POLICY ANALYSIS FOR THE PUBLIC AND PRIVATE SECTORS

M.CUBED

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To: **Robert McDonald, General Manager, CVWD**

From: **Richard McCann, Partner**

RE: **Benefit/Cost Assessment of CVWD's CAPP**

Summary

Carpinteria Valley Water District (CVWD or District) serves southeastern Santa Barbara County with water from the State Water Project (SWP), the U.S. Bureau of Reclamation's (USBR) Lake Cachuma and local groundwater. The Carpinteria Advanced Purification Project (CAPP or Project) is intended to deliver several benefits to District customers, Santa Barbara County, California and the nation. The District has a lower cost option that relies on a combination of additional capacity from the SWP and supplemental transfers during dry periods, but those sources would be less reliable in several ways and more environmentally damaging in relying on exports from the San Francisco Bay-Sacramento-San Joaquin Rivers Delta.

The projected benefits are separated into two categories: Non-public and public. The non-public benefits accrue solely to the District's ratepayers who pay directly for those benefits. Public benefits spread to a wider population who do not pay for these services and commodities in rates. The latter costs are best recovered through financial mechanisms such as taxes or surcharges on those beneficiaries.

The non-public benefits are monetized through the avoided costs of the alternative water resource options and the preservation of high value agricultural production that would not be possible with a less reliable water supply. Those non-public benefits amount to **$68.2 million** in terms of discounted net presented value (NPV) over a 50-year period.

The public benefits are valued using several means. Improving the Delta ecosystem by avoiding water exports is valued through the cost of purchasing water to replace those exports as instream flows. Two different emergency response benefits accrue from improving reliability during an extended multi-year drought and a Delta outage caused by an earthquake or flood. Those benefits are valued using avoided customer shortage costs. Additional regional economic benefits are created by construction of the CAPP along with approximately 380 jobs. The public benefits amount to **$146.8 million** over 50 years.

Table 1 below summarizes the total net benefits and weighs those against the net present value of the CAPP of **$75.3 million**. The total benefits amount to **$215.1 million** for a net benefit of **$139.8 million** or a benefit-cost ratio of 2.86.

Table 1: Summary of CAPP Net Present Value Benefits over 50 Years

Benefits	$ Millions
Non-public Benefits	
Avoided SWP Suspended Table A	$21.9
Avoided Supplemental Purchases	$25.8
Agricultural Production with Firm Water Supply	$20.6
Groundwater Recharge	Not quantified
Total Non-Public Benefits	**$68.2**
Public Benefits	
Delta Ecosystem	$27.7
Emergency Response: Extended Drought Reliability	$80.9
Emergency Response: Delta Outage Relief	$6.8
Emergency Response: South Coast Conduit Outage Relief	Not quantified
Deferred Seawater Intrusion	Not quantified
Regional Economic Activity	
CAPP Construction	$31.2
Agricultural Production with Firm Water Supply	$0.3
Total Public Benefits	**$146.8**
Total Benefits	**$215.1**
CAPP NPV Costs	**$75.3**
Net Benefits	**$139.8**
Benefit/Cost Ratio	**2.86**

Introduction

This technical memo outlines the data and methodological approach for calculating the economic benefits of the Carpinteria Advanced Purification Project (CAPP or Project) to support grant applications, stakeholder engagement, and other Project activities. The Project is a potable reuse project that will augment the Carpinteria Groundwater Basin with advanced treated recycled water. Rather than discharge secondary treated effluent into the Pacific Ocean, the Project will inject 1.0 million gallons per day (MGD) of advanced treated recycled water into the Carpinteria Groundwater Basin for later extraction by existing downgradient wells[1], which will supplement the District's potable water supply by 1,050 acre-feet per year (AFY) after implementation. This adds 52,500 AF of potable water supply over the life of the project, providing over a quarter of the District's water supply needs.

The Project will produce numerous benefits: 1) maximize the beneficial reuse of recycled water supplies through recharge of the Carpinteria Groundwater Basin, 2) create a local supply of potable water that is resilient to drought and disruptions caused by natural disasters, 3) reduce reliance on water supply exports from the Bay-Delta thus improving the ecosystem, 4) adapt to anticipated Cachuma Project delivery reductions due to more competition for this supply, drought and other factors, 5) limit potential seawater intrusion into the aquifer, and 6) reduce discharge to the Pacific Ocean. Groundwater recharge using advanced treated recycled water will result in the additional benefit of improving groundwater quality via lowered salinity and hardness in the Carpinteria Groundwater Basin in the long-term. The consistent supply of water from the Project will provide economic benefits by reducing the impacts of

[1] The Project will have a full capacity of 1.12 MGD.

water shortages on the local economy. In addition, the construction of the Project will generate local jobs and spending through the economy for a short period.

Framework Basis – Proposition 1 Water Storage Investment Program

In general, the economic analysis presented here follows the benefit-cost analysis framework developed by the California Water Commission[2] (CWC) to evaluate applications for funding from the Water Storage Investment Program (WSIP)[3] authorized in state's Proposition 1 $2.7 billion bond issuance.[4] The CWC prepared a "Technical Reference" document that describes in detail the process of developing a benefit-cost analysis and specifies the assumptions to be used in the analysis.[5] Those assumptions and the supporting data include future conditions with and without a project, calculating resulting physical changes, methods for placing economic values on project benefits, how to compare benefits and costs on a commensurate basis, allocating costs to beneficiaries, and including and evaluating uncertainty. The Technical Reference also provides forecasts on the value of water and environmental attributes out to 2050, with geographic specificity.

Benefits: Non-public and Public

There is a long-standing tradition that beneficiaries pay (the "beneficiaries pay principle") for the costs of infrastructure projects from which they derive benefits. Water users, as the recipients of the benefits of clean, reliable water sources for agriculture, industrial, commercial, and residential consumption, are the direct beneficiaries of most water infrastructure projects. These benefits are often referred to as non-public benefits and are generally paid for by water users themselves through their fees and assessments paid to their local water districts.

Public benefits include ecosystem improvements, public trust water quality improvements, and sustainable groundwater resources, flood control benefits to offset hydrologic changes, emergency preparedness, and recreational access. The citizenry is the beneficiary that pays for a benefit through tax dollars. State and federal funding for water infrastructure projects is used to direct public funding to public priorities, and is contingent upon the projects' provisioning of one or more strong public benefits in addition to their non-public benefits.

Public benefits are the economic values that accrue to beneficiaries who do not directly pay for the full the goods or services delivering those benefits. In some cases, those benefits flow out from those who directly consume those goods and services. Examples of the latter are local economic stimulus from increased spending and improved local reliability and resilience that releases resources to others on the water supply network and reduces the probability of needing outside aid to relieve a natural disaster such as flooding or earthquakes.

On the federal side, the US Army Corps of Engineers (ACOE) uses a Principles and Guidelines document that describes a benefit-cost analysis employed by the Corps to ensure that publicly funded projects provide benefits for the public. Generally, ACOE pays for the value of identified public benefits and a commensurate percentage of other project costs that cannot be allocated to a particular benefit.

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[2] See https://cwc.ca.gov/.

[3] CWC, "Proposition 1 Water Storage Investment Program: Funding the Public Benefits of Water Storage Projects," https://cwc.ca.gov/Water-Storage, retrieved February 2022.

[4] California Natural Resources Agency, "Bond Accountability: Proposition 1 Overview," https://bondaccountability.resources.ca.gov/p1.aspx, retrieved February 2022.

[5] CWC, "Technical Reference," *Water Storage Investment Program,* https://cadwr.box.com/shared/static/ay577o2qn7n8y2ob3m4ns786xwkmxw4y.pdf, November 2016.

The CWC's WSIP is one of the first attempts to base state funding on the value of the public benefits provided. The CWC's Technical Reference describes in Section 5 how to monetize the value of project benefits. The relevant criteria are:[6]

- The share of project costs that can be funded depends on the share of project benefits that are public benefits.
- The project must provide benefits cost-effectively in comparison to other feasible means of providing the same benefits.
- A project must be economically feasible; that is, the project's economic benefit must exceed the project cost.

