

4B.4 System Operation of Brazos River Authority Reservoirs

The Brazos River Authority (BRA) has submitted to the Texas Commission on Environmental Quality (TCEQ) a water rights permit application requesting additional appropriation of water that could be made available through system operations of the BRA's existing water rights and reservoirs. The BRA has requested an appropriation of up to 421,449 acft/yr of firm supply. The BRA also requests authorization to use up to 90,000 acft/yr of its firm supply to produce, along with other unappropriated flows, an interruptible supply of up to 670,000 acft/yr for appropriation. By conventional definition, at least 75 percent of an interruptible supply is available at least 75 percent of the time.

At the request of the BRA, the Brazos G RWPG evaluated several aspects of the BRA System Operations as a potential water management strategy for the 2006 Brazos G Regional Water Plan (2006 Plan).

The evaluation was completed through three distinct tasks:

1. Incorporate the BRA System Operations into the Brazos G WAM and determine the maximum amount that could be made available under the constraints of existing contractual obligations and future reservoir sedimentation conditions.
2. Determine the additional water supply that would be made available by the BRA System Operations to Water User Groups (WUGs) with needs that could potentially utilize the additional supply.
3. Determine various effects of the proposed BRA System Operations:
 - on new water management strategies evaluated as being junior in priority to the proposed BRA appropriation;
 - on the increase in supply that could be made available by operating new water management strategies as part of the BRA System; and
 - on the increase in supply that could be made available from existing projects owned by other entities by operating those projects in conjunction with the BRA System.

4B.4.1 Availability of Water from the BRA System Operations

The water requested in the BRA water rights permit application is the maximum amount of water that might be developed by the BRA System if all of the water were utilized (diverted) near the Gulf of Mexico. Diverting all water supply from the BRA System (both existing and new appropriations) near the Gulf maximizes the supply available by (a) allowing all BRA reservoirs to contribute and make releases, and (b) maximizes the area contributing flows

(uncontrolled runoff and wastewater return flows¹) that originate downstream of the BRA reservoirs. Under this hypothetical operation (diverting all supply near the Gulf), uncontrolled flow originating downstream of the BRA reservoirs is diverted during wet times, and firmed up by releases from storage in the upstream BRA reservoir during dry times. In this fashion, a total “system” yield can be developed that is substantially greater than the sum of the individual reservoir yields.

The BRA currently holds multiple contracts to supply water to cities, districts, irrigators and industry throughout the Brazos River Basin. The total of the contracts held by the BRA to supply water total more than 80 percent of their currently authorized diversions from their existing water rights (including Allens Creek Reservoir, which is not constructed). Many of these contracts are supplied proximate to the BRA’s reservoirs, or through lakeside diversions. This reduces the efficiency of the BRA System because (a) not every BRA reservoir can contribute releases to every contractual diversion location, and (b) diversion of the contracts from the basin upstream of the Gulf reduces the opportunity to utilize flows contributed by the basin downstream of the reservoir system. Because of this constraint, the total amount of water that the BRA could realize through system operations of its reservoirs is reduced substantially.

The Brazos G WAM was utilized to determine the availability of water from the BRA System. The Brazos G WAM, as developed by the Brazos G RWPG, includes 600,946 acft of existing BRA contracts simulated at their actual points of diversion in the basin. The BRA System operations concept was incorporated into the Brazos G WAM by specifying which contracts could receive releases from multiple reservoirs, and then allowing those reservoirs to make releases during model simulations. The remaining water available from the BRA System (after supplying current contractual commitments) was then evaluated at the Gulf of Mexico. The BRA application includes estimates of potential system diversions at three locations: Brazos River near Glen Rose, Brazos River near Highbank, and the Brazos River at the Gulf of Mexico. The analysis performed for the Brazos G RWPG evaluating the effects of the BRA System Operations includes only the Brazos River at the Gulf of Mexico system diversion location.

During the model simulations, the BRA contracts are met first from the BRA System, followed by the remaining amount that could be met at the Gulf of Mexico. This would be the

¹ This water management strategy shall not impair or prejudice the rights of an owner of groundwater based discharges to seek or obtain authorization to reuse such discharges either directly or indirectly pursuant to Texas Water Code Section §11.042 (b) consistent with state law.

maximum amount that could be realized by the BRA under the agency’s current contractual commitments. All simulations assume Year 2060 reservoir sedimentation conditions.

Results of the water availability analysis are shown in Table 4B.4-1. The sum of the BRA’s existing contractual obligations included in this analysis total 600,946 acft/year. When all remaining supply from the system is diverted at the Gulf after meeting upstream contractual commitments, an additional 395,000 acft/yr of firm supply could be developed by system operations of the BRA reservoirs. This total includes both currently permitted yield that is not utilized by existing contracts, and unpermitted yield that could be developed by the system operations.

**Table 4B.4-1.
Water Availability from BRA System Operations**

Total BRA Permitted Diversions (acft/yr)	BRA Contractual Diversions (acft/yr)	Diversions at Gulf (acft/yr)	Total BRA System Diversions (acft/yr)	Permitted Unutilized Yield (acft/yr)	Unpermitted Yield (acft/yr)
761,551	600,946	395,000	995,946	160,605	234,395

The availability of interruptible supply was not evaluated for this portion of the analysis, but was included in Task 3 to determine the overall effects of the proposed BRA appropriation on water management strategies considered for the 2006 Plan.

The Gulf of Mexico diversion scenario was utilized as the standard “base run” with which the remaining portion of the analysis was completed.

4B.4.2 Utilization of the BRA System Operations as a Water Management Strategy for Specific WUGs

Water available from BRA System Operations represents a new supply of water that could be utilized to meet future needs in the Brazos G Area without construction of new reservoirs. WUGs with projected needs were identified in counties adjacent to the main stem of the Brazos River. Demands equal to those needs were included as new contractual diversions in the system operations version of the Brazos G WAM. The model was then used to determine if sufficient water was available from system operations to meet the projected needs of each of the WUGs, as well as the facility and operational costs for diversion, transmission, and treatment.

4B.4.2.1 Selected WUG with Needs

In consultation with the BRA, eight potential diversion locations were identified along the main stem of the Brazos River that are proximate to the locations of one or more WUGs with projected needs. Some of the selected diversion locations can be utilized for multiple WUGs. Figure 4B.4-1 shows the eight diversion locations, and Table 4B.4-2 lists the ten WUGs or groups of WUGs selected for which water available from BRA System Operations might be a feasible water management strategy. WUGs with needs based on infrastructure constraints were not included as selected WUGs.

