Water Project Selection Brief

Chengcheng J. Fei, Bruce A. McCarl, Department of Agricultural Economics, Texas A&M University

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Introduction

South Central Texas Region faces a projected water deficit. To address this, regional planning groups have identified several strategies. On the water side, the Texas Water Development Board (TWDB) regional planning group has proposed several possibilities for its regions L and N planning activities. Some of these are ambitious and expensive.

Population growth will, almost inevitably, increase municipal and industrial (M&I) water demand. A 40% population growth level, by 2050, are projected by Texas Demographic Center under an assumption of half the 2010 to 2015 migration rate. To date, much of the M&I water demand growth was accommodated through intersectoral water transfers, mainly from agriculture. Today several projects are under construction, but agriculture is coming close to legislatively setting upper limits on transfers; additionally, the reliability of water from sources like the Edwards Aquifer is an issue.

Climate change is another source of water deficit expansion. Some projections foretell a much drier US Southwest by mid to end of century, such that the major 2011 Texas drought will become the close to normal condition. Hotter, dryer conditions are projected; if this comes to pass, it will stress the situation and raise demand while decreasing aquifer recharge and surface water supplies.

Collectively, regional demand projections coupled with potential supply decreases due to aquifer depletion and altered surface flows/recharge amounts, have stimulated regional water development action. Today major projects are under construction for interregional movement, aquifer storage and recovery, reservoir storage, brackish groundwater desalination, and municipal and industrial water reuse. More projects are being discussed and given substantial lead times for project development, raising the need for current water planning.

Finally, the movement of water out of agriculture and the key importance of agriculture in the more rural parts of the region raises the future of agriculture as another regional issue.

This memo discusses results generated under an NSF supported study that addresses the regional agriculture-food-energy-water nexus[1]. In this study, we focus on construction of potential water projects, provision of electricity, and consequent regional economic effects on agriculture, municipal, energy, and industrial interests. The study also examined the effects of alternative levels of climate change and population growth.

Model Scope

To examine the issues presented above, we developed a model that simulates regional water allocation between agriculture, electricity, power plant cooling, fracturing, and municipal and industrial (M&I) usage. It also models agricultural land use, crop mix, livestock numbers, water flows, groundwater use, water project development, electricity use, electrical production cooling retrofits and new power plant construction. The model covers four river basins (Guadalupe/Blanco, San Antonio, Nueces/Frio and San

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[1] National Science Foundation Award #1739977 entitled Addressing Decision Support for Water Stressed FEW Nexus Decisions

Antonio-Nueces) and four aquifers (Edwards-San Antonio Segment, part of Edwards-Trinity, a segment of Carrizo-Wilcox, part of Gulf Coast) and a few other minor aquifers across South Central Texas.

The model also covers the geographic region shown in Figure 1. It models water and electricity use and agricultural production in all counties in the covered river basins, plus in all cities in the countries shown: including San Antonio, Corpus Christi, and Victoria.