The analysis presented here distinguishes the non-public (or private) benefits accruing to District ratepayers and those that accrue to the public including state and national residents and businesses, as well as the local population and firms who are not District ratepayers. The non-public benefits are represented by the avoided costs of acquiring alternative resources.

The public benefits identified derived from the CAPP include:

- Limiting exports from the Bay-Delta Estuary which is considered one of California's critical ecosystems;
- Improving reliability of District's water supply without acquiring additional external water supplies;
- Improving resilience of the District's water supply against the potential for natural disasters such as an earthquake in the Delta that stops exports by the SWP or a debris flow that damages the South Coast Conduit;
- Delaying seawater intrusion into the coastal aquifer, therefore protecting private as well as municipal wells;
- Reducing wastewater discharge into the ocean through reuse as aquifer recharge; and
- Creating regional economic benefits through near-term construction and sustaining productive agricultural activity over the long term.

Alternative and Avoided Costs

The CWC Technical Reference specifies in Section 5.4 how public benefits can be evaluated, using either alternative or avoided improvement or mitigation costs.[7] An alternative improvement could be, for example, a new hatchery or an ecosystem restoration project in the Delta. An avoided cost could be a foregone water transfer purchase to increase instream flows in the Delta. The Technical Reference requires identifying the least-cost option as the benefits metric. If the proposed project is the least cost solution, then the next lowest cost option stands as the benchmark valuation.

Impact of Climate Change on the Economic Analysis

Climate patterns are different now and may continue to change at an accelerated pace. Increased global GHG emissions are leading to serious consequences for California, including, but not limited to higher air and water temperatures, rising sea levels, variable precipitation patterns, increased wildfires, increased droughts and floods, decreased amount and duration of snowpack, and extreme variability in weather patterns. Many of these climate changes would affect the availability, volume, and quality of California water supplies.

State and local water supplies and water demands will be impacted by climate change via one or more processes, including rising temperatures; increased precipitation, runoff, flood, and drought variability;

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[6] CWC, Technical Reference, p. 5-1.

[7] CWC, Technical Reference, p. 5-19 et seq.

rising sea levels; and increased wildfires. As global temperatures increase, it is anticipated that existing patterns of precipitation will change as well. Although models do not predict an overall net decrease in precipitation, the frequency and variability of severe storm events may increase, leading to more frequent droughts and floods. Runoff from the Sierra Nevada snowpack is also anticipated to occur earlier and be more unpredictable. This change in runoff could affect availability of spring and summer snowmelt from mountain areas, including SWP water from the Sacramento Delta and local rivers and streams. Sustained long-term increases in temperature will likely diminish the overall volume of the Sierra snowpack over the century, reducing the availability of water for many parts of the State, including Carpinteria.

Sea levels have risen by as much as seven inches along the California coast over the last century. According to some estimates, sea level is projected to rise an additional 10 to 18 inches by 2050 and between 30 and 60 inches by 2100. These sea level increases could significantly affect quantity and timing of SWP water exports from the Sacramento Delta. Local increased sea levels will increase the potential seawater intrusion and require higher groundwater levels to prevent intrusion.

Difficulties in statewide water supply planning that may arise with climate change include, but are not limited to, the following:

- hydrological conditions, variability, and extremes that are different than what current water systems were designed to manage.
- changes occurring too rapidly to allow sufficient time and information to permit managers to respond appropriately.
- special efforts or plans to protect against surprises and uncertainties.

It should be noted that the economic analysis is based on historic hydrology – following best practices to quantify economic benefits. However, climate change is already changing and will continue to impact the District's water supplies. Increased temperature leads to increasing reservoir evaporation, evapotranspiration demand, and reduces soil moisture content– leaving less water for eventual use. Reduced snowpack will stress reservoir operations during flood control season and lead to reduced reservoir yields. Total precipitation may increase or decrease but climate change is projected to extend and intensify dry periods and wet periods. All of these factors will reduce typical yield of the District's supplies that is not explicitly captured in this economic analysis.

Furthermore, recycled water improves the District's climate change resilience by increasing reliance on local supplies with a lower embedded energy than SWP supplies or ocean desalination. Recycled water is a resilient supply and is not impacted by changes to temperature, precipitation, and snowpack.

CAPP Cost

The going-forward total Project construction cost is estimated at $38.6 million with an annual debt payment of $1.5 million. Construction is scheduled to begin in January 2024. The project is scheduled to be online in October 2025. The initial annual operating costs are projected to be $1,314 per acre-foot in 2022 dollars plus annual fixed costs of $446,000 and escalate that cost at a projected inflation rate of 2.5%.[8] The net present value cost over 50 years is **$75.3 million** at a levelized annual cost of $3,561 per AF.

Non-public Benefits: Water Supply

The non-public benefits to CVWD ratepayers are measured as the cost of the mix of alternative resources that can provide the same average annual water deliveries. That combination is the purchase of the

[8] Derived from the difference in the U.S. Treasury Bond Rates—Long Term Composite, and the Real Long Term Composite Rates. (U.S. Treasury, "Interest Rate Statistics," https://home.treasury.gov/policy-issues/financing-the-government/interest-rate-statistics, retrieved March 2022.)

suspended Table A capacity from the SWP with supplementary water transfer purchases in dry years when deliveries from the SWP are curtailed.

While the District is proposing the CAPP as the most appropriate resource for providing the most reliable and resilient water source with the least environmental impacts, it is not necessarily the least-cost source from a financial perspective, that is based on a direct accounting basis. The District has access to a combination of imported water sources that would cost less in direct rates to District ratepayers, but using those sources forego other benefits for which the District cannot recover associated costs through rates because the benefits accrue to other parties including the state's and nation's citizens.

Cachuma Project

The District's Cachuma Project annual allocation could decrease in the future due to a number of factors including but not limited to: sedimentation which reduces reservoir storage capacity, water rights, fish flow releases, and hydrologic conditions. For example, siltation has reduced capacity by 10% and recent wildfires in the watershed have increased concerns over accelerated siltation. In addition, the State Water Resources Control Board adopted a new water rights order in 2019 that increases flow for fish and the National Marine Fisheries Service (NMFS) is currently preparing a Biological Opinion for the USBR's operation and maintenance of the Cachuma Project that could affect Cachuma Project operations and the amount of water available for water supply purposes. No additional supply is available from this source and the District is at risk of losing a portion of its current allocation.

State Water Project

SWP infrastructure facilitates the transfer of water from the Sacramento-San Joaquin Delta (Delta) throughout the state with the Coastal Branch delivering to Santa Barbara County and CVWD. Because CVWD does not need SWP water in wet years, the District commonly stores this water in San Luis Reservoir or Central Valley groundwater banks. Each of these storage methods results in water losses and, can result in loss of all water stored if San Luis Reservoir spills. As a result, the District is typically not able to fully draw its SWP supplies and prefers to use lower cost supplies – groundwater and Cachuma Project.

Beyond current operational uncertainties and risks, climate change likely will increase that uncertainty, making the SWP less reliable. The yields applied in this analysis are based on historic conditions but could drop significantly in the next few decades.

In addition, SWP supplies include the potential for future cost increases – for Oroville Dam reconstruction and Delta Conveyance Project – and/or substantial decreases in reliability. The District has negligible influence of SWP cost decisions. In comparison, the District fully controls Project costs and will lock in roughly half the project cost as debt.

SWP Suspended Table A Supply

The District contractually has the ability to acquire an additional 1,000 AF per year of delivery capacity with an associate allocation of Table A supply from the SWP through the Central Coast Water Authority (CCWA) at a cost of $3 million.[9] The annual debt repayment obligation would be $153,000 and the water delivery costs would be the same as the current Table A water that the District now takes. According to Bulletin 132-21 Appendix B, the current charge is $704.91 per AF.[10] Due to the variability in hydrologic conditions and the numerous environmental and regulatory requirements, the expected annual average

[9] This acquisition cost excludes any additional transaction costs that the District may incur such as negotiations, legal support and working capital interest.