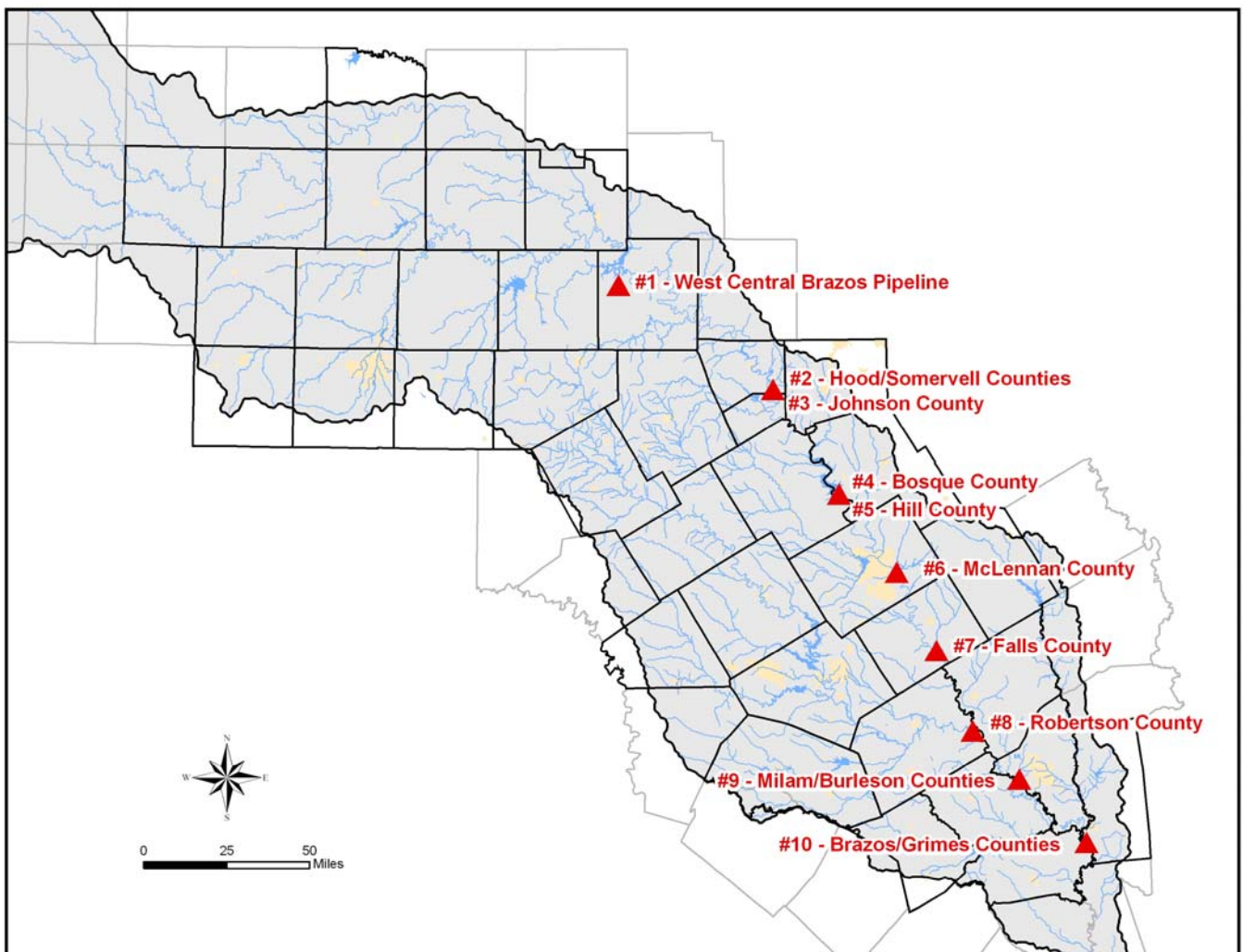


Figure 4B.4-1. WUG Diversion Locations

**Table 4B.4-2.
Selected WUGs for Availability and Cost Analysis**

Diversion Location #	WUG Location	Combined WUG Need (acft/yr)	Included WUGs
1	West Central Brazos Pipeline	10,689	Stephens County Other Stephens County Mining Shackleford County Mining
2	Hood / Somervell Counties	4,089	Oak Trail Shores Subdivision Hood County Other Hood County Manufacturing Hood County Mining Somervell County Other Somervell County Manufacturing Somervell County Mining
3	Johnson County	20,305	Alvarado Bethany WSC Godley Grandview Johnson County SUD Joshua Parker WSC Rio Vista Venus Johnson County Other Johnson County Manufacturing Johnson County Other
4	Bosque County	10,000	Bosque Steam Electric
5	Hill County	1,606	Brandon-Irene WSC Hillsboro Parker WSC White Bluff Community WSC Woodrow-Osceola WSC
6	McLennan County	3,022	Chalk Bluff WSC Crawford Cross County WSC Gholson North Bosqu WSC West Western Hill WSC McLennan County Manufacturing
7	Falls County	1,211	Elm Creek WSC West Brazos WSC
8	Robertson County	8,244	Robertson County Steam Electric
9	Milam / Burleson Counties	1,164	Bell-Milam-Falls WSC Southwest Milam WSC Burleson County Manufacturing
10	Brazos / Grimes Counties	3,162	Bryan Wickson Creek SUD Brazos County Manufacturing Grimes County Manufacturing
Total WUG Needs			65,482

4B.4.2.2 Water Availability to WUGs with Needs

The individual WUG diversions were incorporated into the model in upstream to downstream order, and assigned priority junior to BRA's existing water supply contracts. As additional WUG diversions are added in the downstream direction, additional BRA reservoirs are capable of making releases to meet the demands, and the remaining supply available at the Gulf of Mexico is reduced in response to the additional upstream demand.

All 10 WUG needs are able to be met exclusively by the BRA system without negatively impacting any existing BRA water supply obligations. However, in order to be able to meet the additional 65,482 acft of identified WUG demands, the remaining supply at the Gulf would be reduced by 129,000 acft. As supply is taken upstream it causes a reduction of available supply at the downstream location that is greater than a 1:1 proportion, caused by the system's reduced ability to "firm up" the downstream uncontrolled flows.

4B.4.2.3 Costs for Meeting WUG Needs with BRA System Supply

The following sections describe the estimated facilities and operational costs associated with diverting, transmitting, and treating the BRA system water if it was used to meet the identified WUG needs. Raw water costs were set equal to the current BRA system rate of \$45.75 per acft. Facilities and operation costs for the 10 WUG supply scenarios were estimated using the cost estimating procedure used for other water management strategies evaluated for the 2006 Plan.

No facilities costs were computed for WUG Supply scenario #1 (West Central Brazos Pipeline); the only cost associated with this strategy is for raw water purchased from the BRA, which the BRA has indicated would be sufficient to cover costs of delivering water through system. Since the facilities exist and the end users are expected to be mining operations with proximate access to the existing pipeline, no other additional facilities or operational costs were estimated for this option.

Table 4B.4-3 presents a summary comparison of the costs for the individual WUGs. Unit costs vary considerably due to economies of scale and treatment considerations for the type of use contemplated. Desalination was considered necessary for all municipal and manufacturing uses, but not mining or steam electric uses. Large individual unit costs could be decreased by serving additional WUGs beyond those enumerated herein. Unit costs for supply from the West

Central Brazos Pipeline were provided by BRA. Detailed cost summaries for the other 9 WUG supply options are shown in Tables 4B.4-4 – 4B.4-12.

