed locations by trucking or other means of conveyance. Basic sanitation services will also be available to essential workers using military-style interventions. Secondly, a somewhat positive effect of the COVID-19 pandemic has provided direct experience in carrying on many government and business functions in a remote-work mode – assuming workspaces can be found for those who both work and live in DC. However, economic activity can be both footloose and sticky, meaning that the location of economic activity can shift relatively easily when the distance is not great, and once it shifts, it may not come back (Clower, 2005). It is quite likely that a portion of the anticipated losses will be permanent. Moreover, the damage to the District's business reputation would likely dampen its ability to attract and retain businesses for many years.

Figure 1. Daily Industry Losses Without Water Supply Services District of Columbia



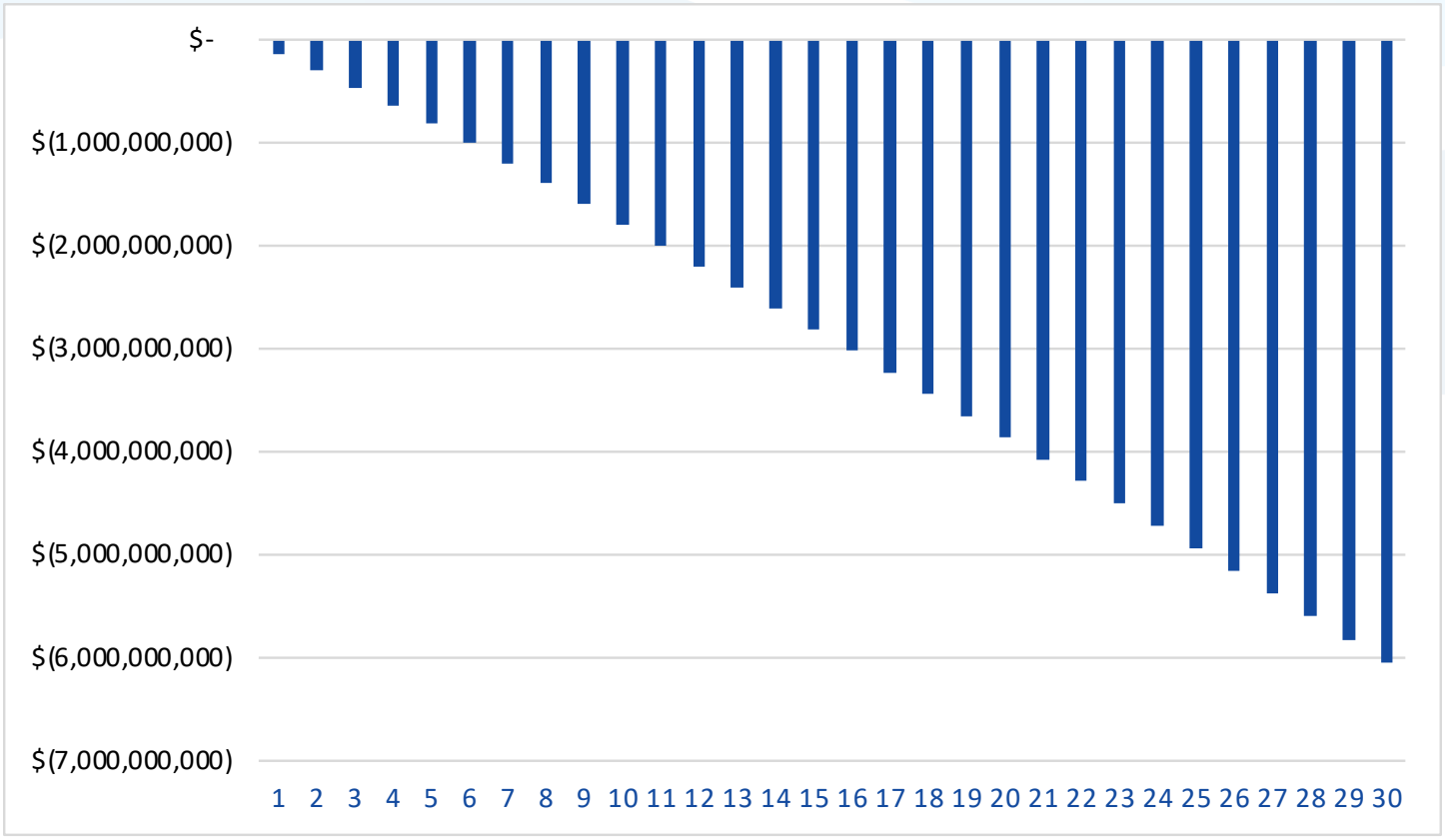
Sources: Sjostrand, et al (2021); Lightcast; author's estimates.

Figure 2. Daily Loss in Gross Regional Product Per Day Through First 30 Days Without Water Supply Services, District of Columbia



Sources: Sjostrand, et al (2021); Lightcast; author's estimates.

Figure 3. Cumulative Daily Losses in Gross Regional Product After Losing Water Supply Services, District of Columbia



Sources: Sjostrand, et al (2021); Lightcast; author's estimates.

Table 3. Cumulative Losses in Gross Regional Product from Extended Water Supply Service Disruptions in the District of Columbia

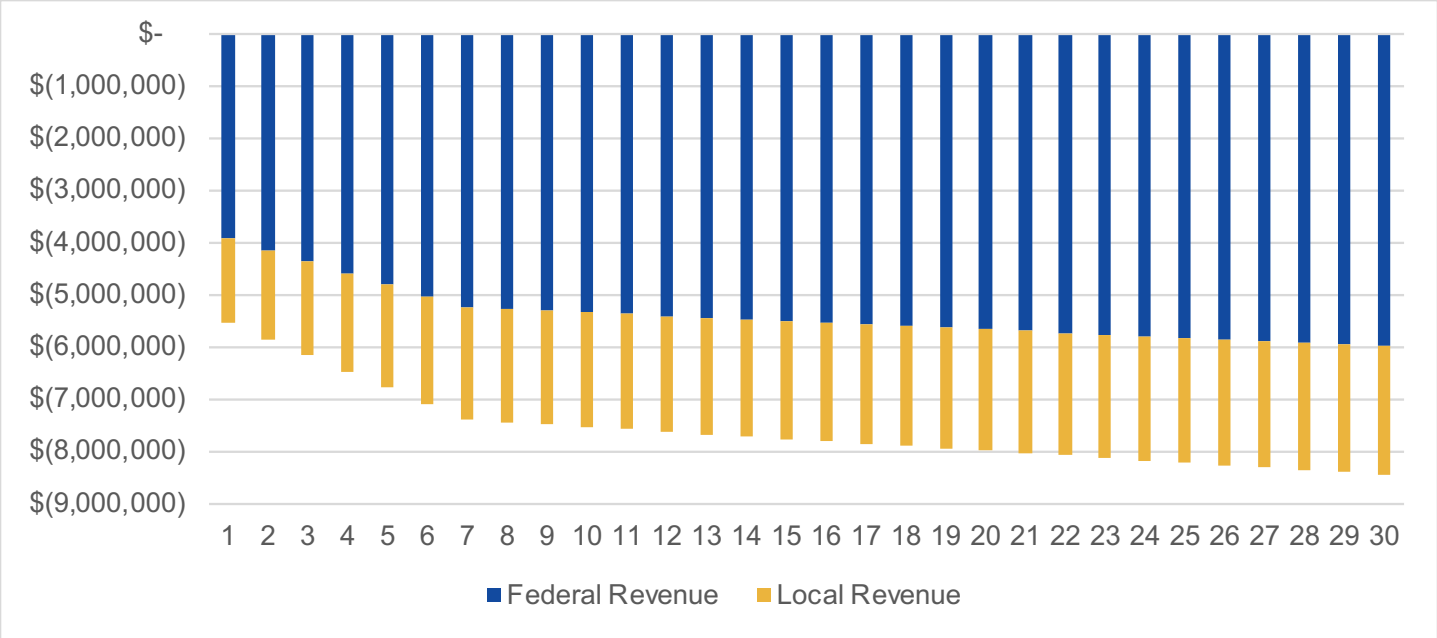
Time Period	Lost Gross Regional Product
Month 1	$(6,050,316,781)
Month 2	$(12,864,894,466)
Month 3	$(19,679,472,151)
Month 4	$(26,494,049,836)

Sources: Sjostrand, et al (2021); Lightcast; author's estimates.