[10] California Department of Water Resources, "Data and Computations Used to Determine 2022 Water Charges," Bulletin 132-21 Appendix B, https://water.ca.gov/programs/state-water-project/management/bulletin-132, December 2021.

yield is projected at 580 AF per year,[11] a value that may fall as the climate changes.[12] In dry years, the average is projected to drop to 154 AF per year and even less in extended droughts.[13] Operational costs are escalated at the rate of inflation. The net present value cost over 50 years is **$21.3 million** at a levelized annual cost of $1,825 per AF.

Supplemental Dry Year Water Transfers

Under dry water conditions that limit SWP deliveries, the District purchases supplemental supplies from third parties that are delivered through the SWP Coastal Branch. The projected annual average amount is 328 AF per year, ranging from zero in most years to 1,000 AF during critically dry periods. [14]

This alternative cost is that of purchasing water through a water market, likely in northern California, that would be exported through the Sacramento-San Joaquin Delta. For an estimate of average costs of purchasing Delta export water on the water market, we use unit values developed by the CWC in their WSIP Technical Reference.[15] These unit values were developed from a statistical analysis based on water transfer prices from 1992 to 2015, the Statewide Agricultural Production Model (SWAP), and assumptions regarding groundwater sustainability requirements in the state by 2045. These unit values were developed for various water year types (wet, above normal, below normal, dry, and critical) for 2030 and 2045, the year it is assumed that groundwater basins will reach sustainable levels. The Delta Export costs are weighted according to historic water year type frequency from to the Sacramento River Water Year Index[16] to arrive at benchmark values for 2030 and 2045. SWP conveyance costs are added to Delta Export costs.

The District during the recent two-year (2020 and 2021) drought paid $1,000 per AF.[17] Based on the forecast developed by the CWC in its Technical Reference,[18] that price is escalated to 2045 at an annual rate of 6% and then is held constant thereafter. The net present value cost over 50 years is **$25.8 million** at a levelized annual cost of $3,903 per AF.

Alternative Cost Benchmark

The mixed cost of these two resources is the weighted average of the expected deliveries based on the historic water conditions in the Delta since 1985.[19] The projected incremental average annual delivery from the two sources would be 908 AF. The net present value cost over the 50 year period is **$47.7 million**, at a levelized annual cost of $2,575 per AF. The net cost of the CAPP above the alternatives is **$27.7 million.**

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[11] CDWR, *The Final State Water Project Delivery Capability Report 2019*, Section 5, https://data.cnra.ca.gov/dataset/state-water-project-delivery-capability-report-dcr-2019, August 26, 2020.

[12] CDWR, *The Draft State Water Project Delivery Capability Report 2021*, Section 5, https://data.cnra.ca.gov/dataset/state-water-project-delivery-capability-report-dcr-2021, December 31, 2020.

[13] CVWD, *2020 Urban Water Management Plan*, Final, October 2021.

[14] This acquisition cost excludes any additional transaction costs that the District may incur such as negotiations, legal support and working capital interest.

[15] California Water Commission, "Technical Reference," https://cwc.ca.gov/-/media/CWC-Website/Files/Documents/2017/WSIP/TechnicalReference.pdf, November 2016.

[16] California Department of Water Resources, "Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices," https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST, retrieved February 2022.

[17] Offers in 2022 have been as high at $1,400 per AF so far.

[18] CWC, "Technical Reference," Appendix D.

[19] California Department of Water Resources, https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST.

Table 2: Comparison of CAPP to Alternative Resource Costs

Resource	Average Annual Deliveries	Initial Variable Cost	Initial Fixed O&M	Debt Repayment	Initial Annual Cost	NPV Total ($M)
CAPP	**1,050**	**$932,600**	**$446,000**	**$1,544,354**	**$2,922,954**	**$75.3**
Suspended Table A	580	$408,842	$160,000	$153,058	$721,900	$21.9
Supplemental Purchases	328	$555,878	$0	$0	$555,878	$25.8
Total Alternative Cost	**908**	**$964,720**	**$160,000**	**$153,058**	**$1,277,778**	**$47.7**

Non-public and Public Benefits: Groundwater Recharge

In 2015, California's Sustainable Groundwater Management Act (SGMA) was enacted to provide for the sustainable management of groundwater basins in California. SGMA planning requirements are mandatory for the high- and medium-priority groundwater basins identified by California Department of Water Resources (CDWR). In these basins, local agencies are required to create a Groundwater Sustainability Agency (GSA) and adopt a SGMA-compliant Groundwater Sustainability Plan (GSP).

The Carpinteria Groundwater Basin was re-designated from a low priority to a high priority basin in 2019 as part of CDWR's re-prioritization of groundwater basins following the 2016 basin boundary modifications, as required by the Water Code. As such, the agencies overlying the Carpinteria Groundwater Basin are required to form a GSA and adopt a GSP or submit an alternative to a GSP. The Carpinteria GSA was formed in January 2020 as a joint powers authority (JPA) comprised of the following four local public agencies: Carpinteria Valley Water District, City of Carpinteria, County of Ventura, and Santa Barbara County Water Agency. The Carpinteria GSA will submit a GSP to CDWR by late 2023 for adoption and implementation in early 2024.The GSP will include an extensive analysis of the projected water budget, monitoring networks, sustainable management criteria, and projects and management actions for the Carpinteria Groundwater Basin.

Because a GSP has not yet been adopted, the District cannot yet quantify the benefits that accrue to both District customers who receive groundwater delivered through District facilities and public benefits that accrue to farmers who operate private wells.

Non-Public Benefits: Agricultural Production with Firm Water Supply

An additional agricultural benefit is the preservation of permanent agricultural crops that otherwise either would be replaced with low-value crops or even eliminated if the water from the project were not available. The CAPP provides a greater degree of reliability for agricultural water supply, which creates benefits to local agriculture that go beyond the value of the water supply itself. If the water from the project is not available in those dry years, we estimate that up to 473 acres of fruit orchards would be removed.

Firming the water supply provides a benefit beyond the water acquisition costs in those dry years—it facilitates the investment in higher value crops that require irrigation in *all* years, not just in years when water is available. SGMA requires that overdrafted groundwater basins will need to achieve balance. That likely will require agricultural acreage that now relies on unrestricted groundwater pumping to adjust cultivation practices to accommodate swings in water supplies, including fallowing in dry years. Permanent orchard crops cannot be fallowed, so the only alternative is to either switch to field crops that can be fallowed or simply not grow anything requiring irrigation. A grower will not maintain an existing orchard, or invest and plant a new orchard that will provide no yield for five to seven years, with the risk that water may have to be acquired in a spot market with volatile prices and uncertain availability. While the value of agricultural water to the existing mix of crops is already included in the calculation of the agricultural water supply benefit, the impact of avoiding crop conversion is a separate benefit.

This analysis drew on several different data sources to get the most accurate picture of agriculture in Santa Barbara County. We used the District's 2020 Department of Interior Crop Report, Ventura County Agricultural Commissioner's 2018 Crop Report,[20] IMPLAN Economic modelling software, and UC Davis Agricultural cost models,[21] as well as Statewide Crop Mapping data from the California Natural Resources Agency[22] as the main sources of agricultural data. IMPLAN is an input/output economic modelling software that is the industry standard in estimating regional economic impacts. It includes detailed industry-level data for each zip code in the United States.

For CVWD, we gathered economic output, value added, and employee compensation from the IMPLAN database for the agricultural crop sectors most likely to be affected, which is fruit orchards. (IMPLAN has ten agricultural industry categories.) We arrived at the net revenue and income changes by netting out Employee Compensation from Value Added. This calculation of net income includes only proprietor income, property income, and Taxes on Production and Imports net of subsidies.

Using crop acreages within the district from the California Natural Resources Agency and Net Revenue calculations we arrive at an estimate of net revenues per acre for fruit farming and nurseries. Table 3 summarizes the acreages and net revenues in fruit and nut farming and flower farming in the district.

Table 3: Acreage and Net Revenue for Fruit/Nut and Flower Farming in CVWD

	Fruit Orchard	Nurseries
Acres in production	2,333	543
Net revenue per acre	$15,684	$14,937

Next, the estimate presented here captures the added value of increased water security and reduced risk to the water supply. That value is reflected in the ability to grow permanent crops rather than annual crops that can be fallowed in dry years. The unit value of water supply reflects only the marginal value of water for *current* crops which is either a change in an acre-foot of water or an acre of land. It does not reflect the incremental value between two different crop types—permanent versus annual crops. Having a sufficient water supply in dry years enables permanent crop production in wet and average water years. Permanent crops cannot be planted based on speculation about whether sufficient water will be available at an affordable price in dry years. Thus, using the current unit value of water provides an incomplete picture that grossly underestimates the economic returns from being able to plant permanent crops that generate income every year compared to annual crops that do not produce income in years when they are fallowed.