**Table 4B.4-3.
Comparison of WUG Costs for Utilization of Supply Available from
BRA System Operation**

WUG #	WUG Location	Demand (acft/yr)	Capital Cost (Millions)	Annual Cost (Millions)	Unit Cost (\$/acft)	Unit Cost (\$/1,000 gal)
1	West Central Brazos Pipeline	10,689	n/a	na/	\$45.75	\$0.14
2	Hood / Somervell Counties	4,089	\$40.68	\$5.22	\$1,277	\$3.92
3	Johnson County	20,305	\$140.70	\$21.06	\$1,037	\$3.18
4	Bosque County	10,000	\$25.49	\$3.82	\$382	\$1.17
5	Hill County	1,606	\$36.15	\$3.78	\$2,355	\$7.23
6	McLennan County	3,022	\$35.69	\$4.35	\$1,439	\$4.42
7	Falls County	1,211	\$23.12	\$2.60	\$2,145	\$6.58
8	Robertson County	8,244	\$16.60	\$2.36	\$286	\$0.88
9	Milam / Burleson Counties	1,164	\$33.47	\$3.39	\$2,909	\$8.93
10	Brazos / Grimes Counties	3,162	\$44.78	\$5.27	\$1,667	\$5.12

**Table 4B.4-4.
WUG #2 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-2 Hood and Somerville Counties	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (5 MGD)	\$1,926,000
Transmission Pipeline (18 in dia., 4 miles)	\$1,245,000
Transmission Pipeline (16 in dia., 8 miles)	\$2,574,000
Transmission Pipeline (12 in dia., 20 miles)	\$5,898,000
Transmission Pump Station(s)	\$1,062,000
Water Treatment Plants (4.84 MGD RO System)	\$14,056,000
Total Capital Cost	\$26,761,000
Engineering, Legal Costs and Contingencies	\$8,880,000
Environmental & Archaeology Studies and Mitigation	\$851,000
Land Acquisition and Surveying (126 acres)	\$1,172,000
Interest During Construction (2 years)	<u>\$3,014,000</u>
Total Project Cost	\$40,678,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$2,955,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$169,000
Water Treatment Plant	\$1,588,000
Pumping Energy Costs (5,357,365 kW-hr @ 0.06 \$/kW-hr)	\$321,000
Purchase of Water (4,089 acft/yr @ 45.75 \$/acft)	<u>\$187,000</u>
Total Annual Cost	\$5,220,000
Available Project Yield (acft/yr)	4,089
Annual Cost of Water (\$ per acft)	\$1,277
Annual Cost of Water (\$ per 1,000 gallons)	\$3.92

**Table 4B.4-5.
WUG #3 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-3 Johnson County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (24.8 MGD)	\$5,374,000
Transmission Pipeline (36 in dia., 24 miles)	\$16,395,000
Transmission Pipeline (12 in dia., 47 miles)	\$10,739,000
Transmission Pump Station(s)	\$9,924,000
Water Treatment Plants (24.42 MGD RO System)	\$48,325,000
Total Capital Cost	\$90,757,000
Engineering, Legal Costs and Contingencies	\$30,408,000
Environmental & Archaeology Studies and Mitigation	\$1,876,000
Land Acquisition and Surveying (277 acres)	\$2,580,000
Interest During Construction (3 years)	\$15,075,000
Total Project Cost	\$140,696,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$10,221,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$632,000
Water Treatment Plant	\$6,799,000
Pumping Energy Costs (41,355,382 kW-hr @ 0.06 \$/kW-hr)	\$2,481,000
Purchase of Water (20,305 acft/yr @ 45.75 \$/acft)	\$929,000
Total Annual Cost	\$21,062,000
Available Project Yield (acft/yr)	20,305
Annual Cost of Water (\$ per acft)	\$1,037
Annual Cost of Water (\$ per 1,000 gallons)	\$3.18

**Table 4B.4-6.
WUG #4 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-4 Bosque County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (12.2 MGD)	\$2,562,000
Transmission Pipeline (24 in dia., 17 miles)	\$8,704,000
Transmission Pump Station(s)	\$5,780,000
Water Treatment Plant (none needed)	\$0
Total Capital Cost	\$17,046,000
Engineering, Legal Costs and Contingencies	\$5,531,000
Environmental & Archaeology Studies and Mitigation	\$430,000
Land Acquisition and Surveying (67 acres)	\$596,000
Interest During Construction (2 years)	<u>\$1,889,000</u>
Total Project Cost	\$25,492,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$1,852,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$284,000
Water Treatment Plant	\$0
Pumping Energy Costs (20,417,920 kW-hr @ 0.06 \$/kW-hr)	\$1,225,000
Purchase of Water (10,000 acft/yr @ 45.75 \$/acft)	<u>\$458,000</u>
Total Annual Cost	\$3,819,000
Available Project Yield (acft/yr)	10,000
Annual Cost of Water (\$ per acft)	\$382
Annual Cost of Water (\$ per 1,000 gallons)	\$1.17

**Table 4B.4-7.
WUG #5 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-5 Hill County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (1.96 MGD)	\$1,230,000
Transmission Pipeline (12 in dia., 56 miles)	\$12,863,000
Transmission Pump Station(s)	\$877,000
Water Treatment Plants (1.96 MGD RO System)	\$7,786,000
Total Capital Cost	\$22,756,000
Engineering, Legal Costs and Contingencies	\$7,321,000
Environmental & Archaeology Studies and Mitigation	\$1,420,000
Land Acquisition and Surveying (212 acres)	\$1,976,000
Interest During Construction (2 years)	<u>\$2,678,000</u>
Total Project Cost	\$36,151,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$2,626,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$180,000
Water Treatment Plant	\$789,000
Pumping Energy Costs (1,895,643 kW-hr @ 0.06 \$/kW-hr)	\$114,000
Purchase of Water (1,606 acft/yr @ 45.75 \$/acft)	<u>\$73,000</u>
Total Annual Cost	\$3,782,000
Available Project Yield (acft/yr)	1,606
Annual Cost of Water (\$ per acft)	\$2,355
Annual Cost of Water (\$ per 1,000 gallons)	\$7.23

**Table 4B.4-8.
WUG #6 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-6 McLennan County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake 1 and Pump Station (1.19 MGD)	\$1,209,000
Intake 2 and Pump Station (2.51 MGD)	\$1,220,000
Transmission Pipelines (12 in dia., 33 miles)	\$8,355,000
Transmission Pump Station(s)	\$953,000
Water Treatment Plants (3.69 MGD RO System)	\$11,552,000
Total Capital Cost	\$23,289,000
Engineering, Legal Costs and Contingencies	\$7,733,000
Environmental & Archaeology Studies and Mitigation	\$849,000
Land Acquisition and Surveying (131 acres)	\$1,178,000
Interest During Construction (2 years)	<u>\$2,644,000</u>
Total Project Cost	\$35,693,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$2,593,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$166,000
Water Treatment Plant	\$1,269,000
Pumping Energy Costs (3,047,084 kW-hr @ 0.06 \$/kW-hr)	\$183,000
Purchase of Water (3,022 acft/yr @ 45.75 \$/acft)	<u>\$138,000</u>
Total Annual Cost	\$4,349,000
Available Project Yield (acft/yr)	3,022
Annual Cost of Water (\$ per acft)	\$1,439
Annual Cost of Water (\$ per 1,000 gallons)	\$4.42

**Table 4B.4-9.
WUG #7 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-7 Falls County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (1.48 MGD)	\$1,215,000
Transmission Pipeline (12 in dia., 24 miles)	\$5,233,000
Transmission Pump Station(s)	\$1,773,000
Water Treatment Plants (1.48 MGD RO System)	\$6,741,000
Total Capital Cost	\$14,962,000
Engineering, Legal Costs and Contingencies	\$4,975,000
Environmental & Archaeology Studies and Mitigation	\$615,000
Land Acquisition and Surveying (96 acres)	\$853,000
Interest During Construction (2 years)	<u>\$1,713,000</u>
Total Project Cost	\$23,118,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$1,679,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$125,000
Water Treatment Plant	\$656,000
Pumping Energy Costs (1,383,144 kW-hr @ 0.06 \$/kW-hr)	\$83,000
Purchase of Water (1,211 acft/yr @ 45.75 \$/acft)	<u>\$55,000</u>
Total Annual Cost	\$2,598,000
Available Project Yield (acft/yr)	1,211
Annual Cost of Water (\$ per acft)	\$2,145
Annual Cost of Water (\$ per 1,000 gallons)	\$6.58