The loss of economic activity also means that revenues would decline both for the District of Columbia and for the federal government. These revenue losses include property taxes, sales and use taxes, incomes taxes, fees, and other sources of government revenue. Based on 2021 ratios between GRP and total government revenues, we expect day one tax revenue losses at about $5.5 million. By the end of one month, those revenue losses will rise to more than $8.4 million per day. This analysis uses the IMPLAN economic input-output model to estimate tax revenue losses associated with business activity reductions distributed federal, state, and local revenues (see Figure 4). The IMPLAN model uses an economic input-output framework to estimate how business transaction spending flows through a regional economy and is based on benchmark economic data developed by the Bureau of Economic Analysis. The IMPLAN model is widely used in academic and professional research.

Following the pattern of cumulative losses, the federal government will lose an estimated $161.5 million from foregone business activity in the first month. District revenue losses after one month of water supply service disruption will total $66.3 million. By the end of the fourth month, government revenue losses will total almost $1 billion with $707 million and $291 million in losses for federal and local coffers, respectively (see Table 4.)

Figure 4. Daily Loss in Government Revenue Per Day Through First 30 Days Without Water Supply Services, District of Columbia



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates.

Table 4. Cumulative Losses of Government Revenue from Extended Water Supply Service Disruptions in the District of Columbia

Time Period	Total	Federal	District of Columbia Revenues
Month 1	$(227,866,826)	$(161,513,774)	$(66,353,053)
Month 2	$(484,517,221)	$(343,429,564)	$(141,087,657)
Month 3	$(741,167,616)	$(525,345,355)	$(215,822,261)
Month 4	$(997,818,011)	$(707,261,145)	$(290,556,866)

Sources: Sjostrand, et al (2021); Lightcast; IMPLAN, author's estimates.

The losses described above are for business and government activities only. While that includes lost earnings for DC workers, it does not include additional expenses incurred by households as they adjust to the loss of services. It also does not include the explicit cost to governments for providing supportive services during the service disruption as described elsewhere in this report.

Not including these other costs and taking a conservative approach in estimating GRP losses suggest that our estimates represent a lower bound of potential impacts of an extended disruption in municipal water services.

Disproportionate Impacts

In this section we consider if the likely economic harm caused by a loss of water supply services will fall disproportionately on any particular group of businesses or individuals. Our approach considers the findings of previous research and compares the estimated 1-month resiliency index, summarized in Table 1, with important industry characteristics.

Researchers and casual observation tell us that small businesses, especially those with constrained finances, are less resilient to disaster events (see for example Wiatt, et al, 2021), though intervention by the Small Business Administration and other federal programs improve small business survival rates (Haynes, et al, 2019). Table 5 compares 1-month resiliency rates for water supply service disruptions to the proportion of businesses with fewer than 10 employees by industry. With the exception of Educational Services and Hotels/Restaurants, there is a clear tendency for industries with smaller employment headcounts per establishment to be more vulnerable to water service disruptions. The Real Estate sector shows to be the most vulnerable among those industries most represented by small businesses. In addition, small and medium sized firms are less likely to carry insurance that would help offset operating losses. In an era of rising costs of all disaster events and an increasing number of events, disaster insurance is becoming more difficult to obtain and more costly to hold, which suggests increased vulnerability among smaller firms.

Table 5. Small Business and Resiliency by Industry, District of Columbia

NAICS	Industry Description	% Establishments <10 Employees	1 mo r
00	Total for All Sectors	67.4%	0.40
53	Real Estate	83.4%	0.26
42	Wholesale Trade	82.0%	0.38
52	Finance & Insurance	77.0%	0.42
31-33	Manufacturing	73.6%	0.39
48-49	Transportation & Warehousing	72.6%	0.51
54	Professional, Scientific, Technical Services	72.5%	0.48
44-45	Retail trade	70.2%	0.38
81	Other Services	69.2%	0.33
23	Construction	68.8%	0.57
22	Utilities	68.7%	0.45
51	Information	67.1%	0.66
56	Administrative & Support	66.7%	0.50
62	Health Care & Related	65.4%	0.28
71	Arts & Entertainment	62.3%	0.31
55	Management of Companies	60.9%	0.50
61	Educational Services	55.3%	0.37
72	Accommodation & Food Services	41.9%	0.10

Sources: Sjostrand, et al (2021); U.S. Census 2020 establishment data.

In this analysis we do not specifically assess resilience by industry representation across Historically Under-represented Businesses. However, the research literature shows that minority-owned, women-owned, and veteran-owned businesses are more likely to fail from the impacts of a disaster event (Marshall, 2015).

We also considered how a water supply disruption disaster would impact lower income households, particularly the working poor. Just like small businesses, households with few spare financial resources will not have the resources to mitigate the loss of water supply services. This is obvious for families currently covered by government assistance programs. However, our analysis shows that the economic impacts of a loss of water services will fall disproportionately on the working poor.

Table 6 compares 1-month resiliency rates to the average wage paid by industry sector. The average 1-month resiliency rate is 0.4 with the median value of 0.39, which means that half of the industries have better that 0.39 resiliency and half are less than 0.39 resiliency. The average wage across all industry sectors that are more resilient is $117,889. The average income of the least resilient industries is $61,677, barely half that of the more resilient group. The relationship between resiliency is quite clear and pronounced with a correlation coefficient of 0.51.

Table 6. Resiliency and Average Wage by Industry, District of Columbia

NAICS	Industry	Avg wage	1 mo r
00	Total for all sectors	$84,411	0.40
52	Finance and insurance	$174,445	0.42
22	Utilities	$160,905	0.45
54	Professional, Scientific, Technical Services	$141,282	0.48
55	Management of Companies	$127,196	0.50
48-49	Transportation & Warehousing	$125,578	0.51
51	Information	$123,018	0.66
81	Other Services	$94,600	0.33
42	Wholesale Trade	$89,413	0.38
53	Real Estate	$86,657	0.26
23	Construction	$75,040	0.57
62	Health Care & Related	$63,762	0.28
61	Educational Services	$58,705	0.37
71	Arts & Entertainment	$49,246	0.31
56	Administrative & Support	$49,124	0.5
31-33	Manufacturing	$44,126	0.39
44-45	Retail Trade	$30,585	0.38
72	Accommodation & Food Services	$20,446	0.10

Sources: Sjostrand, et al (2021); U.S. Census 2020 establishment data.

Projections to other areas of the National Capital Region

In this section, we discuss estimated impacts of loss of water supply services on areas of the National Capital Region in Maryland and Virginia, obtained by projecting results for the District of Columbia onto surrounding water service areas. Detailed estimates are presented in Appendices 1, 2, and 3.

Most suburban areas near the District are supplied with water by three Maryland and Virginia water suppliers: WSSC Water, Fairfax Water, and Loudoun Water. An exception is Arlington County, Virginia, which purchases water from the Washington Aqueduct. The Maryland and Virginia suppliers, WSSC Water and Fairfax Water, obtain the majority of their raw water from the Potomac River. They also have reservoirs in the Patuxent and Occoquan watersheds, respectively, which can meet some portion, but not all, of their customer demands. These suppliers distribute water to their retail customers: homes, businesses, and government facilities located in Montgomery and Prince Georges Counties in Maryland, and Fairfax County, the City of Fairfax and the City of Falls Church in Virginia. They also sell treated water to wholesale customers which include Loudoun Water and Prince William County Service Authority in the case of Fairfax Water, and Charles and St. Mary's counties in the case of WSSC Water. Fairfax Water also purchases some treated water from Washington Aqueduct.

For this study, Arlington County Department of Environmental Services, Fairfax Water, and WSSC Water all provided estimates of the overall percentage of the customers in their respective water service areas that would be without water within several days of an emergency event resulting in the loss of their Potomac River supply. Their estimates were based on their analyses of the impacts on their customers of an extended duration outage scenario at average daily water demands. Results discussed in this section and presented in detail in Appendices 1, 2, and 3, were obtained based on these overall percentage values and the assumption that percentages of customers without water would be uniform throughout each of these water service areas. Table 7 summarizes our findings for the three suburban water service providers included in this analysis.