Based on the estimate that agricultural water supply in CVWD could be reduced without the CAPP by an additional 456 AF in drought years and 473 AF in extended droughts, we estimate the associated economic impact to Santa Barbara County. Table 4 shows the agricultural water delivery shortages under drought conditions and the net gain from adding the CAPP.

[20] Santa Barbara County Office of the Agricultural Commissioner, "2018 Agricultural Production Report," https://countyofsb.org/uploadedFiles/agcomm/Content/Other/crops/2018.pdf, 2019.

[21] UC Davis Agricultural & Resource Economics, "Current Cost and Return Studies," https://coststudies.ucdavis.edu/en/current/, retrieved February 2022.

[22] California Natural Resources Agency, 2016 Statewide Crop Mapping, https://data.cnra.ca.gov/dataset/statewide-crop-mapping

Table 4: Agricultural Water Shortfalls in CVWD

Scenario	w/o CAPP	w/ CAPP	Net Benefit of CAPP
Drought Shortfall	630	174	**456**
Extended Drought Shortfall	777	304	**473**

In order to estimate the economic impact of a water supply reduction in CVWD's service area, we project what specific crop categories are most likely to be reduced, based on their net returns per acre of production. We assume that as water supplies decrease and water prices increase, lowest value crop farming will be reduced until the entire shortfall of water is avoided, while higher value crops like fruits and flowers will continue to be farmed, absorbing the additional water costs.

Overall, we estimate that between 280 and 329 acres of agriculture would be taken out of production in response to the reduction in the reliability of the water supply by relying on the alternative sources. Applying Santa Barbara Agricultural Commissioner values of agricultural output for individual crop type, this represents a reduction in agricultural output between $1.2 million and $1.5 million annually. The addition of the CAPP reduces this range to 84 to 149 acres which creates a net savings of $0.9 million to $1.0 million.

To capture the value of increased water security to the regional economy, the analysis used the difference in economic returns between the crops on the premise that most of the difference in revenues are spent within the local economy. Avoiding the expected crop conversion will result in secondary economic impacts. Indirect and Induced Effects of the additional agricultural output account for the economic boost from the agricultural industry's increased purchase of goods and services from other local industries, and the impact on the local economy from an increase in household spending due to an increase in jobs, respectively. To estimate the effects of crop conversion we use IMPLAN data for the zip code covering the District. IMPLAN is an input-output modeling software that allows users to estimate how economic changes in particular sectors impact the local economy. IMPLAN is an industry standard in modeling local economic impacts.[23]

Table 5 shows the net economic benefits to agriculture from the CAPP. The direct economic benefits in value added or income above the costs of acquiring goods and services would be $640,000 to $690,000 per year. Over a 50 year period, this adds up to **$19.1 million to $20.6 million** at a discounted present value.

We estimate that the indirect and Induced, or secondary, impacts would be approximately $300,000 net present value over the life of the project, based on IMPLAN modeling. These are public benefits that flow to local businesses who supply agriculture and associated activities.

[23] Further detail about IMPLAN is included in Appendix B.

Table 5: Benefits to Agriculture from CAPP

Scenario	Drought	Extended Drought
Added AF available	456	473
Added acreage cultivated	196	180
Output maintained	$930,000	$1,010,000
Net direct income added	$640,000	$690,000
Net secondary income added	$10,000	$10,000
Net employment gain	9.6	10.4
PV direct income - 50 years	**$19,090,000**	**$20,590,000**
PV secondary income - 50 years	**$300,000**	**$300,000**

Public Benefits: Delta Ecosystem

The Project will create increased environmental flows, particularly in dry and critical years, by offsetting Table A water demands and making that water available for instream flows from Lake Oroville, along the Feather and Sacramento Rivers, and in the Delta estuary. California has devoted significant state and federal resources to efforts to maintain and restore the ecosystem in the San Francisco Bay and Sacramento-San Joaquin Rivers Delta Estuary.[24]

We also used the alternative cost approach to calculate the environmental benefit of salmon and other fisheries recovery. Farmers in the Sacramento Valley who would be making water available to transfer through fallowing. Farmers would need to be compensated for this uncertainty in their planting decisions or would need to plant lower-value crops that require less initial investment. This approach is based on the cost of procuring a similar volume for environmental flows. We use Delta Export unit values from the Technical Reference weighted by historic water year types since 1980.[25]

The Project would avoid an average annual export from the Delta of 908 AF per year. The Delta Export values are escalated in the same manner as is done for the Supplemental Purchases with an escalation to 2045 and then holding prices constant thereafter. The total public benefits using this metric applying the USBR discount rate of 2.25%[26] is **$27.7 million**.

Table 6: Delta Ecosystem Benefits per CWC WSIP Alternative Costs

Years	Annual	50-Year PV
2026-2045	$293,191	$15.9
2046-2066	$705,405	$11.7
Total		**$27.7**

Public Benefits: Emergency Response--Extended Drought Reliability

A major benefit of the project is that it provides water to CVWD in the event of extreme drought, when other water resources are at their most expensive and may even not be available. Groundwater stored

[24] Delta Stewardship Council, *Delta Plan*, https://deltacouncil.ca.gov/delta-plan/, retrieved March 2022.

[25] Based on DWR's updated Water Supply Index at http://cdec.water.ca.gov/water_supply.html.

[26] U.S. Bureau of Reclamation, "Change in Discount Rate for Water Resources Planning," https://www.federalregister.gov/documents/2022/02/03/2022-02295/change-in-discount-rate-for-water-resources-planning, February 3, 2022.

as part of the Project will be available to call on during a drought emergency or as an alternative supply in the case of a local supply outage. Here we use the alternative cost approach. We also apply the definition of an emergency drought as a critical year that occurs in the third or later year of consecutive dry and critically dry years.

The CWC identified this emergency-response benefit as a public benefit in its Technical Reference.[27] Avoiding shortage costs are a public benefit for at least three reasons. The first arises from water being a finite resource, particularly within California. If CVWD takes action to acquire water through supplementary purchases, that water is not available to other consumers served by other water utilities.[28] By foregoing these water acquisitions, CVWD is releasing water supply without monetary compensation to other consumers. The second accrues from allowing continued economic activity that is based on the availability of water, such as farming, landscaping, food services and manufacturing.[29] This is a benefit that spreads beyond CVWD ratepayers within Santa Barbara County and the state. Finally, having a more resilient water supply will limit the need for outside funding by the state or federal government as part of an emergency or disaster declaration.

In the case of an extended drought, the District would need to curtail deliveries to customers severely. This action would cause shortages for customers who would incur economic losses, some direct and others in lost opportunities. This memorandum presents a methodology for estimating the cost of water shortage. The cost of water shortage is defined as the dollar amount that water users would be willing to pay to avoid the shortage. The methodology rests on the theory of economic demand, which posits that consumers order their preferences for a good such as water from the most to the least valuable and consume up to the point where the value of the last unit consumed is equal to the price of the good. The ordering of consumption preferences in this way is what gives rise to the ubiquitous downward sloping demand curve.

We use the methodology described in detail in Appendix A to estimate consumer willingness to pay for the increment of water forgone by water users due to restrictions on water use during a water supply shortage. This is a widely used methodology for valuing increments (or decrements) of water supply.[30]

The shortage costs are calculated for two scenarios: (1) with the alternative resources as a combination of the suspended Table A and supplemental purchases and (2) the CAPP. The shortage costs are estimated for each of the rate classes: residential, commercial, industrial and agricultural. Demand elasticities, which measure the change in price or value given a change in quantity, are applied for each customer class and the average rates for each of those classes.[31] Table 7 lists the elasticities, customer shares of use, and average rates.

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[27] CWC, Technical Reference, Section 5.4.6.