**Table 4B.4-10.
WUG #8 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-8 Robertson County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (10.1 MGD)	\$2,566,000
Transmission Pipeline (24 in dia., 17 miles)	\$6,182,000
Transmission Pump Station(s)	\$2,154,000
Water Treatment Plant (none needed)	\$0
Total Capital Cost	\$10,902,000
Engineering, Legal Costs and Contingencies	\$3,506,000
Environmental & Archaeology Studies and Mitigation	\$426,000
Land Acquisition and Surveying (64 acres)	\$591,000
Interest During Construction (2 years)	<u>\$1,234,000</u>
Total Project Cost	\$16,659,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$1,210,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$175,000
Water Treatment Plant	\$0
Pumping Energy Costs (9,969,192 kW-hr @ 0.06 \$/kW-hr)	\$598,000
Purchase of Water (8,244 acft/yr @ 45.75 \$/acft)	<u>\$377,000</u>
Total Annual Cost	\$2,360,000
Available Project Yield (acft/yr)	8,244
Annual Cost of Water (\$ per acft)	\$286
Annual Cost of Water (\$ per 1,000 gallons)	\$0.88

**Table 4B.4-11.
WUG #9 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-9 Milam/Burleson County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (1.42 MGD)	\$1,214,000
Transmission Pipeline (12 in dia., 56 miles)	\$12,168,000
Transmission Pump Station(s)	\$895,000
Water Treatment Plants (1.42 MGD RO System)	\$6,610,000
Total Capital Cost	\$20,887,000
Engineering, Legal Costs and Contingencies	\$6,702,000
Environmental & Archaeology Studies and Mitigation	\$1,422,000
Land Acquisition and Surveying (211 acres)	\$1,976,000
Interest During Construction (2 years)	<u>\$2,479,000</u>
Total Project Cost	\$33,466,000
Annual Costs	
Debt Service (6 percent, 30 years)	\$2,431,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$173,000
Water Treatment Plant	\$639,000
Pumping Energy Costs (1,497,245 kW-hr @ 0.06 \$/kW-hr)	\$90,000
Purchase of Water (1,164 acft/yr @ 45.75 \$/acft)	<u>\$53,000</u>
Total Annual Cost	\$3,386,000
Available Project Yield (acft/yr)	1,164
Annual Cost of Water (\$ per acft)	\$2,909
Annual Cost of Water (\$ per 1,000 gallons)	\$8.93

**Table 4B.4-12.
WUG #10 Facilities and Operation Cost Summary**

Cost Estimate Summary Water Supply Project Option Second Quarter 2002 Prices WUG-10 Brazos/Grimes County	
Item	Estimated Costs for Facilities
Capital Costs	
Intake and Pump Station (3.86 MGD)	\$1,512,000
Transmission Pipeline (14 in dia., 6 miles)	\$1,736,829
Transmission Pipeline (12 in dia., 47 miles)	\$11,568,524
Transmission Pump Station(s)	\$2,098,000
Water Treatment Plants (3.86 MGD RO System)	\$11,922,000
Total Capital Cost	\$28,837,353
Engineering, Legal Costs and Contingencies	\$9,428,000
Environmental & Archaeology Studies and Mitigation	\$1,340,000
Land Acquisition and Surveying (201 acres)	\$1,860,000
Interest During Construction (2 years)	<u>\$3,318,000</u>
Total Project Cost	\$44,783,353
Annual Costs	
Debt Service (6 percent, 30 years)	\$3,253,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	\$219,000
Water Treatment Plant	\$1,316,000
Pumping Energy Costs (5,648,603 kW-hr @ 0.06 \$/kW-hr)	\$339,000
Purchase of Water (3,162 acft/yr @ 45.75 \$/acft)	<u>\$145,000</u>
Total Annual Cost	\$5,272,000
Available Project Yield (acft/yr)	3,162
Annual Cost of Water (\$ per acft)	\$1,667
Annual Cost of Water (\$ per 1,000 gallons)	\$5.12

4B.4.3 Effects of the Proposed BRA System Operations on Water Management Strategies Considered for the 2006 Plan

BRA System Operations would appropriate additional water in the Brazos River Basin with a priority date set in 2004. Under the Doctrine of Prior Appropriation, any water management strategy requiring a new TCEQ water rights permit (a new reservoir or run-of-the-river diversion) would be junior to this priority date, and would be required to pass flows to BRA System needs under the concept of “first in time, first in right.” This would reduce the water available to any new appropriation, and would reduce the supply developed by any new water management strategy. In order to determine the efficacy of including the BRA System Operations as a recommended water management strategy in the 2006 Plan, the potential effects of the new appropriation on other water management strategies considered for the 2006 Plan were evaluated by the Brazos G RWPG.

Nine water management strategies (all new reservoirs) were evaluated with and without the proposed BRA System Operations in place. All nine were operated as if junior to the proposed BRA System appropriation and would be required to pass flows when called on by the proposed new BRA water rights. Two alternative analyses were completed for each reservoir: the first incorporated just the firm portion of the proposed BRA System Diversion at the Gulf of Mexico as a water right senior to the new reservoir; the second analysis added the interruptible portion of the proposed appropriation as a water right senior to the new reservoir.

Table 4B.4-13 presents the yields of each project operated as junior to the BRA System Operation (with and without interruptible water), and compares those yields to the yield if the reservoir were operated senior to the proposed BRA System appropriation. The yields of the projects senior to the BRA System appropriation are identical to those determined for the reservoirs as individual water management strategies in Sections 4B.12 and 4B.13. As shown by the table, operation of the potential new reservoirs at a priority junior to the proposed BRA System appropriation substantially reduces the available yield from each of the projects. The inclusion of the proposed interruptible water further reduces the yields from these projects. This reduction in the yields of these projects is expected, as any new appropriation of water will reduce availability to any other appropriation with a junior priority.

Figure 4B.4-2 presents this information graphically for the Millican-Bundic Reservoir. The last bar on this graph represents the increase in System yield if the reservoir were operated as part of the BRA System Operations. This is discussed later in the next section.

Table 4B.4-13.
Yields of Reservoir Water Management Strategies when Operated Junior to the BRA System Operations Appropriation

Water Management Strategy	Senior to BRA System Operations (acft/yr)	Junior to BRA System Operations (acft/yr)	
		Gulf Diversion, No Interruptible Water¹	Gulf Diversion, with Interruptible Water²
Double Mountain Fork - East Site	40,100	8,625	5,000
South Bend	44,940 ³ (30,635) ⁴	22,700 ⁴	14,700 ⁴
Millers Creek	-	-	-
Cedar Ridge	15,000 (32,570) ⁵	13,900	12,050
Turkey Peak + Palo Pinto	19,130 ⁶	15,580	15,580
Groesbeck	950	200	200
Little River Off-Channel (108" diversion pipeline)	32,110	26,900	22,500
Little River On-Channel	124,000	93,480	92,000
Millican-Bundic	38,080	31,800	30,750

¹ BRA System Diversion of 395,000 acft/yr at Gulf of Mexico, with 600,946 acft/yr contracts diverted at contractual locations.
² Interruptible supply of 670,000 acft/yr diverted at Gulf of Mexico, with firm supply of 395,000 acft/yr at Gulf and 600,946 acft/yr contracts diverted at contractual locations.
³ Yield of South Bend reservoir when operated in conjunction with Possum Kingdom Reservoir.
⁴ These yields are based on the stand alone firm yield of South Bend Reservoir for purposes of determining the impacts to the strategy.
⁵ Includes subordination to Possum Kingdom Reservoir.
⁶ Additional Yield due to Turkey Peak Reservoir is 8,648 acft/yr, keeping Palo Pinto Reservoir rights firm.