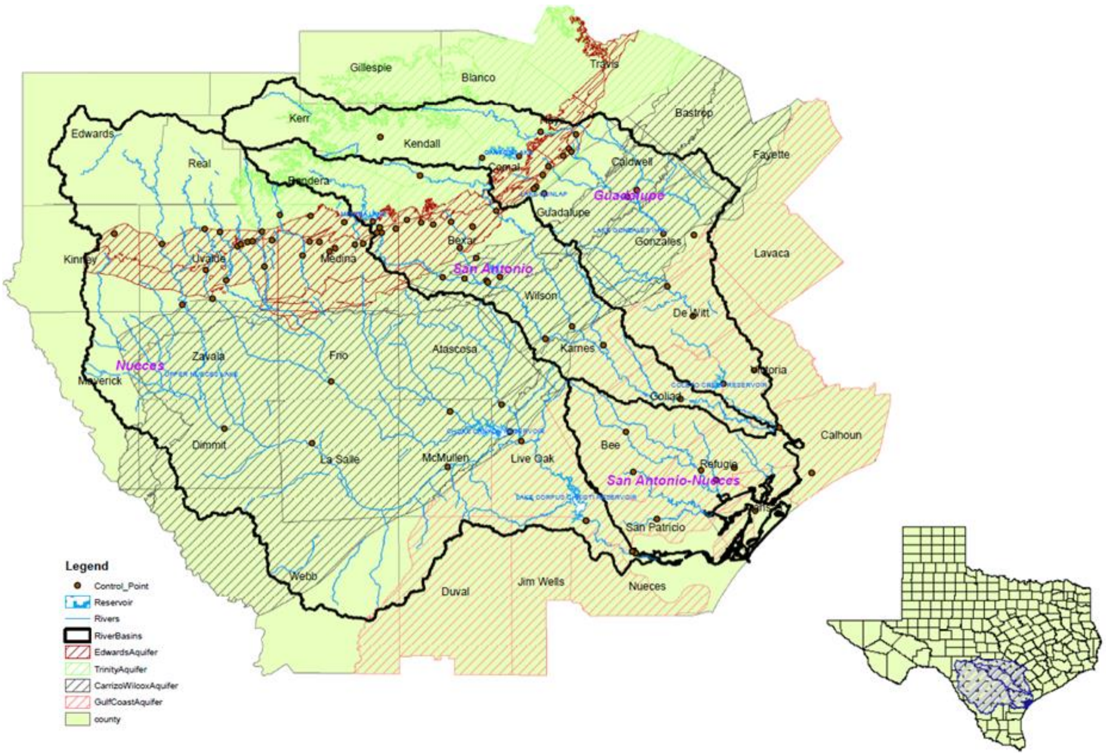

Figure 1: Research Region (South Texas), River Basins and Aquifer

Hydrologically, the model simulates river flows and aquifer status. For surface water it uses naturalized inflow data as generated by the hydrological models: a) Water Rights Analysis Package (WRAP) (Wurbs 2003), and b) Soil & Water Assessment Tool (SWAT) (Arnold et al. 2013). For ground water, the model simulates pumping use by all sectors along with aquifer elevation change, pumping lift, and end elevation. It does so by incorporating and using regressions estimated over simulation results from numerous runs, varying pumping and initial aquifer level within runs of aquifer simulation models. Specifically, we used the SEAWAT model for the Edwards Aquifer and versions of the

TWDB developed Groundwater Availability Model (GAM) made available from TWDB for Carrizo, Gulf Coast and Trinity-Edwards Aquifers. Estuary inflows and aquifer water elevation are also considered.

EDSIMRGW_NEX is a mathematical programming model that presents uncertain water abundance across nine states of nature in regional water abundance and temperature probability distribution representing a distribution of surface water availability and aquifer recharge. The model itself represents decisions in two-stages (following Dantzig (1955)), one independent of the water availability outcomes and one given knowledge of water availability. In the first stage, decisions are made independently of water availability, including water project choice and installation, electrical plant cooling retrofits, land transformation to dryland or pasture, irrigation system installation, crop and livestock mix choice, and new power plant construction. These, once developed, are paid for and available under all water availability cases (state of nature independent – model stage 1). In the second stage operational decisions are made that depend on water availability; these include water drawn from constructed water projects, irrigation water use, crop harvest, M&I water withdrawal, water pricing, and power generation. For example, farmers decide on the acres of each crop, herd size, whether to have furrow or sprinkler irrigation installed, and land shifts to pasture before they know water availability and aquifer lifts. However, they decide how much water to apply under each of the nine water availability possibilities with the crop yield subsequently calculated. Similarly, water projects and new electrical facilities are built independently of water availability, but are operated given knowledge of water availability. The nine water availability states of nature, from driest to wettest, are HDry (Extreme Dry), MDry (medium Dry), Dry, DNormal (Dry normal), Normal, WNormal (Wet Normal), Wet, Mwet (medium wet), HWet (extreme wet). Each represents a select group of years drawn from historical data as shown in Table 1.

The FEW Nexus Model represents activity in a typical sequence of years, during which the nine water availability states occur with the frequency at which they appear in the historical data. It contains within-year water use and agricultural activity on a monthly scale. It is solved at several future points in time when estimating the effects of climate change and population growth on the Nexus, but with water projects and new power plants chosen in early periods imposed as fixed assets in later periods.