[28] Deferring these purchases also creates a pecuniary externality for other consumers through reduced demand in the water transfer market that in turn reduces the prices paid by other water supply agencies to acquire their supplementary water supplies. While pecuniary externalities are generally considered a natural function of a competitive market, the state's water market violates a key assumption that any amount of additional supply can be created to meet increased demand. The fixed nature of water supply causes this pecuniary externality to be a wealth transfer between consumers that cannot be compensated by a supply response.

[29] This benefit can be measured through a detailed regional economic impact analysis using a tool such as the IMPLAN model (discussed in a subsequent section and in Appendix B)

[30] For example, it provides the basis for the calculation of water supply benefits for the California Water Fix (CWF) (Sunding, et al., 2013; Sunding, et al., 2015), the economic cost of the state conservation mandate (M.Cubed, et al., 2015; M.Cubed, et al., 2016), as well as numerous other statewide and regional water resources benefit-cost assessments (e.g., Jenkins, et al., 1999; Jenkins, et al., 2003; EBMUD, 2012). Appendix A further documents the methodology.

[31] How the elasticities are developed and applied are contained in Appendix A.

Table 7: Customer Shortage Cost Parameters

Customer Class	Elasticities	Sales Share	Rate ($/AFY)
Residential	-0.20	34.4%	$6,172
Commercial/Institutional	-0.23	8.6%	$4,324
Industrial	-0.37	1.0%	$4,324
Agricultural	-0.18	56.0%	$1,791
Leakage		3.0%	

Table 8 summarizes the reductions in projected shortages for Years 3 to 5 of the extended drought for five-year increments from 2025 to 2045 and the public benefits in reduced shortage costs. The historic recurrence has been six years of an extended drought over the last 40 years which implies a 15% probability. Over the 50-year period from 2026 to 2075, applying the USBR discount rate of 2.25% and adjusting for a 23.5% probability, the net present value benefits are **$80.9 million**

Table 8: Extended Drought - Customer Shortage Value

	Avoided Shortage (AF)	Average Shortage Benefits ($M)
Year 3 Savings		
2025	911	$5.8
2030	970	$6.7
2035	1,100	$9.1
2040	1,100	$10.1
2045	1,100	$11.2
Year 4 Savings		
2025	566	$2.5
2030	625	$2.9
2035	836	$4.4
2040	907	$5.3
2045	985	$6.3
Year 5 Savings		
2025	366	$1.4
2030	425	$1.7
2035	636	$2.9
2040	707	$3.4
2045	785	$3.9

Public Benefits: Emergency Response--Natural Disaster Disruptions

Emergency Response—Delta Failure

The SWP infrastructure currently relies heavily on the Delta's natural channels to convey water to southern California and is thereby vulnerable to earthquakes and impending sea level rise. According to the United States Geological Survey, there's a 72% chance of a 6.7 or greater magnitude earthquake occurring in the Bay Area by 2043 that could cause levees in the Delta to fail, crippling the state's ability to deliver fresh water. In addition, flood risk is increasing in the Delta as a result of climate change from more intense storms and rising sea levels.[32]

A separate emergency response benefit of the project is the emergency water supply it can provide in the event of a levee failure in the Delta that curtails State Water Project and Central Valley Project deliveries to the Central Coast, as well as the Central Valley and Southern California. The CWC identified this emergency-response benefit as a public benefit in its Technical Reference.[33] We analyze this benefit using an alternative cost approach.

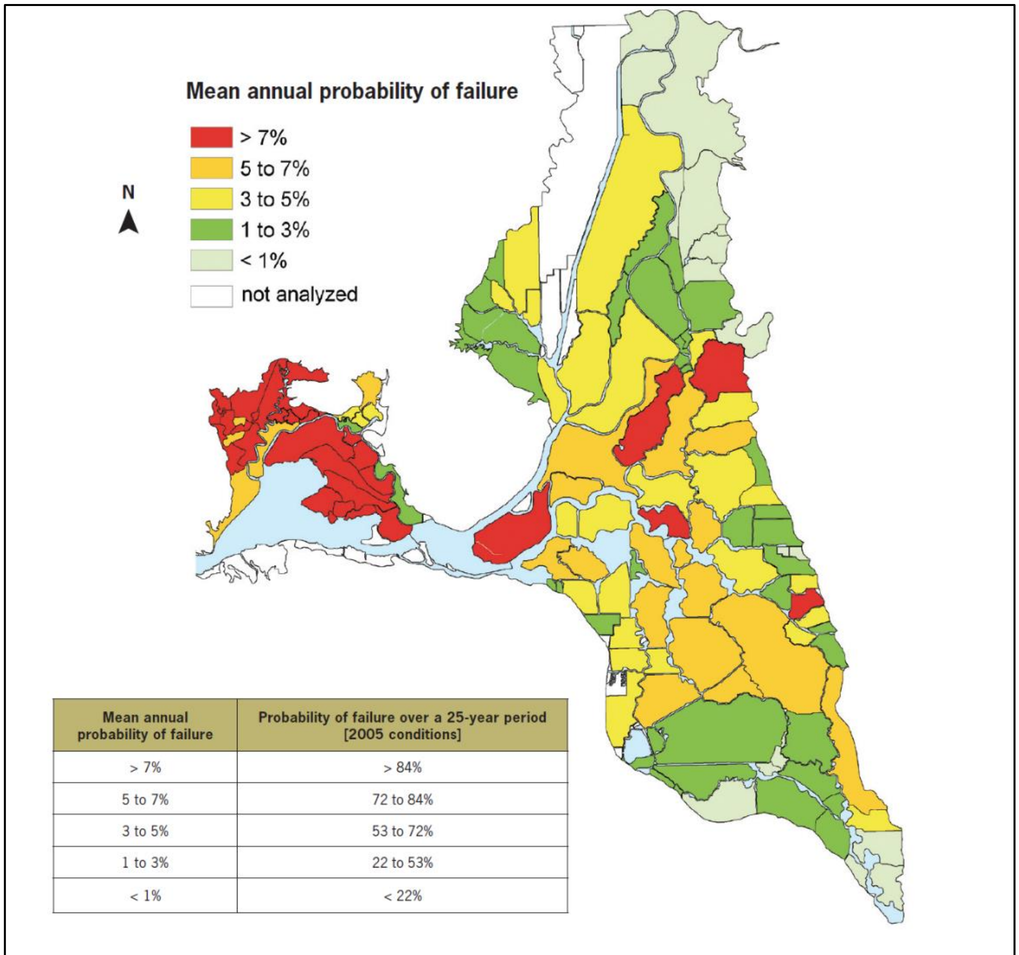
Delta Levee Failure Probabilities

In 2009, DWR released a report on Delta Risk Management Strategy which evaluated potential risk of Delta levee failure from natural hazards including earthquakes (seismic events), high water (flooding events), dry-weather failures, as well as the combined probability of multi-hazard events.[34] This report includes a detailed analysis of the mean annual probability of failure for the Delta levees as well as how many Delta islands may be affected by failure events (Figure 1 and Table 9). These failure events have been categorized in this memo based on islands experiencing failure at "more than 20", "more than 40" and "more than 60," respectively.

[32] Delta Stewardship Council, *Delta Adapts: Creating a Climate Resilient Future*, https://deltacouncil.ca.gov/delta-plan/climate-change, June 2021.

[33] CWC, Technical Reference, Section 5.4.6.

[34] CDWR, *Delta Risk Management Strategy*, https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/SJRECWA/sjrecwa_3.pdf, February 2009.