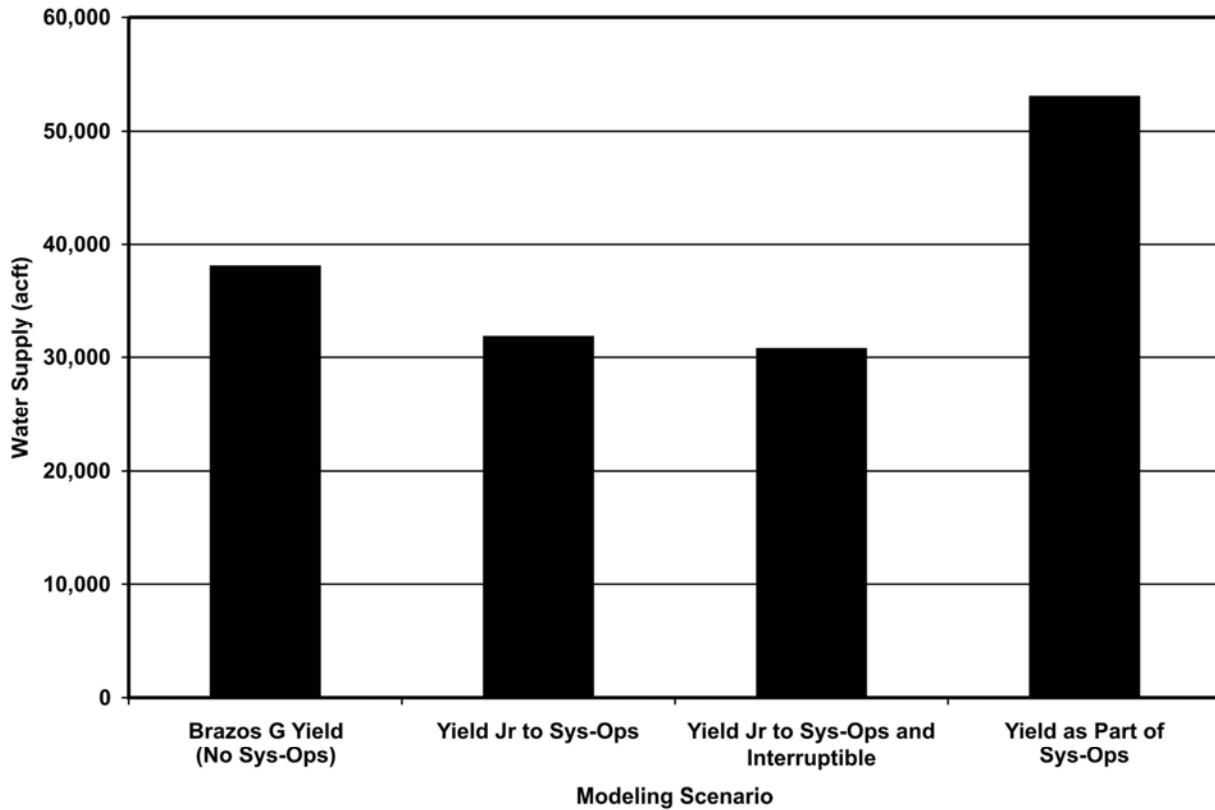


Figure 4B.4-2. Yields of the Millican-Bundic Reservoir Operated with Various Priority Relationships to the BRA System

4B.4.4 Effects of Incorporating Water Management Strategies into BRA System Operations

While the yields of the reservoir strategies evaluated previously are substantially reduced when operated junior in priority to the BRA System Operations appropriation, the projects can provide a substantial benefit to the overall yield of the BRA system if operated conjunctively as part of the system. Table 4B.4-14 presents the increase in overall system supply that would be realized if these projects were operated as part of the BRA System. In all cases, the reservoirs were operated to make releases to a BRA System diversion at the Gulf of Mexico. Figure 4B.4-2 illustrates the yield of the Millican-Bundic Reservoir senior to, junior to, and as part of the BRA System. Results for other potential reservoir projects are similar.

As shown in Table 4B.4-14, the system yield increases that could be realized by incorporating individual new reservoirs into the BRA System generally are greater than the

Table 4B.4-14.
BRA System Yield Results when Water Management Strategies are
Operated with BRA System Operations
(all values in acre-feet per year)

Total BRA Authorization	761,551
BRA Contracts included in Model	600,946
Current Permitted Unutilized Authorization	160,605

Water Management Strategy	Brazos G System Diversion Yield at the Gulf	Contracts Included in Model	Permitted Unutilized Yield	Unpermitted Yield	Total Potential Firm Supply from the BRA System
Base Yield without any WMS	395,000	600,946	160,605	234,395	995,946
Double Mountain Fork East Site	435,000	600,946	160,605	274,395	1,035,946
Cedar Ridge	423,000	600,946	160,605	262,395	1,023,946
South Bend	441,000	600,946	160,605	280,395	1,041,946
Turkey Peak + Palo Pinto	420,000	600,946	160,605	259,395	1,020,946
Little River Off-Channel (108-inch pipe)	435,000	600,946	160,605	274,395	1,035,946
Little River On-Channel	420,000	600,946	160,605	259,395	1,020,946
Millican-Bundic	425,000	600,946	160,605	264,395	1,025,946

stand-alone yield of the projects themselves. This is primarily due to the reservoir storage being operated to “firm up” uncontrolled flows diverted at the Gulf that originate downstream of existing BRA reservoirs and downstream of the potential new reservoir.

Figure 4B.4-3 illustrates different components of supply in the Brazos River Basin, both current and potential. In this figure, the supply from the BRA System is shown in black, both as currently permitted and with the proposed BRA System appropriation. The combined yields of the other major reservoirs are shown in green. As shown by comparing these two bars, the BRA controls the majority of the reservoir firm yield in the basin. Shown in blue are the combined stand-alone yields of three water management strategies considered for the 2006 Plan: Breckenridge Reservoir (Cedar Ridge site), Little River Off-Channel Reservoir and the Millican-Bundic Reservoir. These are shown, alternatively, as stand-alone yields (dark blue) and as operated in conjunction with the BRA System. Finally, the interruptible portion of the proposed BRA System appropriation is shown in grey.