For agriculture, we represent crop and livestock production in the regional counties. Production is constrained by the available land and water access, along with combinations of historical crop and livestock mixes. The crop mix is separate for dryland and irrigated field crops and vegetable crops, and is restricted to a convex combination of the historical crop mixes. Implicitly, this embodies constraints on labor, equipment, and other inputs. Similarly, adherence to historic livestock mixes was imposed. Water use is limited by water rights for surface sources and the Edwards Aquifer. The water rights permit limits were obtained from the Texas Commission on Environmental Quality (TCEQ) and the Edwards Aquifer Authority.

During solution, the model decides whether to build each water project, new power plant or cooling system retrofit given the costs, benefits, and full distribution of water needs. Project construction is a build/no build decision in the first stage of the model chosen independently of states of nature. If a build decision is made, the fixed cost and capacity is incurred and made available across all water states of nature. If the project decision is no-build, then it cannot be used under any state of nature. The decision on the volumes of water and power used from the project varies with water availability. Projects are only used when needed and varies by states of nature. In the results, we find projects are often operated only under select water availability conditions, such as the drier ones, and not under cases where water is plentiful. However, the fixed cost is incurred under all the water availability states. We also assume that once water projects, new power plants, and cooling system retrofits are built, they will exist in that place for all subsequent model runs (i.e., projects built in the 2020 model run are no longer a choice in 2030 model runs: they are assumed to be already built).

Three more features of water projects are modeled in the FEW Nexus Model: 1) existing or under construction water projects, 2) termination of water projects, and 3) mutually exclusive, select water projects. We found 22 of TWDB regionally identified water projects to be either completed or under construction and these were constrained to be built in the model, under all scenarios. Of these projects 13 are municipal reuse water projects, such as water reuse in San Antonio, San Marcos, New Braunfels and Kyle. The other nine water projects are all being built to serve the San Antonio metropolitan region and include: the San Antonio ASR project, pumping, storing and transferring water from Trinity Aquifer, pumping water from the Carrizo Aquifer, desalinating brackish water from the Wilcox Aquifer, and transferring water from Medina Lake (Medina System).

For termination of water projects, we discontinue several based on information in the 2012 SAWS water plan, which identifies those for termination based on contractual terms, water rights, water availability and project cost. For example, the Medina System project, which transfers water from Medina Lake to San Antonio, will be terminated in 2049 when the contract expires. This is the most expensive project now operated by SAWS, with a pre-distribution cost of $3,012 per acre-foot and it has not been utilized since 2013 (SAWS). During drought years, the firm yield from the Medina transfer is considered zero; SAWS plans to retire two Trinity Aquifer related projects (one Canyon Lake project and one Carrizo Aquifer project) after those contracts expire. For more details on terminations, please see the San Antonio Water System (SAWS) website[2,3].

Finally, according to the TWDB Region L and Region N water plans, some of the proposed water projects are mutually exclusive. For example, there are two plans to desalinate brackish water from the Gulf Coast Aquifer to supply water for municipal water use in Nueces County. One will discharge highly concentrated waste into the bay and the second will inject the waste into a deep aquifer. The pumping location and desalination procedures in both plans are identical, thus we modeled them as mutually exclusive: once either project is built, the other cannot be built.

Analysis Design

To analyze water project choice and the effect of demand growth and climate change, we set up multiple scenarios as follows:

- *Base 2015 Scenario*: A current case that includes neither climate change nor population growth. This is used to examine model validity by comparing the model results with observed data.
- *Base scenarios for select future years with only population growth effects and no climate change (Base 2030, Base 2050, Base 2070 and Base 2090 scenarios).* Here we reflect population growth only for select future years. The assumed population growth rate from 2015 to 2050 is adopted from the Texas Demographic Center (2018) using the projection of half the recent historical immigration rate. The growth rate beyond 2050 is assumed to be equal to the rate in the Texas Demographic Center data from the 2030s to 2050s.
- *Scenarios with both climate change and population growth effects*. These add climate change effects on top of the population growth scenarios. For climate change we use projections from IPCC CMIP5 General Circulation Models (GCMs). Specific GCMs were identified by the Texas State Meteorologist as those that did the best job in matching Texas conditions: IPSL-CM5A-LR (yields the driest and hottest scenario) and MIROC5 (yields the wettest scenario). We employed runs of these models under four Representative Concentration Pathways (RCPs) developed by IPCC. The eight resulting scenarios for climate change (2 GCMs crossed with 4 RCPs) were run and we choose projections for the years 2030, 2050, 2070 and 2090; in total yielding 32 alternative climate change scenarios.