Mean annual probability of failure	Probability of failure over a 25-year period [2005 conditions]
> 7%	> 84%
5 to 7%	72 to 84%
3 to 5%	53 to 72%
1 to 3%	22 to 53%
< 1%	< 22%

Figure 12 **Mean annual probability of levee failure in the Delta Region from the combined risk of earthquakes, high water and dry-weather failures [2005 conditions]**

Source: DRMS Risk Report [URS/JBA 2008c], Figure 13-16

Figure 1. Mean Annual Probability of Levee Failure in the Delta Region (Combined Hazards)

Table 9: Summary of Delta Levee Failure Probabilities (25-year Period)

Mean Annual Probability of Failure	Probability of Failure at 25-Year Period	Islands Experiencing Failure (Projected, 25 Years)	Description Category
3%	53%	79	more than 60
5%	**72%**	**51**	**more than 40**
7%	84%	29	more than 20

At 5% mean annual probability of failure, upwards of 40 islands are projected to be affected (experience Delta levee failure) within a 25-year period. The results indicate that at a 5% mean annual probability of failure, for a 25-year period, there would be a 72% probability of at least one Delta levee failure event occurring within a 25-year period. The Delta Risk Management Strategy report also states that, "if 20 islands were flooded as a result of a major earthquake, the export of fresh water from the Delta could be interrupted for about a year and a half" where "emergency repairs for (the) 20 flooded islands could take about three years." For the purposes of modelling, we assume that fresh water Delta exports may be interrupted for three years for this scenario with an annual probability of 2.2%.

Table 10 summarizes the reductions in projected shortages for a Delta outage extending three years in five-year increments from 2025 to 2045 and the public benefits. Over the 50-year period from 2026 to 2075, applying the USBR discount rate of 2.25% and adjusting for a 2.2% probability, the net present value benefits are **$6.8 million**.

Table 10: Extended Drought - Customer Shortage Value

	Avoided Shortage (AF)	Average Shortage Benefits ($M)
Year 3 Savings		
2025	911	$5.8
2030	970	$6.7
2035	1,100	$9.1
2040	1,100	$10.1
2045	1,100	$11.2
Year 4 Savings		
2025	566	$2.5
2030	625	$2.9
2035	836	$4.4
2040	907	$5.3
2045	985	$6.3
Year 5 Savings		
2025	366	$1.4
2030	425	$1.7
2035	636	$2.9
2040	707	$3.4
2045	785	$3.9

South Coast Conduit Debris Flow

A second risk to local water supply is an outage of the South Coast Conduit (SCC) that delivers water from both the SWP and Lake Cachuma. A larger scale event similar to the debris flow that occurred in the City of Montecito in 2018 could threaten this water conveyance facility.

Along the route of the SCC in Santa Barbara County, large wildfires have frequently recurred. Although the threat of debris flow continues for the three rainy seasons following a wildfire, it is most likely that a large-scale event similar to the Montecito flow will occur in the same year as a wildfire, when the threat is highest and the threshold rain intensity is lowest. For a large-scale event scenario, a rain intensity threshold that would trigger an event occur in 15 out of 20 years. By interacting the likelihood of a fire event with the likelihood of sufficiently intense rainfall, we can arrive at a recurrence interval for a large-scale debris flow event that can damage the SCC.

The District estimates that repairing the SCC would take about three months. Given that a debris flow is most likely to occur during the winter when water demand is lower and groundwater pumping can be ramped up for that period to replace the lost surface deliveries it may be possible to replace the lost deliveries with increased pumping. Due to the complexities and uncertainties of modeling the impacts of such an event, this memorandum does not include a quantitative estimate but notes that the CAPP would displace the need for extended pumping in this situation, producing an unknown additional benefit.

Non-public and Public Benefits: Deferred Seawater Intrusion

There are several indicators that the Carpinteria Groundwater Basin is at risk for seawater intrusion: 1) groundwater levels in some aquifers are lower than sea level, 2) modeling completed by the District showed that without the CAPP project, seawater flows inward toward the basin and 3) recently installed monitoring wells near the coast show the presence of elevated chlorides in the lower aquifers. Seawater contains levels of TDS, chloride, sodium, boron and other parameters at much higher concentrations than desired for municipal, industrial, and agricultural use.

In other basins where seawater intrusion has occurred, well owners have redrilled their wells further inland away from the coast to avoid the area where seawater intrusion has occurred, or treatment has been provided, typically desalination, to reduce TDS and related contaminants. While currently it is not possible to fully quantify the effects of deferred seawater intrusion into the Carpinteria Groundwater Basin, the costs to use groundwater in a basin in which seawater intrusion has occurred can be very significant. For example, the cost to redrill a well in the Carpinteria Groundwater Basin into all three aquifers is approximately $1.4 million (2022 costs). The City of Camarillo, located approximately 30 miles to the southeast of Carpinteria, is currently completing its 3,450 AFY Pleasant Valley Desalter at a cost of approximately $67 million plus $4M in annual operating costs, which equates to about $2,000 per AF.

Public Benefits: Economic and Jobs Benefits Associated with Construction

We evaluated the economic and jobs benefits associated with construction of the CAPP in Santa Barbara County using IMPLAN. Construction spending is the sum of direct construction and construction management expenditures and spans from 2023 through 2025, as shown in Table 11, and totals $36.2 million.

Table 11: Construction Costs by Year

	2023	2024	2025	Total
Construction Management	$1.8M	$1.9M	$1.6M	$5.3M
Construction		$24.1M	$6.8M	$30.9M
Total	$1.8M	$26.0M	$8.4M	$36.2M

Across the three years, construction of the plant will generate 271 direct jobs, 35 indirect jobs, and 75 induced jobs. The total labor income generated is nearly $26 million, and the total value added by the project is $31.2 million, for a total increase in output of $55.2 million. This is comprised of $34.4 million in direct output, $8.1 million in indirect output, and $12.7 million in induced output.

Table 12: Aggregate Economic and Jobs Benefits Resulting from Construction in Santa Barbara County

Impact	Employment	Labor Income	Value Added	Output
Direct	271	$18.9M	$18.8M	$34.4M
Indirect	35	$2.7M	$4.5M	$8.1M
Induced	75	$4.3M	$7.8M	$12.7M
Total	**382**	$25.9M	**$31.2M**	$55.2M

The estimated impacts do not include economic activity associated with construction of the plant that does not generate additional effects in Santa Barbara County, referred to as leakages. According to

IMPLAN, leakages occur by way of taxes, savings, profits, imports, and commuting. Commodity demand data for Santa Barbara County for IMPLAN's industry 51 (construction of new manufacturing structures) indicates a gross absorption of 45.4% and regional absorption of 17.8%. Gross absorption refers to the proportion of total output for the construction of new manufacturing structures industry that goes toward purchases of each commodity, and regional absorption refers to the proportion of total output for the construction of new manufacturing structures industry that goes toward local purchases of each commodity. The percentage of total output for the construction of new manufacturing structures industry that is spent on intermediate inputs outside Santa Barbara County is therefore the gross absorption less regional absorption, which is equal to 27.7%.

The total economic benefits from constructing a local supply source are **$31.2** million in added income and creation of **382 jobs**. This is a net local benefit because the alternative resources would have spent the entire amount outside of Santa Barbara County in payments to the State Water Project and to growers in the Central Valley for supplemental purchases. For the latter resource, the Project allows farmers to continue to grow productive crops rather than fallowing to release water for sale, thus maintaining economic activity in those counties that supports the agricultural industry.

M.CUBED

Appendix A: Estimating Water Shortage Costs

David Mitchell, M.Cubed

September 2020

Understanding the economic consequences of water shortages is important for water utility managers and policymakers. For example, the value of improved water supply reliability can be cast in terms of avoided water shortage cost. An important litmus test for whether a proposed project will economically benefit water users is the magnitude of the shortage costs the project would help to avoid. If these avoided costs are large, this may be all that is required to demonstrate the economic feasibility of the project. If they are small, then other benefits generated by the project would need to offset its costs to make it worthwhile. In most cases, investments in new water supply are irreversible and for large water systems may entail hundreds of millions or even billions in cost. The stakes, therefore, may be quite high, making it all the more important to fully enumerate the benefits and costs of the proposed investment.

How can water shortage costs be measured? Direct measurement generally is not feasible for several reasons. First, homes and businesses use water in myriad ways and have many margins at which this use can be adjusted during a shortage. It would be a herculean feat to catalog all the different ways in which homes and businesses could adjust their water use. Second, even if all such adjustments could be identified, it would not be possible in most cases to measure the associated changes in water use. Except in rare situations water is not metered at the point of use. Water going into a home, for example, is metered at the curb not where it is actually being used (e.g., the toilet, dishwasher, etc.). From the utility's vantage point, the home is essentially a black box. This is also the case for most non-residential water uses.1 Third, even if the myriad changes to water use could be measured, what cost should be assigned to these adjustments? What is the cost of flushing a toilet less often or letting a lawn die or changing the way a product is formulated or produced? Market prices do not exist for most of the things people do to reduce their water use during a shortage.