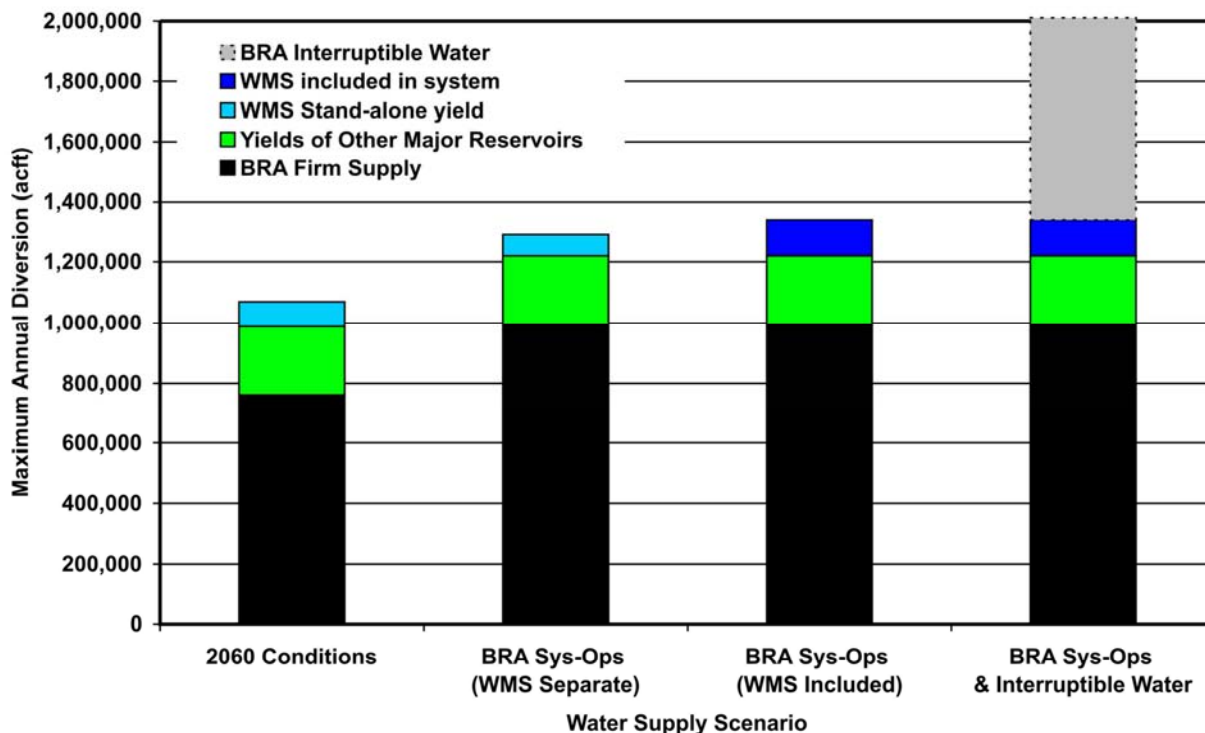


Figure 4B.4-3. Summary of BRA System Diversions When Combined with Three New Reservoir Projects: Cedar Ridge Reservoir, Little River Off-Chanel, and Millican-Bundic Reservoir

4B.4.5 Effects of Including Existing Water Supply Sources as Part of BRA System Operations

A final analysis was completed, wherein an existing water supply reservoir (Lake Waco) would be operated in conjunction with the proposed BRA System appropriation to determine the supply increase that such an operation would have on the BRA System.

For this analysis, Lake Waco's participation in the BRA System was constrained to give priority to local needs and to maintain lake levels for recreational purposes. The lakeside demand on the reservoir was set to the estimated Year 2060 demand on the reservoir plus 15%, or 67,935 acft/yr.² Lake Waco contributions to the BRA System were limited to times when the reservoir was at or above 455 feet elevation; approximately 71% of the reservoir storage would be kept in reserve for local use with the top 29% of the storage used jointly to meet local demands and augment the BRA System. The results of this analysis indicate that the inclusion of Lake Waco in the BRA System Operations under those operational constraints would add approximately 6,000 acft/yr to the firm yield of the BRA System, diverted at the Gulf.

4B.4.6 Summary of Hydrologic Findings Concerning the Proposed BRA System Operations

The proposed BRA System Operations appropriation would add a considerable amount of firm supply to the Brazos River Basin that could be used in the Brazos G Area, but also in adjacent regions where the BRA supplies water, most notably Region H (Houston area). New proposed water management strategies may be negatively impacted by the BRA System Operations, but only to the extent that priority limits availability to the new options.

Supply from the BRA System Operations can be utilized to meet WUG demands throughout the Brazos Basin. Several WUGs with needs were identified, and unit cost estimates for using BRA System Operations supply to meet these needs ranged from \$286 to \$2,909 per acft.

The BRA System Operations would negatively affect the yields of several proposed water management strategies that are considered for the 2006 Brazos G Regional Water Plan.

² At the time this analysis was completed, strategies involving the City of Waco providing additional supply to McLennan County entities had not been identified. Projected local demands on Lake Waco are now greater than 67,935 acft/yr if all water management strategies utilizing the City of Waco as a wholesale water provider are implemented.

The proposed BRA System Operations appropriation would be granted with a priority date senior to any of these proposed reservoir projects, and would have a priority call on inflows. However, any of these proposed reservoirs could be operated in conjunction with the BRA System, and the resulting increase in supply to the Brazos River Basin would be greater than that obtained from the projects operated on a stand-alone basis with a priority senior to the proposed BRA appropriation.

The benefits of including an existing water supply project (Lake Waco) into the BRA System are limited by constraints designed to protect water supply for local needs. These types of constraints would likely be included in agreements with any local entity willing to include a local water supply reservoir in BRA System Operations.

4B.4.7 Environmental and Implementation Issues

Unlike the typical implementation of a large surface water reservoir, the proposed BRA System Operations appropriation requires no environmental permits because the reservoirs are existing. However, instream flow restrictions likely to be placed on the new appropriation could limit supplies that could be developed by the project. Figure 4B.4-4 illustrates streamflows in the Brazos River at the Richmond gage, both with and without the proposed BRA System appropriation. Figure 4B.4-5 illustrates the expected Brazos River flows downstream into the Gulf of Mexico. The figures indicate that with the proposed BRA appropriation, as modeled with the majority of the proposed appropriation diverted from the lower basin, streamflows would generally be greater up to the point of diversion. However, flows into the Gulf of Mexico would generally decrease.

A summary of environmental issues for the BRA System Operations is presented in Table 4B.4-15. This water supply option has been compared to the plan development criteria, as shown in Table 4B.4-16, and the option meets each criterion.