Table 7: Cumulative Losses from Extended Water Supply Service Disruptions, Selected Water Supply Service Providers in the National Capital Region

	GRP	Total Taxes	Federal Taxes	State Taxes	Local Taxes
Arlington					
Month 1	$(1,068,585,202)	$(61,920,566)	$(48,351,528)	$(5,733,772)	$(7,835,266)
Month 2	$(2,280,908,941)	$(132,170,250)	$(103,206,963)	$(12,238,811)	$(16,724,477)
Month 3	$(3,493,232,679)	$(202,419,934)	$(158,062,397)	$(18,743,849)	$(25,613,688)
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Fairfax Water					
Month 1	$(3,595,417,298)	$(162,100,591)	$(113,802,764)	$(23,418,850)	$(24,878,977)
Month 2	$(7,667,984,949)	$(345,713,666)	$(242,708,373)	$(49,945,631)	$(53,059,662)
Month 3	$(11,740,552,601)	$(529,326,740)	$(371,613,981)	$(76,472,413)	$(81,240,346)
Month 4	$(15,813,120,252)	$(712,939,814)	$(500,519,590)	$(102,999,194)	$(109,421,030)
WSSC Water					
Month 1	$(4,161,250,389)	$(200,397,676)	$(150,486,664)	$(28,392,900)	$(21,518,113)
Month 2	$(8,843,257,345)	$(425,873,970)	$(319,805,868)	$(60,339,008)	$(45,729,094)
Month 3	$(13,525,264,300)	$(651,350,263)	$(489,125,073)	$(92,285,115)	$(69,940,074)
Month 4	$(18,207,271,255)	$(876,826,556)	$(658,444,278)	$(124,231,223)	$(94,151,055)

Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

Summary Impacts for the Study Area

Combining the findings of our analyses for the District of Columbia and the three suburban water suppliers for which we presently have data, it is readily apparent that even a short-term loss of water services will spark a devastating reduction in economic activity and severely disrupt federal, state, and local government revenues in the National Capital Region with notable losses beginning in as little as two-hours from the initiation of service disruption. Notable losses will begin in as little as two-hours from the initiation of service disruption for many businesses. As shown in Table 8, the region could see a loss of $65 billion in gross regional product in just the first four months of a loss of water services tied to supply sourced from the Potomac River. Total federal, state, and local jurisdiction losses will top $2.8 billion within four months. For reporting purposes, we include the District of Columbia in the column for state revenue losses.

Table 8. Summation of Economic and Fiscal Losses of Water Supply Disruption, District of Columbia, Arlington, Fairfax Water, WSSC Water

	GRP	Total Taxes	Federal Taxes	State Taxes*	Local Taxes
Month 1	$(14,875,569,670)	$(652,285,660)	$(474,154,730)	$(123,898,574)	$(54,232,356)
Month 2	$(31,657,045,701)	$(1,388,275,107)	$(1,009,150,768)	$(263,611,106)	$(115,513,232)
Month 3	$(48,438,521,731)	$(2,124,264,553)	$(1,544,146,807)	$(403,323,639)	$(176,794,108)
Month 4	$(65,219,997,762)	$(2,860,254,000)	$(2,079,142,845)	$(543,036,171)	$(238,074,983)

Note: These losses begin on the first full day of water supply outage within each service area. The day the water service is disrupted may not be the same across all service areas.

* Includes the District of Columbia

Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

Conclusions

The analysis presented in this paper clearly shows that a disruption in public water supply services would quickly have devastating economic consequences for businesses and households in the District of Columbia and other areas of the National Capital Region, even with government interventions to maintain essential services and the ability of some workers to carry on their job duties remotely. During the first week of a water supply disaster event, daily losses to gross regional product in the District will be almost $147 million per day. By the end of one month of disruption to municipal water supplies, total economic losses will exceed $6 billion. The District of Columbia and the federal government will experience substantial losses in government revenues as businesses reduce or cease operations. In the first full day of business disruption, federal revenue losses will be about $4 million. At the end of one month, federal revenue losses will exceed $161 million, and DC will lose $66 million.

Importantly, the losses experienced by businesses and their employees will disproportionately fall on lower wage households, the working poor, and Historically Disadvantaged Businesses including minority-owned, women-owned, and veteran-owned enterprises. Moreover, the longer such a disaster event continues, the less likely lost business activity will return to the District once the disaster is resolved. The occurrence of even one city-wide short-term disruption to water supply services will have lingering effects on DC's ability to attract and retain business, which could stunt long-term growth prospects.

The cost of doing nothing to address water supply vulnerabilities in the District of Columbia and the larger National Capital Region is too high. Even allowing for risk-adjustments to these costs, investing in resiliency enhancements is an imperative from both human safety and economic perspectives.

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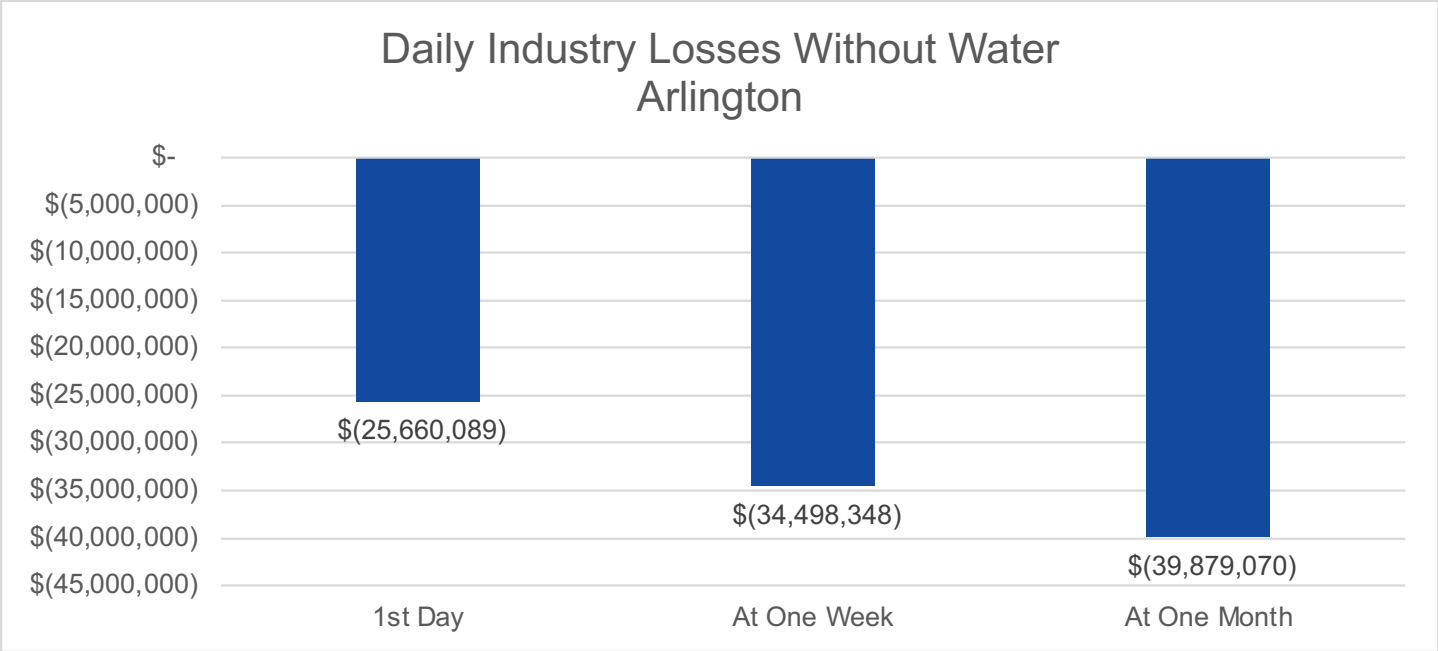
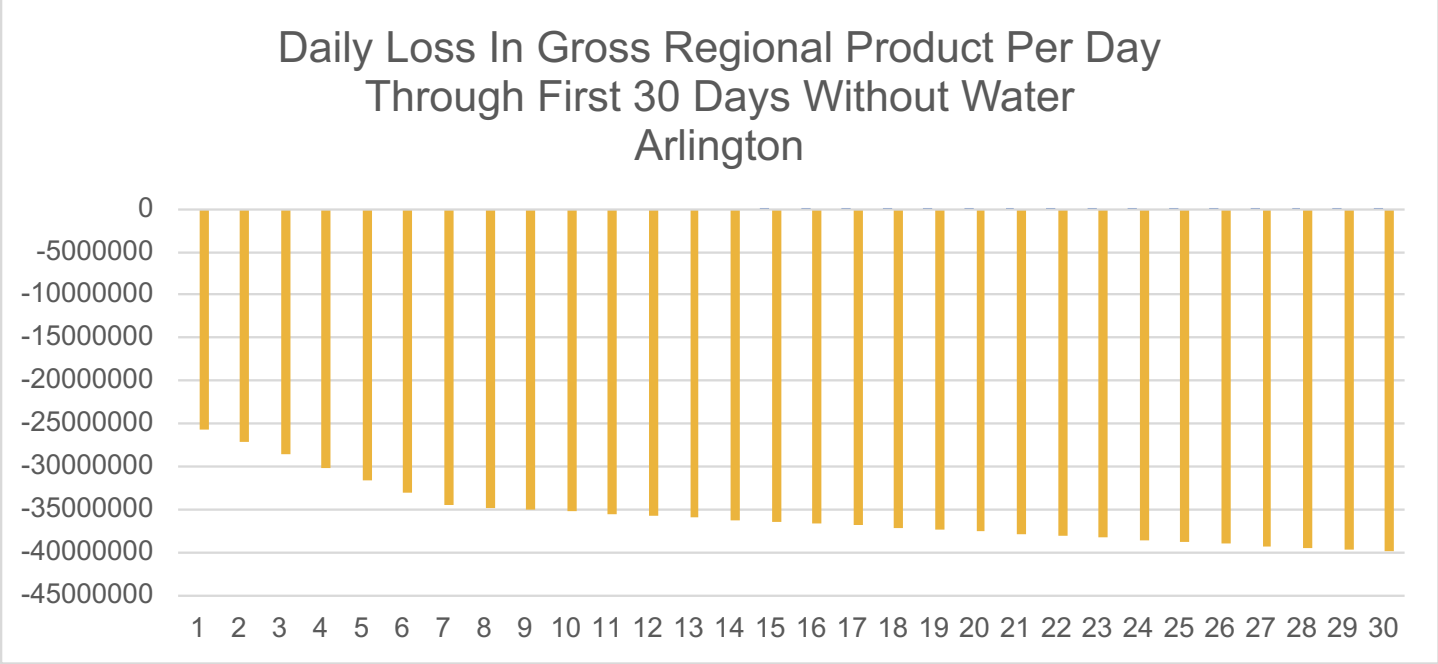
APPENDIX 1