This means that water shortage costs generally must be inferred. Different approaches for doing this have been proposed. One approach is to ask people what they would be willing to pay to avoid a shortage. In the economics literature, this approach is called contingent valuation, and it relies on sophisticated surveying techniques to tease out what homes and businesses would be willing to pay to avoid water shortages of varying duration and magnitude. This approach has been heavily critiqued because it relies on hypothetical situations for which those being questioned may have little knowledge or experience.2

Another approach is to estimate water demand curves from data on water use and prices and then use these demand curves to value changes in water use. Griffin (1990) was the first to apply this method to the estimation of water shortage costs.3 This method is widely used in water planning studies, including in the state's benefit-cost assessments of Delta conveyance proposals and the 2015-16 State Conservation

[1] Some commercial and industrial end uses are metered for sewer billing purposes, but this is the exception rather than the rule.

[2] See, for example, Diamond, Peter A., and Jerry A. Hausman. 1994. Contingent valuation: Is some number better than no number? Journal of Economic Perspectives 8 (Fall): 45-64.

[3] A comprehensive discussion of the method is provided in Chapter 5 of the textbook Water Resource Economics by Ronald C. Griffin. The method is also described in Chapter 7 of Determining the Economic Value of Water: Concepts and Methods by Robert Young.

Mandate, and it is the method that Valley Water uses to estimate the cost of water shortages in its planning studies.

It is broadly understood that demand curves slope downward while supply curves slope upward. Less well known, however, is that this is a consequence of optimization. In the case of demand, it follows directly from consumers optimizing their consumption choices subject to their available income. In terms of water demand, we can envision each home or business as having a schedule of demands for water that is based on the values they place on different uses. For example, households are likely to place the highest value on water used for drinking and basic sanitation, a lesser value on water used for bathing and laundry, and even lesser value on water used for landscaping and other less essential uses, such as car washing and cleaning outdoor surfaces. Thus, if each household were given the task of ordering their preferences for water from highest to lowest valued, these preferences could be arrayed as a set of demand curves like the ones shown in the left-hand panel of Figure 1. Aggregating these curves would then yield a total demand curve like the one shown in the right-hand panel of Figure 1.

Of course, no household is actually given this task to perform. However, by observing how demand for water adjusts as the price for water service changes, we can infer this relationship – in other words, we can trace out the portion of the demand curve that spans the observed range of water prices and quantities. We can then use this information to calculate the value households and businesses place on different levels of water use.

There are several points to emphasize about Figure 1.

- First, a point on the demand curve indicates the marginal value of consumption. If, for example, the first household in the left-hand panel of Figure 1 uses a total of q1 units of water, the value of the marginal unit consumed is P. All the units of water to the left of q1 are worth more than this to the household. We can calculate the total value of consuming q1 units by adding up the values of all the units to the left of q1. This value is equal to the area under the demand curve from 0 to q1. The same calculus can be applied to the aggregate demand curve in the right-hand panel of Figure 1. If aggregate demand is Q_B, then the total value to consumers is the area under the aggregate demand curve from 0 to Q_B.

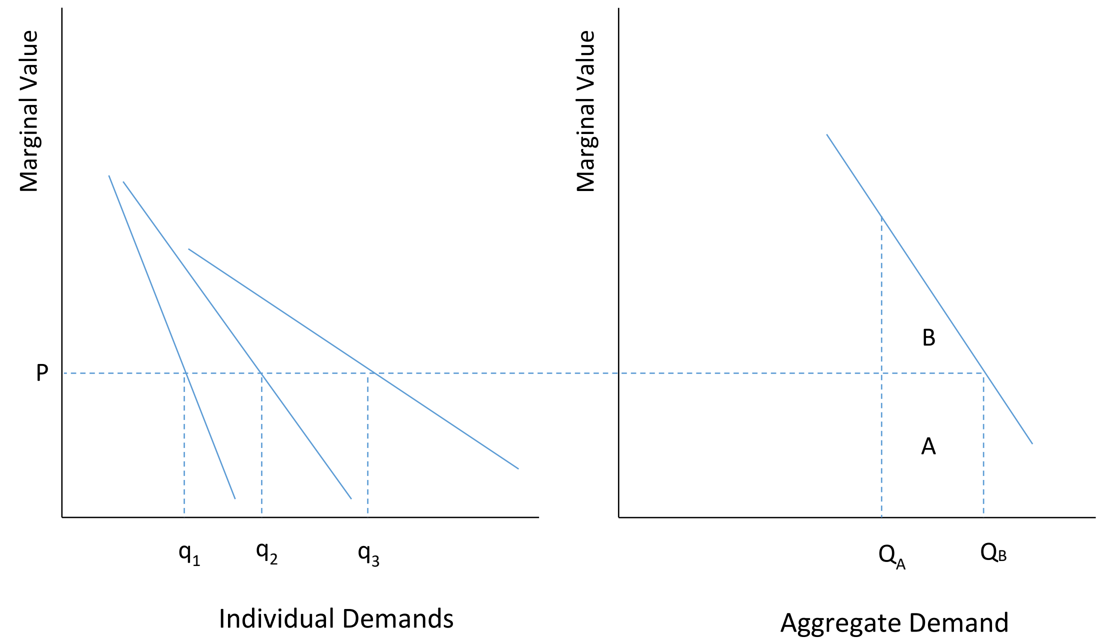


Figure 1. Graphical Depiction of Individual and Aggregate Demand Curves for Water Service

- Second, the total value is greater than the cost of the water. If there were no surplus value, consumers would have no motivation to purchase water from the utility. They would self-supply or choose an alternative source. The surplus value measures the net benefit consumers get from water use. For example, looking at the right-hand side of Figure 1, it would cost consumers an amount equal to area A to go from Q_A to Q_B while the total amount they would be willing to pay is equal to the area A + B. Area B therefore measures the economic benefit to consumers of the additional water use. By the same token, area B measures the economic cost to consumers if they are required to cut back water use from Q_B to Q_A. Thus, the economic cost of a water shortage can be measured in terms of the loss in surplus value.
- Third, the magnitude of the shortage cost depends on the slope of the demand curve. The steeper the curve, the less flexible are consumers in their use of water and the more they would be willing to pay to avoid a shortage. Thus, the calculation of shortage cost critically depends on the estimated slope of the demand curve. Valley Water uses slope estimates based on detailed statistical models of water use for each of the retail water suppliers it serves. The primary sources of these estimates is Sunding (2012) and M.Cubed (2018).

So far this discussion has mostly referenced water used by households. But the same logic applies to water used in business and industry. In this case, water is being used as an input to a production process and the surplus value measures the business/industry profit earned on the water use.[4] Thus, if the right-hand side of Figure 1 represents the demand from the utility's industrial customers, the loss in surplus value from cutting back water use from Q_B to Q_A is measuring the loss of profit. So, whether the

[4] Under general conditions, it can be shown that the producer surplus (i.e. profit) that a business earns on the sale of its product is equal to the sum of the consumer surpluses it receives on the inputs used to produce it (see Just, Hueth, and Schmitz (2004)).

analysis is considering residential or business/industry water use, the same method can be used to compute the shortage cost.

Thus, shortage cost stems from residential and business/industry consumers being unable to consume water at the level they would otherwise freely choose given the price of water service. The cost is measured in terms of the forgone surplus value of this consumption. In the case of residential water users, the income-equivalent change in their economic welfare is being measured. In the case of business/industrial water users, the change in profit or net income is being measured.

It is important to stress that rationing use during a water shortage is fundamentally different from policies designed to help consumers use water more efficiently, such as educational programs and the distribution or subsidy of more efficient water use technology, such as rebates for super-efficient toilets and clothes washers. The intention behind rationing during a shortage is to rapidly reduce water use to balance available supply with demand. The intention behind water use efficiency policies is to allow consumers to realize the same benefits from water use while using less of it. In the rationing case, consumers are unambiguously made worse off. With efficiency policies, provided they are well-designed, consumers are made no worse off and may be made better off.