Table 1 shows the average precipitation changes under these scenarios relative to the 2015 climate; the IPSL-CM5A-LR scenarios are drier than the MIROC5 scenarios.

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[2] https://www.saws.org/your-water/new-water-sources/current-water-supply-projects/

[3] https://www.saws.org/your-water/new-water-sources/2017-water-management-plan/

Table 1: Average Annual Precipitation Changes compared with 2015

GCMs	RCP	2030	2050	2070	2090
BASE	BASE	0.00%	0.00%	0.00%	0.00%
IPSL-CM5A-LR	RCP2.6	-4.24%	-0.26%	-6.06%	-2.92%
IPSL-CM5A-LR	RCP4.5	-13.27%	-14.83%	-11.31%	-11.77%
IPSL-CM5A-LR	RCP6.0	0.22%	-23.70%	3.62%	5.79%
IPSL-CM5A-LR	RCP8.5	12.86%	-4.53%	-17.82%	-24.02%
MIROC5	RCP2.6	-9.33%	20.81%	17.51%	7.13%
MIROC5	RCP4.5	1.11%	17.26%	5.65%	13.86%
MIROC5	RCP6.0	8.50%	2.16%	15.47%	3.44%
MIROC5	RCP8.5	13.32%	-1.07%	-10.53%	2.86%

Results

- **Water project construction**

Table 2 shows the models for water projects and were chosen to meet increasing demands under various population growth and climate change scenarios while maximizing regional welfare. Table 3 shows the designed yields of preexisting and newly constructed projects by climate change and population scenarios. Table 4 shows the regional increased water project yield; regions are defined as: SA the city and counties near the City of San Antonio, (City of San Antonio, Bexar County, Hays County, Comal County, Medina County), VC (Victoria-Corpus Christi Area, including City of Victoria, City of Corpus Christi, Nueces County, Victoria County, San Patricio County). The model selected the water project construction schedule using combined population/climate change scenarios as listed in Table 5.

Table 2: Newly Built Water Projects By scenario and time period

GCMs	RCP	2015	2030	2050	2070	2090
BASE	BASE	3		0	16	14
IPSL-CM5A-LR	RCP2.6	3		0	11	19
IPSL-CM5A-LR	RCP4.5	3		1	11	19
IPSL-CM5A-LR	RCP6.0	3		1	10	20
IPSL-CM5A-LR	RCP8.5	3		1	18	11
MIROC5	RCP2.6	3		0	10	20
MIROC5	RCP4.5	3		1	10	18
MIROC5	RCP6.0	3		1	10	17
MIROC5	RCP8.5	3		1	19	10

Table 3: Total Water Project Designed Yields (Thousand Acre-feet)

GCMs	RCP	2015	2030	2050	2070	2090
BASE	BASE	207	257	243	384	624
IPSL-CM5A-LR	RCP2.6	207	257	243	354	624
IPSL-CM5A-LR	RCP4.5	207	257	249	389	625
IPSL-CM5A-LR	RCP6.0	207	257	249	497	666

IPSL-CM5A-LR	RCP8.5	207	257	249	406	624
MIROC5	RCP2.6	207	257	243	455	624
MIROC5	RCP4.5	207	257	249	470	624
MIROC5	RCP6.0	207	257	249	470	622
MIROC5	RCP8.5	207	257	249	407	624

Table 4: Total Design Yield of Model Selected Water Projects by Region (Thousand Acre-Feet)