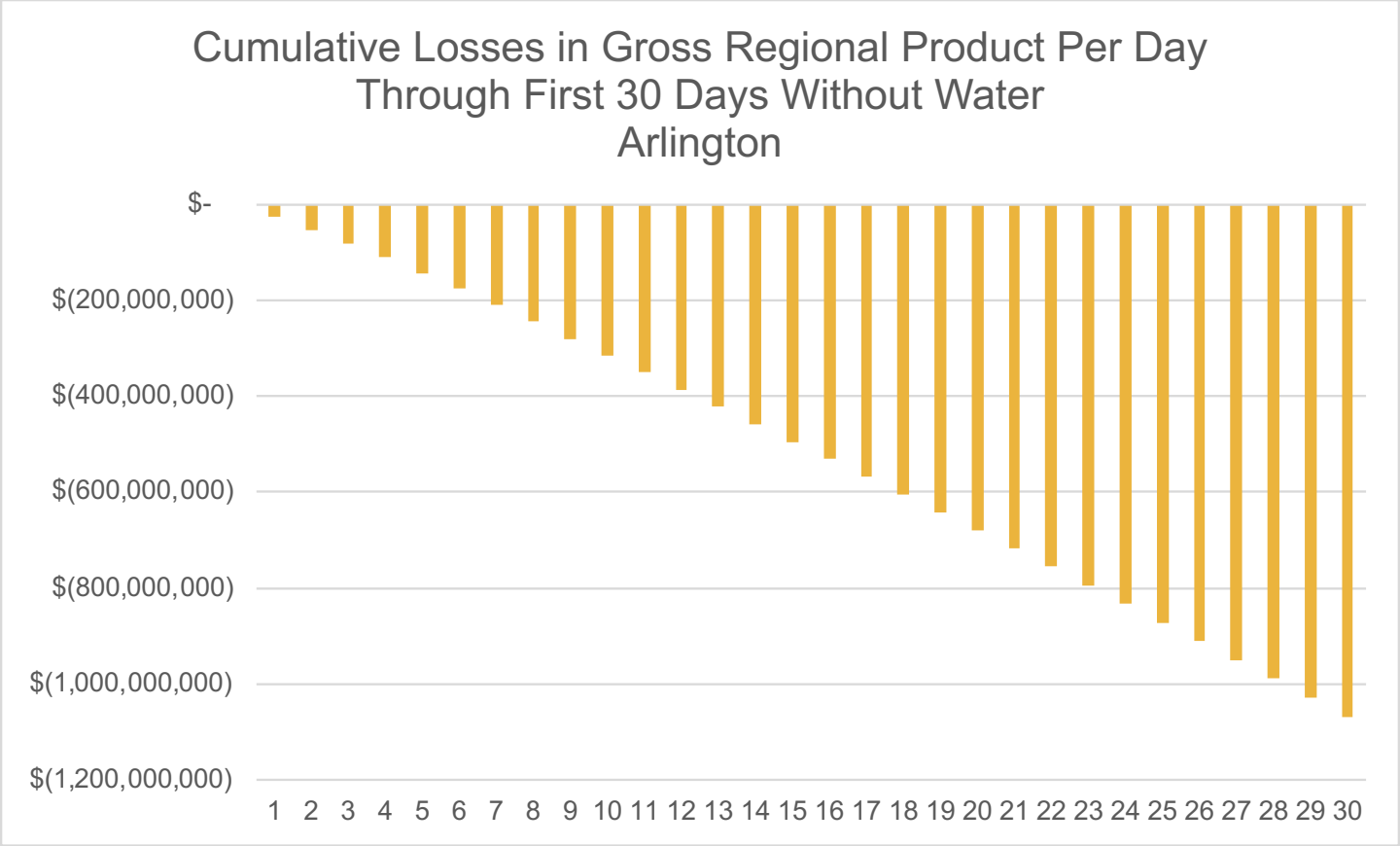
The Economic and Fiscal Costs of Water Supply Disruption



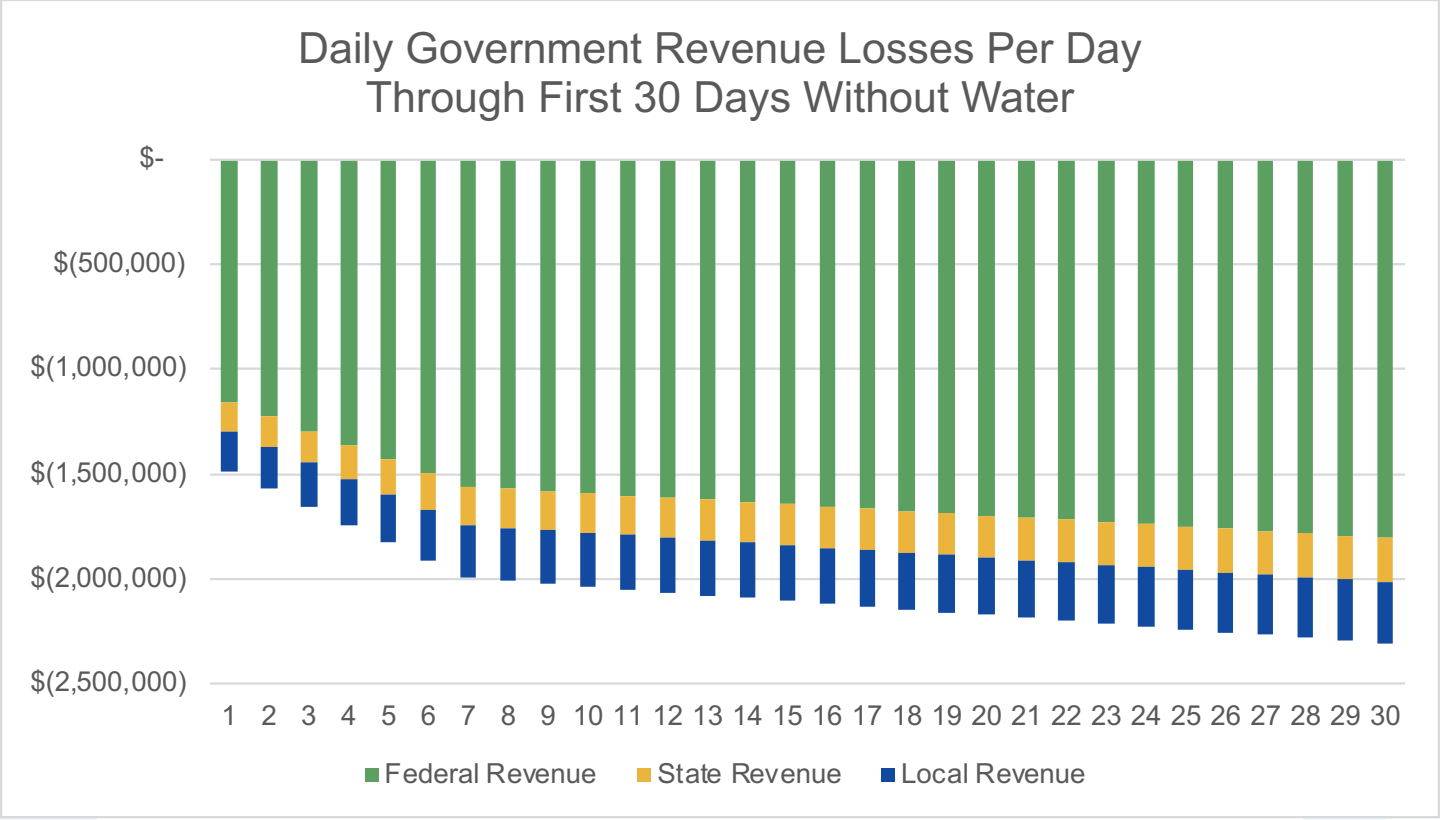
Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