This is graphically depicted in Figure 2.[5] The utility's water use efficiency policy shifts the demand curve from D0 to D1. Average production cost falls from P0 to P1 and consumers save an amount equal to area c + d + e + f. Consumers are better off with this policy so long as it costs less than this amount to implement. In tallying up the implementation costs, both the costs incurred by the utility *and* its customers should be counted. Note, however, that it would be incorrect to count area b in Figure 2 as a cost because it is presumed that consumers are able to realize the same benefits as before while using less water. This is what distinguishes policies designed to help consumers use water more efficiently from policies designed to ration water during a shortage. In the former case, the benefits of water use are preserved even though less water is being used. In the latter case, the benefits are lost. These forgone benefits constitute the principal cost of a water shortage.

[5] Figure 2 is based on Figure 6.5 in Griffin (2016).

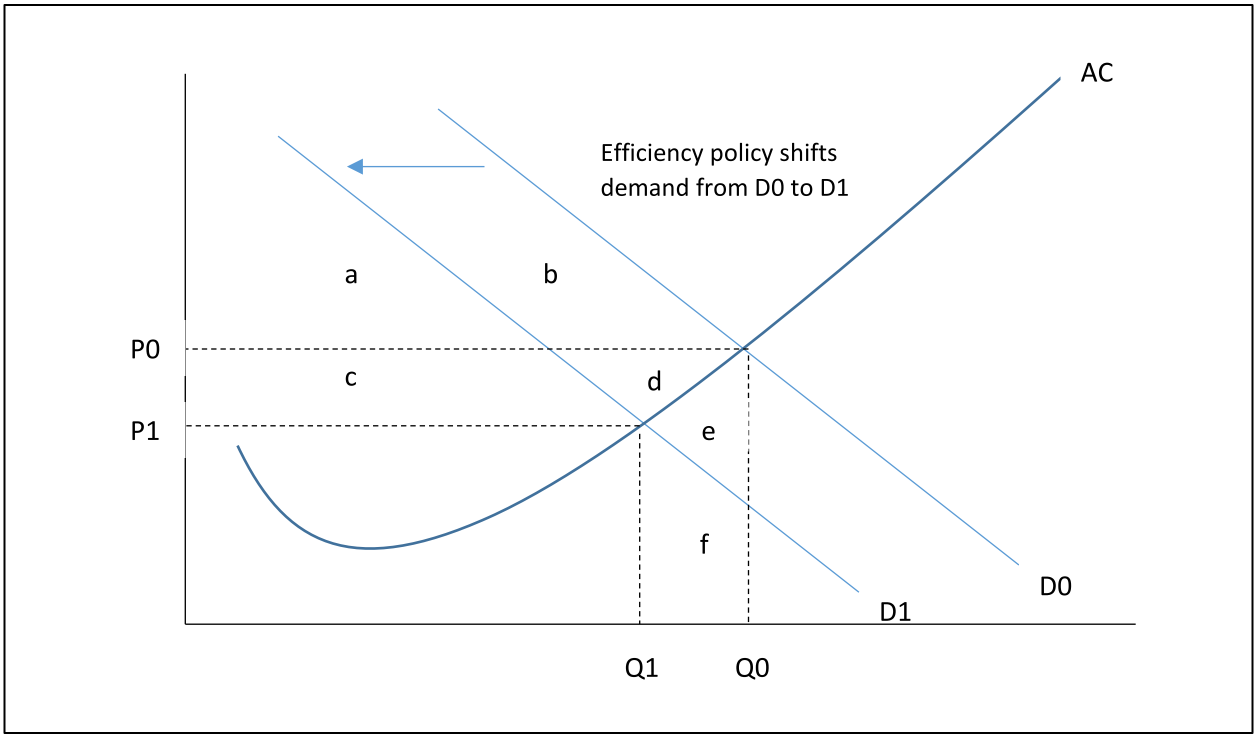


Figure 1. Graphical Depiction of Demand-Shifting Water Use Efficiency Policy

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Appendix B: IMPLAN Regional Economic Model

One tool used to estimate the relative size of different economic sectors within the study area, commercial activity, and agricultural activity for this analysis was the IMPLAN regional economic model.

IMPLAN is a widely accepted economic analysis tool used to value economic sectors and impacts. IMPLAN was originally developed by the USDA Forest Service for community impact analysis and is a standard tool used by the USDA Natural Resources Conservation Service and its partners to analyze watershed and conservation projects and programs. Input-output models such as IMPLAN use area-specific data on industrial and commercial activity to trace how a dollar of investment moves through a regional economy. These models are commonly used to evaluate economic activity in which changes in the total demand for output of the industries being studied results in changes in inputs and outputs by the local economic sectors. For example, these models have been used to estimate the impacts of such projects as construction and operation of new factories, development of tourism facilities, and military base closures. A study by the University of California found that IMPLAN produced an accurate estimate of actual job losses in the Central Valley related to the 2009 drought (Howitt et al, 2011).

IMPLAN draws from economic census data to compile county-level wage and salary information at the four-digit standard industrial code level. National data is adjusted for the subject region's industrial and trading patterns. Based on this structure, IMPLAN estimates the regional economic impact that would result from a dollar change in the output of local industries delivered to final demand (i.e., to ultimate purchasers, such as consumers outside the region).

More specifically, IMPLAN data provides estimated industry output, wage income, proprietary income, other property income, indirect business taxes, value added, and employment for 440 individual economic sectors. Depending on the region in question, some sectors will show no economic activity. For example, IMPLAN sector 7 – Tobacco Farming – shows no economic activity for most regions outside of the southern United States. IMPLAN sectoring is based on the federal North American Industrial Classification System (NAICS) and the individual sectors can be aggregated to the 2-digit and 3-digit NAICS level. Each measure of economic activity contained in the IMPLAN data set is defined as follows:

Industry or Economic Output represents the value of an industry's total production, including both value added and purchased inputs. The IMPLAN data are derived from a number of sources, including U.S. Bureau of Census economic censuses, U.S. Bureau of Economic Analysis output estimates, and the U.S. Bureau of Labor Statistics employment projections. These are aggregated up to estimate the total regional output.

Gross Regional Product (GRP) as an equivalent measure to **value added** which equals the sum of wage income, proprietor income, other property income, and indirect business taxes. It is akin to measures of gross domestic product (GDP), in that it indicates the portion of regional output generated by economic activity occurring *within* the region in question. It is the economic value *added* to the production process beyond purchased inputs such as raw materials, energy or labor from outside the region. We report the

Employment is reported as a single number of jobs (part- and full-time) for each industry. This differs from the full-time equivalent (FTE) measure often reported that adjusts total jobs for the number of hours worked per week (typically 40 hours).

Wage Income describes the total payroll costs (including benefits) of each industry in a region. It includes the wages and salaries of workers who are paid by employers, as well as benefits such as health and life insurance, retirement payments, and non-cash compensation.

Proprietary Income consists of payments received by self-employed individuals as income. Any income received for payment of self-employed work, as reported on Federal tax forms, is counted as proprietary income. This includes income received by private business owners, doctors, lawyers, and the like.

Other Property Income consists of payments for rents, royalties, and dividends. Payments to individuals in the form of rents received on property, royalties from contracts, and dividends paid by corporations are included here as well as corporate profits earned by corporations. The IMPLAN estimates of other property income are derived from U.S. Bureau of Economic Analysis Gross State Product data.

Taxes on Production & Imports consist of sales and excise taxes, customs duties, property taxes, motor vehicle licenses, severance taxes, other taxes, and special assessments. These taxes do not include nontax payments and subsidies. IMPLAN estimates of indirect business taxes are derived from U.S. Bureau of Economic Analysis data.

Personal Income is the measure of total household income in a region. It includes all sources of income, not just direct monetary income, such as salaries, wages, self-employment, retirement and interest, which is the metric reported by the U.S. Census Bureau. The additional categories included in personal income are equity and asset returns.

We report many of the most salient measures from the IMPLAN and other data sets in this impact analysis for reference. IMPLAN is used as the primary data set since IMPLAN will be used to assess any potential impacts. The other data is used to calibrate and reconcile the IMPLAN data where needed.