GCM	RCP	Region	2015	2050	2070	2090
Base	Base	SA			133.8	240.1
Base	Base	VC	53.2		7.3	
IPSL-CM5A-LR	RCP2.6	SA			103.4	270.5
IPSL-CM5A-LR	RCP2.6	VC	53.2		7.3	
IPSL-CM5A-LR	RCP4.5	SA			139.1	234.8
IPSL-CM5A-LR	RCP4.5	VC	53.2	5.6	1.7	0.7
IPSL-CM5A-LR	RCP6.0	SA			205.1	168.7
IPSL-CM5A-LR	RCP6.0	VC	53.2	5.6	43.7	
IPSL-CM5A-LR	RCP8.5	SA			155.5	217.8
IPSL-CM5A-LR	RCP8.5	VC	53.2	5.6	1.7	0.7
MIROC5	RCP2.6	SA			205.1	168.7
MIROC5	RCP2.6	VC	53.2		7.3	
MIROC5	RCP4.5	SA			219.8	153.5
MIROC5	RCP4.5	VC	53.2	5.6	1.7	
MIROC5	RCP6.0	SA			219.8	152.3
MIROC5	RCP6.0	VC	53.2	5.6	1.7	
MIROC5	RCP8.5	SA			156.6	217.2
MIROC5	RCP8.5	VC	53.2	5.6	1.7	

These results reveal several key items:

- In the base 2015 scenario, which does not contain population growth or climate change, the model selects three new water projects to meet water demand. All three projects are in the Victoria-Corpus Christi area: 1) Corpus Christi City water reuse (CorpusChristi_Reuse4), 2) desalinated ground water for Nueces County (NueNWBrackishStevensWell) and 3) desalinated ground water for Bee County (BeeSanBrackishStevensWell). This activity reflects the model addressing current water needs in that region. The total projected yield of the existing and newly built water projects is 207,000 acre feet (acft).
- In the population growth only scenarios for 2030 to 2090, we find that ultimately 30 additional water projects are needed beyond those built for 2015. Only 3 additional projects are chosen in the VC area in 2070, all are reuse projects that provide about 7.3 thousand acft. All other selected projects are in the San Antonio region, mostly reuse projects (9 in 2070, 7 in 2090). Additionally, in 2070, are 2 groundwater projects (CRWAWellsRanch1, ExpandedCzoSSLGC), one that brings water in from outside the region to Hays County (Forestar1) and an ASR project (NBUASR75). In 2090, the model adds one brackish groundwater desalination project (BWCRWA1), three surface

water projects (CRWASiesta, GBRAMidOCR, GBRASurfaceASR), one local groundwater project (HCPUA1) and a sea water desalination project (SeaDesaliSAWS). The net increase in potential water supply is 134 thousand acft in 2070, and 240 thousand acft in 2090. Completion of the Vista Ridge project by 2030 increases the water potential supply to San Antonio by 50 thousand acft.

- As shown (Table 3), the total available water increases from 207 to 257 thousand acft by 2030 with completion of the Vista Ridge project.
- The total available water decreases from 257 to 243 thousand acft between 2030 and 2050 due to the termination of three water projects in San Antonio in the 2050s.
- Three new water projects were built in 2015 in the Corpus Christi-Nueces region, though SA region has excess water supply before 2070. Water projects do not supply water across regions, due to the high cost of water conveyance. Even when expensive pipelines are built (e.g. Vista Ridge projects transferring water from Burleson and Milam Counties to San Antonio via a 142 mile pipeline), the service region is fixed. These results largely show San Antonio region water planning is enough to meet population growth until 2070.
- When climate change is factored, additional water projects are chosen largely due to changes in precipitation:
  - Drier climate scenarios (such as IPSL-CM5A-LR under the driest RCP4.5 and RCP 8.5 scenarios) stimulate construction of yet more water projects.
  - Tables 4 and 5 show the water projects selected under the climate scenarios: the added water project built in 2050 is located in the Corpus Christi- Nueces Area, where a reuse water project for the City of Corpus Christi is chosen.
  - VA area needs little extra water supply beyond that chosen for meeting population needs after 2015; selected water projects are reuse projects.
  - No water projects are built in the 2030s across all scenarios.
  - In 2070s and 2090s, most projects needed are like those selected in the base scenarios and most are designed for San Antonio Region.
  - Climate change causes earlier construction of some water projects. For example, the brackish groundwater desalination project BWCRWA1 is selected for construction in the 2090s in the base scenario, but under the MIRCO5 RCP4.5 and RCP 6.0 climate scenario, it is built in the 2070s. The local groundwater project GBRACzo, which in the population only scenario is added in the 2090s to pump Carrizo aquifer water to San Antonio, is moved forward to 2070 in the climate scenarios.
  - Climate change requires added or alternative water projects be constructed and operated. For example, the surface water project, GBRANewAppropriation, is not selected in the population only scenarios; it is selected under the dry IPSL-CM5a-LR RCP 6.0 scenario. The Comal County reuse water project (Comal_Reuse1) is selected in the Base scenario, but not in IPSL-CM5a-LR RCP 8.5 or MIROC5 RCP 2.6 or RCP 8.5 where other projects are used.