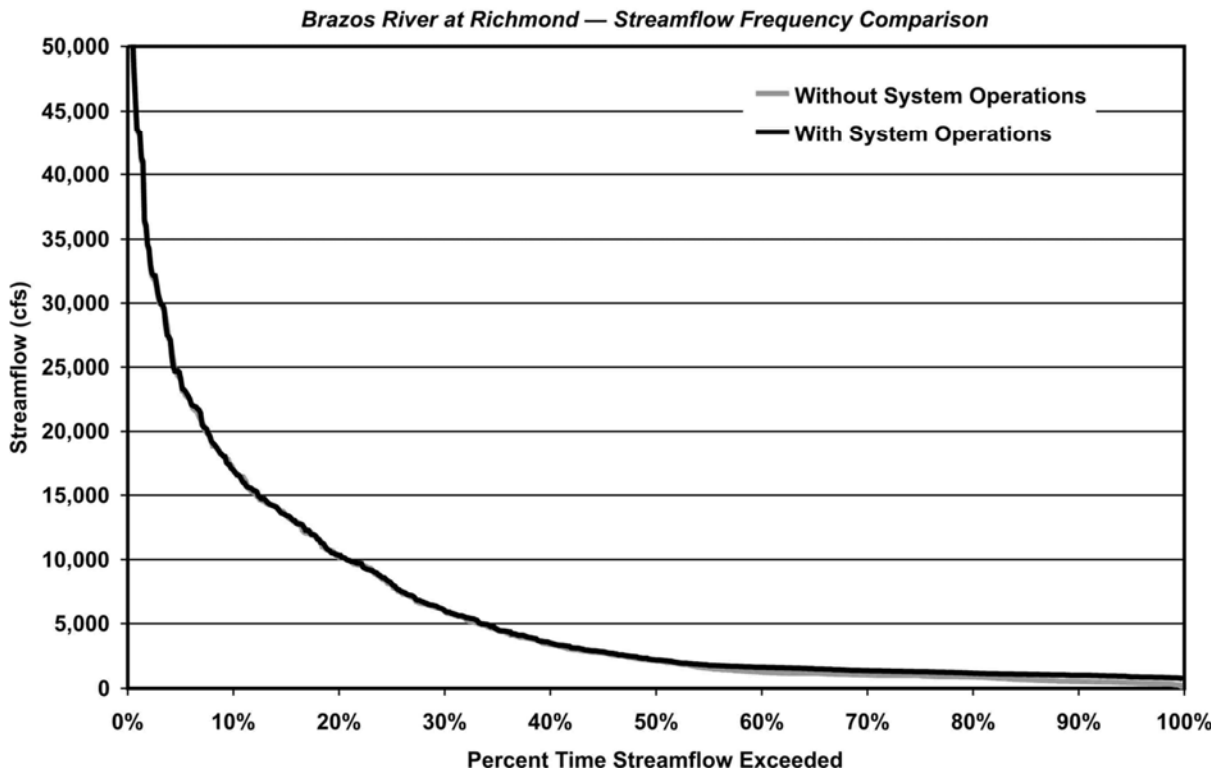
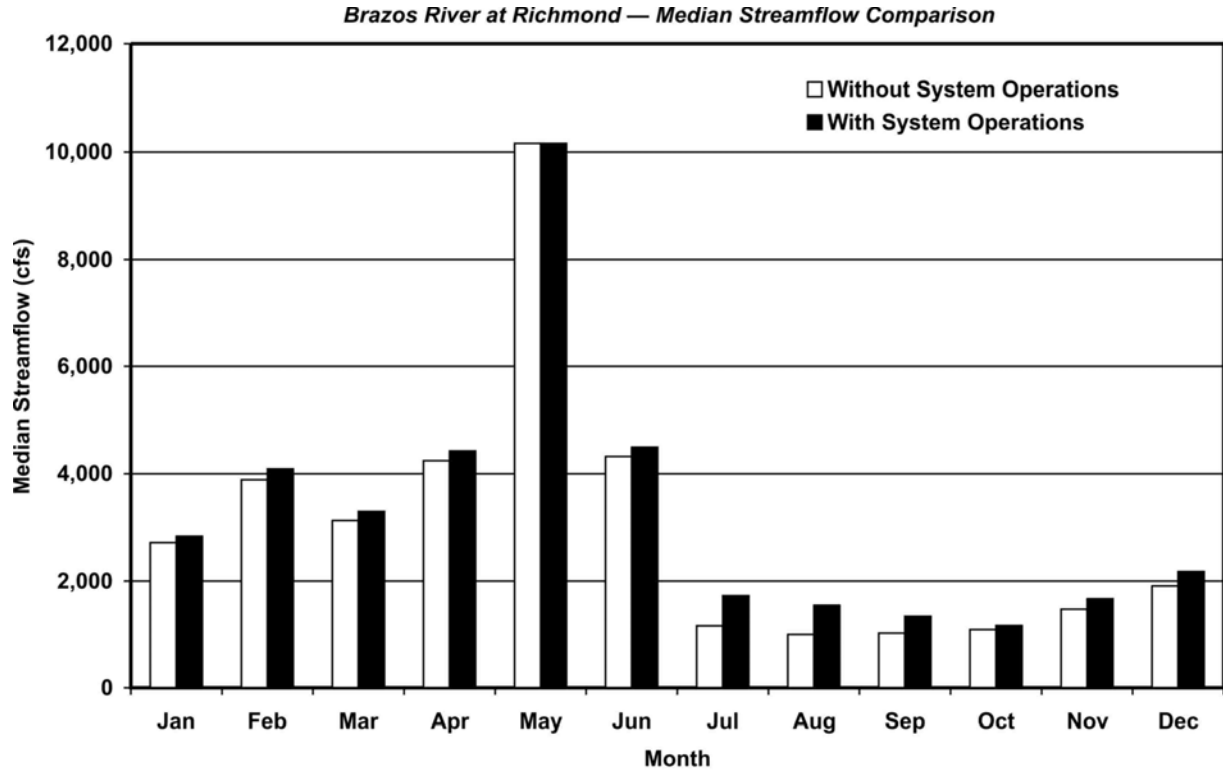


Figure 4B.4-4. BRA System Operations Streamflow Considerations at Brazos River at Richmond Control Point