Table A1: Cumulative Losses Per Month of Losing Water Supply, Arlington

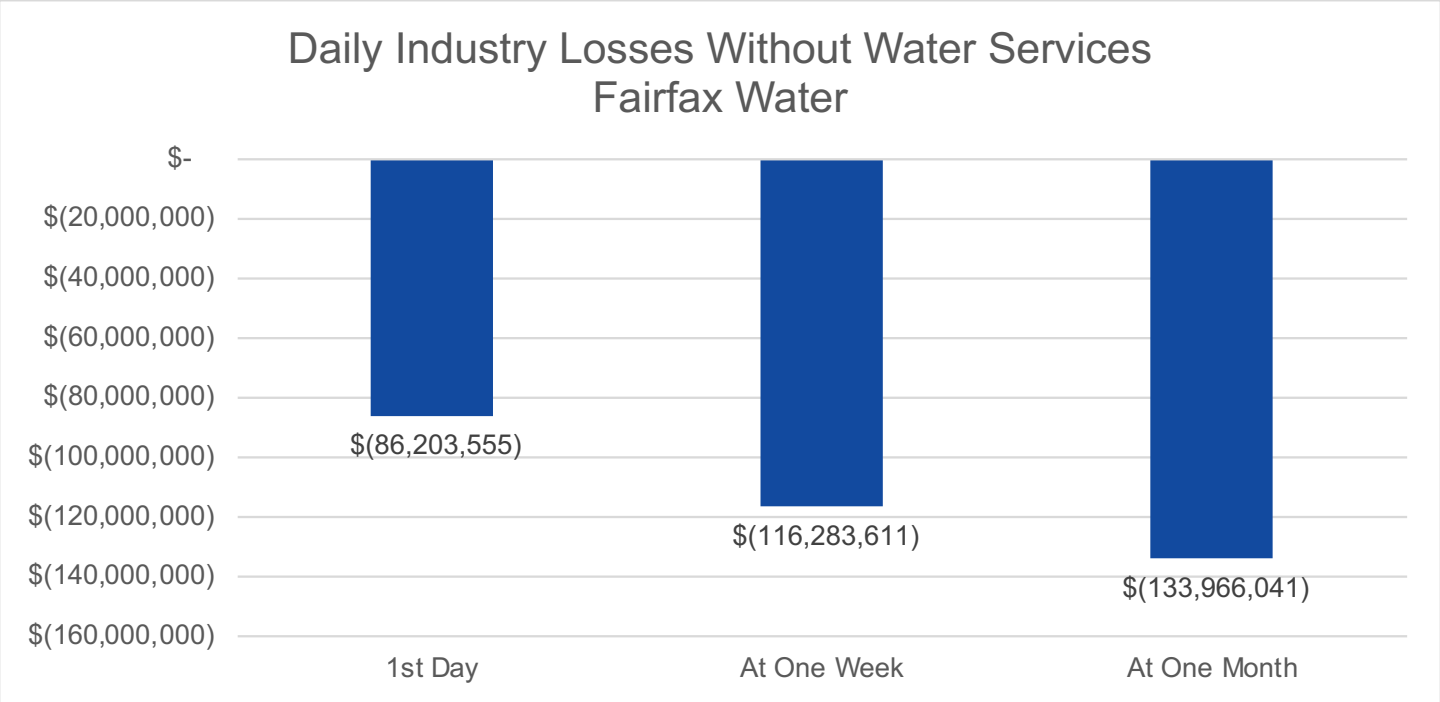
	GRP	Total Taxes	Federal Taxes	State Taxes	Local Taxes
Month 1	$(1,068,585,202)	$(61,920,566)	$(48,351,528)	$(5,733,772)	$(7,835,266)
Month 2	$(2,280,908,941)	$(132,170,250)	$(103,206,963)	$(12,238,811)	$(16,724,477)
Month 3	$(3,493,232,679)	$(202,419,934)	$(158,062,397)	$(18,743,849)	$(25,613,688)
Month 4	$(4,705,556,418)	$(272,669,618)	$(212,917,832)	$(25,248,888)	$(34,502,898)

Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

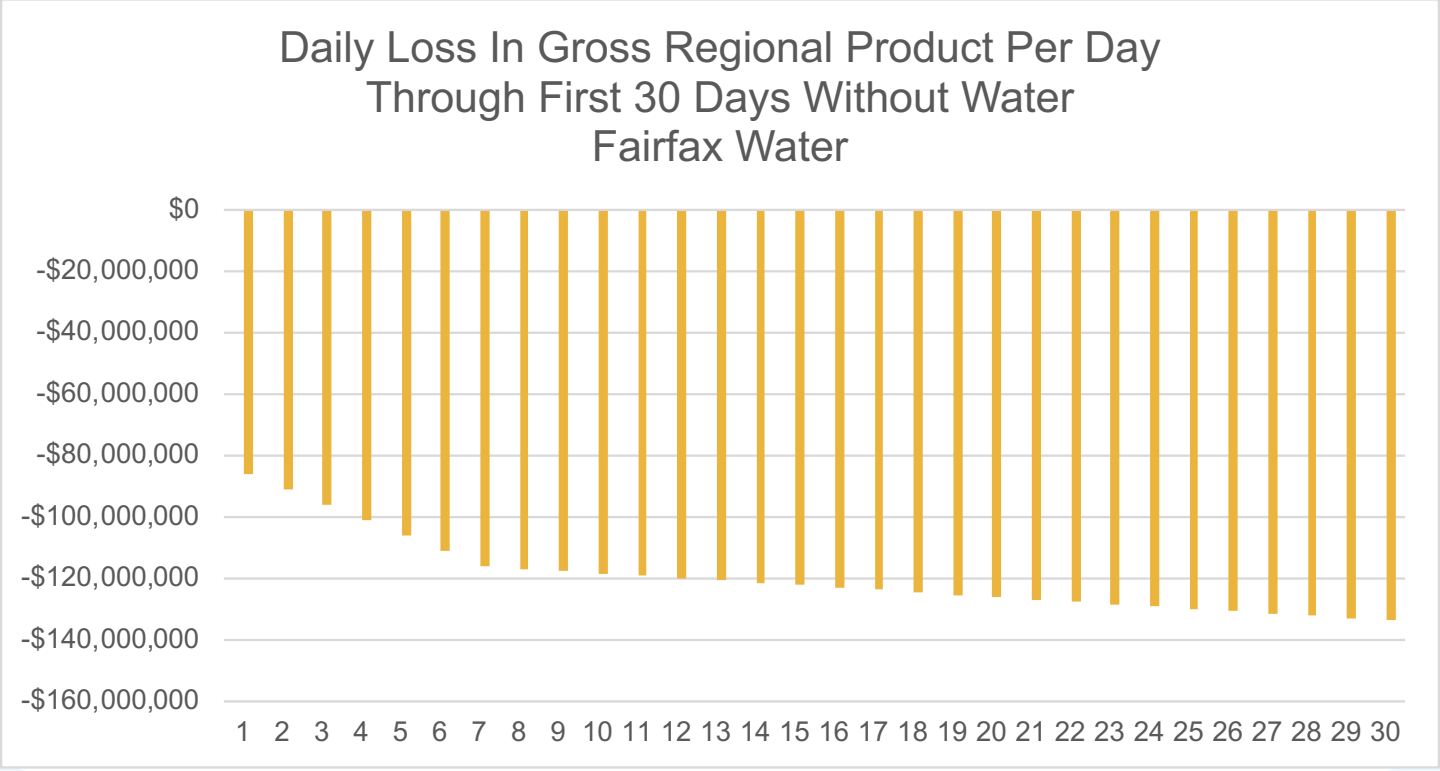
APPENDIX 2

The Economic and Fiscal Costs of Water Supply Disruption

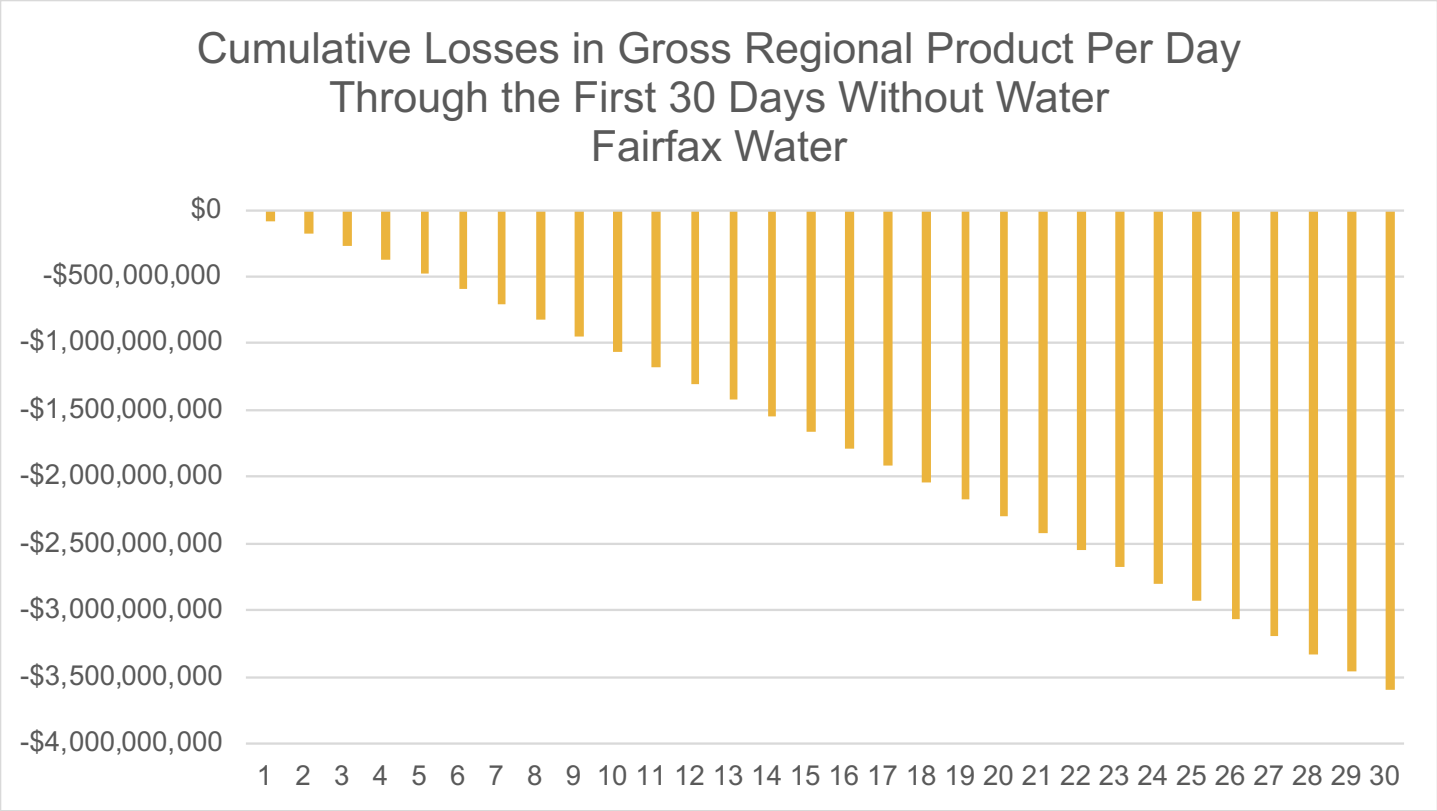
Fairfax Water



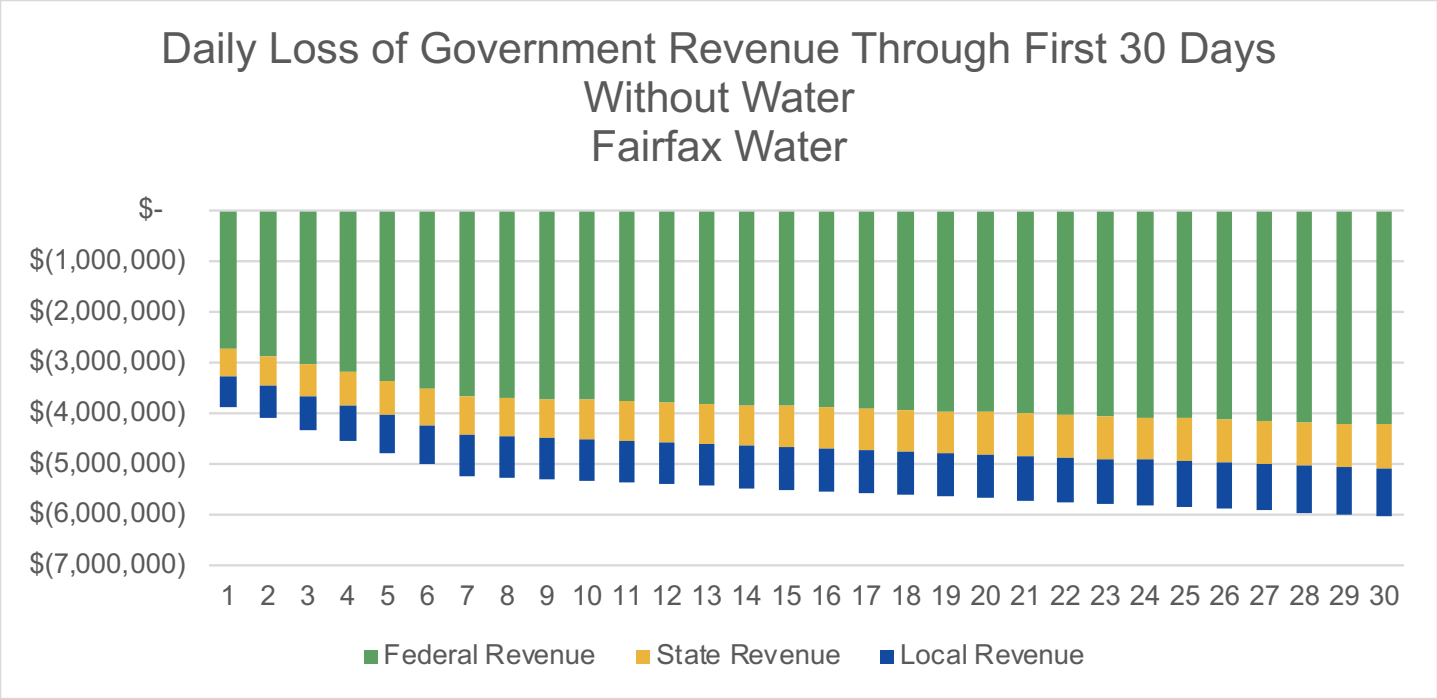
Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