Table 5: Water Projects Selection

water project	Decade	Base	IPSL-CM5a-LR				MIROC5			
			RCP 2.6	Rcp 4.5	RCP 6.0	RCP 8.5	RCP 2.6	Rcp 4.5	RCP 6.0	RCP 8.5
BWCRWA1	2070							1	1	
BWCRWA1	2090	1	1	1	1	1	1			1
BeeSanBrackishStevensWell	2015	1								
Bexar_Reuse1	2090	1	1	1	1	1	1	1	1	1
Bexar_Reuse2	2070									1
Bexar_Reuse2	2090	1	1	1	1	1	1	1	1	
Bexar_Reuse3	2070					1				1
Bexar_Reuse3	2090	1	1	1	1		1	1	1	
Bexar_Reuse4	2070	1				1				1
Bexar_Reuse4	2090		1	1	1		1	1	1	
CRWASiesta	2090	1	1	1	1	1	1	1	1	1
CRWAWellsRanch1	2070	1	1	1	1	1	1	1	1	1
Comal_Reuse1	2090	1	1	1	1		1			1
Comal_Reuse2	2070					1				1
Comal_Reuse2	2090	1	1	1	1		1	1		
Comal_Reuse3	2070	1				1				1
Comal_Reuse3	2090		1	1	1		1	1	1	
Comal_Reuse4	2070	1				1				1
Comal_Reuse4	2090		1	1	1		1	1	1	
CorpusChristi_Reuse1	2070	1	1	1	1	1	1	1	1	1
CorpusChristi_Reuse2	2070	1	1	1	1	1	1	1	1	1
CorpusChristi_Reuse3	2050			1	1	1		1	1	1
CorpusChristi_Reuse3	2070	1	1				1			
CorpusChristi_Reuse4	2015	1								
ExpandedCzoSSLGC	2070	1	1	1	1	1	1	1	1	1
Forestar1	2070	1	1	1	1	1	1	1	1	1
GBRACzo	2070		1	1	1	1	1	1	1	1
GBRACzo	2090	1								
GBRAMidOCR	2090	1	1	1	1	1	1	1	1	1
GBRANewAppropriation	2070				1					
GBRASurfaceASR	2090	1	1	1	1	1	1	1	1	1
HCPUA1	2070			1	1		1	1	1	
HCPUA1	2090	1	1			1				1
Hays_Reuse1	2090	1	1	1	1	1	1	1	1	1
Hays_Reuse2	2090	1	1	1	1	1	1	1	1	1
Hays_Reuse3	2070	1				1				1
Hays_Reuse3	2090		1	1	1		1	1	1	
Hays_Reuse4	2070	1				1				1
Hays_Reuse4	2090		1	1	1		1	1	1	
NBUASR75	2070	1	1	1	1	1	1	1	1	1
NueNWBrackishStevensWell	2015	1								
SanAntonio_Reuse1	2070	1				1				1
SanAntonio_Reuse1	2090		1	1	1		1	1	1	
SanAntonio_Reuse2	2070	1	1	1		1				1
SanAntonio_Reuse2	2090				1		1	1	1	
SanAntonio_Reuse3	2070	1	1	1		1				1
SanAntonio_Reuse3	2090				1		1	1	1	
SanAntonio_Reuse4	2070	1	1	1		1				1
SanAntonio_Reuse4	2090				1		1	1	1	

SeaDesaliSAWS	2070				1		1	1	1	
SeaDesaliSAWS	2090	1	1	1		1				1
SurfacewaterSanPatricio3	2090			1		1				

❖ Water project operations

As discussed, water project construction decisions are independent of knowledge of states of nature, but the operation decision varies by state of nature. Table 6 shows the operational yields of water projects under all states of nature for the base population growth only scenarios.