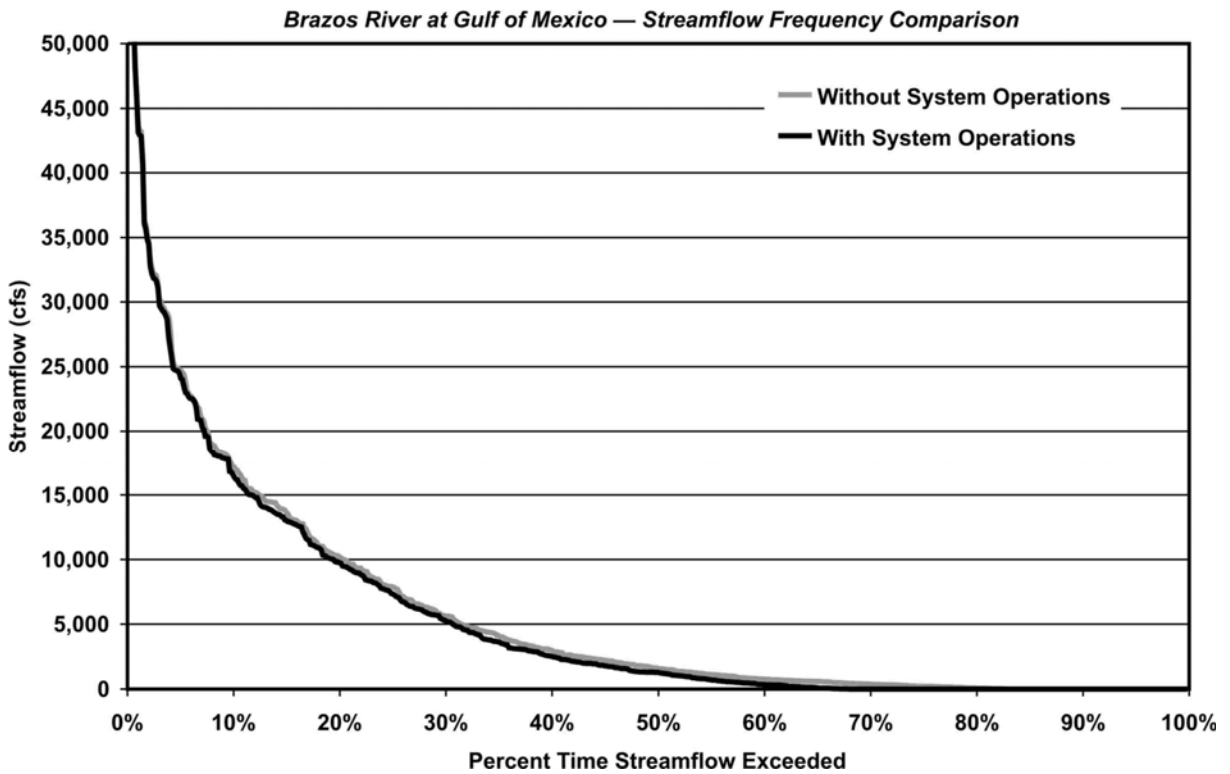
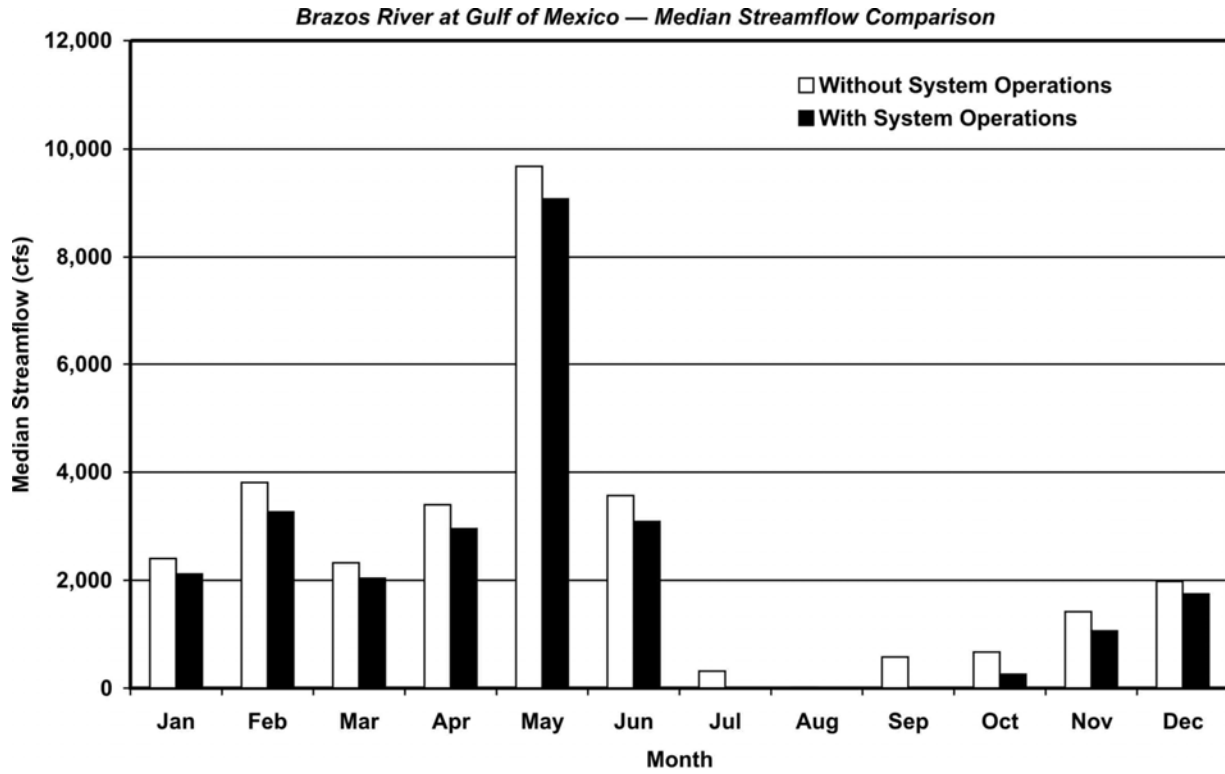


Figure 4B.4-5. BRA System Operations Streamflow Considerations at Brazos River at Gulf of Mexico Control Point

**Table 4B.4-15.
Environmental Issues: BRA System Operations**

Water Management Option	BRA System Operations
Implementation Measures	Each entity receiving the supply would have a water supply contract with the BRA.
Environmental Water Needs / Instream Flows	Possible low impacts. The primary sources of water are existing stored water and unappropriated flows diverted just upstream of the Gulf.
Bays and Estuaries	Possible low impact from reduced inflows to the Gulf.
Fish and Wildlife Habitat	Potential Impacts include constructing and maintaining easements for new pipelines or pump stations. Extent of impacts dependent on location and size of projects.
Cultural Resources	Possible low impact.
Threatened and Endangered Species	Potential Impacts include constructing and maintaining easements for new pipelines or pump stations. Extent of impacts dependent on location and size of projects.
Comments	Assumes infrastructure is needed to distribute purchased water to the entity in need.

**Table 4B.4-16.
Comparison of BRA System Operations to Plan Development Criteria**

<i>Impact Category</i>	<i>Comment(s)</i>
A. Water Supply: 1. Quantity 2. Reliability 3. Cost	1. Sufficient to meet needs ¹ 2. High reliability 3. Reasonable
B. Environmental factors 1. Environmental Water Needs 2. Habitat 3. Cultural Resources 4. Bays and Estuaries 5. Threatened and Endangered Species 6. Wetlands	1. Low impact 2. Low impact 3. Low impact 4. Low impact 5. Low impact 6. Low Impact
C. Impact on Other State Water Resources	• No apparent negative impacts on state water resources; no effect on navigation
D. Threats to Agriculture and Natural Resources	• None
E. Equitable Comparison of Strategies Deemed Feasible	• Option is considered to meet municipal and industrial shortages
F. Requirements for Interbasin Transfers	• None
G. Third Party Social and Economic Impacts from Voluntary Redistribution	• None
¹ Significant quantity for regional use and Region H	

A summary of the implementation steps for the project is presented below.

1. It will be necessary to obtain these permits:
 - a. TCEQ Water Right permit³;
 - b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for reservoirs and pipelines impacting wetlands or navigable waters of the U.S.;
 - c. TPWD Sand, Gravel, and Marl Permit for construction in state owned streambeds;
 - d. NPDES Storm Water Pollution Prevention Plan;
 - e. GLO easement for use of the state-owned streambed; and
 - f. Section 404 certification from the TNRCC related to the Clean Water Act.
2. Permitting, at a minimum, will require these studies:
 - a. Assessment of changes in instream flows in the Brazos River.
 - b. Habitat mitigation plan.
 - c. Environmental studies of potential impact on endangered species.
 - d. Cultural resource studies and mitigation.
3. Land will need to be acquired through either negotiations or condemnation for pipeline and other facilities.

³ Consideration of water rights permits, including the need for water for specific purposes, and conditions of the permits, is the responsibility of TCEQ, not the regional water planning process. However, the Brazos G RWPG assumes that any water appropriated by water right permits associated with this water management strategy will not impair the capability to impound and store water in surface water bodies such as sedimentation ponds, end lakes and other environmental features associated with mining and mining reclamation activities, when such are required by the Railroad Commission of Texas and other regulatory entities. This assumption is applicable only to runoff originating within the watershed that drains directly to each water body, and is not applicable to diversions from rivers or streams to maintain storage in the water bodies. Diversions of water from those water bodies for any reason are also specifically excluded from this assumption.

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