Table A2: Cumulative Losses Per Month of Losing Water Supply, Fairfax Water

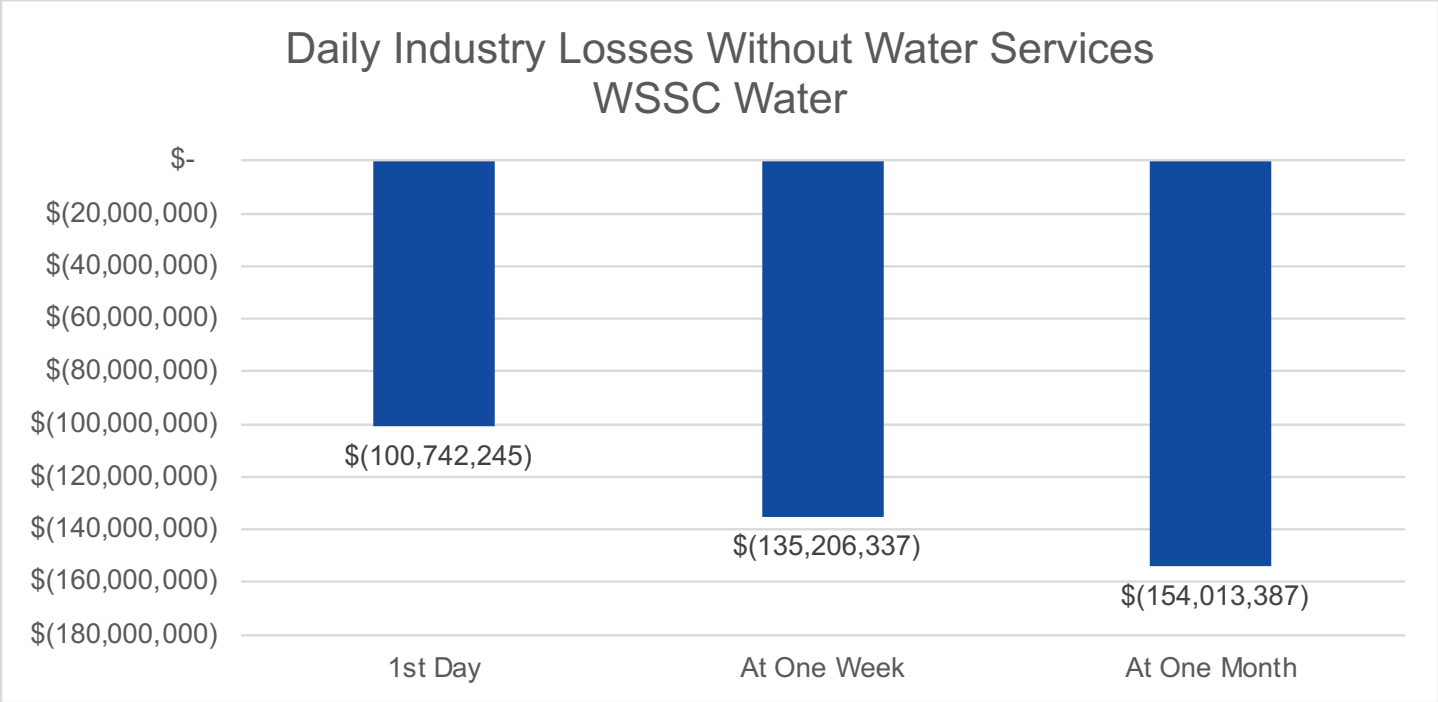
	GRP	Total Taxes	Federal Taxes	State Taxes	Local Taxes
Month 1	$(3,595,417,298)	$(162,100,591)	$(113,802,764)	$(23,418,850)	$(24,878,977)
Month 2	$(7,667,984,949)	$(345,713,666)	$(242,708,373)	$(49,945,631)	$(53,059,662)
Month 3	$(11,740,552,601)	$(529,326,740)	$(371,613,981)	$(76,472,413)	$(81,240,346)
Month 4	$(15,813,120,252)	$(712,939,814)	$(500,519,590)	$(102,999,194)	$(109,421,030)

Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

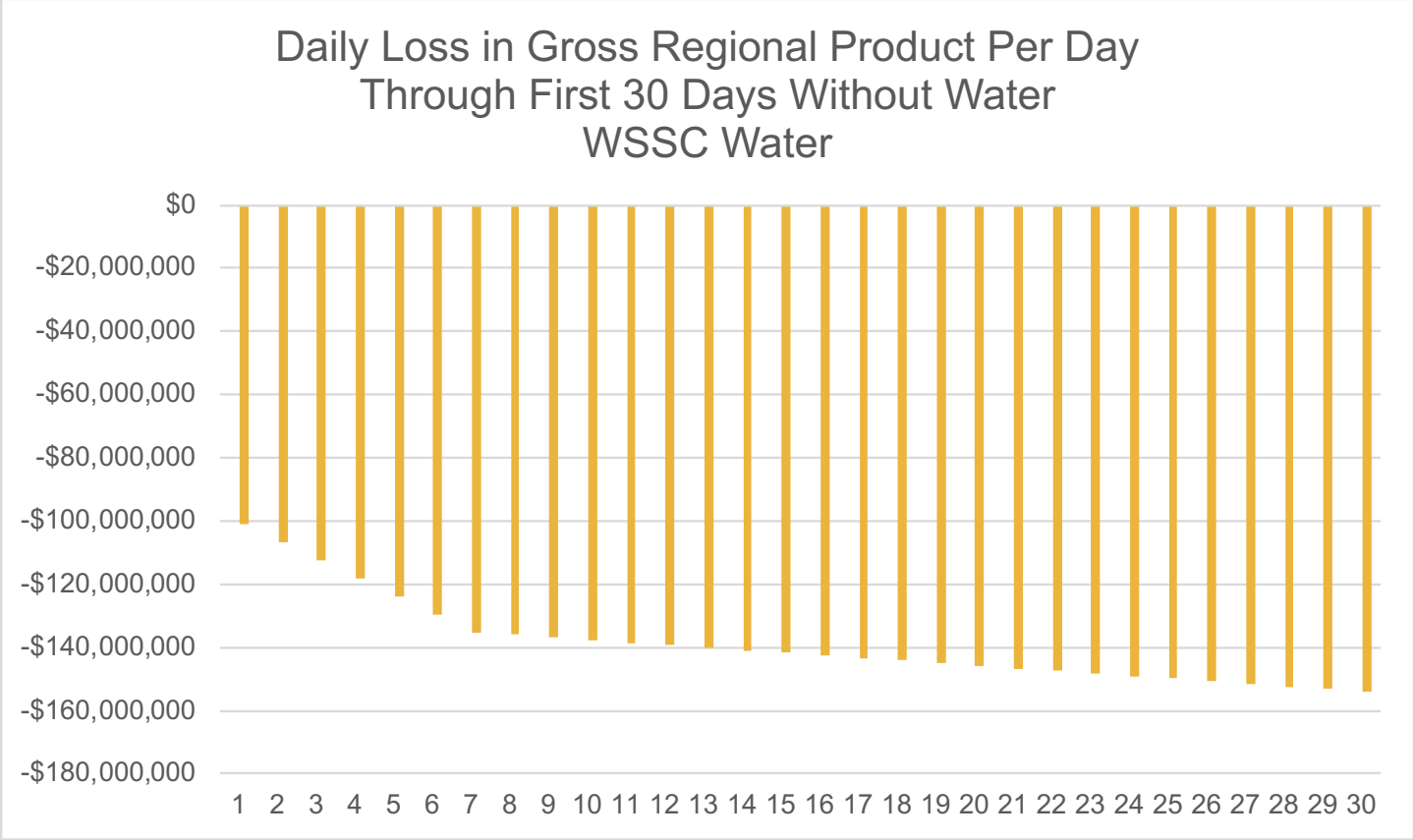
APPENDIX 3

The Economic and Fiscal Costs of Water Supply Disruption

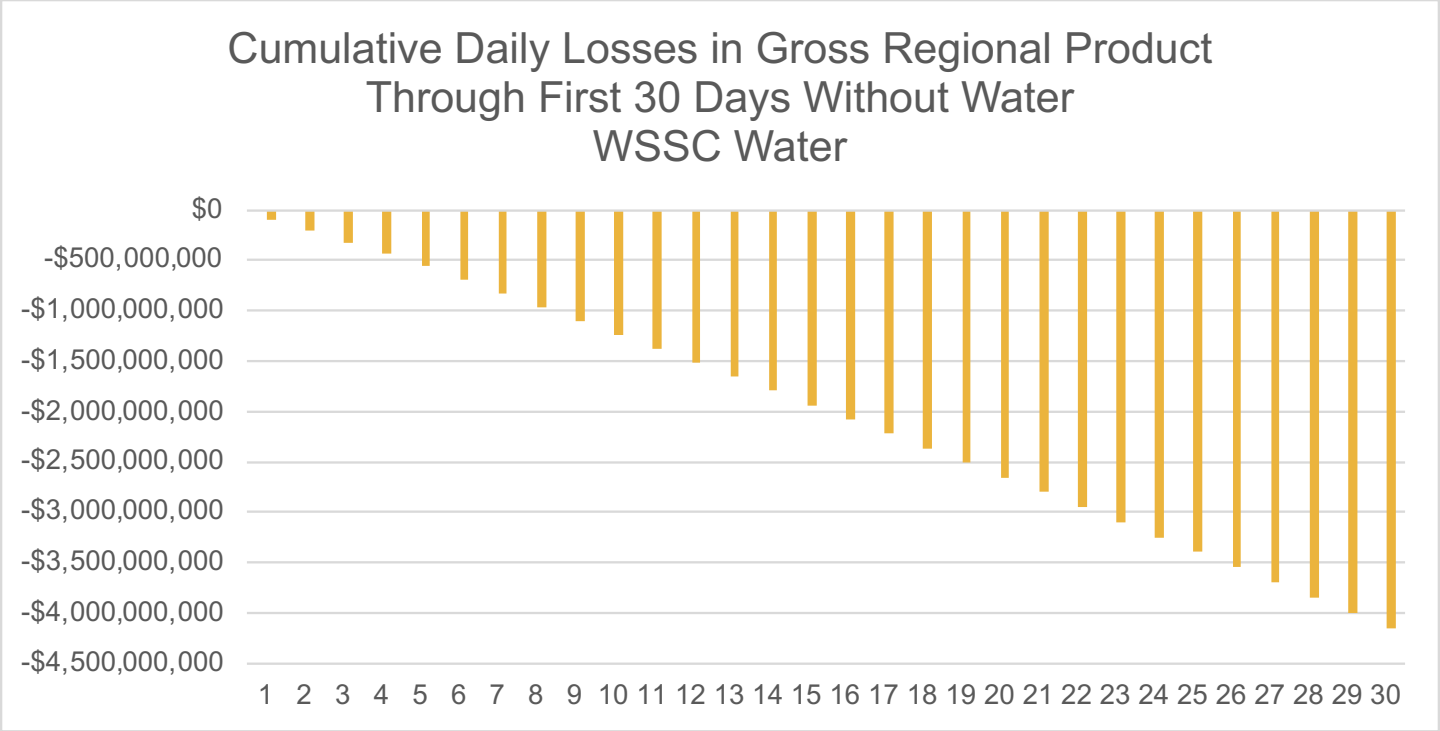
WSSC Water



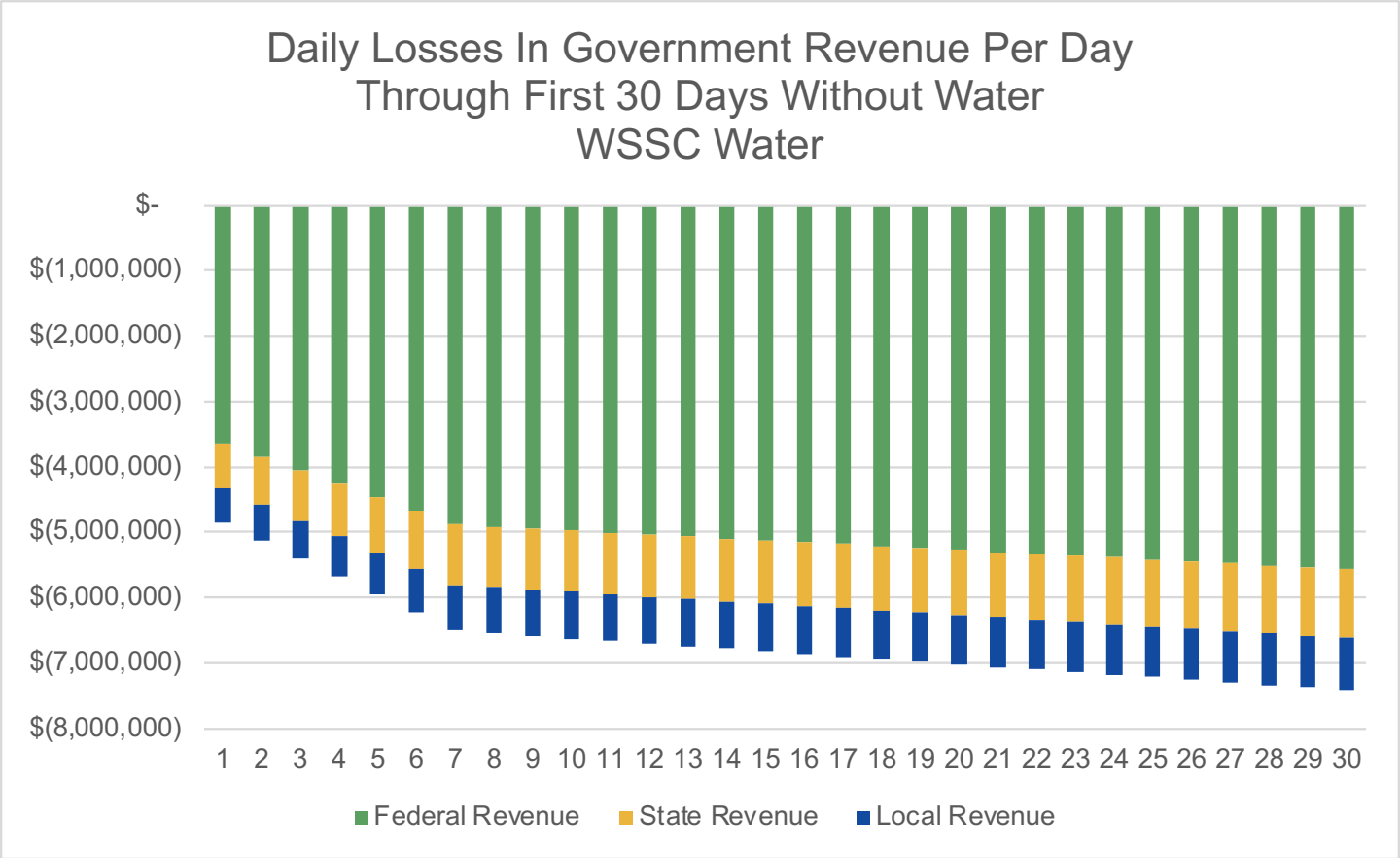
Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates



Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

Table A3: Cumulative Losses Per Month of Losing Water Supply, WSSC Water

	GRP	Total Taxes	Federal Taxes	State Taxes	Local Taxes
Month 1	$(4,161,250,389)	$(200,397,676)	$(150,486,664)	$(28,392,900)	$(21,518,113)
Month 2	$(8,843,257,345)	$(425,873,970)	$(319,805,868)	$(60,339,008)	$(45,729,094)
Month 3	$(13,525,264,300)	$(651,350,263)	$(489,125,073)	$(92,285,115)	$(69,940,074)
Month 4	$(18,207,271,255)	$(876,826,556)	$(658,444,278)	$(124,231,223)	$(94,151,055)

Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates

APPENDIX 4

The Economic and Fiscal Costs of a Two Week Water Supply Disruption to the National Capital Region

The following provides an estimate of the economic and fiscal losses accruing to the District of Columbia, Arlington, and the service areas for Fairfax Water and WSSC Water over the first two week period. The methodology used for these estimates follows the approach used in the previously reported analysis with one notable exception. The industry resilience factors (r) provided in Sjostrand, et al (2021) only show r-factors at one-week and one-month. To estimate the two week impact, we developed a proportional weighted average of the resilience factors by industry sector and applied it to the study region. The weights used to adjust the resilience factors represent the sum of the gross regional product by sector for the four markets assessed in the study. This approach provides a reasonable extrapolation of the resilience factors estimated by Sjostrand, while acknowledging that they are estimates beyond the work reported in the supporting literature.

Table A4 shows the estimates of economic impacts of water service disruption in the region at 2 weeks. For context, the table also repeats the estimates shown in Table 8 for longer period disruptions. Because industry resilience to a loss of water supply declines over time, losses between time periods shown are not proportionate.

Table A4. Summation of Economic and Fiscal Losses of Water Supply Disruption, District of Columbia, Arlington, Fairfax Water, WSSC Water

	GRP	Total Taxes	Federal Taxes	State Taxes*	Local Taxes
2-Week	$(6,544,950,263)	$(286,992,518)	$(208,618,506)	$(54,512,871)	$(23,861,141)
Month 1	$(14,875,569,670)	$(652,285,660)	$(474,154,730)	$(123,898,574)	$(54,232,356)
Month 2	$(31,657,045,701)	$(1,388,275,107)	$(1,009,150,768)	$(263,611,106)	$(115,513,232)
Month 3	$(48,438,521,731)	$(2,124,264,553)	$(1,544,146,807)	$(403,323,639)	$(176,794,108)
Month 4	$(65,219,997,762)	$(2,860,254,000)	$(2,079,142,845)	$(543,036,171)	$(238,074,983)

Note: These losses begin on the first full day of water supply outage within each service area. The day the water service is disrupted may not be the same across all service areas.

* Includes the District of Columbia

Sources: Sjostrand, et al (2021); Economic Modeling Specialists; IMPLAN, author's estimates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