- Generally, the water projects provide added water under drier states of nature (HDry, MDry and Dry), but less water under wetter states (Wet, MWet and HWet). There are two reasons for this: 1) water sourced from water projects has relatively more expensive operating costs than water from other sources. Consequently, the more expensive water projects are not operated or are only used after the cheaper water is used up. 2) When conditions are wetter, water demand is lower: less supply is needed and more expensive, new project sources are not fully used.
- Over time and as demand grows, project use increases and the differences in use between drier and wetter states of nature decreases. This is because more water is needed and more expensive projects are pushed: water project use grows over time under all states of nature.
- In most cases, water project operation level is smaller than the designed yield. This does not mean that water projects are oversized; rather it occurs for two reasons: 1) the water project construction decision is a build-no build binary variable, which means either build the water project to obtain full design capacity or do not build it. However, water project yields are relatively large, with the largest (Vista Ridge) yielding 50,000 acft. Once built, water project capacity is fully available but only used to the extent needed, which occurs when cheaper sources are unavailable. 2) Some water projects do not have continuous access to ample water supplies due to water availability and regulation limits, i.e. surface water projects cannot always be fully operated under drought conditions when water rights become a constraint.
- Under the base 2015 scenario, utilization of existing projects is only about half of the designed yield. This is consistent with current operations: for example, the San Antonio Water System currently does not fully use all its water projects.
- Across time, population growth only scenarios (Base 2030 to 2090) show a difference between designed and operational yield because the San Antonio region has sufficient capacity to meet future water supply needs within current water projects and, given the data in hand, can accommodate population growth through the 2030s and 2050s. However, unused capacity decreases over time: by and after 2070, new projects are needed.
- Results for project construction under the joint population growth and climate change scenarios are similar to those under their population growth only counterparts. Results are shown from the IPSL-CM5A-LR RCP8.5 case in Table 5, but operational yield levels differ substantially. Under climate change scenario, project operational water use is much higher than without climate change for the 2030s, 2050s, and 2070s, even though the designed yields are identical or quite similar. For the drier IPSL-CM5A-LR RCP8.5 case, less water is available from surface and groundwater, but with higher climate change stimulated water demand, water projects supply more water.

Table 6: Water Project Operation Yield in Base Scenarios by state of nature (Thousand Acre-foot)

		Designed Yield	HDry	MDry	Dry	Dnormal	Normal	Wnormal	Wet	MWet	HWet
Base	2015	**207**	111	111	111	66	67	65	66	66	65
Base	2030	**257**	173	165	162	103	101	101	100	100	100
Base	2050	**243**	227	227	227	227	227	212	220	219	205
Base	2070	**384**	368	368	368	368	368	368	368	368	368
Base	2090	**624**	594	594	594	594	594	594	594	594	594

Table 7: Water Project Operation Yield in IPSL-CM5A-LR RCP8.5 Scenarios by state of nature (Thousand Acre-foot)

		Designed Yield	HDry	MDry	Dry	Dnormal	Normal	Wnormal	Wet	MWet	HWet
ipsl-cm5a-lr_rcp85	2030	**257**	195	170	183	113	108	99	140	119	179
ipsl-cm5a-lr_rcp85	2050	**249**	232	232	232	232	232	220	222	222	214
ipsl-cm5a-lr_rcp85	2070	**406**	390	390	390	390	390	390	390	390	390
ipsl-cm5a-lr_rcp85	2090	**624**	594	594	594	594	594	594	594	594	594

Concluding comments

The South-Central Texas region is experiencing high demand growth and exhibits drier and hotter climate change projections plus a projected water deficit. The TWDB sponsored regional water planning groups have proposed several water projects for regions L and N to address population growth and projected deficits. Climate change is also a likely deficit increasing factor.

We used modeling to examine water project needs and selection over time. We examined water project desirability under a current (2015) scenario and then ran scenarios for 2030, 2050, 2070 and 2090 considering projected population growth. We then combined climate change and population growth scenarios.

We found that existing San Antonio regional projects are sufficient to meet demand until the 2050, under population growth only scenarios; we also found that more water projects are needed in the Corpus Christi-Nueces region under current circumstances.

Not surprisingly, scenarios with population growth show that additional water project construction and operation are stimulated.

We also found that climate change scenarios increase needs for water project construction and operation. Not surprisingly, higher levels of water delivery from new and existing water projects are needed under drier conditions.

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